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RESEARCH ARTICLES

CASE REPORTS

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RESEARCH ARTICLE

Evaluation of the Knowledge Level of Dentistry Faculty Students on Cross-Infection Control

Diş Hekimliği Fakültesi Öğrencilerinin Çapraz Enfeksiyon Kontrolü Konusundaki Bilgi Düzeylerinin Değerlendirilmesi

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ABSTRACT

Objective: Cross-infection in dentistry poses significant public health risks due to the transmission of pathogens among patients, dental professionals, and clinical environments. This study aimed to evaluate the knowledge level of dental faculty students regarding cross-infection control measures.

Materials and Methods: Ethical approval was obtained from the Gülhane Scientific Research Ethics Committee (Approval No. 2024/300). An online survey, developed based on prior research and piloted for validity, was distributed to students from two dental faculties. The survey assessed knowledge of cross-infection control measures, and data were analyzed using SPSS for Windows Ver. 29.0.

Results: The study included 483 participants (39.3% male, 60.7% female; mean age: 21.57 years). Correct response rates improved with educational level, with clinical students outperforming preclinical students across most survey categories ($p \leq 0.05$). Specific gaps were noted in knowledge of aerosol transmission, surface disinfection, and protective measures.

Conclusion: The study highlights the critical role of comprehensive educational programs in improving knowledge and adherence to cross-infection protocols. Emphasizing practical training alongside theoretical knowledge is essential for preparing dental students to effectively implement infection control measures.

Keywords: Cross-infection, dental education, infection control, public health, survey.

ÖZET

Amaç: Diş hekimliğinde çapraz enfeksiyon, patojenlerin hastalar, diş hekimi profesyonelleri ve klinik ortamlar arasında iletilmesi nedeniyle önemli halk sağlığı riskleri oluşturmaktadır. Bu çalışmanın amacı, diş hekimliği fakültesi öğrencilerinin çapraz enfeksiyon kontrol önlemleri konusundaki bilgi düzeylerini değerlendirmektir.

Gereç ve Yöntemler: Etik onay, Gülhane Bilimsel Araştırmalar Etik Kurulu'ndan (Onay No. 2024/300) alınmıştır. Önceki araştırmalara dayanarak geliştirilen ve geçerliliği pilot uygulama ile test edilen çevrimiçi anket, iki diş hekimliği fakültesinden öğrencilere dağıtılmıştır. Anket, çapraz enfeksiyon kontrol önlemleri konusundaki bilgi düzeyini değerlendirmiş ve veriler SPSS for Windows Ver. 29.0 kullanılarak analiz edilmiştir.

Bulgular: Çalışmaya 483 katılımcı (39,3% erkek, 60,7% kadın; ortalama yaş: 21,57 yıl) dahil edilmiştir. Doğru cevap oranları, eğitim düzeyi ile artmış olup, klinik öğrenciler çoğu anket kategorisinde preklinik öğrencilere göre daha başarılı olmuştur ($p \leq 0,05$). Aerosol ile bulaş, yüzey dezenfeksiyonu ve koruyucu önlemler konularında belirli bilgi eksiklikleri tespit edilmiştir

Sonuç: Çalışma, çapraz enfeksiyon protokollerine yönelik bilgi ve uyumun artırılmasında kapsamlı eğitim programlarının kritik rolünü vurgulamaktadır. Teorik bilginin yanı sıra pratik eğitimin de vurgulanması, diş hekimi öğrencilerinin enfeksiyon kontrol önlemlerini etkin bir şekilde uygulamaya hazırlanmaları için önemlidir.

Anahtar Kelimeler: enfeksiyon kontrolü,diş hekimliği eğitimi,çapraz enfeksiyon,anket,halk sağlığı

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INTRODUCTION

Cross-infection is a critical public health concern in dentistry due to the potential transmission of harmful pathogens among patients, dental professionals, and the clinical environment. This underscores the necessity for stringent adherence to infection control protocols to mitigate the risks posed by bacteria, viruses, and fungi. Such infections may occur through direct contact with blood, saliva, or body fluids, indirect contact via contaminated instruments or surfaces, or airborne transmission through aerosols generated during dental procedures.[1,2]

High-speed dental handpieces and ultrasonic scalers are significant contributors to aerosol production, which heightens the risk of pathogen dissemination.[3] To address this, effective infection control strategies include the use of personal protective equipment (PPE), sterilization of instruments, and regular surface disinfection. The COVID-19 pandemic has further emphasized the importance of these practices, particularly the use of high-volume evacuators and enhanced environmental disinfection measures.[4]

Comprehensive infection control measures are only as effective as their implementation, which necessitates continuous education and awareness among dental professionals.[1,5] While studies show that compliance with basic protocols such as hand hygiene and the use of PPE is relatively high, gaps persist in areas like aerosol management and advanced sterilization techniques.[3]

The purpose of this study is to assess the knowledge level of dental students regarding cross-infection control, identify gaps in their understanding, and evaluate the effectiveness of their educational programs. These findings aim to guide the enhancement of infection control training in dental education.

MATERIALS AND METHODS

This study received ethical approval from the Gülhane Scientific Research Ethics Committee (Approval No. 2024/300). Participation was voluntary, and informed consent was obtained electronically from all participants before the survey.

The study was conducted among undergraduate dental students from the University of Health Sciences Gülhane Faculty of Dentistry and Cappadocia University Faculty of Dentistry. A total of 483 students participated, representing all academic years.

Data were collected using an online survey tool (Google Forms), which allowed efficient and anonymous data collection. The survey was adapted from validated instruments used in previous studies.[6] It comprised demographic questions (e.g., age, gender, academic year) and 26 items assessing knowledge of cross-infection control measures. These questions covered topics such as PPE usage, disinfection and sterilization protocols, and infection prevention strategies.

A pilot test was conducted with 20 dental students to evaluate the survey's clarity and relevance. Based on participant feedback, minor adjustments were made to the survey format and content to ensure validity and ease of completion.

The final survey, which took approximately three minutes to complete, was distributed to participants via WhatsApp. The survey was administered in Turkish to align with the participants' native language. Personal identifying information was not collected to maintain confidentiality.

Data were analyzed using SPSS for Windows Ver. 29.0 (SPSS Inc., IL, USA). Descriptive statistics were calculated to summarize participant demographics and response frequencies. Since the data were categorical, normality tests were not required. A chi-square test was applied to assess differences between preclinical (1st–3rd year) and clinical (4th–5th year) student groups. Statistical significance was set at $p \leq 0.05$.

RESULTS

A total of 483 dental students participated in the study, with 190 (39.33%) male and 293 (60.67%) female students. The participants ranged in age from 18 to 38 years, with a mean age of 21.57 years. Table 1 details the distribution of participants by gender and academic year. Across all educational levels, the number of female participants exceeded that of males.

Table 1. Distribution and Percentage Graph of Female and Male Participants by Education Year (n, %)

Class	Female	Male	Total
1	70 (63.63%)	40 (36.37%)	110 (22.77%)
2	58 (59.18%)	40 (40.82%)	98 (20.28%)
3	68 (55.28%)	55 (44.72%)	123 (25.47%)
4	58 (62.36%)	35 (37.64%)	93 (19.25%)
5	39 (68.42%)	18 (31.58%)	57 (11.83%)
Total			483 (100%)

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Table 2. Number and percentage of correct and incorrect responses for Grades 1, 2, and 3, and Grades 4 and 5 (n, %)

Question	Grades 1, 2, 3 (331 responses)		Grades 4 and 5 (152 responses)		Total
	Correct	Incorrect	Correct	Incorrect	
5. What is the purpose of the infection control program?	252 (76.13%)	79 (23.87%)	141 (92.76%)	11 (7.24%)	483 (100%)
6. What diseases can be transmitted through cross-contamination to staff and patients?	250 (75.52%)	81 (24.48%)	143 (94.07%)	9 (5.93%)	483 (100%)
7. What is the risk of cross-contamination during dental examination?	241 (72.80%)	90 (27.20%)	146 (96.05%)	6 (3.95%)	483 (100%)
8. Can hands of staff and patients be contaminated with saliva after a dental examination?	256 (77.34%)	75 (22.66%)	147 (96.71%)	5 (3.29%)	483 (100%)
9. Can hands of staff and patients be contaminated with saliva after dental treatment?	258 (77.94%)	73 (22.06%)	146 (96.05%)	6 (3.95%)	483 (100%)
10. Should each clinic have its own written infection control protocols?	294 (88.82%)	37 (11.18%)	148 (97.36%)	4 (2.64%)	483 (100%)
11. Should standard precautions be applied to everyone as if they are infected and should infection control be implemented?	297 (89.73%)	34 (10.27%)	150 (98.68%)	2 (1.32%)	483 (100%)
12. Should disposable gloves be worn during all dental procedures?	296 (89.42%)	35 (10.58%)	149 (98.02%)	3 (1.98%)	483 (100%)
13. Should staff wear goggles, masks, or face shields if contact with body fluids is anticipated?	296 (89.42%)	35 (10.58%)	149 (98.02%)	3 (1.98%)	483 (100%)
14. What are clinical contact surfaces?	288 (87.01%)	43 (12.99%)	144 (94.73%)	8 (5.27%)	483 (100%)
15. Should barriers and surface disinfectants be used to prevent cross-contamination?	282 (85.20%)	49 (14.80%)	148 (97.37%)	4 (2.63%)	483 (100%)
16. What components should good surface disinfectants have?	233 (70.39%)	98 (29.61%)	129 (84.87%)	23 (15.13%)	483 (100%)
17. Are protective covers and single-use carriers an important step in radiographic infection control?	283 (85.50%)	48 (14.50%)	150 (98.68%)	2 (1.32%)	483 (100%)
18. Is sterilization of reusable instruments an important step in infection control?	301 (90.93%)	30 (9.07%)	148 (97.37%)	4 (2.63%)	483 (100%)
19. What is the risk of infection contamination in intraoral radiographs compared to extraoral radiographs?	265 (80.06%)	66 (19.94%)	143 (94.08%)	9 (5.92%)	483 (100%)
20. Is it necessary for dentists to take responsibility for infection control procedures?	263 (79.45%)	68 (20.55%)	141 (92.76%)	11 (7.24%)	483 (100%)
21. While barriers help in infection control, do they replace effective cleaning and disinfection?	251 (75.83%)	80 (24.17%)	137 (90.13%)	15 (9.87%)	483 (100%)
22. Should the chemical agent used by dentists for sterilization or disinfection be tuberculocidal and capable of preventing infectious diseases including HBV and HIV?	260 (78.55%)	71 (21.45%)	141 (92.76%)	11 (7.24%)	483 (100%)
23. Are dental professionals at higher risk of injuries leading to exposure to pathogens compared to other professions?	314 (94.86%)	17 (5.14%)	150 (98.68%)	2 (1.32%)	483 (100%)
24. Can a dentist protect themselves from cross-infection by taking a good medical history?	274 (82.78%)	57 (17.22%)	142 (93.42%)	10 (6.58%)	483 (100%)
25. Is it correct that infected or high-risk patients should be examined in the early hours of the day?	130 (39.27%)	201 (60.73%)	120 (78.95%)	32 (21.05%)	483 (100%)
26. Should air circulation systems be used or should the clinic be frequently ventilated, and should polish and polish motors be fitted with protectors during the treatment of infected or high-risk patients?	299 (90.33%)	32 (9.67%)	148 (97.37%)	4 (2.63%)	483 (100%)

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Participants were distributed across academic years as follows: 110 (22.77%) first-year students, 98 (20.28%) second-year students, 123 (25.46%) third-year students, 93 (19.25%) fourth-year students, and 57 (11.80%) fifth-year students.

Responses to survey questions were analyzed to compare the knowledge levels of preclinical (1st–3rd year) and clinical (4th–5th year) students. Table 2 summarizes the correct and incorrect responses for each question category. Clinical students consistently demonstrated higher correct response rates compared to preclinical students, with statistically significant differences noted across most categories ($p \leq 0.05$).

Awareness and Behavior (Questions 5, 20, 23, 24, and 25):

While clinical students exhibited higher correct response rates overall, Question 25 had the lowest correct response rate among both groups. This suggests a knowledge gap in managing high-risk patients during specific timeframes.

Cross-Infection Protocols (Questions 6, 7, 8, 9, 11, 17, and 19):

Clinical students outperformed preclinical students in this category. However, incorrect response rates for Questions 11, 17, and 19 were higher in both groups, highlighting areas requiring further reinforcement in infection prevention protocols.

Disinfection and Sterilization (Questions 10, 14, 15, 16, 18, 21, and 22):

While most students demonstrated adequate knowledge, Questions 16, 21, and 22 had higher incorrect response rates, particularly among preclinical students. This indicates challenges in comprehending and applying sterilization protocols.

Protecting Staff and Patients (Questions 12, 13, and 26):

Clinical students had a higher rate of correct responses compared to preclinical students. Incorrect responses in this category suggest that theoretical knowledge is retained more effectively when reinforced by clinical practice.

