Year: 2021 January
Volume: 22
Supplement: 1

E-ISSN: 2149-9063

MEANDROS
MEDICAL AND DENTAL JOURNAL

SPECIAL ISSUE OF DENTISTRY

MEANDROS MEDICAL AND DENTAL JOURNAL

THE OFFICIAL JOURNAL OF ADNAN MENDERES UNIVERSITY
FACULTY OF MEDICINE AND DENTISTRY

Citation Abbreviation: Meandros Med and Dental J
(Formerly Adnan Menderes Üniversitesi Tıp Fakültesi Dergisi)

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Publishing Date: January 2021
E-ISSN: 2149-9063

International scientific journal published quarterly.

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Original Article / Özgün Araştırma

Antimicrobial Efficacy of Ozone Therapy on Cariogenic Bacteria

Ozon Tedavisinin Karyojenik Bakteriler Üzerindeki Antimikrobiyal Etkinliği

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Keywords
Ozone, chlorhexidine, gluconate, cavity disinfection, *Streptococcus mutans, Lactobacillus*

Anahtar Kelimeler
Ozon, klorheksidin glukonat, kavite dezenfeksiyonu, *Streptococcus mutans, Lactobacillus sp.*

Received/Geliş Tarihi : 09.04.2020
Accepted/Kabul Tarihi : 07.09.2020

doi:10.4274/meandros.galenos.2020.18853

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Abstract

Objective: This study aimed to evaluate the antimicrobial effectiveness of ozone therapy on cariogenic bacteria.

Materials and Methods: We evaluated 40 children with deep caries in the permanent first molar. Patients were divided into ozone and chlorhexidine digluconate (CHX) treatment groups. Cariogenic dentin samples were collected from permanent molars before and after treatment: 120 seconds with ozone and 60 s with 2% CHX solution. *Streptococcus* mutans (S. mutans) and *Lactobacillus sp.* colonies were counted after 48 hours of incubation in phosphate buffer. Obtained data were statistically analysed.

Results: Significant differences between antimicrobial activities of ozone and CHX against *S. mutans* and *Lactobacillus sp.* were observed ($p<0.05$). In the *Lactobacillus sp.* group, the amount of growth in the CHX group was significantly lesser than that in the ozone group ($p<0.05$).

Conclusion: When applied appropriately and cautiously, ozone treatment can be used for disinfection against cariogenic bacteria.

Öz

Amaç: Ozon tedavisinin karyojenik bakteriler üzerindeki antimikrobiyal etkinliğinin değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntemler: Çalışma derin dentin çürüklü daimi birinci azı dişe sahip 40 çocuk üzerinde gerçekleştirilmiştir. Hastalar klorheksidin diglukonat glukonat (CHX) grubu ve ozon grubu olarak iki gruba ayrılmıştır. Daimi büyük azı dişlerden uygulama öncesi ve sonrası dentin çürüğü örnekleri toplanmıştır (120 sn ozon ile tedavi ve 60 sn %2 CHX çözeltisi uygulanmıştır). Kırk sekiz saat anaerob şartlarda etüvde bekletilen besiyerlerinde *Streptococcus mutans (S. mutans)* ve *Lactobacilus* kolonileri sayılmış ve değerler kaydedilmiştir. Elde edilen veriler istatistiksel olarak değerlendirilmiştir.

Bulgular: Çalışmamızda elde edilen verilere göre, ozon ve CHX uygulamasının antimikrobiyal etkinliği *S. mutans* ve *Lactobacilus*'lar üzerinde istatistiksel açıdan anlamlı bulunmuştur ($p<0,05$). *Lactobacillus sp.* grubunda, CHX grubundaki koloni büyüme miktarı ozon grubundan önemli ölçüde daha azdı.

Sonuç: Ozon tedavisi, uygun ve dikkatli bir şekilde kullanıldığında dezenfektan bir seçenek olabilir.

Introduction

Dental caries is a biofilm-supported, diet-regulated, multifactorial, non-infectious, and dynamic disease that causes mineral loss in dental hard tissues (1). Dental pellicle is an accumulation of organic matter on the tooth surface as a result of the absorption of proteins found in the saliva. A pellicle is formed when the surface of cleaned teeth comes in contact with saliva. Dental pellicle allows microorganisms inside the mouth to adhere to the surface of the teeth (2,3). Dietary carbohydrates are used by microorganisms inside the biofilm present on the tooth surface, and these microorganisms produce acid. As the neutral pH of the biofilm on the enamel surface (7.0) rapidly decreases to below a critical pH (5.5), the enamel surface begins to break down (4-6). Pellicle formation is followed by the adherence of gram-positive [Gr(+)] cocci on the surface of teeth, followed by formation of Gr(+) bacillus, gram-negative anaerobic cocci, and fusiform bacteria (7-10).

Streptococcus mutans (*S. mutans*) accounts for most of the flora present immediately before tooth caries occurrence and is abundant in caries lesions with cavitation. Thus, *S. mutans* plays an important role in the initiation and progression of caries lesions (11). The ability of *S. mutans* to adhere to tooth enamel and plaques and its ability to produce acid are among the factors responsible for its virulence. *S. mutans* ferments the sucrose in food into lactic acid, causing dissolution of the enamel matrix. This allows the bacteria to adhere to the surface of the teeth via the extracellular dextrans (12).

Lactobacilli are Gr(+) bacteria present in the normal oral flora. As *Lactobacilli* are acidogenic and aciduric, they grow in environments with a low plaque pH and on active caries lesions. Studies have demonstrated reduced levels of *Lactobacilli* within the saliva after teeth are restored (13). *Lactobacilli* are responsible for destroying the dentin texture rather than initiating caries, and are more active in the later stages of caries (14). *S. mutans* comprises most of the flora immediately before cavity formation and is present in high abundance in lesions with cavitation. *Lactobacilli* are predominantly present in deeper cavities (11).

As a result of ultraconservative dentistry procedures, ongoing efforts seek to eliminate or reduce the remaining bacteria in the affected dentine. These procedures aim to reduce the risk of secondary caries formation, and include using antimicrobial solutions to clean the cavity before restoration (15). Among currently available antimicrobials, chlorhexidine (CHX) remains the most commonly used agent to reduce plaques and control caries (16). CHX is widely used as an antimicrobial agent for disinfection before restoration (15). Owing to its broad antimicrobial spectrum, CHX has been used to treat endodontic or periodontal diseases and to stop or prevent caries progression. The biocompatibility of CHX with low toxicity levels is also acceptable at clinical concentrations (16).

Liquid or gas ozone has strong antimicrobial effects against bacteria, fungi, protozoa, and viruses, and disrupts the cellular membranes and walls of bacteria and fungi. Ozone inhibits the functions of glycolipids, glycoproteins, and amino acids in cells. This increases membrane permeability, enabling ozone molecules to enter cells and kill microorganisms (17,18). Ozone is particularly effective against antibiotic-resistant bacteria. Ozone activity inhibits viral infections via inhibiting peroxide and viral protein synthesis in infected cells by altering reverse transcriptase enzyme activity (18). As a result of recent studies on new methods for caries treatment, ozone application has begun to be used. Painless ozone application to eliminate bacteria in carious lesions may provide an alternative to traditional treatment methods. Since ozone therapy is a non-invasive method of disinfection, it has the potential to be widely applicable in the field of pediatric dentistry. This study was conducted to evaluate the antimicrobial effectiveness of ozone application, together with a cavity disinfectant containing CHX gluconate, on *S. mutans* and *Lactobacillus*.

Materials and Methods

This study was compared the antimicrobial effectiveness of an agent containing CHX, which is used for cavity disinfection (Cavity Cleanser, Bisco, Schaumburg, IL, USA), and ozone treatment (OzonyTronXP, MIO International OzonyTron, Rosenheim, Germany) against *S. mutans* and lactobacilli. This was an *ex vivo* study.

Study Design

The study protocol was approved by the Ethics Committee of the Atatürk University Faculty of

Dentistry (decision no: 145, date: 04.03.2015). The parents of the children who participated in the research were informed about the study. The necessary permissions and informed consent were obtained before beginning the experiments.

We examined the antibacterial effectiveness of ozone application against *S. mutans* and *Lactobacillus sp.,* which are known to form caries. This was conducted under *ex vivo* conditions for 120 s with an OzonyTronXP device. A cavity disinfectant (Cavity Cleanser) containing 2% CHX, which has been shown to have antimicrobial effects for a period of 60 seconds (s) (19), was administered to a second group of patients.

The study included 40 healthy (ASA 1) children aged 8-15 years who visited the clinic at the Atatürk University Faculty of Dentistry Department of Pediatric Dentistry. All participants had deep dentin caries on their permanent first molars. Procedures were carried out on one tooth of each patient. A total of 40 active caries on the permanent first molars were evaluated. The patients were randomized into two groups of 20 subjects each. CHX was administered to the first group for 60 s, whereas ozone treatment was administered to the second group for 120 s. Local anesthesia was administered to the teeth prior to the disinfection procedures, and a rubber dam was applied to isolate the teeth from the oral environment.

Collection and Preparation of Samples

The overlying superficial layer and soft biological material were removed prior to therapy using a sterile steel bur (Steel bur No.14, Thomas Dental Products, Bourges Cedex, France) on a slow rotating handpiece without water cooling. After the cavity was washed with sterile distilled water, it was air-dried for 5 s. To ensure standardization, soft dentin tissue was removed with a new sterile steel round bur at low-speed from the mesial section of the cavity to fill the grooves of the bur. The tissue was placed in tubes containing phosphate-buffered saline (PBS, Sigma, St. Louis, MO, USA). An OzonytronXP device was used to apply ozone to the same cavity for 120 s according to the manufacturer's instructions. The device delivered gas at a flow rate of 1 L/min. According to the manufacturer, the ozone concentration of the gas was 2100 ppm±10%. Using a new steel round bur, a soft dentin specimen was collected from the mesial section of the cavity adjacent to the site from which the first specimen was collected. Finally, the bur was placed in a separate tube containing PBS. After numbering, the tubes were sent to the laboratory on the same day and plated within 2 h. The same procedures were carried out for subjects treated with the cavity disinfectant containing CHX. Dentin specimens were collected with a sterile steel round bur from the mesial section before the procedure and placed inside a tube containing PBS. After Cavity Cleanser was applied using sterile cotton pellets, excess solution was absorbed with the sterile cotton pellet. The pellet was kept in place for 60 s. A dentin specimen that was large enough to fill the grooves of the drill was collected with a sterile steel round bur. The specimen was collected from the site adjacent to where the first specimen was collected and then placed in tubes containing PBS. The tubes were numbered and sent to the laboratory. Routine treatment procedures were applied to the teeth after collecting the dentin specimens.

Microbiological Method

On the day of specimen collection from the cavities, fresh Mitis Salivarius Agar (Fluka-01337/Sigma-Aldrich) and Rogosa SL Agar (Fluka-R1148/Sigma-Aldrich) media were prepared for each specimen.

After the dentin specimens were mixed with a test tube rotator (GFL SH 3025, GFL Gesellschaft für Labortechnik mbH, Burgwedel, Germany) for 60 min, different dilutions (10^{-2}, 10^{-3}, and 10^{-4}) of each specimen were prepared in PBS in sterile tubes. The samples (0.1 mL) from each group were plated onto the media. One plate was left empty as a control. The media were incubated in an anaerobic environment (inside a jar) for 48 h at 37 °C.

The colonies that formed on the media after 48 h were examined macroscopically under a light and counted. As 0.1-mL samples were plated from the specimens prepared at a 10^{-4} dilution, the number of colonies was multiplied by 10^5. Colony numbers were expressed in units of colony-forming units (CFU)/mL.

The dentin specimens collected from the caries cavity before and after ozone and CHX were placed in sterile tubes and examined with a scanning electron microscope (SEM) (QUANTA FEG 250, FEI, Hillsboro, OR, USA). Images were collected at 30,000x magnification level.

Statistical Analysis

SPSS version 20.0 software for Windows (SPSS, Inc., Chicago, IL, USA) was used for data analysis. For statistical analysis, colony numbers of *S. mutans* and *Lactobacilli* were calculated as log CFU/mL to obtain a normal distribution.

The difference between *S. mutans* and *Lactobacilli* colony numbers before and after treatment was compared via a paired sample t-test.

To determine whether there was a significant difference between the antimicrobial effectiveness of ozone and CHX administration on *S. mutans* and lactobacilli, analysis of variance was performed using a 2×2 factorial design. P<0.05 was considered statistically significant for all analyses.

Results

Colonies obtained from dentin samples of carious cavities and reproduced in medium were determined by the number of *S. mutans* and lactobacilli. The means, standard deviations, and statistical differences (log CFU/mL) of the microbiological results obtained in the study are presented in Table 1. There was a significant difference in the growth of microorganisms in all groups (p<0.05). The observed microorganisms were significantly reduced (p<0.05) in the ozone and CHX groups compared to in the control group. Although CHX appeared to be numerically more effective than ozone on *S. mutans*, this difference was not statistically significant. Lactobacillus growth was significantly lower in the CHX group than in the ozone group (p<0.05).

SEM images show the colonies before and after antimicrobial application (Figure 1). Dentin tubules became more obvious after CHX application, which may be due to the chelation properties of CHX. Only the bacterial components disappeared upon ozone application, and a chelation effect was not observed.

Discussion

Despite advances in protective treatments, fluorine usage and an emphasis on dental health education have guided the practices of pediatric dentistry. Furthermore, the treatment of caries lesions in both primary and permanent teeth is the most common procedure performed on children (20).

Infected dentin tissue must be completely removed before a tooth with caries can be restored. This procedure is extremely important for preventing secondary caries formation (21). However, the inability to clinically distinguish between infected dentin and affected dentin tissue prevents precise determination of the amount of dentin caries. Using a mirror and a probe, it can be partially determined whether the dentin tissue remaining after cavity preparation is healthy. As this method requires the dentist to determine the hardness and color of the dentin tissue, this method is not objective and is insufficient for determining bacterial status (22). Previous studies

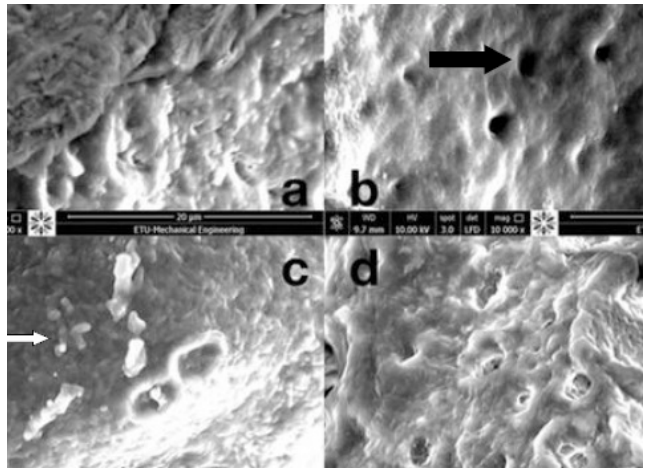

Figure 1. Scanning electron microscopy images before and after antimicrobial application (30,000x magnification)
a. Before chlorhexidine digluconate (CHX) treatment, b. After CHX treatment, c. Before ozone treatment, d. After ozone treatment. White arrow: Bacterial colonies. Black arrow: Dentin tubules after antimicrobial agent application.

CHX: Chlorhexidine digluconate

Table 1. The mean logarithmic values of the number of microorganisms (log colony forming units/mL)

	Before ozone [log_{10} (CFU/mL)]	After ozone [log_{10} (CFU/mL)]	Before CHX [log_{10} (CFU/mL)]	After CHX [log_{10} (CFU/mL)]
Streptococcus mutans	6.11 ± 0.15[a]	5.37 ± 0.29[a]	6.22 ± 0.25[b]	5.46 ± 0.25[b]
Lactobacillus sp.	6.17 ± 0.16[c]	5.57 ± 0.25[c]	6.36 ± 0.20[d]	5.46 ± 0.26[d]

*Same letters in superscript indicate a significant difference. CHX: Chlorhexidine digluconate, CFU: Colony-forming units

indicate that even if the infected dentin tissue of the affected teeth is completely removed, the dentin specimen collected from the cavity base still contains bacteria (23,24).

Several materials, such as CHX, are used as cavity disinfectants. However, administration of cavity disinfectants or adhesive systems can negatively impact the ability of hydrophilic resin to bind to dentin, thus altering its permeability (25,26). Ozone gas is considered an alternative non-invasive antibacterial, antiviral, and antifungal agent and can reduce the number of bacteria in caries. Ozone is effective at lower concentrations and acts more rapidly and without side effects such as taste or odor, which are typical of other disinfectant agents such as chlorine and ammonium compounds. Moreover, ozone treatment is less costly, easier, and faster, and can be applied as a substitute for traditional caries cleaning methods and antimicrobial agents (27).

Ozone treatment is considered appropriate for use in pediatric dentistry owing to its painlessness, and is thought to have antimicrobial features. It is therefore used as an alternative to existing methods for cavity disinfection and their negative effects on the bonding force of resins (27).

S. mutans is the primary bacterium responsible for human tooth caries. The antimicrobial effectiveness of different treatments against *S. mutans* and *Lactobacilli* was therefore evaluated in deep dentin cavities (28). *Lactobacillus acidophilus* and *Lactobacillus casei* are isolated from the saliva, vestibular mucosa, back of the tongue, and hard palate in the oral cavity of humans. All types of *Lactobacilli* catalyze mixed acid fermentation reactions, in which carbohydrates, particularly lactic acid, are transformed into caries-causing acids (29). The cavity disinfectant with CHX and ozone used in this study showed significant antimicrobial effectiveness against *S. mutans* and *Lactobacilli*.

The antimicrobial efficacy of Cavity Cleanser was statistically significant for both types of microorganisms. By comparing antimicrobial activity of Cavity Cleanser on these microorganisms, it was observed that this was more effective against *Lactobacilli* than against *S. mutans*, with a larger number of bacteria being eliminated in the *Lactobacilli* group. SEM showed that microorganisms and the exposed dentin tubules. In contrast, another study used the dental cavity method to evaluate the antibacterial effectiveness of CHX, and found that it was more effective against *S. mutans* than *Lactobacilli* (17).

Ozone treatment has antibacterial effects and has become widely used in the dentistry field in recent years. Ozone treatment has easier and faster application compared to other traditional caries cleaning methods and antimicrobial agents. Caries lesions have been suggested to be reversible, although it is difficult to estimate the extent to which this is possible (30). Polydorou et al. (31) applied ozone on the dentin surface for 80 s under *in vitro* conditions and observed reduced numbers of microorganisms. The biomolecular structure of the caries lesion was examined before and after ozone application by Holmes (30). Holmes (30) reported that when oxidized, the acids formed by the bacteria become more alkaline, which is not a suitable environment for bacterial growth. It was reported that ozone transforms the microbial flora, consisting of acidogenic and aciduric microorganisms, into normal oral flora. Moreover, it ensures remineralization by removing the proteins in the caries lesion, and causes calcium, phosphate, and fluorine ion diffusion in the caries lesion. The use of remineralizing solutions following ozone administration after active caries is stopped, along with good oral hygiene and reduced sugar intake, can make remineralized tissue more resistant to caries attack (30). Other studies reported that the antimicrobial effectiveness of ozone may be affected by various factors such as the administration period, concentration, medium temperature, bacteria types, and colonization. Thus, further *in vivo* and *in vitro* studies of the effects of different treatment parameters on ozone treatment are needed (32,33).

Ozone treatment is pain-free and shows antibacterial properties, making it suitable for use in pediatric dentistry (34-36). We used an *ex vivo* technique to investigate the efficacy of ozone for cavity disinfection. Ozone administration was performed using an OzonyTronXP, which is the latest-generation ozone device. The OzonyTronXP device does not produce ozone gas. The probe of the device degrades oxygen molecules (O_2) present in the environment once the probe is in contact with the patient. Atomic oxygen (O^-) kills bacteria and combines with oxygen in the environment to temporarily create ozone

(O_3) gas, which has strong disinfectant effects. The manufacturer recommends a disinfection period of 120 s for deep dentin cavities.

Baysan and Lynch (37) showed that in primary root surface caries, *in vitro* ozone administration for 10 or 20 s significantly reduced the number of microorganisms. They reported that *in vitro* ozone administration on the surface of caries dentin for 10 s reduced the number of all bacteria. along with *S. mutans* and *S. sobrinus*, to less than 1%. Furthermore, 20 s of administration eliminated 99.9% of microorganisms (37).

We utilized SEM to evaluate changes in dentin tissue, allowing the detection of microorganisms and their accessories following ozone treatment and CHX administration. The SEM images showed that microorganisms and their accessories were removed from the ozone-treated dentin specimens compared to before administration, and that the dentin tubules were exposed.

Conversely, in a study measuring the efficacy of ozone treatment on infected dentin underneath the lesions without cavitation, Baysan and Beighton (38) found that ozone treatment had weak antibacterial effects. The researchers carried out ozone treatment for 40 s (HealOzone). They reported that these results may have been obtained because the ozone did not directly contact the dentin. Additional microbiological evaluation, in which ozone was applied to infected dentin for 40 s after removing the enamel tissue, showed that the microbial counts were significantly reduced. In an *in vitro* study conducted using the "Tooth Cavity Model" technique on permanent teeth, Polydorou et al. (31) compared the effects of ozone treatment (HealOzone 40 s, 80 s) and antibacterial bonding agents (Clearfill Protect Bond, Clearfill SE Bond) on *S. mutans*. They reported that both bonding systems and 80-s ozone treatment were significantly more effective than 40-s ozone treatment. In this study, 120 s of ozone treatment with the OzonytronXP device was effective for reducing bacterial counts.

Conclusion

In clinical practice, applying antimicrobial agents before restoring cavities may reduce the risk of secondary caries. This study showed that the chemical cavity disinfectant (Cavity Cleanser) containing CHX is the most effective antibacterial treatment against *S. mutans* and *Lactobacillus*. However, ozone therapy can also be an effective disinfectant when used carefully and for an appropriate period of time. More extensive clinical studies are needed to determine the effects of ozone treatment on infected dentine tissues, either alone or in combination with other cavity disinfectants. The data obtained in our study show that ozone treatment has antimicrobial efficacy. However, the effect of antimicrobial agents on the restoration of dental joints remains to be investigated.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of the Atatürk University Faculty of Dentistry (decision no: 145, date: 04.03.2015).

Informed Consent: The necessary permissions and informed consent were obtained before beginning the experiments.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: T.G., Design: E.D., Supervision: Ö.B., Fundings: E.D., T.G., Ö.B., Data Collection or Processing: E.D., Ö.B., Analysis or Interpretation: T.G., Literature Search: E.D., Critical Review: E.D., Writing: E.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

101 Top-cited Dentistry Articles From Turkey: A Bibliometric Analysis

Türkiye'den En Çok Atıf Alan 101 Diş Hekimliği Makalesi: Bibliyometrik Analiz

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Abstract

Objective: This study aimed to evaluate and analyse the 100 top-cited published articles with the first author affiliated in Turkey institutions.

Materials and Methods: Dental articles with authors from Turkey were searched using the "Advanced Search" tool of the Web of Knowledge. The main institution was identified as the address of the first author in Turkey. Descriptive statistics were used to summarise the results.

Results: The 101 top-cited articles were cited 12,577 times and were published between 2016 and 1981. The top-cited article with the highest number of citation was cited 351 times. The Journal of Prosthetic Dentistry published the highest number of top-cited articles, and most of the studies covered by top-cited articles focused on prosthetic dentistry. Twenty-two institutions have made contributions to the top-cited articles. Forty-five articles were produced by individual institutions. The field of basic science had the highest number with 54 articles, followed by the field of clinical research with 40 articles. "Implant" was the main study topic of articles. Randomised controlled trial was the most common study design for articles in the field of clinical research, and the majority of the articles had level II of evidence.

Conclusion: This study provided insights about scientific trends of dentistry in Turkey. If the focus of randomised controlled trials is extended to other clinical topics besides implant and international collaboration is increased, articles may be more recognised and cited.

Keywords
Bibliyometrik citation analysis, ISI web of knowledge, Turkey

Anahtar Kelimeler
Bibliometri, atıf analizi, ISI web of knowledge, Türkiye

Received/Geliş Tarihi : 01.08.2020
Accepted/Kabul Tarihi : 01.10.2020

doi:10.4274/meandros.galenos.2020.59023

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Öz

Amaç: Bu çalışmanın amacı, Türkiye kurumlarına bağlı ilk yazar tarafından yayınlanan ve en çok atıf yapılan 100 makaleyi değerlendirmek ve analiz etmektir.

Gereç ve Yöntemler: "Web of Knowledge" veri tabanının "Advanced Search" aracı kullanılarak Türkiye adresli yazarlara ait dental makaleler hakkında bir araştırma yapıldı. İlk yazarın ana kurumunun Türkiye adresli olduğu yayınlar çalışmaya dahil edildi. Sonuçları özetlemek için tanımlayıcı istatistik kullanıldı.

Bulgular: En çok atıf yapılan 101 makale toplam 12.577 alıntı aldı ve 2016 ile 1981 yılları arasında yayınlandı. En çok alıntı yapılan makalenin atıf sayısı 351 idi. Yayımlanan makaleler önemli ölçüde protetik diş hekimliği ile ilgili olup, yayınların en fazla yayımlandığı dergi "The Journal of Prosthetic Dentistry" oldu. Yirmi iki kurum en çok alıntı yapılan makalelere katkıda bulundu. Kırk beş makale tek merkezli kurumlar tarafından üretildi. Temel bilim alanı 54 makale ile en yüksek

sayıya sahipken, bunu 40 makale ile klinik araştırma alanı takip etti. İmplant makalelerin ana çalışma konusuydu. En yaygın çalışma tasarımı klinik araştırma alanındaki makaleler için randomize kontrollü çalışma ve makalelerin çoğunluğu için kanıt düzeyi II. seviyeydi. **Sonuç:** Bu çalışma Türkiye'deki diş hekimliğinin bilimsel eğilimleri hakkında bir fikir ortaya koymuştur. Randomize kontrollü çalışmaların konusu implantın yanı sıra diğer klinik konulara da genişletilirse ve çalışmalarda uluslararası iş birliği artırılırsa, makaleler daha iyi tanınabilir ve daha fazla atıf alabilir.

Introduction

Bibliometric indicators are useful for assessing research performance; however, this is valid when the indicators are right, sophisticated, current, included expert knowledge, and evaluated and used with care (1). The importance of research which is indicated by the citation count is quantified by using citation data in bibliometric studies (2). The Institute for Scientific Information (ISI) has been compiling the most relevant bibliometric information from published scientific articles since 1945, then the Science Citation index (SCI), a specific tool for measuring citations, was available since 1962 (3). Today, in bibliometric studies, the citation indexes created by Thomson Reuters, particularly the Web of Science (WoS) and its predecessor, the SCI, are commonly used databases (1).

Many bibliometric analysis was published in medicine including the topics of oral and maxillofacial surgery (4,5), psychiatry (6), plastic and reconstructive surgery (7), neurosurgery (8), neurophysiology (9), neurosciences (10,11), orthopedic surgery (12), urology (13), pulmonary diseases (14), public health (15). Bibliometric analysis in dentistry has been performed in such areas endodontics (2,16-20), implant (21-23), paediatric dentistry (24), periodontology (25,26), oral medicine and radiology or radiology (27-29), orthodontics (30) and in such topics dental traumatology (31,32), orofacial pain (33), dental education (34). Some citation studies were based on articles published in several dentistry journals (3,35-37), articles published in a single journal (17,38) or articles published by authors in a single country (39).

Analysis of research results may help get information on the development of policies related to scientific and technological aspects in dentistry, especially in developing countries (e.g. China, Thailand, South Korea, Brazil) and in the EU which is currently undergoing a major reorganization (40). According to ISI database from 1999 to 2003, an increase in dentistry-related studies was monitored in developing countries, such as Brazil, Turkey, China, Thailand, South Korea, Jordan and Iran. Moreover, the average number of citations for each document was reported as 1.27 and it was reported that Turkey was in the 10 countries with most published articles from 1999 to 2003 (40). The data from SCImago showed that Turkey was the 4th country in Europe and 8th country in the world in terms of the number of dental articles published between 1996 and 2018. Also, a total 550 citable article from Turkey was published in 2018 with 0.36 citation per article (totally 218 citations) (41).

In the literature, there is no article specifically on the top-cited papers in dentistry published by authors affiliated to the institutions in Turkey. Another study analyzed the characteristics of the top 100 articles which are the most cited on dentistry which are published in scientific journals with international collaboration whose coauthor(s) affiliated to the institutions in Brazil (39). In this study, it was stated that such analysis could help provide the current status of Brazilian dentistry regarding the most cited dental articles, as well as the areas and topics which attract international attention. So, country-based citation analysis studies will provide a panorama in terms of the scientific studies of that country in that field and will provide scientist with guiding data in terms of future planned studies. Also, this study will provide a wider perspective to evaluate the studies that are in the field of dentistry. Therefore, in the present study, we aimed to evaluate and analysis the 100 top-cited articles published by first author affiliated to Turkey institutions.

Materials and Methods

A search about dental articles with authors from Turkey was performed on 23 March 2020 on the WoS (Clarivate Analytics Co., Philadelphia, PA), which is an online platform (http://www.webofknowledge.com) providing bibliographic data on scientific materials.

In order to investigate the publications of the authors addressed in Turkish institutions in both in dental journals and other journals containing articles related to dentistry, as the first step, "All Database" was selected from "Select a Database" option. Following the election of "Advanced Search" option, without any year or language restrictions, the proposed query set [CU =(TURKEY)] was scanned and this search resulted in 658,322 articles (n=658,322). Finally, we used "Dentistry, Oral Surgery & Medicine" as the "Research Area" category filter. With these limitations, 18,243 articles are obtained as a result (n=18,243).

In the present study, the articles without the first authors affiliated to a Turkish institution and publications of the source types such as "books", "book series", "conference proceedings", "trade publications" and "undefined" were excluded. The selection of the articles was performed by two independent researchers (M.D. and F.K.). The articles were listed from the highest to the lowest based on the number of citations received and the 100 most cited articles were identified (Table 1). Accordingly, as for articles which have same number of citations, the more current one was ranked higher.

The 100 articles receiving the most citations were analyzed with regard to citation count, title of the article, the year of publication, the number of authors, journal name, institutions, collaborations type, type of study, distribution of articles to subfield of Dentistry and subfield topic, study design of clinical articles, thematic field and level of evidence of clinical study. Any disagreement between two researchers on article analysis was resolved through discussion and consensus.

The journal names are listed based on the number of the articles which are top-cited, but journals with the same number of articles are ranked based on the Journal Impact Factor (JIF) 2018 which is provided from the Journal of Citation Reports (https://jcr.clarivate.com) (Table 2).

The main institution was indicated by the address of the first author in Turkey. The institutions and the addresses of co-authors were also considered to detect the type of institutional collaboration without considering the departments. Thus, institutional collaboration type was considered as individual institution when all contributing authors were affiliated to the same research institution regardless of the departments. The other institutional collaboration types were classified as "multi-institutional collaboration" if multiple institutions within the Turkey joined the study and as "international collaborations" if there were institutes from different countries (18,20). If the first author is working in multiple institutions addressing Turkey or there is more than one country cooperation in one article, each one of these institutions and countries were counted.

The study types included basic science, clinical research, and review. A study classified as a basic study when it included experiments on extracted human teeth, animal, dental plaque, microorganism, saliva, dental materials or cells (18). While determining the study field, the full text of all the articles in the list was read and discussed until the consensus was achieved by the two researchers to determine the study types. In addition, an abstract of each study in PubMed has been reached and the Medical Subject Headings (Medical Subject Headings terms) given for this study field have been considered. The main subject of the articles was categorized as prosthetic dentistry, endodontics, periodontology, orthodontics, restorative dentistry, oral and maxillofacial surgery, pedodontics, oral and maxillofacial radiology and oral implantology according to the department of which the first author is affiliated. If first author was not affiliated to dentistry, the department of co-author which was affiliated to dentistry was based on. Where no author was affiliated to dentistry, the main subject of the articles was determined according to topic of article. After this, each article for each main subject was classified according to its own subtopics which were investigated in article (Table 3).

The previously described the study design of clinical articles were used as follows: randomized controlled trial (RCT) controlled trial, systematic review of RCT, non-randomized experimental study, systematic review of cross-sectional study among consecutive presenting patients, cross-sectional study among consecutive presenting patients, cross-sectional study among non-consecutive patients, case-control study, case report, and cross sectional study. Afterwards, the level of evidence (level I to V) was defined for the clinical articles according to the type of research question (intervention 1, diagnosis, prognosis and etiology) (Table 4) (42).

Statistical Analysis

Statistical analysis for frequency of descriptive measures was performed using SPSS version 21 (IBMCorp, Armonk, NY).

Results

The 101 top-cited articles are listed according to the citation count in a descending order in Table 1. The last four articles have the same number of citations (91 citations); therefore, 101 articles were listed. The highest top cited article had 351 citations and it is in *in vitro* study on the fracture resistance of endodontically-treated teeth which were restored with different post systems. This study related to Prosthetic Dentistry field and was published 2002. Least cited four articles had 91 citations and one of them is *in vivo* study which is related to orthognathic surgery, three of them are *in vitro* studies on the cytotoxicity of root canal sealers, the strength of translucent fiber post bond to dentin and the biomechanical effects of rapid maxillary expansion, respectively. These studies related to Prosthetic Dentistry and Orthodontics field and they were published 2006 and 1998, respectively. The 101 most top-cited articles received 12,577 citations in total and the mean citation count for each article was 125 (Table 1).

Table 1. Top 100 articles with authors from Turkey

		No. of citations
1	Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 2002; 87: 431-7.	351
2	Effect of zirconium-oxide ceramic surface treatments on the bond strength to adhesive resin. J Prosthet Dent 2006; 95: 430-6.	237
3	Time-dependent effects of EDTA on dentin structures. J Endod 2002; 28: 17-9.	237
4	The effect of improved periodontal health on metabolic control in type 2 diabetes mellitus. J Clin Periodontol 2005; 32: 266-72.	229
5	Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod 2004; 30: 391-8.	229
6	Virulence factors of Enterococcus faecalis: Relationship to endodontic disease. Crit Rev Oral Biol Med 2004; 15: 308-20.	213
7	The influence of functional forces on the biomechanics of implant-supported prostheses - A review. J Dent 2002; 30: 271-82.	189
8	Chemical compositions and antimicrobial activities of four different Anatolian propolis samples. Microbiol Res 2005; 160: 189-95.	182
9	Three-dimensional finite element analysis of the effect of different bone quality on stress distribution in an implant-supported crown. J Prosthet Dent 2005; 93: 227-34.	170
10	Perception of pain during orthodontic treatment with fixed appliances. Eur J Orthod 2004; 26: 79-85.	169
11	Lipid peroxidation levels and total oxidant status in serum, saliva and gingival crevicular fluid in patients with chronic periodontitis. J Clin Periodontol 2007; 34: 558-65.	167
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75	Periodontal infections and pre-term low birth weight: A case-control study. J Clin Periodontol 2005; 32: 174-81.	98
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99	Cytotoxicity of new resin-, calcium hydrooxide- and silicone-based root canal sealers on fibroblasts derived from human gingiva and L929 cell lines. Int Endod J 2007; 40: 329-37.	91
100	Influence of dentin bonding agents and polymerization modes on the bond strength between translucent fiber posts and three dentin regions within a post space. J Prosthet Dent 2006; 95: 368-78.	91
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Journals and The Year of Publication

The top-cited most-cited articles were published in 35 different journals whose publication language is English. 13 journals published three or more top articles. Two of the top-cited articles were published in four journals, and one of them was published in 18 journals. The JIF of 35 journals was between 43.07 and 0.785. Journal of Prosthetic Dentistry published the highest number of top-cited articles (n=17) and "Journal of Endodontics" was the second journal (n=13), followed by "Journal of Clinical Periodontology" (n=5) and "Journal of Oral Rehabilitation" (n=5) (Table 2).

The 101 top-cited articles were published between 2016 and 1981. Fourteen of them was published between 1981 and 2000, 78 between 2001 and 2010 and 9 between 2011 and 2016. In 2004, the highest number of top-cited articles (n=15) was published, which followed by the years of 2002 and 2005 (n=13), and 2007 and 2008 (n=8) (Figure 1). Journal of Prosthetic Dentistry was the first to publish a top-cited article back in 1981. It was related to Prosthetic Dentistry field which was about "causes of fracture of acrylic resin dentures". The newest article was published in Nature in 2016. It was related Restorative Dentistry field which was about "ablation-cooled material removal with ultrafast bursts of pulses" (Table 1).

Authors and Institutions of Origin

A total of 342 unique authors contributed to top 101 most-cited-articles. The number of authors in top-cited articles was between 1 and 12. Four articles had single author. Twenty-two articles were attributed to two authors, 18 articles to 3 authors, 24 articles to 4 authors, and 15 articles to five authors. The number author of 16 articles was between 6 and 9 (Table 5).

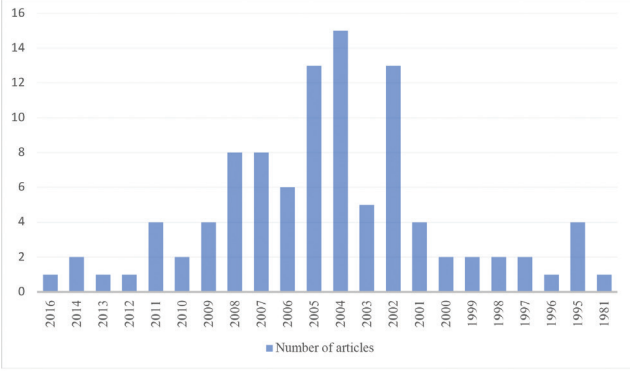

Figure 1. Year of 100 top-cited articles

The number of institutions indicated by the address of the first author in Turkey was 22 (Table 6). 13 of the 22 institutions had two or more top-cited articles which were published. Among the 13 institutions, Hacettepe University had the highest number with 20 top-cited articles (2,393 citations), followed by Ege University with 11 top-cited articles (1,557 citations), Marmara University with 10 articles (1,142 citations) and Selçuk University with 10 articles (1,098 citations). Considering all the authors that contributed to an article, 45 articles were produced by individual institutions, 27 by multi-institutional collaboration within Turkey and 29 by international collaborations. Considering the collaborations made internationally, those with the institutions in the United States had the highest number of published top-cited article (13 articles), followed by those in Finland with three articles, Sweden with three articles and United Kingdom with two articles (Table 7).

Type of Study, Field of Study, and Study Design, Level of Evidence and Type of Research Question of The Clinical Articles

Among 101 top-cited articles, basic science had the highest number of articles with 54 articles. 40 articles focused on clinical research and 8 articles were review. Whenever an article included 2 or 3 topics which were separately defined, it was scored accordingly in 2 or 3 categories (Table 4) (18).

Most of the topics of the 54 top-cited basic science articles were implant with 6 articles, followed by post and/or core materials with 5 articles and root canal sealer with 5 articles. Major topics of interest of 40 clinical research were implant with 4 articles, followed by gingival crevicular or chronic periodontitis with 4 articles. The majority of the topics of 8 top-cited review articles were implant with two articles (Table 3). Prosthetic Dentistry was the field with the highest number of top-cited articles (n=34) followed by Periodontology with 16 articles and Endodontics with 14 articles. Major topics of articles in different dentistry field were shown Table 3.

RCT was the type of study design with the highest number of articles (21 articles) in clinical experience, followed by cross-sectional study with 10 articles. The most frequent type of research question was classified as intervention with 22 articles, followed by diagnosis with 12 articles. Level of evidence was classified as having level II in 27 articles and level II in 7 articles.

Table 2. Journals containing 100 top-cited articles

Journal List	Abbreviated name	No. of articles	JIF 2018
Journal of Prosthetic Dentistry	J Prosthet Dent	17	2.787
Journal of Endodontics	J Endodont	13	2.833
Journal of Clinical Periodontology	J Clin Periodontol	5	4.164
Journal of Oral Rehabilitation	J Oral Rehabil	5	2.341
Journal of Dental Research (Critical Reviews in Oral Biology Medicine)	J Dent Res (Crit Rev Oral Biol M)	4	5.125
Journal of Periodontology	J Periodontol	4	2.768
Angle Orthodontist	Angle Orthod	4	1.88
Clinical Oral Implants Research	Clin Oral Implan Res	3	3.825
International Endodontic Journal	Int Endod J	3	3.331
Journal of Dentistry	J Dent	3	3.28
American Journal of Orthodontics and Dentofacial Orthopedics	Am J Orthod Dentofac	3	1.911
Journal of Oral and Maxillofacial Surgery	J Oral Maxil Surg	3	1.781
International Journal of Prosthodontics	Int J Prosthodont	3	1.533
Dental Materials	Dent Mater	2	4.44
Histochemistry and Cell Biology	Histochem Cell Biol	2	2.640
European Journal of Orthodontics	Eur J Orthodont	2	1.841
Acta Odontologica Scandinavica	Acta Odontol Scand	2	1.565
Nature	Nature	1	43.070
Journal of Controlled Release	J Control Release	1	7.901
International Journal of Pharmaceutics	Int J Pharmaceut	1	4.213
Oral Microbiology and Immunology	Oral Microbiol Immun	1	3.62
Lasers in Surgery and Medicine	Laser Surg Med	1	3.262
Clinica Chimica Acta	Clin Chim Acta	1	2.735
Journal of Biomedical Materials Research Part B-Applied Biomaterials	J Biomed Mater Res B	1	2.674
Oral Diseases	Oral Dis	1	2.625
Clinical Oral Investigations	Clin Oral Invest	1	2.453
Caries Research	Caries Res	1	2.326
Lasers in Medical Science	Laser Med Sci	1	2.076
Bmc Oral Health	Bmc Oral Health	1	2.048
Forensic Science International	Forensic Sci Int	1	1.990
Journal of Cranio Maxillofacial Surgery	J Cranio Maxill Surg	1	1.942
Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology	Oral Surg Oral Med O	1	1.69
Archives of Oral Biology	Arch Oral Biol	1	1.663
Dentomaxillofacial Radiology	Dentomaxillofac Rad	1	1.525
Endodontics Dental Traumatology	Endod Dent Traumatol	1	1.494
Dental Materials Journal	Dent Mater J	1	1.424
British Journal of Oral Maxillofacial Surgery	Brit J Oral Max Surg	1	1.164
Journal of Oral Implantology	J Oral Implantol	1	1.062
Journal of Craniofacial Surgery	J Craniofac Surg	1	0.785

JIF: Journal Impact Factor

Table 3. Numbers of the 100 top-cited articles categorized on basis of type and specific field

Field of study		Type of Study		
		Clinical	Basic	Review
Prosthetic Dentistry	Implant	4	6	2
	Metal-ceramic restorations	1	1	-
	Denture base material	1	2	1
	Luting material	-	3	-
	Post and/or core materials	-	5	-
	Surface roughness	1	3	-
	Provisional restorative materials	-	1	-
	İmpression techniques	1	-	-
	Tooth morphology	1	-	-
	Dental metals and alloys	-	1	-
Endodontics	Microbiology	-	1	1
	Canal morphology	-	2	-
	Root canal sealer	-	5	-
	Root canal preparations	-	1	-
	Dentin structure	-	2	-
	Dental pulp stem cells	-	1	-
	Smear layer	-	-	1
Periodontology	Gingival crevicular or chronic periodontitis	4	-	-
	Periodontal disease and systemic health problems	2	-	-
	Periodontal disease and molecular mechanism	2	4	-
	Periodontal diseases and microbiology	1	1	-
	Photodynamic therapy	1	-	1
Orthodontics	Maxillary expansion	2	1	-
	Orthodontic appliances	2	-	-
	Bonding to enamel of bracket	-	1	-
	Dental anomalies	2	-	-
	Open bite treatment	1	-	-
	Serum and saliva	1	-	-
Restorative Dentistry	Dental composite	-	1	-
	Bleaching agents	-	1	-
	Dentin adhesives	-	2	-
	Dentin	-	1	-
	Luting agents	-	1	-
	Microbiology	1	-	-
Oral and Maxillofacial Surgery	Implant placement	-	2	-
	Oral mucositis	-	1	-
	Oral lichen planus	-	-	1
	Methylprednisolone	1	-	-
	Maxillofacial fractures	1	-	-
	Peripheral osteoma	1	-	-
	Root canal sealer	-	1	-
	Temporomandibular joint arthrocentesis	1	-	-
Pedodontics	Dental caries	2	1	1
	Amelogenesis imperfecta	1	-	-
	Root canal irrigants	-	1	-
	Tooth development/or dental pulp stem cells	1	1	-
	Regenerative endodontic	1	-	-
	Saliva	1	-	-
Oral Implantology	Implant surgery	1	-	-
Oral and Maxillofacial Radiology	Osteoporosis	1	-	-

Table 4. Study design, level of evidence and type of research question of the clinical articles in top 100

	Level of evidence	Type of research question	No. of articles	Total no. of citations
Randomized controlled trial	II	Intervention	21	2,532
Cross-sectional study among consecutive presenting patients	II	Diagnosis	6	805
Cross-sectional study among non-consecutive patients	III	Diagnosis	4	406
Case control study	III	Aetiology	3	298
Systematic review of cross-sectional study among consecutive presenting patients	I	Diagnosis	2	245
Systematic review of randomized controlled trial studies	I	Intervention	1	109
Clinical/case report	-	Not applicable	1	108
Case series	IV	Prognosis	1	105
A cross sectional study	IV	Aetiology	1	92

Table 5. The number of authors of 100 top cited articles

The number of authors	No. of articles
1	4
2	22
3	18
4	24
5	15
6	10
7	4
8	1
9	1
11	1
12	1

Table 6. Institutions of origin of 100 top-cited articles

	No. of articles	Total no. of citations
Hacettepe University	20	2,393
Ege University	11	1,557
Marmara University	10	1,142
Selcuk University	10	1,098
İstanbul University	9	1,144
Gazi University	9	1,121
Yeditepe University	6	737
Ankara University	6	611
Ondokuz Mayıs University	3	387
Çukurova University	3	331
Bogaziçi University	2	243
Kocaeli University	2	232
Dicle University	2	215
Kırıkkale University	1	237
GATA Haydarpaşa Education and Research Hospital	1	229
Süleyman Demirel University	1	229
Bilkent University	1	162
Yakın Doğu University	1	149
İstanbul Medipol University	1	135
Gülhane Military Medical Academy	1	116
İzmir Katip Çelebi University	1	106
Karadeniz Teknik University	1	98

Discussion

The number of citations to an article is not necessary for the quality of that article. However, citation analysis studies that include all disciplines of dentistry can provide clues for author and topics contributing to major development in dentistry (3). Citation analysis studies on different topics such as country-based are used as a tool to evaluate research performance from both institutional and individual point of the process, including funding and hiring decisions, determination of research needs for resource allocation, and investment in research facilities of field or specialty (34). Citation analyses indices showed an increasing trend. Moreover, findings of citation analyses studies would be beneficial for the editors and publishers of dental journals as a comparative criterion for

Table 7. Type of collaboration of 100 top-cited articles		
Type of collaboration	**No. of articles**	
Individual institutions	45	
Multi-institutional collaboration	27	
International collaborations	29	
	United States	13
	Finland	3
	Sweden	3
	United Kingdom	2
	Norway	2
	Germany	2
	Netherlands	1
	Canada	1
	Hong Kong	1
	Denmark	1
	Belgium	1

measuring success and trend of their respective journals as well as providing a self-evaluation for the dental community (37). Therefore, this study evaluated and analyzed the 101 articles which are top-cited and were published by the authors affiliated to the institutions in Turkey.

