RESEARCH

Determination of The Change of Maxillary Sinus Size in Orthodontic Treatment of Different Malocclusions

Betul Yuzbasioglu Ertugrul(0000-0001-6798-7610)[α]

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ABSTRACT

Determination of The Change of Maxillary Sinus Size in Orthodontic Treatment of Different Malocclusions

Background: Craniofacial growth-development has a complex and multifactorial structure. According to functional matrix theory, soft tissues change the development direction of hard tissues and affect the sinus cavities within the cranial structure. The objective of this study is to determine the change in the maxillary sinus dimensions after orthodontic treatments according to malocclusion groups.

Methods: Our study comprises 51 individuals who have met the admission criteria. Our study was carried out retrospectively. The individuals included in the study have been analyzed in terms of malocclusion groups by comparing their maxillary sinus dimensions on panoramic films.

Results: The intended base length, planar length of the maxillary sinus, and the area measurements of the maxillary sinus have been found to be different at pre-treatment and post-treatment in terms of malocclusion. In Class I, the post-treatment maxillary sinus indentation base length has decreased, and the average planar base length and the maxillary sinus area has increased, and in Class II, the post-treatment maxillary sinus indentation base length and the average planar base length has increased, the maxillary sinus area has decreased, and in Class III, The post-treatment maxillary sinus indentation base length and the average planar base length has decreased, and the maxillary sinus area has increased compared to the pre-treatment.

Conclusion: There have been changes in the sinus dimensions of Class I, II, and Class III patients who have received orthodontic treatment compared to the pre-treatment. The changes in the possible craniofacial structures before orthodontic treatments should be taken into consideration carefully, and the dental treatments to be applied should be decided after such considerations.

KEYWORDS

Maksiller Sinüs Boyutları, Maloklüzyon Grupları, Ortodontik Tedavi

ÖZ

Farklı Maloklüzyonların Ortodontik Tedavisinde Maksiller Sinüs Boyutlarındaki Değişimin Belirlenmesi

Amaç: Kraniyofasiyal büyüme-gelişme, karmaşık ve çok faktörlü bir yapıya sahiptir. Fonksiyonel matriks teorisine göre yumuşak dokular, sert dokuların gelişim yönünü değiştirerek kraniyal yapı içindeki sinüs boşluklarını etkiler. Bu çalışmanın amacı, maloklüzyon gruplarına göre ortodontik tedavilerden sonra maksiller sinüs boyutlarındaki değişimi belirlemektir.

Gereç ve Yöntemler: Çalışmamız, kabul kriterlerini karşılayan 51 kişiden oluşmaktadır. Çalışmamız geriye dönük olarak yapılmıştır. Çalışmaya dahil edilen bireyler panoramik filmlerde maksiller sinüs boyutları karşılaştırılarak maloklüzyon grupları açısından analiz edilmiştir.

Bulgular: Ortodontik tedavi öncesi maksiller sinüsün girintili taban uzunluğu, düzlemsel uzunluğu ve maksiller sinüs alan ölçümlerinin tedavi sonrasına göre değiştiği belirlenmiştir. Sınıf I'de, tedavi sonrası maksiller sinüs girintisi taban uzunluğu azalmış ve ortalama düzlemsel taban uzunluğu ve maksiller sinüs alanı artmıştır. Sınıf II'de tedavi sonrası maksiller sinüs girintisi taban uzunluğu ve ortalama düzlemsel taban uzunluğu artmış, maksiller sinüs alanı azalmıştır. Sınıf III'de, tedavi sonrası maksiller sinüs indentasyon taban uzunluğu ve ortalama düzlemsel taban uzunluğu azalmış, maksiller sinüs alanı tedavi öncesine göre artmıştır.

Sonuç Ortodontik tedavi görmüş Sınıf I, II ve III hastaların sinüs boyutlarında değişiklikler olmuştur. Ortodontik tedaviler öncesi olası kraniyofasiyal yapılarda meydana gelen değişiklikler dikkatlice değerlendirilmeli ve uygulanacak ortodontik tedavilere, bu değerlendirmelerden sonra karar verilmelidir.