No statistically significant differences were observed between male and female participants regarding their knowledge of cross-infection control ($p > 0.05$).

The results demonstrate that knowledge levels improve as students progress through their education, particularly in clinical years where practical application complements theoretical learning. However, the data also reveal specific areas where knowledge gaps persist, underscoring the need for targeted educational interventions.

DISCUSSION

Cross-infection control is a critical aspect of dental practice, protecting both healthcare providers and patients from potential pathogen transmission.[5] This study evaluated the knowledge of dental students regarding cross-infection control, highlighting the relationship between their educational level and understanding of infection control protocols. The findings are consistent with previous studies, which have also emphasized the importance of education and practical training in improving infection control compliance among dental students.

The results indicate that clinical students (4th and 5th years) demonstrate significantly higher levels of knowledge compared to preclinical students (1st to 3rd years). This improvement aligns with the increased exposure to practical applications in clinical settings, which reinforce theoretical knowledge. Previous studies similarly report that hands-on experience enhances the retention and application of infection control measures.[3,7,13] However, significant knowledge gaps persist, particularly in areas such as aerosol control, surface disinfection, and sterilization techniques. Despite the overall adequacy of knowledge, several critical areas require improvement:

Aerosol Transmission: Questions related to the risks of aerosol production and its management had higher incorrect response rates, particularly among preclinical students. This aligns with studies emphasizing the need for targeted training on aerosol control in dental clinics.[4,8,11]

Sterilization and Disinfection: Challenges in understanding sterilization protocols were reflected in incorrect responses to questions about surface disinfectants and sterilization techniques. These findings underscore the need for repeated exposure to such topics through both theoretical instruction and practical demonstrations.[5,6,10]

Protective Measures: While knowledge of basic personal protective equipment (PPE) use was high, there were inconsistencies in understanding its application in specific scenarios, such as treating high-risk patients. This highlights the importance of situational training to bridge gaps between theoretical knowledge and practical application.[12,14]

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The study underscores the importance of the educational curriculum in shaping students' knowledge of infection control. Traditional didactic approaches alone may not suffice, as evidenced by the higher knowledge levels among clinical students who have engaged in hands-on learning. Integrating simulation-based learning and case-based discussions into preclinical years may enhance students' comprehension and retention of infection control protocols.[7,15]

Dental clinics are inherently high-risk environments for cross-infection due to the frequent generation of aerosols and the potential for contamination of instruments and surfaces. Effective infection control requires a multifaceted approach, including proper hand hygiene, use of PPE, sterilization of reusable instruments, and environmental disinfection.2,8 Dental education programs must continuously evolve to incorporate emerging evidence and updated guidelines, particularly in the wake of challenges like the COVID-19 pandemic.[4,9]

Further studies should explore the effectiveness of innovative teaching methods, such as virtual simulations and interprofessional training, in enhancing infection control knowledge. Longitudinal studies are also needed to assess how knowledge translates into practice after graduation. Moreover, education programs should prioritize practical demonstrations and continuous professional development to ensure that dental students are equipped to implement infection control measures effectively.[1,16]

To address the identified gaps, dental education programs should:

Place greater emphasis on practical training, particularly in early academic years.

Update curricula to include contemporary infection control guidelines, such as those developed during the COVID-19 pandemic.

Incorporate simulations and case-based learning to reinforce theoretical knowledge with practical applications.

Provide ongoing education and refresher courses for both preclinical and clinical students to ensure long-term retention of infection control protocols.

This study benefits from a large sample size and the inclusion of students from different academic years, allowing for a comprehensive analysis of knowledge trends. However, the use of a self-reported survey introduces potential biases, such as overestimation or underestimation of knowledge. Additionally, the survey's online format may have excluded students with limited internet access, potentially affecting the generalizability of the findings.

Further studies should explore the effectiveness of specific educational interventions in improving infection control knowledge. Longitudinal studies tracking knowledge retention and application from preclinical to clinical years could provide deeper insights into the impact of hands-on training. Additionally, qualitative research exploring students' perceptions of infection control education could help identify barriers to effective learning.

CONCLUSION

The findings of this study highlight the critical relationship between educational content and the knowledge levels of dental students regarding cross-infection control. As students advance through their education, their understanding and application of infection control protocols improve, particularly with the integration of clinical practice. However, persistent knowledge gaps in key areas, such as aerosol management and surface disinfection, emphasize the need for targeted enhancements in dental education programs.

To ensure comprehensive infection control training, dental curricula should prioritize the integration of theoretical knowledge with practical applications, particularly in the early stages of education. Regular updates to infection control protocols and ongoing education programs are essential for equipping students with the skills necessary to protect themselves and their patients.

By addressing these gaps and emphasizing hands-on training, dental education programs can play a pivotal role in reducing cross-infection risks and preparing future dental professionals to implement effective infection control measures confidently and consistently.

CLINICAL RELEVANCE

Scientific rationale: Evaluating students' knowledge provides valuable feedback on the effectiveness of the current curriculum and training programs. Principal findings: hands-on clinical experience influences students' understanding and implementation of infection control practices. Practical

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implications: Students who are well-informed are more likely to implement correct practices confidently and effectively in clinical settings, thereby reducing the risk of infection.

CONFLICTS OF INTEREST

The authors have no conflict of interests to declare.

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RESEARCH ARTICLE

Comparative Evaluation of Alprazolam and Hydroxyzine for Anxiolysis: Effects on Cardiac Autonomic Activity and Physiological Parameters

Alprazolam ve Hidroksizinin Anksiyete Üzerine Etkilerinin Karşılaştırmalı Değerlendirmesi

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ABSTRACT

Objective: This observational retrospective study aims to compare the effects of alprazolam and hydroxyzine on cardiac autonomic activity and physiological parameters in dental anxiety.

Methods: This study included 90 participants, divided into three groups: alprazolam (n=30), hydroxyzine (n=30), and control (n=30). Each group consisted of 15 males and 15 females, with mean ages of 37.68 ± 4.32 years, 38.53 ± 3.98 years, and 37.38 ± 4.15 years, respectively. Alprazolam and hydroxyzine groups received 0.5 mg of their respective medications one hour before oral surgical procedures. Blood pressure, heart rate, and oxygen saturation were measured at: preoperatively, intraoperatively (at 30-minute intervals), and postoperatively. Uniform surgical protocols were followed across all groups, and data were analyzed using ANOVA.

Results: In the control group, there was a significant increase in systolic and diastolic blood pressure and heart rate from preoperative to intraoperative measurements and a significant decrease in postoperative measurements compared to intraoperative values. In the hydroxyzine group, intraoperative systolic blood pressure and heart rate decreased compared to preoperative values, while postoperative values showed no significant change compared to intraoperative values. Diastolic blood pressure did not significantly change over time. In the alprazolam group, all values decreased significantly over time. Also, the alprazolam group showed a statistically significant decrease in all values compared to the hydroxyzine group. Conclusion: Both medications are effective compared to a control group for cardiovascular values. These findings may indicate that alprazolam and hydroxyzine may be viable options for preventing anxiety, with alprazolam being the more potent medication.

Keyword: Benzodiazepines, Hydroxyzine, Dental Anxiety, Blood Pressure, Cardiac Rate

ÖZET

Amaç: Bu gözlemsel çalışmanın amacı alprazolam ve hidroksizinin dental anksiyetede kardiyak otonomik aktivite ve fizyolojik parametreler üzerindeki etkilerini karşılaştırmaktır.

Yöntemler: Çalışmaya alprazolam, hidroksizin ve kontrol olmak üzere 3 grupta 90 katılımcı katılmıştır. Her grupta 30 katılımcı bulunmaktadır. Çalışma grupları işlemden bir saat önce 0,5 mg ilaç almışlardır. Kan basıncı, kalp hızı ve oksijen satürasyonu işlemden önce, işlem sırasında ve işlemden sonra ölçülmüştür.

Sonuçlar: Kontrol grubunda, sistolik ve diyastolik kan basıncı ve kalp hızında ameliyat öncesi ve ameliyat sırasındaki ölçümlerde anlamlı bir artış ve ameliyat sonrası ölçümlerde ameliyat sırasındaki değerlere kıyasla anlamlı bir azalma görülmüştür. Hidroksizin grubunda, ameliyat sırasındaki sistolik kan basıncı ve kalp hızı ameliyat öncesi değerlere kıyasla azalmıştır, ameliyat sonrası değerler ise ameliyat sırasındaki değerlere kıyasla anlamlı bir değişiklik göstermemiştir. Diyastolik kan basıncı zamanla anlamlı bir şekilde değişmemiştir. Alprazolam grubunda, tüm değerler zamanla anlamlı bir şekilde azalmıştır. Ayrıca, alprazolam grubu hidroksizin grubuna kıyasla tüm değerlerde istatistiksel olarak anlamlı bir düşüş gösterdi. Sonuç: Her iki ilaç da kardiyovasküler değerler açısından bir kontrol grubuna kıyasla etkilidir. Bu bulgular, alprazolam ve hidroksizinin anksiyeteyi önlemede uygulanabilir seçenekler olabileceğini, alprazolamın daha etkili ilaç olduğunu gösterebilir.

Anahtar Kelimeler: Benzodiazepin,Hidroksizin,Dental Anksiyete,Kan Basıncı,Kardiyak Aktivite

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INTRODUCTION

Despite the advancements in technology in the field of dentistry, fear and anxiety remain common problems among patients, which affect their overall dental experience. Anxiety is a complex emotional state that affects both the physiological and psychological aspects of an individual. This problem often leads to the postponement of appointments and difficulties during dental procedures, which may worsen the patient's existing pathological conditions. The physical symptoms of anxiety are the result of overactivity of the sympathetic nervous system and intensified muscle tension.[1,2] Dry mouth, difficulty swallowing, tenderness in the epigastrium, a feeling of tightness in the chest, difficulty breathing and excessive breathing may occur. In the cardiovascular system, patients may experience symptoms such as palpitations, chest pain or discomfort, tinnitus, blurred vision, tingling sensations, and dizziness. There may also be complaints due to muscular tension.[3]

Consequently, the use of sedative techniques is on the rise, mainly due to patient demand and the surgeon's recognition that procedures are performed more effectively when the patient is relaxed and cooperative.[4]

Alprazolam is a medication that belongs to the benzodiazepine class, commonly used to treat anxiety and panic disorder.[5] Since its introduction in the 1960s, it has been one of the most widely used drugs due to its rapid relief of anxiety and minimal adverse effects.[5-7] It binds to specific sites on the g-aminobutyric acid (GABA) receptor and works by slowing down the movement of chemicals in the brain, which may become unbalanced, reducing anxiety.[6] Alprazolam is most effective for diminishing abnormal excitement in the brain.[7]

Hydroxyzine, a derivative of the di-phenylethane group of drugs, is classified as an antihistamine or histamine (H1) blocker. It is a regular prescription agent with wide safety margins.[8] It is known as one of the safest sedative agents used in dentistry. It has been used frequently and for many years in combination with different agents in conscious sedation methods.[9] The physical effect of hydroxyzine does not cause true sleepiness. It relaxes the patient while creating a favorable environment, especially for dentistry, and the patient gives fully conscious and balanced responses to stimuli that cause fear.[10]

It is crucial to assess the effectiveness of these widely accessible drugs in clinical settings by monitoring vital signs. The main hypothesis of the study is that alprazolam will lead to a more significant reduction in anxiety-induced cardiovascular changes compared to hydroxyzine.

This study compared the effects of alprazolam and hydroxyzine on cardiac sympathetic and parasympathetic activities using changes in heart rate variability (HRV), systolic-diastolic blood pressure, and oxygen saturation in their use as sedatives.

MATERIALS AND METHODS

The present study investigated a cohort of patients who underwent minor surgical procedures, such as impacted teeth surgery, odontogenic cyst/tumor excision, and implant surgery, under local anesthesia at the Hacettepe University Faculty of Dentistry and the Faculty of Oral and Maxillofacial Surgery between January 2019 and September 2021.

The ethical approval of the retrospective study with project number GO 22/965 was approved by Hacettepe University Non-Interventional Research Ethics Committee with decision number 2022/ 15-35. Patient data were obtained from the archival resources of our university. Once the required number of patients who met the study criteria was reached, the archival search was completed. During the inclusion of patients in the study, their personal information was carefully preserved and reviewed to mitigate the risk of bias. Attention was given to ensuring age and gender compatibility between the groups.

The study was conducted in accordance with the Declaration of Helsinki guidelines. Informed consent was obtained from the participants so that the data could be used for study purposes.

Vital signs of each patient, including heart rate, systolic and diastolic blood pressure, oxygen saturation levels, and encountered side effects, are assessed before, during (at half-hourly intervals), and after the procedure, until the patients are considered suitable for discharge. Since January 2020, our hospital has followed a routine practice of randomly administering either alprazolam or hydroxyzine to patients before surgical procedures for sedation.