In the present study, the numbers of citations were between 351 and 91, and the mean citation count for each article was 125. In contrast to our results, Feijoo et al. (3) reported the citation numbers were between 2050 and 326 for the top 100 most-cited articles which were published in dental journals. In another study, it was reported that the citation received by dental journals was 97,081 in 2003 and 233,232 in 2012. Also, the total number of dental journals which made citations of the articles significantly increased from 46 in 2003 to 83 in 2012 (37). On the other hand, 101 top-cited articles received a total 12,577 in our study. This difference may be due to our study being country-based and involving a single country. Studies involving different countries can enable more topics to be studied and collaborate and can provide a wider perspective on study topics. Another study country-based citation analysis which included the top 100 articles which were the most-cited articles and were published in international dental journals with at least one coauthor affiliated to an institutions in Brazil showed citation numbers between 124 and 657 (39). The difference between this and our study may be due to difference in study design. In our study, the main institution was indicated by the address of the first author in Turkey. However, in this study, it based on at least one coauthor affiliated to Brazil. Therefore, this may have led to greater collaboration opportunities in top cited studies. As a result, it may increase the citation number of top-cited articles compared to our results.

In our study, the majority of the top 101 most-cited articles (71 articles) were published in the journals with a JIF of >2, which included ≥2 top-cited articles. Besides, 20 of the 71 articles were published in the journals with a JIF of ≥3, which is relatively high, and included ≥2 top-cited articles in the field of dentistry. In contrast to our results, it was found that 59 of the top 100 most-cited articles were published in the journals with a JIF of >2, and 2 or more top-cited articles were published in 58 of the 59 journals published (3). This difference may be due to date of publication of this study which published in 2014. Because the JIF of journals may change depending on time. Difference may also be due to the difference between the journals where top 101 cited articles are published. In accordance with this assumption, it was found that the JIF of 10 dental journals significantly increased from 2003 to 2012, but a wide variation in the magnitude of this rise was observed (37). In accordance with our finding, in a study among the top 100 most-cited articles by the authors from Brazil, it was revealed that 65 of the 100 articles which are the most-cited were published in the journals with a JIF of >2, which included ≥2 top-cited articles (39). It was reported that it is known fact that authors consider a JIF as the most important determinant while selecting a journal for publishing their research, on the other hand, high JIF journals draw attention of high quality articles, thereby attracting high quality papers (27). However, in the present study, 20% of the most-cited articles were published in those journals with relatively higher JIFs (3 or more). In agreement with our findings, no significant association has been found between the JIF of a journal and the number of top-cited articles (20,27).

In our study, 92 of the 101 (~92%) top-cited articles were published before the year of 2010. In accordance with our findings, in other studies, the majority of the articles belonged to a decade or more before the

publication of the studies (3,18,20,22,27,30,32,39). In contrast to our results, some studies have reported that those articles which are the most-cited have been published in the last 10 years (2,16,24). It was stated that the oldest articles usually had much more time ahead to be cited than those which have been recently published, without taking their scientific impact account, thereby carrying the risk of excluding the most recent influential articles (27). The total number of citations to an article can only increase over time (39). It was demonstrated that an article requires a minimum of six to 15 years to receive a sufficient number of citations following its publication and become a citations classic (22). In the present study, only 9 top-cited articles were published after the year of 2010 which means those articles have had the last 10 years to be cited. Similarly to our finding, it was reported that the possible reason is the limited amount of time for important studies to receive higher number of citations, or that there is now a higher tendency to submit qualified articles to journals which have the highest JIFs and that those journals are included in other categories of the Journal Citation Report (3,43).

Co-authorship is the resulting close collaboration between or among authors who intensively cooperate during the improving of research and take responsibility for the study content through joint signature, so that, in any situation, they can present and defend the original idea of the research (44). In our study, 24 articles had 4 authors. The number of top-articles with 2-6 authors is 89. Similar with our results, another study which is based on at least one co-author affiliated to an institution in Brazil found 79 top-cited articles had 2-6 authors (39). A study on scientific collaboration in research in Brazil revealed that the most recurrent number of is the 6-author authorship, which accounts for about 76% of its scientific production when added to 5 and 7 or more authors (44). In our study, approximately half of top-cited articles (45 articles) showed a single-center collaboration in the form of individual institutions. Also, international collaboration (29 articles) has secondly the highest citation. The most collaborated country was United States followed by Finland and Sweden. In accordance with our findings, it was found that the country with the most international collaboration was the United States, followed by Finland (39). The explanation for the situation might be the fact that the better the economy a country ranks enables it to produce the higher quantity and quality of biomedical publications (28,45). However, in our studies, the number of a single-center collaboration among top-cited articles was found higher than multi-institutional and international collaboration. It was suggested that young researchers may focus on broad range collaboration of relevant researchers from different disciplines to create a study with high impact/quality (28). Also, a study showed that international collaboration increased the rates of citation which an article received (46). However, in our study, international collaboration with 3600 citations (29% of total citation) did not effect on citation rates. Besides, 18 of 22 (81.8%) institutions with 91 articles are public and 4 of 22 articles (18.2%) are private institutions with 9 articles. This finding agreement with another study in which one co-author affiliated to an institution in Brazil found that of the 138 institutions coauthoring the articles, 73.9% were public and 26.1% were private institutions (39).

In our study, more than half of the top-cited articles (54 articles) were in basic science, followed by clinical research (40 articles) and review (8 articles). In contrast to our study, Feijoo at al. (3) found plurality of clinical research (66%) over basic research (34%). Another study, which is based on minimum one co-author affiliated to an institution in Brazil, found that 75 top-cited articles included epidemiological, clinical, and basic research, and 25 top-cited articles were reviews including those both narrative and systematic (39). In the present study, most of the top-cited articles were on the field of Prosthetic Dentistry with 34 articles and it was followed by the fields of Periodontology and Endodontics with 16 articles and 14 articles, respectively. Partially agreement our results, a study with co-authors from Brazil revealed that the most frequent subjects addressed in 100 top-cited articles were Endodontics, Periodontology, and Dental Materials (61% of the sample). A study including the top 100 most-cited articles in the field of dentistry found that the majority of research was on the field of Periodontology (43 articles), and it was followed by the fields of Implantology and Adhesive Restorations with significantly less number of material (11 articles and 8 articles, respectively) (3). In another study related to the citation rates on the articles in

Scopus which were co-authored by the institutions in Brazil, it was showed that Endodontics had the highest total citations followed by Multidisciplinary and Dental Materials (46). In our study, implant for Prosthetic Dentistry, root canal sealer for Endodontics and, periodontal disease and molecular mechanism for Periodontology were main topic of top-cited articles. On the other hand, for Orthodontics, Restorative Dentistry, Oral and Maxillofacial Surgery, and Pedodontics, there was not predominant topic. In another other 100 top-cited articles studies on one specific area, microbial etiology of periodontal diseases for Periodontology (25), endodontic microbiology for Endodontics (18,20) and implants for Orthodontics (30) were major topics.

In our study, the most common study design of the articles in clinical research were RCTs (21 articles) followed by cross-sectional studies (10 articles). Level of evidence was II at most (27 articles), followed by III (7 articles). In contrast to our findings, the cross-sectional study (24), case series (3,18,21,22,30) or case reports (16) was reported as the most common clinical study design. This difference may be due to difference in study design as most of these studies performed on one area of Dentistry different from our study. Also, it was reported that majority of top-cited clinical experience articles had low level evidence such as level III evidence (20) and IV or V (18,22,27,30) than our study. It was stated that this might indicate relatively easier method of conducting simpler studies (30). In accordance with level of evidence, most of clinical researches were RCTs in our study. It was explained that studies place into a so-called hierarchy of evidence, with systematic reviews and meta-analyses of RCTs at the top contributing to the highest level of evidence, followed by RCTs, non-RCTs, cohort studies, case-control studies, crossover studies, cross-sectional studies, case studies, and expert opinions and uncontrolled studies or opinion at the bottom (36,42,47).

Conclusion

In our study, the top 101 most-cited articles had lower citation when compared to other 100 top-cited articles due to the first author affiliated to Turkey institutions. Journal of Prosthetic Dentistry published the highest number of top-cited articles and Prosthetic Dentistry was the field on which the highest number of articles conducted. A total of 92% of the top-cited articles were published before 2010. The number of top articles with 2-6 authors is 89. More than half of the top-cited articles were in the field of basic science. Most of the topics of the 101 top-cited articles were implant. The most frequently used study design was RCT for the articles in clinical experience. Level of evidence most of clinical researches were level II. Compared to the literature, it is promising that the number of clinical trials and level evidence is high. However, it is necessary to increase the number of international collaborations to boost the citation count of article.

Ethics

Ethics Committee Approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent: For this type of study, formal consent is not required.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: M.D., S.T., Design: M.D., F.K., Data Collection or Processing: F.K, M.B., Writing: M.D., F.K. Critical review: S.T., N.T., Supervision: M.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Oral Health Status of Children with Cerebral Palsy who Have Dysphagia: A Comparative Study

Disfajisi Olan Serebral Palsili Çocuklarda Ağız Sağlığı Durumu: Karşılaştırmalı Bir Çalışma

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Keywords
Cerebral palsy, dysphagia, drooling, oral health, swallowing, swallowing disorders

Anahtar Kelimeler
Serebral palsi, disfaji, salya akıtma, ağız sağlığı, yutma, yutma bozuklukları

Received/Geliş Tarihi : 09.04.2020
Accepted/Kabul Tarihi : 13.11.2020

doi:10.4274/meandros.galenos.2020.75436

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Abstract

Objective: This study aimed to compare oral health status of children with and without cerebral palsy (CP) who have dysphagia.

Materials and Methods: The study included two groups of children with and without CP who suffer from dysphagia. The parents filled a written questionnaire about demographic variables. The oral motor functions of the children, including mouth breathing, tongue thrust, lip closure, tongue posture, severity and frequency of drooling, swallowing, chewing- and eating-related functions, malocclusion and dental caries status were evaluated.

Results: Between-group comparisons showed a significant difference in swallowing functions, chewing and drooling, mouth breathing, lip closure, tongue thrust and malocclusion. However, no significant difference in oral hygiene habits was found between the groups. These results indicated that the orofacial structures of children with CP were more affected than those of children without CP.

Conclusion: Swallowing disorder in CP affects oral functions and oral health negatively as in other neurological diseases. Early diagnosis and management of dysphagia are important to improve the quality of life of children with CP. Therefore, a multidisciplinary approach, including dentists, is necessary for early diagnosis and treatment.

Öz

Amaç: Bu çalışmanın amacı, disfajisi tanısı alan serebral palsili (SP) olan ve olmayan çocukların ağız sağlığı durumlarını karşılaştırmaktır.

Gereç ve Yöntemler: Çalışmaya disfaji tanısı alan SP'li olan ve olmayan iki grup çocuk dahil edilmiştir. Ebeveynler demografik değişkenler hakkında bir anket doldurmuştur. Ağız solunumu, dil itme, dudak kapanışı, salya akıtma şiddeti ve sıklığı, yutma, çiğneme ve yeme ile ilgili fonksiyonlar, malokluzyon ve diş çürükleri değerlendirilmiştir.

Bulgular: Gruplar arasındaki karşılaştırma sonucunda, yutma fonksiyonları, çiğneme ve salya akıtma, ağız solunumu, dudak kapanışı, dil itme ve malokluzyon açısından anlamlı bir fark saptanmıştır. Ancak gruplar arasında ağız hijyeni alışkanlıkları açısından anlamlı bir fark bulunmamıştır. Bu çalışmanın sonuçları, SP'li çocuklarda orofasiyal yapıların SP'li olmayan çocuklardan daha fazla etkilendiğini göstermiştir.

Sonuç: SP'de yutma bozukluğu, diğer nörolojik hastalıklarda olduğu gibi ağız fonksiyonlarını ve ağız sağlığını olumsuz etkilemektedir. Disfajinin erken teşhisi ve tedavisi SP'li çocukların yaşam kalitesini iyileştirmek için önemlidir. Bu nedenle, erken tanı ve tedavi diş hekimlerinin de dahil olduğu multidisipliner bir yaklaşımla yapılmalıdır.

Introduction

Dysphagia is defined as any disruption to the swallow sequence (1). Dysphagia is a symptom of multiple functional disorders associated with the central nervous system in children (1,2). This condition may be due to anatomical or neurological maturation abnormalities, sensory disturbance of the oral cavity or esophageal motility disorders (3). Although approximately 1% of children in the general population experience dysphagia, the incidence rate is much higher in children with neurological diseases (1,4).

Cerebral palsy (CP) refers to a group of non-progressive disorders of movement and posture associated with an immature brain defect (5). It is one of the most common neurological diseases in children with a prevalence of 1.2-2.5 in 1,000 live births in industrialized countries (6). Despite the fact that the technological possibilities increase, the incidence of CP has increased over the years. The situation can be resulted from increasing opportunities for the survival of preterm, low birth weight infants and keeping better records of CP (7). It is a more common condition in Turkey with 4.4-8 at 1,000 live births (6,8). The high prevalence in Turkey is related with excess prevalence of consanguineous marriage; excessive infectious and febrile illnesses, inadequacy of nutrition in infants; negativity in birth conditions; inadequate baby care and diseases during pregnancy (2).

Dysphagia, drooling, tooth decay, enamel hypoplasia, erosion, gingival disease, orthodontic disorders, bruxism, eruption problems, trauma are some of the effects of CP on the oral region (9).

Dysphagia is a common problem for many children with CP (1). However, many children with other muscular disorders, acquired brain injuries, craniofacial or airway malformations, as well as those with respiratory, cardiac or gastrointestinal diseases, also experience the same problem (1). According to the literature, the prevalence of dysphagia in children with and without CP are 19.2-60% (9) and 25-45%, respectively (10).

Dysphagia may cause respiratory problems, insufficient nutrition, growth retardation, motor dysfunction, aspiration, chronic lung diseases and general health deterioration. Moreover, nutrition may be a stressful and undesirable process for all children and their parents who have negative experiences while eating. Dysphagia causes negative interactions between the family and the child. Feeding difficulty and the increased feeding time reduce the quality of life of families and increase the risk of depression (11,12). Motor dysfunction that causes dysphagia may result in mouth breathing. Therefore, dysphagia may adversely affect oral health, oral functions and occlusal development (13,14).

The aim of this study was to compare the oral health statuses of children with and without CP who have dysphagia. In the literature there is no studies on this subject in primary dentition. CP may cause oral health problems even in the primary dentition. It was thought that the quality of life of children with CP and their families can be increased with early measures.

The hypothesis of the study was that swallowing disorder in CP affects oral health and oral function negatively.

Materials and Methods

The sample was selected from among children who were admitted to the Dysphagia Research and Application Center. Considering the number of patients admitted to the center within a year, the sample size was determined to be at least 25 children in each group by using power analysis. As a result, the sample size of this study was determined as 53 children with CP and dysphagia (CP group) and 50 children without CP but with dysphagia [non-cerebral palsy (NCP) group]. Children with primary dentition were included. Hence, children with congenital anomalies that could affect their orofacial development (e.g. cleft lip/palate) were excluded from the study. Before the clinical examination, the parents singed an informed consent form. This study was approved by the Hacettepe University Ethics Committee for

Non-Interventional Clinical Studies (decision no: GO 14/550-12, date: 05.11.2014).

The study's primary outcomes were set to diagnose dysphagia by taking detailed anamnesis, clinical examination, evaluation of nutrition and imaging with videofluoroscopy and/or fiberoptic endoscopic evaluation of swallowing by a physiotherapist specialized in dysphagia. Additionally, the children's oral motor functions including swallowing, chewing and eating functions, as well as drooling, were determined by a pediatric dentistry specialist who has trained by a dysphagia physiotherapist, by using Oreland's scale (15).

Secondary outcomes included the oral health statuses of the children. To determine this, an interview was conducted with the parents who were asked about the medical history, feeding and oral hygiene habits of their children. Intraoral examination consisted of the eruption status of teeth which were recorded according to Logan and Kronfeld's scale (16). Furthermore, the World Health Organization diagnostic criteria were used to determine the dmft/s values (decayed, missing because of caries and filled tooth numbers/surfaces in primary teeth), and gingival health statuses were determined using the gingival, dental plaque and gingival enlargement statuses. Mouth breathing, tongue thrust, macroglossia, lip closure and tongue posture were assessed in each patient by using Oreland's scale (15).

At the end of the study, all children and their parents were informed about oral hygiene practices, and modifications were made for the patient according to their status of disability. Children with co-operation were treated for caries and gingivitis. Uncoordinated and un-cooperative children were referred to the same department for application of general anesthesia for the dental procedures.

Statistical Analysis

The data were analyzed by the SPSS statistics software, version 20.0. Descriptive statistics were calculated as frequency/percentage (n/%) for the qualitative data and mean±standard deviation for the quantitative data. Using chi-squared and t-tests, comparisons between the independent and dependent variables were made in 95% confidence intervals. The odds ratio was assessed for statistically significant outcomes.

Results

The distribution of the children according to age and sex is given in Table 1. The mean age of the CP group was 43.67 months [standard deviation (SD): 13.06], and the mean age of the NCP group was 41.68 months (SD: 13.64). No significant difference was found between the groups in terms of age (p=0.669) and sex (p=0.588).

When the first encountered about dysphagia was asked, most children with CP (41.5%) were observed to have symptoms of dysphagia immediately after birth. In the control group, most of the children (48%) showed signs of dysphagia in transition to solid food intake. Additionally, dysphagia was noticed during feeding in 43 (81.1%) and 29 (58%) children with and without CP, respectively (Table 2).

The results of the questionnaire about breast feeding showed that 74 (71.8%) children were breast-fed. The number of the children who were breast-fed for less than 6 months was 59 (57.3%). No significant difference was found in terms of the duration of breast-feeding or bottle-feeding in the comparison of the children with and without CP (p>0.05).

The eruption status of teeth in 72 (69.9%) children were normal according to Logan and Kronfeld's scale. No significant difference was found about teeth eruption status between the two groups.

As shown in Table 3, DMFT and DMFS scores and in Table 4, gingival health status, presence of dental plaque and gingival overgrowth of the children with and without CP. However, the children with

Table 1. Distribution of children based on age and sex

	Cerebral palsy group		Non-cerebral palsy group		Total	
	n	Month	n	Month	n	Month
Female	24	43.67	20	41	44	42.45
Male	29	43.86	30	42.13	59	42.98
Total	53	43.77	50	41.68	103	42.75
Standard deviation	-	13.06	-	13.64	-	13.39

and without CP showed no statistically significant differences in terms of the mean values of dmft, dmfs and gingival health and plaque indices. There was a statistically significant difference in gingival overgrowth between the children with and without CP (p<0.05).

A significant difference was determined in terms of chewing and swallowing functions, drooling frequency and severity between the two groups (p<0.05). A negative relationship was determined between lip closure (p<0.000) and drooling frequency (p=0.000) and severity (p=0.000), mouth breathing (p=0.000), lip closure, macroglossia (p=0.000), tongue thrust (p=0.000) and tongue position (p<0.005). The differences between the two groups were also found for occlusal problems including anterior open bite and high palate (Table 5).

Discussion

Feeding histories indicated that a large proportion of the children had swallowing disorders within the first years of life which preceded the diagnosis of CP in

Table 2. Feeding problems of the children

		Cerebral palsy group		Non-cerebral palsy group		Total		p
		n	%	n	%	n	%	
When did you notice the swallowing disorder in your child?	When he/she was born	22	41.5	17	34	39	37.9	0.010
	While switching to solid food	10	18.9	24	48	34	33	
	Passed after infection	12	22.6	6	12	18	17.5	
	Sequelae after seizure	9	17	3	6	12	11.Jul	
How did you notice the swallowing disorder in your child?	While feeding (cannot swallow, vomiting, retching, bruising, refusing food)	43	81.1	29	58	72	69.9	0.011 (OR: 0.321)
	Cannot chew	10	18.9	21	42	31	30.1	

OR: Odds ratio

Table 3. Caries status of children

	Cerebral palsy group			Non-cerebral palsy group			p
	n	mean	Standard deviation	n	mean	Standard deviation	
DMFT	53	3.60	5.365	50	4.04	5.525	0.685
DMFS	53	9.68	20.562	50	7.98	15.787	0.641

Table 4. Oral health status of children

		Cerebral palsy group		Non-cerebral palsy group		p
		n	%	n	%	
Gingiva health status	Healthy gingiva	6	11.3	3	6	0.339
	Inflame gingiva	47	88.7	47	94	
Plaque	Present	50	94.3	47	94	0.660
	Absent	3	5.7	3	6	
Degree of gingival enlargement	0	18	34	33	66	0.010
	1	16	30.2	8	16	
	2	14	26.4	8	16	
	3	5	9.4	1	2	

Table 5. Oromotor dysfunction						
		Cerebral palsy		Non-cerebral palsy group		p
		n	%	n	%	
Swallowing	Normal	2	3.8	10	20	0.014
	Infantil	12	22.6	6	12	
	Presence of swallowing reflex	28	52.8	30	60	
	Absence of swallowing reflex	11	20.8	4	8	
Chewing	<3	40	75.5	28	56	0.017
	3-5	9	17	7	14	
	6-10	1	1.9	10	20	
	>10	3	5.7	5	10	
Mouth breathing	Present	38	71.2	9	18	0.000
	Absent	15	28.8	40	80	
Lip closure	Present	18	34	41	82	0.000 OR:0.116
	Absent	35	66	9	18	
Tongue position	Ahead	33	62.3	19	38	0.017 OR: 0.383
	Behind	20	37.7	31	62	
Tongue thrusting	Present	34	64.15	5	10	0.000
	Absent	19	35.85	45	90	
Macroglossia	Present	25	47.17	4	8	0.000 OR: 0.101
	Absent	28	52.83	46	92	
Severity of drooling	Dry	5	9.4	32	64	0.000
	Mild	10	18.9	2	4	
	Middle	9	17	7	14	
	Severe	7	13.2	2	4	
	Too severe	22	41.5	7	14	
Frequency of drooling	Never	5	9.4	32	64	0.000
	Sometimes	15	28.3	6	12	
	Frequently	12	22.6	5	10	
	Always	21	39.6	7	14	
Open bite	Present	22	41.5	7	14	0.002
	Absent	31	58.5	43	86	
High palate	Present	39	73.6	17	34	0.000
	Absent	14	26.4	33	66	
OR: Odds ratio						

many cases (17). According to the results of the study, dysphagia occurred in 41.5% of the children with CP and in 34% of the children without CP just after birth. 74% of the children in the NCP group had no diagnosed chronic diseases, the others had diseases that do not constitute a basis for swallowing disorders

such as heart murmurs and asthma. In other words, children in the NCP group had an acquired swallowing disorder, not a congenital.

In 81.1% of the children with CP and 58% of the NCP children, it was noticed as a result of neglecting eating, coughing or vomiting. Prematurity plays an important role in the etiology of CP (18). No difference was detected about prematurity between the two groups. It is therefore difficult to rule out the possibility that prematurity could have had a role in the oromotor dysfunctions of the two groups.

The influence of swallowing pattern on development of malocclusion has been a subject of studies, and a correlation between the type of swallowing and several malocclusion symptoms has been suggested (19-21). In this study, 22.6% of the CP and 12% of the NCP children had immature swallow, and 20.8% of the CP and 4% of the NCP children did not have any swallowing reflexes. Comparison of the malocclusion frequency of the CP and NCP groups revealed that 75.5% of the CP and 54% of the NCP children had any occlusion anomalies. The etiological factor of malocclusion might be attributed to the swallowing pattern. Melsen et al. (22) evaluated the sucking habits in healthy children with permanent dentition and stated that tongue thrust and teeth apart swallow increased frequency of distal occlusion, extreme maxillary overjet and open-bite. In our study, the common finding in both groups was having open-bite and high palate with a statistically significant difference (open-bite by 41.5% and 14% and high palate by 73.6% and 34% in the CP and NCP groups, respectively). The other findings in both groups was having under-jet, deep-bite, cross-bite, diastema, crowding and midline deviation with no statistically significant difference. The muscles of the face and the oral cavity play an important role in facial growth and occlusal development (23). Hence, the disturbances of the facial, masticatory and tongue musculature cause abnormal facial growth and increase the incidence of malocclusion (23). A number of studies reported greater prevalence of malocclusion in those without CP (24-30). The manifestation of malocclusion in CP has been attributed to the low tonicity of the facial muscles and the uncoordinated movement of the lip and tongue (24,25,31,32). Jackson suggested that disturbances of the facial, masticatory and tongue musculature are the cause of the increasing incidence of orthodontic problems and showed children diagnosed with CP at primary dentition to have more normal or minor malocclusions than older patients with CP whose deranged neuromuscular complexes had a longer period of time to bring about maldevelopment (33).

Chewing, oral food transport and swallowing constitute a continuum (24). These processes, taken together, are often considered to represent the entirety of the feeding process (34). Chewing efficiency, defined as the ability to grind a certain portion of a test food during a given time, is closely related to the number of occluded teeth (35). Shwartz et al. (36) found a significant correlation among chewing efficiency, age and number of posterior teeth in patients with CP. They stated that foods must be broken into smaller pieces through chewing, and it is dealt with based mostly on the efficiency with a full complement of molar teeth. The results of this study showed that the percentages of nonoccluded molar teeth in the CP and NCP children were 40.1% and 38%, respectively. Poor chewing efficiency is associated with few occlusal contacts (37). However, other factors including more extracted teeth, unrestored teeth, poorer oral hygiene and gingival health might contribute to the availability of posterior teeth for chewing (35,38,39).

Delayed tooth eruption is a common finding in children with general developmental delays that involve the oral musculature. Pope and Curzon (40), Moslemi et al. (38) and Rodrigues dos Santos et al. (41) reported delayed time of permanent teeth eruption in children with CP. However, Wessels (42) stated that the eruption status of both primary and permanent teeth in children with CP did not differ significantly from healthy children. In this study, 37.7% of the CP and 30.1% of the NCP children showed delayed primary tooth eruption. The results of this study revealed that, apart from the number of occluded teeth, delayed tooth eruption might also contribute to swallowing disorders in both CP and NCP children.

Unfortunately, no study was in literature about children with dysphagia and CP in primary dentition to compare with our study about caries statues or periodontal diseases. However, in relation to oral health, children with CP are more prone to caries and periodontal diseases than healthy children are (23,43). The results of this study revealed that

children in both groups had high incidence of caries with no statistically significant difference between the two groups (DMFt=3.60 and DMFS=9.68 in the CP group, DMFT=4.04 and DMFS=7.98 in the NCP group). There was also no statistically significant difference in relation to gingival health. Oral health problems occurring as a result of dysphagia are the main reason of orofacial disorders and absence of oral hygiene habits. Therefore, children with dysphagia and their parents should be instructed about practicing oral hygiene and the necessity of routine dentistry follow up.

Conclusion

According to the results of this study, swallowing disorder in CP did not affect oral health negatively and swallowing disorder in CP affected oral function negatively.

The results of this study showed that the risk of children with dysphagia to develop orofacial disorders, dental caries and gingival problems is worrisome. Considering that these problems will increase with age, functional factors disrupting orofacial development must be identified and eliminated as soon as possible. Moreover, long-term preventive measures and dental treatment strategies should be planned. Thus, early diagnosis and treatment should involve a multidisciplinary approach including dentists.

Ethics

Ethics Committee Approval: This study was approved by the Hacettepe University Ethics Committee for Non-Interventional Clinical Studies (decision no: GO 14/550-12, date: 05.11.2014).

Informed Consent: Before the clinical examination, the parents singed an informed consent form.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: S.Ö., N.D., Design: N.D., Supervision: S.S.A., M.T., Fundings: İ.M.G., Materials: İ.M.G., Data Collection or Processing: İ.M.G., Analysis or Interpretation: M.T., S.S.A., Literature Search: S.Ö., Critical Review: S.Ö., N.D., Writing: İ.M.G., M.T., S.S.A.

Conflict of Interest: The authors declare that they have no conflict of interest.

Financial Disclosure: The authors declared that this study received no financial support.

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Questionnaire

EXAMINATION FORM TO EXAMINE THE EFFECT OF SWALLOWING DISORDER IN CHILDREN WITH AND WITHOUT CEREBRAL PALSIED CHILDREN DURING PRIMARY DENTITION ON TOOTH AND JAW STRUCTURES

Date: .../.../20..

Child's name and surname: .....

1. Gender: M....
   F.....

2. Date of birth: ..../..../.....
3. Was your child born on due date?
   0. No (At what week of pregnancy was the child born?.....)
   1. Yes
4. Have you had any illnesses during your pregnancy?

   0. No
   1. Yes (Note.....)
5. Are there any chronic diseases of him/her diagnosed by the doctor?
   0. No
   1. Yes (Note.....)

6. Is there any medication he/she uses regularly?
   0. No
   1. Yes (Note.....)

7. When and how did you first notice the swallowing disorder in your child?

8. How long your child had just breast milk?
   0. Never breastfed
   1. …… months
   2. I don't know / don't remember

9. Does your child use a pacifier or baby bottle?
   0. Never used
   1. He/she used for a while (How long did he/she use? …….. months).
   2. Still using
10. Are your child's teeth cleaned?
    0. No
    1.Yes (with……)
11. Does your child receive fluoride?
    0. No
    1.Yes (in what way .....? What is the frequency and dosage? .....)

12. Has your child ever had a dental examination?

    0. No
    1. Yes

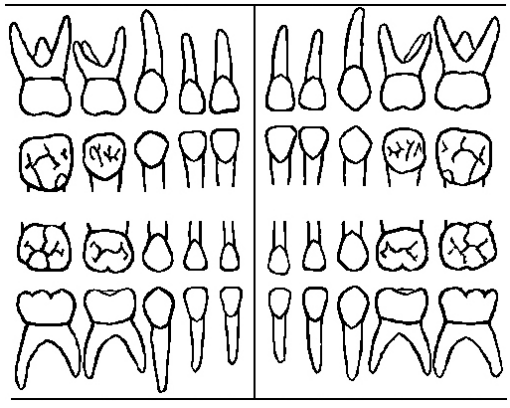
Intraoral Examination

13. Oral photos:
    0. Taken
    1. Not taken

14. Dental development status:
    0. Chronologically behind by age
    1. Normal
    2. Chronologically ahead by age
15. Number of teeth to close:
    0. 0-2
    1. 3-4
    2. 5-6
    3. 7-8
16. Wear condition in canine and molar teeth:
    0. No
    1. Mild (limited to enamel)
    2. Moderate (reached dentine)
    3. Severe (reached dentine and loss of occlusal anatomy)

17. Malocclusion status:
    0. No
    1. Yes

a. Overjet
b. Underjet
c. Deepbite
d. Openbite
e. Crossbite (anterior, posterior, unilateral, bilateral)
f. Crowding
g. Diastema
h. Midline deviation
i. High palate
j. Other (……..)



DMFT: …….
DMFS: …….

21. Gingival Health Status:
    0. Normal
    1. Inflammation
22. Presence of plaque:
    0. No plaque
    1. There is plaque
23.The severity of gingival enlargement:
    0. No gingival enlargement
    1. Gingival enlargement only involves the interdental papilla
    2. Gingival enlargement involves the papillae and the gum edge

3. Gingival growth covers ¾ of the crown or more

Evaluation of Oral Functions (Oreland 1989):

24. Swallowing:
    0. Normal
    1. Infantile
    2. There is a swallowing reflex
    3. No swallowing reflex
25. Chewing:
    0. <3
    1. 3-5
    2. 5-10
    3. >10
    4. Unable to cooperate
26. Mouth breathing:
    0. None
    1. Yes
    2. Cannot be determined
27. Lip closure:
    0. No
    1. Yes
    2. Cannot be determined
28. Tongue posture:
    0. Front
    1.behind
29. Tongue thrusting:
    0. Yes
    1. None
30. Macroglossia
    0. Yes
    1. None

31. Drolling:
    Violence
    Dry (no drooling)
    Mild (lips only)
    Medium (wet lips and chin)
    Severe (dresses get wet too)
    Very violent (clothes, hands, toys…)

    Frequency
    Never wet
    Occasionally
    Often
    Always

    32. Nutritional assessment:
    0. Liquid
    1. Puree
    2. Thick
    3. Mix

    Reliability level of information:

    Person filling out the form:

Original Article / Özgün Araştırma

Evaluation of Dental Anxiety Levels of Students from Different Departments

Farklı Fakültelerdeki Öğrencilerdeki Dental Anksiyetenin Değerlendirilmesi

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Abstract

Objective: This study aimed to evaluate and compare the anxiety levels among dentistry students and students from other departments and to assess the effects of classes at pre-clinic labs or dentistry clinics on the dental fear of dentistry students.
Materials and Methods: A total of 993 students, including 744 (75%) women and 249 (25%) men, were asked to answer the Modified Dental Anxiety scale (MDAS) and Dental Fear scale. Four groups were created according to the departments: Dentistry (group 1), medicine (group 2), health-related (group 3) and others (group 4). The participants scored their anxiety levels from 1 (no anxiety) to 5 (high anxiety). Statistical analysis was performed and values of $p<0.05$ were considered statistically significant.
Results: The dentistry students scored lower than the other three groups in the MDAS ($p<0.001$). For the education process of dentistry, no significant difference was observed in other questions regarding pre-clinic dentistry and dentistry clinic periods ($p>0.05$).
Conclusion: Results of this study showed that the dental anxiety levels of dentistry students were lower than those of students from other departments and that pre-clinic or dentistry clinic classes did not affect dental anxiety.

Keywords
Dental anxiety, anxiety, dental fear, dentistry, education

Anahtar Kelimeler
Dental anksiyete, anksiyete, dental korku, diş hekimliği, eğitim

Received/Geliş Tarihi : 16.06.2020
Accepted/Kabul Tarihi : 02.12.2020

doi:10.4274/meandros.galenos.2020.94834

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Öz

Amaç: Bu çalışmada diş hekimliği fakültesinde ve diğer fakültelerde öğrenim gören öğrencilerin kaygı düzeylerinin karşılaştırılması ile sadece klinik öncesi laboratuvar eğitimi almış diş hekimliği öğrencileri ve klinik eğitimine başlamış ve devam eden diş hekimliği öğrencilerinin dental korkularının değerlendirilmesi amaçlanmıştır.
Gereç ve Yöntemler: Bu çalışmada 744 kadın (%75) ve 249 erkek (%25) olmak üzere 993 üniversite öğrencisinden Modifiye Dental Anksiyete ölçeği (MDAS) ve Dental Korku ölçeğini (DFS) tamamen cevaplamaları istenmiştir. Anketi cevaplayan öğrenciler öğrenim gördükleri fakültelere göre dört gruba ayrılmıştır. Bu gruplar grup 1: Diş hekimliği fakültesi, grup 2: Tıp fakültesi, grup 3: Sağlıkla ilgili diğer fakülteler ve grup 4: Diğer fakülteler şeklindedir. Katılımcılar, anksiyete düzeylerini 1 (anksiyete yok) ile 5 (yüksek anksiyete) şeklinde puanlandırmışlardır. Veriler istatistiksel olarak karşılaştırılmış olup $p<0,05$ değeri anlamlı kabul edilmiştir.
Bulgular: Diş hekimliği öğrencileri MDAS'yi diğer üç gruptan daha düşük puanlamışlardır ($p<0,001$). Bununla birlikte sadece klinik öncesi laboratuvar eğitimi almış diş hekimliği öğrencileri ve klinik eğitimine başlamış ve devam eden diş hekimliği öğrencilerinin arasında anlamlı bir fark gözlenmemiştir ($p>0,05$).
Sonuç: Diş hekimliği öğrencilerinin dental kaygısının bu eğitimi almamış diğer fakülte öğrencilerinden daha az olduğu ve diş hekimliğinde klinik eğitimin öğrencilerin kaygı düzeyini etkilemediği gözlenmiştir.

Introduction

Fear is generally described as a response to a really dangerous or threatening event to protect one's life (1). In many countries, dental anxiety is a very common dental health problem and the prevalence of dental anxiety has taken place in many studies (2,3). Some researchers showed that the prevalence of dental anxiety is 5-20% in populations and females are more anxious than males (4,5). In the Turkish population, approximately 21%-24% of individuals experienced dental anxiety (6-8).

The etiology of dental anxiety is a multidimensional real or imaginative stimulus that leads to development of fear (9). Managing dental anxiety is considered as a crucial issue in dental practice, and therefore different scales have been developed to evaluate dental anxiety. However, surveys and their interpretation should not take the dentist's extra time for clinical practice purposes. For this reason, a short scale of clinical dental anxiety was needed. Corah Dental Anxiety scale has proven to be efficient in dentistry (10). It is bare, easy to score, brief, valid, reliable test for anxiety associated with dental visits (10-13). Moreover, Humphris et al. (14,15) developed a modified scale from the original Corah Dental Anxiety scale as a simpler version, which was named as the Modified Dental Anxiety scale (MDAS). MDAS is a short, 5 item questionnarie with a continious response scheme for each item from not anxious to extremely anxious.

Furthermore, the Dental Fear scale (DFS) was introduced by Kleinknecht et al. (16,17) in 1973 and examined the level of fear against various practices in dentistry. One of the most important advantages of measuring fear in patients is that the dentist realizes fearful situations for the patient before the treatments, eliminates them as much as possible or prevents the patient from facing the same situation (18). DFS includes 20 questions to determine the level of fear/tension related to dental practices, and answers to the questions are scored between 1 and 5 as a Likert-type scale (19). The reliability and consistency of DFS were evaluated in the light of the data of participants consisting of four different demographic groups, and it was reported to have cross validity and consistency (16). Firat et al. (6) was reported in their study, that DFS was valid to evaluate dental fear levels in Turkey.

This study aimed to evaluate and compare the anxiety levels of dentistry faculty students and students from other health faculties. At the same time, this study compares the dental fears of students of the faculty of dentistry based on their knowledge.

Materials and Methods

Ethical Statement

Ethical Approval was given by Bezmialem Vakıf University Non-Interventional Research Ethics Committee (decision no: 10/114, date: 05.11.2019).

Study Design

Data Collection

Both scales were prepared for the students who were continuing their education at dentistry and other faculties. Informed consent forms were collected from the each participant. Therefore, four groups were created according to the faculties as group1: Dentistry faculty, group 2: Medicine faculty, group 3: Other health-related faculties and group 4: Other faculties. Before the surveys were started, each participant was given detailed information, and the students who agreed quickly filled in these questionnaires. In the meantime, the inclusion criterion was determined as receiving undergraduate continuing education at any university in Turkey. The exclusion criteria in this study were determined as not fully answering the tests and simultaneous enrollment at a dentistry faculty and another faculty. Seventeen forms of these questionnaires, which were completed by 1010 people in total, were excluded from the study because they were not fully answered. Eventually, the data were collected from 993 students.

Questionarres

The first part of the questionnaire included basic questions that provided demographic data and the frequency of visiting the dentist. In the second part, the MDAS and the DFS were included, and the participants were asked to answer all questions completely. DFS included statements such as "I feel fear and tension while sitting in the waiting room", "I feel fear and tension when I see the dentist inside" and "When I hear the sound of the aerator (rotating instruments), I feel fear and tension." The participants chose the answers from 5 Likert-type options ("Almost none" to "Too much"). MDAS included questions such as "How do you feel if you are going to the dentist tomorrow?", "If you were about to have a tooth

drilled, how would you feel?" and "If you were about to have a local anesthetic injection in your gum, above an upper back tooth, how would you feel?" The participants chose answers from 5 options ("Worry-free" to "Too worried") as a Likert-type scale. In a study by Tunc et al. (7), the questions of MDAS were categorized in 5 groups which were next-day visit, scale and polish, drill, waiting room and injection, which helped us categorize DFS in 5 groups as a fear of tools, clinic, doctor, procedure and general fear.

Statistical Analysis

According to the questions, the participants scored their anxiety levels from 1 (no anxiety) to 5 (high anxiety) levels. For the evaluation of the results obtained, Kruskal-Wallis tests were used for comparisons between groups, and Mann-Whitney U tests were used for binary comparisons. The maximum acceptable level of possible error by Fisher, a famous statistician, was proposed and accepted as 0.05. Therefore, $p<0.05$ value was considered statistically significant.

Results

All questionarres were answered by 993 students, including 744 women (75%) and 249 men (25%) (Table 1). Participants were classified as dentistry (n=389), medicine (n=372), other health-related departments (n=179) and students in other faculties that are completely unrelated to health (n=52) (Table 2).

Not only in MDAS ($p<0.001$), but also in DFS questionnaire, dentistry students scored significantly lower than all the other three groups for most of the questions ($p<0.001$) (Tables 3, 4). Only in two questions of DFS the anxiety value of dentists was not significantly different from all other groups (Q1: p=0.13; Q2: p=0.74) No questions were non-significant in MDAS questionarre in terms of comparing the scores of the dentists to other groups.

