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Evaluation of Readability Analyses and Contents of Turkish Texts on Dental Pain in the Online Platform

Vahide Hazal ABAT 

ÖZ

Amaç: Bu çalışmada, internet ortamında bulunan diş ağrısı ile ilgili Türkçe metinleri okunabilirlik ve içerik açısından değerlendirmek amaçlanmıştır.

Gereç ve Yöntemler: “Diş ağrısı” anahtar kelimesi kullanılarak Google arama motorundan arama yapıldı. Türkçe metin içeren ve bilgilendirici nitelikteki ilk 50 web sitesi çalışmaya dahil edildi. Metin kaynakları üniversite hastanesi, özel sağlık kuruluşu, uzman diş hekimi, diş hekimi, ağız diş sağlığı merkezi olarak sınıflandırıldı. Çalışmaya dahil edilen web siteleri içerikleri, tanım, önlemler, tedaviler, yapılmaması gerekenler, çocuklarda ve hamilelikte diş ağrısına ilişkin içeriklerine göre değerlendirildi. Ateşman Okunabilirlik İndeksi ve Flesch Okunabilirlik sınıflaması kullanılarak verilerin okunabilirlik düzeyleri belirlendi.

Bulgular: Yapılan aramada ilk 204 web sitesinden 50 tanesi dahil edilme kriterlerini karşıladı. Bunların, %78’ini özel sağlık kuruluşlarının, %8’ini üniversitelerin, %8’ini uzman diş hekimlerinin, %4’ünü diş hekimlerinin ve %2’sini ise ağız, diş sağlığı merkezlerinin oluşturduğu belirlendi. Ortalama Ateşman okunabilirlik indeksi $64,93 \pm 5,67$ bulundu. Buna göre, web sitelerinin %20’si kolay; %80’i orta zorluk düzeyindedir. Flesch okunabilirlik sınıflamasına göre, web sitelerinin %60’ının 9-10. Sınıf düzeyinde olduğu bulundu. Web sitesi kaynakları arasında okunabilirlik düzeyleri bakımından anlamlı bir fark bulunamadı ($p=0,904$).

Sonuç: Türkçe web sitelerinde diş ağrısına ilişkin metinlerin önemli bir kısmının orta zorluk düzeyinde olduğu belirlenmiştir. İçerik bakımından değerlendirildiğinde; diş ağrısını evde geçirebilecek öneriler hakkında çoğunlukla bilgi verilmesine rağmen; kişinin yapmaması gerekenlere, alması gereken önlemlere,

hamilelerde ve çocuklarda diş ağrısına ilişkin bilgilendirmelere yeterince değinilmediği sonucuna ulaşılmıştır.

Anahtar Kelimeler: ağrı, Ateşman formülü, endodonti, internet, okunabilirlik

ABSTRACT

Objective: This study comprehensively evaluates the readability and content of Turkish online texts on ‘dental pain’.

Materials and Methods: Utilizing the search term “dental pain” on Google, we selected 50 pertinent Turkish websites from diverse sources—private healthcare institutions (78%), universities (8%), expert dentists (8%), general dentists (4%), and oral dental health centers (2%). Content analysis focused on descriptions, precautions, treatments, contraindications, and considerations for dental pain in children and during pregnancy. The Ateşman Readability Index and Flesch Readability Index were employed to ascertain the level of readability of the data.

Results: Out of the initial 204 websites, 50 met the inclusion criteria. The average Ateşman readability index was 64.93 ± 5.67 , with 20% categorized as easy and 80% as moderately difficult. According to the Flesch readability classification, it was determined that 60% of websites are in grades 9-10. No significant readability differences were noted among sources ($p=0.904$).

Conclusion: A substantial portion of Turkish dental pain websites presents a moderate level of difficulty. When analyzing the content, it is evident that the information provided primarily focuses on home remedies for decreasing toothache. However, there is a lack of sufficient coverage on what actions individuals should avoid, necessary precautions to take, and specific details regarding toothache in pregnant women and children.

Keywords: Ateşman formula, endodontics, internet, pain, readability

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GİRİŞ

İnternetin yaygınlaşmasıyla birlikte, bireyler sağlık anlamında birçok sorunun cevabını web tabanlı sitelerde aramaktadır. Cep telefonu gibi internete kolayca girilebilen ve elde taşınan cihazlar, sağlığa ilişkin acil durumlarda ilk kaynak olarak görülebilmektedir. Daha da ötesi, mevcut hastalıkların çözümünü ilgili branşın hekimine gitmek yerine internet sitelerinden arayan bireylerin de olduğu göz ardı edilemez. Ancak; bu kaynaklardan bilgilere ulaşmak her ne kadar kolay olsa da güvenilirlikleri ve doğrulukları şüphelidir. İnternette yer alan sağlığa dair bilgilerin içeriğini ve doğruluğunu denetleyen bir yasal mekanizma ve konuyla ilgili yasal mevzuat ise maalesef bulunmamaktadır (Knösel vd., 2011).