The control group comprises patient data obtained in January 2020, before sedation implementation began.

The study included a total of 90 participants, divided equally into three groups: the alprazolam group, the hydroxyzine group, and the control group. Each group consisted of 30 individuals, with 15 males and 15 females in each group to ensure gender

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balance. The mean ages and standard deviations of the participants were as follows: the alprazolam group had a mean age of 37.68 ± 4.32 years, the hydroxyzine group had a mean age of 38.53 ± 3.98 years, and the control group had a mean age of 37.38 ± 4.15 years.

Participants were selected retrospectively from archival records, ensuring age and gender compatibility across all groups to minimize bias. Inclusion criteria included patients aged 18–80 years who underwent minor oral surgical procedures under local anesthesia, such as impacted tooth extractions, odontogenic cyst or tumor excision, or implant placement. Patients with systemic or mental health issues, those taking medications that could interfere with cardiovascular responses, or those with incomplete or missing data were excluded from the study.

The alprazolam and hydroxyzine groups received 0.5 mg of their respective medications one hour before the procedure, while the control group did not receive any preoperative sedation. All groups underwent similar surgical procedures performed under the same local anesthetic protocol to ensure uniformity in the study conditions. The alprazolam and hydroxyzine groups received a dose of 0.5 mg of the respective drug one hour before the procedure, as determined based on the prospectus information. Vital signs were measured 30 minutes after the start of the procedure and again 30 minutes after its completion. Systolic blood pressure, diastolic blood pressure, oxygen saturation, pulse rate, and encountered side effects were evaluated in the study.

Throughout the procedure, the vital signs of all patients were monitored at half-hourly intervals. The procedure site was completely anesthetized with the same local anesthetic for all patients to ensure a painless procedure. The duration of the procedure was recorded following established protocols. The study included patients whose procedure time ranged from 30 to 60 minutes. All patients received standard information and were requested to provide informed consent by signing a consent form.

The analyses were conducted using IBM SPSS Statistics V25 software. Numerical variables were summarized using the mean and standard deviation. The distribution of numerical values was assessed through normality tests (Kolmogorov-Smirnov and Shapiro-Wilk tests) and graphical methods such as histograms and QQ plots. Repeated Measures ANOVA with One Fixed Factor was employed to examine differences between time points, drug groups, and the interaction between time and group. In case a significant interaction was detected, pairwise comparison tests were conducted to identify the source of the difference. The significance level for the analyses was set at 0.05.

The study was conducted according to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist.

RESULT

Each group consisted of 30 participants, with an equal gender distribution (15 males and 15 females). The mean age and standard deviations of the participants were as follows: the alprazolam group had a mean age of 37.68 ± 4.32 years, the hydroxyzine group had a mean age of 38.53 ± 3.98 years, and the control group had a mean age of 37.38 ± 4.15 years. Age and gender compatibility were ensured across all groups to minimize bias.

No adverse effects were encountered in patients, and their vital signs remained within the acceptable range.

The control group exhibited time-dependent changes in systolic and diastolic blood pressure values, as well as heart rate values, as described below: There was a statistically significant increase observed between preoperative and intraoperative measurements. And a statistically significant decrease was observed between intraoperative and postoperative measurements. While there was an increase between preoperative and postoperative measurements, this difference did not reach statistical significance. (Table 1).

During the analysis of time-dependent changes in the hydroxyzine group, it was observed that all intraoperative values showed a decrease compared to the preoperative values. However, the postoperative values did not demonstrate a statistically significant change compared to the intraoperative values. Additionally, when examining the preoperative and postoperative values, it was found that diastolic pressure values did not exhibit a statistically significant change, whereas systolic pressure and heart rate values displayed a statistically significant decrease. (Table 1).

Upon analyzing the time-dependent values of the group treated with alprazolam, it was observed that all values (i.e. systolic pressure, diastolic pressure, and heart rate) displayed a statistically significant decrease over time (Table 1).

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Table 1. Demographic information of the individuals included in the study and descriptive statistics.

		Hydroxyzine	Alprazolam	Control
N		30	30	30
Age (Mean)		38.53	37.68	37.38
Sex				
	Male	15	15	15
	Female	15	15	15
Procedure				
	Implant	12	10	9
	Impacted Teeth	11	10	13
	Cyst/Tumor	7	10	8
Procedure Time (Minute) (mean)		37.83	36.2	38.45
Pre-operative				
Systolic	Mean	141.81	145.21	122.16
	Std. Deviation	23.214	15.407	14.138
Diastolic	Mean	77.81	85.55	68.78
	Std. Deviation	12.576	11.882	10.779
Heart Rate	Mean	99.45	96.17	86.56
	Std. Deviation	14.731	17.929	16.150
Saturation	Std. Deviation	3.393	1.771	1.4
Intra-operative				
Systolic	Mean	126.29	122.83	136.78
	Std. Deviation	21.734	14.170	19.245
Diastolic	Mean	72.26	70.86	75.91
	Std. Deviation	13.677	10.763	12.678
Heart Rate	Mean	87.32	81.48	96.91
	Std. Deviation	13.227	12.880	16.257
Saturation	Std. Deviation	3.243	2.485	1.437
Post-operative				
Systolic	Mean	123.52	115.45	123.94
	Std. Deviation	14.774	13.289	11.706
Diastolic	Mean	73.16	67.59	70.84
	Std. Deviation	13.616	10.655	11.399
Heart Rate	Mean	85.84	75.66	87.28
	Std. Deviation	17.48	01.125	13.274
Saturation	Std. Deviation	2.242	1.769	1.008

Std. Deviation: Standard Deviation

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Table 2 presents the descriptive statistical analysis of the measured values of Alprazolam and Hydroxyzine, excluding the control group. The right side of the table displays the F value and p value obtained from the time-dependent, group-dependent, and group-time-dependent ANOVA analyses.

When the variations related to the administered drugs were examined using ANOVA, it was observed that the drug containing the active substance alprazolam demonstrated a statistically significant decrease in both systolic and diastolic pressure compared to the drug containing the active substance hydroxyzine. No significant differences were found in heart rate and saturation values when considering changes over time and between groups (Table 2).

Descriptive analyses did not reveal any statistical changes in the saturation variable within any group or at any time interval. Consequently, further statistical analysis calculations could not be performed (Table 3).

Table 2. Group-time interactions of systolic and diastolic pressure changes and heart rate in the control, hydroxyzine, and alprazolam group.

Groups				Mean Difference (I-J)	Std. Error	p
Sistolic	Control	Preoperative	Intraperative	-14.625	1.886	<0.001*
			Postoperative	-1.781	2.12	1
		Postoperative	Intraperative	-12.844	2.082	<0.001*
	Hydroxyzine	Preoperative	Intraperative	15.516	1.916	<0.001*
			Postoperative	18.290	2.154	<0.001*
		Postoperative	Intraperative	-2.774	2.115	0.579
	Alprazolam	Preoperative	Intraperative	22.379	1.981	<0.001*
			Postoperative	29.759	2.227	<0.001*
		Postoperative	Intraperative	-7.379	2.187	0.003*
Diastolic	Control	Preoperative	Intraperative	-7.125	1.908	0.001*
			Postoperative	-2.063	2.061	0.959
		Postoperative	Intraperative	-5.063	1.767	0.016*
	Hydroxyzine	Preoperative	Intraperative	5.548	1.938	0.016*
			Postoperative	4.645	2.094	0.087
		Postoperative	Intraperative	0.903	1.795	1
	Alprazolam	Preoperative	Intraperative	14.690	2.004	<0.01*
			Postoperative	17.966	2.165	<0.01*
		Postoperative	Intraperative	-3.276	1.856	0.243
Heart Rate	Control	Preoperative	Intraperative	-10.344	2.311	<0.001*
			Postoperative	-0.719	2.55	1
		Postoperative	Intraperative	-9.625	2.141	<0.001*
	Hydroxyzine	Preoperative	Intraperative	12.129	2.348	<0.001*
			Postoperative	13.613	2.591	<0.001*
		Postoperative	Intraperative	-1.484	2.175	1
	Alprazolam	Preoperative	Intraperative	14.690	2.427	<0.001*
			Postoperative	20.517	2.679	<0.001*
		Postoperative	Intraperative	-5.828	2.249	0.034*

*: <0.05, Preoperative: Pre-operative value, Intraoperative: Intra-operative value, Postoperative: Post-operative value

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Table 3. Descriptive Statistics, Tests of Between- Drugs Effects and Tests of Within-Drugs Effects.

	Time Zone	Grups	Mean	Std. Deviation	Time	Time- Group
		Hydroxyzine	129.68	18.201		
	Preoperative	Alprazolam	131.62	14.683		
		Total	130.62	16.484		
		Hydroxyzine	126.29	21.734		
Sistolic	Intraoperative	Alprazolam	122.83	14.170	F=117.563 p<0.001*	F=7.556 p<0.001*
		Total	124.62	18.399		
		Hydroxyzine	123.52	14.774		
	Postoperative	Alprazolam	115.45	11.816		
		Total	119.62	13.920		
		Hydroxyzine	73.55	11.254		
	Preoperative	Alprazolam	76	13.628		
		Total	74.73	12.412		
		Hydroxyzine	72.26	13.677		
Diastolic	Intraoperative	Alprazolam	70.86	10.763	F=29.046 p<0.001*	F=9.065 p<0.001*
		Total	71.58	12.271		
		Hydroxyzine	73.16	13.616		
	Postoperative	Alprazolam	67.59	10.655		
		Total	70.47	12.492		
		Hydroxyzine	93.87	12.927		
	Preoperative	Alprazolam	85.97	14.386		
		Total	90.05	14.109		
		Hydroxyzine	87.32	13.227		
Heart Rate	Intraoperative	Alprazolam	81.48	12.88	F= 53.481 p<0.001*	F=2.102 p=0.116
		Total	84.5	13.28		
		Hydroxyzine	85.84	17.48		
	Postoperative	Alprazolam	75.66	10.125		
		Total	80.92	15.177		
		Hydroxyzine	96.32	4.4		
	Preoperative	Alprazolam	96.83	1.794		
		Total	96.57	3.382		
		Hydroxyzine	96.58	3.243		
Saturation	Intraoperative	Alprazolam	96.03	2.485	F=0.452 p=0.685	F=1.033 p=0.372
		Total	96.32	2.891		
		Hydroxyzine	96.81	2.242		
	Postoperative	Alprazolam	96.72	1.888		
		Total	96.77	2.061		

*: <0.05, Preoperative: Pre-operative value, Intraoperative: Intra-operative value, Postoperative: Post-operative value

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DISCUSSION

Oral anxiolytics are cost-effective medications that are easy to take, have a high degree of patient acceptance and compliance, and reduce the severity of adverse reactions without the need for additional medical intervention. These drugs provide short procedure times for surgical procedures under local anesthesia.[11] Preoperative anxiety is a common issue among outpatients, highlighting the need for oral premedication with potent anxiety-reducing effects and minimal psychomotor impairment. No studies have been published evaluating the impact of drugs containing the active ingredients alprazolam and hydroxyzine, administered as oral tablets, on vital signs in relation to anxiety. The primary objective of this study was to evaluate the effectiveness of commonly used drugs, alprazolam and hydroxyzine, before oral surgical procedures and to compare their efficacy with a control group.

According to current study results, as expected, the intraoperative values in the control group were statistically significantly higher than the preoperative and postoperative values. In this situation, it may be concluded that patients may experience high levels of anxiety and tension during dental procedures, which can lead to physical reactions such as increased heart rate and blood pressure. This can be attributed to various factors, including fear of pain, discomfort, or loss of control, as well as the general discomfort of being in a clinical setting.

In the groups receiving premedication, the highest values were observed preoperatively, and the lowest values were recorded postoperatively, decreasing over time.

Alprazolam and hydroxyzine are often used in premedication due to their anxiolytic effects, as reported in the literature. In the present study, the anxiolytic effects of the drugs were indirectly examined through the cardiovascular system.

Midazolam is a potential candidate due to its short duration of action and is the most widely used,[12] making it a recommended benzodiazepine for outpatient surgical procedures.[13] However, it should be noted that the oral formulation of midazolam is not approved in certain countries.[14,15] Therefore, oral alprazolam was used in our study. Studies have shown that alprazolam may be a viable option for managing anxiety in countries where oral midazolam is not approved. One study[15] demonstrated that while a dose of 7.5mg of midazolam caused amnesia, a 0.5mg dose of alprazolam was equally effective in treating anxiety without such side effects.

It has been reported that anxiety can cause an increase in blood pressure, particularly in individuals with high blood pressure 16. The use of alprazolam has been shown to reduce the cardiovascular effects of anxiety and lower the risk of ischemic stroke, hemorrhagic stroke, and myocardial infarction events. Thus, it has been recommended to use it to reduce anxiety, especially in patients with high blood pressure.[17,18]

Studies focusing on alprazolam for anxiety management in premedication have shown that alprazolam is more effective than a placebo for anxiety management, with doses ranging from 0.25 to 1 mg having similar efficacy.[19]

In 2022, Hanna et al.[1,11] updated that alprazolam can be used in the control of panic-type anxiety by giving a single dose at a range of 0.25-1 mg before dental procedures.