ANAHTAR KELİMELER

Maxillary Sinus Dimensions, Malocclusion Groups, Orthodontic Treatment

The relationship between the maxillary sinus and the dental root-tooth position has been a subject of interest among researchers for centuries.[1] Crucially, the sinus dimension is a functional indicator with effects on normal craniofacial development.[2] Craniofacial growth and development have a complex, multifactorial structure. According to the functional matrix theory, soft tissues affect the development of hard tissues.[3] The maxillary sinus can be affected by factors such as head posture, functional anterior displacement, the vertical and –sagittal skeletal relationship, and surgical mandibular advancement (4). Thus, many clinicians have performed conducted studies on the changes in the skull bone and the soft tissues resulting from the orthodontic treatments (5). Though such these studies have different results, the general opinion view is that the tooth position affects the sinus dimensions. Maxillary sinus dimensions show an

[α] Izmir Demokrasi University Faculty of Dentistry, Department of Orthodontics, Izmir, Turkey
[β] Van Yüzüncü Yıl University Faculty of Dentistry, Department of Orthodontics, Van, Turkey

increase starting from the mixed dentition period stage to and continuing into the permanent dentition period stage.[6,7] Since teeth and the maxillary sinus are adjacent structures, they likely interact with each other.[8] According to several studies, the a Class II molar relationship and raised frontal face height may be seen in cases where the maxillary sinus dimensions are inadequate.[9,10] Moreover, there has been discussion of whether the relationship between respiratory function and craniofacial morphology may cause dentofacial anomalies.[11,12] Although debate on this subject continues, the general view tends to hold that the upper airway structures have significant effects on the development of the craniofacial complex.[8,13] The maxillary sinus dimensions show differences in males and females.[14] and it has been reported that the maxillary sinus dimensions are higher in healthy male individuals[15] In radiological assessments conducted by researchers, a statistically significant difference has been found between males and females in the sectional measurements obtained in four levels of the maxillary sinus dimensions.[16] In a study where those dimensions were examined through cone beam computed topography (CBCT), it was reported that the maxillary sinus dimensions show an increase until age 15 in males and 18 in females. The increasing overall trend in maxillary sinus dimensions is higher in male patients than in female patients beginning at 11 years of age.[17] Some researchers hold that the maxillary sinus dimensions may change depending on factors such as type of malocclusion and position of teeth.[5,18] Since a great portion of the maxillary sinus remains within the craniofacial complex, orthodontists can also analyze the maxillary sinus dimensions for diagnostic and planning purposes and can modify orthodontic treatment in case of any defects that occur or may occur. This gives them a significant opportunity to prevent possible maxillary sinus complications. The aim of this study is to examine the effect of orthodontic treatment on maxillary sinus sizes according to malocclusion groups.

MATERIALS AND METHODS

The present study reports on examinations of pre- and post-treatment radiological films of patients who presented at the Van Yüzüncü Yıl University Faculty of Dentistry, Department of Orthodontics, in Van, Turkey, for treatment and were suitable for orthodontic treatment. The study was carried out retrospectively. Patients scanned from the archive were either included or excluded according to certain criteria. Fifty-one patients who received fixed orthodontic treatment were examined. The individuals included in the study have been grouped by type of malocclusion. The study's inclusion criteria were as follows: having a panoramic film, not having any pathology in the maxillary sinus region, not having any congenital or acquired anomaly (lips, palate injury, trauma, etc.), and not having previously undergone orthodontic treatment. As to classification according to these by malocclusion groups; , the maxillary sinus dimensions have been were compared by dividing the patients into three groups of 17 each as; : those patients with skeletal Class I malocclusion, those with skeletal Class II malocclusion, and those with skeletal Class III malocclusion.

This study was conducted on the groups who show normodivergent growth patterns. Individuals with skeletal Class I malocclusion had ANB values in the range of 0° ≤ ANB ≤ 4°. In the Class II malocclusion group, individuals were characterized by Class II molar-canine relationship and convex profile, by the ANB angle being greater than 4, and by the presence of a normodivergent growth model. In the creation of the Class III malocclusion group, attention was paid to the fact that the individuals were characterized by Class III molar-canine relationship, concave or flat profile, and that the ANB angle was less than 0 and had a normodivergent growth model. SN / GoGn angles have been taken into consideration for individuals to be normodivergent. Care was taken to keep this angle between 26 ≤ SN / GoGn ≤ 38. The skeletal development of the individuals included in the study was evaluated separately on hand-wrist radiographs, and this evaluation was made according to the Greulich-Pyle atlas standards and the criteria reported by Helm et al. Individuals who showed developmental delay or progress during the evaluation of hand-wrist films were excluded from the study. This deviation is taken as ± 2 years.