İlk olarak Amerika'da 19. yüzyılda ortaya atılan okunabilirlik kavramı, herhangi bir dildeki bir metnin okuyucu(lar) tarafından kolay takip edilebilir olup olmadığı bilgisidir. Bu bilgi, söz konusu dilde hece, kelime ve cümle sayılarının birbirleri arasındaki ilişkileri temel alan bir takım karakteristik özelliklerin göz önünde bulundurulması ile elde edilmektedir (Temur, 2003). Okunabilirlik düzeyi, bir yazı metninin okuyucu tarafından okunabilme ve anlaşılabilmesindeki kolaylık ve zorluk seviyesini belirtmektedir (Cheng & Dunn, 2015; Dubai, 2004). Literatürde okunabilirlik düzeyini belirlemeye yönelik birçok ölçüm aracı bildirilmiştir. Gunning-Fog, Flesch-Kincaid değeri ve Smog-Simple ölçümü gibi formüller bunlardan en çok kullanılanlardır (Gunning, 1952; Flesch, 1948; Hedman, 2008). Türkçedeki kelimeler ek alabildiği için cümlenin anlaşılabilirliğini sadece cümlenin uzunluğu ve hece sayısı etkilememektedir. Bu nedenle, okunabilirlik düzeyi tespiti için mevcut formüller üzerinden çeşitli uyarlamalar yapılmıştır (Bezirci & Yılmaz, 2010). Ateşman Okunabilirlik İndeksi; ortalama sözcük sayısı ve cümle uzunluklarını kullanarak Türkçe metinlerin okunabilirlik düzeyini belirlemeye yardımcı bir araçtır (Ateşman E., 1997). Bu formül, Flesch Okuma Kolaylığı Formülünün Türkçeye uyarlanmasıyla geliştirilmiştir (Ateşman E., 1997; Flesch, 1948).

Özellikle travma, apse gibi ağrıya neden olan acil olarak nitelenen durumlarda, internet kaynaklarından kısa ve öz, reklamsız, konu ile ilgili bilgiye direkt ulaşabilmek önemlidir. Okunabilirlik düzeyinin düşük olması, kaynağa yer alan bilginin anlaşılabilirliğini azaltacağından okuyucuya bir fayda sağlamayacağı gibi zaman da kaybettirir. Bir metnin güç olması okumayı zorlaştırırken, kolay olması da

okumaya karşı ilgiyi düşürmektedir. Goldbort' a göre iyi bir metin, bilinenden bilinmeyene doğru ve karışıklığa neden olmayacak şekilde açık ve net olmalıdır (Goldbort, 2001). Metin, genel olarak anlamı bilinen sözcükleri içermelidir (Goldbort, 2001).

İnternet, genellikle sağlıkla ilgili ilk bilgi kaynağıdır. Bu nedenle internet ortamındaki bilgilerin gerek okunabilirlik düzeyinin gerekse içeriğinin değerlendirilmesi kritik öneme sahiptir. Bu çalışmanın amacı, diş ağrısına ilişkin web tabanlı sitelerde yer alan Türkçe içeriklerin okunabilirlik analizlerini yapmak ve içerik bakımından web sitesi kaynaklarını değerlendirmektir.

GEREÇ VE YÖNTEMLER

Bu çalışmada herkes tarafından ulaşılabilen kamuya açık bilgiler kullanıldığı için çalışma etik kurul onayı gerektirmemektedir.

İnternette yer alan diş ağrısına yönelik içeriklere ulaşmak için, 30 Kasım 2023 tarihinde Google arama motoruna (www.google.com) (Google LLC, Mountain View, California, USA) 'Diş ağrısı' anahtar kelimesi yazılarak arama yapıldı. Arama sonucu çıkan, 10.600.000 web sitesi arasından sıralamada görünen ilk 200 web sitesi kaydedildi.

Yirmi cümleden kısa metinler içeren siteler, akademik amaçlı yazılan makaleler, forum siteleri, sağlık profesyonelleri için oluşturulmuş siteler, ticari amaçlı siteler, tekrarlayan siteler ve sponsorlu reklam siteleri çalışmaya dahil edilmedi. Diş ağrısına ilişkin bilgilendirici ve hasta eğitimine yönelik metinler içeren web tabanlı siteler çalışmaya dahil edildi. Tek bir araştırmacı tarafından yapılan aramada ilk 200 sonuç arasından kriterlere uygun 50 web tabanlı site çalışmaya dahil edildi.

Arama sonucu elde edilen web tabanlı siteler kaynaklarına göre; özel sağlık kuruluşu, üniversite hastanesi, uzman diş hekimi, diş hekimi, ağız diş sağlığı merkezi olacak şekilde sınıflandırıldı. Metinlerin içerikleri kopyalanıp Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) dosyasına yapıştırıldı. Yazarlar ve web site adresleri metinlerle beraber kaydedildi.

Okunabilirlik Düzeyi Hesaplama

Okunabilirlik düzeylerini tespit etmek için veriler ücretsiz çevrim içi okunabilirlik düzeyi hesaplama motoruna (<http://okunabilirlikindeksi.com/>) aktarıldı. Kullanılan okunabilirlik düzeyi hesaplama motoru, Ateşman'ın 1997 yılında oluşturduğu formüle dayanmaktadır (Ateşman E., 1997). Ateşman Okunabilirlik İndeksi'nin sınıflandırması Tablo 1'de görülmektedir.

Flesch'in Okuma Kolaylığı sınıflaması ise Ateşman okunabilirlik formülü geliştirilirken baz alınan bir sınıflamadır. Bu sınıflamada 1-100 arasında puan verilerek metnin kolayca anlaşılacağı eğitim seviyesi belirlenmektedir (Tablo 1). Okunabilirlik düzeyi hesaplama motorundan elde edilen tüm veriler, daha sonra Microsoft Excel'e aktarıldı.