Therefore, the dose of alprazolam was determined as 0.5 mg in the present study.

In the present study, hydroxyzine was less effective than alprazolam in reducing cardiovascular values. Thus, when comparing the cardiovascular values, it was found that alprazolam was more effective than hydroxyzine.

While certain studies have posited that hydroxyzine is ineffective in preventing anxiety, other research has suggested that the drug may be efficacious. Studies indicate that hydroxyzine may prevent anxiety-induced cardiovascular changes but with lower efficacy than benzodiazepines.[20] A study evaluating the efficacy of oral midazolam and midazolam-hydroxyzine combination in premedication for anxiolysis showed that combination therapy was more effective than midazolam alone.[21]

In a double-blind, randomized, prospective, controlled study by Boon et al., a statistically significant decrease in anxiety values was recorded in the group using hydroxyzine, but no statistical difference was observed against placebo. In addition, there was no difference in hemodynamic values (blood pressure, heart rate, respiratory rate) for the study and control groups.[22] A study was conducted to evaluate the effectiveness of different doses of hydroxyzine. The researchers found that administering the drug 24 hours before and on the day of surgery was just as effective as giving a single dose only on the day of surgery.[23]

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No studies show the optimal dose and time of hydroxyzine premedication; hence, the current study has followed the routine clinical practice in our hospital.[20]

Oral surgical procedures can cause a high level of anxiety among patients, as they are typically performed while the patient is awake. The surgeon stays in the patient's field of vision, and local anesthetics don't effectively reduce the sensation of pressure. By effectively managing anxiety, the patient and physician can have a smoother and shorter procedure, which can significantly impact the success of the surgical procedure.

The observed differences between alprazolam and hydroxyzine can be attributed to their distinct biological mechanisms of action. Alprazolam, a benzodiazepine, enhances the inhibitory effect of gamma-aminobutyric acid (GABA) on the central nervous system, resulting in a significant reduction in sympathetic nervous system activity and a more pronounced anxiolytic effect.[6,7] In contrast, hydroxyzine, an H1 receptor antagonist, exerts its anxiolytic effects primarily through histamine receptor blockade and mild sedative properties.[8-10] This difference likely explains alprazolam's superior ability to attenuate anxiety-induced cardiovascular changes, as it directly modulates the central mechanisms responsible for heightened sympathetic arousal.[5]

One of the limitations of this study is that it did not involve patient feedback. Future studies that incorporate patient evaluation would be valuable additions to the literature. Although all participants underwent minor oral surgical procedures, the variability in procedure types (e.g., impacted tooth extractions, odontogenic cyst or tumor excisions, and implant placements) may have influenced the physiological responses and anxiety levels. The lack of subgroup analyses based on procedure types limits the ability to assess the specific effects of each procedure on cardiovascular parameters and anxiety levels. And, the study compared only a single dose (0.5 mg) of alprazolam and hydroxyzine. Exploring different doses and their effects could provide a broader understanding of the dose-response relationship.

Another major limitation of the present study is the indirect evaluation of the effect of the given drugs. The study primarily evaluated the anxiolytic effects of alprazolam and hydroxyzine through changes in cardiovascular parameters, rather than directly measuring anxiety levels via validated psychological scales. While cardiovascular changes are well-documented indicators of anxiety, direct patient-reported outcomes could provide a more comprehensive understanding of the medications' anxiolytic effects.

CONCLUSION

Both alprazolam and hydroxyzine demonstrated efficacy in reducing anxiety-induced cardiovascular changes compared to the control group, with alprazolam showing a more pronounced effect. These findings suggest that alprazolam may be a superior option for managing dental anxiety in patients undergoing minor oral surgical procedures. However, further studies incorporating direct anxiety assessments and subgroup analyses based on procedure types are needed to validate and expand upon these results.

CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ETHICS

The study was approved by the Hacettepe University Non-Interventional Research Ethics Committee with the decision number "GO 22/965".

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RESEARCH ARTICLE

The Effect of Implant Position, Thread Design and Tilting on Marginal Bone Resorption in Tilted Implant System

Açılı İmplant Uygulama Sistemlerinde İmplant Pozisyonu, Diş Tasarımı ve Açının Marjinal Kemik Rezorpsiyonu Üzerine Etkisi

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ABSTRACT

The all-on-four system utilizes 2 parallel anterior implants and 2 distally tilted posterior implants between mental foramina on mandible, between maxillar sinuses on maxilla with an immediately loaded temporary fixed prosthesis. Purpose of this study is evaluating the effect of implant position, thread design and tilting on marginal bone resorption after tilted implant surgery similar to the all-on-four system.

17 patient recieved 92 implants with 2 different forms (level, rapid). Radiographic assessment of marginal bone level change was performed at 1 year follow-up period. The differences between marginal bone resorption for implant position, thread design and tilting degree were analyzed with the Mann Whitney U test. The value p = 0.05 was considered as the level of significance.

Total marginal bone level was, on average, 0.2994mm (SD=0.80026) for mandible, 0.3992mm (SD=0.43636) for maxilla, 0.4377mm (SD=0.82100) for tilted implants, 0.2682mm (SD=0.41187) for axial implants, 0.3785mm (SD=0.70581) for level form implants, 0.2789mm (SD=0.46179) for rapid form implants. Mean bone loss was significantly higher in the tilted implants. There is no significant difference found in marginal bone loss between the maxilla-mandible and different threaded implant forms.

Keywords: All on four, thread design, tilted implants, marginal bone loss, bone resorption

ÖZET

All on four sistemi ile; mandibulada mental formenler arası bölgeye, maksillada maksiller sinüsler arası bölgeye anteriorda iki vertikal, sağ ve sol posteriorda açılı birer implant uygulamasını takiben aynı seansta sabit geçici protez uygulanır. Bu çalışmanın amacı All on four cerrahisi sonrasi implant konumu, yiv yapısı ve açılandırmanın marjinal kemik rezorpsiyonuna etkisini tespit etmektir.

17 hastaya, iki farklı formda(level, rapid), 92 adet implant uygulanmıştır. 1 yıllık takiplerinde panoramik radyografiler üzerinden marjinal kemik kayıpları karşılaştırılmıştır. İmplantların tipi, implantların konumu ve çeneler arasındaki marjinal kemik kaybı farkları Mann Whitney U testi ile analiz edilmiş, istatistik anlamlılık düzeyi 0,05 olarak kabul edilmiştir.

Total kemik kaybı mandibulada ortalama 0,2994mm(SS=0,80026); maksillada ortalama 0,3992mm(SS=0,43636), açılı implantlarda ortalama 0,4377mm (SS=0,82100); aksiyal implantlarda ortalama 0,2682mm(SS=0,41187), level form implantlarda ortalama 0,3785mm(SS=0,70581); rapid form implantlarda ortalama 0,2789mm(SS=0,46179) olarak ölçülmüştür. Total marjinal kemik kayıpları yönünden açılı implantlar yönünde anlamlı fark bulunmuş; maksilla-mandibula, implant yiv formları açısından değerlendirildiğinde anlamlı fark bulunamamıştır.

Anahtar Kelimeler: All on four, yiv şekli, açılı implantlar, marjinal kemik kaybı, kemik rezorpsiyonu

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INTRODUCTION

Edentulism can lead to significant bone resorption in the maxilla and mandible. Along with the bone resorption, retention and functional challenges arise with the use of removable prostheses.[1]

The complete loss of dentition is typically managed through three prosthetic options: removable partial or complete dentures, implant-supported fixed prostheses, and implant-supported removable prostheses. In edentulous arches, implant-supported fixed prostheses are often perceived by patients as an integral part of their own body, addressing both physiological and psychological needs more effectively than removable dentures.[2]

The application of dental implants in their contemporary form was first introduced by Branemark in 1965, and has since evolved and been successfully implemented through to the present day.[3] In cases where dental implant placement is required in edentulous and severely resorbed arches, various anatomical limitations (such as the mandibular canal, mental foramen, and maxillary sinus), as well as insufficient bone height and width, may render the standard approach of placing six to eight axially placed implants with a fixed prosthesis unfeasible. In such cases, advanced surgical procedures, including sinus lift, ridge splitting, and bone augmentation, may be required. However, the applicability of these advanced surgical techniques has decreased due to factors such as increased morbidity risk, longer operative time, higher costs, and extended edentulous periods.[4-6] As a consequence of these considerations, the region between the mental foramina in the mandible and the area between the maxillary sinuses in the maxilla have become established as preferred sites for implant placement in clinical practice.[2,7]

The all-on-four system is a treatment concept first developed by Malo and colleagues in 1998. It involves the placement of four implants in edentulous arches: two vertical implants in the anterior region between the mental foramina in the mandible and between the maxillary sinuses in the maxilla, and two angled implants in the posterior regions on both sides.[8,9] With the all-on-four system, a fixed temporary prosthesis is placed during the same surgical session as the implant placement.[10] Depending on the clinical situation, the procedure may involve the use of 4 to 6 implants in the maxilla.[5,8]

When dental implants begin to function, they are subjected to various forces. If the distribution of these forces is not appropriately designed from both a prosthetic and surgical perspective, undesirable outcomes such as bone resorption and implant failure may occur.[11] To consider implant placement successful, some researchers suggest that the marginal bone loss should be less than 0.2 mm by the end of the first year of implant function.[12] In contrast, other researchers consider a radiographic bone loss of 2 mm or less after the surgical procedure as an indicator of success.[13] Marginal bone loss is considered a crucial factor in determining the success of dental implants. As a result, numerous studies have been conducted to evaluate marginal bone loss in various implant applications.[14,15]

In studies investigating marginal bone loss within the all-on-four concept, axial and angled implants have been evaluated separately, with distinct categorizations for implants placed in the maxilla and mandible.[16,17]

The aim of this study is to evaluate the relationship between marginal bone loss in implants placed in the maxilla and mandible within the tilted implant concept, with regard to variables such as implant positioning, thread design, and angulation.

MATERIAL METHOD

This study has been approved by the Non-Interventional Research Ethics Committee of Istanbul Yeni Yüzyıl University, under decision number 2022/05-860, in accordance with the principles outlined in the Declaration of Helsinki of the World Medical Association. The study included 17 patients (7 females, 10 males) who presented to our clinic due to total edentulism, classified as healthy according to the ASA scale (ASA-1/ASA-2). A total of 65 Mode Level implants (Mode Level Implant; Mode Medikal, Istanbul, Türkiye) and 27 Mode Rapid implants (Mode Rapid Implant; Mode Medikal, Istanbul, Türkiye) were placed in the participants. A total of 48 implants were placed in the maxilla, and 44 implants were placed in the mandible. The surgical placement of the implants was performed by an experienced oral and maxillofacial surgeon, while the prosthetic restorations were carried out by a skilled prosthodontist. In the maxilla, some patients received 6 implants, with the posterior implants angulated distally. Following implant placement, all patients were rehabilitated with immediate acrylic fixed prostheses. After 3 months, permanent fixed restorations

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were applied using hybrid prostheses. A panoramic radiograph was obtained from all patients following the loading of the temporary prosthetic restorations. Panoramic radiographs were obtained digitally using a CCD sensor-based orthopantomograph (PAX-I, Vatech, South Korea). Patient follow-up was conducted radiographically and clinically at 3, 6, and 12-month intervals (Figure 1). During the 12-month follow-up, radiographic images taken with the same device were compared to the initial radiographs, and marginal bone loss at the mesial and distal aspects of the implants was measured using Image J software (US National Institutes of Health, USA) (Figure 2). Radiographic measurements were performed twice by a researcher who was not involved in the treatment process, and the arithmetic mean of the repeated measurements was used for analysis. The arithmetic mean of the mesial and distal marginal bone resorption values was considered the total marginal bone resorption for each implant. The distance from the implant-abutment connection to the first visible bone level in contact with the implant at the closest point was measured and compared with the values on the follow-up radiograph. Axial and tilted implants, as well as their distribution in the maxilla and mandible, were evaluated separately according to the implant thread designs (level, rapid).

Statistical analyses were performed using IBM SPSS Statistics 20.0 software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp., USA). Descriptive statistical methods (mean, standard deviation, frequency) were applied in evaluating the data. The normality of the data distribution and the homogeneity of variances were assessed using the Kolmogorov-Smirnov and Levene tests. It was found that the data did not follow a normal distribution. Differences in distal, mesial, and total marginal bone loss between implant types, implant positions, and arches were analyzed using the Mann-Whitney U test. A significance level of 0.05 was considered for all analyses.