Besides, dentistry students were grouped in terms of the dentistry education of pre-clinical and dental clinical students and the results showed that there was no significant difference in most of the questions ($p>0.05$) except for questions (general fear-related

Table 1. Gender of the students who completed the both questionnaires

Gender	Total number (n=993)
Female	n=744 (75%)
Male	n=249 (25%)

Table 2. Faculty of the students who completed the both questionnaires

Faculties	Total number (n=993)
Dentistry	389 (39%)
Medicine	372 (37%)
Other health-related	179 (19%)
Other	52 (5%)

Table 3. Statistical analysis of some questions in Modified Dental Anxiety scale questionarre

	Dentistry	Medicine	Other health-related	Other	p
	Mean-SD	Mean-SD	Mean-SD	Mean-SD	
Question 1	1.85-0.9	2.15-1	2.18-1	2.44-1	<0.001
Question 3	1.99-1	2.33-1	2.48-1.1	2.42-0.9	<0.001
Question 5	2.5-1.1	2.93-1.1	2.93-1.2	3.11-1.1	<0.001

SD: Standard deviation

Table 4. Question examples and statistical analysis of Dental Fear scale questionarre

	Dentistry	Medicine	Other health-related	Other	p
	Mean-SD	Mean-SD	Mean-SD	Mean-SD	
Question 10	1.67-0.9	1.94-1.06	2.03-1.09	2.05-1.05	<0.001
Question 13	1.5-0.8	1.78-1	1.82-1	1.9-1	<0.001
Question 17	1.86-1	2.69-1.2	2.71-1.2	2.9-1.4	<0.001

SD: Standard deviation

questions) 3rd (p=0.009), 4th (p=0.03), 16th (p=0,01) of DFS and 1st (p=0.004) of MDAS which did not affect the general outcomes of the questionarres (Table 5).

Discussion

The presence of anxiety and fear for dentistry continues to exist despite the advances in clinical practice and pain can be controlled more effectively and has a negative impact on the quality of life (20,21). Dental fear is a major factor in postponing and canceling a dental appointment (22). It has been reported that individuals with high dental anxiety were more likely to have more missing teeth, more caries, and worse oral hygiene in comparison to non-anxious individuals (23,24). On the other hand, most of the patients tend to associate dental fears with a painful experience in childhood and negative staff behavior (25-28).

In this study, the MDAS and the DFS, which are among the most frequently used scales in determining the level of dental anxiety and fear in adults, were used (19,29). The dental anxiety levels of the students from different faculties were measured and compared, and it was concluded that the dental anxiety scores of the dentistry students were generally lower than the other three groups medicine, health-related other and other. Similarly, Al-Omari and Al-Omiri (30) evaluated the relationship between university students' fields of education and dental anxiety on 535 participants, and it was reported that medical and engineering faculty students had higher dental anxiety values than dentistry faculty students.

On the other hand, another study conducted in Turkey reported that students of other faculties and dentistry faculties had no statistically significant difference between their levels of dental anxiety (31). However, even though the study was performed with 751 participants, it did not include dentistry students in their first and second years, and this might have affected the final outcomes of their study. Besides, in this study, 993 students were included, whereas other studies generally did not include adequate numbers of participants to have statistically significant results.

While comparing the levels of anxiety between the dentistry students and other students, the effect of dentistry education on the pre-clinical students' and dental clinical students' evaluation of dental anxiety was evaluated, and it was revealed that there was no significant difference in anxiety between the two groups (p>0.05). However, statistically significant outcomes were observed only in general fear-related questions (p<0.05). In contrast to this result of this study, some studies concluded that dental anxiety decreased with increasing levels of dentistry education (32-35). On the other hand, there is a study which revealed that dental anxiety increased as the level of education increased (34). In the literature, it was stated that education coped with anxiety and reduced the level of anxiety of adolescents (36-39). However, in dentistry, pre-clinical education has become very similar to clinical dentistry education due to phantom or virtual laboratories reflecting the real clinical conditions. Moreover, pre-clinical students have a higher chance to visit the dentistry clinics at their faculties, and this phenomenon might also have affected the final outcome.

Conclusion

In this study, two of the most frequently preferred questionnaires on the topic were included, and the results were promising. According to the statistical analyses of the results, the dental anxiety levels of the dentistry students were significantly lower than those of the students of other departments. Moreover,

Table 5. Significant differences were observed in a few questions between pre-clinic dental students and dental clinic students

Questions	Pre-clinic dental students	Dental clinic students	p
	Mean-SD	Mean-SD	
Question 1 in MDAS	1.77-0.9	2-1.1	0.004
Question 3 in DFS	2.01-0.9	2.1-1	0.009
Question 4 in DFS	1.66-0.8	1.85-0.8	0.03
Question 16in DFS	1.89-1.1	1.64-0.9	0.01

MDAS: Modified Dental Anxiety scale, DFS: Dental Fear scale, SD: Standard deviation

as opposed to the general case in the literature, we report that the dentistry students did not reveal significantly different scores based on whether they were in the pre-clinical education period or dental clinic period.

Ethics

Ethics Committee Approval: Ethical Approval was given by Bezmialem Vakıf University Non-Interventional Research Ethics Committee (decision no: 10/114, date: 05.11.2019).

Informed Consent: Informed consent forms were collected from the each participant.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: T.Y., R.B., Design: T.Y., R.B., Supervision: T.Y., Fundings: T.Y., E.D.Ş., R.B., Materials: R.B., Data Collection or Processing: T.Y., R.B., Analysis or Interpretation: E.D.Ş., Literature Search: T.Y., R.B., Critical Review: T.Y., E.D.Ş., R.B., Writing: T.Y., E.D.Ş., R.B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Evaluation of Dynamic Thiol/Disulphide Homeostasis in Patients with Periodontitis

Periodontitis Hastalarında Dinamik Tiyol/Disülfid Homeostazının Değerlendirilmesi

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Keywords
Thiol/disulphide homeostasis, periodontitis, non-surgical periodontal treatment, oxidative stress

Anahtar Kelimeler
Tiyol/disülfid homeostazı, periodontitis, cerrahi olmayan periodontal tedavi, oksidatif stres

Received/Geliş Tarihi : 25.05.2020
Accepted/Kabul Tarihi : 07.12.2020

doi:10.4274/meandros.galenos.2020.14622

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Abstract

Objective: Thiols are antioxidant organic compounds with sulfhydryl group. Dynamic thiol/disulphide homeostasis is considered a marker of oxidative stress. This study aimed to determine disulphide and thiol levels in patients with generalised stage III grade C periodontitis and to investigate the relationship between biochemical and clinical periodontal parameters, namely, bleeding on probing (BOP), clinical attachment level (CAL) and probing pocket depth (PPD).

Materials and Methods: Forty-eight individuals participated in the study (control, n=23; periodontitis, n=25). BOP, CAL and PPD values of the groups were recorded before and after non-surgical periodontal treatment. Thiol disulphide homeostasis was assessed by an automatic and a new spectrophotometric method. Percentages of disulphide/total thiol, disulphide/native thiol and native thiol/total thiol were calculated.

Results: The clinical periodontal parameters of the periodontitis group were higher ($p<0.01$) before treatment and lowered significantly after the treatment ($p<0.05$). Thiol levels were significantly lower ($p<0.05$) and disulphide levels were significantly higher in the periodontitis group ($p<0.05$). A significant negative correlation was found between native thiol and total thiol with all clinical periodontal parameters ($p<0.05$). A significant positive correlation was noted between % disulphide/thiol ratios with all clinical periodontal parameters before treatment ($p<0.05$).

Conclusion: A significant correlation between the severity of periodontitis and serum total thiol and disulphide levels supported the hypothesis of oxidative stress in the etiopathogenesis of periodontitis.

Öz

Amaç: Tiyoller, sülfhidril grubuna sahip antioksidan organik bileşiklerdir. Dinamik tiyol/disülfid homeostazı, oksidatif stresin bir belirteci olarak kabul edilmektedir. Bu çalışmanın amacı, evre III-derece C jeneralize periodontitisli hastalarda tiyol ve disülfid düzeylerini belirlemek ve klinik periodontal parametrelerle [sondalamada kanama (SK), klinik ataçman kaybı (KAK), sondalamada cep derinliği (CD)] biyokimyasal parametreler arasındaki ilişkiyi araştırmaktır.

Gereç ve Yöntemler: Çalışmaya 48 kişi dahil edildi (Kontrol n+23, periodontitis n=25). Grupların SK, KAK ve CD değerleri cerrahi olmayan periodontal tedaviden

önce ve sonra kaydedildi. Tiyol disülfid homeostazı otomatik ve yeni bir spektrofotometrik yöntemle değerlendirildi. Disülfid/toplam tiyol, disülfür/doğal tiyol ve doğal tiyol/toplam tiyol yüzdeleri hesaplandı.
Bulgular: Periodontitis grubunun klinik periodontal parametreleri tedaviden önce yüksekti (p<0,01) ve tedaviden sonra anlamlı olarak azaldı (p<0,05). Periodontitis grubunda tiyol düzeyleri anlamlı olarak düşüktü (p<0,05) ve disülfid düzeyleri anlamlı olarak yüksekti (p<0,05). Doğal tiyol ve toplam tiyol ile tüm klinik periodontal parametreler arasında anlamlı bir negatif korelasyon vardı (p<0,05). Tedaviden önce % disülfid/tiyol oranları ile tüm klinik periodontal parametreler arasında anlamlı pozitif korelasyon vardı (p<0,05).
Sonuç: Periodontitisin şiddeti ile toplam serum tiyol ve disülfid düzeyleri arasında bulunan anlamlı korelasyon, periodontitisin etyopatogenezinde oksidatif stresin varlığı hipotezini desteklemektedir.

Introduction

During many normal metabolic processes, reactive species are continuously generated. These products give rise to the formation of disulphide bonds in various physiological pathways, including signal transmission, enzyme activation, immune system management, and gene expression. The excessive release of oxidative products contributes to the etiology of cancer, chronic renal failure, type-2 diabetes, cardiovascular diseases, neurodegenerative diseases, ischemic reperfusion injury, immune system diseases (1-5), and periodontitis (6-8). There are antioxidant defense mechanisms that can be employed to prevent the overproduction of oxidant products (9). The imbalance between the oxidant and antioxidant systems is identified as oxidative stress. In the case of oxidative stress, the oxidant products damage numerous biological molecules, particularly proteins, lipids, and nucleic acids (10).

Periodontitis is an inflammatory and multifactorial disease causing tissue damage and loss. During the occurrence of periodontitis in the host, a complex interaction is known to occur between pathogenic bacteria and the immune system (11). Previous data have demonstrated that oxidative stress is a significant factor in the etiopathogenesis of periodontal disease. Periodontal diseases caused by bacterial infections may be related to an increase in oxygen free radicals (8,12) and defective antioxidant mechanisms (13). The excessive production of oxidative products due to a defective antioxidant defense mechanism causes chronic oxidative stress in periodontal tissues. Subsequently, an exaggerated inflammation occurs, which is considered to be an important contributing factor in the development of periodontitis, in addition to the destructive effects of free oxygen radicals associated with the pathogenesis of periodontal disease (6-8).

Compounds that contain thiol groups are organic substances. They play a significant role in resisting oxidative stress owing to their reductive properties. Thiols are considered to be double-acting effective antioxidants that protect cells mostly against free radical injury. However, an excessive increase in free thiols in the circulation is associated with toxic effects caused by an exaggerated oxidation course producing reactive oxygen species (ROS). Low-molecular-weight thiols, albumin thiols, and protein thiols are known to be the main thiols in plasma (14,15) which contain-thiol (sulfhydryl) groups (16). Oxidative products, such as ROS, produced by organisms are reduced by transferring the excess electrons to the thiol-containing compounds, with thiol groups being oxidized (17). Disulphide bonds are formed by the oxidation of thiol groups. However, after this reversible reaction, the disulphide bonds can be reduced back to thiol groups. Thus, the dynamic balance of thiol/disulphide contributes to the antioxidant effect (18,19). In general, the presence of reversible disulphide bonds is the first sign of protein oxidation (20). Dynamic thiol/disulphide homeostasis plays a significant role in antioxidant defense, apoptosis, detoxification, enzymatic activity regulation, and cellular signal transduction (21).

Thiol/disulphide stability has been studied in a number of disorders; however, up until 2014, this balance has been measured as a single-sided thiol/disulphide homeostasis, in which only the increase and decrease in the thiol form could be determined (14). Currently, the levels of both thiol and disulphide can be determined bilaterally using a new method (14,22). In recent studies, homeostasis deterioration has been reported to cause chronic kidney disease, diabetes mellitus, cardiovascular disease, cancer, chronic inflammatory joint disease, and various neurodegenerative diseases. Abnormal

thiol/disulphide homeostasis is the cause of some diseases that involve prominent chronic inflammation (23,24). By measuring the dynamic thiol/disulphide homeostasis, information on numerous normal or abnormal biochemical processes can be obtained (14). However, the role of thiol/disulphide homeostasis is not clearly elucidated in the pathogenesis of periodontal disease, which is known to be a chronic inflammatory disease.

In this study, the total thiol, native thiol, and disulphide levels related to thiol/disulphide homeostasis were evaluated in the study groups, including generalized stage III grade C periodontitis patients and healthy control individuals. Moreover, the relationship between these parameters and the clinical periodontal parameters before and after the non-surgical periodontal treatment (NSPT) has been evaluated.

Materials and Methods

This study was conducted in accordance with the Good Clinical Practices Guideline (2002 Declaration of Helsinki). The study objective and the experiments to be conducted throughout the study were explained in detail to all participants. The study participants were selected from volunteer individuals who applied for periodontal treatment at the Ankara University Faculty of Dentistry, Department of Periodontology, from June 2017 to January 2019. An informed consent form was signed by all the participants. The study protocol has been approved by the Ankara University Faculty of Dentistry Clinical Research Ethics Committee (decision no: 36290600/60-08/01, date: 28.06.2016).

Study Population

Participants who were not diagnosed with diabetes, cardiovascular diseases, respiratory diseases, and osteoporosis; those who did not routinely use medication and antibiotics or anti-inflammatory drugs in the last 3 months; and those who had not been formerly exposed to periodontal treatment were eligible. Participants who were pregnant and breastfeeding and who are currently smokers or former smokers were excluded from the study.

Clinical diagnosis was considered according to the "2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions" (25). In this study, the periodontitis group (n=25) included patients with generalized stage III grade C periodontitis. Patients who had interdental radiographic bone loss at ≥5 mm in the non-adjacent teeth or buccal or oral radiographic bone loss that extends to the middle or apical third of the root with probing depth of >3 mm were diagnosed with stage III periodontitis. Extension of periodontal disease was in more than 30% of all sites so described as generalized. Patients were also diagnosed as grade C based on the bone loss/age index (>1.00= indirect evidence of progression), smoking, and/or diabetes. The control group (n=23) included patients with no history of periodontal disease, clinical or radiographic findings of attachment loss, and clinical signs of gingivitis. Periodontal health (control group) was defined as a probing pocket depth (PPD) of ≤3 mm and bleeding on probing (BOP) of (+) ≤10% (26).

Non-surgical Periodontal Treatment

Individuals were treated with full-mouth scaling and root planing (SCRP). The treatment procedure was performed using an ultrasonic scaler (Cavitron DENTSPLY, York, PA) and hand instruments (Gracey curets, Hu-Friedy, Chicago, IL) and was divided into two sessions with a 24-h interval with the aim of ending all SCRP, in accordance with the original study of Quirynen et al. (27). No time limit was. Thus, the periodontist finished the procedure as soon as the root surfaces were satisfactorily cleaned and flattened. The patients were provided with standard oral hygiene training immediately after the first SCRP procedure (tooth brushing, interdental brushing, flossing, and tongue dorsum brushing) (27). The patients were warned not to use any medication or mouthwash products. One month after the treatment, the patients were followed up two to three times and checked for the instructions given.

Periodontal Examination

BOP (%), PPD (mm), and clinical attachment level (CAL, mm) values were recorded by an experienced periodontist (M.A.T) before the NSPT. Prior to the study, the examiners were calibrated (M.G and M.A.T). A reference examiner (M.G.), with more than 20 years of experience in periodontology, has calibrated our periodontist (M.A.T.). The scores of probing depth exhibited good reproducibility, as evaluated by an inter-examiner. A total of five volunteers were assessed twice, with a 1-h interval between assessments. The reproducibility assessment resulted in 85% of sites

for which the repeat probing mean measurements were within ±1 mm. The Williams periodontal probe (the University of Michigan) was used for the measurements, and the cementoenamel junction was set as the reference point. The examination and recording of the clinical periodontal parameters were repeated by the same periodontist 1 month after the end of the treatment period. A total of six regions of each tooth (mesio-buccal, distobuccal, mid-buccal, mesio-lingual, disto-lingual, and mid-lingual) were examined to obtain the PPD, CAL, and BOP values. The PPD measurements were recorded by rounding off to the nearest millimeter. The CAL measurements were calculated by overlapping gingival recession and PPD. Also, the BOP measurements were expressed as percentage. The average of all the CAL, PDD, and BOP values was then calculated for each patient.

Collection of Serum Samples

Blood samples were obtained from the antecubital vein just before and 1 month after the NSPT. Subsequently, the blood samples were left to stand for 30 min (minutes) prior to centrifugation. All samples were centrifuged at 4,000 g for 10 min to separate the serum and stored at -80 °C until the day of the experiment.

Serum Disulphide/Thiol Homeostasis

A spectrophotometric method was employed, as defined by Erel and Neselioğlu (14), to measure disulphide/thiol homeostasis. Specifically, using this method, free functional thiol groups were obtained by reducing the reducible disulphide bonds, and formaldehyde was applied to remove the remaining sodium borohydride used as a reductant. After the reaction with 5.5'-dithiobis-(2-nitrobenzoic) acid, all thiol groups containing native and total thiols were measured. To calculate the dynamic disulphide amount, half of the difference between the total thiols and native thiols was utilized. Native thiols and total thiols were measured; then, the native thiol/total thiol percentage ratios, disulphide amounts, disulphide/native thiol percentage ratios, and disulphide/total thiol percentage ratios were calculated.

Statistical Analysis

For the statistical analysis, the Statistical Package for Social Sciences (SPSS) (version 20 for Windows, SPSS, Inc., St. Louis, MO) was used. Normal data distribution was controlled using the Shapiro-Wilk test. The parameters with a normal distribution were analyzed via the parametric tests. Intergroup comparisons were performed using the independent-samples t-test. Moreover, the Bonferroni correction was employed to evaluate the statistical significance. Pearson's correlation coefficient (Pearson's r) was employed for the correlation analysis of variables. For each group, 20 patients were collected according to the 80% power calculation to identify the least clinically significant difference with 5% type-I error. $P<0.05$ was considered to be statistically significant.

Results

Demographic Data and Clinical Periodontal Parameters

A total of 48 individuals participated in the study; they were divided into the control group (female/male=12/11, 41±4.6 mean age, years) and the periodontitis group (female/male=13/12, 43±5.2 mean age, years). The patients were able to complete the 1-month recovery and follow-up periods without complications. No statistically significant difference was observed between the study groups in terms of age and gender distribution. The clinical periodontal parameter (CAL, BOP, and PPD) values of the measurements before and after periodontal treatment are presented in Table 1. The clinical periodontal parameter values of the periodontitis group before treatment were statistically higher than those of the control group ($p<0.01$). It was observed that all the clinical parameters significantly decreased at the first month after treatment compared with the pre-treatment baseline measurements ($p<0.05$). However, the results of the periodontitis group after treatment were significantly higher than those of the control group ($p<0.01$).

Serum Parameters

The pre-treatment and post-treatment values of the periodontitis group were compared with those of the control group (Table 2). Before treatment, the levels of native and total thiols were lower in the periodontitis group ($p=0.007$, $p=0.001$, respectively) than in the control group. The disulphide, % disulphide/native thiol, and % disulphide/total thiol ratio levels were significantly higher in the periodontitis group than in the control group ($p=0.038$, $p=0.014$, $p=0.002$, respectively) prior to treatment. There was no significant biochemical parameter between the

control group and the periodontitis post-treatment group (p>0.05).

In the pre-treatment and post-treatment periodontitis groups, the levels of native and total thiols increased after treatment; however, the increase was not significant (p=0.141, p=0.248, respectively). However, after treatment, the disulphide, % disulphide/native thiol ratio, and % disulphide/total thiol ratio levels significantly decreased (p=0.007, p=0.006, p=0.001, respectively). The native and total thiol ratio levels did not change after treatment (p=0.647).

Correlation

Prior to treatment, a significant and positive correlation was observed between all the clinical periodontal parameters (BOP-CAL, BOP-PPD, PPD-CAL) in the periodontitis group (r=0.929, p<0.01, r=0.969, p<0.01, r=0.940, p<0.01, respectively). A significant negative correlation was observed between native and total thiols and all the clinical periodontal parameters (p<0.05). Moreover, a significant positive correlation was observed between % disulphide/native thiol ratio and % disulphide/total thiol ratio and all the clinical periodontal parameters (p<0.05).

Before and after treatment, a significant correlation was observed between the total and native thiol levels (r=0.964/0.962, p<0.001, respectively). In addition, a significant negative correlation was observed between the native thiol level (mmol/L) and % disulphide/native thiol ratio levels (r=-0.737, p<0.01, r=-0.504, p<0.05). There was also a significant positive correlation between disulphide (mmol/L) and % disulphide/total thiol ratio; % disulphide and % disulphide/native thiol ratio (r=0.893/0.834, p<0.001;

Table 1. Demographics of the study population and comparisons of full mouth clinical periodontal parameters between the groups

Variables	Control (n=23)	Generalized stage III grade C periodontitis (n=25)		
		Pre-Treatment	Post-Treatment	Pre-Treatment/Post-Treatment (p)
PPD (mm)	1.12±0.23	3.85±0.56**	2.94±0.32**	p<0.01
BOP (%)	8.74±2.51	79.25±7.35**	30.93±4.74**	p<0.01
CAL (mm)	1.25±0.25	4.96±1.09**	4.34±0.80*	p<0.05
Female/male	12/11	13/12		
Age (year)	41±4.6	43±5.2		

PPD: Probing pocket depth, BOP: Bleeding on probing, CAL: Clinical attachment level. Data are experessed as mean±SD. **p<0.01, *p<0.05 statistically significant difference from control group

Table 2. Serum levels of thiol/disulphide in control and generalized stage III grade C periodontitis groups

Biochemical parameters	Control (n=23)	Periodontitis (n=25) (Pre-Treatment/Post-Treatment)	Control/periodontitis (Pre-Treatment) p	Control/periodontitis (Post-Treatment) p	Pre-Treatment/ Post-Treatment (p)
Native thiol (mmol/L)	363.88±34.39	332.82±34.05/348.17±9.53	0.007*	0.113	0.141
Total thiol (mmol/L)	404.65±29.77	367.99±35.42/381.80±40.68	0.001**	0.052	0.248
Disulphide (mmol/L)	20.38±4.62	23.16±3.30/19.68±4.10	0.038*	0.635	0.007*
% Disulphide/ native thiol ratio	5.73±1.74	6.96±1.18/5.73±1.41	0.014*	0.897	0.006*
% Disulphide/ total thiol ratio	5.09±1.38	6.32±0.91/5.19±1.14	0.002*	0.526	0.001**
% Native thiol/ total thiol ratio	89.80±2.76	90.42±2.44/90.83±3.11	0.462	0.515	0.647

**p<0.01, *p<0.05, Data are experessed as mean ± standard deviation (median)

Table 3. Correlation between clinical periodontal parameters and thiol/disulphide serum levels in the study groups for pre- and post-treatment

Generalized stage III grade C periodontitis (Pre-Treatment/Post-Treatment)									
Parameters		**CAL**	**PPD**	**Native thiol (mmol/L)**	**Total thiol (mmol/L)**	**Disulphide (mmol/L)**	**% Disulphide/ native thiol ratio**	**% Disulphide/total thio ratio**	**% Native thiol/ total thiol ratio**
BOP	r=	0.929/-0.014	0.969/0.171	-0.462/0.977	-0.540/0.025	0.304/0.084	0.398/0.086	0.467/0.082	0.12/-0.175
	p=	0.00/0.948 **/¥	0.00/0.425 **/¥	0.004/0.977 */¥	0.00/0.92 */¥	0.063/0.733 ¥/¥	0.013/0.726 */¥	0.003/0.740 */¥	0.502/0.475 ¥/¥
CAL	r=	-	0,940/0.580	-0.403/0.321	-0.497/0.261	0.340/0.087	0.379/0.066	0.489/-0.032	0.191/0.165
	p=	-	0.00/0.003 **/*	0.012/0.180 */¥	0.001/0.280 **/¥	0.037/0.723 */¥	0.019/0.787 */¥	0.002/0.898 */¥	0.251/0.501 ¥/¥
PPD	r=	-	-	-0.402/0.104	-0.501/0.101	0.322/0.127	0.379/0.083	0.469/0.091	0.206/0.027
	p=	-	-	0.012/0.671 */¥	0.001/0.680 **/¥	0.049/0.603 */¥	0.019/0.735 */¥	0.003/0.712 */¥	0.251/0.912 ¥/¥
Native thiol (mmol/L)	r=	-	-	-	0.967/0.962	-0.338/0.067	-0.737/-0.504	-0.702/-0.478	0.489/0.320
	p=	-	-	-	0.00/0.000 **/**	0.035/0.786 */¥	0.00/0.028 **/*	0.00/0.039 **/*	0.002/0.181 */¥
Total thiol (mmol/L)	r=	-	-	-	-	-0.202/0.234	-0.621/-0.331	-0.610/-0.328	0.250/0.069
	p=	-	-	-	-	0.219/0.335 ¥/¥	0.00/0.167 */¥	0.00/0.170 */¥	0.125/0.778 ¥/¥
Disulphide (mmol/L)	r=	-	-	-	-	-	0.814/0.816	0.893/0.834	-0.561/-0.592
	p=	-	-	-	-	-	0.00/0.00 **/**	0.00/0.00 **/**	0.00/0.008 **/*
% Disulphide/ native thiol ratio	r=	-	-	-	-	-	-	0.939/0.992	-0.655/-0.727
	p=	-	-	-	-	-	-	0.00/0.00 **/**	0.00/0.00 **/**
% Disulphide/ total thiol ratio	r=	-	-	-	-	-	-	-	-0.557/-0.653
	p=	-	-	-	-	-	-	-	0.00/0.002 **/*

**p<0.01, *p<0.05, ¥>0.05, PPD: Probing pocket depth, BOP: Bleeding on probing, CAL: Clinical attachment level

r=0.814/0.816, p<0.001). The correlation levels between the parameters before and after treatment are presented in Table 3.

Discussion

Dynamic thiol/disulphide stability is important for humans. When this balance is disturbed, stabilization of protein structures, enzyme transcription and regulation, cellular signal transduction, and receptor and transporter functions could be affected and damaged. Thus, detoxification, antioxidant preservation, enzymatic activity regulation, and components of the cellular signaling mechanism could also be affected (28,29). In this study, we evaluated the dynamic thiol/disulphide homeostasis of the periodontitis and control groups using a new colorimetric method (14). Based on our results, levels of native and total thiols, which provide information on antioxidant conditions, significantly decreased in the periodontitis group compared to the control group. Contrarily, the disulphide levels significantly increased in the periodontitis group. A few studies obtained results similar to those of our study in different chronic diseases (24,30-32). The plasma thiol levels decrease as oxidative stress increases (33). Various studies have demonstrated the relationship between oxidative stress and chronic inflammation in the development and progression of periodontitis (7,8,12). Additionally, a good correlation was observed between the total and native thiol levels and the clinical parameters in the patient group.

To the best of our knowledge, our study is the first to evaluate the dynamic thiol/disulphide homeostasis in patients diagnosed with periodontitis. Periodontitis is a chronic inflammatory disease caused by the interaction between the host immune response and pathogenic bacteria. The immunological activity and cytokine expression increase in the gingival tissue during the activity of predominant inflammatory cells. As a result, prolonged inflammatory reaction produces a large amount of oxidants, thus causing oxidative damage. In periodontitis, oxidative radicals are known to increase more than the antioxidant molecules and cause oxidative stress (34). These oxidant radicals oxidize the thiol groups present in the side chains of sulfur-containing amino acids of proteins to form disulphide bonds (35). Subsequently, the increased disulphide bonds cause the thiol/disulphide homeostasis to shift toward the disulphide, which results in an abnormal thiol/disulphide homeostasis (14). During abnormal thiol/disulphide homeostasis, vital cellular functions are damaged. Due to oxidative stress, pathologies occur in numerous organelles and cause imbalances (14). Moreover, oxidant radicals formed by other factors, such as inflammation, chemicals, and radiation, can also damage the mechanism of thiol/disulphide homeostasis. In both cases previously described, thiol/disulphide homeostasis is expected to weaken in the periodontitis group than in the control group.

In the present study, the levels of thiol/disulphide were lower in the periodontitis group than in the control group prior to treatment. The thiol levels may be decreased due to increased oxidation of thiol groups by oxidant radicals in periodontitis, which is a disease dominated by chronic inflammation. However, in our study, the radicals that cause oxidative stress were not investigated, which may be considered as a limitation of our study. Previous studies have revealed that oxidant radical concentrations are higher in the periodontitis group than in the control group. It has also been emphasized that periodontitis is a minor local inflammatory condition and is associated with the systemic oxidative stress level in numerous studies conducted on human subjects (36-38). It is believed that inflammation is responsible for the production of oxidant radicals; however, it is also possible for oxidant radicals to stimulate inflammation. According to the results of our study, we suggest that increased oxidant radical levels associated with periodontal inflammation shifted the thiol/disulphide balance in favor of disulphide. As a result, thiol/disulphide homeostasis weakened, thiol levels decreased, and disulphide levels increased in the periodontitis group. The present study aimed to measure systemic markers in patients with periodontitis. It would have been valuable if thiol/disulphide homeostasis was measured in the saliva samples or gingival crevicular fluid samples. This can also be considered as a limitation of our study.

One month after the treatment, the NSPT, BOP, PPD, and CAL values significantly decreased in the periodontitis group. The decrease in periodontal inflammation indicates the clinical effects of the treatment. The clinical results we obtained with the NSPT were consistent with those of the clinical study

conducted by Badersten et al. (39), Haffajee et al. (40), and Pinho et al. (41). Through the NSPT, periodontal pathogens were removed from the patients with periodontitis, systemic inflammatory mediators were reduced, and oxidative stress and disease activity were decreased. Based on the results of this study, it was important to determine a significant decrease in the serum disulphide levels and some increase in the thiol levels after periodontal treatment. This has been confirmed by the significant improvement in the values of the clinical periodontal parameters. However, the clinical periodontal parameters measured in the periodontitis group after the NSPT were still significantly higher than the periodontal parameters measured in the control group. Although the debridement with NSPT provides an improvement in patients with advanced periodontitis, there are still some regions with deep PPD and BOP+. In addition, the CAL cannot be reached on the same basis as in healthy individuals by performing NSPT alone.

Conclusion

In this study, the serum levels of native thiol, total thiol, disulphide, disulphide/native thiol, disulphide/total thiol, and native thiol/total thiol were investigated in patients with periodontitis. Dynamic thiol/disulphide homeostasis provides significant information on various normal or abnormal biochemical processes as a new marker of oxidative stress. Numerous articles on oxidative stress in the literature have demonstrated contradictory data. The results of this study confirmed the efficacy of periodontal therapy and provided valuable information on the thiol/disulphide balance. In this study, the significant relationship between the severity of periodontal disease and the serum total thiol and disulphide levels supported the hypothesis of oxidative stress, which plays a significant role in the etiopathogenesis of periodontitis.

Ethics

Ethics Committee Approval: The study protocol has been approved by the Ankara University Faculty of Dentistry Clinical Research Ethics Committee (decision no: 36290600/60-08/01, date: 28.06.2016).

Informed Consent: An informed consent form was signed by all the participants.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: M.A.T., C.B., M.G., Design: M.A.T., C.B., C.N., M.G., Supervision: M.A.T., C.B., C.N., M.G., Fundings: M.A.T., C.B., Data Collection or Processing: M.A.T., C.B., C.N., M.G., Analysis or Interpretation: M.A.T., C.B., C.N., Literature Search: M.A.T., C.B., C.N., M.G., Critical Review: M.A.T., C.B., C.N., M.G., Writing: M.A.T., M.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Evaluation of Maxillary Sinus Width and Lateral Wall Thickness Using Cone-Beam Computed Tomography

Konik Işınlı Bilgisayarlı Tomografi ile Maksiller Sinüs Genişliği ve Lateral Duvar Kalınlığının Değerlendirilmesi

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Keywords
Cone-beam computed tomography, classification, maxillary sinus, sinus floor augmentation

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Konik ışınlı bilgisayarlı tomografi, sınıflandırma, maksiller sinüs, sinüs tabanı ogmentasyonu

Received/Geliş Tarihi : 06.07.2020
Accepted/Kabul Tarihi : 13.12.2020

doi:10.4274/meandros.galenos.2020.49140

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Abstract

Objective: This study aimed to measure the lateral wall thickness (LWT) and width of the maxillary sinus using cone-beam computed tomography (CBCT) to prevent intra- and post-operative complications by formulating a new sinus classification.

Materials and Methods: Residual ridge height, maxillary sinus width (SW) and lateral wall thickness (LWT) were measured by analysing CBCT scans from 246 edentulous sites. The SW and LWT were measured at 3 mm and 5 mm, respectively, from the sinus floor. The mean SW was stratified by the residual ridge height (<4; ≤4 and <7; ≤7 and <10; ≥10 mm), study site and measurement level.

Results: The mean SW increased at molar sites and at sites with lower residual ridge heights. Sinuses were categorised based on the 33rd and 67th percentile SW values at 3 mm and 5 mm, respectively. The mean value at the lower boundary was 9.33 (1.85) mm, with the 33rd and 67th percentiles being 8.62 and 10.11 mm, and the mean value at the upper boundary was 11.72 (2.20) mm, with the same percentiles being 10.81 and 12.59 mm, respectively. The mean LWTs at 3 and 5 mm were 1.67 and 1.56 mm, respectively.

Conclusion: The proposed SW classification and LWT may help predict the difficulty of sinus elevation when selecting appropriate surgical approaches.

Öz

Amaç: Bu çalışmanın amacı, ameliyat sırasında ve sonrası komplikasyonları önlemek amacıyla yeni bir sinüs sınıflandırması formüle ederek, konik ışınlı bilgisayarlı tomografi yardımıyla lateral duvar kalınlığını ve maksiller sinüs genişliğini ölçmektir.

Gereç ve Yöntemler: İki yüz kırk altı dişsiz bölgeden alınan konik ışınlı bilgisayarlı tomografi taramaları analiz edilerek, rezidüel sırt yüksekliği, maksiller sinüs genişliği ve lateral duvar kalınlığı ölçüldü. Sinüs genişliği ve lateral duvar kalınlığı sinüs tabanından 3 ve 5 mm mesafelerde ölçüldü. Ortalama sinüs genişliği rezidüel sırt yüksekliği (<4; ≤4 ve <7; ≤7 ve <10; ≥10 mm), çalışma bölgesi ve tabandan ölçüm mesafelerine göre sınıflandırıldı.

Bulgular: Ortalama sinüs genişliği molar bölgelerde ve daha düşük rezidüel sırt yüksekliğine sahip bölgelerde arttı. Sinüsler 3 ve 5 mm'de 33. ve 67. yüzdelik dilimlerde sinüs genişliği değerlerine göre sınıflandırıldı. Alt

sınırdaki ortalama değer 9,33 (1,85) mm, 33. ve 67. persentiller 8,62 ve 10,11 mm ve üst sınırdaki 11,72 (2,20) mm, aynı yüzdelikler sırasıyla 10,81 ve 12,59 mm idi. Ortalama lateral duvar kalınlığı 3 ve 5 mm'de sırasıyla 1,67 ve 1,56 mm idi. **Sonuç:** Önerilen sinüs genişliği sınıflandırması ve lateral duvar kalınlığı, uygun cerrahi yaklaşımları seçerken sinüs elevasyonunda güçlüğün tahmin edilmesine yardımcı olabilir.

Introduction

Tooth extractions, resorptions and progressive pneumatization of maxillary sinuses can complicate dental implant placement in the posterior maxillary edentulous region (1-3). The anatomical structures of maxillary sinuses limit surgical procedures. Factors such as maxillary sinus width (SW) (distance between the medial and lateral sinus wall), sinus lateral wall thickness (LWT) and residual ridge height (RRH) influences surgical success. These measurements determine implant placement, orientation and size. Therefore, surgical procedures to increase vertical RRH via sinus lifting have been developed.

The two sinus augmentation methods are crestal osteotomy (crestal sinus lift or closed sinus lift) and lateral window approaches. The latter, which protects the sinus membrane is preferred when residual bone height is particularly poor. Maxillary sinus floor elevation is associated with high implant survival rates, but it carries the risk of complications. Damage to the sinus membrane during sinus lift procedures is the most common issue, but complications may also develop post-operatively (4-7). Therefore, reducing membrane tension from the medial wall during the lift surgery is quite effective in decreasing perforation risk (8). In addition, in this region that is rich in blood vessels, the medial wall supplies blood support for grafting in the lateral window sinus elevation technique. The lateral walls include posterior superior alveolar artery and infraorbital arteries that supply the sinus membrane with blood (8). Therefore, it is also important to position the lateral window perfectly during the lift surgery.

The maxillary sinus mediolateral dimension being too small or large for sinus lift procedures may increase membrane perforation risks. In addition to the angulation between the medial and lateral walls of the sinus, the distance between these walls is also effective in the mediolateral dimension of the maxillary sinus and has an important role in augmentation by osteotomy. In the narrow SWs, contact between implants and sinus walls maximizes. Thus, this situation promotes vascular blood supply for bone formation. However, there is an increased risk of perforation in the narrow sinus compared to wider cases (8,9). Therefore, narrow sinuses and sharp wall angles are related and are associated with increased membrane perforation (10).

In addition to the angle and distance between the lateral and medial walls, LWT is another technical and anatomical factor involved in membrane perforation (11-13). This also means that LWT must be considered during surgery to prevent possible membrane perforation (14). Correct diagnosis of maxillary sinus anatomy can prevent many complications, making it important to perform a sufficient pre-surgical study of the area using advanced imaging techniques, such as cone beam computed tomography (CBCT).

Previous studies have investigated the anatomy of maxillary sinuses via computed tomography (CT) or panoramic X-rays (2D) (15), but there is no well-rounded study evaluating maxillary SW and LWT using CBCT. Therefore, the objectives of this study are as follows:

1. To measure SW and LWT, at different heights from the sinus floor at edentulous sites on CBCT scans.
2. To propose a new sinus classification based on SW values and evaluate their clinical implications for augmentations.
3. To investigate the influence of age and sex on the dimensions of LWT, SW and RRH.

Materials and Methods

This study was approved by the Ethics Committee for Clinical Research at Ege University Faculty of Medicine (decision no: 14-7.1/6, date: 08.09.2014), and signed informed consent form was receipted by the participants.

Study Sample

We evaluated CBCT scans of 400 patients who visited the University Faculty of Dentistry for placement of dental implants between 2015 and 2020. CBCT scanning was performed to evaluate implant placements. Patients' demographic findings, number of teeth lost and medical histories were recorded.

Image Acquisition

CBCT images were obtained using a Kodak 9000 3D (Kodak Dental Systems, Carestream, Rochester, NY, USA) with a 5×3.7 cm field of view (FOV), 70 kVp, 10 mA, a scanning time of 24 s, a voxel size of 0.076 mm and a slice thickness of 0.076 mm. The scans in this study were selected from archives of University Faculty of Dentistry Department of Oral and Maxilofacial Radiology CBCT database. CBCT images were reviewed and measured by a single examiner (N.K.T.) using Kodak 3D Imaging Software 3.1.9 (Kodak Dental Systems, Carestream, Rochester, NY, USA). All examinations to create adequate image quality; It was carried out by an expert licensed radiologist with the required minimum optimal exposure dose and the smallest FOV.

Inclusion Criteria

Axial, sagittal and cross-sectional images projected by a 28-inch desktop monitor of 1024x768 pixels under normal room lighting were evaluated. Included CBCT images met the following criteria:

1. Presence of edentulous sites in the vicinity of the maxillary sinus.
2. Preferably one or two missing teeth so that localization could be clearly identified.
3. Presence of adjacent teeth to the edentulous area to identify locations in correspondence to the missing tooth sites.
4. Visible maxillary sinus, measurable from the floor to at least 6 mm in height.

Images were excluded if any of the following criteria were met:

1. The images were unclear or incomplete.
2. Edentulous sites in correspondence to any tooth sites could not be located.
3. Sinus pathology made measurement impossible.
4. The alveolar ridge outline could not be distinguished.
5. The sinus had been grafted or implants had been placed.
6. The adjacent teeth were too mesialise (mesial tipping) precluding measurements.

Data Collection

Reconstructed images were reoriented to bring the hard palate parallel with the ground and may be used to view certain anatomic areas from all aspects. At the sagittal section images, reference arches were drawn at the level of the crestal bone to comply with the ridge centres. Coronal section images including the centres of each missing tooth site were selected for SW, LWT and RRH measurements. On these images, data were measured using an inbuilt digital calliper, including SW, LWT and RRH at 3 and 5 mm from the sinus floor (Figure 1). SW, LWT and RRH measurements of the posterior maxillary region were completed at edentulous sites from the first premolar to the second molar on the 246 CBCT images (154 scans were rejected because of low quality images; evidence of previous implant placement/ augmentation procedures, leaving insufficient space to place an implant; or no adjacent teeth). SW was measured from the medial to lateral walls of the sinuses. LWT was measured from the inner to outer cortical surfaces in the lateral walls. The minimum and maximum RRH from the sinus floor to the crest top were measured. Sinus classification was performed in patients who were eligible for sinus augmentation in RRH-maximum (max RRH in the investigated sites) <10 mm.

Study Design

Missing tooth sites were categorised: premolar (P), molar (M), premolars (PP), molars (MM) and premolar and molar (PM). RRH ranges of 0-3.99 mm, 4-6.99 mm, 7-9.99 mm and ≥10 mm at edentulous site were classified as severely deficient (SvD), moderately deficient (MdD), slightly deficient (SlD), or normally

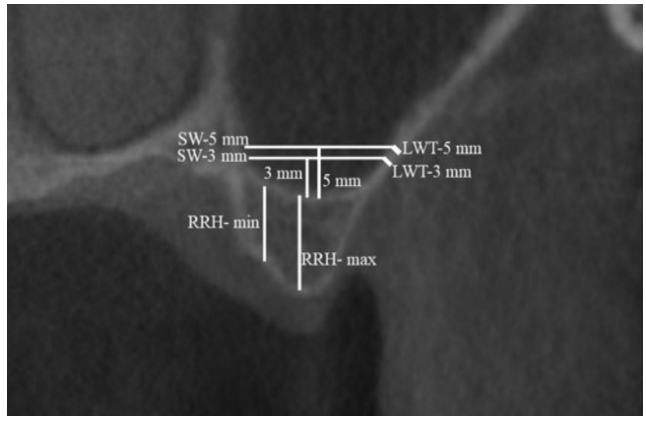

Figure 1. Demonstration of measurements of anatomical landmarks

SW-3-mm: Sinus width which was at 3 mm above from the sinus floor, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor, LWT-3-mm: Lateral wall thickness which was at 3 mm above from the sinus floor, LWT-5-mm: Lateral wall thickness which was at 5 mm above from the sinus floor, RRH-max\min: Residual ridge height maximum\minimum

deficient (ND), respectively. SWs were obtained at each measurement level of each missing tooth site and are expressed as mean [standard deviation (SD)] in mm.

Statistical Analysis

The SWs of three RRH groups (3 mm and 5 mm for SvD, MdD, and SlD) were combined to represent SW at the usual lower limit (3 mm) and upper (5 mm) of the lateral window osteotomy. The mean (SD), median and 33rd and 67th percentile values for SW at the lower and upper limits were worked out.

A One-Way ANOVA was used to compare the measurements, investigated sites and age variables. Independent sample t-tests were used to compare these measurements by gender. The intraclass correlation coefficient (ICC) was calculated to determine the level of agreement between the measurements. Relationships between the variables SW-5-mm (SW which was at 5 mm above from the sinus floor), LWT-5-mm (LWT which was at 5 mm above from the sinus floor), RRH-max and number of missing teeth were investigated via Pearson's correlation coefficient. The mean (SD), median and 33rd and 67th percentile values for the SW at the lower and upper limits were worked out. SPSS 25.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses.

Results

A total of 246 scans were included for analysis. Of the 246 evaluated CBCT scans, 46.7% belonged to female patients and 53.3% to males (mean age of 49.1 years old and age range from 18 to 90 years old).

LWT-3-mm (LWT-3-mm above the sinus floor) showed no significant difference by the investigated sites ($p>0.05$). However, SW-3-mm (SW-3-mm above the sinus floor), SW-5-mm, LWT-5-mm, (SW and LWT-5-mm above the sinus floor) RRH-max and RRH-minimum (max and min RRH in the investigated sites) values showed significant differences by the investigated sites ($p<0.05$).