Class I, Class II and Class III malocclusion individuals included in the study were preferred .018 inch slot conventional brackets during their fixed orthodontic treatments, and the teeth were leveled and alignmented with .012, .014 and .016 nickel titanium arch wires, respectively. Then. Maxillary and mandibular elastics were used when necessary. Finally, the finishing phase was started by applying .016X.016 stainless steel and .016X.022 stainless steel arc wires. At this stage, in cases deemed necessary, vertical elastics were used in the anterior and posterior teeth.

The maxillary sinus dimensions observed from the panoramic radiographs of the patients in all groups taken before orthodontic treatment and the maxillary sinus dimensions observed from the panoramic radiographs taken after orthodontic treatment have been correlated. The maxillary sinus indentation base length, planal base length, and the maxillary sinus area at a height of 5 mm from the apex of the root of the first molar tooth have been measured by correlating the panoramic radiographs taken before the treatments and after the treatment. When measuring maxillary sinus dimensions, the right and left sinus measurements are combined and divided into two. The panoramic radiographs of the patients included into our study taken with the X-ray machine in the Department of Dental and Maxillofacial Radiology of Yüzüncü Yıl University, Dentistry Faculty. The sinus dimensions in the panoramic radiographs analyzed have been chosen from those who had no problem (such as magnification, low contrast and blurriness, such as) affecting the film quality, and from the radiographs taken at and/or close to the natural head position. The panoramic radiographs included into the study have been determined at real dimensions of 1:1 scale after carrying out calibration via software of the X-ray machine. The maxillary sinus dimensions have been determined after carrying out digital calibration by using Image program (Wayne Rasband, National Institutes of Health, Bethesda, MD).

Study tools and methods were approved by IKCU Non-Pharmacological Clinical Research Ethical Committee with committee resolution no: IKCU.16112020.1084.

SPSS 20 statistical program (Statistical Package for the Social Sciences, version 20.0, SSPS Inc., Chicago IL, USA) has been used in the data set analysis. The results have been found statistically significant at a significant level of $p<0.05$. The sample size for the study has been calculated with G*Power analysis (G*Power Ver.3.0.10, Kiel, Germany) in such a manner that it had a significant level of 0.05 and power of 90%, and minimum 16 patients have been determined to be necessary for each group. Kolmogorov-Smirnov test has been used in order to determine data have a normal distribution. Descriptor statistics have been displayed as X (Mean) ± SS (Standard Deviation). In the interactions of subgroups within each other, ANOVA program has been used for the measurement of maxillary sinus dimensions of the patients divided as per malocclusion groups.

RESULTS

When the age data of the patients were grouped as per their chronological age, the average chronological age of the patients between the ages of 12 and 16 was 15,1 ± 0,98 years, while it was 17,6 ± 0,83 years for the patients aged between 16 and 20. There were 35 males and 16 females in the malocclusion groups. There were 5 males and 12 females participants in the Class I malocclusion group, 4 male and 13 female participants in the Class II malocclusion group, and 7 male and 10 female participants in the Class III malocclusion group.

When the patients are were analyzed according to their malocclusion groups, the average chronological ages of 17 patients with Class I malocclusion was 173,94 ± 24 months. The pre-treatment maxillary sinus indentation base length, average planar base length, and maxillary sinus area in the patients with Class I orthodontic treatment were 31,582±5,1 mm, 34,529±7,6 mm, and 276,6841±89,40 mm2 respectively. The post-treatment maxillary sinus indentation base length, average planar base length, and maxillary sinus area at a height in the patients having Class I orthodontic treatment were 32,170±6,7 mm, 33,641±7,4 mm and 270,8229±88,57 mm2 respectively (Table 1). The post-treatment maxillary sinus indentation base length decreased, and the average planar base length and maxillary sinus area has increased compared to the pre-treatment values ($p<0.05$) (Table 1).

