Acta Stomatologica Cappadocia

Volume 5, Issue 1
July 2025

ISSN: 2792-047X

https://asc.kapadokya.edu.tr

Acta Stomatologica Cappadocia (ASC) 2025, vol. 5, no. 1

Adress: Cappadocia University, Urgup Campus, Faculty of Dentistry
Urgup / Nevsehir
Phone: +90 (384) 353 5009 Fax: +90 (384) 353 5125

Adress: Cappadocia University, Urgup Campus, Faculty of Dentistry
Urgup / Nevsehir
Phone: +90 (384) 353 5009 Fax: +90 (384) 353 5125

Asst. Prof. Marilia Daniela Busnardo Canadas (University Of Turku, Finland)

Language Editor

Lecturer Büşra Uyanık (Cappadocia University, Türkiye)

Statistics Editor

Asst. Prof. Selda Öztürk (Cappadocia University, Türkiye)

Adress: Cappadocia University, Urgup Campus, Faculty of Dentistry
Urgup / Nevsehir
Phone: +90 (384) 353 5009 Fax: +90 (384) 353 5125

CAPPADOCIA UNIVERSITY
Logic - Wisdom - Equality - Tradition

Acta Stomatologica Cappadocia

Table of Contents

Research Articles

Case Report

Review Article

Volume 5 / Issue 1 / July 2025

Research Article

Mandibular Kondil, Koronoid Çıkıntı ve Sigmoid Girintideki Morfolojik Varyasyonların Dijital Panoramik Radyografilerde Değerlendirilmesi Yoluyla Kimlik Tanımlanmasında Kullanılması

Aydan Açıkgöz[1*], Özlem Akkemik Kıpçak[2]

[1]Kapadokya Üniversitesi, Diş Hekimliği Fakültesi, Ağız, Diş ve Çene Radyolojisi Anabilim Dalı, Nevşehir, Türkiye.

[2]Barış Tıbbi Görüntüleme Merkezi, İzmir, Türkiye.

**Corresponding author: aydan.acikgoz@kapadokya.edu.tr*

Açıkgöz, Aydan., Akkemik Kıpçak, Özlem. "Dijital Panoramik Radyografilerin Değerlendirilmesiyle Kişisel Kim-lik Belirlemede Mandibular Kondil, Koronoid İşlem ve Sigmoid Çen-tik Morfolojik Varyasyonlarının Kullanılması". *Acta Stomatologica Cappadocia.* 5;1 (June 2025): 1-22.

DOI: https://doi.org/10.54995/ASC.5.1.1

Received: 12.03.2025; Accepted: 29.04.2025

Mandibular Kondil, Koronoid Çıkıntı ve Sigmoid Girintideki Morfolojik Varyasyonların Dijital Panoramik Radyografilerde Değerlendirilmesi Yoluyla Kimlik Tanımlanmasında Kullanılması

Aydan Açıkgöz, Özlem Akkemik Kıpçak

Özet

Problemin Açıklaması: Mandibula güçlü bir kemik olması ve uzun zaman hasar görmeden kalması nedeniyle mandibular koronoid çıkıntı, kondil ve sigmoid girintinin morfolojisinde yaş, cinsiyet ve ırka bağlı izlenebilecek varyasyonlar bireyin ait olabileceği popülasyon, yaş ve cinsiyetin öngörülmesinde ve kimlik tanımlamasında kullanılabilir.

Amaç: Çalışmamızın amacı dijital panoramik radyorafiler kullanarak bir grup yetişkin Türk popülasyonunda her iki tarafta koronoid çıkıntı, kondil ve sigmoid girintideki morfolojik varyasyonları belirlemek ve elde edilen verilerin cinsiyet ve yaş belirlenmesinde kullanılabilirliğini analiz etmektir.

Malzeme ve Yöntemler: Araştırmamızda 20 yaş üstü bireylere ait toplam 1428 panoramik grafi ve 2856 bölge (sağ-sol) değerlendirildi. Kondil, koronoid çıkıntı ve sigmoid girintideki farklı morfolojik varyasyonlar yaş grupları, cinsiyet ve bölgeler kıyaslanarak elde edilen veriler Ki Kare analizi ile karşılaştırılmış, İstatistiksel anlamlılık $p<0,05$ düzeyinde değerlendirilmiştir.

Bulgular: Çalışmaya dahil edilen 1428 hastanın 521'i (%36,5) erkek, 907'si (%63,5) kadın, yaş ortalaması ise 43,20±14,80'dir. Araştırmamızda mandibular kondil, koronoid çıkıntı ve sigmoid girintide farklı varyasyonlar gözlenmiştir. Çalışmamızda en fazla izlenen kondil şekli %38,41 açılı, koronoid çıkıntı şekli %57,45 üçgen ve sigmoid girinti şekli %51,45 yuvarlak olarak bulundu. Her üç anatomik yapı da morfolojik olarak sağ ve sol bölgeler arasında simetrik bir dağılım gösterirken, cinsiyetleri karşılaştırdığımızda koronoid çıkıntı ve sigmoid girintide herhangi bir fark izlenmezken kondil şeklinde cinsiyetler arasında fark olduğu gözlenmiştir. Yaş grupları dikkate alındığında her üç anatomik yapıda da yaş grupları arasında morfolojik varyasyonlarda farklılıklar tespit edilmiştir.

Sonuç: Bu çalışma panoramik radyografi kullanılarak tespit edilen anatomik varyasyonların her iki cinste, her yaş grubunda ve her popülasyonda izlenmesi nedeniyle yaş, cinsiyet ve ırk öngörüsünde bulunabilmek için kullanılabilirliğinin halen belirsizliğini koruduğunu göstermiştir.

Anahtar kelimeler: Kimlik tanımlama, kondil, koronoid çıkıntı, panoramik radyografi, sigmoid girinti.

Abstract

Statement of the problem: Since the mandible is a strong bone and can remain undamaged for a long time, the variations that can be observed in the morphology of the mandibular coronoid process, condyle and sigmoid notch depending on age, gender and race can be used to predict the population, age and gender to which the individual may belong and for identification. The aim of our study was to determine the morphological variations in the coronoid process, condyle and sigmoid notch on both sides in a group of adult Turkish population using digital panoramic radiographs and to analyze the usability of the obtained data in determining gender and age.

Materials and methods: In our study, a total of 1428 panoramic radiographs and 2856 regions (right-left) belonging to individuals over 20 years of age were evaluated. Different morphological variations in the condyle, coronoid process and sigmoid notch were compared by age groups, gender and regions, and the data obtained were compared using Chi Square analysis, and statistical significance was assessed at $p<0.05$.

Results: Of the 1428 patients included in the study, 521 (36.5%) were male, 907 (63.5%) were female, and the mean age was 43.20 ±14,80. In our study, different variations were observed in the mandibular condyle, coronoid process and sigmoid notch. In our study, the most common condyle shape was found to be 38.41% angled, coronoid process shape was 57.45% triangular, and sigmoid notch shape was 51.45 % round. While all three anatomical structures morphologically showed a symmetric distribution between the right and left regions, when we compared the genders, no difference was observed in the coronoid process and sigmoid notch, but a difference in the shape of the condyle was observed between the genders. When age groups were taken into consideration, differences in morphological variations were detected between age groups in all three anatomical structures.

Conclusion: This study has shown that the usability of anatomical variations detected using panoramic radiography to predict age, gender and race is still uncertain, as they are observed in both sexes, all age groups and all populations.

Keywords: Condyle, coronoid process, sigmoid notch, panoramic radiography, personal identification.

Giriş

Canlı veya ölü bir kişinin tanınması, tanımlanması ve diğer insanlardan ayırt edilmesinde yararlanılan tüm özelliklere kimlik, bu özelliklerin ortaya konulmasına ise kimlik tespiti denir. Canlı bireylerin kimlik tespiti kişinin nüfus kayıtlarındaki bilgileri (yaşı, cinsiyeti vb.) kullanıldığından genellikle çok fazla sorun yaratmazken ölü bireylerde kimlik tespiti özellikle önem arz etmektedir. Ceset bütünlüğünün bozulmadığı durumlarda DNA eşleşmesi, diş kayıtlarının karşılaştırılması ve parmak izi analizleri bireyin tanımlanmasında uzun zamandır kullanılan yöntemler olmuştur. Ancak yangın, uçak kazası gibi büyük felaketlerde yüksek ısıyla kömürleşmiş veya zaman içerisinde çürüyüp yapısal bütünlüğün bozulduğu ceset kalıntılarında kimliklendirme işlemi DNA'nın degradasyonu ve parmak izlerinin kullanılamaz hale gelmesi nedeniyle zorlaşmakta ve sorun yaratmaktadır (1-3).

Kemik ve dişlerin en son bozulan dokular olması ve bu dokulardaki anatomik yapıların bireye özgü, tekil özellikler taşıması nedeniyle yapısal bütünlüğün bozulduğu ceset kalıntılarında antropolojik ve dental analizler kişiyi tanımlamada önemli rol oynar (4,5). İnsan vücudunda cinsiyet belirlemede pelvisten sonra kafatası %92' lik doğruluk oranı sağlayan ikinci anatomik yapıdır ve bu nedenle antropolojide kafadaki frontal sinüsler, sella turcica, nazal septum, orbital açıklıklar ve beslenme kanalları gibi farklı anatomik yapılar kimliklendirme işleminde sıklıkla kullanılmaktadır (6,7). Kafatası bütünlüğünün bozulduğu ve sadece kafatasına ait kemik artıklarının kaldığı durumlarda mandibula güçlü ve büyük bir kemik olması ve uzun zaman hasar görmeden kalması nedeniyle adli diş hekimliğinde mandibular yapıların değerlendirilmesi kimliklendirme işleminde majör rol oynamaktadır. Mental foramenin morfolojik görünümü, alveoler kemik yüksekliği, mandibular foramenin pozisyonu, dişlerin boyutu, diş minelerinin incelenmesi ve bunlardaki dejeneratif değişikliklerin cinsiyet ve yaş belirlemede yardımcı olabileceği bildirilmiştir. Mandibulaya ait kondil, koronoid çıkıntı ve sigmoid girintinin de morfolojik varyasyon gösteren diğer anatomik yapılar olmaları nedeniyle ölüm sonrası kimlik belirlenmesinde kullanılabilirliğini araştıran çalışmalar mevcuttur (2,3,6-8).

Mandibular koronoid çıkıntı yukarı ve hafif öne doğru uzanan düz, üçgen şeklinde bir yapıdır ve arka sınırı mandibular girinti ile birleşirken ön sınırı ramus mandibulaya doğru uzanır, kondil ramus mandibula ile dar bir boyun kısmı ile birleşen ve temporal kemiğin glenoid fossası ile eklem oluşturan elipsoid bir kemiktir, aynı zamanda mandibular girinti de

denen sigmoid girinti ise koronoid çıkıntı ve kondili ayıran derin bir girintidir (2,3). Yapılan literatür incelemesinde koronoid çıkıntı (üçgen, yuvarlak, çıkıntı (gaga), kanca, düz, S-şeklinde), kondil (açılı, yuvarlak, dışbükey, düz, oval, kuş gagası, elmas, sivri) ve sigmoid girinti (geniş, yuvarlak, eğimli) ile ilgili farklı varyasyonlar tanımlanmıştır (2,3,6,7,9-12). Anatomik yapılardaki bu morfolojik varyasyonlar kalıtımla ilişkili olabileceği gibi, sosyodemografik faktörler, endokrin bozukluklar, kemikleri etkileyen diğer gelişimsel anomali ve hastalıklara bağlı olarak da meydana gelebilmektedir (9-13). Varyasyonlar üzerinde ırksal farklılıkların rolü olabileceği hipotezinden yola çıkılarak farklı toplumlar üzerinde araştırmalar yapılmış, kimliklendirme işleminde yaş ve cinsiyetin yanı sıra bireyin ait olabileceği toplum veya ırka yönelik bir yorum yapılıp yapılamayacağı da tartışılmıştır.

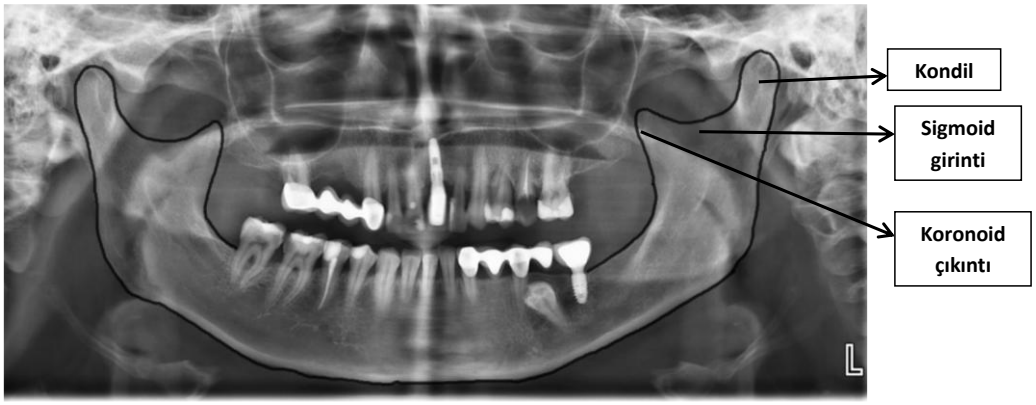
Günümüze kadar adli bilimlerde koronoid çıkıntı, kondil ve sigmoid girintinin toplumlara özgü morfolojik görünümünü ve normalden olan sapmalarını belirlemeye yönelik yapılan pek çok çalışmanın kadavralardan elde edilen kuru mandibulalar üzerinde yapıldığı, (9,10,13-18) 2010'lu yıllardan sonra ise radyolojik çalışmaların ön plana çıktığı görülmektedir (2,3,6,7,11,19-25) Radyograflar fiziksel muayene ile göremeyeceğimiz pek çok gizli bilgileri gösterdiğinden adli diş hekimliğinde kimlik belirlenmesine yönelik çalışmalarda sıklıkla radyolojik verilerden yararlanılmaktadır. Radyografik bulgular, hem mevcut durumu tespit edebilmekte hem de geçmiş kayıtlarla karşılaştırma yapmamıza olanak tanımaktadır. Özellikle radyoloji alanında dijitalizasyona geçildikten sonra hasta kayıtlarının daha iyi arşivlenebilmesi nedeniyle ölüm öncesi bireye ait korunmuş mevcut kayıtların ölüm sorası kayıtlarla karşılaştırılabilme olanağı da artmıştır.

Günümüz diş hekimliğinde panoramik radyografiler maksillofasiyal bölgenin görüntülenmesinde, tanı ve tedavi planlamasının uygulanmasında rutin olarak kullanılan bir görüntüleme yöntemidir. Bilgisayarlı Tomografi (BT), Manyetik Rezonans Görüntüleme (MRG) veya Konik Işınlı Bilgisayarlı Tomografi (KIBT) gibi ileri görüntüleme yöntemlerine göre hem çok daha ucuz hem de kolay ulaşılabilen, radyasyon dozunun daha düşük olduğu bir yöntemdir, ayrıca alt ve üst çenenin tamamı ile birlikte maksiller sinüs, nazal fossa, temporomandibular eklem, styloid çıkıntı ve hyoid kemik gibi komşu anatomik yapılarla birlikte geniş bir alanı görüntüleme imkânı sağlar. Panoramik radyografilerde koronoid çıkıntı, kondil ve sigmoid girintinin şekli rahatlıkla değerlendirilebilir, bilateral değerlendirme yapılabilir ve bu nedenle canlı veya ölü bireylerde kimliklendirme işlemlerinde kullanılabilir

Literatür taramasında koronoid çıkıntı, kondil ve sigmoid girintideki varyasyonların tespitine yönelik yapılan çalışmalarda her üç anatomik yapının birlikte çalışıldığı sınırlı sayıda araştırma olduğu gözlenmiştir. Tek bir panoramik görüntüde her üç anatomik yapının da görüntü alanında olması nedeniyle bireysel farklılıkların ortaya konmasında bu üç anatomik yapının birlikte değerlendirilmesinin daha sağlıklı sonuçlar vereceği düşüncesi ile retrospektif olarak planladığımız çalışmamızda, dijital panoramik radyografileri kullanarak erişkin Türk popülasyonunda koronoid çıkıntı, kondil ve sigmoid girintideki farklı morfolojik varyasyonları belirlemek, cinsiyet ve yaşla olan ilişkilerini, sağ-sol arasında simetri olup olmadığını değerlendirmek ve kendi coğrafik bölgemize ait elde ettiğimiz verileri farklı coğrafik bölgelerdeki verilerle karşılaştırmayı amaçladık.

Malzeme ve Yöntemler

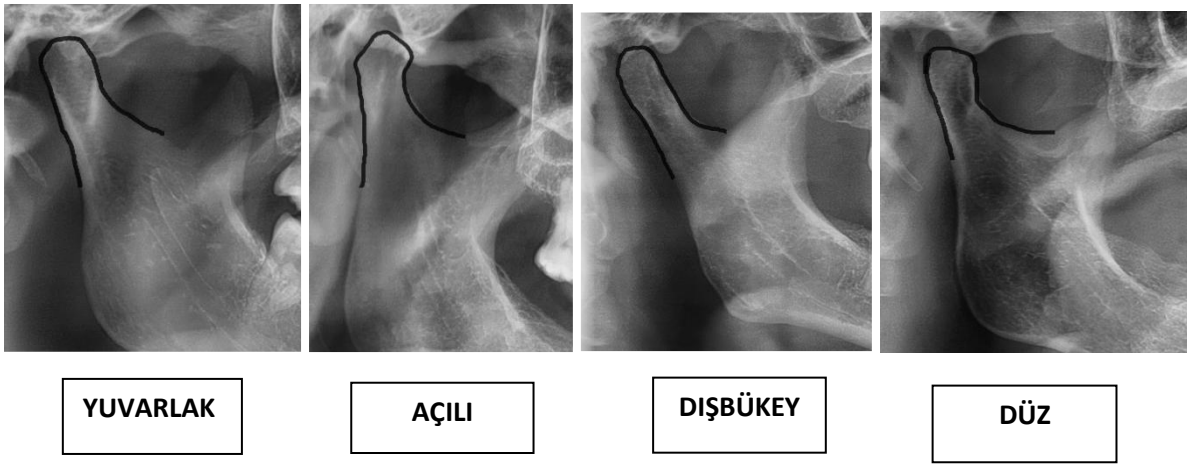
Araştırmamızda İstanbul Yeni Yüzyıl Üniversitesi Diş Hekimliği Fakültesi arşivinde kayıtlı, 01.01. 2018-31.12. 2020 yıllarına ait, rutin muayene amaçlı alınmış 20 yaş ve üstü hastalara ait dijital panoramik radyografiler kullanıldı. Tüm dijital görüntüler, Vatech, PaX-i makine (Vatech; Güney Kore) ile 73 kVp, 07 sn ışınlama süresi, 10 mA ile elde edilmiş ve EzDent-i software ile Tıp Plus Hastahane Otomasyon Yazılımı üzerinde, LCD monitörde ortam ışığında değerlendirildi. Görüntüler arasında üretici firmanın önerdiği ideal ve uygun pozisyonda çekilmiş, kondil, koronoid çıkıntı ve sigmoid girintinin net olarak izlendiği (Şekil 1), mandibulanın sağlıklı olduğu panoramik radyografiler değerlendirmeye alınmış, hastaların demografik bilgilerini içermeyen, kurallara uygun çekilmeyen, distorsiyon ve artifakt izlenen, mandibulayı etkileyen gelişimsel defekt veya kemik lezyonu izlenen görüntüler çalışma dışı bırakıldı.



