ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Current Research in Dental Sciences

Research Article *Araştırma Makalesi* DOI: 10.17567/ataunidfd.993727

Comparison of tmj morphology in orthodontic malocclusions using cone-beam computed tomography

Konik ışınlı bilgisayarlı tomografi kullanılarak ortodontik maloklüzyonlu bireylerde tme morfolojisinin karşılaştırılması

Mert OCAK[1]
Mehmet Eray KOLSUZ[2]

[1]Department of Anatomy, Dentistry School, Ankara University, Ankara, Turkey
[2]Department of Dentomaxillofacial Radiology, Dentistry School, Ankara University, Ankara, Turkey

ABSTRACT

Objective: The purpose of this investigation was to study morphometry of the head of the mandible in patients with Class I, Class II and Class III malocclusions.

Methods: Cone beam computerized tomography (CBCT) images of 39 patients were evaluated (each group consisted of 13 patients). The morphology of mandibular condylar which tissue volume, trabecular bone volume, bone density and the bone surface were measured and calculated according to Angle classifications.

Results: A statistically significant difference was found between the tissue volume (*P* = .05) and bone surface (*P* = .028) variables between Class II and III. The volume of tissue between the Class III group and the other groups (Class I *P* = ,016, Class II *P* = ,006), trabecular bone volume (Class I *P* = ,002, Class II *P* = .001) and bone surface (Class I *P* = ,016, Class II *P* = ,005) were statistically different for women.

Conclusion: The morphology of mandibular condylar changes in terms of tissue volume, trabecular bone volume, bone density and the bone surface can be related to malocclusions. Moreover, further studies must be done for future studies on temporomandibular joint development and the measurements of condylar volume and relation with the skeletal patterns.

Key Words: TMJ, morphology, CBCT, bone parameters, malocclusions

ÖZ

Amaç: Bu araştırmanın amacı Sınıf I, Sınıf II ve Sınıf III maloklüzyonlu hastalarda condylus mandibula morfometrisinin incelenmesidir.

Yöntemler: 39 hastanın konik ışınlı bilgisayarlı tomografi (CBCT) görüntüleri değerlendirilmiştir (her grup 13 hastadan oluşmaktadır). Angle sınıflandırmalarına göre 3 eşit grup oluşturulmuş ve doku hacmi, trabeküler kemik hacmi, kemik yoğunluğu ve kemik yüzeyleri ölçülmüştür.

Bulgular: Sınıf II ve III arasında doku hacmi (*P* = ,05) ve kemik yüzeyi (*P* = ,028) değişkenleri arasında istatistiksel olarak anlamlı fark bulunmuştur. Sınıf III grubu ile diğer gruplar arasındaki doku hacmi (Sınıf I *P* = ,016, Sınıf II (*P* = ,006), trabeküler kemik hacmi (Sınıf I *P* = ,002, Sınıf II *P* = ,001) ve kemik yüzeyleri (Sınıf I *P* = ,016, Sınıf II (*P* = ,005) kadınlar için istatistiksel olarak farklıydı.

Sonuç: Mandibular kondiler değişikliklerin doku hacmi, trabeküler kemik hacmi, kemik yoğunluğu ve kemik yüzeyi açısından morfolojisi maloklüzyonlarla ilişkili olabilir. Ayrıca, temporomandibular eklem gelişimi ve kondil hacminin ölçümleri ve iskelet paternleri ile ilişkisi üzerine ileride yapılacak çalışmalar için daha ileri çalışmalar yapılmalıdır.

Anahtar Kelimeler: TME, morfoloji, cbct, maloklüzyon, kemik parametreler

Received/Geliş Tarihi: 13.07.2021
Accepted/Kabul Tarihi: 10.09.2021

Corresponding Author/Sorumlu Yazar:
Mert OCAK
E-mail: drmertocak@gmail.com

Cite this article: Ocak M, Kolsuz M.E. Comparison of tmj morphology in orthodontic malocclusions using cone-beam computed tomography. *Curr Res Dent Sci*. 2022; 32(1): 63-66.