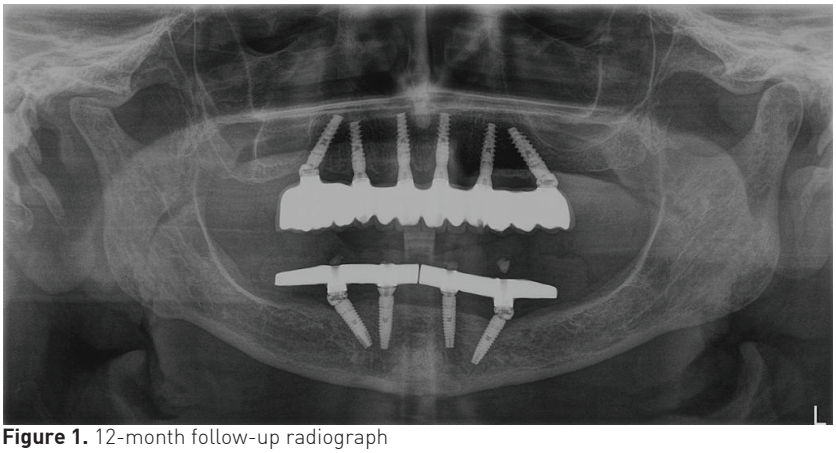

Figure 1. 12-month follow-up radiograph

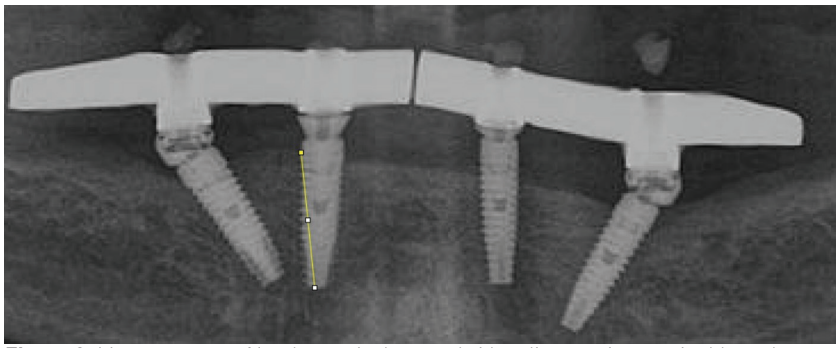

Figure 2. Measurement of implant apical-crestal ridge distance in marginal bone loss assessment

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RESULTS

None of the 92 implants placed in the 17 patients participating in this study experienced failure. The follow-up results for all patients were compared over a 1-year period.

Table 1. Distribution of marginal bone loss in the mandible and maxilla

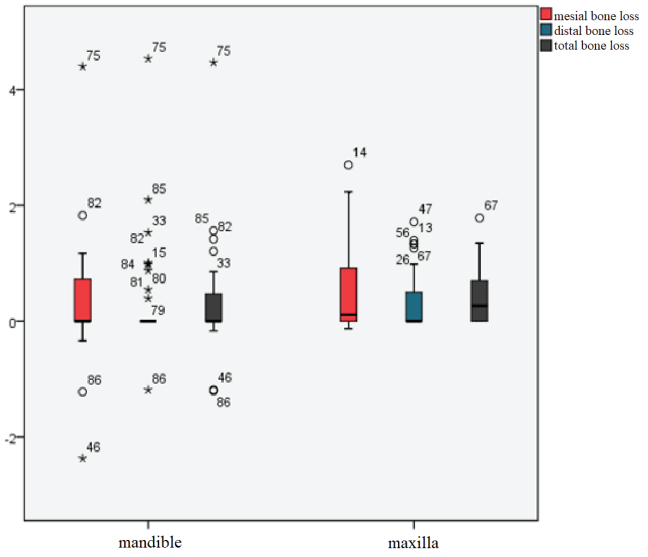
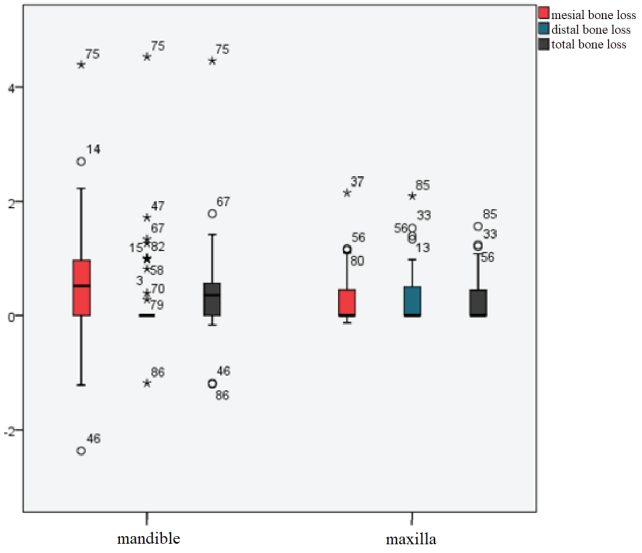


Table 2. Statistical results of marginal bone resorption in the mandible and maxilla, the Mann-Whitney U test (p<0.05)

	jaw	N	Mean	Std. Deviation	Std. Error Mean
Mesial bone loss	mandible	44	0.3433	0.88996	0.13122
	maxilla	48	0.5167	0.71808	0.10588
P*			0.36		
Distal bone loss	mandible	44	0.2555	0.81440	0.12008
	maxilla	48	0.2816	0.47757	0.07041
P*			0,18		
Total bone loss	mandible	44	0.2994	0.80026	0.11799
	maxilla	48	0.3992	0.43636	0.06434
P*			0.08		

When marginal bone resorption was examined, the following measurements were obtained: in the mandible, the average mesial bone resorption was 0.3433mm (SD = 0.88996) and the distal bone resorption was 0.2555mm (SD = 0.81440); in the maxilla, the average mesial bone resorption was 0.5167mm (SD = 0.71808) and the distal bone resorption was 0.2816mm (SD = 0.47757). The total marginal bone loss was measured as 0.2994mm (SD = 0.80026) in the mandible and 0.3992 mm (SD = 0.43636) in the maxilla (Table 1). According to statistical results, no significant difference was found in marginal bone loss between the mandible and maxilla when the tilted implant concept was applied (Table 2).

Table 3. Distribution of marginal bone loss according to implant angulations



When evaluated based on implant angulation, the following bone resorption measurements were observed: for the angulated implants, the average mesial bone loss was 0.6000mm (SD = 1.03537) and the distal bone loss was 0.2755mm (SD = 0.81820). For the axial implants, the average mesial bone loss was 0.2743mm (SD = 0.48391) and the distal bone loss was 0.2622mm (SD = 0.49109). The total bone loss was measured as 0.4377mm (SD = 0.82100) for angulated implants and 0.2682mm (SD = 0.41187) for axial implants (Table 3). In the application of the all-on-four concept, a significant difference in marginal bone loss was observed at the mesial site between angulated and axial implants, with angulated implants exhibiting greater bone loss. However, no significant difference in marginal bone loss was found at the distal site.

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Additionally, a significant difference in total marginal bone loss was noted, with angulated implants showing greater resorption (Table 4).

Table 4. Statistical results of marginal bone resorption in implants with angled and axial placements, the Mann-Whitney U test (p<0.05).

	Angulation	N	Mean	Std. Deviation	Std. Error Mean
Distal bone loss	Angled	44	0.2755	0.81820	0.12335
	Axial	48	0.2622	0.49109	0.07088
P*			0.92		
Mesial bone loss	Angled	44	0.6000	1.03537	0.15609
	Axial	48	0.2743	0.48391	0.06985
P*			0.01		
Total bone loss	Angled	44	0.4377	0.82100	0.12377
	Axial	48	0.2682	0.41187	0.05945
P*			0.05		

Table 5. Distribution of marginal bone loss according to implant thread shape

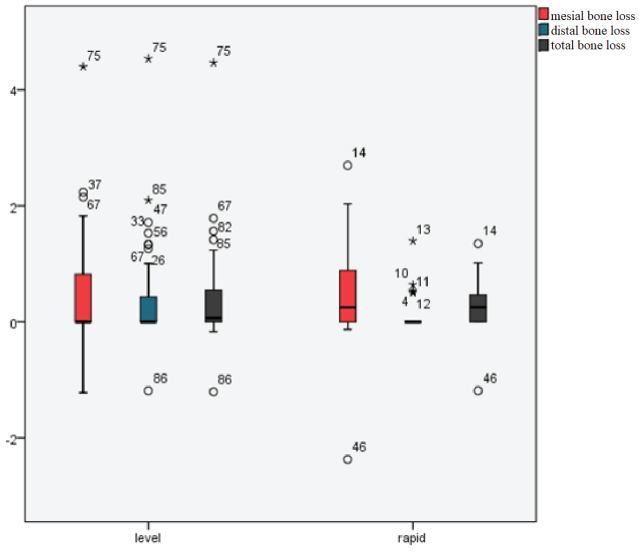

Table 6. Statistical results of marginal bone resorption according to implant thread shapes, the Mann-Whitney U test (p<0.05).

	implant	N	Mean	SS.	Std. Error Ort.
Mesial bone loss	level	65	0.4321	0.77850	0.09656
	rapid	27	0.4250	0.89332	0.17192
P*			0.97		
Distal bone loss	level	65	0.3249	0.75764	0.09397
	rapid	27	0.1329	0.32136	0.06185
P*			0.91		
Total bone loss	level	65	0.3785	0.70581	0.08754
	rapid	27	0.2789	0.46179	0.08887
P*			0.42		

When evaluated according to thread design, the following bone resorption measurements were obtained: for the level-threaded implants, the average mesial bone loss was 0.4321mm (SD = 0.77850) and distal bone loss was 0.3249mm (SD = 0.75764). For the rapid-threaded implants, the average mesial bone loss was 0.4250mm (SD = 0.89332) and distal bone loss was 0.1329mm (SD = 0.32136). The total bone loss was measured as 0.3785mm (SD = 0.70581) for level-threaded implants and 0.2789mm (SD = 0.46179) for rapid-threaded implants (Table 5). The thread design of the implants did not result in a significant difference in marginal bone loss when the all-on-four concept was applied (Table 6).

DISCUSSION

Studies have demonstrated the success of placing fixed prostheses on 4-6 standard axial implants in the region between the mental foramina.[7,18,19] However, the need to increase cantilever length can lead to long-term prosthetic failures.[2,10,13] Research has shown no significant difference in stress distribution between angulated and axial implant placements, with angulated implants being considered a viable option for placement.[14,20–22] In studies applying the all-on-four concept with 4 or 6 implants, high success rates have been observed and supported by clinical evidence.[5,8,17]

The successful outcomes of the immediate loading procedure have been demonstrated in numerous studies, and it has also been frequently applied with favorable results in the all-on-four system.[11,17,18,23,24] In a systematic review conducted by Gaonkar

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et al., it was noted that the placement of angulated or axial implants with immediate loading in the maxilla or mandible under the all-on-four concept did not affect the marginal bone levels.[24]

Fracture of acrylic prostheses is among the most frequently encountered prosthetic complications in immediate loading procedures, as observed in numerous studies. As a preventive measure, it has been recommended that permanent prostheses be reinforced with a metal framework.[17,24]

In this study, the total bone resorption was measured as an average of 0.2994mm (SD = 0.80026) in the mandible and 0.3992mm (SD = 0.43636) in the maxilla. In studies conducted by Malo et al., at the 1-year follow-up, marginal bone loss was measured as 0.9mm (SD = 1.0) in the maxilla and 0.6mm (SD = 0.6) in the mandible.[18,19] In a systematic review by Patzelt et al., no significant difference was found in the marginal bone resorption between the maxilla (1.0mm, SD = 0.5) and mandible (0.8mm, SD = 0.4) based on the 13 studies examined. [25] The results obtained in our study are consistent with those of previous research.

The total bone resorption was measured as an average of 0.4377mm (SD = 0.82100) for angulated implants and 0.2682mm (SD = 0.41187) for axial implants in this study. Agliardi et al. reported 0.8mm of bone loss for angulated implants and 0.9 mm for axial implants[2]; Francetti et al. found 0.7mm (SD = 0.5) for angulated implants and 0.7mm (SD = 0.4) for axial implants[11]; Hinze et al. reported 0.76mm (SD = 0.49) for angulated implants and 0.82mm (SD = 0.31) for axial implants[13]; and Tironi et al. found 1.2mm for angulated implants and 1.4mm for axial implants.[27] In all of these studies, no statistically significant difference was found in marginal bone resorption between angulated and axial implants.

The total bone loss was measured as an average of 0.3785mm (SD = 0.70581) for level-threaded implants and 0.2789mm (SD = 0.46179) for rapid-threaded implants. There are few studies examining the relationship between implant thread design and marginal bone resorption. Wu et al., in their study using finite element analysis and in vitro comparisons, compared two implant forms with different thread designs but the same size and diameter. They found no significant differences in the stresses occurring in the peri-implant bone between the two implant designs.[26] Our findings are consistent with these results.