Tablo 1. Ateşman ve Flesch okunabilirlik sınıflamaları

İndeks değer aralıkları	Ateşman okunabilirlik sınıflaması	Flesch okunabilirlik sınıflaması
90-100	Çok kolay	4. sınıf ve altı
80-89	Kolay	5-6. sınıf
70-79	Kolay	7-8. sınıf
60-69	Orta zorluk	9-10. sınıf
50-59	Orta zorluk	11-12. sınıf
40-49	Zor	13-15. sınıf (ön lisans)
30-39	Zor	Lisans
1-29	Çok zor	Lisansüstü

Metin İçeriğinin Değerlendirilmesi

Web sitelerinde yer alan metinlerdeki hasta bilgilendirme içeriklerini değerlendirmek amacıyla, belirli sorulardan yararlanıldı:

- Diş ağrısının tanımı ve nedenleri hakkında bilgilendiriyor mu?
- Diş ağrısının klinik tedavisi hakkında bilgi veriyor mu?
- Diş ağrısının nasıl önleneceği hakkında bilgilendiriyor mu?
- Diş ağrısının evde tedavisine yönelik bilgi veriyor mu?
- Diş ağrısını gidermek için yapılmaması gerekenler hakkında uyarılar içeriyor mu?
- Hamilelikte 'diş ağrısı' hakkında bilgilendiriyor mu?
- Çocuklarda 'diş ağrısı' hakkında bilgilendiriyor mu?

Metin içeriği belirtilen bu soruların cevabını kapsamasına göre, elde edilen web siteleri için içerik sınıflandırılması yapıldı. İçerik sınıflandırması (A, B, C, D, E, F, G) veriler içerisine aktarıldı ve tüm veriler için istatistiksel analiz yapıldı.

İstatistiksel Analiz

Verilerin analizinde SPSS 23 (SPSS Inc., Chicago, IL, ABD) istatistik paket programı kullanıldı. Araştırma kapsamında verilerin normallik dağılımı Kolmogorov-Smirnov testi ile hesaplandı. Elde edilen sonuçlara göre; ortalama kelime uzunluğu, ortalama cümle uzunluğu ve ateşman okunabilirlik indeksi normal dağılım göstermekteyken, diğer veriler normal dağılım göstermemektedir. Verilerin ortalama, standart sapması ve minimum maksimum değerleri hesaplandı. Bağımsız değişkenlerin karşılaştırılmasında Fisher's exact testi kullanıldı.

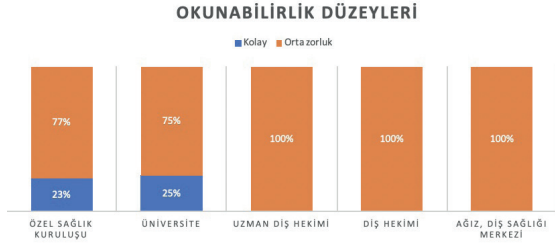
BULGULAR

Değerlendirilmeye alınan ilk 200 web sitesinden 50 tanesi dahil edilme kriterlerini karşıladı. Çalışmaya dahil edilen metin kaynakları incelendiğinde, %78'i özel sağlık kuruluşu, %8'i üniversite hastaneleri, %8'i uzman diş hekimi, %4'ü diş hekimi ve %2'sinin ağız ve diş sağlığı merkezi kaynaklı olduğu belirlendi.

Metinlerin dil yönünden betimleyici istatistikleri Tablo 2'de verilmiştir. Buna göre, ortalama Ateşman okunabilirlik indeksi 64.93 ± 5.67 bulunmuştur. Flesch okunabilirlik sınıflamasında okuma seviyesi 7-8. sınıf olanların oranı %5,1, 9-10. sınıf olanların oranı %50, 11-12. sınıf olanların oranı %40,8, 13-15. sınıf olanların ve lisans olanların oranı %2 bulunmuştur. Ateşman okunabilirlik indeksi doğrultusunda elde ettiğimiz bulgulara göre, web sitelerinin %20'si kolay; %80'inin ise orta zorluk düzeyindedir (Tablo 3). **Tablo 2.** Web sitesi kaynaklarının dil bakımından betimleyici istatistikleri

Betimleyici	Standart				
	Ortalama	Medyan	Sapma	Minimum	Maksimum
Sözcük sayısı	869,46	717,00	633,14	223	3504
Karakter sayısı	6597,22	5381,00	4972,32	1647	27181
Zor sözcük sayısı	864,00	711,50	630,15	222	3495
Benzersiz sözcük sayısı	469,74	421,50	274,11	157	1667
Kısa sözcük sayısı	182,46	163,50	123,09	48	714
Boşluksuz karakter sayısı	5701,60	4649,00	4308,07	1420	23622
Cümle sayısı	83,70	70,00	59,95	22	371
Paragraf sayısı	35,10	31,00	24,71	7	148
Ortalama sözcük uzunluğu	2,65	2,64	0,08	2,48	2,85
Ortalama cümle uzunluğu	10,53	10,30	2,07	6,00	14,80
Ateşman okunabilirlik indeksi	64,93	65,95	5,68	51,40	79,10

Web sitesi kaynaklarına göre ateşman okunabilirlik düzeyleri karşılaştırıldığında, web sitesi kaynakları arasında anlamlı bir fark bulunamadı ($p=0,904$) (Tablo 3). Web sitesi kaynaklarına göre Ateşman okunabilirlik düzeyleri grafik halinde sunulmuştur (Şekil 1). Web sitesi kaynaklarına göre Flesch okunabilirlik düzeyleri karşılaştırıldığında web sitesi kaynakları arasında anlamlı bir fark bulunamadı ($p=0,965$) (Tablo 4).