INTRODUCTION

The temporomandibular joint (TMJ), is a synovial joint between mandibular fossa (glenoid fossa) of each temporal bone and mandibular condyles.[1] In anatomy textbooks type of this joint is mentioned as bicondylar (similar to knee joint because two condyles are involved in this joint) or compound type of joint (requiring the presence of at least three bones) whereas in dental literature technically it is specified as a ginglymoarthroidal joint because it provides for hinging movement in one plane (a ginglymoid joint), and at the same time provides for sliding movements (an arthrodial joint).[1-4] The TMJ is one of the most complex as well as most used joint in a human body.[3] Mastication and speech are the two most essential activities of the TMJ, and they are of tremendous interest to physicians and radiologists. This interested arises from structural, functional, pathological, and imaging considerations.[2]

TMD (temporomandibular disorder) is a catch-all term for any issue involving the jaw joint. TMD affects up to 75% of the population, with only 34% claiming to have TMD. TMD can be caused by injuries to the jaw, temporomandibular joint, or head and neck muscles. As a result, the architecture of the TMJ is strongly linked to the majority of TMD. The most common TMJ disorders are pain dysfunction syndrome, internal derangement, arthritis, and traumas.[3,5]

While the factors leading to the development of TMD have been investigated, it has been stated that certain morphological malocclusions observed during childhood will trigger functional disorders that may occur during adulthood. The association of malocclusion with TMD has been reported in many studies. Especially Class II and Class III types are more closely associated with TMD than others. The cephalometric analysis reveals to the orthodontist the skeletal component of the patient's malocclusion.[6-11]

TMD is a problem that needs to be investigated more. Because a substantial percentage of TMD causes are currently unknown, a greater knowledge of their etiology will aid in preventing not just the formation of TMDs, but also the failure of an implanted joint in the same way that the joint it replaced failed.[3,5]

The anatomical analysis of condylar structures related with TMJ can provide useful information about the dysfunction. Different TMJ implant designs can also be evaluated using a similar manner. By defining the healthy structure of the TMJ we will be able to see the differences in these variables after mandibular osteotomies and compare changes in TMJ morphology. Several investigations have been made in different populations with regard to clinical and imaging findings in TMDs which figured out that TMD issues are widespread, affecting up to one-third of all adults, as well as children and adolescents, at some point in their lives.[3,5] Moreover, the anatomical analysis of structures related with TMJ can provide useful information about the dysfunction of the joint.

Nowadays, mandibular condyle can be displayed in 3D, especially with cone beam computerized tomography systems (CBCT) as it is seen with traditional 2D methods. CBCT produces high-resolution images in axial, coronal and sagittal axes. And these images are useful to reveal the anatomy of the temporomandibular joint and possible pathologies.[12-15]

Therefore, it is useful to determine the total tissue (TV) and trabecular bone volume (BV), bone density (BV/TV), and bone surface (BS) area values of mandibular condyle morphology in different malocclusion classes using cone beam computerized tomography (CBCT) images. The aim of this study was to determine the anatomical parameters of the head of the mandible in patients with Class I, Class II and Class III malocclusions.

MATERIAL AND METHODS

All changes and revisions to the research protocol were carried out in accordance with the principles outlined in the Declaration of Helsinki. The local institutional ethics committee gave its approval to the project. (Ankara University Faculty of Dentistry Clinical Research Ethics Committee 2016/36290600/95). CBCT data of patients who were recruited to the outpatient clinic for several reasons such as airway basement without a history of any systemic illnesses were retrospectively examined for a variety of reasons, including pre-orthodontic therapy impacted teeth surgery. The study excluded patients with signs of bone illness (particularly osteoporosis), relevant medication intake, skeletal asymmetries or injuries, congenital abnormalities, a history of surgery and TMJ condition, as well as any tumor or malignancy. The Low-quality images that did not allow sufficient visualization of bone borders or those with artifacts or insufficient magnification were also not included the study.