It is well-established that marginal bone loss can lead to implant failures in the long term. In a 10-year follow-up study conducted by Pera et al., it was noted that marginal bone loss is most commonly observed within the first month following implant placement and loading.[27] In a longitudinal study by Malo et al., which involved surgical and prosthetic rehabilitation using the all-on-four system with follow-up periods ranging from 10 to 18 years, it was reported that the risk of implant failure increased when marginal bone loss exceeded 3mm.[17] Considering that the expertise and experience of the clinicians providing patient care can influence the outcomes of the studies, long-term follow-up in additional research is essential to confirm the accuracy of these evaluations.

CONCLUSION

The implant thread design, implant positioning, angulated or axial placement, and thread morphology in the tilted implant system have been shown to have no significant effect on marginal bone loss. This study presents only 1-year follow-up results. Further clinical studies with longer follow-up periods are needed to assess long-term outcomes.

CONFLICT OF INTEREST

The authors of the article declare that there are no personal or financial conflicts of interest related to the study.

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RESEARCH ARTICLE

The Evaluation of The Treatment Options With Intermaxillary Fixation Screws and Miniplates in Bilateral Mandibular Fractures By Finite Element Analysis

İki Taraflı Mandibüler Kırıklarda Intermaksiller Fiksasyon Vidaları ve Miniplaklarla Tedavi Seçeneklerinin Sonlu Elemanlar Analizi ile Değerlendirilmesi

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ABSTRACT

Objective: The aim of this study is to assess the stress values and the amount of displacement (D) that occurs on the fracture line during the application of various numbers and ligation methods of intermaxillary fixation screws (IMFS) by using finite element analysis and to perform a comparison to the internal fixation technique with miniplates.

Material and Method: A three-dimensional model of the maxilla, mandible, and temporomandibular joint was created using the DICOM data obtained from Cone Beam Computed Tomography (CBCT). The nonhomogeneous bone structure was transferred to the model based on the Hounsfield Unit (HU) values obtained from DVCT. In the scenario created, a mandible having parasymphysis and corpus fractures together was modeled. IMFS and internal fixation methods were analyzed in eight different scenarios.

Results: Results of the analysis showed that the most successful fracture fixation models were the standard method of IMFS which is 4-point fixation (D:0,068 mm) or horizontal ligation (D:0,066 mm). It is observed that the increase in the number of IMFS has no effect on fracture displacement or the reduction of the stress formed in the bone surrounding the screws. The analysis of internal fixation shows that increasing the number of plates and screws does not change the amount of displacement, but it is influential on the distribution of stresses.

Conclusion: It has been observed that the number of IMFS has no effect on fracture fixation and stress distribution. It is observed that the amount of displacement is less in parasyphysis fractures than it is in corpus fractures.

Keywords: mandibular fracture, intermaxillary fixation, intermaxillary fixation screw, finite element analysis

ÖZET

Amaç: Bu çalışmanın amacı, sonlu eleman analizi kullanılarak intermaksiller fiksasyon vidası (IMFV) uygulamalarında farklı sayı ve bağlama yöntemlerinin kırık hattında oluşturduğu gerilme değerlerini ve yer değiştirme miktarını (D) değerlendirmek ve miniplaklarla yapılan internal fiksasyon tekniği ile karşılaştırma yapmaktır.

Materyal ve Metod: Maksilla, mandibula ve temporomandibular eklemin üç boyutlu modeli, Konik Işınlı Bilgisayarlı Tomografi (KIBT) verilerinden elde edilen DICOM verileri kullanılarak oluşturulmuştur. Homojen olmayan kemik yapısı, KIBT'dan elde edilen Hounsfield Birimi (HB) değerlerine dayanarak modele aktarılmıştır. Oluşturulan senaryoda, parasimfizis ile korpus kırıklarının birlikte bulunduğu bir mandibula modellenmiştir. IMFV ve internal fiksasyon yöntemleri sekiz farklı senaryoda analiz edilmiştir.

Sonuçlar: Analiz sonuçları, en başarılı kırık fiksasyon modellerinin, 4 noktalı fiksasyon (D: 0,068 mm) veya yatay bağlama (D: 0,066 mm) olan standart IMFV yöntemi olduğunu göstermiştir. IMFV sayısının artışının, kırık deplasman miktarının veya vida etrafındaki kemikte oluşan gerilmenin azalması üzerinde bir etkisi olmadığı gözlemlenmiştir. Internal fiksasyon analizinde, plak ve vida sayısının artırılmasının deplasman miktarını değiştirmediği, ancak gerilmelerin dağılımı üzerinde etkili olduğu görülmüştür.

Sonuç: IMFV sayısının, kırığın fikse edilmesi ve gerilme dağılımı üzerinde bir etkisi olmadığı görülmüştür. Ayrıca anterior kırıklarda deplasman miktarının, posterior kırıklara göre daha az olduğu gözlemlenmiştir.

Anahtar Kelimeler: Mandibular kırık, İntermaksiller fiksasyon, İntermaksiller fiksasyon vidaları, sonlu eleman analizi

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INTRODUCTION

The conventional treatment methods for maxillofacial fractures are closed reduction and extraoral-intraoral maxillomandibular fixation (MMF). With the emergence of miniplate and screw systems, open reduction and internal fixation (ORIF) techniques have also been added to the treatment options of mandibular fractures.[1]

The fundamental principle of fracture treatment is bringing the occlusion to the most optimal location and preserving this condition until ossification. Various methods, such as Erich arc bars for MMF, Ivy Loops ligatures, Ernst ligatures, orthodontic brackets, intermaxillary fixation screws (IMFS), are used in closed reduction. The advantages of closed reduction are its simplicity, the short operation duration, the low risk of damaging adjacent anatomical structures, and its low cost. Besides unfavorable conditions such as the failure to achieve a sufficient reduction on the fracture line, difficulties in feeding, speech, and breathing, it also has disadvantages such as wire-related injuries, difficulty maintaining oral hygiene, and the possibility of the system damaging periodontal tissues.[2]

Recently, the advantages of the use of intermaxillary fixation screws have increased their application.[3] These screws that are placed in the alveolar bone are used as an anchorage for MMF by means of their screw tips specialized for ligation. IMFS with MF is an advantageous method when compared to others because it is atraumatic, it is easy to maintain hygiene, and its application is rapid and practical.[4]

Lately, the use of finite element analysis (FEA) has become popular in scientific studies, which are hard to conduct on living tissues in the maxillofacial area. Using FEA, it is possible to create three-dimensional models consistent with ideal anatomy from patient data derived from computed tomography. By creating different scenarios with the models created, it becomes possible to perform measurements and compare the results obtained in a virtual environment.[5,6]

In the current literature, many studies investigating the mechanical stress formed in the plates, bones, and screws during treatment of fractures with ORIF are available.[7,8] However, there is no FEA study that compares the fracture fixation methods that use IMFS placed in various configurations or assesses the responses that these configurations would give to simple masticatory forces.

In our study, the goal is to evaluate IMFS placed in different configurations and to compare it to the ORIF technique in cases with bilateral multiple mandibular fractures using finite element analysis.

MATERIAL AND METHOD

In this study, the localizations, number, various ligation options, the displacement amounts of the IMFS used in mandibular fractures and the stress formed in the bone, ligature wire, and screws were assessed by finite element analysis.

Mandible with a fractured parasymphysis and corpus that has "multiple" fractures was modeled using the FEA technique. Six models were prepared to analyze IMFS placed in varied locations and numbers and its ligation options. As the control group, two models of fixation with miniplate and screw systems were modeled. In one of the models, internal fixation was performed with a single plate, and in the other model 2, plates were placed superior and inferior to the fracture line based on the Champy technique.[1]

The cone beam computed tomography (CBCT) data of a twenty-three-year-old healthy female having full dentition and Angle class I occlusion obtained for diagnostic purposes was used for FEA. The Digital Imaging and Communications in Medicine (DICOM) data obtained from the CBCT were transferred to 3D Slicer software and three-dimensional skeletal modeling was performed. Tooth contacts were formed between the first and second molar teeth on the right and the left. The occlusion between the molar teeth was formed by straightening the occlusal surfaces. This was performed to minimize the margin of error that may be caused by the punctate contact points on the occlusal surfaces of teeth that have an irregular anatomic structure. Teeth contacts have been defined as cleaving-frictional surfaces. Temporomandibular joint (TMJ) was modeled the as closely as possible to its anatomy. The TMJ disc was modeled as a pillow between two joint surfaces, and it was fixated to the mandibular condyle and temporal bone. The fracture line was created as an irregular space with 0.1 mm indentations and protrusions, and not entirely planar. The tip of the IMFS was modeled with a diameter of 4 mm and height of 3 mm, and the shaft with a diameter of 2 mm and length of 11 mm. The IMFS were placed perpendicular to bone approximately 12 mm away from the fracture line in such a way that they would not come into contact with tooth roots and alveolar inferior nerve. Ligature wires with diameters of 0.5

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mm were fixated to the tip of the IMFS to facilitate IMF.

Modeling of the Scenarios

Model A: The modeling of the conventional treatment method defined as 4-point-fixation was executed. In every quadrant, one screw was placed posterior to the fracture lines, and vertical ligation was performed (Figure 1).

Model B: 8 IMFS were used. These screws were placed as 4 each on the left and right, and vertical ligation was performed. In the right mandible where the parasymphysis fracture was, the screws were placed posterior to the fracture line. There is only one screw in the middle segment that lies between the two fracture lines (Figure 1).

Model C: 8 IMFS were used, and vertical ligation was performed on the right and oblique on the left. The screws on the parasymphysis fracture line that were located on the anterior were slid medially from the fracture line. Hence, IMFS are present at both borders of the middle segment (Figure 1).

Model D: A total of 6 IMFS were used, 3 were placed on each side and formed a triangular shape on the two fracture lines. Two screws were placed in the mandible and one in the maxilla.

Model E: Oblique ligation was performed in both of the fractures. Screws were placed medial and distal to both of the fracture lines (Figure 1).

Model F: Vertical ligation was performed in both of the fractures. Screws were placed medial and distal to both of the fracture lines (Figure 1).

Model G: In this analysis, where fixation was modeled with double miniplate and screw systems, two miniplates were placed superior and inferior to the fracture line on both sides. A total of 4 miniplates was used for fixation (Figure 1).

Model H: In this model, 1 miniplate was placed inferior to each of the fracture lines. (Figure 1)

Defining the Materials

Because the mandible is a nonhomogeneous structure with anisotropic characteristics, the Youngs Module of the bone was calculated according to the formula below. The Hounsfield Unit (HU) values which are density data obtained from CBCT were used to define mechanical parameters specific to the individual. By means of the equation, the elasticity values of bone with visco-elastic and anisotropic characteristics that

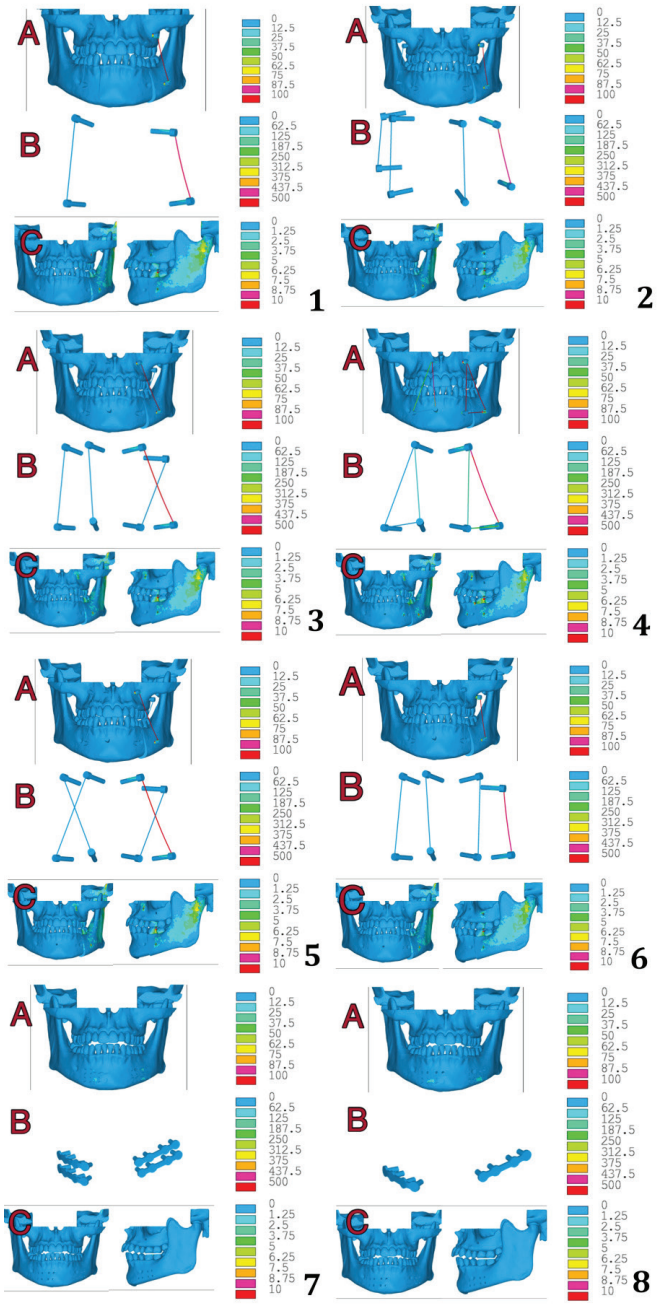

Figure 1. (1) Model A. (2) Model B. (3) Model C. (4) Model D. (5) Model E. (6) Model F (7) Model G (8) Model H. ; (A) The appearance of the fracture lines, IMFS, and ligatures on the maxilla and mandible, and beside it the scale of the stress values. (B) The stresses formed in the IMFS and ligature wires, beside it the scale of the stress values. (C) The stresses formed in osseous tissue, beside it the scale of the stress values.