Şekil 1. Web sitesi kaynaklarına göre Ateşman okunabilirlik düzeyleri

Tablo 3. Web sitelerinin kaynağına göre metinlerin Ateşman okunabilirlik düzeylerinin karşılaştırılması

Web sitesi kaynağı		Ateşman Okunabilirlik Düzeyleri			p
		Orta zorluk	Kolay	Total	
Özel sağlık	Sayısal değer	30	9	39	0,904
	Yüzdeler (%)	%76,9	%23,1	%100,0	
Üniversite	Sayısal değer	3	1	4	
	Yüzdeler (%)	%75,0	%25,0	%100,0	
ADSM	Sayısal değer	1	0	1	
	Yüzdeler (%)	%100,0	%0,0	%100,0	
Uzman	Sayısal değer	4	0	4	
	Yüzdeler (%)	%100,0	%0,0	%100,0	
Diş hekimi	Sayısal değer	2	0	2	
	Yüzdeler (%)	%100,0	%0,0	%100,0	
Total	Sayısal değer	40	10	50	
	Yüzdeler (%)	%80,0	%20,0	%100,0	

Fisher's exact test

Table 4. Web sitelerinin kaynağına göre metinlerin Flesch okunabilirlik düzeylerinin karşılaştırılması

Web sitesi kaynağı		Flesch okunabilirlik düzeyi			Total	p
		9-10. sınıf	11-12. sınıf	7-8. sınıf		
Özel sağlık	Observed	21	9	9	39	0,965
	% of total	%42,0	%18,0	%18,0		
Üniversite	Observed	3	0	1	4	
	% of total	%6,0	%0,0	%2,0		
ADSM	Observed	1	0	0	1	
	% of total	%2,0	%0,0	%0,0		
Uzman	Observed	3	1	0	4	
	% of total	%6,0	%2,0	%0,0		
Diş hekimi	Observed	2	0	0	2	
	% of total	%4,0	%0,0	%0,0		
Total	Observed	30	10	10	50	
	% of total	%60,0	%20,0	%20,0		

Fisher's exact test

Web sitesi kaynağına göre metin içerikleri değerlendirildiğinde, elde edilen bulgular Tablo 5'de sunulmuştur. Buna göre, çalışmaya dahil edilen tüm web sitelerinin %94'ünün diş ağrısının tanımı ve nedenleri hakkında bilgi içerdiği görülmüştür. %64'ünün diş ağrısını önlenmesi konusunda okuyucuyu bilgilendirdiği, %42'sinin diş ağrısının klinikte tedavilerine ilişkin bilgi verdiği

görülmüştür. Diş ağrısını gidermek için okuyucunun yapmaması gerekenler hakkında bilgilendiren ve buna dair uyarılar içeren web siteleri, çalışmadaki tüm web sitelerinin %10'unu oluşturmaktadır. Çalışmaya dahil edilen tüm web sitelerinin %4'ünün hamilelikte diş ağrısı, %14'ünün ise çocuklarda diş ağrısı hakkında bilgilendirmeler içerdiği görülmüştür (Tablo 5).

Tablo 5. Web sitesi kaynağına göre metin içeriklerinin orantısal değerlendirilmesi

Kaynakların Metin İçerikleri	Yüzde % (n:sayısal değer)					
	Toplam	Özel sağlık kuruluşu	Üniversite hastanesi	Uzman diş hekimi	Diş Hekimi	ADSM
Diş ağrısının tanımını ve nedenlerini kapsamaktadır.	%94 (n=47)	%92 (n=36)	%100 (n=4)	%100 (n=4)	%100 (n=2)	%100 (n=1)
Diş ağrısının klinik tedavisi hakkında bilgi vermektedir.	%42 (n=21)	%46 (n=18)	%50 (n=2)	%25 (n=1)	%0 (n=0)	%0 (n=0)
Diş ağrısının nasıl önleneceği hakkında bilgilendirmektedir.	%42 (n=21)	%46 (n=18)	%50 (n=2)	%25 (n=1)	%0 (n=0)	%0 (n=0)
Diş ağrısının evde tedavisine yönelik bilgi verir.	%64 (n=32)	%67 (n=26)	%25 (n=1)	%50 (n=2)	%100 (n=2)	%100 (n=1)
Diş ağrısını gidermek için yapılmaması gerekenlere ilişkin uyarılar içermektedir.	%20 (n=10)	%21 (n=8)	%0 (n=0)	%25 (n=1)	%0 (n=0)	%100 (n=1)
Hamilelikte diş ağrısı hakkında bilgilendirmektedir.	%4 (n=2)	%5 (n=2)	%0 (n=0)	%0 (n=0)	%0 (n=0)	%0 (n=0)
Çocuklarda diş ağrısı hakkında bilgilendirmektedir.	%14 (n=7)	%13 (n=5)	%50 (n=2)	%0 (n=0)	%0 (n=0)	%0 (n=0)