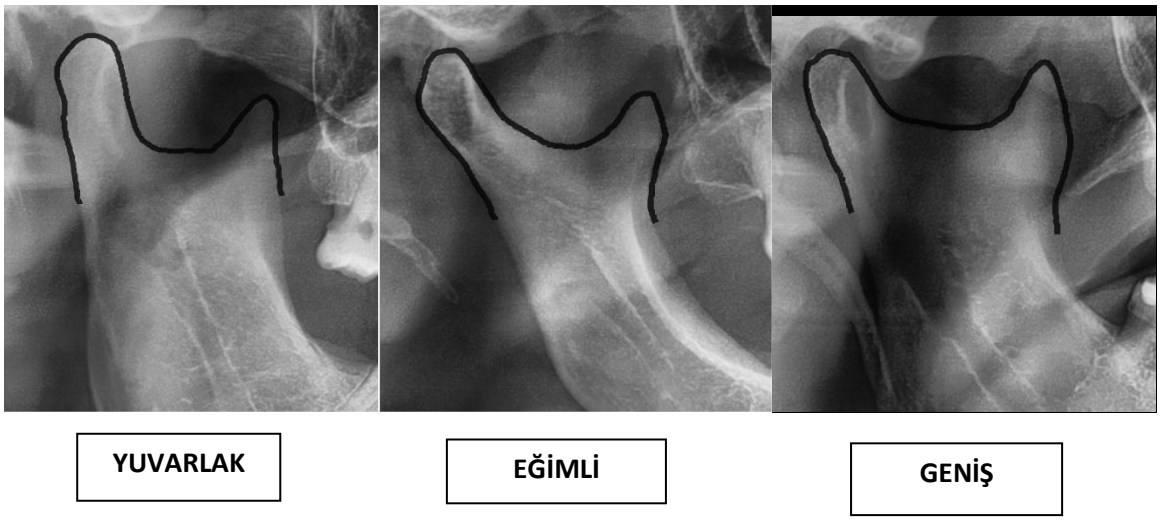
Şekil 1. Panoramik radyografide mandibular kondil, koronoid çıkıntı ve sigmoid girintinin görüntüsü.

Kondil, koronoid çıkıntı ve sigmoid girintiye ait morfolojik varyasyonların sınıflamasında Sahithi ve ark. (5) referans alındı (Şekil 2,3,4). Yaş grupları 10 yıl aralıklarla 20-29, 30-39, 40-49, 50-59, 60-69, ≥ 70 olacak şekilde sınıflandırıldı. Toplam 1428 hastada, sağ-sol 2856 bölge incelendi. Tüm görüntüler alanında uzman maksillofasiyal radyolog tek gözlemci (AA) tarafından değerlendirildi.

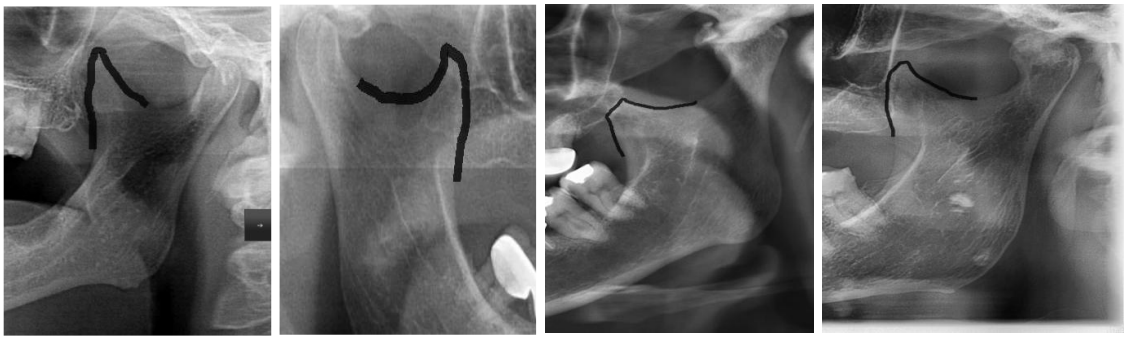
İstatistiksel analizler IBM SPSS 25.0. programı ile yapılmıştır. Analizlerde tanımlayıcı istatistikler frekans (f) ve yüzde (%) olarak belirtilmiştir. Araştırmada ilk olarak hastaların sosyo-demografik profili incelenmiştir. Daha sonra hastaların cinsiyetine ve yaşına göre kondil, koronoid çıkıntı ve sigmoid girinti şekillerinin dağılımları Ki Kare analizi ile karşılaştırılmıştır. İstatistiksel anlamlılık $p<0,05$ düzeyinde değerlendirilmiştir.



Şekil 2. Farklı kondil şekillerinin panoramik görüntüleri.



Şekil 3. Farklı sigmoid girinti şekillerinin panoramik görüntüleri.



Şekil 4. Farklı koronoid çıkıntı şekillerinin panoramik görüntüleri.

Bulgular

Araştırmamızda hastaların 521'i (%36,5) erkek, 907'si (%63,5) kadın, yaş ortalaması ise 43,20±14,80'dir (erkekler 43,24±15,10, kadınlar 43,17±14,62). Çalışmamızda, erkek hastaların %23,4'ünün, kadın hastaların %22,7'sinin ve tüm hastaların %23,0'ünün 30-39 yaş aralığında olduğu görüldü (Tablo 1).

Tablo 1. Cinsiyete göre yaş dağılımı.

Yaş aralıkları (yıl)	Kadın			Erkek			Toplam	
	N=907	*	**	N=521	*	**	N=1428	**
20-29	192	61,9	21,2	118	38,1	22,6	310	21,7
30-39	206	62,8	22,7	122	37,2	23,4	328	23,0
40-49	206	65,2	22,7	110	34,8	21,1	316	22,1
50-59	165	66,8	18,2	82	33,2	15,7	247	17,3
60-69	98	60,9	10,8	63	39,1	12,1	161	11,3
>70	40	60,6	4,4	26	39,4	5,0	66	4,6

* Satır yüzdesi ** Sütun yüzdesi

Kondil

2856 bölgede en fazla izlenen kondil şekli %38.41 açılı olarak tespit edilmiştir. Bunu sırası ile yuvarlak %34,6, dışbükey %21,2 ve düz %5,75 izlemiştir. Sağ-sol bölgeler arasında

kondil şekli %79,7 simetri göstermiştir (Tablo2). Kondil şeklinin cinsiyetlere göre dağılımı incelendiğinde kadınlarda en fazla %41,6 açılı tip kondil izlenirken, erkeklerde en fazla %40,4 yuvarlak tip kondile rastlanmıştır. Sağ ve sol kondil tiplerinin cinsiyete göre dağılımları incelendiğinde her iki taraf için de kadın ve erkekler arasında istatistiksel açıdan fark görülmüştür ($p<0,05$). Kondil şeklinin cinsiyetler arasında bilateral simetrisine bakıldığında da cinsiyetler arasında istatistiksel açıdan farklılık gösterdiği tespit edilmiştir ($p<0,05$). Kadınlarda açılı tip bilateral simetri %33,4, erkeklerde yuvarlak tip bilateral simetri %32,8 daha fazla izlenmiştir. Unilateral kondil şekli kadın hastalarda %21,4, erkeklerde %18,4 olarak gözlenmiştir, ancak bu durum istatistiksel olarak anlamlı değildi ($p>0,05$) (Tablo 3).

Tablo 2. Farklı kondil şekillerinin sağ ve sol tarafa göre dağılımları.

		f	**%**
Sağ taraf	Yuvarlak	484	33,9
	Açılı	561	39,3
	Dışbükey	304	21,3
	Düz	79	5,5
Sol taraf	Yuvarlak	504	35,3
	Açılı	536	37,5
	Dışbükey	302	21,1
	Düz	86	6,0
Bilateral	İzlenmiyor	290	20,3
	Yuvarlak	384	26,9
	Açılı	441	30,9
	Dışbükey	264	18,5
	Düz	49	3,4
Unilateral	Yok	1138	79,7
	Var	290	20,3

Kondil şeklinin yaş gruplarına göre dağılımı incelendiğinde 20-29 ve 60-69 yaş aralığında en fazla yuvarlak tip kondil izlenirken diğer tüm yaş gruplarında açılı tip kondile daha fazla rastlanmıştır ($p<0,05$) (Tablo 4).

Tablo 3. Cinsiyete göre farklı kondil şekillerinin sağ ve sol taraftaki dağılımları.

		Kadın			Erkek			p
		N=907	*	**	N=521	*	**	
Sağ taraf	Yuvarlak	271	56,0	29,9	213	44,0	40,9	,000
	Açılı	388	69,2	42,8	173	30,8	33,2	
	Dışbükey	207	68,1	22,8	97	31,9	18,6	
	Düz	41	51,9	4,5	38	48,1	7,3	
Sol taraf	Yuvarlak	296	58,7	32,6	248	41,3	39,9	,000
	Açılı	366	68,3	40,4	170	31,7	32,6	
	Dışbükey	202	66,9	22,3	100	33,1	19,2	
	Düz	43	50	4,7	43	50	8,7	
Bilateral	Yok	194	66,9	21,4	96	33,1	18,4	,000
	Yuvarlak	213	55,5	23,5	171	44,5	32,8	
	Açılı	303	68,7	33,4	138	31,3	26,5	
	Dışbükey	175	66,3	19,3	89	33,7	17,1	
	Düz	22	44,9	2,4	27	55,1	5,2	
Unilateral	Yok	713	62,7	78,6	425	37,3	81,6	,180
	Var	194	66,9	21,4	96	33,1	18,4	

* Satır yüzdesi ** Sütun yüzdesi

Tablo 4. Yaş gruplarına göre farklı kondil şekillerinin sağ ve sol taraftaki dağılımları.

		20-29			30-39			40-49			50-59			60-69			70+			p
		N=310	*	**	N=328	*	**	N=316	*	**	N=247	*	**	N=161	*	**	N=66	*	**	
Sağ	Yuvarlak	131	27,1	42,3	101	20,9	30,8	97	20,0	30,7	76	15,7	30,8	56	11,6	34,8	23	4,8	34,8	,001
	Açılı	126	22,5	40,6	131	23,4	39,9	132	23,5	41,8	94	16,8	38,1	54	9,6	33,5	24	4,3	36,4	
	Dışbükey	35	11,5	11,3	75	24,7	22,9	68	22,4	21,5	69	22,7	27,9	40	13,2	24,8	17	5,6	25,8	
	Düz	18	22,8	5,8	21	26,6	6,4	19	24,1	6	8	10,1	3,2	11	13,9	6,8	2	2,5	3,0	
Sol	Yuvarlak	135	26,8	43,5	111	22,0	33,8	104	20,6	32,9	70	13,9	28,3	62	12,3	38,5	22	4,4	33,3	,004
	Açılı	119	22,2	38,4	126	23,5	38,4	120	22,4	38,0	97	18,1	39,3	49	9,1	30,4	25	4,7	37,9	
	Dışbükey	39	12,9	12,6	68	22,5	20,7	75	24,8	23,7	67	22,2	27,1	36	11,9	22,4	17	5,6	25,8	
	Düz	17	19,8	5,5	23	26,7	7	17	19,8	5,4	13	15,1	5,3	14	16,3	8,7	2	2,3	3,0	
Bilateral	Yok	76	26,2	24,5	71	24,5	21,6	59	20,3	18,7	45	15,5	18,2	32	11	19,9	7	2,4	10,6	,004
	Yuvarlak	101	26,3	32,6	80	20,8	24,4	79	20,6	25	57	14,8	23,1	48	12,5	29,8	19	4,9	28,8	
	Açılı	93	21,1	30,0	99	22,4	30,2	107	24,3	33,9	79	17,9	32	40	9,1	24,8	23	5,2	34,8	
	Dışbükey	30	11,4	9,7	63	23,9	19,2	60	22,7	19	61	23,1	24,7	34	12,9	21,1	16	6,1	24,2	
	Düz	10	20,1	3,2	15	30,6	4,6	11	22,4	3,5	5	10,2	2	7	14,3	4,3	1	2	1,5	
Unilateral	Yok	234	20,7	75,8	257	22,6	78,4	257	22,6	81,3	202	17,7	81,4	129	11,3	80,1	59	5,2	89,4	,152
	Var	76	25,9	24,2	71	24,5	21,6	59	20,3	18,7	45	15,9	18,6	32	11	19,9	7	2,4	10,6	

* Satır yüzdesi ** Sütun yüzdesi

Tablo 5. Cinsiyete göre farklı koronoid çıkıntı şekillerinin sağ ve sol taraftaki dağılımları.

		Kadın			Erkek			p
		N=907	*	**	N=521	*	**	
Sağ	Üçgen	500	63,1	55,1	292	36,9	56,0	,910
	Yuvarlak	365	64,4	40,2	202	35,6	38,8	
	Çıkıntı	31	62,0	3,4	19	38,8	3,6	
	Düz	11	57,9	1,2	8	42,1	1,5	
Sol	Üçgen	523	61,7	57,7	325	38,3	62,4	,120
	Yuvarlak	337	66,7	37,2	168	33,3	32,2	
	Çıkıntı	39	67,2	4,3	19	32,8	3,6	
	Düz	8	47,1	0,9	9	52,9	1,7	
Bilateral	Yok	118	59,9	13,0	79	40,1	15,2	,439
	Üçgen	463	62,8	51,0	274	37,2	52,6	
	Yuvarlak	305	66,4	33,6	154	33,6	29,6	
	Çıkıntı	16	64,0	1,8	9	36,0	1,7	
	Düz	5	50,0	0,6	5	50,0	1,0	
Unilateral	Yok	789	64,1	86,9	442	35,9	84,8	,282
	Var	118	60,1	13,1	79	39,9	15,2	

* Satır yüzdesi ** Sütun yüzdesi

Koronoid çıkıntı

2856 bölgede en fazla izlenen koronoid çıkıntı şekli %57,45 üçgen olarak tespit edilmiş, bunu sırası ile yuvarlak %37,55, çıkıntı %3,8 ve düz %1,00 izlemiştir. Sağ-sol bölgeler arasında koronoid çıkıntı şekli %86,1 simetri göstermiştir.

Koronoid çıkıntı şeklinin cinsiyetlere göre dağılımı incelendiğinde hem erkek hem kadın hastalarda en fazla üçgen tip izlenmiş (sırası ile %56,0, %55,1) ve istatistiksel olarak anlamlı bir fark bulunamamıştır ($p>0.05$). Bilateral simetri yönünden değerlendirildiğinde %86,1 vakada simetri izlenmiş ve cinsiyetler açısından istatistiksel olarak anlamlı bir fark bulunamamıştır ($p>0.05$) (Table 8).

Koronoid çıkıntı şeklinin yaş gruplarına göre dağılımı incelendiğinde tüm yaş gruplarında en fazla üçgen şekil izlenmiş, ancak yaş gruplarına göre dağılımları açısından istatistiksel açıdan fark görülmüştür (p<0.05) (Tablo 6).

Tablo 6. Yaş gruplarına göre farklı koronoid çıkıntı şekillerinin sağ ve sol taraftaki dağılımları.

		20-29			30-39			40-49			50-59			60-69			70+			p
		N=310	*	**	N=328	*	**	N=316	*	**	N=247	*	**	N=161	*	**	N=66	*	**	
Sağ	Üçgen	203	25,3	65,5	177	22,3	54,0	173	21,8	54,7	132	16,7	53,4	78	9,8	48,4	29	3,7	43,9	,020
	Yuvarlak	97	17,1	31,3	137	24,2	41,8	131	23,1	41,5	99	17,5	40,1	72	12,7	44,7	31	5,5	47,0	
	Çıkıntı	8	16,0	2,6	8	16,0	2,4	10	20,0	3,2	12	24,0	4,9	7	14,0	4,3	5	10,0	7,6	
	Düz	2	10,5	0,6	6	31,6	1,8	2	10,5	0,6	4	21,1	1,6	4	21,1	2,5	1	5,3	1,5	
Sol	Üçgen	214	25,2	69,0	187	22,1	57,0	183	21,6	57,9	146	17,2	59,1	87	10,3	54,0	31	3,7	47,0	,002
	Yuvarlak	89	17,6	28,7	131	25,9	39,9	110	21,8	34,8	83	16,4	33,6	61	12,1	37,9	31	6,1	47,0	
	Çıkıntı	6	10,3	1,9	6	10,3	1,8	19	32,8	6,0	13	22,4	5,3	10	17,2	6,2	4	6,9	6,0	
	Düz	1	5,9	0,3	4	23,5	1,2	4	23,5	1,3	5	29,4	2,0	3	17,6	1,9	-	-	-	
Bilateral	Yok	36	18,3	11,6	41	20,8	12,5	45	22,8	14,2	40	20,3	16,2	28	14,2	17,4	7	3,6	10,6	,042
	Üçgen	191	25,9	61,6	165	22,4	50,3	159	21,6	50,3	123	16,7	49,8	71	9,6	44,1	28	3,8	42,4	
	Yuvarlak	79	17,2	25,5	118	25,7	36,0	102	22,2	32,3	75	16,3	30,4	56	12,2	34,8	29	6,3	43,9	
	Çıkıntı	3	12,0	1,0	2	8,0	0,6	8	32,0	2,6	6	24,0	2,4	4	16,0	2,5	2	8,0	3,1	
	Düz	1	10,0	0,3	2	20,0	0,6	2	20,0	0,6	3	30,0	1,2	2	20,0	1,2	-	-	-	
Unilateral	Yok	274	22,2	88,1	287	23,3	87,5	271	22,0	85,8	207	16,8	83,8	133	10,8	82,6	59	4,8	89,4	,428
	Var	36	18,7	11,9	41	20,7	12,5	45	22,7	14,2	40	20,0	16,2	28	14,1	17,4	7	3,5	10,6	

* Satır yüzdesi ** Sütun yüzdesi

Sigmoid girinti

2856 bölgede en fazla izlenen sigmoid girinti şekli %51.45 yuvarlak olarak tespit edilmiştir. Bunu sırası ile eğimli %31,0 ve geniş %17,55 izlemiştir. Sağ-sol bölgeler arasında sigmoid girinti şekli %73,6 simetri göstermiştir.

Sigmoid girinti şeklinin cinsiyetlere göre dağılımı incelendiğinde hem erkek hem kadın hastalarda en fazla yuvarlak tip izlenmiş ve cinsiyetler arasında bilateral simetri arasında istatistiksel olarak anlamlı bir fark bulunamamıştır (p>0.05) (Tablo 7).