A power analysis was conducted. It was indicated that the minimum sample size should be at least 21 patients. For this reason, this study was based on CBCT Images on 39 patients (20 women, 19 men) who had remotely consulted or pre-orthodontically evaluated for the evaluation of impacted third molars. The patients were divided into 3 malocclusion groups according to Angle (Class I, Class II and Class III). 13 adult patients (bilateral 26 joints) were selected in each study group.

The Planmeca Promax 3D Max CBCT (Planmeca Oy, Helsinki, Finland) was used to create the CBCT imaging. All CBCT scans were performed according to a strictly standardized scanning procedure in both clinics; patients were put in a stand-up vertical posture, stabilized with a headband and chin support, and watched during the scan to ensure that they stayed immobile. All constructions and measurements were performed on a TFT medical display (NEC MultiSync MD215MG, Munchen, Germany).

In order to make a quantitative analysis of mandibular condyle, DICOM image files were imported into a 3D rendering software CTAn (ver. 1.12.9, Skyscan), The cortical boundaries of the condylar region starting from the mandibular notch that was visible in the cross-sections of volumetric datasets were outlined using a semi-automatic segmentation procedure. For this, region of interests (ROI) were drawn manually on all images. The final ROI along the mandible condyle constituted the semi-automatic adaptive interpolation of these ROIs (Figure 1). After ROI selection, to subtract the condyle thresholding (binarization) process was used, which entails processing the range of gray levels to obtain an imposed image of black/white pixels (Figure 2). Descriptive analysis was made according to sites and incidental findings. The overall quantity of bone present in relation to the assessed bone volume is referred to as Bone Density (BV/TV). It is a parameter widely used to perfectly reflect bone structure. It shows how much of a particular volume of interest is taken up by mineralized tissue. Bone surface (BS) refers to the connection between the total trabecular bone surface and mineralized bone volume (Figure 1-2).

All measurements were done twice by a single observer. To determine intra observer precision were calculated: the difference, % change, intraclass correlation coefficient (Single Measures) (ICC) and the coefficient of variation (CV). Analysis of variance test and post hoc Tukey were performed for statistical analysis of differences gender, localization (right/left), and measurements. P-value ≤.05 was considered statistically significant.

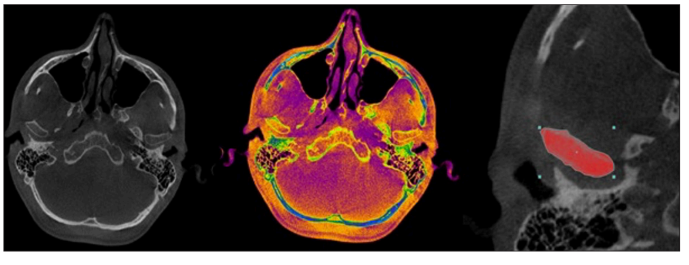

Figure 1. Process of region of interest (ROI). In the axial section, the cross-section in which the joint was displayed as widest was determined and the head of the mandible was marked as ROI

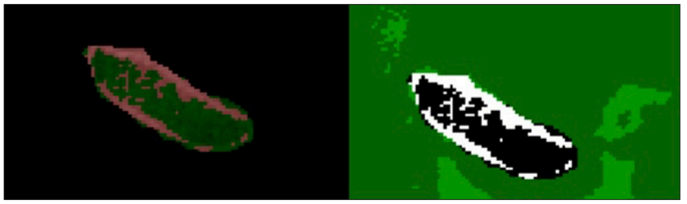

Figure 2. Process of thresholding. In the marked ROI area, bone tissue and air gaps were identified semi-automatically. And threshold operation was done automatically.

RESULTS

The statistical test showed low intra observer variation ($P > .05$ for differences in all parameters (Table 1). Table 2 shows the bone parameter results. No significant difference was found for the left and right sides of the condyles. Hence the mean of the measurements was the final measurement for statistical analyses. A statistically significant difference was found between the tissue volume ($P = .05$) and bone surface ($P = .028$) variables between Class II and III (Table 2).