TARTIŞMA

Literatürde okunabilirliğin okuduğunu anlama becerisi üzerine etkisini inceleyen birçok araştırma bulunmaktadır (Davis vd., 1990; Jubelirer et vd., 1994; Rooney vd., 2021). Bu araştırmalara göre, okuma düzeyi ile anlama düzeyi arasında doğrusal bir ilişki vardır (Davis vd., 1990; Jubelirer vd., 1994; Rooney vd., 2021). Örneğin, bir metin okuyucunun düzeyine ne kadar uygunsu okuyucunun anlaması da o derece yüksek olur (Davis vd., 1990). Diş ağrısı ile ilgili hızlı ve kesin çözüm arayışında olan okuyucu kitlesi göz önüne alınır, internette yer alan metinlerin de kolay anlaşılabilir ve yalın olması beklenmektedir. Bugüne dek, ‘diş ağrısı’ ile ilgili internet ortamında yer alan metinlerin okunabilirlik analizi yapılmamıştır. Bu çalışmada, internet ortamında yer alan, Türkçe dilinde yazılmış, diş ağrısına yönelik metinlerin okunabilirlik düzeyinin ve içeriğinin değerlendirilmesi amaçlanmıştır.

Türkiye genelinde en sık kullanılan arama motoru Google olması nedeniyle bu çalışmada arama motoru olarak sadece Google kullanılmıştır (<https://gs.statcounter.com>). Arama motoruna ‘diş ağrısı’ yazıldıktan sonra, kriterleri sağlayan ilk 50 web sitesi çalışmaya dahil edilmiştir. Bu sayının daha ötesine gitmenin gereksiz olduğuna karar verildi. Çünkü, internet kullanıcılarının yüzde 90’ı arama yaptığında, genellikle çıkan ilk 30 sonucu incelemektedirler (IProspect Search Engine User Behavior Study). Benzer şekilde, literatürdeki çoğu okunabilirlik çalışmalarında da 30,42, ya da 48 web sitesi analiz edilmiştir (Ateşçi & Kılınç, 2022; Taşdemir, 2023; Szmuda vd., 2020).

Hasta eğitim metinlerinin hastalar tarafından anlaşılabilirliği için Flesch indeksine göre, okunabilirliğinin 6-7. sınıf seviyesinde ya da altında olması önerilmektedir (Badarudeen & Sabharwal, 2010). Çalışmamızda diş ağrısı ile ilgili metinlerin tamamının 6-7. sınıftan daha yüksek okunabilirlik düzeyinde olduğu bulunmuştur. Buna göre, diş ağrısına ilişkin web sitesi yazılarının çoğu internet kullanıcılarına hitap etmediği anlaşılmaktadır. Ateşman indeksine göre ise, web sitelerinde yer alan metinlerin yüzde 80’inin ‘orta zorluk’; yüzde 20’sinin ‘kolay’ okunabilirlik düzeyinde olduğu bulunmuştur. Çalışmamızın sonuçları, dahil edilen tüm web sitesi kaynakları için ‘orta zorluk’ okunabilirlik düzeyindeki metinlerin, anlaşılabilirliği arttırmak amacıyla kolaylaştırılması konusunda farkındalık sağlayabilir.

Ateşman’a göre Türkçede ortalama cümle uzunluğu 9-10 kelime, ortalama sözcük uzunluğu ise 2,6’dır (Ateşman E., 1997). Çalışmamızda incelenen web sitesi kaynaklarındaki metinlerin hem sözcük uzunlukları hem de cümle uzunlukları bu verilerle uyumludur.

Son 1 yıl içerisinde Google trends (www.google.com/trends) verilerine göre, Google arama motorunda diş ağrısı ile alakalı en çok artış gösteren arama ‘çocuk diş ağrısı nasıl geçer’ sorusu olmuştur (Erişim tarihi: 18.12.2023). Diş ağrısı aramasına ilişkin çalışmamıza dahil edilen ilk 50 web sitesinin yalnızca %14’ünde çocuklarda diş ağrısı için bilgilendirme yapılmaktadır. Buna göre, web sitelerinde çocuklarda diş ağrısına ilişkin metinlere daha fazla yer verilmesi daha faydalı olabilir.