Sigmoid girinti şeklinin yaş gruplarına göre dağılımı incelendiğinde tüm yaş gruplarında en fazla yuvarlak izlenmiş, sağ tarafta yaş gruplarına göre dağılımda istatistiksel olarak fark izlenirken (p<0.05), sol tarafta böyle bir farka rastlanmamıştır (p>0.05) (Tablo 8).

Tablo 7. Cinsiyete göre farklı sigmoid girinti şekillerinin sağ ve sol taraftaki dağılımları.

		Kadın			Erkek			p
		N=907	*	**	N=521	*	**	
Sağ	Yuvarlak	432	60,3	47,6	285	39,7	54,7	,004
	Eğimli	309	69,8	34,1	134	30,2	25,7	
	Geniş	166	61,9	18,3	102	38,1	19,6	
Sol	Yuvarlak	450	59,8	49,6	302	40,2	58,0	,008
	Eğimli	303	68,6	33,4	139	31,4	26,7	
	Geniş	154	65,8	17,0	80	34,2	15,3	
Bilateral	Yok	231	61,3	25,5	146	38,7	28,0	,003
	Yuvarlak	358	59,9	39,5	240	40,1	46,1	
	Eğimli	223	71,7	24,5	88	28,3	16,9	
	Geniş	95	66,9	10,5	47	33,1	9,0	
Unilateral	Yok	676	64,3	74,5	375	35,7	72,0	,292
	Var	231	61,3	25,5	146	38,7	28,0	

* Satır yüzdesi ** Sütun yüzdesi

Tablo 8. Yaş gruplarına göre farklı sigmoid girinti şekillerinin sağ ve sol taraftaki dağılımları.

		20-29			30-39			40-49			50-59			60-69			70+			p
		N=310	*	**	N=328	*	**	N=316	*	**	N=247	*	**	N=161	*	**	N=66	*	**	
Sağ	Yuvarlak	156	21,8	50,3	175	24,4	53,4	167	23,3	52,8	119	16,6	48,2	74	10,3	46,0	26	3,6	39,4	,008
	Eğimli	116	26,2	37,4	93	21,0	28,4	89	20,1	28,2	77	17,4	31,2	45	10,2	28,0	23	5,2	34,8	
	Geniş	38	14,2	12,3	18,3	60	22,4	19,0	51	19,0	51	19,0	20,6	42	15,7	26,1	17	6,3	25,8	
Sol	Yuvarlak	173	23,0	55,8	181	24,1	55,2	163	21,7	51,6	121	16,1	49,0	81	10,8	50,3	33	4,4	50,0	,697
	Eğimli	95	21,5	30,6	100	22,6	30,5	95	21,5	30,1	80	18,1	32,4	49	11,1	30,4	23	5,2	34,8	
	Geniş	42	17,9	13,5	47	20,1	14,3	58	24,8	18,4	46	19,7	18,6	31	13,2	19,3	10	4,3	15,2	
Bilateral	Yok	84	22,3	27,1	81	21,5	24,7	72	19,1	22,8	62	16,4	25,1	53	14,1	32,9	25	6,6	37,9	,126
	Yuvarlak	131	21,9	42,3	150	25,1	45,7	142	23,7	44,9	99	16,6	40,1	57	9,5	35,4	19	3,2	28,8	
	Eğimli	72	23,2	23,2	68	21,9	20,7	66	21,2	20,9	57	18,3	23,1	31	10,0	19,3	17	5,5	25,8	
	Geniş	23	16,2	7,4	29	20,4	8,8	36	25,4	11,4	29	2,4	11,7	20	14,1	12,4	5	3,5	7,6	
Unilateral	Yok	226	21,5	72,9	247	23,5	75,3	244	23,2	77,2	185	17,6	74,9	108	10,3	67,1	41	3,9	62,1	,053
	Var	84	22,3	27,1	81	21,5	24,7	72	19,1	22,8	62	16,4	25,1	53	14,1	32,9	25	6,6	37,9	

* Satır yüzdesi ** Sütun yüzdesi

Tartışma

Adli diş hekimliği, dental verilerin adaletin yararına saklanması ve değerlendirilmesini kapsayan adli bilimlerin bir dalı olarak tanımlanır (3-5,8). Görüntüleme teknolojisindeki hızlı gelişmeler ve dijital sistemlere geçiş sayesinde radyolojik veriler modern diş hekimliği uygulamalarının yanı sıra adli diş hekimliğinin de önemli bir bileşeni haline gelmiştir. Radyograflar dental ve kemik dokuya ait detayları koruyup araştırıcılara objektif veri sağladığından ölüm öncesi ve ölüm sonrası kayıtların karşılaştırılması yöntemi ile adli analizler kimlik tanımlanmasında hızlı ve güvenilir olarak yapılabilmektedir. Diş hekimliği alanında güvenilirliği kanıtlanmış bir görüntüleme yöntemi olan panoramik radyografiler uzun yıllardır dünya genelinde yaygın kullanımları nedeniyle pek çok merkezde geniş bir panoramik görüntü arşivi mevcuttur. Bu arşiv görüntüleri kullanılarak başta mandibula olmak üzere fasiyal kemiklerde izlenen anatomik varyasyonların yaş, cinsiyet ve ırkla ilişkisini retrospektif olarak araştıran pek çok çalışma mevcuttur. Araştırmalar sonucunda elde edilen verilerin kimliklendirme işlemlerinde yaş ve cinsiyetin yanı sıra, bireyin ait olabileceği toplum veya ırka yönelik tanımlamalarda, temporomandibular eklem hastalıklarının etiyolojik faktörlerinin belirlenmesinde, doku kaybı yaratan geniş cerrahi operasyonlarda kullanılmak amacıyla popülasyonlara uygun yapay protez oluşturulması ve rekonstrüksiyon amaçlı kullanımları da hedeflenmiştir (6,9,16,25). Bizim araştırmamızda da dijital panoramik radyografiler kullanılarak mandibular kondil, koronoid çıkıntı ve sigmoid girinti şeklindeki farklılıklar değerlendirilmiş, yaş ve cinsiyetle ilişkisi araştırılmıştır.

Koronoid çıkıntı yukarı ve hafif öne doğru uzanan düz, üçgen şeklinde mandibulaya ait bir kemik parçasıdır. Koronoid çıkıntıda izlenen morfolojik varyasyonlarının kalıtımsal olabileceği gibi büyüme sürecindeki fonksiyonel alışkanlıklara, temporal kasın etkisine ve hormonal faktörlere bağlı olarak edinsel olabileceği de bildirilmiştir (7,13,15,16,20). Araştırmamızda koronoid çıkıntı en fazla üçgen (%57,45) olarak bulunmuş, bunu sırası ile yuvarlak (%37,55) ve çıkıntı (%3,8) takip etmiştir. Düz tip en az izlenen koronoid çıkıntı (%1,0) şekli olarak tespit edilmiştir. Hindistan'ın farklı bölgeleri ve Nepal'de panoramik radyografilerde yapılan çalışmalarda da araştırmamızla uyumlu olarak en fazla üçgen, en az düz tip koronoid çıkıntı izlenmiştir (2,3,7,20,23,24). Taşsöker ve ark (22) da Türk popülasyonunda, KIBT kullanılarak yaptıkları çalışmalarında araştırmamızla uyumlu olarak en fazla üçgen tip izlendiğini bildirmekle beraber araştırıcılar çalışmalarında sadece üçgen ve yuvarla olmak üzere iki tip

sınıflama kullanmışlardır. Hindistan'ın farklı bölgelerinde kuru mandibulalar üzerinde yapılan pek çok çalışmada da en yaygın izlenen koronoid çıkıntı şeklinin üçgen olduğu bildirilmiştir (9,13-17). Subbaramaiah ve ark. (10) ise 100 kuru mandibulada yaptıkları incelemede genel kanının aksine en fazla %61,5 kanca şeklinde koronoid çıkıntı tespit ettiklerini, üçgen şeklin ise sadece %14,0 oranında izlendiği bildirmişlerdir.

Sağ ve sol tarafın karşılaştırıldığı çalışmamızda koronoid çıkıntının tüm farklı varyasyonlarında %86,1 gibi yüksek oranda simetri olduğu izlenmiştir. Birçok araştırmada da bizim sonuçlarımızla uyumlu olarak koronoid çıkıntı şeklinin genellikle simetri gösterdiği bildirilmiştir (2, 10,13,14,16,20,24). Nagaraj ve ark. (3) 300 hastaya radyografik görüntüler üzerinde yaptıkları çalışmalarında ise sağ ve sol arasında istatistiksel olarak fark olduğunu ve üçgen şeklin sağ tarafta, yuvarlak şeklin ise sol tarafta daha fazla izlendiğini bildirmişlerdir.

Koronoid çıkıntının cinsiyetlere göre dağılımını araştırdığımız çalışmamızda hem şekil hem de simetrik dağılım yönünden erkek ve kadınlar arasında istatistiksel olarak anlamlı bir fark bulunamamıştır. Benzer şekilde Nagaraj ve ark. (3), Gouthaman ve ark. (9), Shakya ve ark. (20), Chaulagain ve ark. (23) da araştırmalarında cinsiyetler arasında bir farklılık gözlemlemediklerini bildirmişlerdir. Bir grup araştırıcı ise cinsiyetler arasında koronoid çıkıntı şeklinin farklılık gösterdiğini ve bu nedenle adli çalışmalarda cinsiyet belirlemede kullanılabilecek bir parametre olabileceğini bildirmişlerdir (7,10,14-17,25) Cinsiyetler arasında farklılık izlenmekle birlikte her iki cinste de tüm varyasyonların görülebilmesi ve ayni ırka ait popülasyonlarda farklı sonuçların elde edilmesi cinsiyet ayırımında koronoid çıkıntı şeklinin tek başına yeterli bir kriter olamayacağı, ancak adli bilimlerde kimlik tanımlamada yine de yardımcı bir belirleyici olabileceği bildirilmiştir (10,20).

Yaş gruplarını karşılaştırdığımızda tüm gruplarda en fazla üçgen şekil izlenmekle birlikte gruplar arasındaki dağılımda istatistiksel olarak fark görülmüştür. Elli yaş ve üstü bireylerde üçgen ve yuvarlak tip koronoid çıkıntı görülme sıklığı azalırken yaşla birlikte çıkıntı ve düz tip koronoid çıkıntı sayısında artış olduğu izlenmiştir. Gouthaman ve ark. (9) benzer şekilde genç ve erişkin bireylerde üçgen ve yuvarlak tipin daha fazla izlendiğini, kanca tipin ise sadece yaşlı popülasyonda görüldüğünü bildirmişlerdir. Pradhan ve ark. (16) bizim bulgularımızdan farklı olarak araştırmalarında genç bireylerde yuvarlak tipin daha fazla izlendiğini, yaş ilerledikçe koronoid çıkıntının yuvarlaktan üçgen şekle dönüştüğünü, ayrıca kanca şeklin gençlerde izlenmediğini ve daha çok yaşlı popülasyonda görüldüğünü bildirmişlerdir. Yaşla

olan bu değişikliklerin temporal kasın çekim gücüne bağlı olabileceği ileri sürülmüştür (9,16). Taşsöker ve ark. (22) da benzer şekilde Türk popülasyonunda tüm yaş gruplarında en fazla üçgen şeklin izlendiğini bildirmişlerdir.

Toplumlara veya yaş gruplarına özgü koronoid çıkıntı şeklinin tanımlanması sadece adli tıpta kullanımı için değil aynı zamanda maksillofasiyal cerrahi işlemler için de önemlidir. Koronoid çıkıntıda rezorpsiyonun az olması, yaşla birlikte boyut olarak minimum değişiklik izlenmesi, cerrahi olarak minimal morbidite ile alınabilmesi ve ağız içinden kolay ulaşıldığından kutanöz skar dokusu oluşmaması nedeniyle alveoler defektlerin ve orbita tabanının rekonstrüksiyonunda, maksiller ogmentasyonlarda ve iyileşmeyen mandibular kırıklarda otojen kemik grefti olarak da kullanılmaktadır (7,9,13-15). Bu nedenle operasyon öncesi cinsiyet, yaş veya ırklara özgü kabul gören veya önceden öngörülebilen koronoid çıkıntı şeklinin bilinmesi cerrahi operasyonlarda kolaylık sağlayacaktır.

Kondil ramus mandibula ile dar bir boyun kısmı ile birleşen ve temporal kemiğin glenoid fossası ile eklem oluşturan elipsoid bir kemiktir. Kondil şeklinin araştırıldığı çalışmamızda en fazla açılı tip kondil bulunmuş (%38,41), bunu sırası ile yuvarlak (%34,6) ve dışbükey (%21,2) tip izlemiştir. Görülme sıklığı sıralamasında farklılık izlenmekle birlikte çalışmamızla uyumlu olarak Chaulagain ve ark. (23) da araştırmalarında en fazla açılı kondil tipi izlediklerini bildirmişlerdir. Bir grup araştırıcı ise Hint ve Keşmir popülasyonlarında yaptıkları çalışmalarında en fazla yuvarlak ve daha sonra açılı tip kondile rastladıklarını bildirmişlerdir (2,3,6,19). Yalcin ve ark. (21) ve Taşsoker ve ark.nın (22) KIBT kullanarak erişkin Türk popülasyonunda yaptıkları çalışmalarında ise en fazla dışbükey tip kondil tespit edilmiştir. Pek çok çalışma (2,3,6,19) ile uyumlu olarak araştırmamızda en az (%5,75) düz tip kondile rastlanmıştır.

Çalışmamızda sağ ve sol taraf arasında kondil şeklinin %79,7 oranında simetri gösterdiği izlenmiş ve bu sonuç kondil tipinin simetrisini araştıran birçok araştırıcının bulguları ile uyumlu bulunmuştur (2,3,6,19,24) Al-Saedi ve ark (11) ise Irak popülasyonunda kondil şeklini araştırdıkları çalışmalarında sağ ve sol taraf arasında istatistiksel olarak anlamlı fark olduğunu bildirmişlerdir.

Kondil şeklinin cinsiyetlere göre dağılımı incelendiğinde kadınlarda en fazla %41,6 açılı tip kondil izlenirken, erkeklerde %40,4 yuvarlak tip kondile rastlanmış ve bu fark istatistiksel olarak anlamlı bulunmuştur. Araştırmamızla uyumlu olarak Al-Saedi ve ark.11, Wangai

ve ark. (18), Maqbool ve ark. (19), Yalçın ve Ararat (21), Chaulagain ve ark. (23), Dudde ve ark. (25) da kondil şeklinin cinsiyetler arasında farklılık gösterdiğini bildirmişlerdir. Kadın ve erkekler arasında kondil morfolojisindeki bu farklılıkların hormonal etki ve gelişim paternindeki değişikliklere bağlı olabileceği ve bu farklılıkların kraniofasiyal büyüme ve mandibula gelişimini etkileyebileceği bildirilmiştir ancak cinsiyetler arasında fark olmadığını bildiren araştırmalar da mevcuttur (2,3,6).

Kondil şeklinin yaş gruplarına göre dağılımı incelendiğinde çalışmamızda 20-29 ve 60-69 yaş aralığında en fazla yuvarlak tip kondil izlenirken diğer tüm yaş gruplarında açılı tip kondile daha fazla rastlanmıştır. Taşsoker ve ark. (22), Dudde ve ark. (25) kondil şeklinin yaşla birlikte değiştiğini, dışbükey, içbükey ve yuvarlak tip görülme oranının yaş ilerledikçe azaldığını, düz tipin ise ileri yaşlarda daha fazla görüldüğünü bildirmişlerdir. Kondildeki düzleşmenin nedeninin yaşa bağlı olarak TME'deki dejenetaif değişiklikler olabileceği ileri sürülmüştür (25).

Kemik yapısındaki değişikliklerin değerlendirilmesinde üç boyutlu görüntüleme yöntemlerinin iki boyutlu röntgen görüntülerine kıyasla tartışılmaz üstünlüğü olmakla birlikte KIBT veya BT gibi yöntemler radyasyon dozlarının yüksek olması ve maliyetli olmaları nedeniyle halen günümüzde rutinde kullanılmamaktadır, bu nedenle yeterli hasta arşivi oluşturulmamış olması da kimliklendirme işlemlerinde bu yöntemlerin kullanımını sınırlandırmaktadır.

Adli tıp alanı dışında, cerrahi işlemlerde de yine ırklara özgü kondil tipini belirlemenin önemine vurgu yapan çalışmalar mevcuttur. 18 Maksillofasiyal bölgede izlenen tümörlerin büyük bir kısmının alt çenede izlenmesi nedeniyle tümör uzantıları çoğu zaman kondili de etkilemekte ve cerrahi operasyonlarda kondil protezleri gerekebilmektedir. Fonksiyonel yüksekliği sağlamak, maloklüzyon ve çenelerin hipomobilitesini önlemek amacıyla yerleştirilecek kondil protezlerinin uyumlu olması önemlidir. Farklı bir ülkede üretilen fabrikasyon protezlerin bir başka ülkedeki bireylerde kullanımı sırasında anatomik uyumlandırmada sorun oluşturabileceği gerçeğinden yola çıkılarak toplumlara özgü kondil şeklinin genel olarak belirlenmesi önemli bir konudur.

Sigmoid girinti kondil ve koronoid çıkıntı arasındaki girintiyi tanımlar ve sigmoid girintideki farklılıklar koronoid çıkıntı ve kondilin şekline bağlıdır (20,22). Araştırmamızda en fazla izlenen sigmoid girinti %51,45 yuvarlak olarak tespit edilmiş, bunu sırası ile eğimli %31,0

ve geniş %17,55 şekilleri izlemiştir. Maqbool ve ark. (19), Tassoker ve ark. (22) da çalışmamızla uyumlu olarak en fazla yuvarlak tip izlediklerini bildirirlerken, Sahithi ve ark. (2), Gupta ve Mohan (24) çalışmalarında geniş girinti tipinin, Nagaraj ve ark. (3), Kanjani ve ark. (6), Shakya ve ark. (20), Chaulagain ve ark. (23) ise eğimli tipin daha fazla görüldüğünü tespit etmişlerdir.

Diğer bazı araştırıcıların (2,3,6,19,20,24) sonuçları ile uyumlu olarak çalışmamızda sağ-sol taraf arasında sigmoid girinti şekli %73,6 simetri göstermiş ve istatistiksel olarak bir fark izlenmemiştir. Cinsiyetlerin karşılaştırılması sonucunda da araştırmamızda bir farklılık olmadığı görülmüştür. Maqbool ve ark. (19), Gupta ve Mohan (24) ise çalışmalarında sigmoid girinti şeklinin cinsiyetler arasında farklılık gösterdiğini bildirmişlerdir.