The SW-3-mm and SW-5-mm averages of PM, MM and M were significantly higher than those of PP and P ($p<0.05$). The LWT-5-mm averages of PM, P and M were significantly higher than those of MM ($p<0.05$). The averages of RRH-max and RRH-min were significantly higher in PP and P than those of MM, PM and M ($p<0.05$).

The ICC showed strong agreement between the results of the first, second and third series of measurements ($ICC|>0.75$). Therefore, the mean values of dual measurements were applied for further analysis to minimise error in the variable measurements.

Correlations were evaluated at a single measurement level (5 mm) only. An insignificant negative correlation was found between SW-5-mm and LWT-5-mm. SW-5-mm was negatively correlated with both RRH-max and number of missing teeth. Finally, there was a significant positive correlation between LWT-5-mm and RRH-max and an insignificant negative correlation between LWT-5-mm and number of missing teeth (Table 1).

The mean SW is presented in Table 2, classified by RRH, investigated site and measurement level. In RRH-max, 22, 81, 52 and 91 investigated sites were available, respectively, for SvD, MdD, SlD and ND. In RRH-min, 89, 68, 37 and 52 investigated sites were available for SvD, MdD, SlD and ND. In RRH-max, for the 3 mm measurement level of each RRH group, the mean SWs were 8.22 (±2.25), 9.44 (±1.62), 9.62 (±1.86) and 7.36 (±2.93) mm, respectively, for SvD, MdD, SlD and ND. For the 5 mm measurement level of each RRH group, the mean SWs were 10.07 (±2.45), 12.10 (±1.94), 11.85 (±2.18) and 9.47 (±3.89) mm, respectively, for SvD, MdD, SlD and ND. In RRH-min, for the 3 mm measurement level of each RRH group, the mean SWs were 9.02 (1.70), 9.47 (±2.28), 9.07 (±2.39) and 6.24 (±2.67) mm, respectively, for SvD, MdD, SlD and ND. For the 5 mm measurement level of each RRH group, the mean SWs were 11.41 (±2.02), 11.87 (±2.69), 10.96 (±3.37) and 8.48 (±3.94) mm, respectively, for SvD, MdD, SlD and ND (Table 2).

When RRH-max and RRH-min were evaluated for sinus augmentation requirements, SvD, MdD and SlD were further analysed for SW classifications. The distributions of SW at the lower and upper limits of the lateral window osteotomy were examined. On the basis of the 33rd and 67th percentile SW values, a new sinus classification was proposed (Table 3). The mean value at the lower limit was 9.33 (±1.85), with the 33rd and 67th percentiles at 8.62 and 10.11 mm, respectively. The mean value at the upper limit of the lateral window osteotomy was 11.72 (±2.20), with the 33rd and 67th percentiles at 10.81 and 12.59 mm, respectively (Table 3). The distributions of SW

Table 1. Investigation of relations between measurements

Measurements	Statistical analysis methods	SW-5-mm	LWT-5-mm	RRH-max	Number of missing teeth
SW-5-mm	Pearson correlation	1	-	-	-
	Significance (two-tailed)	-	-	-	-
LWT-5-mm	Pearson correlation	-0.084	1	-	-
	Significance (two-tailed)	0.196	-	-	-
RRH-max	Pearson correlation	-0.399**	0.372**	1	-
	Significance (two-tailed)	0.000	0.000	-	-
Number of missing teeth	Pearson correlation	0-.146*	-0.079	0.172**	1
	Significance (two-tailed)	0.024	0.223	0.007	-

*p<0.05, **p<0.01, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor, LWT-5-mm: Lateral wall thickness which was at 5 mm above from the sinus floor, RRH-max: Residual ridge height maximum

at the lower and upper limits of the lateral window osteotomy are plotted in Figures 2a and b. A sinus classification was proposed based on the 33rd and 67th percentile SW values. For narrow, average and wide sinuses, the SWs at the lower limit of lateral windows were <8.62, 8.62-10.11 and >10.11 mm; at the upper limit, the SWs were <10.81, 10.81-12.59 and >12.59 mm, respectively (Table 4). It was found that the widest and narrowest sinuses were respectively on the MdD and SvD groups, at both measurement level and RRH groups (Table 3).

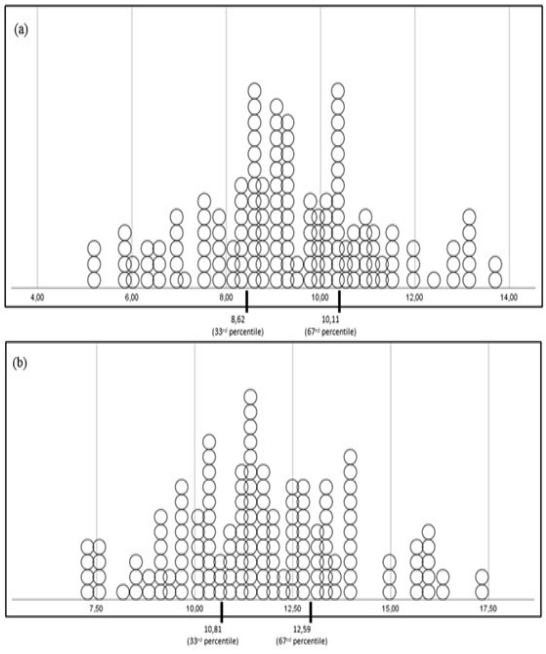

Figure 2. Distributions of sinus width measurements from 155 sites with thirty-third and sixty-seventh percentile values at the (a) lower limit and (b) upper limit of lateral window osteotomy

When measurements were compared by gender, the SW-3-mm and RRH-max mean value were not statistically significant (p>0.05). However, the SW-5-mm, LWT-3-mm and LWT-5-mm averages were significantly different in favour of male partially edentulous patients; RRH-min averages were significantly different in favour of female partially edentulous patiens (p<0.05) (Table 5). When the measurements were compared by age, SW-3-mm, SW-5-mm, LWT-3-mm, LWT-5-mm, RRH-min and RRH-max averages were not statistically different (p>0.05) (Table 6).

Discussion

Sinus membrane elevation via lateral windows creates complications due to sinus-associated fragile structures and anatomical variations. One such complication is Schneiderian membrane perforation, the most common intraoperative complication during sinus elevation. Also, membrane perforation may consist as a result of difficulties in approaching the surgical site, indirect and/or blind manipulation a lateral window instrument-related complications during elevation and the thin structure of the membrane itself (7).

Table 2. Sinus width presented as mean (standard deviation) at edentulous sites (first premolars to second molars) with different ridge height (severely deficient, moderately deficient, and slightly deficient, normally deficient) and measurement levels (3-5 mm from the ridge crest)

Residual ridge height classification			Investigated sites	N	SW-3-mm	SW-5-mm
RRH-max	SvD	X<4 mm	PP	0	Na	Na
			PM	2	*	*
			MM	11	8.67 (2.64)	10.6 (2.98)
			P	0	Na	Na
			M	9	8.20 (1.67)	9.97 (1.60)
			Total	22	8.22 (2.25)	10.07 (2.45)
	MdD	4≤X<7 mm	PP	0	Na	Na
			PM	27	8.72 (1.85)	11.7 (2.46)
			MM	39	9.91 (1.45)	12.4 (1.72)
			P	0	Na	Na
			M	15	9.54 (1.06)	11.9 (1.20)
			Total	81	9.44 (1.62)	12.10 (1.94)
	SID	7≤X<10 mm	PP	3	11.2 (0.50)	12.4 (0.98)
			PM	11	9.23 (1.31)	10.9 (1.70)
			MM	26	9.32 (1.95)	11.8 (2.19)
			P	0	Na	Na
			M	12	10.2 (2.05)	12.5 (2.63)
			Total	52	9.62 (1.86)	11.85 (2.18)
	ND	X≥10 mm	PP	20	4.51 (1.39)	6.56 (2.24)
			PM	33	7.42 (3.01)	9.40 (3.91)
			MM	15	8.30 (3.52)	10.5 (5.40)
			P	5	6.46 (0.92)	6.93 (1.46)
			M	18	9.17 (1.62)	11.6 (2.12)
			Total	91	7.36 (2.93)	9.47 (3.89)
RRH-min	SvD	X<4 mm	PP	1	*	*
			PM	16	8.61 (1.72)	11.5 (2.52)
			MM	47	9.21 (1.80)	11.2 (1.63)
			P	0	NA	NA
			M	25	9.07 (1.40)	11.2 (1.63)
			Total	89	9.02 (1.70)	11.41 (2.02)
	MdD	4≤X<7 mm	PP	3	11.2 (0.50)	12.4 (0.48)
			PM	24	8.38 (2.57)	10.5 (2.87)
			MM	30	9.87 (1.82)	12.4 (2.34)
			P	0	NA	NA
			M	11	10.2 (2.21)	12.7 (2.70)
			Total	68	9.47 (2.28)	11.87 (2.69)
	SID	7≤X<10 mm	PP	0	NA	NA
			PM	17	9.43 (2.24)	11.3 (3.06)
			MM	6	9.29 (4.02)	11.8 (5.81)
			P	2	*	*
			M	12	8.89 (1.51)	10.8 (1.67)
			Total	37	9.07 (2.39)	10.96 (3.37)
	ND	X≥10 mm	PP	19	4.41 (1.39)	6.53 (2.34)
			PM	16	5.89 (1.95)	8.12 (3.84)
			MM	8	7.67 (3.85)	9.55 (5.83)
			P	3	6.58 (1.28)	7.59 (1.61)
			M	6	9.81 (1.80)	12.7 (2.47)
			Total	52	6.24 (2.67)	8.48 (3.94)

*Mean (standard deviation) was not calculated due to small sample size. NA: Not applicable, RRH-max\min: Residual ridge height maximum\minimum, SvD: Severely deficient, MdD: Moderately deficient, SID: Slightly deficient, ND: Normally deficient, P: Premolar, M: Molar, PP: Premolars, MM: Molars, PM: Premolar and molar, SW-3-mm: Sinus width which was at 3 mm above from the sinus floor, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor

Table 3. Sinus width presented as mean (standard deviation), median, and thirty-third and sixty-seventh percentile at lower and upper limit of the lateral window osteotomy

Residual ridge height classification			Measurements	n	Mean	Median	Thirty-third percentile	Sixty-seventh percentile
RRH-max	SvD	X<4 mm	SW-3-mm	22	8.22 (2.25)	7.80	7.03	8.57
	MdD	4≤X<7 mm	SW-3-mm	81	9.44 (1.62)	9.73	9.09	10.30
	SID	7≤X<10 mm	SW-3-mm	52	9.62 (1.86)	9.07	8.67	10.30
RRH-min	SvD	X<4 mm	SW-3-mm	89	9.02 (1.70)	9.27	8.53	10.06
	MdD	4≤X<7 mm	SW-3-mm	68	9.47 (2.28)	9.07	8.53	10.20
	SID	7≤X<10 mm	SW-3-mm	37	9.07 (2.39)	9.07	8.00	10.53
			RRH-max total	155	9.33 (1.85)	9.27	8.62	10.11
RRH-max	SvD	X<4 mm	SW-5-mm	22	10.07 (2.45)	9.53	10.3	10.3
	MdD	4≤X<7 mm	SW-5-mm	81	12.10 (1.94)	12.10	11.30	13.00
	SID	7≤X<10 mm	SW-5-mm	52	11.85 (2.18)	11.40	10.60	12.80
RRH-min	SvD	X<4 mm	SW-5-mm	89	11.41 (2.02)	11.47	10.37	12.10
	MdD	4≤X<7 mm	SW-5-mm	68	11.87 (2.69)	11.39	10.71	12.87
	SID	7≤X<10 mm	SW-5-mm	37	10.96 (3.37)	10.77	9.92	13.23
			RRH-min total	194	11.72 (2.20)	11.47	10.81	12.59

RRH-max\min: Residual ridge height maximum\minimum, SvD: Severely deficient, MdD: Moderately deficient, SlD: Slightly deficient, SW-3-mm: Sinus width which was at 3 mm above from the sinus floor, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor

Table 4. New sinus classification based on sinus width at the lower and upper limit of lateral window osteotomy

Sinus width (mm)	Narrow	Average	Wide
SW-3-mm	<8.62	8.62-10.11	10.11>
SW-5-mm	<10.81	10.81-12.59	12.59>

SW-3-mm: Sinus width which was at 3 mm above from the sinus floor, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor

Table 5. Comparison of measurements by gender

Measurements	Gender	N	Mean	Standard deviation	Sig.
SW-3-mm	Female	115	8.31	2.79	0.06
	Male	131	8.91	2.12	
SW-5-mm	Female	115	10.42	3.38	0.02
	Male	131	11.39	2.74	
LWT-3-mm	Female	115	1.46	0.70	0.00
	Male	131	1.91	1.08	
LWT-5-mm	Female	115	1.41	0.69	0.01
	Male	131	1.69	0.92	
RRH-min	Female	115	7.73	5.86	0.01
	Male	131	6.00	4.50	
RRH-max	Female	115	10.24	5.73	0.06
	Male	131	8.96	5.02	

SW-3-mm: Sinus width which was at 3 mm above from the sinus floor, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor, LWT-3-mm: Lateral wall thickness which was at 3 mm above from the sinus floor), LWT-5-mm: Lateral wall thickness which was at 5 mm above from the sinus floor), RRH-max\min: Residual ridge height maximum\minimum

Table 6. Comparison of measurements by age

Measurements	Age	n	Mean	SD	Sig.
SW-3-mm	18-35	27	9.08	2.23	0.18
	36-53	127	8.82	2.44	
	54-71	91	8.28	2.48	
SW-5-mm	18-35	27	11.22	2.62	0.13
	36-53	127	11.30	2.89	
	54-71	91	10.41	3.34	
LWT-3-mm	18-35	27	1.84	0.78	0.33
	36-53	127	1.71	1.12	
	54-71	91	1.61	0.68	
LWT-5-mm	18-35	27	1.92	1.13	0.14
	36-53	127	1.54	0.90	
	54-71	91	1.47	0.56	
RRH-min	18-35	27	5.98	5.08	0.47
	36-53	127	6.61	5.27	
	54-71	91	7.24	5.21	
RRH-max	18-35	27	8.13	5.58	0.36
	36-53	127	9.55	5.40	
	54-71	91	9.88	5.27	

*The 72+ age group is not included in the analysis due to small sample size, SW-3-mm: Sinus width which was at 3 mm above from the sinus floor, SW-5-mm: Sinus width which was at 5 mm above from the sinus floor, LWT-3-mm: Lateral wall thickness which was at 3 mm above from the sinus floor, LWT-5-mm: Lateral wall thickness which was at 5 mm above from the sinus floor, RRH-max\min: Residual ridge height maximum\minimum, SD: Standard deviation

In addition to, the presence of an overly large or narrow sinus, such as a thin or thick lateral wall, increases the risk of membrane perforation (16,17). However, despite this, few clinical studies (8,18-22) have assessed the LWT of maxillary sinuses, the width of the mediolateral sinus or their relationship to various parameters. This study evaluates LWT and SW in patients with one and two edentulous sites using CBCT with a limited FOV. It proposes a new sinus classification based on those values to outline clinical implications for augmentation. It investigates the influence of age and sex on bony structures surrounding the sinus and determines the mean value of each parameter for the evaluated sample. To the best of our knowledge, this study is the most comprehensive examination of radiological markers of lateral wall osteotomy available.

Zijdervald et al. (16) found that LWT to be mostly thin (78%), in their study. Because lateral wall evaluation was performed intraoperatively, the lateral wall was defined as thin if the mucocilium was greyish-bluish and thick if the lateral wall was at least as thick as the diameter of a stainless steel bur (2.3 mm) (16). Similar to this study, the thicknesses obtained at each investigated site were found to be smaller than 2.3 mm. Therefore, it is important to evaluate LWT before surgical operations, since the integrity of sinus membranes may be affected during procedures.

In lateral wall osteotomy, infracture and wall-off techniques are used (23,24). The infracture technique involves tapping of the lateral wall as a roof over the graft materials, while in the wall-off technique, the lateral wall should be removed to gain an access to the sinus. In both techniques, it is recommended to place the inferior border of the window at a distance of 3-5 mm from the sinus floor, accordingly in the present study LWT, SW and RRH measurement points were assessed at 3 and 5mm from the sinus floor (23,25).

Based on our findings, the bone above the PP area has the highest LWT (1.86 mm), and the lowest LWT was documented in the MM area (1.34 mm) at both heights (Table 2). Therefore, care should be taken

when preparing the lateral window or collecting bone in the MM region. Similar results were obtained by Kang et al. (20) in CBCT imaging of Korean patients. Kang et al. (20) reported that the lateral wall of the anterior region was generally thicker than the posterior regions. On the other hand, Yang et al. (21) indicated that LWT diminishes from the second molars to the first premolar regions. This LWT difference is caused by the position of adjacent anatomical structures (22,26). Therefore, clinicians should consider these anatomical landmarks in the presurgical planning and during surgery.

LWT can be affected by chronic inflammatory diseases of the maxillary sinus (27). Therefore, further studies are needed to investigate the relationship between maxillary sinus pathologies and bone changes. Factors such as anatomical landmarks, differences in study populations and uneven sample distributions cause differences between studies (20-22,26).

In this study, the relationship between dental deficiency and LWT has also been evaluated. Monje et al. (22) found that a correlation between longer edentulous spans and thinner lateral walls. It might be related with maxillary sinus pneumatization and bone resorption. This could not be replicated here because we used only one or two edentulous sites. However, similar to the study of Kang et al. (20), the thinnest LWT was observed in the MM sites of LWT-3-mm and -5 mm regions (Table 2).

Few studies have assessed the effects of age and sex on LWT (20-22). Kang et al. (20) found a significant difference between males and females at 3 mm from the sinus floor. Similarly, this study demonstrated a significant difference in mean LWT between males and females at both heights ($p<0.05$). Men were found to have thicker lateral walls than women. Important sex-specific differences are already known to occur in bone physiology, geometry and bone gonadal hormone response. Therefore, these values were significantly different between both sex ($p<0.05$).

When RRH and SW parameters were evaluated in relation to sex in this study, SW-5-mm averages were found to be significant in favour of male partially edentulous patients, while RRH-min averages were significant in favour of female partially edentulous patients. However, since the relation of these parameters with sex is not evaluated in the literature, comparison is not possible.

Regarding aging, it is thought that age-related pneumatization of maxillary sinuses may lead to lateral bone thinness (28). As a result, older patients may have thinner lateral sinus walls due to osteoporosis. However, in this study, LWT did not differentiate with age ($p>0.05$). Furthermore, SW and RRH averages were not statistically different according to age ($p>0.05$).

Interwall angle and mediolateral wall distances from sinus morphology parameters are effective in predicting sinus membrane perforation risks in surgical procedures (8). According to Chan et al. (8) the mediolateral wall distances to reach the medial wall have been considered clinically important because they directly determine the amount of membrane elevation. Therefore, SW measurements were made from lateral osteotomy levels (3-5 mm) at different distances from the sinus floor in this study. Only a limited number of studies have evaluated the maxillary SW (18,19). Jang et al. (19) found mean mediolateral distances at 12.7±4.0, 15.2±3.7 and 14.4±4.0 at the second premolar, first molar and second molar, respectively, when measured from the CBCT sections of the implants. Avila et al. (18) found SWs of 10.2±3.4, 12.7±3.2 and 14.6±3.2 at 8 mm, 10 mm and 12 mm from the alveolar crest, respectively. However, a direct comparison with this study is not possible because different measurement levels and tooth sites were used. When collecting the data from sites with different RRHs in this study, the average SWs at 3 mm and 5 mm (23,25) for PP, PM, MM, P and M sites. They were 5.64 mm, 8.13 mm, 9.34 mm, 6.46 mm and 9.35 mm at 3 mm height level, respectively. They were 7.67 mm, 10.44 mm, 11.74 mm, 6.93 mm and 11.65, at 5 mm height level respectively (Table 2).

Different classifications related to maxillary sinuses have been made, (1,8,9,29-31) focusing on the adjacent structures of maxillary sinuses (1,29-31). Similar to this study, Chan et al. (8) and Teng et al. (9) evaluated mediolateral dimensions of maxillary sinuses from different heights to establish classifications of narrow, average and wide. A narrow sinus may cause the trapdoor to obstruct during the lateral sinus floor elevation procedure when creating the final horizontal position of the new floor (3,25). On the other hand, narrow sinus walls, which usually complicate traditional lateral sinus floor elevation, may provide significant advantages to sinus elevation

via crestal osteotomy (9). In this case, the presence of narrow SWs maximizes the contact of the implant to the bone along the lateral walls and prevents the use of excess grafts, providing better retention for the primary stability of the implants. This close relationship between bone and implant induces initial bone formation with abundant blood flow. In the presence of a wide sinus, it takes more time to release the Schneiderian membrane during the lateral wall sinus elevation. In this case, the crestal approach should be preferred. Tighter contact with the sinus walls can ensure a better blood supply and passage of the inductive element for ossification of the graft materials. Therefore, primary stability and predictable success will likely increase.

Chan et al. (8) and Teng et al. (9) found that SW was wider in molar sites and that RRH was smaller in these sites than in others. Their studies had higher measurements than this study, although similar results were obtained. Jang et al. (19) measured SW in the cross-sectional imaging of CBCT, showing the apex of the implant after operation. They found that the 0%, 29.9%, 95.7% and 100% of grafts made contact with the medial walls when SW was ≥16.0, >12.1, ≤12.1 and ≤11.3 mm, respectively. Consequently, they suggested that graft contact with the medial sinus wall tends to increase in narrower maxillary sinuses. Similarly, Zheng et al. (32) indicated that SW was 13.68±2.66 mm and found a positive relationship between SW and graft resorption.

When Teng et al. (9) evaluated the relationship between RRH and SW parameters, they found a significant negative correlation. Similarly, in this study, a statistically significant negative correlation was found between SW-5-mm and RRH-max. Additionally, there was a significant negative correlation between the number of missing teeth and SW-5-mm and a significant positive correlation between LWT-5-mm and RRH-max.

SW classification, which was made via small-FOV CBCT, will help identify the sizes of maxillary sinuses and will improve predictions and success in surgical procedures. Further studies should be planned to check the performance the validity and reliability of the current classifications and to investigate their clinical inferences, which may include evaluation of various parameters such as ease of sinus elevation procedures, calculation of graft quantity, rates of complication and success of bone graft material in different SWs.

There are some limitations in our study that include a considerably less datasets for investigated premolar sites (P), unequal ratio among the sexes (female/male =115/131) and unknown times when subjects became edentulous. In this study, the proportions of PP, PM, MM, P and M in the samples were 9%, 30%, 37%, 2% and 22% respectively. Less data sample was expected for the premolars area, because molars were the most frequently lost teeth (33-37). Moreover, RRH in premolar regions is usually sufficient without sinus augmentation. The mean RRH in the sites associated with premolars (P, PP, PM) was more than 10 mm.

Conclusion

The SW was evaluated on CBCT scans at several ranges from the ridge crest in 246 edentulous sites. Mean SW increased at molar sites and at the regions with lower RRHs. Sinuses were categorised based on 33rd and 67th percentile SW values at 3 and 5 mm. The mean value of the lower limit was 9.33 (1.85) mm, with 33rd and 67th percentiles being 8.62 and 10.11 mm and of the upper limit was 11.72 (2.20) mm, with same percentiles being 10.81 and 12.59 mm, respectively. Mean LWT at 3 and 5 mm was 1.67 and 1.56 mm, respectively. Based on the 33rd and 67th percentile SW values of this study, a new maxillary sinus classification was suggested, with narrow, medium and wide dimensions. The proposed SW classification model and LWT can make the choice of surgical approaches more predictable.

Ethics

Ethics Committee Approval: This study was approved by the Ethics Committee for Clinical Research at Ege University Faculty of Medicine (decision no: 14-7.1/6, date: 08.09.2014).

Informed Consent: Signed informed consent form was receipted by the participants.

Peer-review: Externally and internally peer-reviwed.

Authorship Contributions

Concept: N.K.T., Design: N.K.T., Supervision: E.A., Fundings: N.K.T., Materials: N.K.T., Data Collection or Processing: N.K.T., Analysis or Interpretation: N.K.T., Literature Search: N.K.T., E.A., Writing: N.K.T., E.A., Critical Review: N.K.T., E.A.

Conflict of Interest: The authors declare that they have no conflict of interest.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Evaluation of the Knowledge and Attitudes of Dental Health Care Workers Regarding the New Coronavirus Disease-2019 Outbreak

Diş Hekimliği Sağlık Çalışanlarının Koronavirüs Hastalığı-2019 Salgınına Karşı Bilgi Düzeyi ve Davranışlarının Değerlendirilmesi

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Keywords
Dentistry, coronavirus, infections, knowledge, attitudes

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Diş hekimliği, koronavirüs, enfeksiyon, bilgi, davranışlar

Received/Geliş Tarihi : 11.11.2020
Accepted/Kabul Tarihi : 23.12.2020

doi:10.4274/meandros.galenos.2020.96636

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Abstract

Objective: Coronavirus disease-2019 (COVID-19) is contagious through respiratory droplets, close contact and aerosols emitted from high-end instruments. Dentists are at high risk for infection and have become carriers of the disease. Thus, dental health professionals should have sufficient knowledge and a high level of awareness on this issue. This study aimed to investigate the levels of knowledge and awareness about COVID-19 among dentists, students of dentistry and dental nurses.

Materials and Methods: This study included 124 dentists, 122 students of dentistry and 128 nurses. A closed-ended questionnaire was developed with the help of the existing literature. The questionnaire, containing ten questions, was divided into three parts.

Results: Dentists, nurses and students of dentistry had adequate information regarding COVID-19. It was determined that all the participating dentists (100%) and nurses (100%) and most students of dentistry (97.5%) felt threatened by being exposed to COVID-19 infection. A significantly higher proportion of dentists (58.9%) and clinical students (55.7%) compared to nurses (9.4%) believed that using protective equipment during dental practice will not protect them against COVID-19 infection.

Conclusion: Dental health care workers should be trained in the prevention and control of COVID-19, and they should regularly renew these skills to protect themselves against new infections that may occur in the future.

Öz

Amaç: Koronavirüs hastalığı-2019 (COVID-19) solunum damlacığı, yakın temas ve yüksek hızlı aletlerden yayılan son aerosoller yoluyla bulaşıcıdır, diş hekimleri enfeksiyon için büyük risk altındadır ve hastalığın taşıyıcıları haline gelmişlerdir. Bu nedenle diş hekimliği sağlık çalışanlarının bu konuda yeterli bilgiye sahip olması ve farkındalık yaratması gerekmektedir. Bu çalışmanın amacı, diş hekimleri, diş hekimliği klinik öğrencileri ve diş hekimliği hemşirelerinin COVID-19 hakkındaki bilgi ve farkındalık düzeylerini araştırmaktır.

Gereç ve Yöntemler: Bu çalışmaya 124 diş hekimi, 122 diş hekimliği klinik öğrencisi ve 128 diş hekimliği hemşiresi dahil edildi. Mevcut literatür yardımıyla kapalı uçlu bir anket geliştirildi. On soru içeren anket üç bölüme ayrıldı.
Bulgular: Diş hekimleri, hemşireler ve klinik öğrencileri COVID-19 hakkında yeterli bilgiye sahiptir. Tüm diş hekimleri (%100) ve hemşirelerin (%100) ve çoğu klinik öğrencisinin (%97,5) COVID-19 enfeksiyonuna karşı tehdit altında hissettiği belirlendi. Diş hekimi muayenesi sırasında koruyucu ekipman kullanmanın COVID-19 enfeksiyonuna karşı korumayacağını düşünen diş hekimleri (%58,9) ve klinik öğrencilerinin oranı hemşirelere göre istatistiksel olarak daha yüksekti (%9,4).
Sonuç: Diş hekimliği sağlık çalışanları, COVID-19'un önlenmesi ve kontrolü konusunda eğitilmeli ve gelecekte oluşabilecek yeni enfeksiyonlara karşı korunmak için bu becerileri düzenli olarak yenilemelidirler.

Introduction

In 2019, an outbreak of a novel coronavirus, named coronavirus disease-2019 (COVID-19), appeared in Wuhan, China (1). This new coronavirus belongs to the family of single-stranded RNA viruses known as Coronaviridae (2). This family of viruses first appeared as severe acute respiratory syndrome coronavirus (SARS-CoV) in 2002 and later as Middle East respiratory syndrome coronavirus (MERS-CoV) in 2012. The new coronavirus has a close resemblance to other ß-coronaviruses, such as SARS-CoV and MERS-CoV (3). Although SARS-CoV-2 is the novel coronavirus's scientific name, the disease it causes is popularly referred to as COVID-19 (4-6).

COVID-19 has spread globally, being labeled a public health crisis and pandemic by the World Health Organization (WHO) (7). The governments of China, Italy and other nations have restricted the constant movement of workers outside their homes and required social distancing and the use of protective masks and gloves to "flatten the curve" of infection by minimizing contact with individuals who serve as carriers (7,8).

According to recent studies and to China National Health Commission data, the rate of serious cases among all patients with COVID-19 in China stands at around 15-25% (9,10). While the majority of patients experience fever and dry cough, some have also been reported to have other atypical symptoms, such as shortness of breath, fatigue, confusion, headaches, sore throat, diarrhea and vomiting (9,11). Although SARS-CoV-2 is known to be highly contagious when patients are most symptomatic, it has been reported that the incubation period can range from 0 to 24 days, so transmission may occur before any symptoms are seen (9,12).

Given the widespread contagion of SARS-CoV-2 and reports that health workers are infected, it has been reported that dentists are at high risk for hospital infection and may be potential carriers of the disease. Additionally, it has been shown that dental patients could potentially be exposed to cross contamination if adequate precautions are not taken (4). The saliva, secretions and blood of patients who cough and sneeze with high-speed hand tools or ultrasonic instruments in their mouth during dental treatment cause the virus to be aerosolized and spread through the environment. Thus, the dental instruments in the clinical environment become contaminated with various pathogenic microorganisms. After this, infection occurs as a result of sharp tool injury or direct contact of the mucosa with contaminated hands (13,14). Due to the unique feature of dental treatments that result in the production of large numbers of droplets and aerosols, standard preservatives used in daily clinical trials are not effective enough to prevent COVID-19, especially when the disease is in the incubation process (14). As the number of cases and deaths worldwide continues to increase, prevention of disease, identification of sick individuals and appropriate management of this process by health care workers are needed to prevent further spread.

It has been reported that every patient who comes to the clinic needs to be questioned about their temperature, whether they have travelled abroad and whether they have met with someone from abroad (15,16). Likewise, the use of antimicrobial mouthwash before processing and avoiding processes that may cause coughing, such as intraoral X-rays, and aerosol-producing processes such as using high-speed hand tools, should be delayed as much as possible (13,17-19). The information levels and behaviors of dentists, dental clinic students who are in close contact with patients and dental nurses who are involved in all kinds of procedures of interest to the patient are very important in order to prevent the spread of the

disease in the face of such a pandemic. In order to prevent the spread of the disease to other patients through cross-infection, it is very important for health workers to know how to protect both the patient and themselves. The purpose of this study was to determine the level of knowledge and behavior of dentists, nurses and dental clinical students regarding the COVID-19 pandemic.

Materials and Methods

This study ran at the Faculty of Dentistry of the University of Uşak. It was performed pursuant to the Helsinki Declaration, and ethical permission was taken from the Ministry of Health (2020-07-01T06-55-00) and the Local Ethics Committee of Usak University (decision no: 27-12-16, date: 22.07.2020). All participants provided informed consent. In this study, COVID-19 knowledge level and behavior of dental health care workers were evaluated.

The study included individuals who responded online to questions about COVID-19. The sample consisted of 124 dentists, 122 dentistry clinical students and 128 nurses. A closed-ended questionnaire was developed by the researchers and guided by the existing literature. The questionnaire contained 13 questions that measured the knowledge and attitude of dental health care workers in regard to the COVID-19 pandemic.

In order to prevent the spread of the disease, the study was conducted online, and participants were asked 10 questions in 3 sections:

1. Source of information about COVID-19,
2. Knowledge about COVID-19 (mortality rate, incubation period, individuals at risk, symptoms and prevention techniques),
3. Attitudes about COVID-19.

Statistical Analysis

Data analysis was performed using the software Statistical Package for the Social Science (SPSS) version 17.0, and statistical significance level was set at 0.05. Demographic information was evaluated using descriptive statistical analysis. Chi-square tests were used to compare general knowledge levels and attitudes of dental health care workers toward COVID-19.

The G*Power 3.1 package program was utilized to define the adequate specimen dimension. When evaluating the specimen size, type 1 error (α) =0.05, effect size =0.293 and test power (1-β) =0.90 were used. Conclusion of the evaluation, the specimen volume was defined as a minimum of 172 individuals.

Results

Data were collected from 374 patients and the ages ranged from 18 to 59 years. The study population comprised 257 (68.70%) women and 117 (31.30%) men. Demographic information (gender and age) of individuals according to each group is shown in Table 1. In this study, 33.16% of the participants are dentists, 34.22% are nurses and 32.62% are dentistry clinic students.

The sources of information about COVID-19 for each group are shown in Table 2. There was a statistically meaningful difference among the groups. Although dentists and nurses tend to rely on social media and the Ministry of Health of the Republic of Turkey, dental clinic students rely on all resources to gather information. The proportion of dentists and nurses who answered “Ministry of Health,” is significantly higher than the proportion of clinical students who did.

Table 3 shows the level of knowledge about COVID-19 among the three groups. There were meaningful differences among groups in terms of information about mortality proportion and symptoms COVID-19. There were no meaningful differences among groups in terms of information about incubation period, individuals at risk or ways to prevent the spread of COVID-19.

Table 1. Distrubition of gender and age

Healthcare workers	Gender				Age					
	Male		Female		18-25		26-39		40-59	
	n	%	n	%	n	%	n	%	n	%
Dentist	67	54.0	57	46.0	17	13.7	86	69.4	21	16.9
Clinical student	71	58.2	51	41.8	122	100	-	-	-	-
Nurse	119	93.0	9	7.0	6	4.7	35	27.3	87	68

Dentists (39.7%) and clinical students (37.5%) were significantly more likely to answer the mortality rate question correctly compared to. The percentage of dentists and nurses who answered the question about symptoms of COVID-19 correctly was significantly higher than that of clinical students.

Likewise, participants' attitudes toward COVID-19 are shown in Table 4. There were meaningful

Table 2. Sources of information about coronavirus disease-2019

Sources information	n (%)	Healthcare workers		
		Dentist	Nurse	Clinical students
Mass media	n	18	18	5
	%	43.9	43.9	12.2
Social media	n	65	45	30
	%	46.4	32.1	21.4
Ministry of health	n	39	62	12
	%	34.5	54.9	10.6
Public	n	2	3	-
	%	40	60	-
Total	n	124	128	122
	%	33.2	34.2	32.6

Table 3. Knowledge about coronavirus disease-2019

Questions and answers	Answer results	Healthcare workers						p
		Dentist		Nurse		Clinical students		
		n	%	n	%	n	%	
What is the COVID-19 mortality rate? (0.39%-4.05%)	False	35	23.3	77	51.3	38	25.3	0.001*
	True	89	39.7	51	22.8	84	37.5	
What is the longest incubation period of COVID-19? (21 days)	False	39	32.5	44	36.7	37	30.8	0.792
	True	85	33.5	84	33.1	85	33.5	
Which individuals are at risk for coronavirus? (Health care workers, indivudials who have cardiovascular disease, elders)	False	2	15.4	3	23.1	8	61.5	0.069
	True	122	33.8	125	34.6	114	31.6	
What are the ways to prevent COVID-19 infection? (Isolation, hand hygiene, mask)	False	10	43.5	3	13.0	10	43.5	0.087
	True	114	32.5	125	35.6	112	31.9	
What are the symptoms of COVID-19 infection in people? (Fever and dry cough, headaches and vomiting, loss of taste and smell)	False	11	24.4	3	6.7	31	68.9	0.001*
	True	113	34.3	125	38	91	27.7	

COVID-19: Coronavirus disease-2019

differences among groups in terms of attitudes about feeling threatened, wearing personal preventive devices (PPE), treating infected patients and focusing on treatment condition when treating patients infected with COVID-19. All dentists (100%) and nurses (100%) and most clinical students (97.5%) feel threatened by exposure to the virus. The proportion of dentists (58.9%) and clinical students (55.7%) who assume that applying PPE, such as glasses, gloves, face guards, masks and preventive clothing, during dental treatment will not prevent them versus COVID-19 disease is statistically higher than among nurses. The proportion of dentists (52.4%) and nurses (51.6%) who would treat an individual who has had COVID-19 and recovered is statistically higher than among clinical students (29.5%). The proportion of dentists (34.7%) focusing on therapy while curing a subject who has recovered from COVID-19 was significantly higher than among clinical students (21.3%) and nurses (18%) Table 4.

Discussion

The outbreak of the novel coronavirus has been declared a public health emergency of international concern by WHO. Infection control measures must be taken to prevent further spread of the virus and to help control the pandemic. Dental treatment involves exposure to blood and saliva in the patient's mouth, and the devices used are associated with aerosols, corresponding to a potentially high risk of cross-infection among dental health care professionals. Training on strict and effective infection control protocols and the development of a new behavior model are urgently needed in dentistry clinics in areas affected by COVID-19. At the same time, this research sought to determine the attitudes and behaviors of dental professionals in the face of the pandemic and to discover the deficiencies that need to be improved to reduce the spread of infection and the mortality rate.

Dentists and nurses received information about COVID-19 from the Ministry of Health and social media, while the majority of clinical students received information from social media. In Fatiregun et al. (20) and Albano et al. (21), it was reported that the main source of information was television. These differences can be explained by recent progress in internet technologies. Today, most educational materials and health messages are published online by health care providers, and information about

Table 4. Attitude towards coronavirus disease-2019

Questions	Healthcare workers	Yes (n/%)	No (n/%)	No idea (n/%)	p
Do you sense greater endangered by be exposed to COVID-19 contaminations as a healthcare worker than other people?	Dentist	124/33.4%	0/0	0/0	0.037*
	Nurse	128/35.5%	0/0	0/0	
	Dental student	119/32.1%	1/100	2/100	
Do you think preventive devices such as glasses, gloves, face guards and masks will prevent you from COVID-19 diseases?	Dentist	45/22.1%	73/47.7%	6/35.3%	0.001*
	Nurse	110/53.9%	12/7.8%	6/35.3%	
	Dental student	49/24%	68/44.4%	5/29.4%	
Would you want to treat an individual who have had COVID-19 infection and cured?	Dentist	65/38.9%	47/29.9%	12/24%	0.001*
	Nurse	66/39.5%	50/31.8%	12/24%	
	Dental student	36/21.6%	60/38.2%	26/52%	
When treating a patient with a COVID-19 infection would you focus primarily on not being infected?	Dentist	81/65.3%	43/34.7%	0/0%	0.001*
	Nurse	105/82%	23/18%	0/0%	
	Dental student	96/78.7%	26/21.3%	0/0%	

COVID-19: Coronavirus disease-2019

COVID-19 is regularly provided on the Ministry of Health's website. In addition, while many dentists and nurses go to the Ministry of Health to obtain information, this rate is found to be very low among clinic students. This is likely due to changing patterns of acquiring information, as knowledge and skills increase over the years and older adults come to depend on public institutions.

Dentists, nurses and clinical students had adequate knowledge about COVID-19 (incubation period, individuals at risk and prevention techniques). Dentists' and clinical students' knowledge of the mortality rate of COVID-19 was significantly higher than that of nurses. In contrast, dentists' and nurses' knowledge of the symptoms of COVID-19 was significantly higher than that of clinical students. It is thought that dentists and clinical students who continue their education have a higher level of academic knowledge that focuses on details, such as the mortality rate, and that nurses who have been side-by-side with physicians in the clinic for many years are more alert to symptoms of the disease.

All dental health care workers sense greater endangered by be exposed to COVID-19 than individuals outside the health care field. COVID-19 is a new infection, and health workers have never experienced such a disease before. The nature of the dentistry profession requires that it is performed at close proximity to the patients, specifically face-to-face and in the patient's oral cavity. It is also known that droplets released from infected individuals in dental clinics and aerosols released from electronic tools hang in the air for long periods of time. Due to the peculiar nature of dental treatment procedures and the increased media reporting that health workers are infected, dental health workers feel much more threatened.

Dentist and clinical students tend to assume that utilizes shield device, like as glasses, gloves, face guards, masks and preventive clothing, during dental treatment will not prevent them versus transmission. This is thought to be due to the fact that dentists and clinical students have to work in close contact with their patients, and not all of the protective clothing meets the necessary standards of protection and endurance. In contrast, nurses think that their protective equipment will protect them adequately. This may be because nurses do not have direct contact with patients and, as a result, they may feel more secure by maintaining adequate distance in addition to wearing protective equipment.

The proportion of dentists (52.4%) and nurses (51.6%) who want to treat an individual who has had COVID-19 and recovered was found to be low but significantly higher than for clinical students (29.5%). Studies have reported that factors such as being female, the timing of infection, presence of supportive staff and status of family members are factors associated with being less willing to work in the event of a public health emergency, such as the flu (22). A study by Quereshi et al. (23), in which health workers' willingness to work during catastrophic disasters was evaluated, reported that 48% of the sample volunteered to work during the SARS outbreak.

In our study, volunteering to care for an infected patient was found to be similarly low, as in other studies. This is thought to be due to the lack of adequate protective equipment, inability to maintain adequate distance with their patients and having children waiting at home. Clinical students have lower willingness than other health care workers, likely due to their lack of professional experience, the unease of their parents and having never experienced such a situation before. A study by Shapira et al. (24) reported that, by increasing access to PPE, willingness to treat patients during such situations can be raised. Dental workers are in contact with droplets, aerosols and small, sharp instruments, and many health workers are unwilling to treat infected and recovered patients. Likewise, patients may not give accurate information about their illness due to the reluctance of health workers to treat them. This unethical situation could pose a serious public problem. The way to encourage clinicians to treat patients with infectious diseases is to improve their attitudes, not enact legal penalties. Changing attitudes can only be possible with improved knowledge and the creation of a safe environment.

Furthermore, 82% of nurses, 78.7% of clinical students and 65.3% of dentists talk that they concentrate on not contaminated themselves rather of providing therapy while healing a patient who has had COVID-19. The proportion of dentists focusing on treatment was significantly higher than the other two groups. A potential explanation is that dentists have more professional experience and that their control over patients and dental instruments is better, as well

as their knowledge about the infection, compared to the other groups.

In this study, it was found that dental health care workers had sufficient knowledge of COVID-19 incubation periods, prevention routes and individuals at risk, and that dental students and nurses needed to increase their levels of knowledge about the mortality rate and symptoms. Dental health care workers tend to feel threatened when treating patients with COVID-19, and they often focused on not contaminated themselves, rather than treating the patients. They were also largely unwilling to treat patients who had been infected with COVID-19, even if they had recovered, and they did not have much trust in the ability of PPE to keep them safe. Additionally, dental health care workers were found to have received information about COVID-19 mostly from social media and the Ministry of Health.

There is currently no recommended treatment for coronavirus infections, but increased infection control measures are recommended for patients with COVID-19. Avoiding cross-infection is very important for health professionals who come in contact with mucous membranes, blood or bodily fluids (25). Therefore, COVID-19 infection is a very significant occupational hazard in dentistry.

Conclusion

Dental health care workers have sufficient knowledge about COVID-19 infection, and transmission and prevention methods are very important in the practice of infection control. The dentist should be very alert to the incubation period of the disease and postpone elective treatments until the risk of transmission has passed. Likewise, support should be planned to decrease the psychological influence of realized infection jeopardy by increasing access to equipment to protect dental health care workers. These supports can be in the form of training, improving morale, providing counseling and offering incentives. On the other hand, there is also a need to evaluate professional development programs by the Ministry of Health to identify gaps and adopt best practices. In the same context, dental health care workers should be encouraged to visit official websites to seek information on health-related issues, and the Ministry of Health's website should also be kept up-to-date.

Ethics

Ethics Committee Approval: This study ran at the Faculty of Dentistry of the University of Uşak. It was performed pursuant to the Helsinki Declaration, and ethical permission was taken from the Ministry of Health (2020-07-01T06-55-00) and the Local Ethics Committee of Usak University (decision no: 27-12-16, date: 22.07.2020).