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vary depending on the region were calculated closest to the actual values.[9] Because values under 0.05 GPa would exhibit excessive elasticity, the lower limit was set at 0.05 GPa for cancellous bone.[9]

Density (app) = -200 + 1.2 HU [kg/m3]

E (Youngs modulus) = 0.024 x Density (app) 1.762 [MPa].[9]

The modeling contains four contact surfaces. These surfaces are the space between the right and left teeth and two fracture lines. The coefficient of friction between teeth was defined as 0.2, and the coefficient of friction on the fracture line was 0.6110 . The elasticity coefficient and Poisson's ratio of the materials are presented in the Table 1.

Table 1. The elasticity coefficients and Poisson's ratio of the materials in the model

LIST OF MATERIALS		
MATERIALS	ELASTICITY COEFFICIENT	POISSON'S RATIO
CANCELLOUS BONE	0.05 GPa	0.3
CORTICAL BONE (min)	0.56 GPa	0.3
CORTICAL BONE (max)	14.07 GPa	0.3
TEETH[9]	150 GPa	0.3
TME DISC[10]	6 GPa	0.47
WIRES[11]	220 GPa	0.3
TITANIUM PLATES AND SCREWS[11]	110 GPa	0.3

Defining the Boundary Conditions

In this section of the analysis, the amount, direction, application time, and type of forces that will be applied and the degrees of freedom in the nodal points were defined. The locations and vectors of the masticatory muscles were calibrated in the model specific to the individual based on anatomy. The muscle forces are presented based on the calculations Korioth performed for masticatory muscles.[11]

Analysis Method

The amount of displacement was calculated by measuring the distance that appears between two coincident points on the fracture line where maximum movement is observed. And to measure the stresses received by the screws, the bone area approximately 2 mm deep surrounding the screw-tips was taken into consideration. In ligature wires, the stress received by the wires was analyzed.

RESULTS

The stresses formed in the screws, the cortical bone surrounding the screws, and the wires in the models were measured in terms of MPa (N/mm2) by employing von Mises stress analysis. The amount of displacement in the fracture line was also calculated in terms of millimeters. The results are presented in detail in Table 2.

The Amount of Displacement in the Fracture Line

It was observed that segments come into contact by falling on top of each other in the occlusal parts, while separation occurred on the inferior margin of the mandible due to the tensile forces. In terms of fixation of the corpus fracture, it became evident that the most successful IMFS formations were in the A and D models. In model A, four IMFS were used, and vertical ligation was performed. In model D, symmetric triangular ligation was performed. Although an IMF screw is present in both posterior borders of the middle fragment (model C,E,F), it is seen that displacement is slightly increased in fractures of the corpus when compared to models A and D. In the models C and E, oblique ligation was performed on the side of the fracture of the corpus. The fact that the fixation of the segment in the middle of model B was facilitated by a single IMFS placed far from the parasymphysis fracture and that this screw was ligated to a screw far from it has subjected the middle segment to posterosuperior tensile forces and caused separation on the parasymphysis fracture line. The amount of displacement in fractures of the parasymphysis in this model increased dramatically when compared to the models that contained more than four IMFS. However, in parasymphysis fractures, the maximum displacement was observed in parasymphysis fractures that occurred in model A in which four screws were used (0.003 mm). Although the displacement of the fracture line is increased when compared to the others, it is rather low when it is compared to fractures of the corpus. While there was a slight increase in the amount of displacement in the A and B models, the results of fixation with IMFS in parasymphysis fractures were nearly similar to the results of fixation with miniplates. Among fractures of the corpus, maximum displacement was measured as 0.107 and 0.108 mm in models B and F, respectively. In these models, the fracture of the corpus was measured by placing IMFS to the distal and medial, and it was ligatured vertically. While parasymphysis fractures in these models were fixated well, separation occurred in fractures of the corpus.

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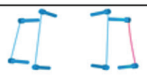
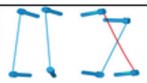
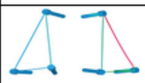
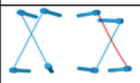
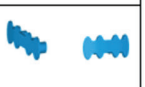
Table 2. The amount of displacement that occurred in the fracture line and the von Misses stress values

	MODEL A		MODEL B		MODEL C		MODEL D		MODEL E		MODEL F		MODEL G		MODEL H	
	Parasymphysis	Corpus	Parasymphysis	Corpus	Parasymphysis	Corpus	Parasymphysis	Corpus	Parasymphysis	Corpus	Parasymphysis	Corpus	Parasymphysis	Corpus	Parasymphysis	Corpus
Fixation types																
Maximum displacement on the fracture line (mm)	0.003	0.068	0.0012	0.107	0.0005	0.095	0.0003	0.066	0.0003	0.092	0.0001	0.108	0.0001	0.0003	0.0002	0.0003
The stresses formed in the cortical bone surrounding the screws (MPa)	0.04 0.05	2.43 2.58	0.38 0.26 0.3 0.04	0.14 2.15 0.03 2.5	0.12 0.15 0.09 0.03	14.8 0.15 0.025 11.2	0.35 0.18 0.6	3.27 1.55 3.45	0.07 0.16 0.03 0.02	2.9 0.37 0.02 2.83	0.27 0.28 0.13 0.11	0.16 2.24 0.13 2.5	0.001 0.001	0.002 0.002	1.74	1.94
The stresses formed in the wires or screws (MPa)	2	511	7 0.8	0.5 502	4 3	554 1.5	48 96 7	138 514 270	1.1 6.3	556 4.0	22 4	25 505	10.1 8.5	10.6 13.5	16.3	25.6

The Stresses Generated in the Cortical Bone Surrounding the Screws

In all of the models, the screws markedly subjected to the most stress were the screws located distal to the fracture of the corpus. The screws tied by a ligature extending from the screw placed in the anterior of the maxilla distal to the fracture of the corpus in model C, in which oblique ligation was performed were subjected to the most stress. In the model in which triangular ligatures were used, it was observed that the stress in the bone surrounding the screw was higher than it was in the other models. In the model fixated with a single plate placed inferiorly, the stress that forms in the cortical bone is close to the models where horizontal and triangular ligatures were used. Despite this, less stress formed in the bone as well due to less movement. Among the models of fixation with plates, the least stress formed in the scenario of fixation with a double plate. Increasing the number of plates and screws has contributed to the distribution of stress.

The Stress Formed in the Wires and Plates

In models of MMF, the ligatures that are subjected to the most stress are those tied to the screw that is placed posterior to the fracture of the corpus (min 502; max 556). In these areas where the effect of muscular forces is most evident, the wires also receive the most force. In the area where the parasymphysis fracture is, minimal stresses formed in the wires (max. 96 MPa - Model D). While very little stress formed with vertical ligation in the area where the parasymphysis fracture is 22 Mpa (max), an increase occurred with triangular ligation (max 96 Mpa). However, in ligatures tied obliquely, the increase is particularly high in wires tied distal to the corpus (max. 556 MPa- Model E).

In the models where fixation was performed using plates, more stress was measured in fixation with one plate placed inferiorly when compared to using double plates. In the model of double plates, the stresses formed on the plates are segregated from fixation by MMF. In fixation with MMF, while the stress received by the screws and wires in the region of the parasymphysis fracture was rather low when compared to the corpus area, in fixation with plates, the stress values measured in both

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fracture areas were similar. The comparison of the stresses formed in the cortical bone and plate shows that the plate is subjected to more stress than.

DISCUSSION

There are studies that show treating by closed reduction and MMF have a lower risk of complications than ORIF12, 13. In a study performed that investigated infection, nonunion, osteomyelitis, tissue opening, malocclusion, and nerve injuries, the complication rate of MMF was 9.1%, and this rate is 29.2% for treatment with ORIF14. However, Moreno et al. have reported that closed reduction and treatment with MMF is the treatment option where infections are encountered the least, that the risk of complications and the severity of the fracture are correlated, and that the treatment method selected does not influence the complication rates.[15]

The complications of malocclusion and nonunion are more common in posterior fractures.[14,15,16] In the study we conducted, excessive movement on the posterior fracture line supports the fact that the risk of nonunion is higher in posterior fractures than it is in parasymphysis fractures. It is clear that establishing stability on posterior fracture lines is harder than it is in anteriorly located fractures. As the fracture line slides posteriorly, it is thought that the effect of muscles on the segment that is distal to the fracture increases and consequentially displacement occurs. However, when ORIF is performed, the amount of displacement is significantly less. (max. 0,0003mm) In posterior fractures, the risk of malocclusion increases when treatment is applied using IMFS without ORIF. In minimally displaced symphysis fractures, sufficient occlusal control can be facilitated by a small number of IMFS.

Due to patient non-compliance and high screw loss ratios in closed reduction that will continue for 4-6 weeks, the use of IMFS remains in the background even though it is as successful as ORIF in terms of final occlusion and fracture healing in non-complicated fractures[17]. However, if internal fixation is not at the correct position and it is not rigid enough, the risk of postoperative malocclusion increases[15]. Hence, the proper application of MMF is a factor that increases the success of treatment. Placing IMFS balanced with a symmetrical distribution in a case with multiple fractures reduces the amount of displacement. In our study, it was observed that the vertical ligation method that is used commonly has been rather successful. However, it is seen that placing screws close to the fracture line, both distal and medial to the fracture, and horizontal ligation contributes to stability. It is observed that excessive stress forms in the wires and screws when oblique ligation is performed. Vertical and horizontal ligation of IMFS placed in the maxilla and mandible are regarded as the most ideal ligatures. When the amount of displacement under masticatory force is taken into consideration IMFS and MMF is a reliable method.

The screw loosening or falling out are also common complications. The length of the IMFS depends on the amount and density of bone in the region it is placed in and anatomical structures.[18,19] In the finite element analysis we performed, it is seen that the stress formed in the cortical bone surrounding the wires and screws increases significantly as the location of the IMFS slides towards the posterior. Due to this stress, the risk of screw loosening increases. Because screws are assessed under ideal biological conditions in finite element analysis, the complications that may develop related to the screw and wires should be assessed in in vivo studies.

It has been reported that bone requires stresses between 1.4 and 5.0 MPa to maintain healthy bone.[20] Stress outside this range causes bone resorption. In this study, the analysis of oblique ligation in the left fracture line in model C shows that the amount of stress is much higher than the ratios stated by Rieger in the bone in the cervical part of those ligatured to the anterior screw from the screw distal to the posterior fracture (max. 14.8MPa). Ligation of the screw to a screw distant from it leads to the formation of more stress than the bone can bear. In models in which oblique ligation was performed, it turns out that both the amount of displacement and the stress formed in the bone increases despite increasing the number of screws. In the models in which vertical ligation was performed, the stress formed in the bone is within biological ranges. Similarly, the stress formed in oblique ligatures also increases. As advanced to the posterior, the tension of the wires also increases.

In finite element analysis, the distribution of stress varies based on geometric modeling, material properties, and the boundary conditions. While preparing the structure of the mesh, reducing the sizes of the elements and increasing their number increases the sensitivity of the analysis and helps to obtain results close to actual values. Due to the properties the mandible possesses, its structure is nonhomogeneous and anisotropic. Due to these characteristics, it has different

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strain and elasticity module values depending on tensile stresses under compression stresses.[21] In this study, a model based on the HU values was created to be able to transfer the nonhomogeneous and anisotropic properties of the mandible and to define the material properties of the bone. Our defining of the material properties of the bones in such a manner helped us obtain a model that reduced assumptions.

One limitation of this study is that, in the study using finite element analysis models, during modeling, a fixated structure was formed under the assumption that the IMFS was placed in the bone with high torque under ideal conditions. However, in practice, the stability required may not be achieved due to the resorption that might occur or procedural errors. In treatment with closed reduction, depending on the long-term need to use IMFS, loosening of the screws or wires, and even screw losses can develop. Although the finite element analysis which assesses ideal conditions, provides results through mathematical analysis, biological responses could be different. Another imitation of the study is that it was performed in a near-ideal occlusion. It was considered possible that non-ideal occlusion could affect the fragment spacing and stress distribution. However, the evaluation of different occlusion types in such studies may lead to an excessive number of scenarios and confusion in the evaluation of the study results.