Sigmoid girinti şeklinin yaş gruplarına göre dağılımı incelendiğinde tüm yaş gruplarında en fazla yuvarlak şekil izlenmekle birlikte yaşla birlikte yuvarlak şeklin gittikçe azaldığı, geniş şeklin görülme sıklığının ise arttığı gözlenmiştir. Shakya ve ark. (20) Güney Hindistan, Dudde ve ark. (25) Alman popülasyonlarında yaptıkları çalışmalarında ileri yaşlarda izlenen temel sigmoid girinti şeklinin geniş olduğunu bildirmişlerdir. Yaşa bağlı olarak TME ve kondil başındaki fonksiyonel ve dejeneratif değişiklikler sigmoid girinti şeklinde de dolaylı olarak şekil değişikliğine neden olmaktadır.

Sonuç

Araştırmamızda mandibular kondil, koronoid çıkıntı ve sigmoid girintide farklı varyasyonlar gözlenmiştir. Her üç anatomik yapı da morfolojik olarak sağ ve sol bölgeler arasında simetrik bir dağılım gösterirken, her iki cinsin kıyaslanması sonucunda koronoid çıkıntı ve sigmoid girintide herhangi bir fark izlenmezken kondil şeklinde cinsiyetler arasında fark olduğu gözlenmiştir. Yaş grupları dikkate alındığında her üç anatomik yapıda da yaş grupları arasında morfolojik varyasyonlarda farklılıklar tespit edilmiştir. Farklı sınıflamalara ait tüm morfolojik varyasyonların her iki cinste, her yaş grubunda ve her popülasyonda izlenmesi bu anatomik yapılardaki farklılıkların yaş, cinsiyet ve ırk belirlenmesinde kriter olarak kullanılabilirliği yönündeki belirsizliklerin halen devam ettiğini düşündürmektedir. Ancak konu ile ilgili hasta sayılarının artırılarak daha geniş ve farklı ırklara sahip popülasyonlarda yapılacak radyolojik retrospektif çalışmalara ihtiyaç olduğu kanaatindeyiz.

Kaynakça

1. Zeyfoğlu Y, Hancı İH. İnsanlarda kimlik tespiti. STED 2001; 10: 375-377.

2. Sahithi D, Reddy S, Teja DVD, Koneru J, Sai Praveen KN, Sruthi R. Reveal the concealed-Morphological variations of the coronoid process, conyle and sigmoid notch in personal identification. Egypt J Forensic Sci 2016; 6: 108-113.

3. Nagaraj T, Nigam H, Santosh HN, Gogula S, Sumana CK, Sahu P. Morphological variations of the coronoid process, condyle and sigmoid notch as an adjunct in personal identification. Journal of Medicine, Radiology, Pathology & Surgery 2017; 4:1-5.

4. Okkesim A, Mısırlıoğlu M, Adışen MZ, Akyıl YY. Adli bilimlerde diş hekimliğinin yeri. ADO Klinik Bilimler Dergisi 2018; 9: 1593-1600.

5. Afşin H, Karadayı B, Büyük B. Adli dişhekimliğinin adli bilimlerdeki rolü-Bölüm 1: Felaket kurbanlarının kimliklendirilmesi ve adli olaylarda dişlerden yaş tahmini. Adli Tıp Dergisi 2014; 28: 275-286.

6. Kanjani V, Kalyani P, Patwa N, Sharma V. Morphometric variations in sigmoid notch and condyle of the mandible: A retrospective forensic digital analysis in North İndian population. Arch Med Health Sci 2020; 8: 31-34.

7. Ashwinirani SR, Suragimath G, Nayak A, Kamala KA, Sande A. Evaluation of coronoid process morphology in gender determination using orthopantomograms in Western part of Maharashtra. Int J Forensic Odontol 2017: 2: 77-79.

8. Alias A, Nor FM. Mandible in forensic anthropology. Dental Res Manag 2019; 3:1-2.

9. Gouthaman AP, Yuvaraj MF, Dev R, Sankaran PK, Begum MZ, Kumaresan M, Raghunath G. Morphological and Morphometrical study of coronoid process in human mandibles. IJPSR 2017; 8: 3881-3886.

10. Subbaramaiah M, Bajpe R, Jagannatha SR, Jayanthi KS. A study of various forms of mandibular coronoid process in determination of sex. Indian J Clin Anat Physiol 2015; 2: 199-203.

11. Lazi Al-Saedi AI, AL-Taee R, AL-Jasim NH, AL-Bakhakh. A panoramic study of the morphology of mandibular condyle in a sample of population from Basrah City. Int J Morphol 2020; 38: 1707-1712.

12. Hegde S, Praveen BN, Shetty SR. Morphological and radiological variations of mandibular condyles in health and diseases: A systematic review. Dentistry 2013; 3: 1-5.

13. Kala M, Mukkera U, Rajasree TK, Devi Sattiraju SSS. Variation in shapes of coronoid process in human mandibles. MRIMS Journal of Health Sciences 2017; 5: 60-62.

14. Kadam SD, Roy PP, Ambali MP, Doshi MA. Variation in the shape of coronoid process in dry mandible of Maharashtra Population. Int J Anat Res 2015: 3: 895-898.

15. Kanwar R, Agrawal R. Morphological study of variation in shape of coronoid process of mandible in dry human bone in Mahakaushal region. International Journal of Medical Research and Review 2018; 6:355-359.

16. Pradhan S, Bara DP, Padra S, Nayak S, Mohapatra C. Anatomical study of various shapes of mandibular coronoid process in relation to gender and age. IOSR- JDMS 2014; 13; 09-14.

17. Quaidri A, Tanveer Ahmed Khan HS. Variations in shape of mandibular coronoid process in 200 South Indian Subjects. Int J Sci Stud 2016; 4: 159-160.

18. Wangai L, Mandela P, Butt F, Ongeti K. Morphology of the mandibular condyle in a Kenyan Population. Anatomy Journal of Africa 2013; 2: 70-79.

19. Maqbool S, Wani BA, Chalkoo AH, Sharma P. Morphological assessment of variations of condylar head and sigmoid notch on orthopantomograms of Kashmir population. Int J Recent Sci Res 2018; 9: 29162-29165.

20. Shakya S, Ongole R, Nagraj SK. Morphology of coronoid process and sigmoid notch in orthopantomograms of South Indian Population. World J Dent 2013: 4: 1-3.

21. Yalcin ED, Ararat E. Cone-Beam Computed Tomography study of mandibular condylar morphology. J Craniofac Surg 2019: 30: 2621-2624.

22. Tassoker M, Kabakci ADA, Akin D, Sener S. Evaluation of mandibular notch, coronoid process, and mandibular condyle configurations with cone beam computed tomography. Biomed Res 2017; 28: 8327-8335.

23. Chaulagain R, Chaudhary S, Poudel P, Gautam A. Morphological variation of coronoid process, sigmoid notch, and condylar process among patients of tertiary care centre of Nepal. JKMC 2022; 11:169-172.

24. Gupta KK, Mohan V. Radiomorphological variations of the coronoid process, condyle and sigmoid notch according to age, gender and dentition. J Pierre Fauchard Acad 2024; 38:1-8.

25. Dudde F, Giese M, Schuck O, Duda S, Krüger C. Panoramic radiographic analysis of age- and sex-related variations in upper mandibular morphology: focus on the condyle, sigmoid notch, and coronoid process. In vivo 2025;39.1:311-317.

Volume 5 / Issue 1 / July 2025

Research Article

Maxillofacial Radiology Report Expectations

Nihal Yetimoğlu Özdil[1*], Candan Semra Paksoy[2]

[1]İstanbul Yeni Yuzyıl University, Faculty of Dentistry, Maxillofacial Radiology Department, Istanbul, Turkey.
[2]Ankara University, Faculty of Dentistry, Maxillofacial Radiology Department, Ankara, Turkey.

*Corresponding author: nihal.yetimoglu@yeniyuzyil.edu.tr

Özdil, Nihal Yetimoğlu., Paksoy, Candan Semra. "Maxillofacial Radiology Report Expectations". *Acta Stomatologica Cappadocia.* 5;1 (July 2025): 23-34.

DOI: https://doi.org/10.54995/ASC.5.1.2
Received: 27.03.2025; Accepted: 28.05.2025

Maxillofacial Radiology Report Expectations

Nihal Yetimoğlu Özdil, Candan Semra Paksoy

Abstract

İntroduction: In dentistry, multiple imaging methods are used for diagnosis and treatment planning.

Objective: The aim of this study is to determine the expectations and preferences of final-year dental students, dentists, and dental specialists regarding the style and content of maxillofacial radiology reports in order to improve the quality of such reports.

Method: A multiple-choice survey consisting of nine questions has been prepared. A total of 168 general dentists and specialists working in university hospitals or state hospitals were divided into six groups based on whether they were specialists, final-year dental students, or clinicians and their work experience. The survey was administered to participants through face-to-face interviews. The results were analyzed for each group using Pearson's chi-square test and Fisher's exact test.

Results: Except for the third and ninth questions related to the identification of image artifacts and measurements on images for implant planning, no statistically significant differences were found between the six groups. Clinicians with at least 10 years of experience preferred more detailed radiological reports regarding image artifacts ($p<0.05$). Dentists with less than 10 years of experience preferred printed measurements on images for implant planning ($p<0.05$). There were also differences in the preferred imaging techniques that should be reported.

Conclusion: It has been determined that dentists and specialists prefer detailed, standardized radiology reports that include clinical information (especially localization, internal structure, lesion size, and relationship to anatomical landmarks), technical information, findings, conclusions, and recommendations for further imaging techniques. This study has provided important data for maxillofacial radiologists to write more effective reports.

Keywords: Maxillofacial radiology, report, standardization.

Introduction

By offering a comprehensive and unambiguous framework, standardized radiology reporting seeks to increase patient safety and accuracy. The radiology community's increasing focus on structured reporting, which is acknowledged globally, draws inspiration from research in other fields [1]. Referring clinicians may rate a specific aspect of the radiology workflow as low performing, but their overall satisfaction with radiology depends more on other aspects of the workflow, so it's critical to understand how each component of the radiology process map affects clinicians' overall satisfaction. The radiologist reports pertinent information about the image created and supports decision-making during the diagnosis, treatment, and communication processes. To solve complicated issues in the health care sciences, teamwork and shared methods are needed to find the best practice, standardize it, and then disseminate it to enhance patient care (2,3).

A useful management tool for understanding how a radiology practice is operating from the viewpoint of a crucial component—the professionals who refer patients for imaging and interventions—is the referral clinician survey. The outcomes of these surveys can be used to track performance and improvement over time, as well as to identify and prioritize improvement initiatives (3).

The radiology report is generally the key point of contact between maxillofacial radiologists and other dental specialties. Maxillofacial radiology reports may contain many elements: a description of the technique, examination of the image; lesion localization, size, border structure, normal anotomical landmarks and their relations and a differential diagnosis; and recommendations for further investigations. To date few studies have examined the attitudes of referring physicians to these elements but many questions remain open. As a speciality do dentists and specialists really need a radiology report in maxillofacial radiology? Are they convinced of clinical information wil improve the quality of the report? What are their preference for the report content? What can be left out of the report and what ought to be included (4)?

In this article, we report the results of a multiple-choice questionnaire about maxillofacial radiology report expectations. The purpose of our study was to improve the quality of reports in maxillofacial radiology imaging interpretation we aimed to assess the dentists and specialists expectations and preferences in terms of radiology report style and content. We also

analyzed maxillofacial radiology report preferences due to various imaging tecniques like. panoramic, extraoral projections, cone-beam computed tomography (CBCT), magnetic resonance imaging (MRI) and ultrasonography (USG).

Materials and Methods

After ethical approvel has taken from Ankara University Faculty of Dentistry Ethical Committee the questionnaire was applied to participants by face-to-face interview. A multiple-choice questionnaire, containing 9 questions, was formed. In the first section, participants were asked to enter demographic data. The second section consisted of 9 questions about the radiology report, for which participants were asked to indicate their preference. One-hundred and sixtyeight dentists and specialists, working either in a university hospital or a public hospital, were allocated into 6 groups according to be a speacialist or not, be a dentistry student or a clinician and work experience. Statistical analysis was performed by using SPSS 15.0 for Windows (SPSS, Chicago, Ill). Results were analyzed for each group using Pearson chi-square test and Fisher's exact test. P-value < 0.05 was considered as statistically significant.

A multiple-choice questionnaire, containing nine questions, was formed. The questionnaire was as follow;

Which imaging technique must be reported? (you can choose more than one technique): periapical radiography, occlusal radiography panoramic, extra-oral projections (cephalograms, TMJ projections), CBCT, MRI, and USG.

Do you give clinical information to radiologists when you refer a patient for imaging? Yes /No.

Which information must a radiology report contain? Anatomic landmarks, imaging artifacts, and all anomalies in the field of view.

What do you want to know about the lesion in the image? Location, size, border structure, internal structure, relationship with the anatomic landmarks, and differential diagnosis.

Must the artifacts or anatomic landmarks that seem like lesions be reported? Yes/No

Must the border of the lesion marked on the image? Yes/No

Must the probable diagnosis written in the report? Yes/No

Must the recommended imaging technique written in the report? Yes/No

For implant planning, measurements must be marked on the image in the report; there is no need to measure. Let the clinician do it himself.

We also asked participants about their years of experience and specialty.

One-hundred and sixty-eight dentists and specialists, working either in a university hospital or a public hospital, were allocated into six groups according to be a specialist or not, a dentistry student or a clinician, and work experience. Among the participants, the mean age was 25 (22-63) years, and the mean year of experience was seven (1-40) years. The questionnaire was applied to participants through face-to-face interviews. The statistical packet for SPSS (version 11.5) was used for statistical evaluation. Results were analyzed for each group using the Pearson chi-square test and Fisher's exact test. A p-value < 0.05 was considered statistically significant.

Results

One hundred and sixty-eight participants (52 male and 116 female) took the survey. The age range varied from 22-to-63 (mean 25) years, and years of occupational experience varied from 1-40 (mean 7) years. The number of participants who had under 10 years of experience was 54 (58.1%), and more than 10 years of experience was 39 (41.9%). Seventy-eight of the participants were specialist dentists, and 90 of the participants were dentists. Seventy-one participants were working at a university hospital, 18 were at public hospitals, one was at a private clinic, three were at a private hospital, and 75 were undergraduate dental students last year Table 1.

The questionnaire consisted of periapical radiography, occlusal radiography, panoramic radiography, extraoral techniques, cone beam computed tomography(CBCT), magnetic resonance imaging (MRI), and ultrasonography (US). Periapical radiography reporting preferences were significantly higher in participants who had under 10 years of occupational experience, undergraduate dental students, and dentists ($p<0.05$). There was no significant difference in occlusal radiography reporting among the three groups ($p>0.05$). 70.2% of the participants did not want occlusal radiographs to be reported. Panoramic radiography reporting preferences were also significantly higher in undergraduate dental students than postgraduates

and in dentists than specialist dentists ($p<0.05$). There were no significant differences between the six groups in reporting the extraoral techniques ($p>0.05$); they preferred the extraoral techniques to be reported. There were significant differences in CBCT reporting preference. CBCT report preference was higher in dentists specialist dentists ($p<0.05$). 88.7% of the participants preferred CBCT reported. There were no significant differences found between the groups about reporting MRI and US ($p>0.05$). Participants preferred MRI and US to be reported Table 2.

There were no significant differences found between the groups in giving clinical information ($p>0.05$). 67.9% of the participants declared that they gave clinical information before prescribing radiographic imaging.

When the participants were asked about the prescribing anatomic landmarks, imaging artifacts, and all anomalies in the field of view, clinicians with at least 10 years of experience preferred radiological reports more detailed about image artifacts ($p<0.05$). There were no significant differences found between the groups regarding prescribing anatomic landmarks and anomalies in the field of view ($p>0.05$). The participants preferred a detailed report about anatomic landmarks and anomalies in the field of view Table 3.

Questions four to seven addressed the types of content that would be preferred in a maxillofacial radiology report. Most of the participants who had under 10 years of occupational experience expected to know about the localization of the lesion 81.5%, lesion size 85.2%, border structure 81.5%, internal structure 68.5%, relationship with the anatomic landmarks 85.2% and differential diagnosis 61.1%. Dentists who had at least 10 years of occupational experience also preferred the localization of the lesion at 94.9%, lesion size at 97.4%, border structure at 87.2%, internal structure at 79.5%, relationship with the anatomic landmarks at 97.4% and differential diagnosis at 71.8%. There were no significant differences found between the groups regarding prescribing localization, size, border structure, internal structure, relationship with the anatomic landmarks, and the differential diagnosis of the lesion ($p>0.05$). Table 4.

Dentists who had experienced under 10 years preferred measurements printed in the report ($p<0.05$).

No statistically significant difference was found among the six groups except for the third and ninth questions, which were about the determination of the image artifacts and making measurements on the images for implant planning. Clinicians with at least 10 years of experience preferred radiological reports more detailed about image artifacts ($p<0.05$). Dentists who had experience under 10 years preferred measurements printed on the images for implant planning ($p<0.05$). There were also differences in the imaging technique preferences that should be reported. It has been determined that dentists and specialists preferred detailed, standardized radiological reports with clinical information (esp. localization, internal structure, size of the lesions, and relation with the anatomical landmarks), technique information, findings, conclusion, and recommendations for further imaging techniques. There were also differences between dentistry students and dentists. Dentists' preference reporting panoramic, CBCT, and USG significantly ($p<0.05$) more than dentistry students. In spite of dentists, dentistry undergraduate students preferred to give clinical information to radiologists ($p<0.05$).

Discussion

The ability of radiologists to evaluate examination images, identify normal and abnormal findings, incorporate these findings into their own medical knowledge base, arrive at a diagnosis or correctly ranked differential diagnosis, and sometimes recommend additional diagnostic tests is defined as radiological reporting. When imaging methods were examined individually, dentists with less than 10 years of experience participating in our study preferred to report panoramic radiography images (44.4%). This result suggests that more focus should be placed on this topic in the undergraduate education program. Dentists in both groups believe that CBCT, MRI, and ultrasound images should be reported. This result demonstrates that advanced imaging techniques are recognized as a specialty in maxillofacial radiology.

When asked what a radiology report should include, most participants stated that the report should indicate typical anatomical structures. This result suggests that undergraduate education should focus on the radiological appearance of normal anatomical structures (5, 6).

On the other hand, the technical details of the images taken can affect image quality. Therefore, including information such as the kVp, mA, and second values at which the image was obtained, the focal spot size of the device, the contrast and spatial resolution of the detec-

tor used, the pixel/voxel size, and any artifacts present in the image in the report will contribute to a more accurate interpretation of radiological images. While all participants expected artifacts to be written in the report, there was a statistically significant difference between those who thought that artifacts should not be included in the report ($p<0.05$). We accept that this difference may be due to misinterpretation of exposure parameters, focal spot size, and artifacts originating from detector characteristics.

There is no significant difference between the two groups in reporting anomalies in the imaging area ($p>0.05$); both groups believe that anomalies should be reported. When it comes to the localization of anomalies, their border structure, internal structure, relationship with anatomical formations, and differential diagnosis, there is no significant difference between the two groups ($p>0.05$), and both groups believe that this information about anomalies should be included in the report. In contrast to Selim et al., we found that dentists with more than 10 years of experience wanted slightly more detailed reports (7).