Informed Consent: All participiants provided informed consent.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: A.D., Design: A.D., F.K., Supervision: Ş.E., Data Collection or Processing: A.D., F.K., Analysis or Interpretation: Ş.E., F.K., Literature Search: Ş.E., A.D., Critical Review: A.D., Writing: Ş.E., A.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Evaluation of Soft Tissue Projection on Axial Cone Beam Computed Tomography Images After Surgically Assisted Rapid Maxillary Expansion

Cerrahi Destekli Hızlı Üst Çene Genişletmesi Sonrası Yumuşak Doku Değişikliklerinin Aksiyal Konik Işınlı Bilgisayarlı Tomografi Görüntüleri Üzerinde Değerlendirilmesi

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Keywords
SARME, soft tissue projection, CBCT, orthodontics, oral surgery

Anahtar Kelimeler
SARME, yumuşak doku projeksiyonu, CBCT, ortodonti, çene cerrahisi

Received/Geliş Tarihi : 28.11.2020
Accepted/Kabul Tarihi : 31.12.2020

doi:10.4274/meandros.galenos.2020.57625

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Abstract

Objective: Surgically assisted rapid maxillary expansion (SARME) is one of the major treatment objectives in orthodontics. It is very obvious that SARME has non-negligible clinical impacts on the facial soft tissues of patients. This study aimed to investigate the correlation between hard tissue expansion and soft tissue projection after SARME on axial cone beam computed tomography (CBCT).

Materials and Methods: Sixteen patients (9 women, 7 men) with a mean age of 22.18±1.64 years and having a transverse maxillary deficiency were enrolled in this retrospective study. A tooth borne Hyrax maxillary expander was applied to the patients and CBCT images were taken before (T0) and 6 months after (T1) SARME. Soft and hard tissue changes were superimposed and evaluated digitally on pre-surgical and post-surgical axial CBCT images by using *In Vivo* Dental Software.

Results: The mean value of the hard tissue expansion was 4.50±1.38 mm for the anterior region and 3.92±1.31 mm for the posterior region. The difference between these values was not significant ($p>0.05$). There was no correlation between soft tissue projections ($p=0.509$; $r=0.178$) and anterior and posterior hard tissue expansion values ($p=0.424$; $r=0.102$) on both sides.

Conclusion: There was no correlation between soft tissue projection and hard tissue expansion values after SARME. In addition, the difference between the anterior and posterior hard tissue expansion values was not statistically significant.

Öz

Amaç: Cerrahi destekli hızlı üst çene genişletmesi (SARME) (surgically assisted rapid maxillary expansion) ortodontide ana tedavi seçeneklerinden biridir. SARME'nin hastaların yüzleri ve yumuşak dokuları üzerinde göz ardı edilemeyecek klinik etkileri olduğu ortadadır. Bu çalışmanın amacı, konik ışınlı bilgisayarlı tomografinin (KIBT) aksiyel görüntülerinde SARME sonrası elde edilen sert doku genişlemesi ve yumuşak doku projeksiyonu arasındaki korelasyonu incelemektir.

Gereç ve Yöntemler: Bu retrospektif çalışmaya transvers maksiller yetmezliği olan ve yaş ortalaması 22,18±1,64 yıl olan 16 hasta (9 kadın, 7 erkek) alındı. Hastalara

Hyrax maksiller ekspansiyon apare uygulandı ve KIBT görüntüleri SARME öncesi (T0) ve 6 ay sonra (T1) olacak şekilde çekildi. Yumuşak ve sert doku değişiklikleri, *In Vivo* Dental Yazılımı kullanılarak cerrahi öncesi ve cerrahi sonrası aksiyel KIBT görüntülerinde dijital olarak değerlendirildi.
Bulgular: Sert doku genişlemesinin ortalama değeri ön bölge için 4,50±1,38 mm ve arka bölge için 3,92±1,31 mm idi. Bu değerler arasındaki fark anlamlı değildi (p>0,05). Her iki tarafta yumuşak doku projeksiyonları ile ön ve arka sert doku genişleme değerleri arasında korelasyon yoktu (p=0,509; r=0,178) (p=0,424; r=0,102).
Sonuç: SARME sonrasında yumuşak doku projeksiyonu ile sert doku genişleme miktarları arasında bir ilişki yoktu. Ayrıca ön ve arka sert doku genişleme miktarları arasındaki fark istatistiksel olarak anlamlı değildi.

Introduction

Transverse deficiency of the maxilla is a major problem in treatment of some types of malocclusions. Palatal expansion is the most preferred method for transversal advancement of the maxilla (1). The most used methods for palatal expansion are: rapid maxillary expansion (RME), slow maxillary expansion (SME) and surgically assisted rapid maxillary expansion (SARME). RME and SME are generally applied in growing patients while SARME is preferred for non-growing or adult patients (2). Skeletally mature patients with a narrow maxilla need separation of mid-palatal suture most often with SARME or Le Fort I surgery (3-5). Skeletal and dental outcomes of maxillary expansion is comprehensively presented in the literature (6). Koudstaal et al. (3) presented that besides the lack of the consensus in the literature regarding the surgical technique and the type of the distractor used (tooth-borne or bone-borne), surgically assisted maxillary expansion is found to be more stable than orthodontic RME.

Surgical procedures for management of skeletal anomalies may affect the shape and position of the overlying soft tissues (7). Orthopedic effects of RME and SARME have previously been investigated in various studies with lateral cephalograms and cone beam computed tomography (CBCT) images (3,7-10).

In some of the previous studies soft tissue responses to skeletal effects were evaluated on two-dimensional data (11-13). Lateral cephalograms can be used to assess the sagittal and vertical soft and hard tissue changes but can not be used to investigate the transversal changes (14). For an optimum treatment planning and treatment prediction, it is required to evaluate the soft tissue response to underlying skeletal movement precisely. Visualization of the post-operative (post-op) 3D model predictions can help orthodontists and surgeons to make better treatment plannings (15).

Nevertheless, advantages of CBCT enables the clinicians to visualize the craniofacial complex in three dimensional images without any image superposition or size distortion (16,17). There are many studies which evaluated the facial soft and skeletal tissue changes on 3D CBCT images (14,18,19). The aim of this study was to investigate the relationship between the amount of hard tissue expansion and soft tissue projection; and to examine whether there was a correlation between these parameters after SARME on axial CBCT. The null hypothesis was, there was no correlation between hard tissue expansion amounts and soft tissue projection amounts after SARME.

Materials and Methods

Ethical approval of the study was given by İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (decision no: 10840098-604.01.01-E.28865, date: 23.08.2017).

CBCT images were collected from the pool of the Medipol University Dental Hospital. CBCTs were taken for other dental and maxillofacial purposes previously before SARME (T0) and at least 6 months after SARME (T1). Sixteen patients (9 females and 7 males) who had SARME because of transverse maxillary deficiency, aged from 20 to 24 with a mean age of 22.18±1.64 were enrolled in the study. Written informed consents were taken from all of the patients. Inclusion criteria were: similar orthodontic anomaly and presence of bilateral posterior cross-bite with transverse maxillary deficiency. Exclusion criteria were: previous orthodontic treatment and congenital malformations.

All of the patients were applied a tooth-borne, 4-banded Hyrax (Hyrax, 10 mm., Dentaurum, Ispringen, Germany) appliance, that included first premolars and first molars, 1 day before surgery. All of the patients had the same type of appliance, same activation procedure and same retention time. The expansion screw was activated two turns a day for 14

days beginning from the operation. The first two turns were activated by the orthodontist in the operation room for the first day. Patient was told to activate the screw two turns a day for the remaining 13 days. The post-activation retention time was 6 months.

Pre-operative (pre-op) and post-operative CBCT slices which were reconstructed at nasal floor base level were superimposed (Figure 1). The area between apex of left and right maxillary canines and point subnasale on both sides was defined as peri-alar region and the area between canines and first molars on both sides was defined as malar region (Figure 2). To evaluate the soft tissue projection changes in peri-alar region and malar region, the areal spatial amount of projection was calculated in (mm^2) on superimposed axial images (Figure 2). For evaluation of the linear transversal maxillary hard tissue expansion amount in anterior segment; linear differences (mm) between the pre-op and post-op locations of the apices of the right and left canine were used. For evaluation of the linear transversal maxillary hard tissue expansion amount in posterior segment; linear differences (mm) between the pre-op and post-op locations of the apices of the right and left molar teeth's palatal root were used. Superimpositions and all of the measurements were done by using Invivo 5 Software (ver. 5.2, Anatomage Dental, San Jose, CA, USA).

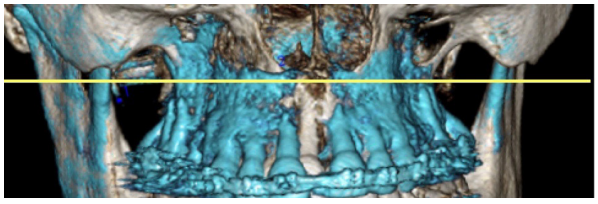

Figure 1. The illustration showing the evaluation level of axial cone beam computed tomography

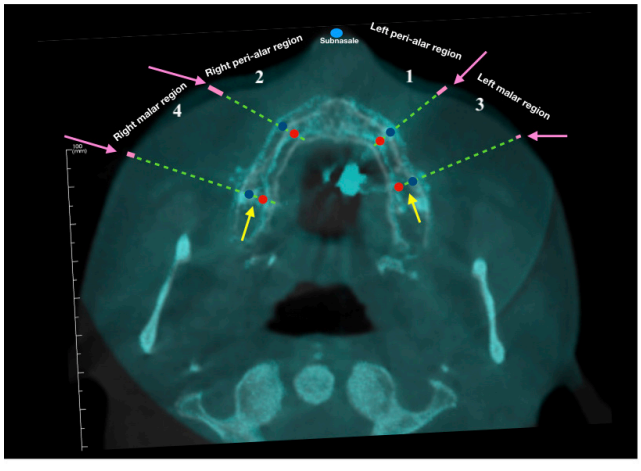

Figure 2. Superimposition of pre-expansion and post-expansion cone-beam computed tomography images

Sn: Subnasale, 1,2: Peri-alar region areal soft tissue projections; 3,4: Malar region areal soft tissue projections; Yellow arrows: Hard tissue expansion regions; Pink arrows: Soft tissue projection regions

I-CAT Imaging System was used for the study (i-CAT 17-19, Imaging Sciences International Inc., Hattfield, Pa, USA). Every CBCT image was obtained by a strict, standardized scanning protocol. Patients were seated in a vertical position in front of the CBCT machine, stabilized with head support, strap and chin cup when occlusal plane was oriented horizontally to the ground. The patients were monitored to ensure that they remained motionless throughout the duration of scanning (8.9 seconds). The images were taken by the same technician in the same conditions while the patients' head positions were oriented in perspective of Frankfort Horizontal Plane to ensure their accurate and repeatable positioning. All images were recorded at 120 kVp and 20.27 mAs using a 16x6 cm field of view and 0.30 voxels. The kV and mA parameters were automatically determined from scout views obtained from the i-CAT Imaging System.

Surgical Technique

Following nasotracheal intubation, infiltration of anesthetic solution containing 2% lidocaine and epinephrine 1:1,000,000 IU was made vestibular sulcus of the maxilla. Vestibular incision was performed from first premolar to contralateral first premolar. After incision, the anterior nasal spina and maxillary surface below the infraorbital foramen were exposed. Buccal corticotomy was performed from the priform aperture to the pterygoid fissure. Maxillary separation was achieved by decortication by a thin osteotome at the level of the anterior nasal spine and by separation of pterygoids on both sides.

Statistical Analysis

Data were analyzed with IBM SPSS V23 (SPSS for Windows, version 23.0, SPSS Inc., Chicago, IL, USA). The Paired sample t-test was used to compare the data which comply with normal distribution. Pearson correlation analysis was used for the relationship between variables. Data with normal distribution were presented as mean ± standard deviation. The significance level was taken as ($p<0.05$).

Results

Out of 16 patients, the proportion of females was 56.3% and of males was 43.7%. The mean value of the anterior hard tissue expansion was 4.50±1.38 mm and the mean value of posterior hard tissue expansion was 3.92±1.31 mm. The difference between anterior and posterior hard tissue expansion values was not statistically significant (p=0.173) (Table 1).

Total peri-alar region projection was measured as 94.23±26.6 mm^2. Total malar region projection was 103.21±32.8 mm^2. There was a statistically significant difference between total peri-alar and malar areal projection values (p<0.05) (Table 2).

The mean value of right soft tissue peri-alar region projection was 57.8±16.6 mm^2 while the left peri-alar region projection at same level was 36.4±10.7 mm^2. There was a statistically significant difference between right and left expansion values (p<0.05). The mean malar region expansion was 57.61±22.3 mm^2 for right side and 45.6±12.5 mm^2 for left side. There was a statistically significant difference between right and left expansion values (p<0.05) (Table 3).

There was no correlation between anterior hard tissue expansion values and total peri-alar soft tissue projection values (p=0.509, r=0.178). There was no correlation between posterior hard tissue expansion values and total malar region soft tissue projection values (p=0.424, r=0.102) (Table 4).

Table 1. Comparison between anterior and posterior hard tissue lineer expansion amounts

	Mean ± SD	p
Anterior hard tissue expansion (mm)	4.5±1.38	NS
Posterior hard tissue expansion (mm)	3.92±1.31	

Paired samples t-test, NS: Non-significant, SD: Standard deviation

Table 2. Comparison between total perialar region and malar region soft tissue areal expansion amounts

	Mean ± SD	p
Total perialar region soft tissue projection areal amount t (mm^2)	94.23±26.6	<0.05*
Total malar region soft tissue projection areal amount (mm^2)	103.21±32.8	

Paired samples t-test, SD: Standard deviation, *Statistically significant

Discussion

In the literature, there are studies which evaluated the projection amounts on face after RME and SARME (9,14,18-23). In the present study, the peri-alar and malar projection after SARME was evaluated because, the authors observed clinically that there are non-neglectable changes on the faces of patients after SARME which could be related to the supporting projection of expanded hard tissue.

It was presented that, edema was fully resolved at least 6 months after surgical interventions (24). That's why, patients with second CBCT images which were taken at least 6 months after SARME for other reasons

Table 3. Comparison between right and left soft tissue areal projection amounts

	Right Mean ± SD	Left Mean ± SD	p
Perialar region soft tissue projection amount (mm^2)	57.8±16.6	36.4±10.7	<0.05*
Malar region soft tissue projection amount (mm^2)	57.61±22.3	45.6±12.5	<0.05*

Paired samples t-test, SD: Standard deviation,*Statistically significant

Table 4. Correlation between hard tissue expansion and soft tissue expansion

	Peri-alar region soft tissue projection amount	Malar region soft tissue projection amount
Anterior hard tissue expansion	r=0.178 p=0.509	-
Posterior hard tissue expansion	-	r=0.102 p=0.424

Pearson Correlation test, r: Pearson correlation coefficient, p: p value

were selected form the data pool in this retrospective study.

In the literature there are many studies presenting the relationship between the bony changes and soft tissue changes after SARME (14,19-22). It is emphasized that the ratio of osseous repositioning to soft tissue response for surgical procedures is very important in the treatment planning. The opportunity of predicting the amount of soft tissue movement correlated with hard tissue allows the clinician make more acceptable and aesthetic treatment plans (25). Soft tissue responses to skeletal changes was evaluated on two-dimensional data in the literature previously (9,12,13). It was stated that lateral cephalograms can be used to evaluate the sagittal soft and hard tissue changes but cannot be used to investigate the transversal changes (14). Nonetheless, CBCT enables the clinicians to visualize the craniofacial complex in 3D images without any image superposition or size distortion (5,7).

The amount of the three dimensional changes of the maxillary structures after RME is still contradictious (26). Berger et al. (27) and Pangrazio-Kulbersh et al. (28) presented a 1:1 soft tissue response to the skeletal changes associated with RME while Badreddine et al. (16) gave this ratio as 0.5 mm soft tissue alteration to 1 mm skeletal movement. Nada et al. (14), Torun (23), and Ramieri et al. (29) reported an increase in soft tissue malar projection after maxillary expansion because of the underneath bony expansion. Their results were consistent with our results. In the present study, malar projection after SARME on both left and right sides of samples with a mean value of 57.61±22.3 mm^2 for right and 45.6±12.5 mm^2 for left was found. Moreover, Torun (23) evaluated the malar projection on sagittal plane and reported a significant linear malar projection increase of 1.60 mm on both the right and left sides in pubertal and prepubertal RME patients.

In our study a tooth borne Hyrax expander was applied to the patients. Nada et al. (14) found that the type of the distractor didn't have a significant effect in the changes on the malar region while they stated that using a transpalatal distractor instead of a RME would be effective on the more posterior and less anterior alveolar expansion amounts resulting with the less retraction of the lips.

In some previous CBCT studies, inter molar width expansions were reported to be between 3.6 mm and 4.8 mm (6,30). In our study we determined hard tissue expansion both on the anterior (canine to canine) and posterior (first molar to first molar) regions. The mean value of the anterior inter-canine hard tissue expansion was 4.50±1.38 mm while the mean value of posterior inter-molar hard tissue expansion was 3.92±1.31 mm. The difference between anterior and posterior hard tissue expansion values was not statistically significant (p=0.173).

In a previous study evaluating hard tissue enlargement after SARME, the difference between right and left sides of the subjects was clinically significant if the difference between the right and left expansion amounts was more than 3 mm (30).

In the present study, soft tissue expansions in left and right sides of the subjects was evaluated and was found to be different. Expansion difference both in peri-alar and malar regions in the right and left sides of the subjects was found to be statistically important however it was not thought to be important clinically. This disparity between the right and left sides may be related to the surgery.

The small sample size and narrow age interval could be evaluated as the weaknesses of our study.

CBCT can not be used in all cases for ethical reasons. In our study, patients with second CBCT due to other dental reasons were selected retrospectively from the data pool. That is the reason of small sample size of this study. Further investigations with larger sample sizes and larger age intervals are needed to determine absolute soft tissue effects of SARME.

Conclusion

There was no correlation between soft tissue projection and hard tissue expansion amounts after SARME thus the null hypothesis was accepted. In addition, the difference between the anterior and posterior hard tissue expansion amounts was not statistically significant.

Ethics

Ethics Committee Approval: Ethical approval of the study was given by Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee (decision no: 10840098-604.01.01-E.28865, date: 23.08.2017).

Informed Consent: Written informed consents were taken from all of the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: D.D.K., E.D., Design: D.D.K., E.D., Data Collection or Processing: D.D.K., E.D., Analysis or Interpretation: D.D.K., E.D., Literature Search: D.D.K., E.D., Writing: D.D.K., E.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Influence of Different Parameters on the Smile Esthetic Perception of Dentists, Prosthodontists and Laypeople

Genel Diş Hekimleri, Protetik Diş Tedavisi Uzmanları ve Meslek Dışı Bireylerin Gülümseme Estetiği Algılarının Değerlendirilmesi

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Abstract

Objective: This study aimed to determine different parameters on the smile aesthetic perceptions of prosthodontists, general practitioner dentists and laypeople.

Materials and Methods: A close-up, posed smile image of a young woman was digitally altered by using software. The shape of the incisal curvature was arranged as ideal, flat, reverse and the width-to-length ratio of the maxillary central tooth was set to 75%, 80% and 85% in the photographs. Incisal edge asymmetries in the maxillary central, lateral and canine teeth and midline diastema at varying dimensions of 0.5 mm, 1 mm and 2 mm were created. As the control group, a photograph without any asymmetry or diastema was used. A questionnaire was created using these photographs and subsequently administered by a researcher. The images were assessed by 180 evaluators, which included 60 prosthodontists, 60 dentists and 60 laypeople. Each evaluator was asked to rate the smile images with the help of a visual analogue scale. Obtained data were analysed by using One-Way ANOVA with post hoc Tukey test.

Results: The ideal incisal curvature, small amount of diastemas and incisal asymmetries and 80% width-to-length ratio of the maxillary central teeth were more aesthetic to all participants ($p<0.001$).

Conclusion: Laypeople's aesthetic scores were higher than those of general practitioner dentists and prosthodontists in all groups. Aesthetic scores increase as the size of asymmetries decreases. Diastemas and incisal edge asymmetries were less perceptible laterally.

Keywords
Esthetics, dental, diastema

Anahtar Kelimeler
Estetik, dental, diastema

Received/Geliş Tarihi : 24.09.2020
Accepted/Kabul Tarihi : 23.12.2020

doi:10.4274/meandros.galenos.2020.83723

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Öz

Amaç: Bu çalışmanın amacı protetik diş tedavisi uzmanları, genel diş hekimleri ve meslek dışı bireylerin gülümseme estetiği algılarını belirlemektir.

Gereç ve Yöntemler: Bu çalışmada, kadın bir gönüllüden poz gülümsemesi esnasında alınan yakın çekim fotoğrafları kullanılmıştır. Fotoğraflar bir yazılım programıyla dijital olarak düzenlenmiştir. Fotoğraflarda insizal kurvatür şekli ideal, düz ve ters olarak ve maksiller santral dişin genişliği %75, %80 ve %85 olarak değiştirilmiştir. Maksiller santral, lateral ve kanin dişlerinde 0,5 mm, 1 mm ve 2 mm olmak üzere farklı boyutlarda insizal asimetri ve orta hatta aynı boyutlarda diastema oluşturulmuştur. Kontrol grubu olarak ise, herhangi bir asimetriye veya diastemaya sahip olmayan bir fotoğraf kullanılmıştır. Bu fotoğraflar kullanılarak bir anket oluşturulmuş ve bir araştırmacı tarafından uygulanmıştır. Fotoğraflar 60

genel diş hekimi, 60 protetik diş tedavisi uzmanı ve 60 meslek dışı birey olmak üzere toplam 180 kişi tarafından değerlendirilmiştir. Her bir katılımcıdan fotoğrafları görsel analog skala yardımıyla değerlendirmesi istenmiştir. Elde edilen veriler tek yönlü varyans analizi ve post hoc Tukey testi ile değerlendirilmiştir.
Bulgular: İdeal insizal kurvatür, küçük boyutlardaki diastemalar ve insizal asimetriler ile %80 genişlik/uzunluk oranına sahip maksiller santral dişler bütün katılımcılar tarafından daha estetik bulunmuşlardır (p<0,001).
Sonuç: Tüm gruplarda meslek dışı bireylerin estetik skorları, genel diş hekimleri ve protetik diş tedavisi uzmanlarından yüksek bulunmuştur. Asimetri azaldıkça estetik skorlar artmıştır. Orta hattan lateral yönde gidildikçe, daha büyük boyutlardaki insizal kenar asimetrileri algılanmıştır.

Introduction

Esthetics, which becomes increasingly important in modern dentistry, means an interest in beauty or liking of beauty (1). The smile plays a fundamental role in facial esthetics and attractiveness (2). Furthermore, an attractive and pleasant smile creates the first positive effect in the social lives of individuals and ensures that the person is accepted in bilateral relationships (3). Smile esthetics, one of the most essential components of dentofacial esthetics, is of major importance in dental treatments nowadays (4,5). In smile esthetics, factors such as gingival display (6,7), ratio and symmetry of maxillary incisors (8-10), incisal curvature (11-14), the presence of gingival and dental asymmetries (3,15-19), and the presence of midline diastema are effective (15,20,21).

Esthetic perception may vary from person to person with the effect of social environment and personal experiments (22). Due to the same reason, there are differences among beauty perceptions of laypeople and dental professionals (23). A smile that is beautiful and attractive to dentists may not create the same perception in other individuals (24). When evaluating esthetics, dentists were determined to be stricter than laypeople (15).

There are many studies in the dental literature comparing the perceptions of smile esthetics of dentists, orthodontists, and laypeople (3,9,15,18,25-36). However, there has been no extensive study in the dental literature examining the effects of the different smile esthetic parameters on prosthodontists' smile esthetic perception.

The aim of this study was to determine the effects of different smile esthetic parameters, such as incisal curvature shape, incisal asymmetry of anterior teeth, the presence of diastema, different width/length ratios of central teeth on the smile esthetic perceptions of prosthodontists, general practitioner dentists and laypeople. The hypothesis of the study was that participants' occupations (general dentists, prosthodontists, laypeople) would not significantly affect their perceptions of smile esthetics.

Materials and Methods

This research obtained the research ethics committee approval from the Sakarya University Faculty of Medicine (protocol number: 71522473/050.01.04/537, date: 08.10.2020). Also, a female individual who posed for the study signed an image use authorization. All participants has signed an informed constent form (26).

Sample size in the study was determined by using a software (G*Power 3.01, Franz Faul, Christian-Albrechts-Universität Kiel, Kiel, Germany) to achieve 80% power, and "effect size" was 0.25. According to the results of this calculation, 56 subjects in each group were necessary. However, n=60 was determined as safety margin. Consequently the present study was conducted with a total of 180 volunteers which was consistent with the other studies that used similar methods (9,26,37).

In this study, three groups evaluated different smile images: Prosthodontists, dentists and, laypeople. The inclusion criteria for prosthodontists and dentists were completing their specializations or dental educations at least 2 years. This information was confirmed by the Turkish Society of Dentistry. For laypeople, inclusion criterias were being older than 18 years old, having a university education, not being a dental technician, oral hygienist and dental assistant, not having any dental education, not being associated with artistic activities or not being an artist. The present study was conducted among laypeople in a shopping mall (38). While, conducted among generaal practitioner dentists and prosthodontists in a congress center.

A close-up smile image of a young female volunteer having an attractive smile without any facial asymmetries (39) were taken by using a DSLR

camera (Nikon, DX SWM VR ED IF Aspherical ø72, Thailand). Changes were made in photographs by using a software (Photoshop CS6 v.13.0.4; Adobe Inc, Mountain View, CA, USA) (9,18,23-25,36-44).

By using the photoshop program a symmetrical smile (right to left) was created, most parts of chin, cheeks and, nose were removed discoloration in skin and, lips were retouched, to reduce variables within the images (15,16). Photographs were arranged to achieve identical measurements of volunteer. It was provided that each millimeter measured on the digital image was equivalent to the volunteer, determining maxillary central teeth as a reference point (45). Furthermore, all of the images were standardized in 300 dots per inch resolution (9,46).

In the photographs, the shape of the incisal curvature was changed to be ideal, flat, and reverse (Figure 1) (7,11,18,25,32,37,47). Midline diastemas were also created at varying dimensions: 0.5 mm, 1 mm, 1.5 mm and 2 mm (Figure 2) (17,25,33,34). Furthermore, 0.5 mm, 1 mm, and 2 mm incisal edge asymmetries were created in maxillary central, lateral and canine teeth (Figure 3-5) (3,16,25,34). The width to length ratio of the maxillary central tooth was changed to be 75%, 80%, and 85% (Figure 6) (48,49). A questionnaire was created by the changing esthetic parameters in the photographs and turning them into questions by a software (Google Docs, Google Inc., Mountain View, CA) (46).

Figure 1. Alterations in smile arc a) ideal b) flat c) reverse

Figure 2. Different degrees of midline diastema a) 0.5 mm b) 1 mm c) 2 mm

Figure 3. Different incisal asymmetries in maxillary central teeth a) 0.5 mm b)1 mm c) 2 mm

Figure 4. Different incisal asymmetries in maxillary lateral teeth a) 0.5 mm b)1 mm c) 2 mm

Participants' sociodemographic datas including age, gender, occupation and education level were gathered by using a questionnaire (17). Images were arranged in a random order (15,45) and showed to the participants individually by a single researcher. The observation time for each image was determined as 20 seconds (38). The participants were allowed to view one image at a certain time, and it was not allowed to go back to other photographs and compare the images (50).

The esthetic value of each image was determined using the visual analog scale (VAS) (9,15,23,26,41-46). The VAS was prepared to be 10 mm long, and the participants were asked to score different smiles according to their own esthetic values. The esthetic score was arranged to be between 0-10. Zero corresponds to the minimum (least attractive), while ten corresponds to the maximum (most attractive) esthetic value (49).

Statistical Analysis

Statistical analysis was performed using the SPSS program (version 22.0, SPSS). Kolmogorov-Smirnov normality test was conducted to the assessment of the data for skewness, kurtosis, and outliers, it was concluded that the data was normally distributed. Then, One-Way ANOVA tests were performed within each group to assess how the study groups rated at each level of deviation and within each level of variation to compare each groups' esthetic scores. Multiple comparisons corrected with Bonferroni adjustments and post hoc Tukey test were performed to calculate the threshold level of deviation at which each study group was differentiated and also to determine how groups' esthetic scores have distinguished from the

Figure 5. Different incisal asymmetries in maxillary canine teeth a) 0.5 mm b)1 mm c) 2 mm

Figure 6. Different width to length ratio of maxillary central teeth a) 75% b) 80% c) 85%

other groups. The level of significance was set at α=0.05.

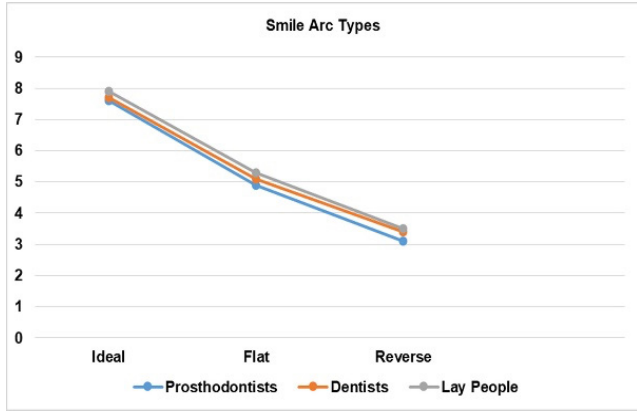
Results

The results of the study presented that, 47.2% of the participants were men while 52.8% were women, 27.8% were between 26-35 years and 24.4% were between 36-45 years old. The participants' demographic characteristics are shown in Table 1.

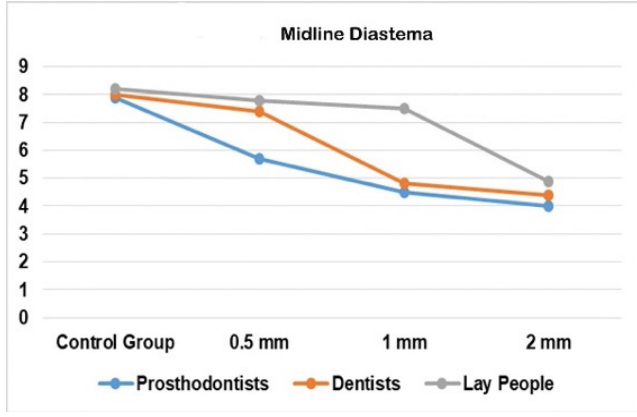
The mean esthetic score of the smiles with the ideal incisal line was 8.4, flat incisal line was 5.1 and reverse incisal line was 3.3. The esthetic scores of smiles with ideal incisal line were higher than flat and reverse incisal lines (p<0.001). In addition, esthetic scores of laypeople were higher than dentists and laypeople in each incisal line type but there wasn't any difference between groups (p>0.05) (Graphic 1).

As a result of the study, the highest esthetic scores were observed in 0.5 mm midline diastema (mean: 7.8); lowest esthetic scores in 2 mm midline diastema (mean: 4.4) in all study groups (p<0.001). Dentists' and prosthodontists' esthetic scores were lower than laypeople's in each level of diastema (p<0.001). Threshold levels of significant difference of esthetic scores were 0.5 mm for prosthodontists, 1 mm for dentists, 2 mm for laypeople. Prosthodontists were more critical than general practitioner dentists and laypeople when evaluating midline diastemas (Graphic 2).

When the incisal edge asymmetries of maxillary anterior teeth were compared, the highest esthetic scores were observed in canine teeth with 0.5 mm incisal asymmetry (mean: 7.2); the lowest esthetic scores were observed in the central teeth with 2 mm incisal asymmetry (mean 3.4). When the amount of incisal asymmetries increased, the esthetic scores of maxillary central, lateral, and canine teeth decreased (p<0.001). Laypeople had higher esthetic scores than



Graphic 1. Attractiveness of images with different smile arc types



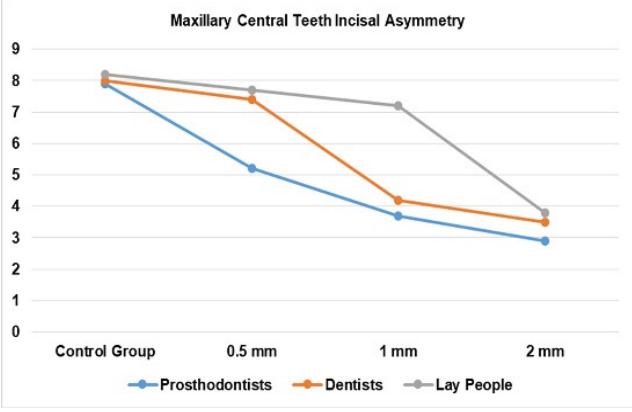
Graphic 2. Attractiveness of images with different degrees of midline diastema

Table 1. Demographic characteristics of the participants

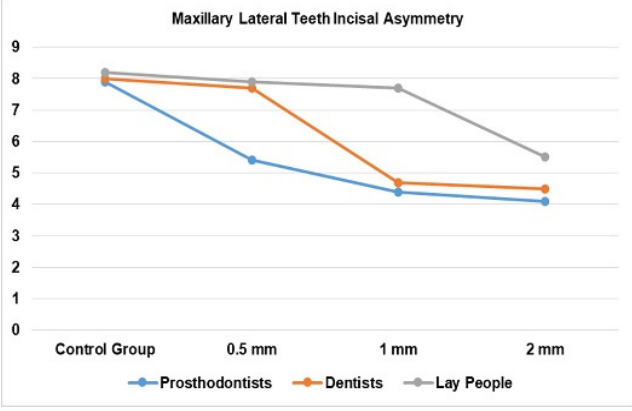
Characteristics	Prosthodontists	Dentists	Laypeople
Genders			
Male	31 (51.7%)	26 (43.3%)	28 (46.7%)
Female	29 (48.3%)	34 (56.7%)	32 (53.3%)
Age groups			
18-25 y	0 (0%)	3 (5%)	16 (26.7%)
26-35 y	20 (33.3%)	17 (28.3%)	13 (21.7%)
36-45 y	19 (31.7%)	14 (23.3%)	11 (18.3%)
46-55 y	11 (18.3%)	14 (23.3%)	9 (15%)
55-65 y	7 (11.7%)	8 (13.3%)	6 (8.3%)
>65 y	3 (5%)	3 (6.8%)	6 (10%)

dentists and laypeople in each level of asymmetries of all teeth (p<0.001). Prosthodontists were more critical than general practitioner dentists and laypeople when evaluating incisal edge asymmetries. Threshold levels of significant difference of esthetic scores were 0.5 mm for prosthodontists, 1 mm for dentists, 2 mm for laypeople in all teeth. Canine teeth's esthetic scores in each level of incisal asymmetries were higher than central and lateral incisors, in all groups (p<0.001) (Graphic 3-5).

Maxillary central teeth with 80% width/length ratio had highest esthetic scores (mean 7.9), while the 85% ratio had lowest esthetic scores (mean: 5.9). Esthetic scores of prosthodontists and dentists were lower than laypeople in 75% width/length ratio (p=0.011), in 80% ratio (p=0.007), in %85 ratio (p=0.002) (Graphic 6).



Graphic 3. Attractiveness of images with different incisal asymmetries of central teeth

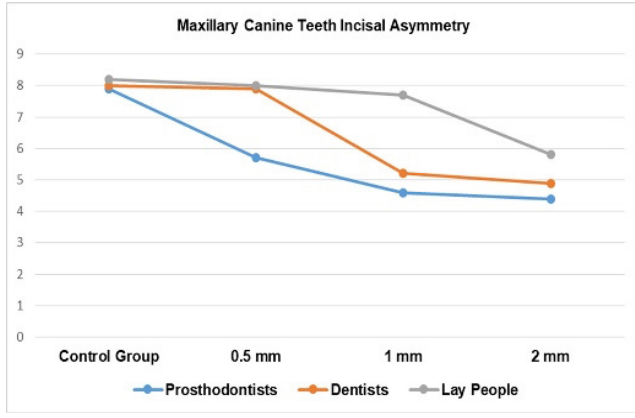


Graphic 4. Attractiveness of images with different incisal asymmetries of lateral teeth

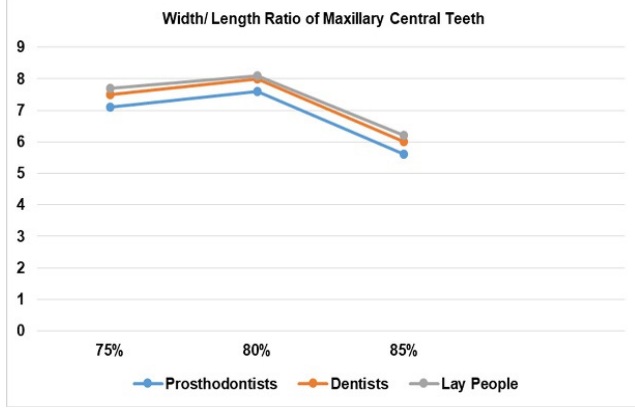
Discussion

Dental and gingival asymmetries adversely affect esthetics in adults (9). Age, genders, professions, ethnicities may influence people's smile esthetic perceptions (28-31). As a consequence of the present study, while the esthetic scores of smiles which had different incisal curvature shapes, the esthetic scores of smiles had different amounts of asymmetry, rotation, and diastema in the anterior teeth and different width to length ratios of the central tooth, differed among dentists, prosthodontists and laypeople. The null hypothesis, which estimated that there would be no differences among the study groups, was partially accepted.

When the incisal edge curvatures of the upper anterior teeth is parallel to the lower lip curvature, this is defined as the ideal smile arc (11). While the ideal smile arc increases the attractiveness of the



Graphic 5. Attractiveness of images with different incisal asymmetries of canine teeth



Graphic 6. Attractiveness of images with maxillary central teeth's different width/length ratios

smile, the straight smile arc decreases it (11,32,45). In different ethnicities, different smile arcs can be considered esthetic (31). In the literature, it was reported that orthodontists, dentists, and laypeople found the ideal smile arc more esthetic, while they found the flat smile arc less esthetic (7,25,45). Rodrigues et al. (20) stated that laypeople found the reverse smile arc less esthetic. In our study, similarly to studies in the literature (7,11,25,32,45), while the ideal smile arc was perceived to be more esthetic by prosthodontists, dentists, and laypeople, flat smile arc obtained lower esthetic scores. Furthermore, in our study, similarly, Rodrigues et al. (20) reverse smile arc received the lowest esthetic scores in all groups.

In the literature, some researchers (15,25) noted that the esthetic scores of those with small diastemas (0.5 mm) in the midline were generally higher than those with 1 mm, 1.5 mm and 2 mm diastemas. Kokich et al. (15) stated that in order not to find the smile attractive, the threshold value of the diastema in the midline was 1 and 1.5 mm for orthodontists, and 2 mm for dentists and laypeople. At the same time, Al Taki et al. (25) concluded that the threshold value of midline diastema was 1 mm for orthodontists and dentists and 1.5 mm for laypeople. While in India, for accepting that the diastema is esthetic, the threshold value is 1.5 mm for orthodontists, general dentists, and laypeople (34), in Africa, this value is 2-3 mm for laypeople (33). According the results of this study, different from other studies (15,25,33) threshold values were 0.5 mm for prosthodontists, 1 mm for dentists, 2 mm for laypeople. In our opinion, this difference is because of the fact that prosthodontists are stricter than orthodontists in detecting midline diastemas.

In the dental literature, Kokich et al. (3) evaluated asymmetries in the length of teeth, and they reported that orthodontists could distinguish even a 0.5 mm shortness of the crown length of teeth, dentists could notice a 1.5 mm shortness of the crown length, and laypeople could notice a 2 mm shortness of the crown length. It was reported that laypeople living in the United States did not accept teeth with a 1.5-2 mm shortness as symmetric (16), while those in India did not accept teeth with a shortness of more than 1.5 mm (34), and the Arabic people did not accept a 2 mm shortness as symmetric (25). As a result of the current study, similarly to the study by Kokich et al. (3) only the esthetic scores of prosthodontists decreased in the case of a 0.5 mm shortness in lateral and central incisiors and canine teeth. Similarly to other studies in the literature (16,25), the esthetic scores of general dental practitioners decreased in the case of a 1 mm shortness, while the esthetic scores of laypeople decreased in the case of a 2 mm shortness.

Furthermore, Chiche and Pinault (14) considered that symmetry at the midline was essential, while more laterally a certain amount of asymmetry was permissible. According to the results of this study, supporting Chiche and Pinault (14) incisal asymmetries of central teeth had the lowest while canine teeth had the highest esthetic scores, and also esthetic scores increased laterally.

The ideal width to length ratio of maxillary central incisors is between 75-85% (37). Sterrett et al. (48) stated that the teeth size of males was larger than that of females, and while the width/length ratio was expected to be closer to 75% for females, values close to 85% were more acceptable for males. Álvarez - Álvarez et al. (27) reported that maxillary central teeth with a width/length ratio of 85% were considered to be more esthetic by dentists and laypeople. Unlike the study by Álvarez - Álvarez et al. (27) as a results of the current study, the esthetic scores of maxillary central teeth, which had a width/length ratio of 80%, were higher in all three groups. This situation is thought to be related to the changes in esthetic perception due to the difference in ethnicity in the two studies.

In our opinion, information obtained about the perceptions of smile esthetics of prosthodontists, dentists and laypeople as a result of the current study will help clinicians in treatments in the esthetic zone. Knowing which situations are found as esthetic or unesthetic by patients can help dental professionals to avoid unnecessary treatments, especially in the esthetic zone. The first limitation of the current study is that not all parameters of the esthetic checklist were evaluated. The another limitation was that 2D photographs of volunteer were evaluated and 3D models were not used. The third limitation is that individuals were not asked to evaluate the photographs repetitively over a specific period of time, and the results were obtained with the evaluation performed by the individuals once. The fourth limitation is that this study was performed only in one ethnicity, and the results of the study did not

provide general information about the smile esthetics of prosthodontists, dentists, and non-professionals around the world.

Conclusion

Within the limitations of the present study, it was concluded that:

1. Ideal smile arc had the highest esthetic scores.

2. Prosthodontists can notice smaller diastemas and asymmetries in comparison with dentists and laypeople.

3. As the size of asymmetries and diastemas increases, esthetic scores decrease at that rate.

4. The maxillary central tooth with a width/length ratio of 80% has the highest esthetic scores.

Ethics

Ethics Committee Approval: This research obtained the research ethics committee approval from the Sakarya University Faculty of Medicine (protocol number: 71522473/050.01.04/537, date: 08.10.2020).

Informed Consent: All participants has signed an informed constent form.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: M.K., Design: M.K., Supervision: F.B., Fundings: M.K., Materials: M.K., Data Collection or Processing: M.K., Analysis or Interpretation: M.K., Literature Search: M.K., Critical Review: F.B., Writing: M.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Effect of Cone-beam Computed Tomography on Treatment Decision of Wisdom Tooth

Konik Işınlı Bilgisayarlı Tomografinin Yirmi Yaş Dişin Tedavi Kararına Etkisi

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Keywords
Cone-beam computed tomography, three-dimensional imaging, mandibular canal, diagnostic accuracy

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Konik ışınlı bilgisayarlı tomografi, üç boyutlu görüntüleme, mandibular kanal, tanısal doğruluk

Received/Geliş Tarihi : 15.10.2020
Accepted/Kabul Tarihi : 23.12.2020

doi:10.4274/meandros.galenos.2020.59002

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Abstract

Objective: This diagnostic accuracy study aimed to evaluate the relationship between mandibular third molars (M3) and mandibular canal (MC) using panoramic radiographs (PR) and cone-beam computed tomography (CBCT) and to assess the effect of CBCT on treatment decision.

Materials and Methods: CBCT scans of 150 patients with close association between MC and M3 on PR were included in the study. The degree of superimposition, Bucco-lingual position (buccal, central and lingual) and physical relationship (separation, contact and involved) were measured on CBCT images. Fisher's Exact test was used to evaluate differences between PR and CBCT.

Results: All M3 were directly superimposed on the MC on PR; however, CBCT showed separation from the canal in 10% of M3 roots. Evaluation of CBCT images revealed that the probability to observe an involvement was significantly higher when the MC was in the lingual position (57.6%) than in other positions.

Conclusion: Three-dimensional imaging is very useful to clarify the true relationship between M3 and MC relative to two-dimensional panoramic images, and the clinician may decide to change the treatment plan based on CBCT images in patients with high risk. Nevertheless, PR can be considered an acceptable diagnostic method with low radiation dose compare with CBCT.