Murray ve ark. yaptıkları çalışmada, hastaların %85'inin doktor randevusu öncesinde problemlerini internette arattıklarını bildirmişlerdir (Murray vd., 2003). Son 1 yıl içerisinde Google trends verilerine göre de Google arama motorunda diş ağrısı ile en alakalı aratılan soru 'diş ağrısına ne iyi gelir' olmuştur (www.google Trends.com) (Erişim tarihi: 18.12.2023). Buna göre, internet kullanıcılarının diş ağrısı tedavisine yönelik kendi başlarına çözümler geliştirme eğiliminde olduğu ortaya çıkmaktadır. Bu durum, bilinçsiz ilaç kullanımına veya ev kürleri gibi tıptan uzak alternatif yollar denemeye yol açabilmektedir. Doktor kontrolünden uzak bu yöntemler, geri dönüşü olmayan birtakım zararlara yol açabilir ve tedavi edilmeye çalışılan durum daha da kötüye gidebilmektedir. Çalışmamızda, konuya ilişkin 2 soru sorulmuştur: 'Diş ağrısının evde tedavisine yönelik bilgi veriyor mu?' ve 'Diş ağrısını gidermek için yapılmaması gerekenlere ilişkin uyarılar içeriyor mu?' Metin kaynaklarına göre bu soruların cevabını içeren web siteleri analiz edilmiştir. Sonuçta, web sitelerinin yüzde 64'ünün evde diş ağrısını gidermeye yönelik çözümler sunduğu, ancak; web sitelerinin yalnızca yüzde 20'sinin yapılmaması gerekenler hakkında uyarılar içerdiği görülmüştür. Web sitesi kaynaklarının hastaları doğru yönlendirmeleri ve bilinçlendirmeleri kritik öneme sahiptir. Bu hususta, evde denenebilecek yöntemler kişiye çözüm olarak sunulsa dahi, kendi başına çözümün yeterli olmadığı, doktor kontrolünün ihmal edilmemesi gerektiği okuyucuya mutlaka vurgulanmalıdır.

Okuyucunun sağlık ehemmiyeti bakımından web sitelerinde yer alan metinlerin başta doğru olması, ardından anlaşılabilir olması konusunda dikkat edilmelidir. Bu nedenle, sağlık konusunda hasta bilinçlendirmelerini ve yönlendirmelerini kapsamına alan web sitelerinin okuyucuya ulaşmadan önce içerik ve okunabilirlik bakımından standardize edilmiş bir mevzuata tabi tutulması faydalı olabilir. Bu metinler, kolay anlaşılmadıklarında ve içerik bakımından eksik kaldıkları takdirde okuyucular için faydalı olmayacak; aksine yanlış anlaşılmalara yol açabilecektir. Bu nedenle, özellikle diş ağrısı gibi acil olarak nitelendirilebilecek durumlarla ilgili metinlerin içerik ve okunabilirlik düzeyi bakımından standart değerlendirmelerden geçtikten sonra yayımlanabilmesi kritik öneme sahiptir.

İnternette bulunan materyaller sürekli olarak giderek arttığından, çalışmamızın sonuçları yalnızca yapıldığı dönemde, okuyucular için mevcut olan bilgileri yansıtmıştır. Bu çalışmamızın bir limitasyonu olarak düşünülebilir. Bunun

yanı sıra, çalışmamızın bir diğer limitasyonu; yalnızca web sitelerinde bulunan metne dayalı olmasıdır. Web sitelerinde, metinle beraber bulunan videolar, grafikler, görseller, harflerin büyüklüğü gibi fiziksel etmenler metin içeriğinin anlaşılabilirliğini etkilemektedir. Ancak, benzer çalışmalarda da olduğu gibi, bizim çalışmamızda da okunabilirlik analizi yapılırken bu etkenler göz ardı edilip, yalnızca metin analiz edilerek okunabilirlik indeksi hesaplanmıştır.

SONUÇ

Çalışmamızın sonucunda, diş ağrısına ilişkin Türkçe web sitelerinde yer alan metinlerin önemli bir kısmının orta zorluk düzeyinde olduğu belirlenmiştir. İçerik bakımından ise, ağrıya ilişkin alınması gereken önlemlere, ağrıyı geçirmek amacıyla yapılmaması gerekenlere, ve hamileler ile çocuklarda diş ağrısına ilişkin bilgilendirmelere yeterince değinilmediği ortaya konulmuştur.

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Yazar Katkısı

Bu çalışma, yazarın tamamen kendi eseri olup, başka hiçbir yazarın çalışmada katkısı bulunmamaktadır.

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Biomechanical Comparison of Two Types of Compression Screws Using Finite Element Analysis and Servo-Hydraulic Testing Unit: An Ex Vitro Study

Mandibular Simfiz Fraktürlerinde Kullanılan İki Farklı Kompresyon Vidasının Biyomekanik Özelliklerinin Sonlu Elemanlar Analizi ve Servohidrolik Test Ünitesi ile Değerlendirilmesi ve Karşılaştırması: Ex Vitro bir Çalışma

Alanur ÇİFTÇİ ŞİŞMAN¹ , Altan VAROL² 

ABSTRACT

Objectives: Various types of fixation systems have been developed to stabilize the fractured fragments in their original position. The purpose of this ex vitro study was to compare the biomechanical properties of 2 fixation units provided by different types of second-generation headless cannulated compression screws (SG-HCCS) using a servo-hydraulic testing unit (STU) and finite element analysis (FEA).

Materials and Methods: Fourteen fresh frozen sheep cadaveric mandibles were divided into 2 groups randomly (n=7). 3.0 millimeters (mm) diameter, 20mm length partially threaded Herbert screws were used in Group 1 and 2.8mm diameter, 20mm length fully threaded HCCS were used in Group 2 for the fixation of the fragments that was made by a vertical osteotomy at the midline. 2 screws were placed in each model, parallel to each other but in opposite directions. All models were examined biomechanically for the stability of fixation by using STU and FEA.

Results: Both FEA and STU analysis revealed that the forces required to fail the fixation system provided by HCCS were significantly higher than Herbert screws.