When asked about the measurements to be taken for implant planning, all participants preferred to view the measurements on the image, while physicians with less than 10 years of experience requested that the measurements also be included in the report. Most participants stated that they did not prefer to perform the measurements themselves. This preference also suggests that participants are aware of and recognize the competence of maxillofacial radiology specialists.

Dental imaging is a standard part of radiology applications as a targeted examination during the detection of other problems or in patients with dental or oral trauma. Although oral hygiene has improved and preventive measures have been taken in dentistry in recent years, resulting in improved dental health among the population, diseases of the teeth and supporting structures continue to significantly affect and limit the quality of life of affected patients. Early diagnosis of these diseases is also an important task for radiologists (8). The structural characteristics and details of the reports prepared for this purpose assist in making accurate diagnoses, preventing unnecessary treatments, and preventing potential legal disputes. In our country, the Oral Diagnosis and Maxillofacial Radiology Association (ODMFR) has prepared "Standard Radiology Reporting Forms" to ensure that diagnostic processes are carried out in a more effective, standardized, and reliable manner.

Conclusion

This study provided essential data for maxillofacial radiologists to write more effective reports. McLoughlin et al. concluded in 1994 that "The value of radiologists will depend on how much other people value us. We must be ever vigilant in assessing and responding to the needs of other physicians (9)" It is important that maxillofacial radiology reports contain information desired by referring physicians in a format preferred by them. Clinicians requested detailed reports about the lesion size, border structure, internal structure, relationship with the anatomic landmarks, and the differential diagnosis.

Table 1. Demographic profile of participants

	n	**%**
Male	52	31
Female	116	69
Working experience < 10 years	54	58.1
Working experience >10 years	39	41.9
Place of work		
Dental last year student	75	44.6
Private practice	1	0.6
Policlinic	3	1.8
Public hospital	18	10.7
University hospital	71	42.3
Situation		
Student	75	44.6
Dentist	93	55.4
Specialist	78	46.4
Not specialist	90	53.6

Table 2. Imaging methods to be reported

	≤10 years		>10 years		
Which imaging tecnique must be reported?	n	%	n	%	p*
Periapical radiography					
Yes	16	29.6	2	5.1	0.003
No	38	70.4	37	94.9	
Occlusal radiography					
Yes	17	31.5	6	15.4	0.076
No	37	68.5	33	84.6	
Panoramic radiography					
Yes	24	44.4	11	28.2	0.111
No	30	55.6	28	71.8	
CBCT					
Yes	50	92.6	39	100	0.136
No	4	7.4	0	0	
Ultrasonography					
Yes	43	79.6	36	92.3	0.092
No	11	20.4	3	7.7	

Table 3. Content of the radiology report

	≤ 10 years		**> 10 years**		
Report Content	n	%	n	%	p*
Anatomical landmarks					
Yes	34	63	22	56.4	0.366
No	20	37	17	43.6	
İmaging artefacts					
Yes	33	61.1	33	66.7	**0.014**
No	21	38.9	6	15.4	
Abnormalities on FOV					
Yes	51	94.4	38	97.4	0.637
No	3	5.6	1	2.6	

Table 4. Expectations from the radiology report regarding pathological lesions

	≤ 10 years		**> 10 years**		
İnformation about the lesion	n	%	n	%	p*
Localization					
Yes	44	81.5	37	94.9	
No	10	18.5	2	5.1	0.057
Size					
Yes	46	85.2	38	97.4	
No	8	14.8	1	2.6	0.074
Border structure					
Yes	44	81.5	34	87.2	
No	10	18.5	5	12.8	0.461
Internal structure					
Yes	37	68.5	31	79.5	
No	17	31.5	8	20.5	0.239
Relationship with the anatomic land-marks					
Yes	46	85.2	38	97.4	0.074
No	8	14.5	1	2.6	
Differential diagnosis					
Yes	33	61.1	28	71.8	
No	21	38.9	11	28.2	0.285

Table 5. Expectations for radiology images and reports in implant treatments

	≤ 10 years		**> 10 years**		
For implant planning measure-ments must…	n	%	n	%	p*
On the image					
Yes	41	75.9	28	71.8	
No	13	24.1	11	28.2	0.653
In the report					
Yes	39	72.2	13	33.3	
No	15	27.8	26	66.7	0.000
Let the clinician measure himself					
Yes	5	9.3	6	15.4	
No	49	90.7	33	84.6	0.367

References

1. Powell DK, Lin E, Silberzweig JE, Kagetsu NJ. Introducing Radiology Report Checklists among Residents. Academic Radiology [Internet]. 2014. Feb; 6:21(3):415–423. Available from: https://doi.org/10.1016/j.acra.2013.12.004
2. Haas BM, Zhang L, Nichols H, Orwig N, Hess CP, Kolli KP. What referring clinicians value most: Accuracy of radiology results and personal interactions with radiologists. Clinical Imaging [Internet]. 2023. Feb;15:97:72–7. Available from: https://doi.org/10.1016/j.clinimag.2023.02.006
3. Rocha DM,Brasil LM,Lamas JM,Luz GVS,Bacelar SS.Evidence of the benefits, advantages and potentialities of the structured radiological report: An integrative review. Artif Intell Med. 2020. Jan;102:101770. doi: 10.1016/j.artmed.2019.101770. Epub 2019 Nov 25. PMID: 31980107.
4. Marcovici P. Structured radiology reports are more complete and more effective than unstructured reports. American Journal of Roentgenology. 2014.Dec;203(6):1265-71. doi: 10.2214/AJR.14.12636. PMID: 25415704.
5. Pesapane F. et al. How scientific mobility can help current and future radiology research: a radiology trainee's perspective. Insights Into Imaging [Internet]. 2019.Aug;27;10(1). Available from: https://doi.org/10.1186/s13244-019-0773-z
6. McNab, Scott, et al. Knowledge of undergraduate and graduate dentists and dental therapists concerning panoramic radiographs: knowledge of panoramic radiographs. Open Journal of Dentistry and Oral Medicine 2015.Feb;3; 46-52.
7. Selim D, Sexton C, Monsour P. Dentomaxillofacial radiology in Australia and dentist satisfaction with radiology reports. Australian Dental Journal [Internet]. 2018. Jul; 2;63(4):402–13. Available from: https://doi.org/10.1111/adj.12642
8. Masthoff M, Gerwing M, Masthoff M, Timme M, Kleinheinz J, Berninger M, et al. Dental Imaging – A basic guide for the radiologist. RöFo - Fortschritte Auf Dem Gebiet Der Röntgenstrahlen Und Der Bildgebenden Verfahren [Internet]. 2018. Jun; 18;191(03):192–8. Available from: https://doi.org/10.1055/a-0636-4129
9. McLoughlin RF, So CB, Gray RR, Brandt R. Radiology reports: how much descriptive detail is enough? American Journal of Roentgenology [Internet]. 1995. Oct; 1;165(4):803–6. Available from: https://doi.org/10.2214/ajr.165.4.7676970

Volume 5 / Issue 1 / July 2025

Case Report

Restoration of Endodontically Treated Teeth With Bundle Fiber Post; Two Case Series

Elif Yıldız[1*], Emre Bodrumlu[1]

[1]Zonguldak Bulent Ecevit University, Faculty of Dentistry, Department of Endodontics, Zonguldak, Turkey

*Corresponding author: elif.yldz.99@gmail.com

Bodrumlu, Emre., Yıldız, Elif. "Restoration of Endodontically Treated Teeth With Bundle Fiber Post; Two Case Series". *Acta Stomatologica Cappadocia.* 5;1 (July 2025): 35-44.

DOI: https://doi.org/10.54995/ASC.5.1.3
Received: 23.01.2025; Accepted: 13.05.2025

Restoration of Endodontically Treated Teeth With Bundle Fiber Post; Two Case Series

Elif Yıldız, Emre Bodrumlu

Abstract

Objective: Bundle fiber post and direct composite resin application is one of the preferred methods in conservative dentistry in root canal treated teeth with excessive material loss. The aim of this case series is to describe the restoration and function of maxillary central incisor and premolar teeth with bundle fiber post and composite resin application.

Case Reports: Excessive loss of material was detected in the maxillary central and premolar teeth of two patients who presented to our clinic with the complaint of fracture of old restorations. Radiographs obtained from the patients did not show any lesion on the root tip and surrounding tissues. After root canal treatment, a bundle fiber post was placed and a core structure was formed with composite resin. Patients were referred to the prosthesis department for the superstructures of the teeth with post core restoration.

Conclusion: Successful results are obtained with the application of bundle fiber post systems to support the remaining root structure and restore excessive material loss.

Keywords: Bundle fiber post, Core structure, Root canal treatment, Case reports.

Introduction

Endodontically treated teeth that show coronal structure damage and have undergone extensive restorations are usually restored with post and core, followed by prosthetic crown restoration (1,2). Among the various techniques, posts and materials reported in the literature for cementation and cortex construction, cast post and cortex are traditionally used due to their high mechanical strength and compatibility with the root canal (3,4). Furthermore, in teeth restored with such systems, oblique/horizontal fractures in the middle third and vertical root

fractures due to increased stress accumulation in the apical region of the post can be seen more frequently (5,6).

Fiber posts are frequently used in the repair of teeth with excessive material loss. Fiber posts are preferred because they are aesthetically compatible with the tooth colour of the patients, biocompatible, less likely to break and damage the tooth structure compared to metal posts, elastic modulus similar to dentin, and bonding properties to the tooth and composite. An ideal core and post increase the biomechanical stability of the abutment tooth, prevent dentin attachment and root fracture or abutment fracture (7). For this reason, fiber posts, especially bundled fiber posts, have been used as an alternative in recent years (8). The bundle post manufacturer reports that bundle posts, evenly distributed over the entire structure of the post and core restoration, provide better fracture resistance than fiber posts and a stronger foundation for a conventional crown or veneer. The developing bundle fiber post is based on the principle that no additional preparation is required to prevent further weakening of the tooth structure. It adapts to the existing anatomical shape of the root canal. In this way, the compatibility between the post and the canal wall increases and this allows the thickness of the cement layer to be reduced. Reduced cement thickness reduces the risk of microleakage by providing a more homogeneous adhesion on the bonding surfaces and positively affects the long-term success of the restoration (9,10). In addition, fiber posts, whose modulus of elasticity is similar to that of dentin, provide a more balanced distribution of stress to the root structure, which is considered to be an important factor in reducing the risk of root fracture.

Especially in irregular or oval shaped root canals, these new generation post systems stand out as effective methods that increase both the biomechanical and clinical success of restorative treatment.

The bundle of fiber posts consists of a package of varying numbers of thin individual posts. After removal of the sheath, the bundle is spread and the thin individual posts are distributed over the entire root canal. The post adapts to all kinds of root canal morphology. In addition, the translucency of the material increases aesthetics (11).

This case series describes the restoration of teeth with excessive loss of material with a bundle fibre post and composite core to create a suitable abutment.

Case Reports

Case 1: A 24-year-old female patient was admitted to Zonguldak Bülent Ecevit University Faculty of Dentistry with the complaint of fracture of her upper anterior teeth. The patient's anamnesis revealed that she did not have any systemic disease. Periapical radiographs showed no lesions in the apex and surrounding tissues. It was not possible to isolate the teeth with excessive material loss with rubber dam. Retractors and cotton rolls were used for isolation. After the clinical and radiographic evaluation was completed, root canal treatment was performed, a post cavity was created with a number three Gates glidden drill, maintaining a 7 mm apical seal, and 2/3 of the gutta percha was removed from the canal. After the post cavity was created, the canals were acid treated for 20 s and irrigated with distilled water, dried with a paper point (Dentsply Maillefer, Tulsa, OK). A homogeneous mixture of Biolight Bond DC Part A and Part B (Medicaux, France) was applied to slightly wet root canal walls with a brush for 15 s and polymerised with air and light for 20 s. The appropriate size Biolight Bundle Fiber Post (Medicaux, France) was selected. The length of the post was determined and confirmed using a radiograph. Bonding of the canal and post was performed by coating the canal and post using the self-etch dual cure adhesive cement Biolight Core DC (Medicaux, France). The post was then inserted into the canal and the sheath was removed. The bundled fibres were spread using a spreader and polymerised by direct light.

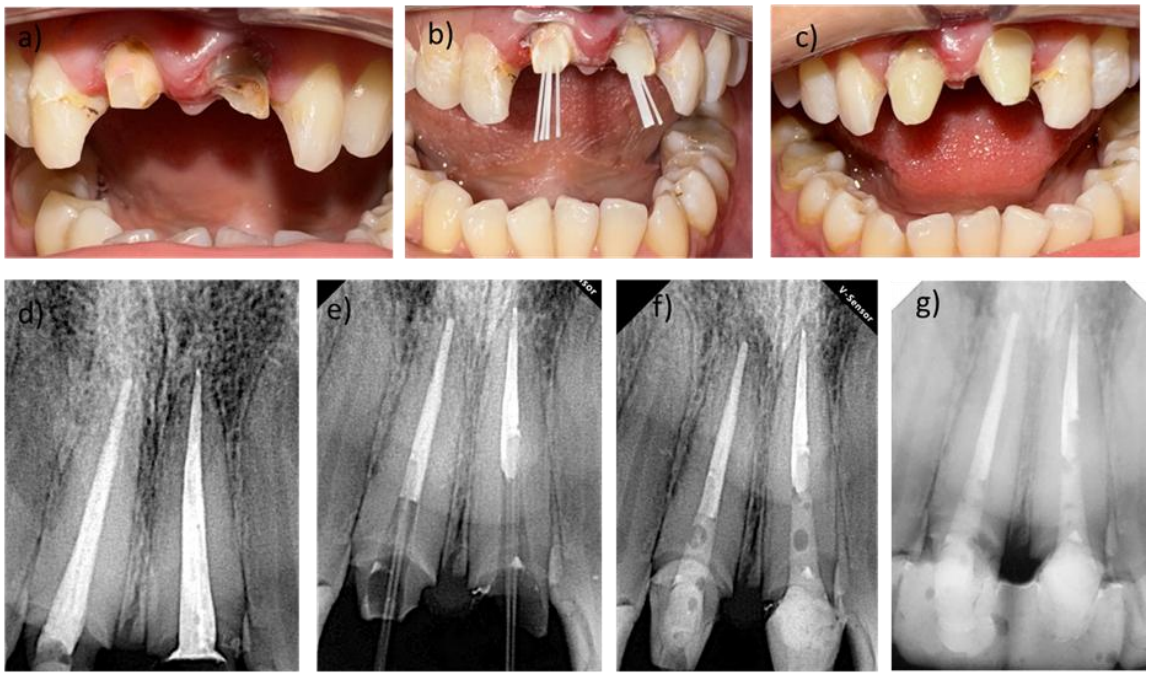


Figure 1: Visual of case 1, a) Initial intraoral view, b) Intraoral view with bundle post inserted, c) Intraoral view of the core structure, d) Radiograph after root canal treatment, e) Bundle post control radiograph, f) Post-core restoration radiograph, g) 3-months follow-up radiograph

The extra length was cut and then the core was formed by successive addition of composite resin (Tokuyama Estelite, Japan). In the 3-month follow-up, clinical and radiological examination revealed no problems (Figures 1 and 2).

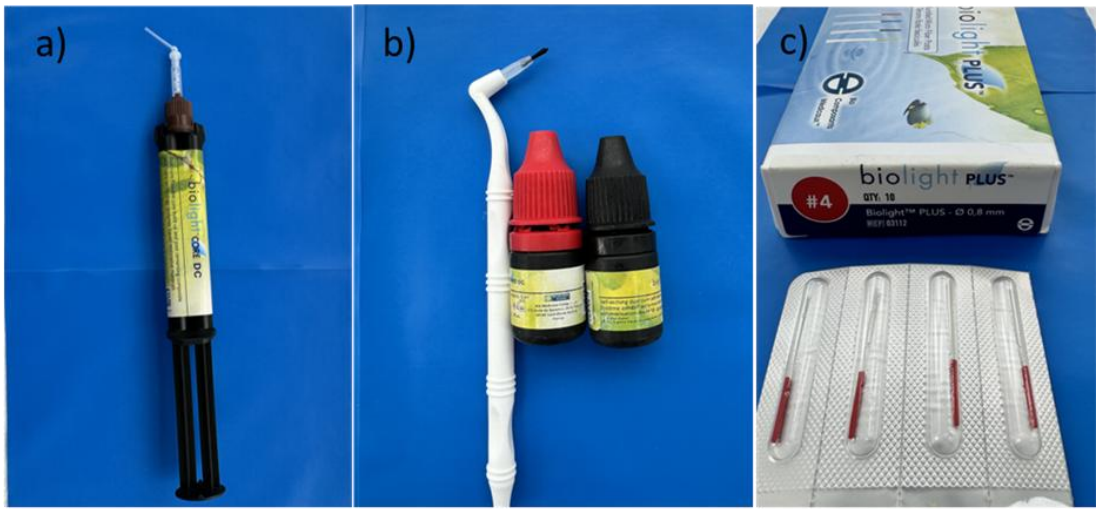


Figure 2: Bundle post sytsem, a) Biolight Core DC , b) Biolight Bond, c) Bundle fiber post

Case 2: A 27-year-old female patient came to Zonguldak Bülent Ecevit University Faculty of Dentistry with the complaint of a fracture in her upper right first premolar tooth. The patient's anamnesis revealed that she was systemically healthy. It was not possible to isolate the teeth with excessive material loss with rubber dam. Retractors and cotton rolls were used for isolation. After the clinical and radiographic evaluation was completed, root canal treatment was performed, a post cavity was created with a number three Gates glidden drill, maintaining a 7 mm apical seal, and 2/3 of the gutta percha was removed from the canal. After the post cavity was created, the canals were acid treated for 20 s and irrigated with distilled water, dried with a paper point (Dentsply Maillefer, Tulsa, OK). A homogeneous mixture of Biolight Bond DC Part A and Part B (Medicaux, France) was applied to slightly wet root canal walls with a brush for 15 s and polymerised with air and light for 20 s. The appropriate size Biolight Bundle Fiber Post (Medicaux, France) was selected. The length of the post was determined and confirmed using a radiograph. Bonding of the canal and post was performed by coating the canal and post using the self-etch dual cure adhesive cement Biolight Core DC (Medicaux, France). The post was then placed in the canal and the sheath was removed. The bundled fibres were spread using a spreader and polymerised by direct light. The extra length

was cut and then core formed with composite resin (Tokuyama Estelite, Japan). In the 3-month follow-up, clinical and radiological examination revealed no problems (Figure 3).