Öz

Amaç: Bu tanısal doğruluk çalışmasının amacı, mandibular üçüncü molar (M3) dişler ile mandibular kanal (MK) arasındaki ilişkiyi panoramik radyografi (PR) ve konik ışınlı bilgisayarlı tomografi (KIBT) kullanarak incelemek ve KIBT'nin tedavi kararına etkisini değerlendirmektir.

Gereç ve Yöntemler: Çalışmaya, MK ile M3 arasında yakın ilişki bulunan 150 hastanın KIBT taramaları dahil edildi. KIBT'de üst üste binme derecesi, Bukko-lingud pozisyon (bukkal, merkez ve lingual) ve fiziksel ilişki (ayrı, temas ve dahil) ölçüldü. PR ve KIBT arasındaki farklar için Fisher's Exact testi kullanıldı.

Bulgular: PR üzerinde, tüm M3'ler MK ile ilişkili görüldü. Ancak, KIBT, M3 köklerinin %10'unun kanalla ilişkisi olmadığını gösterdi. KIBT görüntülerinin değerlendirilmesi

gösterdi ki, MK lingual pozisyonundayken (%57,6), diğer pozisyonlar ile karşılaştırıldığında, dahil tip ilişkinin görülme olasılığı belirgin biçimde yüksekti.
Sonuç: Üç boyutlu görüntüleme, iki boyutlu panoramik görüntüleme ile karşılaştırıldığında, M3 ve MK arasındaki gerçek ilişkiyi açıklamak için oldukça kullanışlıdır. Ayrıca klinisyen, yüksek riskli hastalarda KIBT görüntülerine dayalı olarak tedavi planını değiştirmeye karar verebilir. Bununla birlikte, KIBT'ye kıyasla düşük radyasyon dozu ile PR, kabul edilebilir bir teşhis yöntemi olarak düşünülebilir.

Introduction

Surgical removal of impacted lower third molars (LM3) is one of the most common procedures carried out in oral and maxillofacial surgery (1-4). As a result of close proximity of the root apices of LM3 and the mandibular canal (MC), this surgical procedure carry the risk of inferior alveolar nerve injury (IANI) (5,6). In some cases neurological complications such as paresthesia may occur, characterized by temporary or permanent numbness or unexpected sensation in the lower jaw, mental region and lower lip of the affected side, significantly disturbing the patient's quality of life (3,7,8). Therefore, it is very important to evaluate the risk and inform the patients about this undesirable complication prior to surgery.

In clinical practice, panoramic radiography (PR) is the imaging modality most commonly used by oral and maxillofacial surgeons to view impacted LM3 and to estimate the risk of IANI. Darkening of the root apices, loss of the cortical border of MC and defected roots have been reported to be significant radiographic signs for risk of IANI (9,10). However, it was clearly demonstrated that two-dimensional (2D) panoramic imaging fails to demonstrate the Bucco-lingual relationship of tooth roots and MC (4,10,11). Even with definitive radiographic markers, three-dimensional (3D) imaging is particularly recommended to establish the exact relationship between the two structures and to minimize the risk of IANI (4,8,10,12). Cone-beam computed tomography (CBCT) have been advocated as a 3D imaging method of choice for the imaging of LM3 and adjacent anatomical structures, which offers lower radiation dose and high image quality (13). Studies evaluating the risk assesment of IANI using various imaging modalities demonstrated that significantly more patients were re-classified to a lower risk of injury after CBCT examination (14,15). However, recent studies reported contradictory results regarding the advantages of CBCT on diagnostic accuracy, diagnostic thinking and treatment outcomes (16-18). In general, few studies have validated the effect of accuracy of anatomical relationship of LM3 with various imaging methods and its relevance to IANI (19,20).

In the present study, it was hypothesized that, if there is an increased risk of IANI, the diagnostic accuracy of CBCT examination contributes to more accurate and comprehensive presurgical planning by assesing the location and morphologic characteristics of the MC before surgery and additional pre-operative CBCT imaging has an effect on treatment decision. Therefore, the aim of this study was to evaluate the relationship between LM3 and the MC using PR and CBCT and to assess the impact of CBCT on treatment decision.

Materials and Methods

Study Design and Patient Selection

A total of 312 patients who were referred to oral and maxillofacial radiology and oral and maxillofacial surgery departments for the extraction of LM3 from September 2017 through November 2018, were examined as high risk for IANI due to third molars' being directly superimposed on the canal on 2D panoramic images.

The inclusion criteria to the study sample were the presence of overlapping between LM3 and MC on pre-operative panoramic radiographs. Patients with aforementioned radiographic relationship were considered to be associated with a high risk for IANI and nominated for CBCT examination to determine the further anatomical details. Patients with neurological diseases(n=13), mandibular third molars with incomplete root formation (n=103), displacement of the root due to pathology such as cyst or tumor (n=27) and declined to participate (n=19) were excluded from the study (Figure 1). Therefore; the study group consisted a total of 150 patients (101 females and 49 males). Before participation, the aim and procedures were detailed and a written consent was signed in

accordance with the Declaration of Helsinki to all participants. All patients signed constent forms that included details regarding the surgery and possible complications.

The study protocol was approved by the Ethics Committee of the Ege University Faculty of Medicine Clinical Research Ethics Committee (decision no: 15-5.2/4, date: 15.06.2015).

The study variables were classified as demographic data, PR and CBCT images. The demographic data included age and sex of the patient. The panoramic images were evaluated for the angulation of the impacted tooth and vertical relationship between the LM3 and MC. The CBCT images were used to delineate the Bucco-lingual position of the MC as regards to the impacted LM3 as well as the physical relationship of the root(s) of LM3 and MC.

Radiographic Procedures

PR were obtained using the OP 100 (GE Healthcare, Tuusula, Finland) panoramic X-ray unit at 70 kV, 16 mA and 17.6 s. CBCT acquisition of each patient was done with the Kodak 9000 3D (Kodak Carestream Health, Trophy, France) system operating at 70 kVp and 10 mA with 2.5 mm Al equivalent filtration. CBCT acquisition of each patient was completed after a single 360° rotation with 10.8 s scan time, and a volume with a spatial resolution of 76 µm (50x37 mm field of view) was reconstructed. The same operator took all images.

Evaluation of Panoramic and Cone-beam Computed Tomography Images

The angulation of an impacted LM3 was evaluated using Winter's classification with reference to the angle formed between the intersected longitudinal axes of the second and third molars (The vertical impaction (10° to -10°), mesioangular impaction (11° to 79°), horizontal impaction (80° to 100°) and distoangular impaction (-11° to -79°) (21).

The vertical relationship of LM3 apices and the MC was classified according to the superimposition degree on the panoramic radiograph (7). Following criteria was used for the classification;

Class A; root apex of the impacted LM3 superimposed on less than one third of the MC

Class B; root apex of the impacted LM3 superimposed on one third- two thirds of the MC

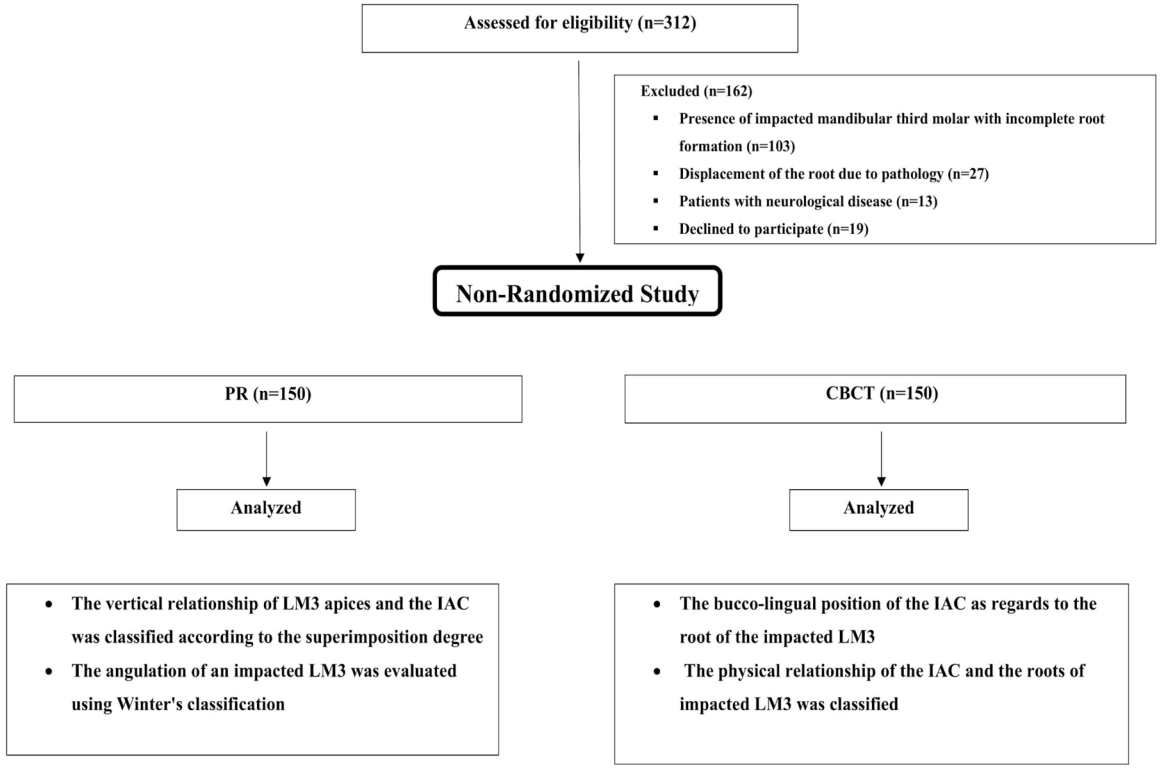

Figure 1. Detailed workflow diagram for excluded and included participants

PR: Panoramic radiography, CBCT: Cone-beam computed tomography, LM3: Lower third molars, IAC: Inferior alveolar canal

Class C; root apex of the impacted LM3 superimposed on more than two thirds of the MC (Figure 2).

The Bucco-lingual position of the MC as regards to the root of the impacted LM3 on CBCT was determined using cross sectional images with the dedicated software of the imaging system (Kodak Dental Imaging software, v.6.11.6.2, 3D module v.2.1) and classified as; lingual, buccal, inter-radicular or inferior position (Figure 3) (21).

The physical relationship of the MC and the roots of impacted LM3 was classified as (Type I) separated, (Type II) contact or (Type III) involved (7) (Figure 4).

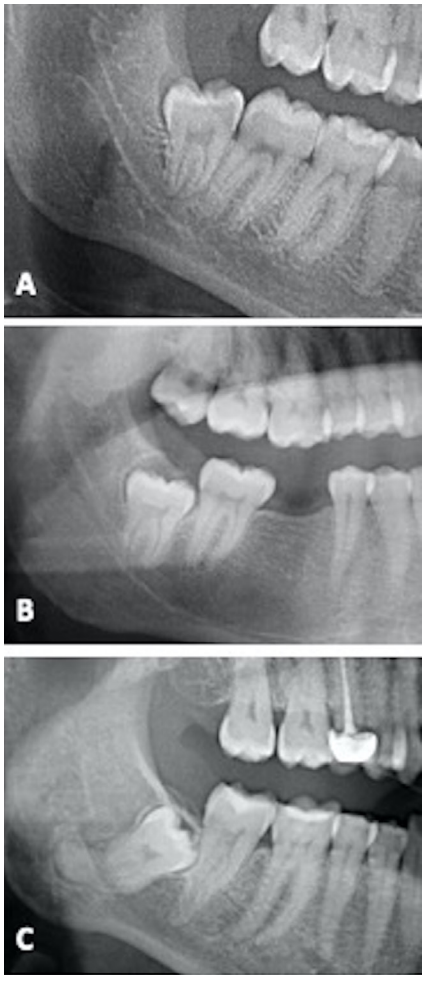

Figure 2. The vertical relationship between the lower third molars (LM3) root and the inferior alveolar canal (IAC) was classified according to the degree of superimposition on the panoramic image (a) Root apex of the impacted LM3 superimposed on less than one third of the IAC (class A) (b) Root apex of the impacted LM3 superimposed on one third-two thirds of the IAC (class B) (c) Root apex of the impacted LM3 superimposed on more than two thirds of the IAC (class C)

The presence of cortication around the MC was also evaluated on axial and coronal slices of CBCT images.

Surgical Procedure

Before surgery, each patient was informed of the necessity to obtain a CBCT examination and the possible complications of surgery including the potential risk of IANI. The same surgeon with 8 years

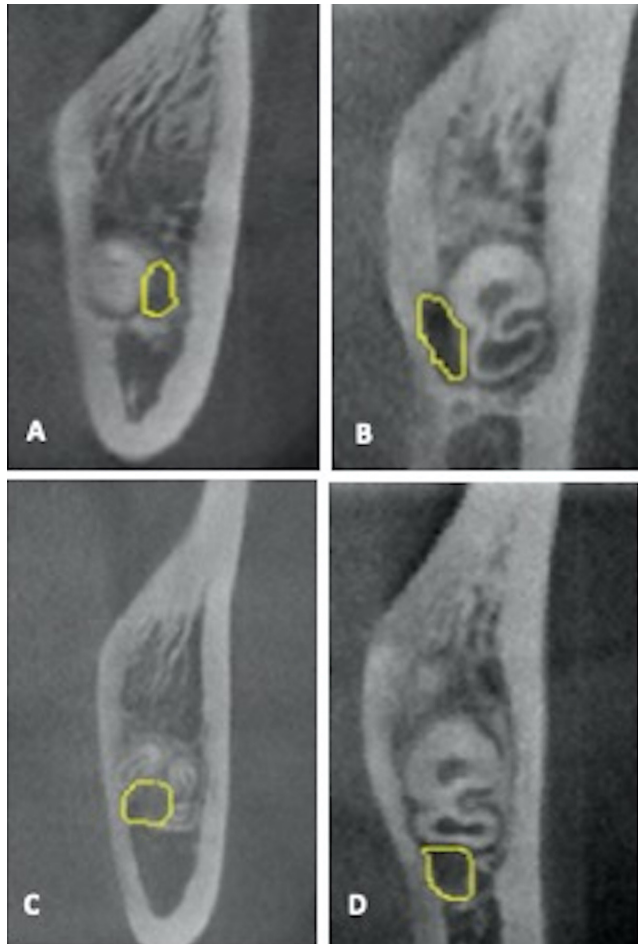

Figure 3. The Bucco-lingual position of the inferior alveolar canal as regards to the root of the impacted lower third molars classified as (a) lingual, (b) buccal, (c) inter-radicular, (d) inferior position

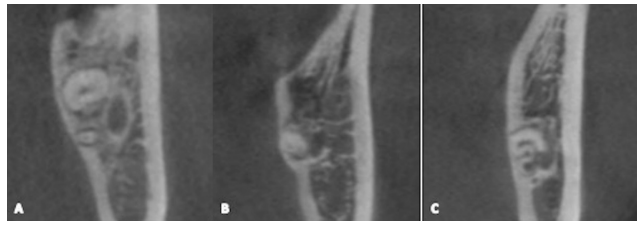

Figure 4. The physical relationship of the inferior alveolar canal and the roots of impacted lower third molars was classified as (a) separated, (b) contact, (c) involved

of experience conducted all surgical procedures. Surgical procedures were done under local anaesthesia (Ultracaine DS Forte, Sanofi-Aventis; articaine hydrochloride 4%; epinephrine, 1:100,000). Seperated and contact type of impacted LM3 (n=65) were removed by using similar rotary instruments under continious irrigation with sterile saline solution. If there are 2 or more roots, the tooth was sectioned carefully. After the removal of the tooth the socket was cleaned and the area was primarily closed.

Coronectomy (partial odontectomy) technique was performed in involved type of impacted LM3 (n=85); the crown of the tooth removed by using the same rotary instruments under continuous irrigation as mentioned above and after removal of the crown, the surface was lowered 2-3 mm under bone margin. The roots were leaved in place and the area was primarily closed.

Postoperatively, amoxicillin (1000 mg twice per day for five days), 0.2% chlorhexidine mouthwash (twice per day for seven days) and ibuprofen (400 mg four times per day for five days) were prescribed to all patients.

Neurosensory Disturbance Assessment

Post-operative sensory function was evaluated by two-point discrimination neurosensory test at various time intervals after surgery.

The follow-up examinations were done at regular intervals; the following day, 1 week and 1, 3, 6 months after surgery. Patients were questioned about the presence of any sensory change or disturbance in the lower jaw, mental region and lower lip of the operation side such as paresthesia or numbness. When the above-mentioned symptoms were recovered within 6 months it was defined as a transient, but when there is no recovery within 6 months after surgery it was defined as permanent injury.

Statistical Analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences version 20.0 (SPSS, IBM Corp., Armonk, NY, USA). The relation between predictor variables among the categories on panoramic and CBCT images and outcome factors was analyzed using the Fisher's Exact test. P<0.05 was considered statistically significant.

Results

One hundred fifty third molars, which had a close relationship with MC in PR from 150 patients (101 female, 49 male), were included in the study. The mean age of the patients was 29.71 years ranging between 18-78 years (Table 1).

Mesioangular impaction showed the highest prevalence with 62% ratio followed by vertical (22%), horizontal (10.7%) and distoangular impaction (5.3%). The prevalence and classification of impaction of LM3 did not show any significant difference between male and female patients (p>0.05).

Vertical relationship between the root apices of the impacted third molars and the MC evaluated using PR showed that 73.3% of the molars have class A relationship while 23.3% and 3.3% have class B and class C type of relationship. Evaluation of coronal slices for Bucco-lingual relationship showed that 39.3% of the MCs were at the lingual side of the impacted tooth, while 30% were at the buccal side. Moreover, CBCT evaluation demonstrated that 26% and 4.6% of the MCs were in inferior and inter-radicular position respectively (Table 2). The percentage of panoramic images showing direct superimposition of impacted third molar apices on the inferior alveolar canal (IAC) (class A-C) was 100%, but on the contrary CBCT findings revealed that only 56.67% of the roots had involved with 33.33% showing direct contact and 10% showing seperate type of relationship with the MC (Table 3).

Evaluation of the CBCT images revealed that the probability to observe involved type of relationship was significantly higher when the MC was in the lingual position (57.6%) as compared to the other positions (p<0.05).

Transient paresthesia was observed in two patients as a post-operative complication. Both patients' LM3 had contact type of relationship with the MC and they had undergone total extraction. MC was in the lingual position in both patients with complication.

Table 1. Age and sex of the patients

Age (years)	Male	Female	Total
<25	20	52	72
25-40	18	39	57
>40	11	10	21
Total	49	101	150

Table 2. Relationship between impact third molar and inferior alveolar canal in cone-beam computed tomography and panoramic radiography images

CBCT physical relationship	CBCT Bucco-lingual position	Degree of superimposition on panoramic radiography images			Total
		Class A	Class B	Class C	
Separated	Buccal	8	2	0	10
	Inferior	4	0	0	4
	Lingual	0	1	0	1
	Interradicular	0	0	0	0
	Subtotal	12	3	0	15 (10.00%)
Contact	Buccal	14	4	2	20
	Inferior	11	4	0	15
	Lingual	6	3	0	9
	Interradicular	6	0	0	6
	Subtotal	37	11	2	50 (33.33%)
Involved	Buccal	10	4	1	15
	Inferior	18	1	1	20
	Lingual	33	15	1	49
	Interradicular	0	1	0	1
	Subtotal	61	21	3	85 (56.67%)
Total		110 (73.30%)	35 (23.30%)	5 (3.30%)	150 (100.00%)

CBCT: Cone-beam computed tomography

Table 3. Proximity between third molars and the inferior alveolar canal in panoramic radiography and cone-beam computed tomography images

	Class A (%)	Class B (%)	Class C (%)
Separated	12 (10.9)	3 (8.6)	0 (0)
Contact	37 (33.6)	11 (31.4)	2 (40)
Involved	61 (55.5)	21 (60)	3 (60)
Total	110	35	5

Discussion

Radiographic evaluation is of paramount importance to reduce the possible postoperative risks and complications of surgical extraction of mandibular third molars. Meticulous pre-operative radiographic examination prevents many post-operative complications such as pain, swelling, bleeding, infection, alveolitis, trismus, fracture and injury to the IAN, buccal and lingual nerve (10,11,22). IANI is the most serious and unpleasant complication that arise from third molar surgery which usually causes medicolegal problems and functional problems as well as decreased quality of life.

Pre-operative radiographic evaluation should be discriminating and should provide information about the location of the tooth in relation to the neigbouring roots and vital anatomical structures as well as the position, depth and the type of impaction of the third molars. However, if the relationship between the apices of impacted third molar and the IAN is not clear on 2D panoramic radiographs, 3D imaging is indicated for accurate preoperative assessment (1,4,23,24). European Commision guidelines as well as the position paper of the European Academy of Dentomaxillofacial Radiology suggest using CBCT only when the surgeon has a very specific clinical

question that cannot be answered by conventional 2D imaging (23). Accordingly, in the present study only patients requiring comprehensive evaluation were referred for further evaluation with CBCT in order to avoid any complications and change the treatment modality. According to the results obtained CBCT findings revealed 56.67% of the roots had involved type relationship with IAC, even though all third molar roots were seen as directly superimposed on the canal on 2D panoramic images. Therefore, it was once again proved that 3D accurate determination of the proximity of IAC and impacted third molar roots is mandatory. It was previously claimed that the most important parameter for the assesment of proximity of mandibular M3 apices to the IAC was not only the Bucco-lingual position of IAC relative to third molars, but also physical relationship between the LM3 roots and inferior alveolar canal (25). Furthermore, the location of third molar root apices with the IAC (inside or in contact) was suggested to be a more important parameter for the IANI risk evaluation (7).

Coronectomy technique was first introduced in 1989 by Knuttson et al. (26) to avoid IANI in high risk patients. Since its introduction, numerous studies have reported the benefits and limitations of this technique; the excessive advantages of the technique in high risk patients makes the technique a favorable option in maxillofacial surgery practice (27-31). Coronectomy is a widely accepted alternative treatment modality which can reduce the risk of IANI compared with complete surgical removal when treating high-risk LM3. Pedersen et al. (29) reported a good long-term prognosis of coronoctomy treatment in 231 mandibular third molar coronoctomies and stated the surgical procedure as a safe technique. Similarly, in their research both Leung and Cheung (32) and Renton et al. (33) reported that coronectomy technique was associated with a low incidence of nerve damage compared with surgical removal of mandibular third molars. Also, Monaco et al. (30) reported low rate of postoperative complications in coronectomy technique. Based on these data; due to CBCT enables accurate surgical planning; in the present study patients with the presence of overlapping between LM3 and IAC on pre-operative panoramic radiographs were referred to additional CBCT and the treatment modality changed from total extraction to coronectomy in 85 patients.

It was previously demonstrated that the mesioangular impaction is the most common angulation of impacted mandibular third molars. However, studies evaluating the effect of angulation type on prevalance of IANI showed that the highest risk of nerve injury was observed when the tooth was impacted in either distoangular or horizontal position (25). The high number of mesioangular impacted third molars included to the present study may be the possible reason of low incidence of IANI in the total extraction group.

Although there are contradictory results, buccal course of MCs were predominant in many reports (20,25,34). Supplementary to this finding, utilizing a buccal technique through the entire mandibular thickness was advised for most third molar surgeries (22,25). However, according to the results obtained in the present study most of the MCs were positioned lingual to the impacted third molars similar to the report of Ohman et al. (35) Consequently, the high incidence of lingual position of MCs and removal of impacted mandibular third molars by buccal surgical technique may be another reason for low incidence of IANI for this study.

The radiation burden of CBCT should always be considered and as recommended by recent position paper CBCT should only be used if it will change the treatment plan or treatment outcome for the patient (36). Otherwise, two dimensional images can be considered an acceptable diagnostic methods with lower effective doses, to compare with CBCT images. Furthermore, the sample size for this study was small which may be regarded as a limitation to this study, therefore; further studies with a large group of patients are needed to generalise the findings.

Conclusion

It is possible to conclude that 3D imaging did not influence the prevalence of IANI but provided better deliniation of the relationship between impacted molar tooth roots and surrounding vital structures as compared to 2D panoramic images. However, given the radiation burden of CBCT, PR can be considered an acceptable diagnostic method with low radiation dose. Therefore, CBCT should only be used for risk assessment; when a direct anatomical relationship between the LM3 and MC was observed on PR, thus the surgeon can change the treatment plan before the surgery.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of the Ege University Faculty of Medicine Clinical Research Ethics Committee (decision no: 15-5.2/4, date: 15.06.2015).

Informed Consent: Before participation, the aim and procedures were detailed and a written consent was signed in accordance with the Declaration of Helsinki to all participants.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: M.Ö.Y., E.Ş., G.I., E.A., B.Ö.K., B.G.B., C.G., Design: M.Ö.Y., E.Ş., G.I., E.A., B.Ö.K., B.G.B., C.G., Supervision: M.Ö.Y., E.Ş., G.I., E.A., B.Ö.K., B.G.B., C.G., Fundings: M.Ö.Y., E.Ş., G.I., E.A., B.Ö.K., B.G.B., C.G., Materials: M.Ö.Y., G.I., E.A., Data Collection or Processing: M.Ö.Y., G.I., E.A., Analysis or Interpretation: M.Ö.Y., E.Ş., E.A., Literature Search: M.Ö.Y., G.I., E.A., Critical Review: M.Ö.Y., E.Ş., G.I., E.A., B.Ö.K., B.G.B., C.G., Writing: M.Ö.Y., E.Ş., G.I., E.A., B.Ö.K., B.G.B., C.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Oral Health Related Knowledge, Practices and Opinions of Caregivers at the Biggest Care Home for People with Disability in Turkey

Türkiye'deki En Büyük Engelli Bakım Evindeki Bakım Personelinin Ağız Sağlığına Dair Bilgi, Uygulama ve Fikirleri

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Keywords
Oral health, oral hygiene, disabled persons, caregivers

Anahtar Kelimeler
Ağız sağlığı, ağız hijyeni, engelli bireyler, bakım personeli

Received/Geliş Tarihi : 13.04.2020
Accepted/Kabul Tarihi : 01.01.2021

doi:10.4274/meandros.galenos.2021.15870

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Presented in: The research was presented at the 23rd Congress of the European Association of Dental Public Health (EADPH) in Palma de Mallorca, October, 2018.

Abstract

Objective: People with disability have worse oral health than the healthy ones usually because of their inability to perform good daily oral hygiene, lack of knowledge of their caregivers and inadequate health policies. This study aimed to evaluate the oral health-related knowledge, practices and opinions of a group of caregivers in the biggest care home in Turkey.

Materials and Methods: A total of 170 caregivers were requested to complete a questionnaire prior to receiving training regarding oral health. The chi-square test was used to evaluate the statistical significance.

Results: Among the 322 residents with disability, 255 (79.2%) had mental disability and 64 (19.9%) had physical disability. Of the caregivers, 147 volunteered to participate (response rate 86.5%). Their mean age was 41.4 years. More than half of the caregivers (n=98, 66.6%) had been working for 5 to 14 years. Most of them (81.6%) reported that they performed oral hygiene procedures for 228 residents, and 97 (44.1%) reported that they brushed the teeth of residents three times per day. However, 102 caregivers reported that they did not know about the significance of dental plaque. Nearly two-thirds of the caregivers (n=95, 64.6%) had not previously received any education regarding oral care and 98 declared that they need training, of whom 74 requested that it should be practical. Female caregivers needed oral care training more than male caregivers. Although not statistically significant, caregivers who have been working for ≤5 years and those with at least a high school education reported more need for oral care training. The caregivers working ≤5 years had the least level of previous education on oral care.

Conclusion: The caregivers need comprehensive training on oral health in the biggest care home in Turkey to be able to provide adequate oral health care for the disabled residents.

Öz

Amaç: Engelli bireyler, genellikle günlük ağız bakımlarını iyi yapamamaları, bakımlarından sorumlu kişilerin bilgi eksikliği ve yetersiz sağlık politikaları nedeniyle sağlıklı bireylere göre daha kötü ağız sağlığına sahiptir. Bu çalışma, Türkiye'deki en büyük bakım evinde bir grup bakım personelinin ağız sağlığı ile ilgili bilgi, uygulama ve görüşlerini değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntemler: Yüz yetmiş bakım personelinden, ağız sağlığı konusunda eğitim verilmeden önce bir anket doldurmaları istenmiştir. İstatistiksel anlamlılığı değerlendirmek için ki-kare testi kullanılmıştır.
Bulgular: Üç yüz yirmi iki engelli birey arasında, 255'i (%79,2) zihinsel engelli ve 64'ü (%19,9) fiziksel engellidir. Yüz kırk yedi bakım personeli çalışmaya katılmak için gönüllü olmuştur (yanıt oranı %86,5) ve ortalama yaşları 41,4 yıldır. Bakım personelinin yarısından fazlası, (n=98, %66,6) 5-14 yıldır engelli bireyler için çalışmaktadır. Çoğunluğu (%81,6) 228 engelli bireyin ağız bakım uygulamalarını yaptığını ve 97'si (%44,1) engelli bireylerin dişlerini günde üç kez fırçaladıklarını bildirmiştir. Bununla birlikte, 102 bakım personeli dental plağın önemini bilmediklerini belirtmiştir. Bakım verenlerin yaklaşık üçte ikisi (n=95, %64,6) daha önce ağız bakımı konusunda herhangi bir eğitim almadığını ve 98'i eğitime ihtiyaç duyduklarını, eğitim isteyenlerin 74'ü ise eğitimin uygulamalı olması gerektiğini bildirmiştir. Kadın bakım personeli erkeklere göre daha fazla ağız bakımı eğitimine ihtiyaç duymuşlardır. İstatistiksel olarak anlamlı olmasa da 5 yıldan daha az süredir çalışan bakıcılar ve en az lise mezunu olan bakıcılar ağız bakım eğitimine ihtiyaç duyduklarını daha fazla belirtmişlerdir. Beş yıldan az çalışan bakıcılar ağız bakımı üzerine en az eğitim almış olanlardır.
Sonuç: Türkiye'deki en büyük bakım evinde bakım personelinin, engelli bireylere yeterli ağız sağlığı bakımı sağlayabilmeleri için, ağız sağlığı konusunda kapsamlı eğitim ihtiyaçlarının olduğu görülmektedir.

Introduction

People with disabilities have poorer oral health than their counterparts. Especially person with disabilities living in care homes have higher general and oral healthcare needs than those living in their homes. Unfortunately, their oral health is generally neglected as they commonly face challenges for getting access to dental healthcare (1,2).

The inability of maintaining activities related to oral health by themselves results in a need for long term care, treatment and rehabilitation for the disabled people (3). Therefore, knowledge and motivation of the caregivers/parents about oral health as well as adequate health policies are important (2,4).

According to the data of a nationwide survey conducted on 2002, there were 9 million disabled people (12.3% of the total population) living in Turkey (5). Parallelly, there has been a dramatically rise for the requirement of oral health services for the disabled people. However, the willingness of the dentists to manage a disabled person is low. This situation might be sourced from the necessity of too much time to perform dental procedures, life-threatening medical emergency possibility, limited mouth opening, requirement of hospitalization and lack of specialized dentists (6). Therefore, training of the caregivers/parents regarding primary preventive measures including proper nutrition, tooth brushing, flossing, fluoride applications to improve oral health status and minimize dental treatment needs is necessary. However, caregivers are frequently unaware of the importance of oral health and lack of the appropriate knowledge and skills to perform oral health care (7,8).

In Turkey, there have been recent reports regarding the oral health status of older people or people with specific disability living in care homes (9,10). On the other hand, there has been no report concerning caregivers, based on our literature search. From this point, the aim of this study was to evaluate the oral health related knowledge, practices and opinions of a group of caregivers in the biggest care home for the disabled in Turkey.

Materials and Methods

This descriptive study was approved by the Ministry of Family and Social Policy in Turkey (20240283-202.99-E.58558/2017). It was conducted at the biggest care home in Ankara, Turkey, between September and December 2017 (11). The care home was considered as the biggest depending on acreage, numbers of homes, person capacity as stated in the website of the Ministry of Family and Social Policy (11).

In the care home, a total of 700 caregivers in charge of 670 disabled people have been working with three shifts. Among them, 170 caregivers working between 08:00 am-16:00 pm, and belonging to the second shift period, were invited to participate in the study and requested to complete a structured, a face-to-face questionnaire. Out of the 170 caregivers, 147 of them who looked after 332 disabled people, volunteered to take part in the study (response rate 86.5%).

The variables in the questionnaire included oral care practices of the disabled people; knowledge of the caregivers about dental plaque, oral health; attitude to oral care of the disabled people. For pre-testing regarding the content and intelligibility, the first draft of the questionnaire was implemented on 15 caregivers in different age groups in the institution. Due to the feedbacks of the caregivers, some related open-ended questions were restructured.

Among the three questions related on oral health knowledge, the first one was about the frequency of dental visits for the disabled people. The correct answer was accepted as every three months since the disabled people need special health care with low health literacy level (12). The second question was about dental plaque and the answer defining the dental plaque as food accumulations on the teeth was accepted as correct. In the third question it was asked whether the oral health effects the general health. The correct answer was "yes" as World Health Organization defines the oral health as an integral part of the general health (13). The percentage of the caregivers who answered the three questions correctly was calculated.

Statistical Analysis

After completing of the questionnaires, the obtained data were analyzed statistically by using SPSS for Windows 21.0 (IBM Corp. Released 2012. Armonk, NY: IBM Corp.). Number and percentages were estimated for descriptive statistics. Chi-square and Fisher Exact test were used to assess the significance of the differences between categorical variables. The significance level was considered as 0.05 in all analyses.

Results

The mean age of the caregivers was 41.4±7.4 years (minumum-maximum: 23-58). Two-thirds (66.7%) were female. Only 11 (7.5%) had received university education and 57 (38.8%) had graduated primary school.

Regarding the disabled residents whom the caregivers given care, almost half of them (45.3%) were between 19-34 years of age; 255 (79.2%) were mentally disabled and 64 (19.9%) had physical disability (Table 1).

Of the caregivers, 120 (81.6%) reported that they performed oral hygiene procedures for 228 residents (70.8% of 322) but brushing frequency of the 8 residents had not been recorded. The caregivers reported that they brushed the teeth of 97 residents (44.1%) three times a day, among the remaining 220 residents.

Among the caregivers, 61.0% talked that they did not feel anything while performing oral care of the disabled residents, while 21.6% did not like oral hygiene procedures. The reasons of feeling uncomfortable were "having nausea during the procedures", "not accepting the procedure as part of their profession" and "not having enough time". Only 6 caregivers (5.0%) stated that they felt better while performing oral care of the disabled people.

The answers also revealed that time concerns as well as uncooperative behaviors of the disabled residents were the most common reasons for not dealing with the oral care of the residents. Some of the caregivers suggested that there was a need for a dental stuff in that care home.

Regarding the questions related to the knowledge of the caregivers about oral health, 102 (69.4%)

Table 1. The distribution of disabled people by age and disability type (Ankara-Turkey, 2017)

Age groups and disability type (n=322) / Age groups	n	%
≤5	5	1.6
6-11	18	5.6
12-18	25	7.8
19-34	146	45.3
35-64	124	38.5
≥65	4	1.2
Disability type*		
Mental	255	79.2
Physical	64	19.9
Psychiatric	24	16.3
Neurological	7	2.2

*More than one disability; the percentages calculated from total disabled people

reported that they had no idea about dental plaque and only 9 (12.9%) suggested that the frequency of dental visits should be once in three months. Ninety-four-point six percent of the caregivers stated that general health was related to oral health. Only 6 caregivers answered all the three questions correctly. Although the questions on dental plaque and frequency of dental visits for the disabled people were answered correctly more by females than males, the difference was not statistically significant (Table 2). The caregivers with at least a high school education, defined the dental plaque correctly more than those of the caregivers with primary school and elementary school education (p<0.000). However, the question asking the frequency of dental visit for the disabled people was answered less correctly by the caregivers with at least a high school education but there was no statistically significant difference (p>0.05).

More than half of the caregivers (54.4%) did not agree providing oral care of the uncooperative disabled residents by force. However, it was learned that at the care home, most of the disabled people being referred to a dentist only when needed.

The duration of working as a caregiver (in years) was also questioned. More than half of the caregivers (n=98, 66.6%) had been working for 5 to 14 years. Although statistically insignificant, a correlation of increase in the duration of working and decrease in the number of correct answers of the questions regarding the dental plaque and the frequency of dental visit was detected.

Of the caregivers, 46.3% asserted that they knew how to provide oral care. However, nearly two-thirds (n=95, 64.6%) had no previous training on oral care of disabled. On the other hand, 98 (66.7%) declared that they need training, and the most preferred method was practical training. According to their reports, it was

Table 2. The knowledge of the caregivers about dental plaque and dental visit frequency by some characteristics (Ankara-Turkey, 2017)

Characteristics	Dental plaque					p	Frequency of dental visit for disabled					p
	Known		Not known		Total		Known		Not known		Total	
	n	%*	n	%*	n		n	%*	n	%*	n	
Sex												
Male	11	22.4	38	77.6	49	0.129**	6	12.2	43	87.8	49	0.543**
Female	34	34.7	64	65.3	98		13	13.3	85	86.7	98	
Age group												
≤29	5	45.6	6	54.5	11	0.127**	-	-	11	100.0	10	0.567***
30-39	17	39.5	26	60.5	43		7	16.3	36	83.7	43	
40-49	20	26.7	55	73.3	75		9	12.0	66	88.0	70	
≥50	3	16.7	15	83.3	18		3	16.7	15	83.3	18	
Level of education												
Primary school	6	10.5	51	89.5	56	<0.001**	11	20.8	46	79.2	57	0.082**
Secondary school	12	35.3	22	64.7	44		5	14.7	29	85.3	34	
≥High school	27	48.3	29	51.8	56		3	5.4	53	94.6	56	
Duration of working as caregiver (years)												
≤5	15	37.5	25	62.5	40	0.708**	6	15.0	34	85.0	40	0.682**
5-9	15	28.8	37	71.2	52		7	13.5	45	86.5	48	
10-14	13	28.3	33	71.7	46		6	13.0	40	87.0	45	
≥15	2	22.2	7	77.8	9		-	-	9	100.0	8	

*Row percentages, **Chi-square test, ***Fisher Exact test

found that females need oral care education (75.5%) more than males (55.1%), (p=0.035). Although not statistically significant, the caregivers who have been working for less than five years and those with at least a high school education, reported more need for oral care training. The caregivers who have been working for a time between ten to fourteen years were found to be more educated on oral care previously (p=0.013). Many of the caregivers with a duration of working less than 5 years (75.0%) reported that they needed oral care education (Table 3).

Discussion

Oral health is undoubtedly accepted as part of the general health (13). One of the common problems effecting oral health is dental caries. Although it is assumed to be preventable, dental caries still remains to be a great public health problem especially in underdeveloped and developing countries (14).

Primary preventive applications are necessary in order to decrease caries prevalence. The first step should be the timely delivery of educational information to populations at high risk for developing caries. Educational programs for both the parents and caregivers are important to promote good oral health (2). Especially, the parents/caregivers of people belonging to high-risk groups should be targeted. Within this respect, the caregivers working in care homes should not be neglected. This group may involve very high numbers in countries with high disabled people populations. In the biggest rehabilitation center in Ankara where the current study held, 670 disabled people were living and 700 caregivers were responsible from them. Since the data collection of this study was performed between 9:00-16:00, only 170 caregivers were reached because of their shifted working system and 147 of them accepted to participate.

The area of responsibility of the caregivers at the survey care home includes nursing of the disabled individuals with regard to daily requirements such as nutrition, wearing, intake of medicines and medical consultation. Not all but 81.6% of the caregivers stated that they performed oral care of the disabled people. The rest of the caregivers did not deal with oral care because of the uncooperative behaviors of the disabled residents and time concerns. In parallel, Wardh et al. (15) reported that lack of time was the most asserted reason for not performing oral care of the disabled individuals. In another study, the main problem for the caregivers was to gain access to the oral cavity of the geriatric patients. They found oral health care is a low priority for the stuff (16). On the contrary, in another study, nursing staff considered oral care of the disabled individuals as a part of their role (17). Phylpo et al. (18) conducted a study on oral care needs and barriers perceived by caregivers. Physical resistance to oral care and lack of time have been regarded as barriers by the caregivers. In present study, some of the caregivers reported that they did not consider the oral care of the residents as part of their profession. Our results indicated a need for the encouragement of the caregivers to take part in the oral hygiene procedures of the disabled people. This may be accomplished by emphasizing the importance of oral hygiene in preventing caries and periodontal disease and in improving oral health. They might feel better in case the importance of their role is explained.

With regard to the feelings of the caregivers during oral care, 61.0% of them reported no change in their feelings while 21.6% did not like the procedure because of nausea or time concerns. Wardh et al. (15) compared attitude of nursing personnel working with elderly and severely disabled patients. They reported that nearly 30.0% of the respondents indicated some degree of embarrassment similar to the results of the present study. These results again emphasize the importance of encouragement of the caregivers in taking part of the oral care procedures.

More than half of the caregivers in this study reported that they did not agree in providing oral care of the uncooperative disabled people by force. In the current study, 79.2% of the residents whom the participants gave care were mentally disabled. Socially learning theory which posits that learning is influenced by psychological factors and behavioral learning theory could aid caregivers to better communicate and guide people with learning disability during oral care (19).

Diet, nutrition, oral hygiene, exposure to fluorides, tobacco and alcohol, acute and other chronic medical conditions are the six main factors included in the etiology of dental diseases (20). People with disabilities are at more risk of some of these factors (21). People at high risk for caries must visit dentist once in three months, regularly (12). In the present

study, only 12.9% of the caregivers suggested that the frequency of dental visits should be once in three months. Most of the disabled people have being referred to dental visit only in case of a complaint. Tiller et al. (22) also reported that people living in the community care were found to access dental services less frequently and more likely to attend only when having trouble. Financial problems or lack of specialized medical center with special equipment were stated as the reasons for not attending regular visits (16,23). In Turkey, the general health insurance covers the fees of dental examination, preventive procedures and most of the dental treatments. In the city where the present study was conducted, there have been enough oral health care centers and university clinics belonging to the government. Given these circumstances, the lack of regular visits is related to disregarding the importance of oral care.

In the present study, the distribution of correct knowledge on dental plaque and frequency of dental visits by sex, age groups and experience did not differ significantly. Abullais et al. (24) also evaluated 161 caregivers' knowledge, attitudes and practices on oral healthcare for the disabled and reported no difference in knowledge levels by sex and experience but reported significantly better knowledge in 20-29 years age group compared to the other age groups. They recommended that the knowledge of dental biofilm and its etiology in dental and periodontal diseases should be taught to the caregivers.

The second step of the primary prevention for the disabled people is the practical programs to promote appropriate oral hygiene procedures. Reportedly by Phylpo et al. (18), 70% and 75% of the caregivers stated to have enough/comprehensive theoretical knowledge and practical skills, respectively and 46% were relevant to getting oral health education. In this study, more than half of the caregivers reported that they did not know how to provide oral care of disabled individuals as they had not a training before. However, many of them were eager to get the oral care training. In parallel, the nursing staff in a study (15) claimed

Table 3. Previous oral care education and opinion about oral care training of the caregivers by to some characteristics (Ankara-Turkey, 2017)

	Previous education on oral care					p**	Need for oral care training					p**
	Yes		No		Total		Yes		No		Total	
Characteristics	n	%*	n	%*	n		n	%*	n	%*	n	
Sex												
Male	14	28.6	35	71.4	49	0.223	27	55.1	22	44.9	48	0.035
Female	38	38.8	60	61.2	98		71	75.5	27	24.5	94	
Age group												
≤29	3	27.3	8	72.7	11	0.770	8	72.7	3	27.3	9	0.868
30-39	15	34.9	28	65.1	43		27	62.8	16	37.2	41	
40-49	29	38.7	46	61.3	75		50	66.7	25	33.3	74	
≥50	5	27.8	13	72.2	18		13	72.2	5	27.8	18	
Level of education												
Primary school	22	38.6	35	61.4	57	0.202	37	66.1	20	33.9	56	0.835
Secondary school	15	44.1	19	55.9	34		22	68.8	12	31.3	32	
≥High school	15	26.8	41	73.2	56		39	72.2	17	27.8	54	
Duration of working as caregiver (years)												
≤5	10	25.0	30	75.0	40	0.013	30	75.0	10	25.0	39	0.378
5-9	14	26.9	38	73.1	52		31	59.6	21	40.4	49	
10-14	25	54.3	21	45.7	46		32	69.6	14	30.4	46	
≥15	3	33.3	6	66.7	9		5	55.6	4	44.4	8	

*Row percentages, **Chi-square test

education and training in daily oral care and suggested practical help from dental personnel. Abullais et al. (24) also recommended that educational and training programs should be routinely organized by the dental professionals in oral healthcare for the caregivers. It was reported by Wang et al. (25) that such training programs are effective in promoting oral health and hygiene conditions of the disabled patients.