The average chronological age of 17 patients with Class II malocclusion was 172,88 ± 54 months. The pre-treatment maxillary sinus indentation base length, the average planar base length, and the maxillary sinus area in the patients having Class II orthodontic treatment has been found to be 38,441±6,0 mm, 41,091±9,1 mm and 316,6894±89,40 mm2, respectively. The post-treatment maxillary sinus indentation base length, average planar base length, and maxillary sinus area in the patients with Class II orthodontic treatment were 36,888±5,5 mm, 38,800±8,2 mm and 319,7570±97,68 mm2 respectively (Table 1). The post-treatment maxillary sinus indentation base length and the average planar base length has increased, and the maxillary sinus area has decreased compared to the pre-treatment ($p<0.05$) (Table 1).

The average chronological age of 17 patients with Class III malocclusion was 171,68 ± 46 months. The pre-treatment maxillary sinus indentation base length, average planar base length, and maxillary sinus area in the patients with Class III orthodontic treatment were 31,156±3,1 mm, 37,442±1,0 mm and 279,2412±75,00 mm2, respectively. The post-treatment maxillary sinus indentation base length, average planar base length, and maxillary sinus area in the patients with Class III orthodontic treatment were 33,931±4,8 mm, 38,312±4,5 mm and 277,3137±53,94 mm2, respectively (Table 1). The post-treatment maxillary sinus indentation base length and the average planar base length has decreased, and the maxillary sinus area has increased compared to the pre-treatment ($p<0.05$) (Table 1).

Table 1.

Maxillary sinus sizes according to Orthodontic malocclusion groups.

	Maxillary Sinus Base Length Before Orthodontic Treatment (mm)	Maxillary Sinus Base Length After Orthodontic Treatment (mm)	Maxillary Sinus Base Length Change	p
Class I malocclusion	31,582±5,1	32,170±6,7	-0,588	(p<0.05)
Class II malocclusion	38,441±6,0	36,888±5,5	1,553	(p<0.05)
Class III malocclusion	31,156±3,1	33,931±4,8	-2,775	(p<0.05)
	Maxillary Sinus Base Planar Length Before Orthodontic Treatment (mm)	**Maxillary Sinus Base Planar Length After Orthodontic Treatment (mm)**	**Maxillary Sinus Base Planar Length Change**	**p**
Class I malocclusion	34,529±7,6	33,641±7,4	0,888	(p<0.05)
Class II malocclusion	41,017±9,1	38,800±8,2	2,217	(p<0.05)
Class III malocclusion	37,442±1,0	38,312±4,5	-0,87	(p<0.05)
	Maxillary Sinus Area Before Orthodontic Treatment (mm^2)	**Maxillary Sinus Area After Orthodontic Treatment**	**Maxillary Sinus Area Change**	**p**
Class I malocclusion	276,6841±89,40	270,8229±88,57	5,8612	(p<0.05)
Class II malocclusion	316,6894±127,36	319,7570±97,68	-3,0676	(p<0.05)
Class III malocclusion	279,2412±75,00	277,3137±53,94	1,9275	(p<0.05)

DISCUSSION

The maxillary sinus is one of the important regions of the craniofacial structure as well. When we analyze the literature, it is seen that maxillary sinus dimensions are affected by many factors.[19,20] The hypothesis of this study; In different orthodontic malocclusions, sinus size will decrease after orthodontic treatment. In our study, the maxillary sinus dimensions have been compared in pre-orthodontic treatment and post-orthodontic treatment periods according to the skeletal Class I, skeletal Class II, and skeletal Class III malocclusion groups. In Class I group, the post-treatment maxillary sinus indentation base length has decreased, and the average planar base length and the maxillary sinus area has increased, and in Class II group, the post-treatment maxillary sinus indentation base length and the average planar base length has increased, the maxillary sinus area has decreased, and in Class III group, The post-treatment maxillary sinus indentation base length and the average planar base length has decreased, and the maxillary sinus area has increased compared to the pre-treatment.

In order to assess the maxillary sinus dimensions, different methods have been used in the literature. Although, nowadays CBCT is popular, panoramic radiographs have been examined in our study due to the reasons that the radiation dosage, high cost, and the routine use of CBCT were not convenient.