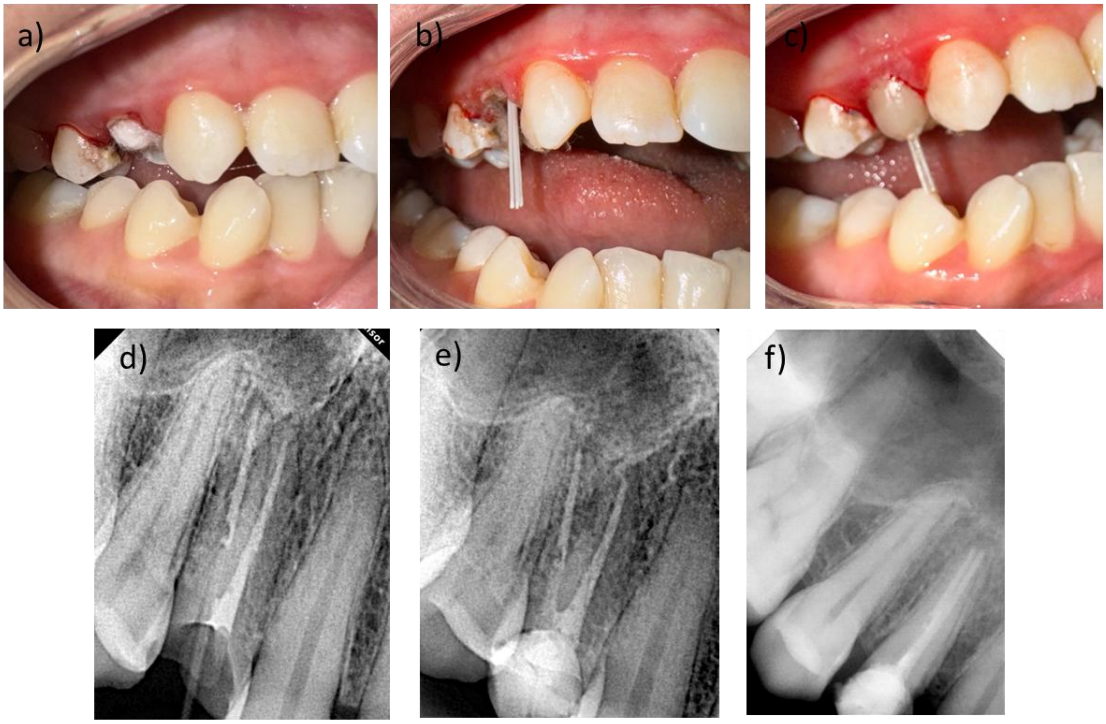


Figure 3: Visual of case 2, a) Initial intraoral view, b) Bundle post intraoral view, c) Core structure intraoral view, d) Bundle post control radiograph, e) Post-core restoration radiograph, f) 3-months follow-up radiograph

Discussion

The clinical success rate of fiber posts is evaluated in longitudinal studies. Fiber posts are preferred in cases where a metal post may compromise aesthetic results. Furthermore, the fracture resistance of fiber posts against the risk of root fracture in an endodontically treated tooth is higher than that of metal posts, because fiber posts have similar physical properties to dentin, especially in terms of modulus of elasticity. Physical properties, aesthetic factor, root and restoration fracture risk, adhesion, radiopacity, biocompatibility, chemical stability and many other aspects show many additional advantages over conventional post systems (12).

The main problem encountered when using the prefabricated post system is to compromise the remaining root dentin thickness in order to open the post cavity to place the post in the root canal. Therefore, the durability of the tooth may be threatened. In their in vitro study, Eric et al (13). concluded that intra-canal preparation up to a size 5.0 milling cutter increases the risk of perforation or root weakening in the buccal and palatal directions, especially

at the apical level. Fiber posts are used to hold the coronal segment and reduce the stress on the two separate parts and minimise the stress on the remaining tooth structure (14). A new concept, the bundle fiber post, is a strip of multiple small and flexible posts that are spread across the canal cavity and can be adjusted to adapt to any root canal configuration. For this reason, this post can be used in elliptical or curved root canal conditions (15).

Bundle fiber posts, a new concept, are multiple small and flexible post strips that are spread into the canal cavity. The manufacturer reports that bundle posts increase fracture resistance by homogeneously distributing the stress on the post core restoration. The use of the bundle post system has the advantage that they conform to the canal morphology, thus minimising the loss of residual dentin thickness to achieve the conformity that leads to conservative root preparation for the post.

In a study by Hedge et al. (16) in which bundle fiber posts were compared with other post systems, it was found that bundle fiber posts showed more resistance to both vertical and oblique loads. Bundle fiber posts can be used to strengthen the weakened tooth, especially in cases with large canal spaces. This is because the individual fibres spread out and adapt to the canal morphology, filling and strengthening the canal cavity well. The results of a study revealed a significant increase in the fracture resistance of endodontically treated teeth restored with bundle fiber posts compared to a single wider post. The results were similar at different load angles in the posterior and anterior regions. In the canine region, the fracture resistance of teeth restored with bundle fiber posts was 1843.80 N, while this value was 1623.98 N in the single fiber post group. A similar trend was also observed with the metal post, corresponding to values of 1493.17N and 1648.99 N, respectively. Researchers have reported large differences in the stress produced and its distribution within teeth restored with intact post-cor (17).

The presence of bundle posts allows the cement layer to be minimised, similar findings were also found in the study by Latempa et al. (18) and it was concluded that the bond strength to dentin could be increased by using accessory posts (19). In addition, due to the increased number of fibers, it provides better attachment to the core structure and adaptation to the canal walls. All of these together result in increased strength (20).

Due to the above-mentioned advantages of bundle posts, bundle fiber post and composite core were preferred in both of our cases. While the treatment proved successful in the

two cases that utilised bundle fiber post, further research is necessary to comprehensively assess its efficacy. Longer-term studies and a more extensive case series are required to provide a more robust evaluation of the impact of bundle fiber post and core restorations.

Conclusion

Bundle fiber posts represent a treatment option for the repair of teeth with excessive material loss, due to their adaptation to the morphology of the canal system, and their fast and straightforward application without the need for large post slots.

Conflıcts of Interest

The authors have nothing to declare.

Acknowledgement

There is nothing to declare.

Financing

No funding was used for the study.

Authors' Contributions

Concept: Star E, Design: Yıldız E, Data Collection or Processing: Yıldız E, Analysis or Interpretation: Bodrumlu E, Literature Review: Star E, Summer: Star E, Bodrum E

Ethics

Written informed consent was obtained from our patients.

References

1. Okamoto K, Ino T, Iwase N, et al. Three-dimensional finite elementanalysis of stress distribution in composite resin cores with fiber postsof varying diameters. Dent Mater J. 2008;27(1):49-55.
2. Ishikawa Y, Komada W, Inagaki T, et al. The effects of post and corematerial combination on the surface strain of the 4-unit zirconia fixedpartial denture margins. Dent Mater J. 2017;36(6):798-808.
3. Skupien JA, Sarkis-Onofre R, Cenci MS, et al. A systematic review offactors associated with the retention of glass fiber posts. Braz OralRes. 2015;29(1):1-8.
4. Soejima H, Takemoto S, Hattori M, et al. Effect of adhesive system onretention in posts comprising fiber post and core resin. Dent Mater J.2013;32(4):659-666.

5. Qing H, Zhu Z, Chao Y, Zhang WQ. In vitro evaluation of the fractureresistance of anterior endodontically treated teeth restored with glassfiber and zircon posts. J Prosthet Dent. 2007;97(2):93-98.

6. Ni CW, Chang CH, Chen TY, et al. A multiparametric evaluation ofpost-restored teeth with simulated bone loss. J Mech Behav BiomedMater. 2011;4(3):322-330.

7. Mamoun J. Post and core build-ups in crown and bridge abutments:bio-mechanical advantages and disadvantages. J Adv Prosthodont.2017;9(3):232-237

8. Zogheib LV, Pereira JR, do Valle AL, et al. Fracture resistance ofweakened roots restored with composite resin and glass fiber post.Braz Dent J. 2008;19(4):329-333

9. Desai P, Dutta K, Das UK. Comparison of push out bond strength of customizable fiber post using two self adhesive resin cement-an in-vitro study. Adv Dent Oral Health. 2016;2(1):6.

10. Amin RA, Mandour MH, El-Ghany OS. Fracture strength and nanoleakage of weakened roots reconstructed using relined glass fiber-reinforced dowels combined with a novel prefabricated core system. J Prosthodont. 2014;23(6):484-94.

11. Yanık D, Turker N. Stress distribution of a novel bundle fiber post with curved roots and oval canals. J Esthet Restor Dent, 2022; *34*(3), 550-556.

12. R Sarkis-Onofre, JA Skupien, MS Cenci RR de Moraes, T Pereira-Cenci. The Role of Resin Cement on Bond Strength of Glass-fiber Posts (GFPs) Luted Into Root Canals: A Systematic Review and Meta analysis of In Vitro Studies. Operative Dentistry · August 2013.

13. Eric et al. The impact of post preparation on the residual dentin thickness of maxillary molars. J Prosthet Dent 2011;184-90.

14. Zarow M et al. Effect of fiber posts on stress distribution of endodontically treated upper premolars: Finite element analysis. *Nanomaterials*. 2020;*10*(9), 1708.

15. Alkhalidi EF, Ahmad ZA. Bond Strength of New Fiber Post-system (Rebilda GT). Open Access Maced J Med Sci. 2022;10(D), 347-351.

16. Vibha Hegde, Nikita Arora. Fracture Resistance of Endodontically Treated Teeth Restored Using Three Different Esthetic Post Systems. J Operative Dent and Endod. (January–June 2019);Volume 4 Issue 1

17. Tuma Halabi MA, Bakry SI, Aly YM. Fracture Resıstance Of Dıfferent Fıber Post Materıals (In Vıtro Study). Alex Dent J. 2024

18. Latempa AM, Almeida SA, Nunes NF, Da Silva EM, Guimarães JG, Poskus LT. Techniques for restoring enlarged canals: An evaluation of fracture resistance and bond strength. Int Endod J. 2015;48(1):28-36.

19. Bouillaguet S, Bertossa B, Krejci I, Wataha JC, Tay FR, Pashley DH. Alternative adhesive strategies to optimize bonding to radicular dentin. J Endod. 2007;33(10):1227-30.

20. Egilmez F, Ergun G, Cekic-Nagas I, Vallittu PK, Ozcan M, Lassila LV. Effect of surface modification on the bond strength between zirconia and resin cement. J Prosthodont. 2013;22(7):529-36.

Volume 5 / Issue 1 / July 2025

Case Report

Orthodontic and Surgical Treatment of an Impacted Tooth in a Large Dentigerous Cyst

Abdullah Alper Oz[1*], Bora Ozden[2], Aslıhan Zeynep Oz[3], Burcu Bas Akkor[4]

[1]İstanbul Galata University, Faculty of Dentistry, Department of Orthodontics, İstanbul, Turkey.
[2]Private Practice, Samsun, Turkey
[3]Ondokuz Mayıs University, Faculty of Dentistry, Department of Orthodontics, Samsun, Turkey.
[4]Ondokuz Mayıs University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery.
Corresponding author: alperoz@hotmail.com

Oz, Abdullah Alper., Ozden, Bora., Oz, Aslıhan Zeynep. & Bas Akkor, Burcu. "Orthodontic and Surgical Treatment of an Impacted Tooth in a Large Dentigerous Cyst". *Acta Stomatologica Cappadocia.* 5;1 (July 2025): 45-54.

DOI: https://doi.org/10.54995/ASC.5.1.4
Received: 09.05.2025; Accepted: 24.05.2025

Orthodontic and Surgical Treatment of an Impacted Tooth in a Large Dentigerous Cyst

Abdullah Alper Öz, Bora Özden, Aslıhan Zeynep Öz, Burcu Baş Akkor

Abstract

Standard treatment of a dentigerous cyst involves enucleation of the cyst and extraction of the involved teeth. The aim of this case report was to present an alternative combined surgical and orthodontic treatment of an impacted mandibular premolar within a large dentigerous cyst. An 11-year-old female patient was referred to the orthodontic clinic due to a swelling of the left lower jaw. Radiographic evaluation revealed a large dentigerous cyst with an impacted premolar. A CBCT scan showed a radiolucency in close proximity to the roots of the adjacent teeth. In the initial stage of treatment, the cyst was marsupialized. Spontaneous eruption of the impacted tooth was observed following decompression of the cyst, and orthodontic treatment was used to bring the impacted tooth into a proper occlusion. Total surgical and orthodontic treatment time was 19 months. Class I canine and molar occlusion with complete permanent dentition was achieved through combined surgical and orthodontic treatment. No recurrence was observed, and the position of the mandibular premolar was judged successful. Marsupialization of a dentigerous cyst and orthodontic traction may be an appropriate alternative method for treating impacted teeth in young patients with no tooth resorption.

Keywords: Dentigerous cyst, impacted tooth, orthodontic treatment.

Introduction

A dentigerous cyst is an odontogenic cyst of unknown pathogenesis (1) that contains an unerupted tooth crown within its borders (2) and generally inhibits the eruption of the involved permanent tooth. Dentigerous cysts have been observed in preadolescents during tooth development. After radicular cysts, dentigerous cysts are the most common developmental cysts of the jaws, accounting for 14%-20% of all jaw cysts (3). While they are most often located in proximity to the mandibular third molars or maxillary canines (4), dentigerous cysts are also frequently encountered in the mandibular premolar region (5).

Dentigerous cysts are usually asymptomatic and discovered during routine radiographic examination. Sometimes the cysts are identified during radiographic evaluation when a patient is referred to an orthodontist due to failure of eruption following eruption of the symmetric tooth. In such patients, treatment usually involves removal of the entire cyst and associated teeth; however, extraction of these teeth can be difficult, as they may have been displaced due to pressure from the cyst (5). Another treatment approach that protects the associated teeth is marsupialization, which causes the cyst to gradually decrease in size, leading to a change in tooth angulation and direction that helps to accelerate eruption (6). One study reported that 81% of impacted mandibular premolars spontaneously erupted approximately 100 days after marsupialization (5), while another study reported spontaneous eruption of the impacted premolar to be related to cyst position, jaw angulation and patient age (7).

This case report presents a large dentigerous cyst with an impacted mandibular premolar treated using a combined surgical and orthodontic approach.

Case Presentation

A female patient aged 11 years and 2 months was referred to the Ondokuz Mayıs University Faculty of Dentistry for a consultation on a swelling in the area of the left mandible. The patient was physically healthy with no systemic diseases. Extra-oral examination revealed a slight expansion, but the patient reported no pain or sensitivity in the associated tissue. Intra-oral clinical examination showed the patient to be in mixed dentition with all second deciduous molars present in the dental arches. Radiographic evaluation showed a large cyst with an impacted and displaced tooth (Fig.1). Clinical and radiographic evaluation also showed the patient to have a Class II, Division I malocclusion with an increased overjet and overbite.

Figure 1. Panoramic radiograph showing well-defined radiolucent lesion with left second premolar which was placed in the lesion. The root apex of the impacted tooth is open.

A CBCT scan was taken to identify the borders of the cyst and its proximity to the adjacent teeth roots (Fig. 2). While no root resorption was observed, the cyst had expanded to the lateral border of the mandible (Fig. 3).

Figure 2. A CBCT record showed the border of the cyst and relation of the cyst border with the adjacent teeth. There were no root resorption areas on the roots

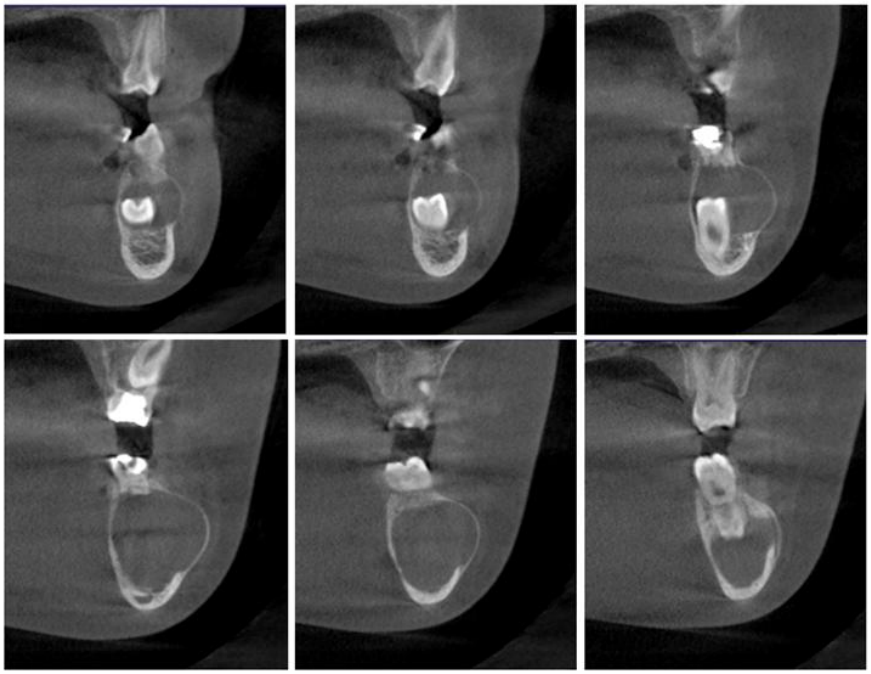


Figure 3. The cyst made an expansion on the lateral border of mandible.

Based on clinical and radiographic examinations, it was determined that treatment objectives should include obtaining healthy bone-formation in the area of the left mandible and correcting the Class II skeletal malocclusion to achieve a proper overbite and overjet relationship with good occlusion and vertical facial proportions.

Two surgical treatment alternatives were considered and discussed with the patient and her parents, as follow: (1) Standard treatment for a dentigerous cyst, with enucleation and extraction of the associated impacted and displaced tooth; or (2) Extraction of the deciduous tooth, suppression of the cyst through marsupialization, and spontaneous eruption of the impacted and displaced tooth.

Orthodontic treatment was suggested in connection with both surgical alternatives, with functional treatment to correct the skeletal discrepancy and close the extraction space suggested in the first case, and fixed orthodontic mechanics to move the mandibular premolar into the proper position as well as functional treatment of the skeletal Class II malocclusion in the second case.

In consultation with the patient's parents, who provided their written consent prior to treatment the second treatment alternative was selected, given the patient's age and the possibility of spontaneous eruption of the impacted premolar.

Marsupialization was performed by excising the overlying mucosa and opening an appropriately sized window into the cystic cavity under local anesthesia. Next, the mandibular left deciduous second molar was extracted, also under local anesthesia. The biopsy material was also taken from the cyst epithelium. The cavity was kept open by suturing a short piece of tubing from a dental syringe, and the patient was instructed to irrigate the cyst cavity 3-4 times a day, especially after meals, to prevent food accumulation and closure of the fistula. The patient was also prescribed antibiotics and analgesics before being discharged. Pathological examination revealed a dentigerous cyst.