In the present study, theoretical information about oral care has been given to the caregivers and they have been trained practically soon after the completion of the study. Both the education and training were scheduled to be performed in regular intervals in order to reach all the caregivers, but because of the shifted working system, it was not possible to train all staff.

This study was a non-representative descriptive study of the caregivers of an institute. In the present study, the caregivers' behavior about oral care was evaluated subjectively with a questionnaire. In the second step of the research, it was planned to assess oral hygiene status of the disabled people.

Health policy and some strategies including dentists, allied health professionals, primary care providers must be arranged to obtain the optimum oral health and thereby improve quality of life the disabled people.

Conclusion

The results of the present research highlighted that it would be reasonable including dentists within the staff as the dentists play a significant role in providing preventive and interceptive dental care, training parents and caregivers of the disabled individuals to obtain optimum oral hygiene. In this way, in-service training of caregivers and conveying education to disabled people on oral hygiene and ensuring follow-up with dental examinations of disabled four times a year can be organized. Besides, some preventive approaches like fluoride applications can be performed.

The results of the present research also revealed the need of the caregivers for training on oral care. Therefore, considering the shifted working system of the caregivers, efforts should be directed on oral care training both theoretically and especially practically to the all caregivers in regular intervals. Further prospective research aimed to evaluate the effectiveness of the training is required. The significance of the oral health should be emphasized to the caregivers to provide an intrinsic motivation. For improving the oral health of the disabled people, the caregivers must consider the oral care as a part of their profession.

Ethics

Ethics Committee Approval: This descriptive study was approved by the Ministry of Family and Social Policy in Turkey (20240283-202.99-E.58558/2017). This study does not require ethics committee approval.

Informed Consent: The patient is not included in this study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: M.U.T., B.G.D., M.D.T., Design: M.U.T., B.G.D., M.D.T., Supervision: M.U.T., M.D.T., E.E., Materials: E.B., M.U.T., E.E., Data Collection or Processing: E.B., E.E., Analysis or Interpretation: E.B., B.G.D., M.U.T., Literature Search: E.B., M.D.T., Critical Review: M.U.T., B.G.D., M.D.T., E.E., E.B., Writing: E.B., M.D.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Original Article / Özgün Araştırma

Clinical Evaluation of Using Three Different Materials in Primary Molar Class II Restorations

Süt Molar Dişlerinin Sınıf II Restorasyonlarında Üç Farklı Materyalin Klinik Başarısının Değerlendirilmesi

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Keywords
Primary molar teeth, compomer, glass carbomer cement, glass ionomer cement, restoration

Anahtar Kelimeler
Süt molar diş, kompomer, cam karbomer siman, cam iyonomer siman, restorasyon

Received/Geliş Tarihi : 21.10.2020
Accepted/Kabul Tarihi : 01.01.2021

doi:10.4274/meandros.galenos.2021.58966

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Abstract

Objective: This study aimed to compare the 12-month clinical performance of a glass carbomer cement (GCP glass fill), a glass hybrid cement (Equia Forte) and a compomer material (Dyract XP) in primary molar class II restorations.

Materials and Methods: The study was carried out on 105 primary molars with class II lesion in 35 children aged 6-9 years. Three different restorative materials were placed in each child. Restorations were evaluated according to the modified United States Public Health Service criteria after the first week and at sixth and 12th months. Data obtained were evaluated statistically.

Results: After 12 months, 32 children were available and 96 restorations were evaluated. The clinical success of the compomer material, glass carbomer cement, and glass hybrid cement were 96.9%, 15.6%, and 9.4%, respectively.

Conclusion: After the 12-month treatment period, the clinical success of the compomer material was significantly higher than those of the glass carbomer cement and glass hybrid cement groups.

Öz

Amaç: Bu çalışmanın amacı süt dişi sınıf II restorasyonlarında bir cam karbomer siman (GCP Glass Fill), bir cam hibrid siman (Equia Forte) ve bir kompomer materyalin (Dyract XP) 12 aylık klinik performansının karşılaştırılmasıdır.

Gereç ve Yöntemler: Çalışma 6-9 yaş arası 35 çocuğun sınıf II çürüğü bulunan 105 adet süt molar dişinde yürütülmüştür. Tüm çocuklarda her 3 materyal de kullanılmıştır. Restorasyonlar 1. hafta, 6. ay ve 12. ay sonunda modifiye Birleşik Devletler Halk Sağlığı Servisi kriterleri ile skorlanarak, sonuçlar istatistiksel olarak değerlendirilmiştir.

Bulgular: On iki ay sonunda 32 çocukta 96 restorasyon değerlendirilebilmiştir. Grupların klinik başarısı sırasıyla; kompomer grubunda %96,9, cam karbomer grubunda %15 ve cam hibrid grubunda ise %9,4 olarak bulunmuştur.

Sonuç: Kompomer materyalinin klinik başarısı 12 aylık takip sonunda hem cam karbomer hem de cam hibrid siman gruplarına göre istatistiksel olarak anlamlı düzeyde yüksek bulunmuştur.

Introduction

In recent years, the studies on restorative materials used for the restoration of primary teeth are continuing intensively. The properties required for these restorative materials are; physical and chemical properties should be compatible with the dental tissue, the aesthetic and mechanical properties should be satisfactory and its technical application to the cavity should be quick and easy.

Polyacid-modified composite resins, also known as compomers, and resin-modified glass ionomer cements are the most commonly used materials for the restoration of primary teeth; however, both materials are controversial due to their resin content (1,2). The use of traditional glass ionomer cements (GICs), which do not contain resin, is limited due to its moisture sensitivity, fracture resistance, low wear resistance, difficulties in processing materials and lack of aesthetics (3). For these reasons, the search for the restorative material of the primary tooth, which does not contain resin material but is sufficient regarding the physical and mechanical properties until the exfoliation of the primary tooth, continues.

In the recent years, glass hybrid restorative systems (Equia Forte Fil) in the high viscosity GIC group, which are developed to eliminate the existing problems such as moisture sensitivity and low physical-mechanical properties of GICs, have been introduced to the market. Glass hybrid cements are easy-to-use restorative systems with smaller and more reactive silicate particles and acrylic acid molecules with higher molecular weight (4).

Glass carbomer cements, which were developed as a result of the biomimetic studies while the search for an ideal restorative continues, are GIC with carbomer filler and nano-sized flourapatite/ hydroxyapatite speacially designed for its compounds. These materials are chemically hardened and do not contain monomer, resin, metal and Bisfenol A. Heat application and coating its surface with a special varnish is necessary for glass carbomer cements to develop (5).

There are many studies showing that compomer materials are successful alternatives to the composite, amalgam and GICs for the primary teeth class II cavities (6-8). However studies on clinical success of glass carbomer and glass hybrid cements are limited. The aim of this study was to compare the clinical succes of a glass carbomer cement (GCP Glass Fill) and a glass hybrid cement (Equia Forte Fil) in comparison with a compomer material (Dyract XP); due to the concerns over the resin content of compomer materials.

Materials and Methods

Ethics committee approval required for our research was received from the Board of Research Ethics Committee of Aydın Adnan Menderes University Faculty of Dentistry (protocol no: 2017/002, date: 22.03.2017). The patients and their parents who participated in the study, were informed in details and their written consents were received.

The G*Power program (version 3.1.9.2 for Windows) was used to determine the success rate of the power analysis: the total number of samples detected was n=24, for the effect size: 0.576, with a power: 0.80 and α: 0.05. Considering the follow-up aspect of the study, total sample size was determined as 35 due to the possibility of loss in the follow-up.

This study was performed on 35 (20 boys, 15 girls) children aged between six to nine years (average 7,5) who applied Aydın Adnan Menderes University, Faculty of Dentistry Department of Pediatric Dentistry and those participants with a behavior rating three or four scores according to the Frankl behavioral scale (9). Patients having at least three primary molar teeth with class II caries not exceeding ½ of dentin in the radiographic examination, no indication for pulp therapy or other restorative treatment, no undermining of cusps by caries, no caries lesions extending below the gingival margin, not showing pathological internal or external root resorption, and not exceeding 2/3 of the root of physiological root resorption were included to the study. The children were given oral hygiene instructions and additional dental treatments required for other teeth were done during the study period.

Patients with a history of known or suspected allergy and with a history of bruxism, skeletal and dental malocclusion, congenital developmental defect and those who stated that they could not come to their controls regularly were excluded from the study.

The cavity preparation was performed under water cooling with high-speed diamond burs, under local anesthesia if needed, according to minimally invasive preperation rules. Caries was removed with

hand tools and steel burs. Rubber-dam (OptiDam™, Kerr) isolation was used in children who were cooperative and first molar teeth was present in the mouth. Isolation was achieved with cotton roll and suctions in such cases as; the first molar teeth was not present in the mouth; or when parents did not approve the application of rubber dam or in children whose cooperation was affected negatively during the rubber-dam application. In each child three teeth were restored with different materials, by using stratified block randomization and simple randomization methods. The teeth were restored with one of the Compomer material (Dyract XP, Dentsply, Germany), Glass Carbomer Cement (GCP Glass Fill, GCP, Netherlands) or Glass Hybrid Cement (GC Equia Forte Fil, GC Industrial Co, Tokyo, Japan) by using Palodent® Plus matrix system. Restorative materials were applied according to the manufacturers' directions by a single practitioner. Glass carbomer and glass hybrid cements were exposed to heat treatment with a light-curing of GC D-Light Duo LED at 1200-1350 mW/cm^2 light intensity during hardening. For surface protection, both of the glass carbomer and glass hybrid cements were covered with GCP Gloss (GCP, Netherlands) which does not contain resin material. The content of the materials used in the research are provided in details in Table 1.

Restorations were evaluated clinically after one week, six months and 12-months according to the modified United States Public Health Service (USPHS) evaluation criteria (10). Radiographic examination was performed with bite-wing radiographs at sixth and 12th months.

Statistical Analysis

Statistical analysis was performed using the IBM SPSS Statistics 17.0 (IBM Corporation, Armonk, USA) programme. Cochran's Q test was used to determine the significance of the difference in terms of success rates with respect to monitoring time regarding USPHS criteria. The results for $p<0.05$ were considered statistically significant unless indicated otherwise.

Results

Statistical evaluation was carried out from the data of 32 patients and 96 (91.42%) restorations; since three patients did not attend their appointments during the 12-month follow-up. The average age of the patients was 7.5±1.0 (year) and 19 (59.4%) of them were boys and 13 (40.6%) of them were girls. In eight (25.0%) cases restorations were performed under rubber-dam isolation.

When overall results in three restorative material groups were evaluated, no statistically significant differences were observed in the incidence of success between the genders ($p>0.0056$). Also, there was not any significant difference between the restorations performed under rubber dam or cotton rolls isolation ($p>0.0056$).

Table 1. Materials and their contents used in the study

Material	Type	Content	Producing company
Dyract XP	Compomer	UDMA, TCB Resin, TEGDMA, trimethacrylate and dimethacrylate resin, camphoquinone, ethyl-4benzoate, BHT, UV stabilizator, strontium-alumino-sodium-floro-fhosphor-silicate glass, silicon dioxide, stronsium flour, iron oxide and titanium oxide pigments	Dentsply, Germany
Prime & Bond NT	Dentin bonding agent	PENTA, UDMA, Tresin, D-resin, nanofiller, photoinitiator, stabilizators, acetone, cetylamine hidroflorid	Dentsply, U.S.A
GCP Glass Fill	Glass carbomer cement	Floro-aluminosilicate, glass apatite, polyacid	GCP, Netherlands
GC Equia Forte Fil	Glass hybrid cement	Floroaluminosilicate glass, polyacrylic acid dust, processed glass particule	GC Industrial Co (Tokyo, Japan)
GCP Gloss	-	Modified polysiloxane	GCP, Netherlands

UDMA: 4-trimethylhexane, TCB: Tungsten-carbide burs, TEGDMA: Triethylene glycol-dimethacrylate, BHT: Butylhydroxytoluene, UV: Ultraviolet

The results of the restorations regarding modified USPHS criteria during the 12-months follow-up period are shown in Table 2. In terms of overall success, success rates at first week are statistically similar between the three groups of restorative materials (p=0.174), however; there is a statistically

Table 2. The results of the restorations regarding modified United States Public Health Service criteria during the 12-months follow-up period

			Compomer	Glass carbomer cement	Glass hybrid cement
Anatomical form	1st week	Alpha	32 (100%)	28 (87.5%)	30 (93.8%)
		Bravo	-	2 (6.3%)	1 (3.1%)
		Charlie	-	2 (6.3%)	1 (3.1%)
	6th month	Alpha	31 (96.9%)	10 (31.3%)	9 (28.1%)
		Bravo	-	2 (6.3%)	-
		Charlie	1 (3.1%)	20 (62.5%)	23 (71.9%)
	12th month	Alpha	31 (96.9%)	5 (15.6%)	2 (6.3%)
		Bravo	-	1 (3.1%)	2 (6.3%)
		Charlie	1 (3.1%)	26 (81.3%)	28 (87.5%)
Marginal integrity	1st week	Alpha	32 (100%)	30 (93.8%)	29 (90.6%)
		Bravo	-	-	2 (6.3%)
		Charlie	-	2 (6.3%)	1 (3.1%)
	6th month	Alpha	31 (96.9%)	6 (18.8%)	8 (25%)
		Bravo	-	6 (18.8%)	1 (3.1%)
		Charlie	1 (3.1%)	20 (62.5%)	23 (71.9%)
	12th month	Alpha	30 (93.8%)	2 (6.3%)	3 (9.4%)
		Bravo	1 (3.1%)	4 (12.5%)	1 (3.1%)
		Charlie	1 (3.1%)	26 (81.3%)	28 (87.5%)
Marginal discoloration	1st week	Alpha	32 (100%)	32 (100%)	31 (96.9%)
		Bravo	-	-	-
		Charlie	-	-	1 (3.1%)
	6th month	Alpha	32 (100%)	21 (65.6%)	20 (62.5%)
		Bravo	-	-	-
		Charlie	-	11 (34.4%)	12 (37.5%)
	12th month	Alpha	31 (96.9%)	10 (31.3%)	9 (28.1%)
		Bravo	-	1 (3.1%)	-
		Charlie	1 (3.1%)	21 (65.6%)	23 (71.9%)
Color match	1st week	Alpha	32 (100%)	16 (50%)	23 (71.9%)
		Bravo	-	16 (50%)	8 (25%)
		Charlie	-	-	1 (3.1%)
	6th month	Alpha	32 (100%)	6 (18.8%)	11 (34.4%)
		Bravo	-	14 (43.8%)	8 (25%)
		Charlie	-	12 (37.5%)	13 (40.6%)
	12th month	Alpha	31 (96.9%)	2 (6.3%)	2 (6.3%)
		Bravo	-	8 (25%)	6 (18.8%)
		Charlie	1 (3.1%)	22 (68.8%)	24 (75%)

Table 2 continued

Retention loss	1st week	Alpha	32 (100%)	29 (90.6%)	31 (96.9%)
		Bravo	-	3 (9.4%)	-
		Charlie	-	-	1 (31%)
	6th month	Alpha	31 (96.9%)	11 (34.4%)	9 (28.1%)
		Bravo	-	9 (28.1%)	11 (34.4%)
		Charlie	1 (3.1%)	12 (37.5%)	12 (37.5%)
	12th month	Alpha	31 (96.9%)	6 (18.8%)	3 (9.4%)
		Bravo	-	4 (12.5%)	6 (18.8%)
		Charlie	1 (3.1%)	22 (68.8%)	23 (71.9%)
Secondary caries	1st week	Alpha	32 (100%)	32 (100%)	32 (100%)
		Bravo	-	-	-
	6th month	Alpha	32 (100%)	27 (84.4%)	29 (90.6%)
		Bravo	-	5 (15.6%)	3 (9.4%)
	12th month	Alpha	31 (96.9%)	12 (37.5%)	9 (28.1%)
		Bravo	1 (3.1%)	20 (62.5%)	23 (71.9%)

significant difference between the clinical success of the materials at sixth and 12th months (p<0.001) (Figure 1). The overall success rates are significantly lower in glass carbomer cement and glass hybrid cement groups, when compared to the compomer group (p<0.001). The overall success rates of glass carbomer cement and glass hybrid cement groups are statistically similar at sixth and 12th month (p=0.774 and p=0.687 respectively) (Table 3).

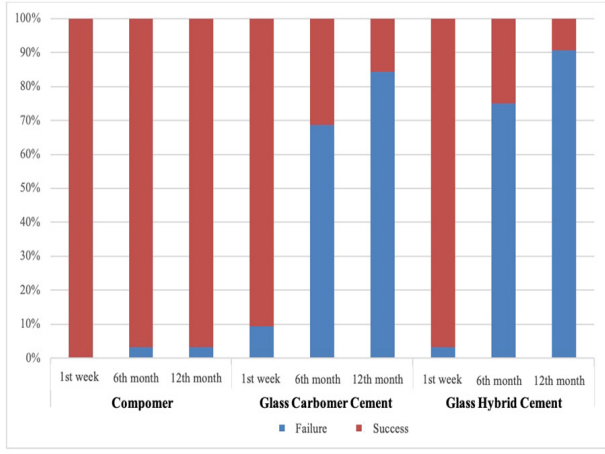

Figure 1. Overall success rates of the three groups

Discussion

As concerns over the biocompatibility of resin-based materials have increased over the last few years, there has been an increasing trend towards resin-free, biocompatible, remineralization-enhancing

Table 3. Overall success rates according to materials and follow-up times

	Compomer (n=32)	Glass carbomer cement (n=32)	Glass hybrid cement (n=32)	p-value †¶
1st week	32 (100%)	29 (90.6%)[a,b]	31 (96.9%)[a,b]	0.174
6th month	31 (96.9%)[A,B]	10 (31.3%)[A,a]	8 (25%)[B,a]	<0.001
12th month	31 (96.9%)[A,B]	5 (15.6%)[A,b]	3 (9.4%)[B,b]	<0.001
p-value ‡¶	0.368	<0.001	<0.001	-

•†Comparisons between materials within each follow-up time, ‡Comparisons between follow-up times in material groups, ¶Cochran's Q test, results for p <0.0167 were considered statistically significant according to the Bonferroni Correction, [A]The difference between the Compomer group and the Glass Carbomer Cement group is statistically significant (p<0,001), [B]The difference between the Compomer group and the Glass Hybrid Cement group is statistically significant (p<0.001), [a]The difference between the 1st week and the 6th month is statistically significant (p<0.001), [b]The difference between the 1st week and the 12th month is statistically significant (p<0.001)

restorative materials (11,12). GICs are one of the most frequently used restorative materials in pedodontics. However; the weak physical and mechanical properties of conventional GIC, its sensitivity to dryness and moisture, lack of aesthetics limits its use (13). Manufacturers have introduced restorative materials such as glass carbomer cement and glass hybrid cement in order to eliminate the negative features of GIC's and provide alternative restorative materials used frequently in the posterior region (3,14). In this clinical study, it was aimed to examine the clinical success of these biocompatible materials compared to a compomer material, which has been widely used in primary teeth.

The negative impact of external effects on the material during the long-lasting hardening reaction of GICs is one of the most important disadvantages and to reduce this critical time as much as possible is desired. It is thought that heat polymerization shortens this period and enables GIC to reach optimum physical properties in a shorter time (15,16). With all this information and according to the recommendation of the manufacturer, in order to obtain the best clinical results; glass carbomer and glass hybrid cement restorative materials were processed with heat through D-Light Duo LED Curing Light light source of 1200-1350 mW/cm^2 light power for 90 seconds, in our study.

Moisture isolation can be provided by the use of rubber dam or cotton rolls together with the suctions. In eight patients who participated our study, isolation was provided with rubber-dam and suctions; and for the rest of the patients cotton rolls and suctions were used. It has been reported that the use of rubber dam or cotton rolls for isolation had the same effect on the clinical success of the restorations (17-19). Similarly, in our study, no significant difference was found between the restorations done with either rubber dam or cotton rolls.

USPHS criteria, first published in 1971 and reprinted in 2005, is still the most widely used system to evaluate the important features of dental restorations (10) so; in our study, modified USPHS criteria was used to evaluate restorations.

The results of our clinical study has shown that, the rate of clinically successful restorations at the end of 12 months were 96.9% in the Dyract XP group, 15.6% in the GCP Glass Fill group and 9.4% in the Equia Forte group. In the literature there are many studies showing that compomer materials are successful alternatives to the composite, amalgam and GICs for the primary teeth class II cavities (6-8). Pascon et al. (7) who compared the clinical success of compomer and composite restorations for 24 months; have concluded that the compomer groups showed high clinical success in both class I and class II restorations when compared to composite restorations. Welbury et al. (20) compared the clinical success of a compomer material with a glass ionomer material in primary molar teeth restorations. They reported that after 42 month follow up compomer restorations were significantly more successful than the glass ionomer restorations. Similarly Duggal et al. (8) have reported high retention rates of compomer restorations in class II primary molar teeth when compared with amalgam restorations. In our study the compomer material group showed 96.9% success after 12-months and this result was significantly better than the other two restorative materials.

When the clinical studies examining the GICs were evaluated, it has been reported that the annual failure rates for class I restorations vary between 0% and 17% and for the class II restorations these rates vary between 2.2% and 25.8%. One of the reasons for the varying failure rates in the studies may be the different types of GICs used in the studies (21). The two types of GICs used in our study showed much more higher failure rates than these studies. Although the number of in-vivo studies using GCP Glass Fill is very low, studies evaluating the clinical performance of this material have shown that it has significantly lower clinical success (36%) than a compomer material (56%) in class II restorations (22,23). Similarly in our study GCP Glass Fill restorations were found to be unsuccessful compared to the Dyract XP restorations and have the same clinical success as Equia Forte Fil. The failure of the GCP Glass Fill restorations may be due to the low mechanical properties and the surface covering that cannot protect the material sufficiently.

Success of high viscosity GICs in permanent teeth was evaluated in a few clinical trials and acceptable retention performance was reported (24-26). The studies evaluating the clinical performance of high viscosity glass ionomers in primary teeth are fewer. De França et al. (22) compared the survival rate of atraumatic restorative treatment (ART) class II

restorations in primary teeth, performed with glass carbomer cement and a high-viscosity GIC. After 12 months, the overall success rates of glass carbomer cement and high-viscosity GIC groups were 56% and 86%, respectively and this difference was found to be statistically significant. Olegário et al. (23) have reported a survival rate of 56% after three years of occlusoproximal ART restoration with high-viscosity GIC. The results of these studies do not fully agree with the results of our study. The reason for the low clinical success results in Equia Forte Fil group in our study may be contributed to the covering applied over the material. During the application of restorations, the recommendations of the manufacturers have been followed but as a result of our search for alternative resin-free, biocompatible restorative material for primary teeth, instead of using resin containing surface covering Equia Forte Coat, the surface of the Equia Forte Fil restorations were covered with resin-free silicone-containing surface covering GCP Gloss. This may have negative effects on the mechanical properties of the material (27). Another group with Equia Forte Coat coverage could be added to find out the effect of resin covering on Equia Forte Fil, and this could be the limitation of our study.

Conclusion

Widely used compomer materials in primary teeth restorations have high clinical success rates but they have resin content. In this study we aimed to find an alternative restorative material for primary teeth restorations with no resin content. However; it can be concluded that neither GCP Glass Fill nor Equia Forte Fil applied without resin covering was found to be a good alternative to Dyract XP. Different clinical studies with long-term follow-ups are needed regarding this issue.

Ethics

Ethics Committee Approval: Ethics committee approval required for our research was received from the Board of Research Ethics Committee of Aydın Adnan University Faculty of Dentistry (protocol no: 2017/002, date: 22.03.2017).

Informed Consent: The patients and their parents who participated in the study, were informed in details and their written consents were received.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: I.S., Design: I.S., Ş.E., Supervision: I.S., Ş.E., Fundings: I.S., Ş.E., Materials: Ş.E., Data Collection or Processing: Ş.E., Analysis or Interpretation: I.S., Ş.E., Literature Search: Ş.E., Critical Review: I.S., Ş.E., Writing: I.S., Ş.E.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: This work was supported by Aydın Adnan Menderes University Research Fund (project no: DHF-17001).

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Original Article / Özgün Araştırma

Effect of Non-surgical Periodontal Treatment on Gingival Crevicular Fluid Interleukin-1beta and Interleukin-37 in Different Periodontal Diseases

Farklı Periodontal Hastalıklarda Cerrahisiz Periodontal Tedavinin Diş Eti Oluğu Sıvısı İnterlökin-1beta ve İnterlökin-37 Üzerine Etkisi

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Keywords
Gingival crevicular fluid, interleukin-37, periodontal treatment, periodontitis

Anahtar Kelimeler
Diş eti oluğu sıvısı, interlökin-37, periodontal tedavi, periodontitis

Received/Geliş Tarihi : 31.07.2020
Accepted/Kabul Tarihi : 03.01.2021

doi:10.4274/meandros.galenos.2021.09821

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Abstract

Objective: Interleukin-37 (IL-37), which is a natural inhibitor of innate immunity, is correlated with chronic inflammation and some autoimmune diseases. Pro-inflammatory cytokines, for example, interleukin-1beta (IL-1β), which plays a key part in the periodontium, can induce IL-37. This study aimed to investigate the effect of non-surgical periodontal treatment on gingival crevicular fluid (GCF) IL-37 and IL-1β levels in generalized aggressive periodontitis (G-AgP) and generalized chronic periodontitis (GCP).

Materials and Methods: Thirty-five patients with G-AgP, 30 patients with GCP and 30 volunteers with healthy periodontal status (C) were included in this research. Patient groups received scaling and root planning with periodontal hand instrumentations. Clinical periodontal parameters and GCF samples were collected at baseline and at six weeks following SRP. Biomarker levels in GCF were analysed by enzyme-linked immunosorbent assay.

Results: Both periodontitis groups exhibited significant improvement in clinical parameters ($p<0.05$). GCF IL-37 levels were significantly higher in G-AgP and GCP groups than in the C group at baseline ($p<0.05$). Following periodontal treatment, GCF IL-37 levels were decreased and comparable in all groups. The GCF IL-1β levels were significantly higher at baseline in the G-AgP group than those in GCP and C groups, and after periodontal therapy, a decrease was detected in GCF IL-1β levels. GCF levels of IL-1β were positively correlated with GCF IL-37 levels.

Conclusion: Clinical improvement was found in both periodontitis groups after periodontal treatment. IL-1β is a key regulator of periodontal inflammation and bone resorption. According to the results of our research, IL-37 may be useful marker of determining the clinical health and disease status of patients with periodontitis. However, further studies are required to determine the mechanism of IL-37 in periodontal inflammation.

Öz

Amaç: Doğal bağışıklığın doğal bir inhibitörü olan interlökin-37 (IL-37), kronik enflamasyon ve bazı otoimmün hastalıklarla ilişkilidir. Periodonsiyumda önemli bir rol oynayan IL-1beta (IL-1β) gibi pro-enflamatuvar sitokinler, IL-37'yi indükleyebilir.

Bu araştırmada, cerrahi olmayan periodontal tedavinin generalize agresif (G-AgP) ve generalize kronik periodontitiste (GCP) diş eti oluğu sıvısı (DOS) IL-37 ve IL-1β düzeyleri üzerine etkilerinin araştırılması amaçlanmıştır.
Gereç ve Yöntemler: Otuz beş G-AgP hastası, 30 GCP hastası ve 30 periodontal olarak sağlıklı gönüllü (C) çalışmaya dahil edildi. Hasta gruplarına periodontal el aletleri ile detertraj ve kök yüzeyi düzleştirmesi uygulandı. Klinik periodontal parametrelerin ve DOS örneklerinin toplanması başlangıçta ve tedaviden 6 hafta sonra gerçekleştirildi. DOS'daki biyobelirteç seviyeleri enzim bağlı immünosorbent deneyi ile analiz edildi.
Bulgular: Her iki periodontitis grubu da klinik parametrelerde anlamlı düzelme gösterdi ($p<0,05$). Başlangıçta DOS IL-37 düzeylerinin G-AgP ve GCP gruplarında C grubuna göre anlamlı olarak yüksek olduğu belirlendi ($p<0,05$). Periodontal tedaviyi takiben tüm gruplarda DOS IL-37 düzeyleri düştü ve benzerdi. Başlangıçta DOS IL-1β düzeylerinin G-AgP grubunda GCP ve C gruplarına göre anlamlı olarak daha yüksek olduğu ve ayrıca periodontal tedaviden sonra DOS IL-1β düzeylerinde bir azalma olduğu tespit edildi. DOS IL-1β'nın düzeyi, DOS IL-37 düzeyleri ile pozitif korelasyon gösterdi ve ayrıca periodontal tedaviden sonra DOS IL-1β düzeylerinde bir azalma tespit edildi.
Sonuç: Periodontitis gruplarında periodontal tedavi sonrası klinik iyileşme gözlendi. IL-1β, periodontal enflamasyon ve kemik rezorpsiyonunun önemli bir düzenleyicisidir. Araştırmamızın bulgularına göre, IL-37, periodontitisli hastaların klinik sağlık ve hastalık durumlarını belirlemek için yararlı bir belirteç olabilir. Bununla birlikte, periodontal enflamasyonda IL-37'nin mekanizmasını belirlemek için daha fazla çalışmaya ihtiyaç vardır.

Introduction

Periodontal diseases represent inflammatory diseases, which cause the destruction of hard and soft tissues (1). The inflammatory pathway is triggered by dysbiotic microbiota and several other factors, including gender, smoking, and diabetes, which make a contribution to the development and progression of inflammation (2). Besides, factors influencing the immune response, especially the suppression of the host immune system, also take a considerable part in the progress of periodontal diseases (3-5). Since inflammation is a versatile sequence of events, inflammatory and immune responses involve a multifaceted group of protective and damaging reactions that are mainly intervened by a network of chemokines, pro-inflammatory cytokines, anti-inflammatory cytokines, and matrix metalloproteinases, eventually leading to degradation of the periodontium (6). The interactions of these networks determine the course of inflammation either towards the disease or health.

Proinflammatory cytokines, including interleukin-1beta (IL-1β) are very important in initiating and regulating immune responses in the periodontium by stimulating osteoclastic activity and inflammation-induced bone resorption (7). Higher IL-1β levels were also demonstrated at the moderate and deep pocket sites, indicating a positive correlation between the degree of inflammation and IL-1β levels in gingival tissues and gingival crevicular fluid (GCF) (8-13). Decreases in IL-1β levels after periodontal therapy also support this correlation (8,14).

There are also inhibitory pathways to suppress IL-1β and inflammation within the IL-1 family. IL-37, which represents a member of the IL-1 family (IL-1F7), is an anti-inflammatory cytokine and can be induced by pro-inflammatory cytokines including IL-1β, tumor necrosis factor-alpha (TNF-α), and interferon-γ (IFN-γ) in dendritic cells and peripheral blood mononuclear cells (PBMCs) (15). IL-37 has been detected in synoviocytes obtained from subjects with rheumatoid arthritis (RA), macrophages obtained from subjects with *Mycobacterium avium* infection, foam cells obtained from the atheroma plaque, bowel macrophages obtained from subjects with Crohn's disease, keratinocytes obtained from psoriasis lesions, and monocytes obtained from subjects with lupus (16-18). IL-37 functions as an anti-inflammatory cytokine by reducing the release of pro-inflammatory cytokines. The expression of IL-37 was anomalous in autoimmune diseases, including the increased expression of IL-37 in plasma or peripheral PBMCs (19,20). According to our knowledge, there is only few study that presents information on IL-37 in periodontal diseases. Sağlam et al. (21) conducted on subjects having gingivitis and chronic periodontitis (CP) and reported no significant change in levels of cytokines in GCF, saliva, and plasma specimens. GCF IL-37 levels have also been showed positively correlated with IL-1β in aggressive periodontitis (AgP) patients (22).

Imbalanced pro- and anti-inflammatory cytokine activities provide suitable conditions for the initiation of chronic inflammation. The decreased levels of IL-37 are associated with disease activity in chronic inflammatory and auto-immune diseases. However,

there is limited data on IL-37 in the pathogenesis and disease activity of periodontitis. Moreover, whether IL-37 and IL-1β are correlated with each other and the impacts of periodontal treatment on IL-37 levels remain unclear in periodontitis. Therefore, the present research aimed to assess whether GCF IL-37 and IL-1β levels were correlated in patients with aggressive and CP and in comparison with healthy controls and also to reveal the impacts of periodontal therapy on these cytokines levels.

Materials and Methods

Patient Population

Patients were enrolled in the current research by collecting the whole mouth clinical periodontal data. This research was designed as a case-control study. The research protocol of this study was confirmed by the Clinical Research Ethics Committee of Cumhuriyet University in accordance with the Declaration of Helsinki (2016-02/05, date: 16.02.2016), and informed consent was acquired from all subjects. The total number of subjects in the current research was 95, consisting of 35 subjects with generalized aggressive periodontitis (G-AgP) (24 females, 11 males), 30 subjects with generalized chronic periodontitis (GCP) (17 females, 13 males), and 30 periodontally healthy controls (19 females, 11 males).

Clinical examinations [gingival index (GI), plaque index (PI), clinical attachment level (CAL), and probing depth (PD)] were performed (23). Panoramic radiographs were taken and assessed to measure interproximal bone loss from the cementoenamel junction of the tooth to the bone crest in order to diagnose G-AgP or GCP or being periodontally healthy. The diagnostic criteria for G-AgP and GCP were determined according to the classification, which was accepted at the World Workshop for Periodontics and the American Academy of Periodontology (1999) (24).

The selected patients had a minimum of 16 teeth with at least one tooth in each posterior sextant with a minimum of 3 natural teeth. The body mass index (BMI) can affect the release of inflammatory cytokines that we choose the patients who were BMI values between 18.5 and 24.5. Patients over the age of 35 years, having attachment loss equal to or higher than 5 mm at multiple tooth sites and having more than three sites of PD higher than 6 mm including more than one tooth distributed in every quadrant were diagnosed with GCP.

Patients having more than eight teeth with the attachment loss equal to or higher than 5 mm and the PD equal to or higher than 6 mm, and minimum three affected teeth, being not first molars or incisors, were diagnosed with G-AgP.

Patients without the evidence of attachment loss at multiple sites or with the pocket depth equal to or less than 3 mm were diagnosed as being periodontally healthy and utilized as controls.

According to "Classification of Periodontal and Peri-implant Diseases and Conditions 2017", our G-AgP patients can be included in the "Stage 4, Generalized, Grade C" and our GCP patients can be included in the "Stage 3, Generalized, Grade B" group, based on the clinical parameters, the age of onset and the clinical course of the disease (25).

Exclusion criteria were having the receipt of antibiotics or having undergone periodontal therapy 3 months before the research, conservative or prosthetic restorations in the anterior region, periodontal destruction caused by poor restorations, pregnancy and lactation, a history of systemic disease or medication that might influence the periodontal condition, and subjects lacking capacity to consent for themselves. Furthermore, smoking may constitute the main risk factor in periodontal diseases. Therefore, we have excluded smokers from the study.

Clinical Measurement and Periodontal Therapy

Full-mouth measurements of probing pocket depth (PPD) and CAL were obtained at six points per tooth. The PI was utilized for scoring the presence of supragingival plaque, while the GI was used for scoring gingival inflammation (26). A Williams periodontal probe (Hu-Friedy, Chicago, IL, USA) was utilized to obtain PD and CAL measures. In all subjects, individual acrylic stents were formed using grooves as reference points to measure CAL. A single specialist performed the collection of clinical data and specimens (E.P.G.). The intra-examiner reproducibility of PPD was evaluated, and the intra-examiner reliability was found to be high (≥98%). After the baseline measurements were recorded, phase 1 therapy, consisting of oral hygiene instructions, scaling and root planing (SRP), was implemented on patients having periodontitis (27). The SRP procedure was carried out within 10 days by utilizing Gracey curettes (Hu-Friedy, Chicago,

IL, USA). No antibiotics were prescribed. Recording of the clinical measurements and GCF sampling from the exemplification sites was performed at baseline and six weeks.

Gingival Crevicular Fluid Collection and Analysis

Before starting to collect GCF samples, the area surrounding the tooth was isolated using cotton rolls, dried, and the removal of the supragingival plaque was performed by means of a sterile curette. The collection of GCF specimens was carried out, and they were pooled from 3 non-adjacent proximal sites with a moderate PPD. The collection of GCF samples was performed using Periopaper® strips, and they were stored at a temperature of -80 °C until the analysis was conducted. 300 µL of phosphate buffer solution was added to Eppendorf tubes to extract the collected GCF specimens by impregnating Periopaper. The vial was mixed by the vortex mixer for 1 minute to allow the passage of the GCF liquid to the solution. The obtained contents were used for analyzing IL-1β and IL-37. An enzyme-linked immunosorbent assay kits (Boster, Pleasanton, CA and Elabscience, Wuhan, China) were utilized for measuring the IL-1β and IL-37 levels, following the instructions of the manufacturer.

The calculation of GCF cytokine levels was performed from the standard curves, and they were defined as picogram/site for the total amount of cytokine levels. The score of 0 was given to sites having cytokine levels lower than the limits of the detectability of the assay.

Statistical Analysis

Clinical and biochemical analyses were carried out using SPSS 22 (IBM, Chicago, IL, USA) program. The Kolmogorov-Smirnov test was performed for analyzing the data distribution. Comparisons between the groups were evaluated by the One-Way ANOVA and Unpaired T tests. The Paired T test was conducted for assessing differences between baseline and 6-week values in the GCP and G-AgP groups. Pearson correlation was done to compare the GCF IL-37 and IL-1β levels with a significance set at $p<0.01$. The level of $p<0.05$ was considered to be statistically significant. The calculation of the sample size was performed under a 5% error considering a required sample size of 30 in every group, with a statistical power of 80% (28).

Results

A total of 35 subjects with G-AgP, 30 subjects with CP, and 30 healthy controls took part in the research. Table 1 contains information on the demographic features of the study groups. When the groups were compared with the healthy controls, no statistically significant differences could be determined with regard to gender. The mean age was significantly lower in the G-AgP group than the GCP group ($p<0.05$), but the mean age was similar in the G-AgP and control groups.

In accordance with the results of the statistical analysis of clinical parameters, a significant decrease was detected in subjects with G-AgP and GCP in all clinical parameters with significant improvement at 6 weeks ($p<0.05$) (Table 2). The PI differed statistically significantly between the G-AgP and GCP groups at baseline. However, after periodontal therapy, the PI was found to be similar in both groups.

In accordance with the findings of GCF cytokine statistical analysis (Table 3, Figure 1), the GCF IL-1β level was determined to be significantly higher in the G-AgP group in comparison with that in the GCP and

Table 1. Demographic characteristics of the study groups

	G-AgP (n=35)	GCP (n=30)	Healthy controls (n=30)
Age (years)			
Mean ± standard deviation	28.9±5.8[¥]	35.2±5.9[*]	30.2±5.7
Range	18-39	25-48	22-44
Gender			
Male n (%)	11 (31.4)	13 (43.3)	11 (36.6)
Female n (%)	24 (68.5)	17 (56.7)	19 (63.4)

*P<0.05 different from healthy controls, [¥]p<0.05 different from the generalized chronic periodontitis group, GCP: Generalized chronic periodontitis, G-AgP: Generalized aggressive periodontitis

C groups at baseline. In addition, the GCF IL-1β level decreased significantly at 6 weeks in the G-AgP group. The GCF IL-1β level was determined to be significantly higher in the GCP group compared to that in the C group at baseline. Following periodontal therapy, the GCF IL-1β level was similar in G-AgP and GCP groups but GCF IL-1β level was significantly higher in G-AgP and GCP groups than control group.

A significantly higher GCF IL-37 level was determined in the G-AgP and GCP groups in comparison with the C group at baseline, but after periodontal therapy, the GCF IL-37 level decreased significantly in the patient groups ($p<0.05$).

In the GCP and G-AgP groups, GCF IL-1β and IL-37 levels were positively correlated at baseline ($p<0.05$, $r=0.930$; $p<0.05$, $r=0.916$). Moreover, these cytokines were positively correlated after periodontal therapy in the GCP group ($p<0.05$, $r=0.918$).

In the GCP group, a negative relationship was determined between the baseline PI and GCF IL-1β and IL-37 levels after periodontal therapy ($p<0.05$, $r=-0.565$, $r=-0.499$, respectively).

Discussion

In the current research, we evaluated the levels of pro- and anti-inflammatory cytokines, IL-1β and IL-37, in GCP and G-AgP patients before and after non-surgical periodontal treatment. As far as we know, the present research is the first study that reports data on the impacts of non-surgical periodontal treatment on GCF IL-37 and IL-1β levels in both aggressive and CP. Along with the improved clinical parameters, the GCF IL-1β and IL-37 levels were determined to be elevated and positively correlated in both periodontitis subjects and significantly decreased following periodontal therapy.

On comparison of PI, GI, PD and CAL values amoung the groups, the mean PI, GI, PD and CAL was found to be statistically highly significant between groups. All clinical periodontal parameters were highly in G-AgP and GCP groups. All clinical parameters decreased after periodontal therapy. Moreover, in good agreement, non-surgical periodontal therapy was found to be effective in this study. It resulted in a significant mean

Table 2. Clinical parameters of the study groups at baseline and 6 weeks (mean ± standard deviation)

		G-AgP	GCP	Healthy controls
PI	Baseline	1.27±0.7[c,b]	1.5±0.6[b,d]	0.5±0.5
	6-week	0.3±0.4[a]	0.5±0.5[a]	
GI	Baseline	1.8±0.5[b]	1.8±0.4[b]	0.06±0.2
	6-week	0.6±0.5[a,b]	0.5±0.5[a,b]	
PD (mm)	Baseline	5.4±1.2[b]	5.6±1.2[b]	2.8±0.3
	6-week	3.2±0.7[a,b]	3.3±0.6[a,b]	
CAL (mm)	Baseline	9.7±2.2[b]	10±2.1[b]	-
	6-week	8.1±1.8[a,b]	8.4±1.9[a,b]	

[a]p<0.05 different from baseline, [b]p< 0.05 different from healthy controls, [c]p<0.05 different from generalized chronic periodontitis, [d]p<0.05 different from generalized aggressive periodontitis. G-AgP: Generalized aggressive periodontitis, GCP: Generalized chronic periodontitis, PI: Plaque index, GI: Gingival index, PD: Pocket depth, CAL: Clinical attachment level, NA: Not applicable

Table 3. Gingival crevicular fluid cytokine levels of the study groups at baseline and 6 weeks (pg/30 s, mean ± standard deviation)

		G-AgP	GCP	Healthy controls
IL-1β	Baseline	298.09±86.93[b,c]	152.0±96.72[b]	92.81±20.63
	6-week	139.40±53.64[a]	137.68±73.04	
IL-37	Baseline	768.85±129.91[b]	714.45±108.76[b]	489.69±82.45
	6-week	484.77±139.12[a]	531.1±101.08[a]	

[a]p<0.05 different from baseline, [b]p<0.05 different from healthy controls, [c]p<0.05 different from generalized chronic periodontitis, GCP: Generalized chronic periodontitis, G-AgP: Generalized aggressive periodontitis, IL: Interlevkin

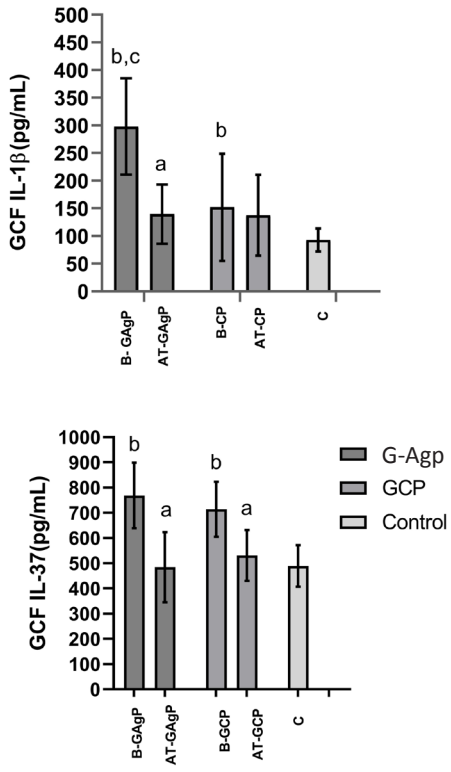

Figure 1. Gingival crevicular fluid (GCF) cytokine levels of the study groups at baseline and after treatment (pg/30 s, mean ± standard deviation). Mean levels of GCF interleukin-1β and interleukin-37 in the generalized aggressive periodontitis, generalized chronic periodontitis (GCP) and control groups. Significances are shown as marked with different letters ($p<0.05$), [a]$p<0.05$ different from baseline; [b]$p<0.05$ different from healthy controls; [c]$p<0.05$ different from GCP.