Conclusions: Within the limits of this experimental study, the findings suggest that the biomechanical adequacy provided by second-generation compression screws may be a promising alternative in the treatment of mandibular symphysis fractures, aided by the favorable anatomy of the region. The study may also be useful for further studies in terms of evaluating and comparing different fixation systems in virtual environments using FEA.

Keywords: Bone screws, compression, finite element analysis, fracture fixation, mandible.

ÖZ


Amaç: Kırık parçaları orijinal pozisyonlarında sabitlemek için çeşitli fiksasyon sistemleri geliştirilmiştir. Bu ex vitro çalışmanın amacı, bir servohidrolik test ünitesi (STU) ve sonlu elemanlar analizi (SEA) kullanılarak 2 farklı tasarıma sahip ikinci nesil başsız kanüllü kompresyon vidaları kullanılarak oluşturulan fiksasyonun biyomekanik özelliklerini karşılaştırmaktır.

Gereç ve Yöntemler: On dört adet taze dondurulmuş koyun kadavra alt çenesi rastgele 2 gruba ayrıldı (n=7). Mandibular simfiste orta hatta vertikal osteotomi ile kırık hattı oluşturuldu. Oluşturulan kırık fragmanların fiksasyonu için Grup 1’de 3,0 mm çapında, 20 mm uzunluğunda kısmen yivli Herbert vidaları, Grup 2’de ise 2,8 mm çapında, 20 mm uzunluğunda tam yivli HCCS vidaları kullanıldı. Her modele birbirine paralel ancak zıt yönlerde 2 adet vida yerleştirildi. Tüm modeller, STU ve SEA kullanılarak fiksasyonun stabilitesi açısından biyomekanik olarak incelendi.

Bulgular: Hem SEA hem de STU analizleri, HCCS kullanılarak oluşturulan fiksasyonun bozulması için gereken kuvvetlerin Herbert vidalarından istatistiksel olarak anlamlı derecede yüksek olduğu gözlemlendi.

Sonuç: Bu deneysel çalışmanın sınırları dahilinde, bulgular, ikinci nesil kompresyon vidalarının sağladığı biyomekanik yeterliliğin, bölgenin uygun anatomisinin de yardımıyla mandibular simfiz kırıklarının tedavisinde umut verici bir alternatif olabileceğini düşündürmektedir. Çalışma ayrıca SEA kullanılarak sanal ortamlarda farklı sabitleme sistemlerinin değerlendirilmesi ve karşılaştırılması açısından ileriki araştırmalara da faydalı olabilir.

Anahtar Kelimeler: Çene kırıkları, kırık sabitlemesi, mandibula, sonlu eleman analizi.

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INTRODUCTION

Mandibular fractures occur more frequently than any other facial fracture, because the mandible is the most prominent and the only mobile bone of the facial skeleton. Among mandibular fractures, mandibular symphysis

fracture were reported as the most common (Brasileiro et.al.,2009). The key factors in managing a fracture are the stabilization and fixation of fracture segments. To provide a optimal fixation, various fixation systems have been developed up to date, ranging from wires to pins, plates and screws (Franz,2009).

Lag screw osteosynthesis in mandibular symphysis fractures is a well-established technique known for its effectiveness in providing stability due to its high compressive capability. However, a notable drawback of lag screws is bone resorption and tissue irritation caused by protrusion of the screw head. To prevent this, various modifications to screw design have been developed over time. Second generation cannulated compression screws (SG-HCCS) are one example of such modifications. Nonetheless, it was reported that the modifications in screw designs may compromise their biomechanical properties (Kozakiewicz,2018).

The aim of this study was to compare the biomechanical properties of two different designed SG-HCCSs—Herbert and HCCS—using a servo-hydraulic test unit (STU) and finite element analysis (FEA).

MATERIALS AND METHODS

This study was carried out in accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Animal Care and Use Committee of Marmara University (Istanbul, Turkey) with the approval number: 07.2014. mar dated 20.02.2014. Fourteen fresh sheep cadaveric mandibles were used in this study. The soft tissues of all mandibles were stripped off, and a linear vertical osteotomy was performed in the midline at the symphysis region using a micro-saw under saline irrigation. The samples were randomly divided into 2 experimental groups (n=7). In Group-1, 3.0mm diameter 20mm length cannulated Herbert screws (*TST Medical Devices, Istanbul, Turkey*) and in Group-2 2.8mm diameter 20mm length cannulated HCCS (*TST Medical Devices, Istanbul, Turkey*) were used for the fixation of the fragments. In each mandible 2 screws were placed, perpendicular to the osteotomy line, parallel but in an opposite direction to each other, 2-3 mm away from the apex of the anterior teeth.

Servo-hydraulic Tests

To set the experimental station properly, a pilot mandible model was generated by a 3D printer (*Flashforge creator, USA*) and a custom-made stainless steel holder was manufactured according to the model. Acrylic resin polymers were used to embed the angulus portions and fix the samples to the holder. All samples were examined in the STU (*Testometric M500 30 kn, Testometric Company Ltd. England*) for the following properties:

1. Maximum force (MF): The maximum force (N) that the fixation unit could tolerate before failure of the fixation.
2. Maximum displacement (MD): The amount of maximum displacement (mm) of the fractured fragments just before the screws slipping out from the bone.