The results show that the volume of tissue between the Class III group and the other groups (Class I p = 0,016, Class II *P* = ,006), trabecular bone volume (Class I *P* = ,002, Class II *P* = .001) and bone surface (Class I *P* = ,016, Class II *P* = ,005) were statistically different among women. No significant differences were found in male groups and variables. (Table 3)

Table 1. Intraobserver precision

	Difference	% Change	*P**	ICC**	*P****	CV
TV (mm^3)	24,71	3,9	0,343	0,881	0,001	51,67
BV (mm^3)	10,40	2,9	0,502	0,888	0,001	53,67
BV/TV (%)	-2,11	-3,7	0,178	0,853	0,001	27,83
BS (mm^2)	48,18	4,9	0,186	0,842	0,001	40,66

* *P* value for differences
* Intraclass correlation coefficient (Single Measures)
* *P* value for ICC

Table 2. The measured bone parameters according to Class.

		Mean	Standard Deviation	Minimum	Maximum
TV (mm^3)	Class I	587,27	187,63	238,15	851,44
	Class II	499,93*	153,52	221,76	813,32
	Class III	775,61*	479,42	257,5	2300,8
BV (mm^3)	Class I	352,99	160,57	114,08	693,18
	Class II	303,52	104,15	152,4	548,96
	Class III	419,79	283,61	123,89	1355,3
BV/TV (%)	Class I	58,92	15,21	31,86	83,84
	Class II	62,01	15,14	37,71	88,09
	Class III	55,39	20,95	22,56	87,44
BS (mm^2)	Class I	923,57	297,67	404,14	1517,47
	Class II	830,95*	284,94	407,12	1496,27
	Class III	1110,06*	519,79	481,15	2606,33

*indicates statistical significance

DISCUSSION

The developmental process of mandibular condyle continues from childhood to adulthood. Even in adulthood, the development of condyle volume and shape responds to functional demands. Condyle volume is one of the most controversial variables in shaping the craniofacial complex. Mandibular condyle is thought to play a key role in the success of long-term orthognathic therapy.[6,7,16,17]

In our study, there was a statistically significant difference between the Class II and Class III patient groups in terms of tissue volume ($P = .05$) and bone surface ($P = .028$) variables. In addition, tissue volume, trabecular bone volume, and bone surface values are significantly higher in the Class III patients than in the other groups, and these variables are the lowest in Class II patients.

In the study which was made by Saccucci et. al[19] among the Caucasian race, no difference was found in joints between patient groups and so the results were consistent with our work. When they evaluated the groups among themselves, they found differences between Class III and other groups, which were compatible with our findings. The findings of the study regarding the size of the condyle are compatible with our study. The difference of our study is the size of the condyle; in which the parameters are designated as tissue volume, trabecular bone volume, bone surface, and bone density separately. Saccucci et al. used semi-automatic mimics software for 3D analysis. According to a study made by Saccucci et. al and Periago et. al this method has limitations.[18,19] In our study, we used the CTan software, which is the software program of computerized microtomography operating on the same principle as CBCT. In this software, pixel losses were minimized automatically and result equivalent to actual measurements were taken.[20,22]

Katsavrias[23] investigated the difference in the shape of the condyle and reported that the Class III group had a long, wide and anteriorly tilt condyle head than the other groups.[23] This result is consistent with the difference in total tissue volume and the bone surface area between class III and class II patient groups in our study. We have found significant differences in women's patient groups when we evaluate gender in itself, unlike this study.

In this study, there was a statistically significant difference in the tissue volume (Class I *P* = ,016, Class II *P* = ,006), trabecular bone volume (Class I *P* = ,002, Class II *P* = ,001) and bone surface (Class I *P* = ,016, Class II *P* = ,005) among the Class III group and the other groups in women.