G-AgP: Generalized aggressive periodontitis, GCP: Generalized chronic periodontitis

PPD reduction (G-AgP: 2.2 mm, GCP: 2.3 mm) and attachment gain (1.6 mm in both groups).

In addition to clinical parameters, various laboratory-based diagnostic methods are employed for diagnosing periodontal diseases. The most popular one of these is the GCF content, which is regarded to be of an exudative origin (29). GCF is a fluid that gives significant information about the development of periodontal disease with the components it contains, and at the same time, it is an important step in the host defense mechanism (30,31). In this research, the collection of GCF was performed by paper strips along 30 seconds for the purpose of avoiding serum contamination and cytokine secretion caused by the mechanical irritation stimulated by a longer period of collection. Moreover, we evaluated the total amount of cytokines in GCF samples, because the total amount of cytokines in a GCF sample per sampling time has been indicated as a better marker of relative GCF constituent activity in comparison with the GCF volume which may lead to the reduced cytokine concentration (32,33).

In the present study, in accordance with the results of studies mentioned below, GCF IL-1β level decreased after treatments of G-AgP and GCP patients IL-1β prominently mediates the inflammatory response and takes part in cell proliferation, differentiation, apoptosis, and in the periodontitis pathophysiology. A number of studies indicated an association between GCF IL-1β levels and the inflammatory status of periodontal disease (34). Furthermore, IL-1β and TNF-α effectively induce bone resorption and inhibit bone formation (35). Toker et al. (13) reported that periodontal treatment meaninfully healed the clinical complaints and this positive effects were in accordance with the decreased IL-1β in GCF.

Being a member of the IL-1 family, IL-37 was determined to be the main suppressor of innate immunity and the major regulator of inflammation on mucosal surfaces (18). A negative feedback loop, regulating excessive inflammatory responses, is induced by IL-37. Furthermore, IL-37 represents a new pro-angiogenic cytokine, which effectively stimulates endothelial cell activation and pathological angiogenesis, playing a mediating role in the binding of IL-37 to the TGF-β receptor complex (36). It was stated that the elevated IL-37 expression in plasma cells (in normal as well as in pathological tissues) indicates a possible function of IL-37 in the production of immunoglobulin and B-cell activation (37). Furthermore, there has been a correlation between IL-37 and inflammatory and autoimmune diseases, including systemic lupus erythematosus (SLE) and Guillain-Barré syndrome (19,38). Moreover, circulating IL-37 levels were determined to be higher in individuals having systemic inflammatory diseases, e.g. RA (18) and SLE (19), and cardiovascular diseases (39). In an independent sample including 4927 German/Dutch adults, an association was found between IL-37 variants and severe CP, incident tooth loss (≥3 teeth) for 10 years, and AgP. Additionally, a decrease was determined in two IL-37 variants having

functional roles in the expression of IL-37, which caused the up-regulation of IL-1β and IL-6. Decreased IL-37 levels lead to the upregulation of IL-1β and IL-6 and thus to the increased hyperinflammatory state, which was indicated by Offenbacher et al. (40). They also reported that the IL-37 variants are associated both severe inflammatory response and clinical parameters of the periodontal diseases. Similarly, in the current research, all subjects were systemically healthy, and the GCF IL-37 level was found to be significantly higher in the G-AgP and GCP groups in comparison with the C group at baseline. Unlike our findings, Sağlam et al. (21) suggested a similar total amount of IL-37 in GCF, or salivary or plasma concentrations of IL-37 in gingivitis and CP subjects and healthy controls. In clinical studies, creating a study population with similar disease severity, systemic condition, environmental factors, or stress levels, all of which could influence the overall inflammatory condition of an individual, is a challenging task. Therefore, the difference between the present study and the study by Sağlam et al. (21) might result from the patient selection and the degree of inflammation in their study population.

Cytokines like IL-1β may up-regulate IL-37. We revealed that GCF IL-1β and IL-37 levels were positively associated in the GCP and G-AgP groups at baseline, but these cytokines were positively correlated after periodontal therapy only in the GCP group. Here, it made us think about the rate of decrease in cytokines after treatment, the decrease in the amount of GCF IL-37 in G-AgP was as pronounced as it caught C group. In a disease with an aggressive course, there may be a more significant improvement in the inflammatory process with treatment.

Nevertheless, according to our knowledge, no research has been conducted to compare our results. However, in a study which investigated the alteration in the concentration of IL-37 in RA subjects undergoing disease-modifying anti-rheumatic drug (DMARD) therapy and in which an association was determined between IL-37 and pro-inflammatory cytokines in plasma and disease activity, the researchers detected a positive association between the plasma IL-37 level in RA subjects and pro-inflammatory cytokines, including IL-17A and TNF-α, and disease activity (C-reactive protein, DAS28). Additionally, a decrease was observed in the plasma anti-inflammatory cytokine IL-37 level in drug responders following DMARD therapy (41). Furthermore, in another study, IL-37 levels were determined to be significantly lower after glucocorticoid therapy than before treatment in untreated subjects who had been recently diagnosed with lupus (16). In terms of the function of IL-37 in inflammation and inflammation-driven bone resorption, Saeed et al. (42) reported that lipopolysaccharide-induced osteoclast formation and bone resorption were inhibited. Additionally, in a recent study, systemically administrated rhIL-37b was reported to reduce alveolar bone loss via suppressing IL-beta and myeloperoxidase levels in the inflamed gingival tissue in rats (40). The anti-inflammatory impact of IL-37b has also been investigated *in vivo* and *in vitro* in different diseases (43,44). According to the research results, anti-IL-37 therapy can be a therapeutic target for treating periodontitis in the future. In a study, Talmac et al. (22) analyzed the correlation between GCF IL-1β, IL-37 levels and periodontal parameters in AgP patients after periodontal therapy with different laser therapies. They reported a significant decrease in GCF IL-1β, IL-37 levels in all groups and they highlighted protective role of IL-37 from excessive inflammatory response in periodontal diseases.

Conclusion

According to the results of the present research, IL-37 increased with the disease activity, and it might be utilized for monitoring the disease progression in patients having severe periodontal inflammation. In the current research, an association between GCF IL-37 levels and disease activity was determined.

As a result of the study, it was found out that the GCF levels of IL-37 and IL-1β were elevated in subjects having G-AgP and GCP and decreased after periodontal treatment, accompanied by improved clinical parameters. IL-37 and IL-1β levels were positively associated in both periodontitis groups. Moreover, these findings indicate a possible role of IL-37 in the pathogenesis of periodontitis. However, the detailed molecular mechanism of IL-37 and its relation to the cytokine network in periodontitis should also be proved in future research.

Ethics

Ethics Committee Approval: The research protocol of this study was confirmed by the Clinical Research

Ethics Committee of Cumhuriyet University in accordance with the Declaration of Helsinki (2016-02/05, date: 16.02.2016).

Informed Consent: Informed consent was acquired from all subjects.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: E.P.G., Design: E.P.G., H.T., Supervision: E.P.G., Fundings: E.P.G., Materials: E.P.G., Data Collection or Processing: E.P.G., H.T., Ö.P., Analysis or Interpretation: Ö.P., Literature Search: E.P.G., Critical Review: E.P.G., H.T., Writing: E.P.G., H.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The Scientific Research Project Fund of Cumhuriyet University provided support for the study under project number Dis-179.

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Original Article / Özgün Araştırma

Three-dimensional Accuracy of Angled Dental Implant Placement: A Comparison Study of the Dynamic Navigation System and Free-hand Method

Açılı Dental İmplant Yerleşiminde Üç Boyutlu Doğruluk: Dinamik Navigasyon Sistemi ve Serbest El Yöntemi Karşılaştırma Çalışması

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Keywords
Implant accuracy, dynamic navigation system, free-hand method, angled implant placement

Anahtar Kelimeler
İmplant doğruluğu, dinamik navigasyon sistemi, serbest el yöntemi, açılı implant yerleşimi

Received/Geliş Tarihi : 19.12.2020
Accepted/Kabul Tarihi : 01.01.2021

doi:10.4274/meandros.galenos.2021.36349

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Abstract

Objective: This study aimed to compare the success of the free-hand technique and dynamic navigation system in a completely edentulous patient model. The two methods were compared by comparing the results achieved after the surgery against the planning made before the surgery.

Materials and Methods: The cone-beam computed tomography imaging data obtained after the implants were placed and the previously planned results of the procedure were overlapped in a three-dimensional space and compared. Four types of deviations were measured in the evaluation of each implant: coronal, apical, depth and angular deviations.

Results: The mean deviation values in the coronal, apical and angular deviation parameters were higher in the free-hand technique (group 1) compared to the dynamic navigation method (group 2). Statistically significant differences between the two groups of angle implants were found in the coronal and apical positions of implants, and in the angular deviation ($p<0.001$).

Conclusion: Angled implant applications could be performed with higher accuracy with the dynamic navigation system than the free-hand method. Dynamic navigation increases the quality and accuracy of the surgical procedure by offering a high level of precision and ease of use. Its precision and accuracy are particularly high when placing angled implants.

Öz

Amaç: Bu çalışma tam dişsiz hasta modelinde serbest el tekniğinin ve dinamik navigasyon sisteminin başarısını karşılaştırmayı amaçlamıştır. Çalışmada operasyon sonrası elde edilen sonuçların operasyon öncesi yapılan planlama ile karşılaştırılmasına göre iki yöntemin karşılaştırması yapılmıştır.

Gereç ve Yöntemler: İmplantlar yerleştirildikten sonra elde edilen konik ışınlı bilgisayarlı tomografi verileri ve işlemin daha önce planlanan sonuçları, 3 boyutlu alanda üst üste bindirilerek karşılaştırma yapıldı. Her implant için değerlendirmede dört tür sapma ölçüldü: Koronal, apikal, derinlik ve açısal sapma.

Bulgular: Koronal sapma, apikal sapma ve açısal sapma parametrelerindeki ortalama sapma değerleri, serbest el tekniğinde (grup 1) dinamik navigasyon yöntemine (grup 2) göre daha yüksek bulundu. İki grup açılı implantlar arasında implantların koronal pozisyonunda, implantların apikal pozisyonunda ve açısal sapmada istatistiksel olarak anlamlı fark bulundu (p<0,001).
Sonuç: Dinamik navigasyon yöntemi ile açılı implant uygulamaları serbest el tekniğinden daha yüksek doğrulukla yapılabilmektedir. Dinamik navigasyon, yüksek düzeyde hassasiyet ve kullanım kolaylığı sunarak cerrahi prosedürün kalitesini ve doğruluğunu artırır. Özellikle açılı implantları yerleştirirken hassasiyeti ve doğruluğu yüksek olarak görülmüştür.

Introduction

Resorption in the alveolar bone in completely edentulous patients may often lead to the loss of sufficient vertical bone distance for dental implant placement. In cases of severe vertical insufficiency as a result of this situation, advanced surgical procedures, including bone augmentation, may be required to achieve the ideal implant length. However, instead of extensive and advanced surgical procedures, different solutions can also be put forward with more up to date and minimally invasive approaches. In cases where advanced surgical procedures are not preferred, angled implant applications performed as an alternative method to avoid critical anatomical regions have taken place in the literature (1-3).

Successful angled implant applications are provided by implant planning in the appropriate region, at the appropriate angle and in the appropriate position in three dimensions. Although there are conventional approaches in implant surgery that can be called free-hand techniques as no stent is used, computer-aided dynamic navigation systems are also employed (4). Dynamic navigation is a system that allows the precise and continuous detecting and tracking of the location of the patient and the instruments used during surgery in 3-dimensional (3D). This method is based on the use of a stereotaxy map in which each reference point is linked with a particular external reference mark in a coordinate system. The software makes a 3-dimensional position determination on this map. Thus, it enables the surgeon to relate the anatomy of the operation region with the tomography information acquired before surgery, which makes it possible to find critical anatomical and pathological structures without any damage. The system enables dynamic navigation to be operated simultaneously and in real-time with the surgical procedure (5-7).

This study aimed to compare the success of the free-hand technique and dynamic navigation system in a completely edentulous patient model. The comparison of the two methods was made according to the comparison of the results achieved after the operation against the planning made before the operation. Deviations in vertical, horizontal, and sagittal planes compared to surgical planning in 3D and the accuracy achieved were evaluated. In other words, evaluating which surgical method provides results more in accordance with surgical planning was the main objective of our study.

Materials and Methods

Power analysis was performed to determine the required sample size in this study (GPower, Düsseldorf, Germany). As a result of the power analysis, fifty polyurethane jaw models and 200 implants with four implants in each model were included in this study. In group 1, 100 implants on 25 models were set to be applied by dynamic navigation method, and in group 2, 100 implants on 25 models were set to be applied by the free-hand technique (Table 1). Before making implant planning, removable complete mandibular dental prostheses were made using barium sulfate teeth on polyurethane jaw models. In these models, the exit points of the mental foramen were marked with a radiopaque composite filling material. The images of the prepared models were taken using cone-beam computed tomography (CBCT) (Planmeca Promax 3D Mid, Planmeca, Finland) and these images were uploaded to computers as Digital Imaging and Communications in Medicine data.

Table 1. Distribution of study groups

Group 1 (n=25) dynamic navigation system	Implant 1= Vertical-right
	Implant 2= Vertical-left
	Implant 3= 30° Angel-left
	Implant 4= 30° Angel-right
Group 2 (n=25) free-hand technique	Implant 1= Vertical-right
	Implant 2= Vertical-left
	Implant 3= 30° Angel-left
	Implant 4= 30° Angel-right

To achieve standardization between groups, standard 10x3.5 mm implants and the same plans were used on the models. In implant planning, the findings showed that that the right and left distal implants would be placed at an angle of 30° in front of the mental foramen, and the medial implants would stand vertical in the anterior region and be placed parallel to each other (Figures 1, 2). Accordingly, the exit points of the distal implants were determined to be between the teeth numbered 5 and 6, and the exit points of the anterior implants were determined to be teeth numbered 2 (Figure 3).

Implants were applied in group 1 by Dynamic Navigation System (Navident®, ClaroNav Inc., Toronto, Canada) and in group 2 by free-hand technique. The free-hand technique was determined as the conventional method. The regions of the previously prepared complete prosthesis in which implants will be placed were scraped and these scrapings were used as a manual guide for free-hand surgery.

The Evalunav® (ClaroNav Inc., Toronto, Canada) program was used to compare the post-operative accuracy of implants versus surgical planning in the planar three dimensions. The CBCT imaging data obtained after the implants were placed, and the previously planned results of the procedure were overlapped in the 3-dimensional space and then

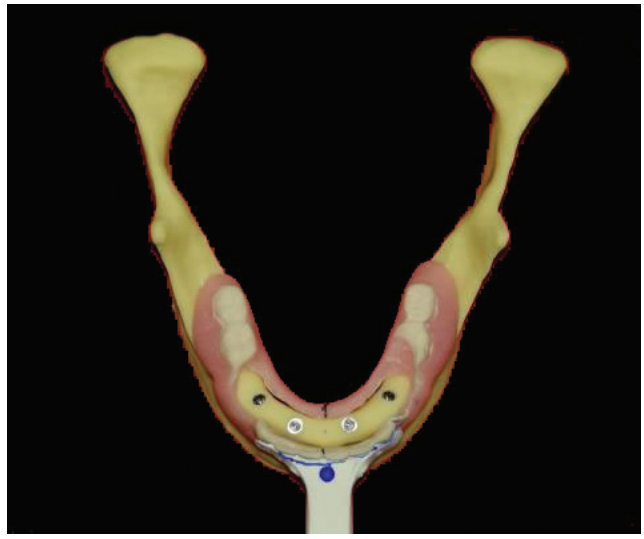

Figure 1. Implant placement on polyurethane jaw models

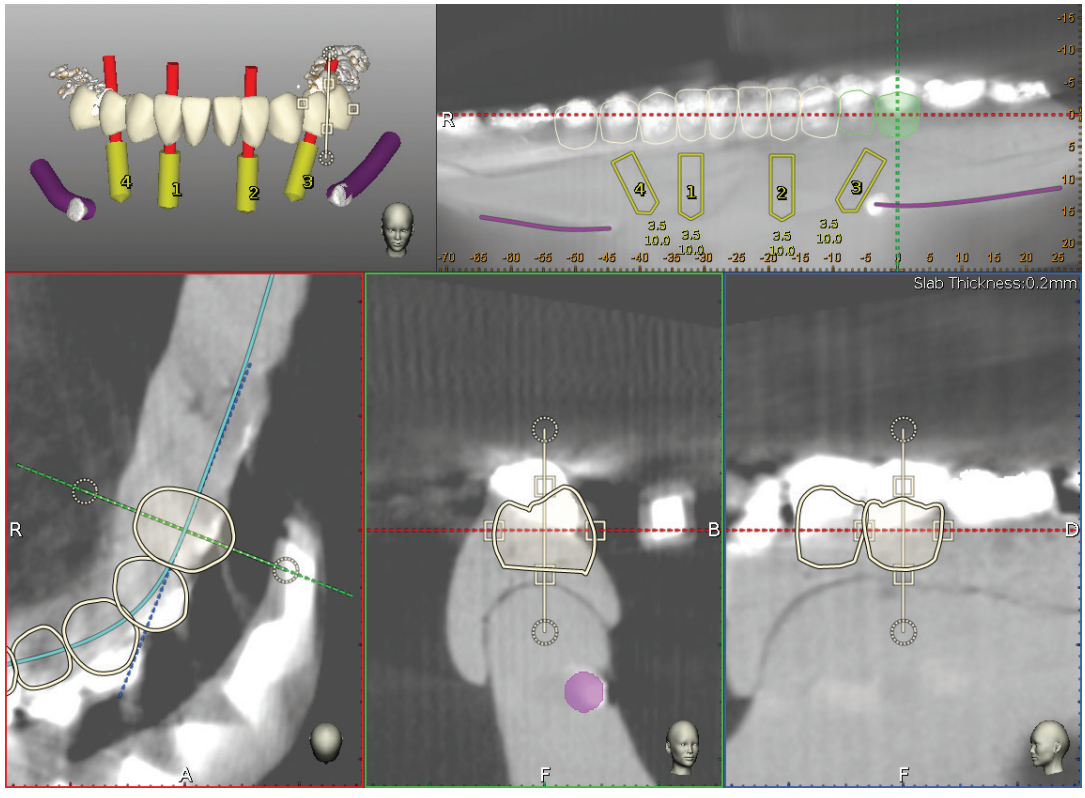

Figure 2. Implant planning with using dynamic navigation system software. Standard implants and the same plans were used on the models

a comparison is made (Figure 4). Four types of deviations were measured in the evaluation for each implant:

● Coronal-entry deviation (2D): The 2D sum of the deviation between the planned (yellow) and actual (red) implant in the occlusal plane, vectorially, and in millimeters.

● Depth-vertical deviation: A numerical statement of the distance between the apex points of the planned and actual implants in the occlusal plane.

● Apical-apex deviation (3D): The 3D sum of the 3D distance between the apex points of the planned and the actual implants, vectorially and in millimeters.

● Angular-angle deviation: A numerical statement of the angle between positions of the planned and actual implants.

In our study, mean deviations between planned and post-operative positions of implants were analyzed in both groups for all implants (Figure 5).

Statistical Analysis

Normality was assessed using the Kolmogorov-Smirnov test within the groups. Data were compared both as independent groups and as dependent groups. In the independent group analyses, the independent samples t-test was used for variables with normal distribution, and the Mann-Whitney

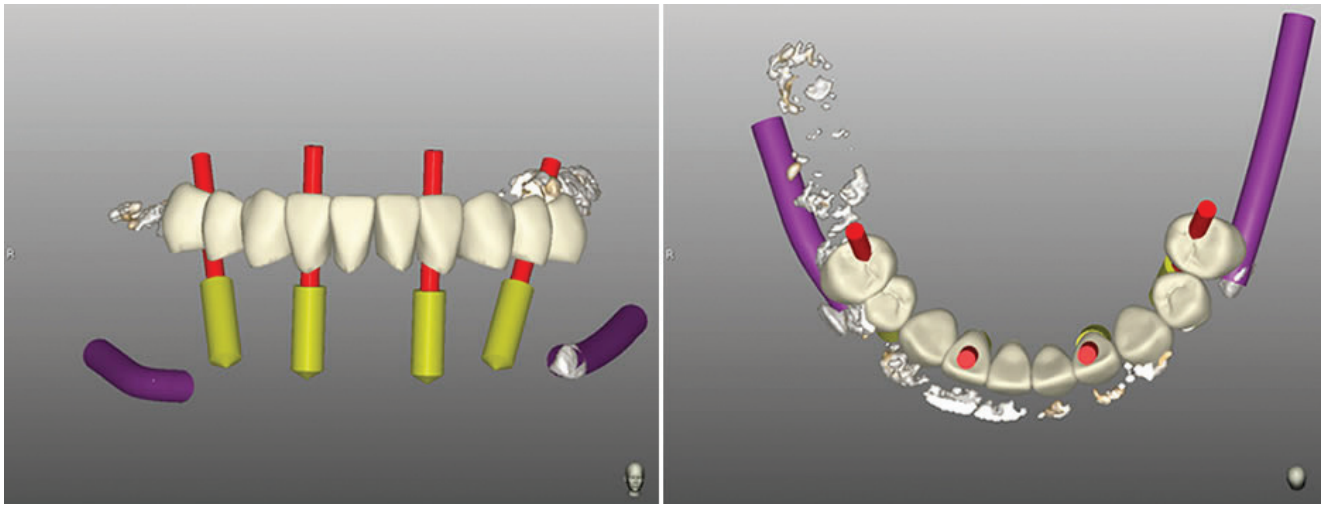

Figure 3. Implant positions in the occlusal plane

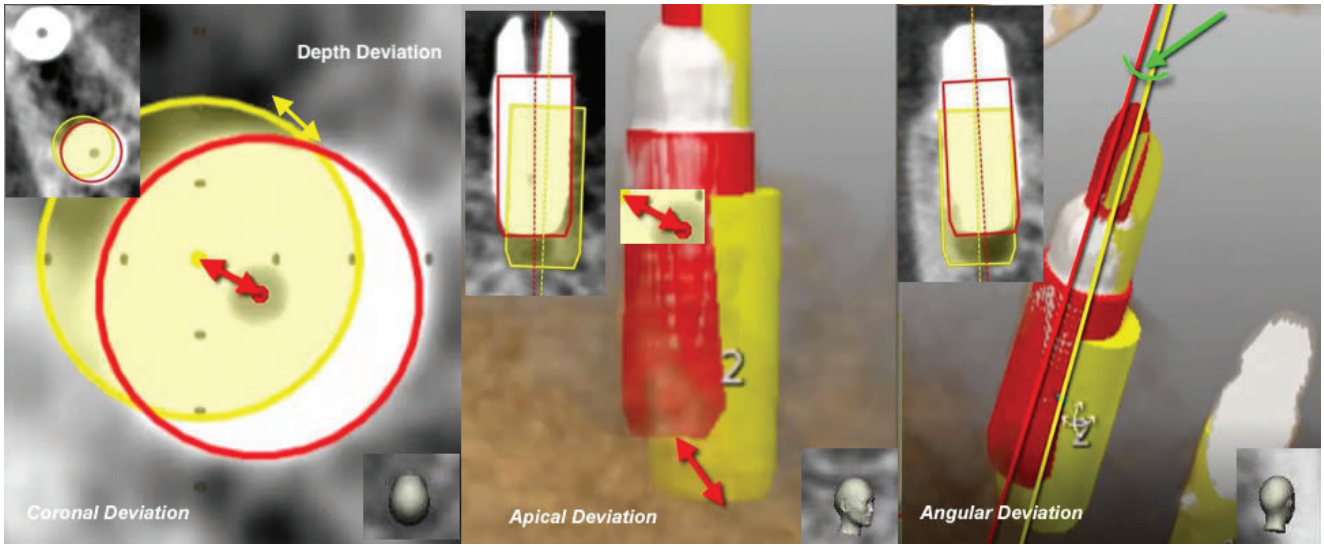

Figure 4. Schematic representation of deviations on the program. The difference between the planned implant position and the post-operative implant position in 3-dimensional space

U test was used for variables not showing normal distribution. Descriptive statistics were presented as mean ± standard deviation for normally distributed variables and as median (25^{th}-75^{th} percentile) for non-normally distributed variables. A p-value of <0.05 was considered statistically significant.

Results

In our study, it was observed that the mean deviation values in the coronal deviation, apical deviation and angular deviation parameters were higher in the free-hand technique (group 1) compared to the dynamic navigation method (group 2). The depth deviation was the parameter with the least difference between the planning and results of the operation in both techniques. In addition, the depth deviation parameter has been the only parameter in which implants applied with free-hand technique can achieve the closest accuracy compared to implants applied with dynamic navigation. Angular deviation was the parameter in which the maximum deviation occurred in the free-hand technique, particularly in angled implants (Table 2).

In our study, mean deviations between planned and post-operative positions of implants were compared in both groups for angled implants and vertical implants. In group 1, where dynamic navigation was performed, the average coronal deviation was 0.89 mm in vertical implants and 1.01 mm in those planned with 30° inclination. When the apical deviation parameter was evaluated, it was 0.93 mm in vertical implants and 1.27 mm in angled implants. Looking at the depth deviation

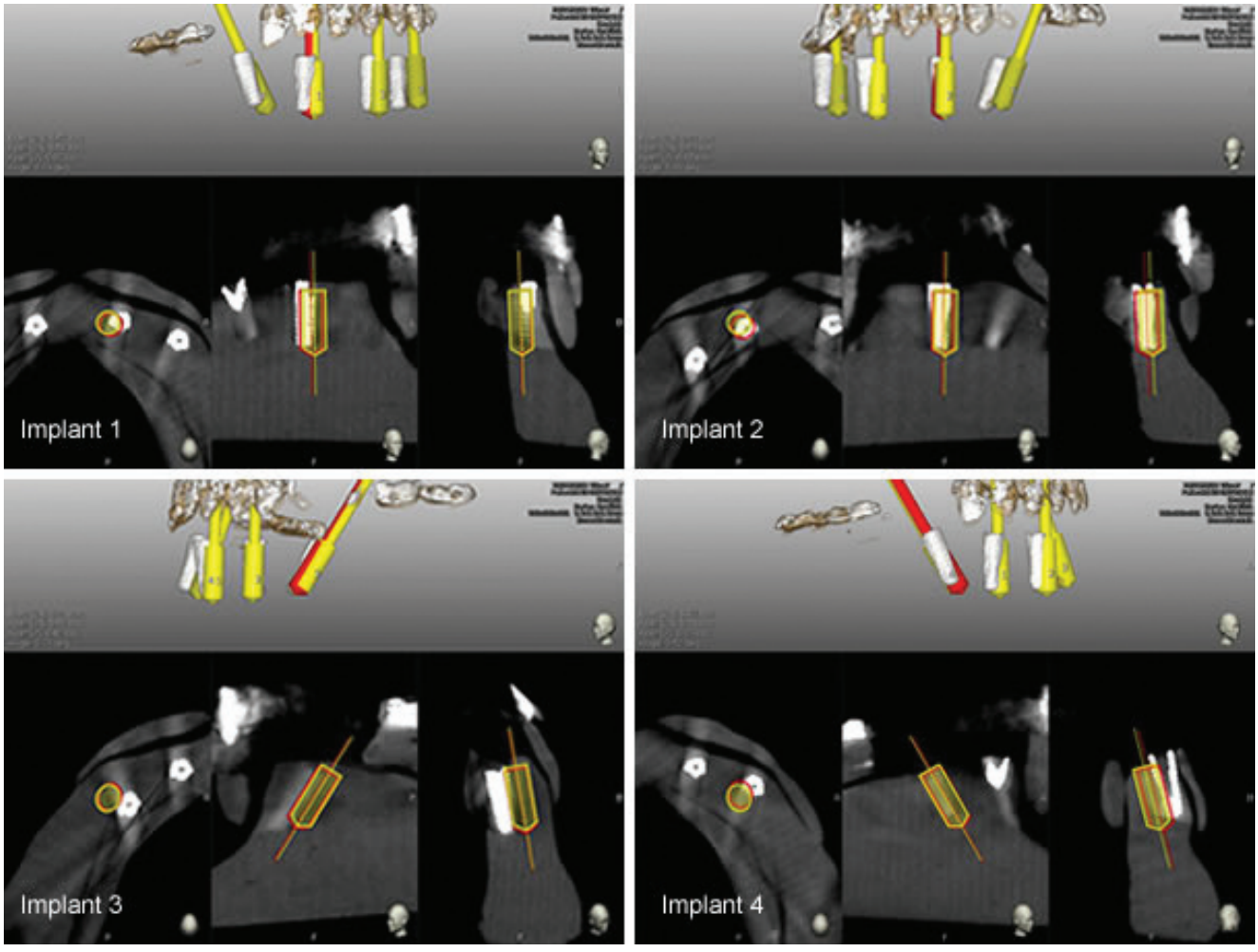

Figure 5. The deviations between planned and actual implant positions were measured by matching the pre- and post-operative images for each implant

parameter, it was 0.19 mm for vertical implants and 0.30 mm for angled implants. The mean angular deviation was 0.53° in vertical implants and 0.94° in angled implants. In group 2, where the free-hand technique was performed, the average coronal deviation was 1.48 mm in vertical implants and 2.20 mm in those planned with 30° inclination. When the apical deviation parameter was evaluated, it was 2.12 mm in vertical implants and 3.62 mm in angled implants. Looking at the depth deviation parameter, it was 0.28 mm for vertical implants and 0.39 mm for angled implants. The mean angular deviation was 2.34° in vertical implants and 6.73° in angled implants (Table 3).

When the table is examined, there was a statistically significant deviation in all parameters except for the coronal deviation in the dynamic navigation group in

Table 2. The mean deviation values calculated by including each implant in group 1 and group 2 and comparison between groups

	Implant	Group 1	Group 2	p
Coronal deviation	Vertical right*	0.93±0.44	1.17±0.41	<0.001
	Vertical left*	0.86±0.42	1.56±0.40	<0.001
	Angel left**	1.31 (0.86-1.42)	2.32 (1.83-2.58)	<0.001
	Angel right*	0.86±0.31	2.17±0.40	<0.001
Apical deviation	Vertical right*	1.03±0.39	2.12±0.25	<0.001
	Vertical left*	0.92±0.31	2.12±0.16	<0.001
	Angel left**	1.55 (1.09-1.65)	3.65 (3.23-3.87)	<0.001
	Angel right*	1.08±0.37	3.66±0.54	<0.001
Depth deviation	Vertical right**	0.12 (0.03-0.29)	0.25 (0.16-0.35)	0.006
	Vertical left**	0.19 (0.09-0.34)	0.30 (0.21-0.34)	0.103
	Angel left*	0.32±0.23	0.36±0.17	0.503
	Angel right**	0.26 (0.13-0.36)	0.38 (0.23-0.70)	0.017
Angular deviation	Vertical right*	0.58±0.36	2.14±0.54	<0.001
	Vertical left**	0.34 (0.25-0.79)	2.41 (1.98-2.91)	<0.001
	Angel left*	0.86±0.43	6.25±2.09	<0.001
	Angel right*	1.01±0.36	7.20±2.33	<0.001

*Results acquired using the t-test: Mean deviation and (± standard deviation) values are given for the implants marked with the number 1-2-3-4 in both groups

**Results acquired using the Mann-Whitney U test: Median and (25^{th}-75^{th} percentile) values are given for implants marked with the number 1-2-3-4 in both groups

Table 3. Comparison of the mean deviation values of angled and vertical implants within their groups

		group 1	p	group 2	p
Coronal deviation	Verticals'	*0.89±0.35	0.277	**1.48 (1.40-1.41)	<0.001
	Angles'	*1.01±0.24		**2.20 (1.95-2.57)	
Apical deviation	Verticals'	**0.93 (0.80-1.16)	0.019	*2.12±0.19	<0.001
	Angles'	**1.27 (1.01-1.41)		*3.62±0.54	
Depth deviation	Verticals'	*0.19±0.13	0.041	**0.28 (0.20-0.32)	0.003
	Angles'	*0.30±0.15		**0.39 (0.28-0.48)	
Angular deviation	Verticals'	*0.53±0.28	<0.001	*2.34±0.53	<0.001
	Angles'	*0.94±0.33		*6.73±1.94	

*Data showing normal distribution and analyzed with paired t-test: mean deviation value between planned and post-operative positions was given as ± standard deviation

**The data that did not show the normal distribution and analyzed by Wilcoxon t-test were given as median and (25^{th}-75^{th} percentile) values

angled implants compared to vertical implants. In the free-hand technique, the findings showed that the deviation amount of angled implants was significantly higher than vertical implants in all parameters. In addition, it was observed that the deviation between the planned and post-operative positions in all parameters and both groups in angled implants was greater than in vertical implants. The least difference between angled and vertical implants was seen in the depth deviation parameter. The greatest difference was observed in apical deviation and angular deviation. Again, the amount of angular deviation in angled implants is significantly higher in the free-hand technique. This increase in deviation in angled implants appears to be even greater in the free-hand technique.

In our study, the average deviation amounts of the angled implants for group 1 and group 2 were calculated separately. Then, whether there was a difference between these two groups concerning angled implants was compared and presented in Table 4. More errors occurred in the free-hand technique compared to dynamic navigation, except for the depth deviation (Table 4). No significant difference was found in the depth deviation parameter of the angled implants applied with the dynamic navigation method compared to the free-hand technique. In the depth deviation parameter, there were similar results between the free-hand technique and the dynamic navigation method. However, in all other parameters, the deviation amount in the dynamic navigation technique was less than in the free-hand technique.

In our study, the angled implants on the right and left sides were compared with each other, and the results are presented in Table 5 for both groups. The purpose of this comparison is to determine the amount of deviation between the planned and post-operative positions in the implants applied in the right and left jaw by a right-handed physician. In the dynamic navigation group, it was observed that the amount of deviation of the implants in the left jaw was greater than the right ones in all parameters except angular deviation. It was observed that the angular deviation parameter was higher on the right side than on the

Table 4. Comparison of mean deviation amounts of angled implants for group 1 and group 2

	Group 1	Group 2	p
Coroal deviation*	1.01±0.24	2.19±0.44	<0.001
Apical deviation**	1.27 (1.01-1.41)	3.65 (3.31-3.95)	<0.001
Depth deviation**	0.28 (0.15-0.44)	0.39 (0.28-0.48)	0.148
Angular deviation*	0.94±0.33	6.73±1.94	<0.001

*Data showing normal distribution and analyzed with paired t-test: Mean deviation value between planned and post-operative positions was given as ± standard deviation

**The data that did not show the normal distribution and analyzed by Wilcoxon t-test were given as median and (25^{th}-75^{th} percentile) values

Table 5. Comparison of the deviation values of the angled implants located on the right and left sides with respect to each other

		Gruop 1	p	Gruop 2	p
Coronal deviation	Left	**1.31 (0.86-1.42)	0.005	*2.21±0.49	0.340
	Right	**0.97 (0.62-1.07)		*2.17±0.40	
Apical deviation	Left	**1.55 (1.09-1.65)	0.030	*3.58±0.60	0.292
	Right	**1.13 (0.74-1.40)		*3.66±0.54	
Depth deviation	Left	*0.32±0.23	0.579	**0.34 (0.25-0.48)	0.115
	Right	*0.28±0.18		**0.38 (0.23-0.70)	
Angular deviation	Left	*0.86±0.43	0.090	*6.25±2.09	0.035
	Right	*1.01±0.36		*7.20±2.33	

*Data showing normal distribution and analyzed with paired t-test: mean deviation value between planned and post-operative positions was given as ± standard deviation

**The data that did not show the normal distribution and analyzed by Wilcoxon t-test were given as median and (25^{th}-75^{th} percentile) values

left side. Among these differences, coronal deviation and apical deviation values were statistically significant for the dynamic navigation group. In the free-hand technique group, the deviation seen in the right implants in all parameters except the coronal deviation was higher than the left ones. In the coronal deviation parameter, it was observed that the left side implants deviated more than the right side ones. Among these differences, only the angular deviation amount was statistically significant for the free-hand group.

Discussion

Navigation in implant surgery is the process of transferring correct implant planning made based on computed tomography data to the patient accurately. This process can be performed statically with the help of stents prepared in the laboratory or dynamically with computer-aided navigation instruments. Besides, implants can be applied by the free-hand technique based on the surgeon's clinical experience. In this method, the surgeon provides navigation by comparing the distances to the reference points he sees in the patient's mouth with patient radiographs. However, this would be the most error-prone method given that the precision in this method depends entirely on the clinical experience of the surgeon and it will not be possible to control the three-dimensional placement of the implants. Placement of the implants in the correct position is essential for a successful and sustainable prosthetic treatment. The success of the implant application is achieved by obtaining the correct data with the methods listed above and transferring the planning made on these data into the mouth in the most accurate way (8,9).

Although the development of advanced imaging methods enables us to make more accurate planning, transferring this planning to the patient is one of the biggest problems. Guided surgical applications provide great advantages for placing implants in planned positions. Taruna et al. (10) stated that hybrid prostheses using angled implants are very sensitive and should be applied with a surgical guide. In the same study, it was stated that it is not always possible to achieve the implant positions required for the prosthesis using the free-hand technique. The preferred guided surgery procedures should be applicable in terms of reliability and practicality and should have reasonable learning time. Authors showed that the utilization of static or dynamic navigation systems is superior to free-hand implant placement in transferring the position planned to the patient's mouth accurately (11,12).

Dynamic navigation allows critical anatomical structures to be found in real time without being damaged during surgery, enabling the operation to proceed with safe surgical distances. Compared to static navigation, the most prominent advantage of dynamic navigation is that it enables planning at the bedside and changes in the plan during surgery. In addition to all these, the locations where dental crowns will be placed in the region of defect can be determined on the computer screen during the planning phase. The positions of the crowns can be adjusted in three dimensions in mesio-distal, bucco-lingual and vertical directions. The size of the crowns can be altered in three dimensions and the crowns can be adjusted at ideal angles. After determining the ideal positions and sizes of the crowns, adjustments can be made by evaluating the most appropriate positions, angles and exit profiles of the implants according to the placement of the crowns, which ensures that the correct implant position and angle can be provided in accordance with the superstructure (5,6).

Somogyi-Ganss et al. (13) reported in their study that the amount of deviation seen in implants applied with dynamic navigation in the laboratory is less than the deviations seen in clinical studies. In this study, entry point deviation amount was determined as 1.14 mm±0.55 mm, apical deviation amount was determined as 1.18 mm±0.56 mm, depth deviation amount was determined as 1.04 mm±0.71 mm, total apical deviation amount was determined as 1.71±0.61 mm, and angular deviation amount was determined as 2.99°±1.68°. Emery et al. (14) compared the angular and linear deviations of implants placed with a dynamic navigation system (X-Guide, X-Nav Technologies, LLC, Lansdale, PA) in dentulous and edentulous models in their model-based study. The angular accuracy of the implants placed using the tested instrument was reported as 0.89°±0.35° in dentulous models and 1.26°±0.66° in edentulous models. 3D positional accuracy for dentulous models was reported as 0.38 mm±0.21 mm, while it was 0.56 mm±0.17 mm for edentulous models.

Stefanelli et al. (15) used the same navigation instrument as in our study in their retrospective

study, in which they included 231 implants. In this study, implant placement was performed in 89 jaws in total, which includes 106 implants for partially edentulous patients and 125 implants for completely edentulous patients applied by a single surgeon. In partially edentulous patients, deviation values between planned and post-operative positions were reported as 0.70 mm at the entry point, 0.96 mm at the apex and angle deviation was 2.21°. The deviation values of the last 50 implants (entry point: 0.59 mm, apex: 0.85 mm, angular: 1.98°) placed in the study were significantly lower than the first 50 implants (entry point: 0.94 mm, apex: 1.19 mm, angular: 3.48°) was interpreted as the learnability of the dynamic navigation system.

Mediavilla Guzmán et al. (16) compared the accuracy of 40 implants they placed using static and dynamic navigation systems. There was no statistically significant difference between static and dynamic navigations at coronal (p=0.6535) and apical (p=0.9081) levels. However, a statistically significant difference was shown between angle deviations (p=0.0272). In the same study, the amount of coronal deviation was determined as a mean of 0.78 mm±0.43 mm in dynamic navigation and 0.85 mm±0.48 mm in static navigation, apex deviation was reported as a mean of 1.20 mm±0.4 8 mm in dynamic navigation, 1.18 mm±0.60 mm in static navigation, and deviation in implant angles was reported as a mean of 2.95°±1.48° in dynamic navigation and 4.00°±1.41° in static navigation.

In our study, apical deviation, depth deviation and angular deviation amounts showed a statistically significant increase in angled implants applied in the dynamic navigation group compared to vertical implants. In the free-hand group, a statistically significant increase was observed in deviation amounts of all parameters in angled implants compared to vertical implants. In addition, dynamic navigation and free-hand technique for angled implants were compared. In this comparison, the amounts of coronal deviation, apical deviation and angular deviation were significantly higher in the free-hand group than the dynamic navigation group. Especially in the apical deviation and angular deviation parameters, it was observed that the free-hand technique group had higher deviation amounts compared to the dynamic navigation group. This shows how difficult it is to get the right angle in angled implants with the free-hand technique. The depth deviation parameter showed almost identical deviation amounts in the free-hand technique with a dynamic navigation method because the reference lines showing drill depth on the implant drill systems can be followed during the procedure. Thus the planned vertical depth can be precisely applied in both techniques. However, the ability to control other parameters during the operation depends entirely on the experience and skills of the surgeon in the free-hand technique. On the contrary, the dynamic navigation technique constantly guides the surgeon during the operation and allows implant placement with a closer accuracy to the planning accordingly. Aydemir and Arısan (17) also showed in their studies that the accuracy of the dynamic navigation system is higher than the free-hand technique.

Dynamic navigation systems enable flapless surgery in clinical practice. This provides great comfort for the patient in the post-operative period. In addition, since the continuity of the periosteum is not disturbed, complaints, such as edema and pain, will be minimal after the operation, which will reduce the recovery time after the operation and eliminate the fears of patients about implant surgery. Besides, not using flaps during the operation increases the success of the implant placement by reducing the risk of infection. Since there is no flap removal, bleeding will be minimal during surgery, which will increase the surgeon's field of vision, making the surgery easier. The use of the dynamic navigation method is not limited to implant applications. Nowadays, the frequency of utilization of this method in anesthesia applications, endodontics and oral surgery is increasing (18-20).

On the other hand dentistry practice is one of the areas where there is much close contact with the patient, and the risk of infectious diseases is very high. Therefore, minimizing contact with the patient in today's pandemic conditions, which deeply affect public health, is a must. Performing an operation using a screen instead of looking directly at the patient's mouth is quite significant in reducing the risk of infection. The improvement and renovation of dynamic navigation systems in future studies, especially the inclusion of artificial intelligence technologies, will prepare the ground for safer operations. The increase in technological advancements, the development of

robotic surgery and artificial intelligence will facilitate surgical procedures in the future and minimize medical malpractices.

Conclusion

The findings obtained in this study showed that angled implant applications could be performed with higher accuracy by the dynamic navigation method than the free-hand technique. Dynamic navigation systems increase the quality and accuracy of the surgical procedure by offering a high level of precision and ease of use. Its precision and accuracy are particularly high when placing angled implants.

Acknowledgment: We are thankful for the statistical analysis conducted by research assistant Hakan Öztürk.

Ethics

Ethics Committee Approval: The ethics committee approval is not required as it is a model study.

Informed Consent: Informed consent was not obtained as it is a model study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: H.O.Ş., Design: H.O.Ş., Supervision: H.O.Ş., Fundings: H.O.Ş., Data Collection or Processing: G.K.Ü., Analysis or Interpretation: H.O.Ş., G.K.Ü., Literature Search: H.O.Ş., G.K.Ü., Writing: H.O.Ş., G.K.Ü., Critical Review: H.O.Ş.

Conflict of interest: The authors declare that they have no conflict of interest.

Financial Disclosure: The authors declared that this study received no financial support.

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