Follow-up examinations were conducted after 1 week, 1 month (Fig. 4A) and 2 months (Fig. 4B). After 1 week, eruption of the premolar was observed to have begun, but to have stopped due to obstruction by the alveolar bone ledge. Therefore, a removable appliance was designed to erupt the tooth. A metal button with a hook constructed from ligature wire was bonded to the enamel surface of the impacted premolar, and intra-oral 3/16" lumen elastics were used to attach the button to the appliance, which the patient was advised to wear at all times. The force level of the intra-oral elastics was checked at monthly intervals. At the end of the first phase of orthodontic treatment (2-month follow up), the impacted premolar had been brought into alignment in the dental arch (Fig. 4C), and the cyst was reduced in size; however, the patient still had a Class II skeletal malocclusion with increased overjet (Fig. 5)

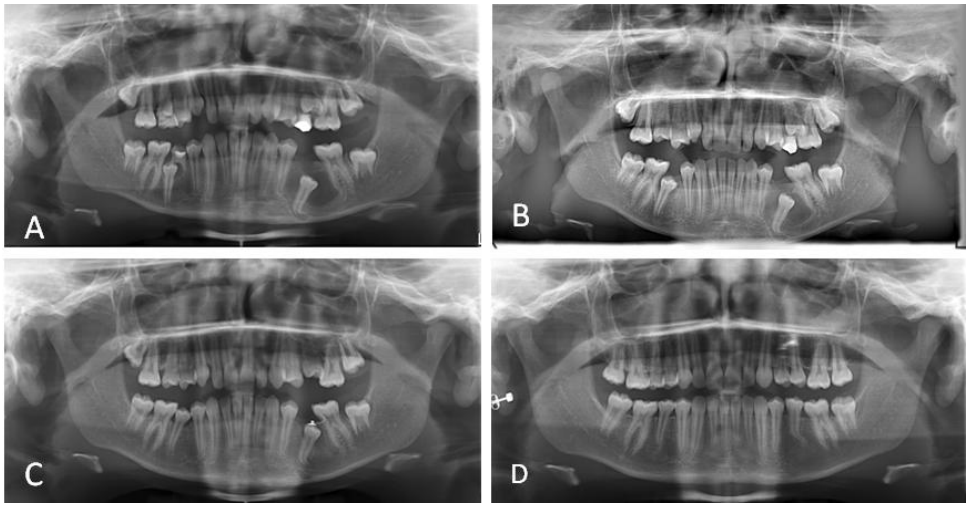


Figure 4. A) Panoramic radiograph 1 month after marsupialization; B) 2 month after marsupialization; C) after orthodontic traction with removable appliance; D) Panoramic radiograph after fixed orthodontic treatment.

Figure 5. Intra oral and extra oral photographs of the patient before fixed orthodontic treatment.

In the second phase of orthodontic treatment, 0.022" slot brackets (Gemini, 3M Unitek, Monrovia, Calif, USA) were placed in both the maxillary and mandibular arches. Fixed orthodontic treatment was started with light continuous force. A 0.014" NiTi arch wire was used for aligning and leveling, with the left mandibular second premolar excluded from the arch wire in this phase. After alignment and leveling of the maxillary and mandibular arches was achieved, 0.019"x0.025" stainless-steel arch wires were installed, and an auxiliary arch wire was used to bring the mandibular left second premolar into alignment with the dental arch. Once this tooth was leveled, 0.021"x0.025" stainless-steel arch wires were installed and a Forsus Fatigue Resistant Device (Forsus; 3M Unitek, Monrovia, CA, USA) was connected to correct the Skeletal Class II malocclusion.

The total surgical and orthodontic treatment time was 19 months. At the end of treatment, the impacted mandibular premolar was erupted (Fig. 4D); Class I molar and canine relationships were achieved; and an ideal overjet and overbite were provided (Fig. 6). In the final panoramic radiograph taken at the end of fixed orthodontic treatment, ideal root alignment with no new cystic formation was observed.

Discussion

The adverse effects of dentigerous cysts include resorption of surrounding tissue, tooth roots and bone; tooth displacement; and expansion of bone and soft tissue, with or without facial asymmetry (8), Inferior alveolar nerve paresthesia resulting from a dentigerous cyst has

also been reported (9); however, in most cases, cysts are asymptomatic and are diagnosed during routine dental visits (6). In the case reported here, swelling was present in the left mandibular region, but the patient had no pain or sensitivity.

Figure 6. Intra oral and extra oral photographs of the patient just after fixed orthodontic appliances were removed.

Treatment modalities for jaw cysts include marsupialization, enucleation, enucleation with bone grafting, and resection. Marsupialization, or decompression of the cystic lesion, relieves the pressure within the cyst and reduces the size of the lesion so that subsequent enucleation or curettage can be performed more easily and with less risk to adjacent vital structures (10). In some cases, marsupialization by itself can lead to complete resolution and cyst disappearance (11), and in other cases, marsupialization is followed by cyst enucleation. Hyomoto et al. found that natural eruption of the impacted tooth associated with a dentigerous cyst occurred in 72.4% of subjects after marsupialization of the cyst (5).

Whether or not orthodontic traction will be performed should be decided within three months following marsupialization. Miyawaki et al. recommended that orthodontic traction be initiated 3 months after marsupialization in preadolescents when there is sufficient space for spontaneous eruption (12). Tooth position and angulation have an effect on eruption, with a greater change of spontaneous eruption occurring when the angle between the long access of the impacted tooth and that of adjacent teeth is small (5). Unerupted maxillary teeth located less than 9 mm above the alveolar bone are also good candidates for eruption. In the present case the angle between the long axes of the impacted second premolar and adjacent teeth was small, and spontaneous eruption began within the first 2 months following marsupialization.

However, the crown of the impacted tooth was blocked by the alveolar bone, which prevented further eruption; thus, the decision was made to apply orthodontic traction.

Clinicians should also take patient age into consideration in selecting among treatment alternatives. Children and young adults have a greater and quicker capacity for bone regeneration than older individuals, and teeth with open apices are also more likely to undergo spontaneous eruption (3).

In the case presented here, radiographic and clinical examinations indicated sufficient space for the eruption of the impacted premolar. While the cyst was observed to be relatively large, cyst size and shape were not considered the main factors to affect eruption (5).

The outcome of the case reported here supports the choice of treatment of a dentigerous cyst and impacted premolar by marsupialization of the cyst and orthodontic traction mechanics in young patients with no tooth resorption.

Competing Interests

The authors declare that they have no competing interests.

References

1. Tournas AS, Tewfik MA, Chauvin PJ, Manoukian JJ. Multiple unilateral maxillary dentigerous cysts in a non-syndromic patient: a case report and review of the literature. Int J Pediatr Otorhinolaryngol Extra 2006;1(2):100-106.

2. LUCAS, Raleigh Barclay. Pathology of tumours of the oral tissues. J. & A. Churchill, 1964.

3. Motamedi, M. H. K., and K. T. Talesh. Management of extensive dentigerous cysts. British dental journal 198.4 (2005): 203-206.

4. Buyukkurt M, Omezli M, Miloglu O. Dentigerous cyst associated with an ectopic tooth in the maxillary sinus: a report of 3 cases and review of the literature. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109(1):67-71.

5. Hyomoto M, Kawakami M, Inoue M, Kirita T. Clinical conditions for eruption of maxillary canines and mandibular premolars associated with dentigerous cysts. Am J Orthod Dentofacial Orthop 2003;124(5):515-520.

6. Ertas Ü, Yavuz MS. Interesting eruption of 4 teeth associated with a large dentigerous cyst in mandible by only marsupialization. J Oral Maxillofac Surg 2003;61(6):728-730.

7. Fujii R, Kawakami M, Hyomoto M, Ishida J, Kirita T. Panoramic findings for predicting eruption of mandibular premolars associated with dentigerous cyst after marsupialization. J Oral Maxillofac Surg 2008;66(2):272-276.

8. Ziccardi VB, Eggleston T, Schneider Re. Using fenestration technique to treat a large dentigerous cyst. J Am Dent Assoc 1997;128(2):201-205.

9. Sumer M, Bas B, Yildiz L. Inferior alveolar nerve paresthesia caused by a dentigerous cyst associated with three teeth. Med Oral Patol Oral Cir Bucal 2007;12(5):388-390.

10. Meiselman F. Surgical management of the odontogenic keratocyst: conservative approach. J Oral Maxillofac Surg 1994;52(9):960-963.

11. Singh S, Kaur K, Kochhar GK, Gupta A. Marsupialisation: a treatment modality of a dentigerous cyst. BMJ Case Reports. Aug 22;2014; pii: bcr2014205150

12. Miyawaki S, Hyomoto M, Tsubouchi J, Kirita T, Sugimura M. Eruption speed and rate of angulation change of a cyst-associated mandibular second premolar after marsupialization of a dentigerous cyst. . Am J Orthod Dentofacial Orthop 1999;116(5):578-584.

Volume 5 / Issue 1 / July 2025

Review Article

A New Perspective on Developments in Orthodontics: Artificial Intelligence

İrem Can[1], Tevhide Sökmen[1*], Burcu Baloş Tuncer[1]

[1]Gazi University, Faculty of Dentistry, Department of Orthodontics, Ankara, Turkey

Corresponding author: tevhidesokmen@gazi.edu.tr

Can, İrem., Sökmen, Tevhide. & Baloş Tuncer, Burcu. "A New Perspective on Developments in Orthodontics: Artificial Intelligence". *Acta Stomatologica Cappadocia.* 5;1 (July 2025): 55-70.

DOI: https://doi.org/10.54995/ASC.5.1.5
Received: 07.02.2025; Accepted: 22.04.2025

A New Perspective on Developments in Orthodontics: Artificial Intelligence

İrem Can, Tevhide Sökmen, Burcu Baloş Tuncer

Abstract

The rapidly increasing advances in technological developments, the importance of economic gains, and the need to carry out business processes in a shorter and more efficient manners increased the demand for digital systems in order to enable the rapid collection and analysis of large amounts of data. In this respect, artificial intelligence (AI) has emerged, and played an important role in the digitalization of societies. Recently, AI applications have become popular in dentistry, which are also evident in orthodontics to provide guidance in diagnosis, treatment planning, and/or prediction of prognosis. There are large standardized data sets for patient follow-ups in orthodontics, which pose great potential for the application of AI due to their longitudinal and multimodal dataset structures. Therefore, the aim of this review was to give a general definition of artificial intelligence and provide a perspective on orthodontic diagnosis, treatment planning and ethical limitations.

Keywords: Artificial intelligence, diagnosis, machine-learning, orthodontics, treatment planning.

Introduction

Artificial intelligence (AI) has been defined by a Stanford Professor John McCarthy in 1955 as the science and engineering of making intelligent machines to mimic the cognitive abilities of humans. Fundamentally, most of their behavior arises learning from data or experience by using algorithms (1). There are different AI systems, such as machine learning (ML), convolutional neural networks (CNN), genetic algorithms (2). ML focuses on computer agents to improve their perception, knowledge, or actions based on experience or data. Deep learning is a subset of ML in which artificial neural networks (algorithms modeled to work like the hierarchically organized neurons in human brain) learn from large amounts of data, and perform the required tasks such as classification, regression and representation learning (3).

In the field of orthodontics, AI systems were declared to provide benefits in detecting cephalometric landmarks, in treatment-decision stages, remote-monitoring of patients, or in data archiving and documentation, which are all important steps that need to be performed carefully (4). This review aimed to evaluate the advances in the field of AI in orthodontics based on the current literature knowledge.

Orthodontic diagnosis

Digitalization in orthodontics provided benefits, especially in accelerating diagnostic steps, enabling more accurate and predictable results to be interpreted with clinical data. In this respect, three-dimensional (3D) images, computer-aided diagnosis and treatment planning, 3D based manufacturing systems (CAD/CAM) and 3D printing technologies are being used more frequently. The large amount of data and differences in observer experiences can lead to differences in orthodontic diagnosis and treatment planning, so AI systems aimed to speed up these stages and eliminate variations. One of the most common strategies in ML is visual learning, where an algorithm is exposed to pairs of data. During the model training phase, these data pairs are repeatedly shown to the algorithm to minimize the error in the DL model's preliminary predictions. The DL model learns to represent the statistical structure of the input data and its relationship to the given label and can eventually predict a label on the data (images). DL-based cephalometric software applications from different companies are available to orthodontists all over the world. In general orthodontists use their knowledge and experience to identify cephalometric landmarks (5).

The need to accelerate the diagnostic steps is important as it will also accelerate clinical functioning. A recent study used a computational deep CNN digital model to assess the orthodontic treatment need from intraoral clinical photographs of 700 patients, and revealed that the CNN model provided an accuracy of 99.99 % in detecting malocclusions (6). Similarly in 2022, automated lateral cephalogram landmarking advanced diagnosis, and a successful detection rate of landmarks with 98% has been reported with CephX; ORCA Dental AI (7). Lately, the applicability of a deep learning neural network was analyzed in a multi-center, multi-ethnic, and multi-device data of 309 CBCT scans from Finnish and Thai patients, and the authors advocated the inclusion of this method into clinical settings (8). Yurdakurban et al (9). evaluated the compatibility between traditional methods and machine learning in facial midline de-

termination and asymmetry assessment by marking anatomical landmarks on facial photographs of 90 patients. They argued that automatic marking has the potential to assist the clinician when used in combination with manual methods. On the other hand, some studies revealed significant deviations with AI-based landmarking compared to the human gold standard in some parameters (7,10,11).

Recent studies have shown that AI-based systems can accurately predict bone maturity by the classification of cervical vertebrae maturation stages and hand-wrist radiographs (12-14). Algorithms for upper airway segmentation have also been developed over the last decade, and numerous automated software programs have been validated for volumetric assessment (15). In 2021, Park et al. (16) assessed the accuracy of airway volume measurement using a DL model based on regression neural networks, and suggested that airway segmentation can be trained using an AI-assisted DL. Shujaat et al. (17) investigated a deep learning-based 3D convolutional neural network model to automatically segment the pharyngeal airway space. As a result, the segmented region could be distinguished by this model with the best accuracy.

A systematic review and meta-analysis by Jha et al. declared that AI algorithms developed for diagnosis of automatic temporomandibular joint diseases (TMD) can be used as a tool to support clinicians in the decision-making process (18). More recently, a randomized trial used a predictive machine-learning algorithm on 502 patients, 170 normal and 332 with degenerative TMD, and concluded that the model might contribute to the clinical screening of such patients in clinical practice (19). Gracea et al. (5) stated in their review article that automated landmark detection by the aid of AI was the most prevalent topic, followed by determination of maturation, and diagnosis of occlusal traits according to the data from 2021- 2023. They further emphasized that cephalometric landmark detection carried out by ML or DL algorithms provided high reliability and accuracy. Again, a recent study investigated the performance of a convolutional neural network (CNN)-based online cloud platform for automated segmentation of maxillary impacted canine on CBCT images, and revealed rapid and consistent findings (20).

Despite all the aforementioned results, more evaluations are still needed by including images obtained from different devices, with different resolutions and with different acquisition parameters in future studies (21).

Treatment planning

Analyzing qualitative and quantitative measures of dental and skeletal components is vital for accurate treatment planning procedures, which include tooth extraction techniques, anchorage requirements, and the necessity of surgical treatments (22). In orthodontic treatments worldwide, digitization and the pursuit of better outcomes generate a lot of data daily. Artificial intelligence can aid orthodontists in decision-making by utilizing extensive data through mathematical models and data integration. Studies based on planning and algorithms mainly focused on orthodontic treatment planning, orthognathic treatment issues and the need for extraction (5).

The assessment of the necessity for orthognathic surgery may differ among clinicians due to variations in expertise and preferences (23), with less experienced orthodontists frequently facing challenges in making such evaluations (24). Choi et al. (25) used AI models to evaluate whether orthognathic surgery is required for patients who will undergo orthodontic treatment and they suggested that these algorithms should be utilized when planning before orthognathic surgery. Kim et al. (24) utilized various convolutional neural networks as artificial intelligence algorithms, to predict the necessity of orthognathic surgery based on cephalometric radiographs, achieving accurate prediction rates ranging from 91% to 94%. Similarly, Shin et al. (26) achieved a 95% accuracy in predicting the indication for surgery using a deep learning network. A recent study evaluating the efficacy of various ML models in predicting the necessity for orthognathic surgery demonstrated that a combined ML approach model accurately predicted both Class II and III patients (27).

The simulation of surgical outcomes is essential as it facilitates the planning of the surgical treatment and provides a visual communication tool among the orthodontist, surgeon, and the patient. The accuracy of the simulated image is crucial, because it can significantly affect the expectations of both patients and the professionals (28). DL can demonstrate simulated soft-tissue profiles through generated surgical plans. A study illustrated that the generated DL model can precisely simulate soft-tissue profiles following mandibular advancement surgery using preoperative 3D photos and CBCT images (29). Another study assessing the validity of a 3D planning software for predicting postoperative soft tissue outcomes of bimaxillary orthognathic surgery in skeletal class 3 cases, found that the predictions were clinically

satisfactory (28). On the other hand, Jeong et al. (30) evaluated facial photographs of individuals requiring orthognathic surgery with deep convolutional neural networks, and stated that soft tissue profiles alone are not sufficient to identify orthognathic surgery cases by the AI-based model. In conclusion, it has been proposed that additional investigations are necessary to further verify these results. Until that point, AI can serve as a valuable adjunct to conventional treatment planning by enhancing decision-making processes and offering a visualization tool for predicting soft tissue outcomes in orthognathic treatment (28,31).

Decision Making for Orthodontic Extractions

Making the decision to extract teeth for orthodontic treatment is important and challenging because it usually depends on the practitioner's experience. A study on the consistency of orthodontic extraction decisions revealed that, orthodontists utilized varying criteria in making extraction decisions, which affects orthodontic patients. An incorrect decision regarding extraction may lead to a range of irreversible issues, including an undesirable profile, abnormal inclination of the anterior teeth, inadequate overjet and overbite, improper occlusion, and challenges in closing the extraction space (32).

Jung and Kim (33) evaluated the accuracy of an AI model on tooth extraction decision with cephalometric data of 156 patients, including their clinical examinations, overjet, molar relationship, amount of crowding, and soft tissue characteristics. As a result, they found 93% success in the decision of treatment with/without extraction and 84% for the detailed diagnosis of extraction patterns using AI. In 2021, Etemad et al. (34) evaluated the success of ML models in diagnosing the need for tooth extraction, and determined an accuracy rate of 86% in the diagnosis of extraction, and 96% in the diagnosis of non-extraction treatment. They emphasized that incompatible data made it difficult for the AI model to work, and that these models need to be developed to adequately support clinical decision making. While ML models showed high performance in extraction decisions, they were unable to exhibit the same efficacy in extraction pattern. The findings demonstrated that machine learning models significantly aid in decision-making related to orthodontic extractions, particularly for less experienced orthodontists (35).

AI models are continuously developing by learning from data sets and improving day by day. Variability due to experience between evaluators is very important in treatment planning when considering extraction (36), or orthognathic surgery (10).