Table 3: Comparison of Classes between genders.

Gender			*P* (Male)	*P* (Woman)	Gender			*P* (Male)	*P* (Woman)
TV (mm^3)	Class I	Class II	,308	,880	BV/TV (%)	Class I	Class II	,721	,982
		Class III	,967	,016			Class III	,476	,465
	Class II	Class I	,308	,880		Class II	Class I	,721	,982
		Class III	,331	,006			Class III	,115	,554
	Class III	Class I	,967	,016		Class III	Class I	,476	,465
		Class II	,331	,006			Class II	,115	,554
BV (mm^3)	Class I	Class II	,675	,817	BS (mm^2)	Class I	Class II	,746	,826
		Class III	,287	,002			Class III	,827	,016
	Class II	Class I	,675	,817		Class II	Class I	,746	,826
		Class III	,835	,001			Class III	,968	,005
	Class III	Class I	,287	,002		Class III	Class I	,827	,016
		Class II	,835	,001			Class II	,968	,005

Yılancı et al.[24] stated that in their study of condylar hyperplasia, there was more condyle growth in women. Raijmakers et al.[25] have reported also that the female gender is a risk factor for condylar hyperplasia and may be due to the chromosomal origin of estrogen. In these studies, differences in the female patient group may be due to hormonal or genetic factors. This shows the importance of the differences between genders in our study.

CONCLUSION

The morphology of mandibular condylar changes in terms of tissue volume, trabecular bone volume, bone density and the bone surface can be related to malocclusions. Moreover, further studies must be done for future studies on temporomandibular joint development and the measurements of condylar volume and relation with the skeletal patterns.

Ethics Committee Approval: This study was approved by Ethics committee of Ankara University Faculty of Dentistry Clinical Research Ethics Committee , (Approval No: 2016/36290600/95).

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.O., M.E.K.; Design – M.O., M.E.K.; Supervision – M.E.K..; Resources – M.O., M.E.K.; Materials – M.O., M.E.K.; Data Collection and/or Processing – M.E.K.; Analysis and/or Interpretation – M.O., M.E.K.; Literature Search – M.O.; Writing Manuscript – M.O.; Critical Review –M.O., M.E.K.

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

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

Etik Komite Onayı: Bu çalışma için etik komite onayı Ankara Üniversitesi Diş Hekimliği Fakültesi'nden (Karar No: 2016/36290600/95) alınmıştır

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir – M.O., M.E.K.; Tasarım – M.O., M.E.K.; Denetleme – M.E.K.; Kaynaklar – M.O., M.E.K. Veri Toplanması ve/veya İşlemesi –M.E.K.; Analiz ve/veya Yorum –M.O., M.E.K.; Literatür Taraması – M.O.; Yazıyı Yazan – M.O.; Eleştirel İnceleme – M.O.

Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

REFERENCES

1. Standring S. Gray's Anatomy E-Book: The Anatomical Basis of Clinical Practice. Elsevier Health Sciences. 2015.
2. Alomar X, Medrano J, Cabratosa J, et al. Anatomy of the temporomandibular joint. *Semin Ultrasound CT MR*. 2007;28(3):170-183.
3. Ingawalé S, Goswami T. Temporomandibular joint: disorders, treatments, and biomechanics. *Ann Biomed Eng*. 2009;37(5):976-996.
4. Moore KL, Dalley AF, Agur AM. Clinically oriented anatomy. Lippincott Williams & Wilkins. 2013
5. Ueki K, Marukawa K, Nakagawa K, Yamamoto E. Condylar and temporomandibular joint disc positions after mandibular osteotomy for prognathism. *J Oral Maxillofac Surg*. 2002;60(12):1424-1432; discussion 1432-144.
6. Egermark I, Magnusson T, Carlsson GE. A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. *Angle Orthod*. 2003;73(2):109-115.
7. Katsavrias EG, Halazonetis DJ. Condyle and fossa shape in Class II and Class III skeletal patterns: a morphometric tomographic study. *Am J Orthod Dentofacial Orthop*. 2005;128(3):337-346.
8. Kuvvetli SS. Temporomandibular disorders in children and adolescents: Literature review. *Curr Res Dent Sci*. 2007;2:1-9
9. Mohlin BO, Derweduwen K, Pilley R, Kingdon A, Shaw W, Kenealy P. Malocclusion and temporomandibular disorder: a comparison of adolescents with moderate to severe dysfunction with those without signs and symptoms of temporomandibular disorder and their further development to 30 years of age. *Angle Orthod*. 2004;74(3):319-327.
10. Pahkala R, Laine-Alava M. Do early signs of orofacial dysfunctions and occlusal variables predict development of TMD in adolescence? *J Oral Rehabil*. 2002;29(8):737-743.
11. Sari S, Sonmez H, Oray G, Camdeviren H. Temporomandibular joint dysfunction and occlusion in the mixed and permanent dentition. *J Clin Pediatr Dent*. 1999;24(1):59-62.
12. Aksoy S, Orhan K. Temporomandibular joint Imaging. *J Ondokuz Mayıs Uni Fac Dent*. 2010;11-18.
13. Lewis EL, Dolwick MF, Abramowicz S, Reeder SL. Contemporary imaging of the temporomandibular joint. *Dent Clin North Am*. 2008;52(4):875-890.
14. Orhan K. The importance of cone-beam computed tomography (CBCT) in Dentistry. *Yeditepe Üni Diş Hek Fak Derg*. 2012.
15. Scarfe W, A F. Cone-beam computed tomography. In: Oral Radiology Principles and Interpretation. 6 edn. St Louis, Elsevier. 2009.
16. Krisjane Z, Urtane I, Krumina G, Bieza A, Zepa K, Rogovska I. Condylar and mandibular morphological criteria in the 2D and 3D MSCT imaging for patients with Class II division 1 subdivision malocclusion. *Stomatologija*. 2007;9(3):67-71.
17. Krisjane Z, Urtane I, Krumina G, Zepa K. Three-dimensional evaluation of TMJ parameters in Class II and Class III patients. *Stomatologija*. 2009;11(1):32-36.
18. Saccucci M, D'Attilio M, Rodolfino D, Festa F, Polimeni A, Tecco S. Condylar volume and condylar area in class I, class II and class III young adult subjects. *Head Face Med*. 2012;8:34.
19. Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. *Angle Orthod*. 2008;78(3):387-395.
20. Ho JT, Wu J, Huang HL, Chen MY, Fuh LJ, Hsu JT. Trabecular bone structural parameters evaluated using dental cone-beam computed tomography: cellular synthetic bones. *Biomed Eng Online*. 2013;12:115.
21. Ordinola-Zapata R, Bramante C, Versiani M, et al. Comparative accuracy of the Clearing Technique, CBCT and Micro-CT methods in studying the mesial root canal configuration of mandibular first molars. *Int Endod J*. 2017;50(1):90-96.
22. Van Dessel J, Huang Y, Depypere M, Rubira-Bullen I, Maes F, Jacobs R. A comparative evaluation of cone beam CT and micro-CT on trabecular bone structures in the human mandible. *Dentomaxillofac Radiol*. 2013;42(8):20130145.
23. Katsavrias EG. Morphology of the temporomandibular joint in subjects with Class II Division 2 malocclusions. *Am J Orthod Dentofacial Orthop*. 2006;129(4):470-478.
24. Yılancı HÖ, Akkaya N, Özbek M. Kondiler hiperplazinin terminolojisi ve sınıflandırılması: İki olgu sunumu ve derleme. *Tr-ENT*. 2015;25(6):367-374.
25. Raijmakers PG, Karssemakers LH, Tuinzing DB. Female predominance and effect of gender on unilateral condylar hyperplasia: a review and meta-analysis. *J Oral Maxillofac Surg*. 2012;70(1):e72-76.