The maxillary sinus dimensions differ in males and females.[14] In healthy individuals, pharyngeal structures, soft palate, and maxillary sinus dimensions are reported much more in males.[15] In a study performed by Daniel et al. on maxillary sinus dimensions with MRG images, in the measurements of the sections taken at four levels of maxillary sinus dimensions, no significant difference has been found among males and females.[15] In the cephalometric assessment made by Mermut et al, in the measurements of the sections taken at four levels of maxillary sinus dimensions, a significant difference has been found among males and females.[16] In a study where the maxillary sinus dimensions have been examined used CBCT, it has been reported that the airway dimensions increase till the age of 15 in females and 18 in males. The increasing trend of total airway volume has been stated to be higher in male patients compared to female patients starting from the age of 11. It has been concluded that the maxillary sinus dimensions of male patients are higher.[17] In a 3D study performed by Abramson et al. to analyze the change of the maxillary sinus dimensions depending on age and gender, there was statistically no significant difference in the planar, spatial, and volumetric measurements except for the vertical airway length.[18]

Class II malocclusion is one of the malocclusions which is encountered frequently together with different combinations of skeletal and dental factors and it comprises almost 1/3 of all orthodontic malformations.[19] This kind of malocclusion that can occur as a result of mandibular retrognathia, maxillary prognathism or a combination of both has been reported to occur mainly as a result of mandibular retrognathia.[20] The rearward positioning of the mandibula leads to the increase in the soft palate length and inclination, and eventually the upper pharyngeal airway narrows, causing the change in the maxillary sinus dimensions.[21] The maxillary sinus dimensions of the patients with Class II malocclusion have been examined in many studies. As a result of these studies, it has been reported that the maxillary sinus dimensions of the patients with Class II malocclusion are wider, or have the same width, while their hypopharyngeal and oropharyngeal areas are narrower.[22,23,24] The patients with skeletal Class III malocclusion are characterized by maxillary retrusion/inadequacy, mandibular protrusion, and/or mandibular enlargement. Since the lower and the middle part of the face are retro lined, the patients with Class III malocclusion clinically have a concave profile.[25] In a CBCT study performed in prepubertal period by Iwasaki et al., it has been reported that maxillary sinus dimensions of the patients with Class III malocclusion were plain, the position of the tongue was at a lower level and the palatial tonsillitis was hypertrophic, and the nasopharyngeal airway had no significant difference.[26] In a study performed in the prepubertal period by Alves et al., where the maxillary sinus dimensions of the patients with Class II and Class III malocclusion have been compared; the nasopharyngeal airway dimensions of the patients with Class III malocclusion have been reported to be wider than the patients with Class III malocclusion.[27]

In another study where the maxillary sinus dimensions of the patients with mandibular prognathism have been examined, the maxillary sinus dimensions have been measured at high levels, while nasopharynx and hypopharynx dimensions have been reported to be independent of the enlargement of the sagittal mandibular. In this study, the Class III patients have been found to have the thickest soft palate and the shortest soft palate length.[28]

In our study, the measurements have been chosen by taking into consideration criteria such as the results being comparable with recent studies and being repeatable. It has been expressed that the anteroposterior position of the mandibula may affect the genioglossus muscle and the position of the tongue root, and therefore those having the mandibula positioned at the posterior position may suffer problems with the upper airway.[29] Moreover, the expansion of the maxillary sinus dimensions of those having a mandibula that is brought forward used orthopedic devices indicates that the airway is affected by the position of the mandibular.[30]

The maxillary sinus dimensions, tongue, and soft palate dimensions increase together with the age. Also, the hyoid bone significantly moves vertically downward by age. In general, the men have wider maxillary sinus dimensions, longer tongue length, and a larger sinus area. Whereas women have longer soft palate length. Maximum maxillary sinus dimensions have been observed in individuals with skeletal Class II malocclusion, and wider maximum maxillary sinus dimensions have been observed in individuals with skeletal Class II malocclusion.

As a result, the maxillary sinus dimensions are wider in Class I-II patients and narrower in Class III patients. This needs to be proven with much larger patient groups having skeletal classification. In this study, the maxillary sinus dimensions of the patients with three different skeletal relationships have a significant difference.

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Corresponding Author:

Betul Yuzbasioglu ERTUGRUL

İzmir Demokrasi University
Faculty of Dentistry
Department Orthodontics,
İzmir, Turkey
E-mail : betulyuzbasioglu@outlook.com