Treatment duration prediction

The duration of the orthodontic treatment is an essential detail that patients frequently prioritize. Offering a reliable and accurate estimate of treatment duration is important as it constitutes an essential element of the orthodontic informed consent procedure and payment structure, hence greatly impacting patient satisfaction (37,38). Experienced orthodontists possess extensive knowledge, enabling them to confidently and efficiently plan and anticipate the duration of orthodontic treatment. Nonetheless, orthodontic residents and newly certified orthodontists mostly lack this benefit. While they possess the necessary technical skills, it demands additional time and experience (39). In a study aimed at constructing and comparing machine learning models to predict the duration of orthodontic treatment and identify factors influencing this duration through a machine learning approach found that, various algorithms demonstrated similar effectiveness in predicting treatment length. The primary parameters affecting the prediction of treatment time were age, crowding, AI case difficulty score, overjet, and overbite (40). Similarly, in another study aiming to predict treatment duration using an AI model, important determinants affecting treatment duration were identified and the potential of the AI model to predict orthodontic treatment duration using pre-treatment variables were emphasized (39). As a result of all the specified information, it has been stated that, more comprehensive and multi-center data sets are necessary to generalize the proposed algorithms (41).

Clear Aligner Treatments

Over the past two decades, clear aligners have emerged as an increasingly favored option to fixed appliance therapy for mild to moderate malocclusions. This treatment option is generally considered more esthetic and comfortable compared to traditional fixed appliances (42, 43). However, some patients express varying levels of discomfort and anxiety (44). Evaluating patient experiences during treatment can assist orthodontists in developing optimal patient-centered treatment plans. If significant discomfort occurs, modifications to the attachment design may be considered to enhance patient comfort and compliance. Artificial intelligence systems designed to predict patient comfort may have clinical applications that enhance patient compliance. A study used artificial neural networks to predict patient experiences,

pain, anxiety, and quality of life associated with Invisalign treatment. As a clinical consequence, they found that lingual attachments were the most significant factor impacting negative experiences (45).

AI can assist patients in visualizing potential outcomes prior to beginning actual treatment. Invisalign SmileView (SV) is an interactive application that employs a ML algorithm to accurately demonstrate prospective patients regarding the potential enhancement of their smile after undergoing treatment with aligners. A recent study found that SV simulates broader smiles, which are mostly achievable with aligner treatments, and shows high predictability for vertical incisor movements. It modified the upper incisors' mesiodistal size in simulations and identified and corrected dental midline deviations from the face midline (46).

Recently, AI methods have also been utilized in digital setup software to automate teeth segmentation and alignment processes. Orthodontic tooth setup simulates orthodontic treatment by separating individual teeth and aligning them in the desired position (47). It can be utilized to fabricate orthodontic appliances, including indirect bonding systems and clear aligners (48). Im et al. (49) conducted a comparison of automatic segmentation techniques, specifically the landmark-based method (Ortho analyzer), tooth designation method (Autoalign), and deep learning. They reported the highest success rate of 97.26% with the deep learning approach. A recent study assessed the accuracy and efficiency of automated digital setup software, indicating a significant enhancement in time efficiency. While the setup results have improved, additional manual adjustments may still be required for clinical applications, including indirect bonding and clear aligner therapy (48).

Teleorthodontics

Nowadays, Dental Monitoring (Dental Mind, Paris, France) (DM) applications another area that utilizes deep learning AI to facilitate orthodontists in tracking aligner treatment progress and allowing shorter treatment time because of improved patient compliance and early interception of problems. Using a smartphone, DM lets patients scan and record their teeth and lets the orthodontist check their development from far away. This technology detects gaps between aligners and teeth (unseats), indicating deviations from planned movements. The application also directs the patient to either change to the next aligner (GO) or continue with the current aligner for a specified duration prior to re-scanning (NO-GO), according to the provider's established preferences (50,51). The evaluation of clear aligner treatment with and

without dental monitoring presented that the monitoring improved aligner tracking. Additionally, study confirmed that patients utilizing AI-driven remote monitoring with Invisalign needed nearly 25% fewer visits than those treated conventionally (51). A case report indicated that the DM system is a promising method for enhancing doctor-patient interaction. Treatment outcomes also showed DM is generally acceptable and beneficial to patients, even in critical clinical situations, provided there is optimal compliance and proper usage of the tool (50). Conversely, a recent study indicated that the technology is presently unsuitable for independent use and requires ongoing orthodontist supervision during treatment (52).

AI applications can be used to inform patients to ensure proper oral hygiene, motivate them to use appliance/intermaxillary elastics or to remind clinical appointments (53). Li et al. (54) utilized the WeChat application to remind patients about their appointments and provided informative messages regarding oral hygiene. Consequently, they achieved less bracket detachment, and reduced treatment duration. Nevertheless, the innovative AI technologies enable real-time feedback, ultimately boosting motivation for both patients and orthodontists (55).

Ethical dilemmas of using artificial intelligence

Data confidentiality in orthodontic diagnostic materials may create ethical challenges, especially clinical photographs may pose a security problem in terms of identifying patients. Ethical dilemmas revolve around issues related to informed consent, respect for privacy, protection of personal data and reliability of data information. A debate is being held regarding AI systems in the field of health due to moral subjectivity, lack of empathy and insufficient level of critical thinking. The ethical issues raised by AI in healthcare in the future must fundamentally address nonmaleficence and beneficence (56).

Conclusion

Rapidly evolving AI models have the potential to improve orthodontic diagnosis, treatment planning, prediction processes and patient follow-up by automating tasks, increasing accuracy, and minimizing variability. With the development of AI technologies, prediction of treatment options becomes easier even for difficult patients, and patient motivation and satisfaction increases. However, different AI methods used in the studies create a limitation in terms of comparability, and most algorithms are trained on unicentric data. Despite the advances in AI algortihms, generalizing the results may still be inaccurate when clinical cases

with individual differences and ethical issues are taken into account. In conclusion, orthodontists still have to rely on their experience and knowledge for decision-making and further studies are needed to ensure the safety of AI-based models in clinical performance.

References

1. Georgian-Smith D, Moore RH, Halpern E, Yeh ED, Rafferty EA, D'Alessandro HA, Staffa M, Hall DA, McCarthy KA, Kopans DB. Blinded comparison of computer-aided detection with human second reading in screening mammography. American Journal of Roentgenology 2007;189(5):1135-41.
2. Khanagar SB, Al-Ehaideb A, Maganur PC, Vishwanathaiah S, Patil S, Baeshen HA, Sarode SC, Bhandi S. Developments, application, and performance of artificial intelligence in dentistry–A systematic review. Journal of dental sciences 2021;16(1):508-22.
3. Louis S, Nah S. A systematic review of scholarship in AI and communication research (1990-2022). Research Handbook on Artificial Intelligence and Communication 2023:2-28.
4. Liu J, Zhang C, Shan Z. Application of artificial intelligence in orthodontics: current state and future perspectives. Paper presented at: Healthcare, 2023.
5. Gracea RS, Winderickx N, Vanheers M, Hendrickx J, Preda F, Shujaat S, de Llano Perula MC, Jacobs R. Artificial intelligence for orthodontic diagnosis and treatment planning: A scoping review. Journal of Dentistry 2024:105442.
6. Talaat S, Kaboudan A, Talaat W, Kusnoto B, Sanchez F, Elnagar MH, Bourauel C, Ghoneima A. The validity of an artificial intelligence application for assessment of orthodontic treatment need from clinical images. Paper presented at: Seminars in Orthodontics, 2021.
7. Davidovitch M, Sella-Tunis T, Abramovicz L, Reiter S, Matalon S, Shpack N. Verification of convolutional neural network cephalometric landmark identification. Applied Sciences 2022;12(24):12784.

8. Sahlsten J, Järnstedt J, Jaskari J, Naukkarinen H, Mahasantipiya P, Charuakkra A, Vasankari K, Hietanen A, Sundqvist O, Lehtinen A. Deep learning for 3D cephalometric landmarking with heterogeneous multi-center CBCT dataset. PloS one 2024;19(6):e0305947.

9. Yurdakurban E, Duran GS, Görgülü S. Evaluation of an automated approach for facial midline detection and asymmetry assessment: A preliminary study. Orthodontics & Craniofacial Research 2021;24:84-91.

10. Kunz F, Stellzig-Eisenhauer A, Boldt J. Applications of artificial intelligence in orthodontics—an overview and perspective based on the current state of the art. Applied Sciences 2023;13(6):3850.

11. Kunz F, Stellzig-Eisenhauer A, Widmaier LM, Zeman F, Boldt J. Assessment of the quality of different commercial providers using artificial intelligence for automated cephalometric analysis compared to human orthodontic experts. Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie 2023:1-16.

12. Kim DW, Kim J, Kim T, Kim T, Kim YJ, Song IS, Ahn B, Choo J, Lee DY. Prediction of hand-wrist maturation stages based on cervical vertebrae images using artificial intelligence. Orthodontics & Craniofacial Research 2021;24:68-75.

13. Mathew R, Palatinus S, Padala S, Alshehri A, Awadh W, Bhandi S, Thomas J, Patil S. Neural networks for classification of cervical vertebrae maturation: a systematic review. The Angle Orthodontist 2022;92(6):796-804.

14. Atici SF, Ansari R, Allareddy V, Suhaym O, Cetin AE, Elnagar MH. AggregateNet: A deep learning model for automated classification of cervical vertebrae maturation stages. Orthodontics & Craniofacial Research 2023;26:111-17.

15. Jeong Y, Nang Y, Zhao Z. Automated evaluation of upper airway obstruction based on deep learning. BioMed Research International 2023;2023(1):8231425.

16. Park J, Hwang J, Ryu J, Nam I, Kim S-A, Cho B-H, Shin S-H, Lee J-Y. Deep learning based airway segmentation using key point prediction. Applied Sciences 2021;11(8):3501.

17. Shujaat S, Jazil O, Willems H, Van Gerven A, Shaheen E, Politis C, Jacobs R. Automatic segmentation of the pharyngeal airway space with convolutional neural network. Journal of Dentistry 2021;111:103705.

18. Jha N, Lee K-S, Kim Y-J. Diagnosis of temporomandibular disorders using artificial intelligence technologies: A systematic review and meta-analysis. PLoS One 2022;17(8):e0272715.

19. Fang X, Xiong X, Lin J, Wu Y, Xiang J, Wang J. Machine-learning–based detection of degenerative temporomandibular joint diseases using lateral cephalograms. American Journal of Orthodontics and Dentofacial Orthopedics 2023;163(2):260-71. e5.

20. Swaity A, Elgarba BM, Morgan N, Ali S, Shujaat S, Borsci E, Chilvarquer I, Jacobs R. Deep learning driven segmentation of maxillary impacted canine on cone beam computed tomography images. Scientific Reports 2024;14(1):369.

21. Rauniyar S, Jena S, Sahoo N, Mohanty P, Dash BP. Artificial Intelligence and Machine Learning for Automated Cephalometric Landmark Identification: A Meta-Analysis Previewed by a Systematic Review. Cureus 2023;15(6).

22. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. American journal of orthodontics and dentofacial orthopedics 1993;103(4):299-312.

23. Baumrind S, Korn EL, Boyd RL, Maxwell R. The decision to extract: part II. Analysis of clinicians' stated reasons for extraction. American Journal of Orthodontics and Dentofacial Orthopedics 1996;109(4):393-402.

24. Kim Y-H, Park J-B, Chang M-S, Ryu J-J, Lim WH, Jung S-K. Influence of the depth of the convolutional neural networks on an artificial intelligence model for diagnosis of orthognathic surgery. Journal of Personalized Medicine 2021;11(5):356.

25. Choi H-I, Jung S-K, Baek S-H, Lim WH, Ahn S-J, Yang I-H, Kim T-W. Artificial intelligent model with neural network machine learning for the diagnosis of orthognathic surgery. Journal of Craniofacial Surgery 2019;30(7):1986-89.

26. Shin W, Yeom H-G, Lee GH, Yun JP, Jeong SH, Lee JH, Kim HK, Kim BC. Deep learning based prediction of necessity for orthognathic surgery of skeletal malocclusion using cephalogram in Korean individuals. BMC Oral Health 2021;21:1-7.

27. de Oliveira PHJ, Li T, Li H, Gonçalves JR, Santos-Pinto A, Gandini Junior LG, Cevidanes LS, Toyama C, Feltrin GP, Campanha AA. Artificial intelligence as a prediction tool for orthognathic surgery assessment. Orthodontics & Craniofacial Research 2024.

28. Lee KJC, Tan SL, Low HYA, Chen LJ, Yong CW, Chew MT. Accuracy of 3-dimensional soft tissue prediction for orthognathic surgery in a Chinese population. Journal of Stomatology, Oral and Maxillofacial Surgery 2022;123(5):551-55.

29. Ter Horst R, van Weert H, Loonen T, Bergé S, Vinayahalingam S, Baan F, Maal T, de Jong G, Xi T. Three-dimensional virtual planning in mandibular advancement surgery: Soft tissue prediction based on deep learning. Journal of Cranio-Maxillofacial Surgery 2021;49(9):775-82.

30. Jeong SH, Yun JP, Yeom H-G, Lim HJ, Lee J, Kim BC. Deep learning based discrimination of soft tissue profiles requiring orthognathic surgery by facial photographs. Scientific reports 2020;10(1):16235.

31. Salazar D, Rossouw PE, Javed F, Michelogiannakis D. Artificial intelligence for treatment planning and soft tissue outcome prediction of orthognathic treatment: A systematic review. Journal of Orthodontics 2024;51(2):107-19.

32. Ribarevski R, Vig P, Vig KD, Weyant R, O'Brien K. Consistency of orthodontic extraction decisions. The European Journal of Orthodontics 1996;18(1):77-80.

33. Jung S-K, Kim T-W. New approach for the diagnosis of extractions with neural network machine learning. American Journal of Orthodontics and Dentofacial Orthopedics 2016;149(1):127-33.

34. Etemad L, Wu TH, Heiner P, Liu J, Lee S, Chao WL, Zaytoun ML, Guez C, Lin FC, Jackson CB. Machine learning from clinical data sets of a contemporary decision for orthodontic tooth extraction. Orthodontics & Craniofacial Research 2021;24:193-200.

35. Köktürk B, Pamukçu H, Gözüaçık Ö. Evaluation of different machine learning algorithms for extraction decision in orthodontic treatment. Orthodontics & Craniofacial Research 2024.

36. Suhail Y, Upadhyay M, Chhibber A, Kshitiz. Machine learning for the diagnosis of orthodontic extractions: a computational analysis using ensemble learning. Bioengineering 2020;7(2):55.

37. Pachêco-Pereira C, Pereira JR, Dick BD, Perez A, Flores-Mir C. Factors associated with patient and parent satisfaction after orthodontic treatment: a systematic review. American Journal of Orthodontics and Dentofacial Orthopedics 2015;148(4):652-59.

38. Jharwal V, Trehan M, Rathore N, Rathee P, Agarwal D, Mathur N. Informed consent for braces. International journal of clinical pediatric dentistry 2014;7(2):105.

39. Volovic J, Badirli S, Ahmad S, Leavitt L, Mason T, Bhamidipalli SS, Eckert G, Albright D, Turkkahraman H. A novel machine learning model for predicting orthodontic treatment duration. Diagnostics 2023;13(17):2740.

40. Elnagar MH, Pan AY, Handono A, Sanchez F, Talaat S, Bourauel C, Kaboudan A, Kusnoto B. Utilization of Machine Learning Methods for Predicting Orthodontic Treatment Length. Oral 2022;2(4):263-73.

41. Nordblom N, Büttner M, Schwendicke F. Artificial Intelligence in Orthodontics: Critical Review. Journal of Dental Research 2024;103(6):577-84.

42. Chan V, Shroff B, Kravitz ND, Carrico C, Hawkins D, Tran P, Lindauer S. Orthodontic pain with fixed appliances and clear aligners: A 6-month comparison. American Journal of Orthodontics and Dentofacial Orthopedics 2024;166(5):469-79.

43. Partouche AJD, Castro F, Baptista AS, Costa LG, Fernandes JCH, Fernandes GVdO. Effects of multibracket orthodontic treatment versus clear aligners on periodontal health: an integrative review. Dentistry journal 2022;10(10):177.

44. Gao M, Yan X, Zhao R, Shan Y, Chen Y, Jian F, Long H, Lai W. Comparison of pain perception, anxiety, and impacts on oral health-related quality of life between patients receiving clear aligners and fixed appliances during the initial stage of orthodontic treatment. European Journal of Orthodontics 2021;43(3):353-59.

45. Xu L, Mei L, Lu R, Li Y, Li H, Li Y. Predicting patient experience of Invisalign treatment: An analysis using artificial neural network. Korean Journal of Orthodontics 2022;52(4):268-77.

46. Mourgues T, González-Olmo MJ, Huanca Ghislanzoni L, Peñacoba C, Romero-Maroto M. Artificial Intelligence in Aesthetic Dentistry: Is Treatment with Aligners Clinically Realistic? Journal of Clinical Medicine 2024;13(20):6074.

47. Kesling HD. The diagnostic setup with consideration of the third dimension. American Journal of Orthodontics 1956;42(10):740-48.

48. Woo H, Jha N, Kim Y-J, Sung S-J. Evaluating the accuracy of automated orthodontic digital setup models. Paper presented at: Seminars in Orthodontics, 2023.

49. Im J, Kim J-Y, Yu H-S, Lee K-J, Choi S-H, Kim J-H, Ahn H-K, Cha J-Y. Accuracy and efficiency of automatic tooth segmentation in digital dental models using deep learning. Scientific reports 2022;12(1):9429.

50. Caruso S, Caruso S, Pellegrino M, Skafi R, Nota A, Tecco S. A knowledge-based algorithm for automatic monitoring of orthodontic treatment: the dental monitoring system. Two cases. Sensors 2021;21(5):1856.

51. Hansa I, Katyal V, Ferguson DJ, Vaid N. Outcomes of clear aligner treatment with and without dental monitoring: a retrospective cohort study. American Journal of Orthodontics and Dentofacial Orthopedics 2021;159(4):453-59.

52. Ferlito T, Hsiou D, Hargett K, Herzog C, Bachour P, Katebi N, Tokede O, Larson B, Masoud MI. Assessment of artificial intelligence–based remote monitoring of clear aligner therapy: A prospective study. American Journal of Orthodontics and Dentofacial Orthopedics 2023;164(2):194-200.

53. Baheti MJ, Toshniwal N. Orthodontic apps at fingertips. Progress in orthodontics 2014;15:1-5.

54. Li X, Xu Z-R, Tang N, Ye C, Zhu X-L, Zhou T, Zhao Z-H. Effect of intervention using a messaging app on compliance and duration of treatment in orthodontic patients. Clinical oral investigations 2016;20:1849-59.

55. Sosiawan A, Jordana J, Dhywinanda DE, Salim JF, Ramadhani NF, Nurdiansyah R, Ardani IGAW, Nugraha AP. Artificial intelligence driven dental monitoring and surveillance of malocclusion treatment in orthodontic patients. World Journal of Advanced Research and Reviews 2022;16(3):049-53.

56. Astărăstoae V, Rogozea LM, Leaşu F, Ioan BG. Ethical dilemmas of using artificial intelligence in medicine. American Journal of Therapeutics 2022:10.1097.