CONCLUSION

The assessment of the analysis performed shows that the balanced placement of IMFS enables the formation of a stable structure on the fracture line. It was observed that the immobilization of the segments was facilitated when the segments distal to the mandibular fracture are equally fixated to the maxilla with IMFS bilaterally. In this scenario having two fracture lines, it was discovered that independent from numbers, it is necessary to create a symmetric structure for the fixation of the segment that is in the middle of the fracture lines. It is required to increase clinical studies and to assess treatment results to develop the ideal algorithm for the use of IMFS.

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The authors report no conflicts of interest.

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CASE REPORT

Multidiciplinary Approach for Odontogenic Keratocyst Treatment: A Case Report

Odontojenik Keratokist Tedavisinde Multidisipliner Yaklaşım: Bir Olgu Sunumu

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ABSTRACT

Objective: Odontogenic keratocyst is an aggressive cystic lesion and a common type of tooth-derived cyst due to the presence of odontogenic epithelial remnants in various regions of the jaw. Odontogenic keratocysts can occur at any age, but are typically observed in individuals under 40 years old. Complete eradication is challenging due to the cyst's delicate and thin nature, with recurrence rates ranging from 13% to 60%. The treatment may cause large defects which requires bone reconstruction. Guided bone regeneration (GBR) utilizing titanium mesh is a prevalent technique for bone augmentation, especially in cases of significant alveolar ridge defects, providing stable and excellent results. This paper reports the treatment of a recurrent odontogenic keratocyst case and reconstruction of the remaining bone defect.

Case: A 19-year-old female patient presented with swelling and pain in the right anterior mandibular region because of the third recurrens of keratocyst. Clinical and radiographic assessments revealed a unilocular cystic lesion. Under general anesthesia, the cyst was enucleated, and associated teeth were extracted. Aggressive curettage and peripheral osteotomy was performed to prevent recurrence of the lesion. Implant treatment was planned for the edentulous space. Following cystic cavity healing; vertical and horizontal defect augmentation was performed using autogenous graft and custom titanium membrane. Subsequently, two dental implants were placed, followed by prosthetic rehabilitation

Conclusion: This multidisciplinary approach addressed both the cystic lesion and subsequent bone loss, resulting in successful implant integration and functional restoration. Our case highlights the efficacy of combining surgical and prosthetic interventions in managing odontogenic keratocysts, leading to favorable clinical outcomes.

Keywords: Keratocyst, custom-made titanium membrane, implant dentistry

ÖZET

Amaç: Odontojenik keratokist, çenenin çeşitli bölgelerinde, odontojenik epitel kalıntılarından köken alan agresif bir kistik lezyon olup, odontojenik kistlerin yaygın bir türüdür. Odontojenik keratokistler her yaşta görülebilir, ancak genellikle 40 yaş altındaki bireylerde gözlemlenir. Kistin hassas ve ince yapısı nedeniyle tam olarak çıkarılması zordur ve nüks oranları %13 ile %60 arasında değişmektedir. Tedavi, büyük defektlere neden olabilir ve bu da kemik rekonstrüksiyonu gerektirebilir. Titanyum ağ kullanılarak yönlendirilmiş kemik rejenerasyonu (YKR), özellikle şiddetli alveolar kret defektlerinde yaygın bir kemik artırma tekniğidir ve stabil sonuçlar sağlar. Bu makale, tekrarlayan bir odontojenik keratokist vakasının tedavisi ve kalan kemik defektinin rekonstrüksiyonunu rapor etmektedir.

Vaka: 19 yaşında kadın hasta, keratokistin üçüncü tekrarı nedeniyle sağ ön mandibular bölgede şişlik ve ağrı şikayetiyle başvurdu. Klinik ve radyografik değerlendirmelerde uniloküler bir kistik lezyon tespit edildi. Genel anestezi altında kist enükle edildi ve ilgili dişler çekildi. Lezyonun tekrarlamasını önlemek amacıyla agresif küretaj ve periferik osteotomi yapıldı. Dişsiz alan için implant tedavisi planlandı. Kistik boşluğun iyileşmesini takiben, otogen greft ve özel titanyum membran kullanılarak vertikal ve horizontal defekt artırımı yapıldı. Sonrasında iki dental implant yerleştirildi ve protetik tedavi tamamlandı.

Sonuç: Bu multidisipliner yaklaşım, hem kistik lezyonu hem de sonrasında oluşan kemik kaybını ele alarak başarılı implant entegrasyonu ve fonksiyonel restorasyon sağladı. Vakamız, odontojenik keratokistlerin yönetiminde cerrahi ve protez müdahalelerinin birleştirilmesinin etkinliğini vurgulamakta ve olumlu klinik sonuçlara yol açmaktadır.

Anahtar Kelimeler: Keratokist, kişiye özel titanyum membran, implantoloji

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INTRODUCTION

Odontogenic keratocyst (OKC) is an aggressive cyst derived from the dental lamina and its remnants.[1] They strongly prefer the mandible,[2] particularly in the molar-ramus region.[3]

Treating a recurrent OKC may result in the loss of multiple teeth, necessitating implant-supported prosthesis. Additionally, significant alveolar bone defects may require horizontal and vertical bone reconstruction.

Guided bone regeneration (GBR) allowed practitioners to offer patients more reliable and durable bone augmentation outcomes.[4] When treating significant bone defects with GBR, especially in cases of vertical deficiencies, the choice of membrane is crucial. Resorbable membranes may not offer enough rigidity and stabilization, so using non-resorbable, rigid membranes would be more beneficial.[5] We report a recurrent OKC, which treated with GBR using custom-made titanium membrane after aggressive curettage in anterior mandible.

CASE

A 19-year-old systemically healthy female patient was referred to Bezmialem Vakıf University Oral and Maxillofacial Surgery department with a third recurrence of OKC. After clinical examination, swelling and pain in the right anterior mandibular region were observed, and radiographic assessments revealed a unilocular cystic lesion extending between 31 to 44 teeth. Under general anesthesia, the cyst was enucleated, and associated teeth were extracted. Aggressive curettage and peripheral ostectomy were performed to prevent the recurrence of the lesion.

Following cystic cavity healing, implant treatment was planned for edentulous space. Vertical and horizontal augmentations were indicated because of significant bone defect after recurrent cyst operations (Figure 1). The patient was followed for one year to observe the risk of recurrence and healing before undergoing bone augmentation.

One year after the cyst operation, the patient underwent a dental volumetric tomography (DVT) to determine the extent of the defect. The DVT was sent to "Custimesh Private Healthcare Services", and a lower jaw model was created based on it. A custom-made titanium membrane was designed using this model, manufactured and for sterilized in an autoclave.

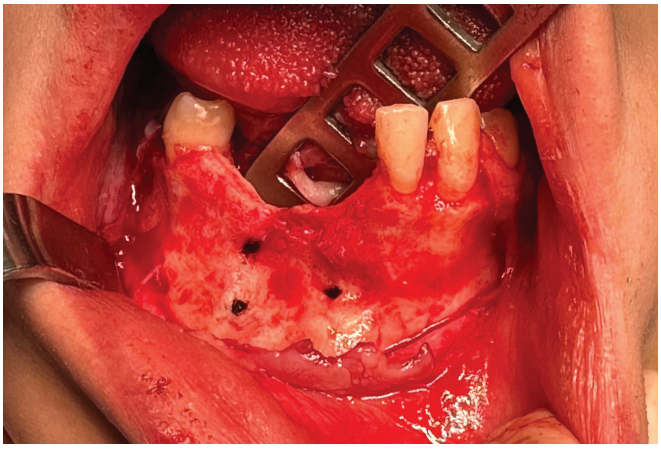

Figure 1. Vertical and horizontal bone defect caused by recurrent OKC

The patient underwent an operation under general anesthesia for bone augmentation. The mucoperiosteal flap was elevated between teeth number 46 to 34 due to allowing stretching of the periosteum after placing the titanium membrane. Autogenous bone graft was harvested from the iliac crest and mixed with 1 cc Botis-Cerabone bovine-derived bone graft to provide mechanical strength. Graft material was placed in titanium membrane, and the membrane was placed on the defective bone area. The membrane was fixed with three 5-millimeter screws (Figure 2). After fixation was controlled, the rest of

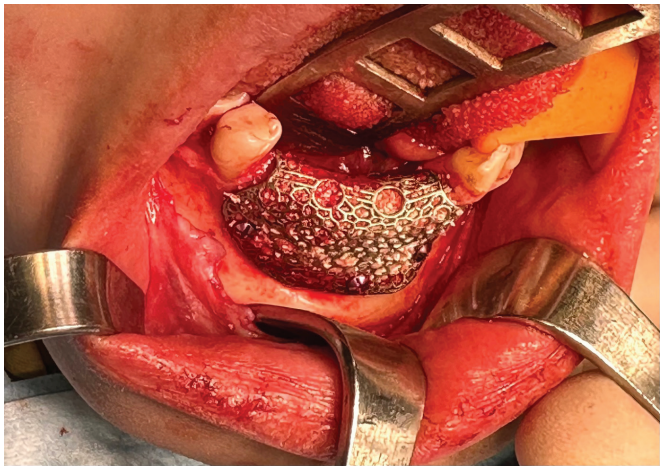

Figure 2a. Customized titanium membrane was stabilized via three 5-mm screws.

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Figure 2b. Postoperative panoramic radiograph.

the graft material was inserted from holes of the titanium membrane to the defect area. A 30x40 mm Botis-Cerabone resorbable collagen membrane was placed over the titanium mesh to cover it and secured with four membrane fixation pins. The periosteum was incised, and the flap was stretched and sutured without tension.

An infection was observed in the patient during a one-month follow-up. The mesial region of the flap was exposed, and pus formation was seen. To achieve appropriate bone volume, extraction of titanium mesh was delayed until bone formation was completed. 1 mg amoxicillin-clavulanate was prescribed. The infection was followed twice a week during the healing process by washing it with saline and rifamycin solution.

After a two-month follow-up, the titanium membrane was removed under local anesthesia. Before closing the flap, a PRF membrane was placed in the operation area to support healing.

It was observed that the infection healed after the membrane had been removed. Two Straumann implants were placed in areas of 41 and 44 numbered teeth (Figure 3). After osteointegration was provided, the patient was referred to the prosthesis department for crowns (Figure 4).

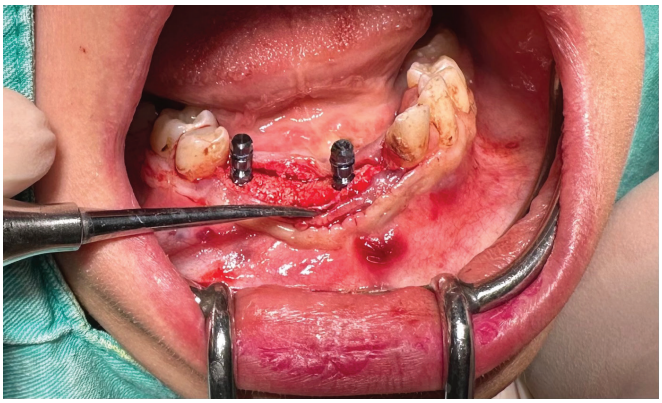

Figure 3. implant placement 9 months after bone augmentation with custom-made titanium mesh membrane and iliac crest bone graft

Figure 4. Prosthetic Rehabilitation

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DISCUSSION

Three mechanisms may be responsible for the recurrence of OKC. Firstly, remnants of dental lamina within the jaws can be accountable for forming new cysts. Secondly, incomplete removal of the original cyst can occur due to the thin and fragile lining of OKCs, leading to cortical perforation and adherence to adjacent soft tissue. Thirdly, the remaining rest of dental lamina and satellite cysts after enucleation can cause recurrence.[6]

A progressive treatment approach may be needed for recurrent bone and tooth loss. Resorbable membranes are effective for horizontal bone insufficiency while space-preserving barriers are required for vertical defects. Vertical bone augmentation can be achieved using a titanium mesh covered by a resorbable membrane.[7]

Titanium mesh has high strength, stiffness, stability, and elasticity, making it ideal for bone support, graft volume maintenance, and reduced oral mucosa pressure. Its good plasticity allows for shaping to fit various bone defects, making it perfect for GBR, achieving stable osteogenesis and simultaneous bone augmentation.[8] Titanium mesh causes exposed gingival areas more than resorbable membranes because its rigid structure may irritate the soft tissue. Nevertheless, the formation of a pseudo-periosteum layer directly underneath the exposed site sometimes protects the underlying bone graft from infection.

CONCLUSION

This report aims to show severe bone defects caused by multiple recurrences of OKC. This type of defect requires a progressive approach to provide dentition and reduce patient morbidity. With GBR using a custom-titanium-mesh membrane, practitioners may gain adequate vertical and horizontal bone to achieve ideal implantation.

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