The STU was calibrated with a 0.1 N pre-load force. To increase the sensitivity of the test, the displacement was arranged as 0.1 mm/minute. A continuous force, beginning from 0 N and increasing with a constant acceleration (0,1 mm displacement/minute) was applied perpendicular to the osteotomy line, until the stability of the fixation system failed as a result of the deformation of the screw, plate, or models. The data obtained from the STU were simultaneously transferred to computer and force-displacement graphics were formed by the Testometric Software (*Testometric Company Ltd. England*). For all samples, MF and MD were recorded.

Finite Element Analysis

FEA was initiated with post-op CT scans (0.5-mm sections in DICOM format) and followed by reverse engineering that can be described as converting the CT scans into solid models for computer supported engineering procedures. The data gained from the CT scan were saved as .stl data using MIMICS 10.01 (*Materialise, Leuven, Belgium*). For editing and refinement of the data, CATIA V5 R17 (*Computer Aided Three-dimensionnal Interactive Application, Dassault Systèmes, France*) was used. The material properties of the bone and screws in the model were defined according to experimental data from a previous study (Korkmaz,2007). Appropriate boundary conditions were imposed using Ansys Workbench 14.5 (*ANSYS Inc, PA, USA*). (Table 1) To obtain accurate results, the finite element model (FEM) was meshed into 10-nodal 132053 tetrahedral finite elements and 213500 nodes. Frictional contact was applied as the type of contact. FEA tests are applied virtually to simulate biomechanical tests. The

amount and distribution of maximum stress (MS) in the symphysis region, osteotomy line and screw were recorded under 100 N force.

Table 1. The material properties of the bone and screws (Korkmaz, 2007).

Material properties	Bone	Screw (Ti6A14V)
Elastic modulus	13700 MPa	113800 MPa
Poisson Ratio (ν)	0.3	0.342
Yield strength	100 MPa	880 MPa

Statistical Analysis

Statistical analysis were performed using SPSS 21.0 (IBM Corp, US) software. Shapiro-Wilk test was used to test the compliance of the data with normal distribution and Mann-Whitney U test was used to compare non-normally distributed variables. Results were evaluated at the $p < 0.05$ significance level, in 95% confidence interval (95% CI).

RESULTS

In the STU, MF ranged between 100-238N for Group-1 and 90-250N for Group-2. The MD ranged between 2-12mm for Group-1 and 5-12mm for Group-2. (Table-2)

Table-2. MF and MD values that recorded in STU.

Metrics	MF (N)			MD (mm)		
	Median (IQR)	Mean rank	Sum of rank	Median (IQR)	Mean rank	Sum of rank
Group-1	107,00	5,29	37,00	5,00	3,29	35,50
Group-2	138,00	9,21	68,00	12,00	7,20	69,60

*U=9,00 (p=0,047 p<0,05) *U=7,50 (p=0,026 p<0,05)

In FEA, MS under 100 N was measured as 107.05 MPa in Group-1. Considering that this value was greater than the bone's yield strength (107.05 MPa > 100 MPa), the fixation was predicted to fail. The stress occurring on the Herbert screw was measured as 120 MPa. As this average value was much smaller than the yield strength of the titanium screw (120 MPa < 880 MPa), the titanium screw was not expected to be damaged. In Group 2, MS under 100 N was measured as 102.75 MPa. Since this value was greater than the bone's yield strength (102.75 MPa > 100 MPa), the fixation unit was expected to fail. MS occurring on the HCCS was measured as 322.56 MPa. Since this value was much smaller than the yield strength of the titanium screw (120 MPa < 880 MPa), no damage was expected to the titanium screw.

DISCUSSION

Compression screws were reported as the most efficient tools for approximating fracture sites and enhancing stability through the generation of interfragmentary pressure (Franz,2009). Different modifications of a compression screw with the same diameter and length result in variable anchorage in the bone (Kozakiewicz & Sołtysiak,2017). We aimed to evaluate the stability of fixation provided by 2 differently designed SG-HCCS. Our null hypothesis was that a screw with a fully threaded design would increase friction along the fracture line and promote compression of the fragments, thus improving resistance against destructive forces. This study revealed that fixation provided by the 2.8 mm diameter HCCS was more able to withstand destructive forces than the 3.0 mm diameter Herbert screw.

The resistance of a screw to destructive stress is affected by various factors, including its profile, design, diameter, sharpness, and the number of threads (Galuppo et.al.,2002). HCCS and Herbert screws share common features including being headless, cannulated, conical in shape (narrowing from head to apex), titanium (Ti6A14V) made, self-cutting and self-tapping. The modified design of these screws offers several advantages. Being headless, eliminates the necessity for countersinking, which can lead to screw loosening and compromise stability. The ability to embed the leading and trailing tips into the drilled path minimizes irritation to the surrounding soft tissues (Kozakiewicz & Sołtysiak,2017). These 2 SG-HCCSs differ in terms of thread design: the HCCS is threaded along its entire long axis, whereas Herbert screw has no threads on the middle third. Rahpeyma et al. reported that the blank shaft in the center of Herbert screws allowed the approximation of fractured fragments without preventing their reduction but also the continuous thread design of the HCCS confers of greater compression compared to partially threaded Herbert-style screw designs (Rahpeyma,2016).

Mandibular symphysis was identified as an appropriate area for the screw fixation with the absence of any important vascular or neural anatomical structures. The curvature of interforaminal region allows for the accommodation of the entire length of the screw into the bone for the fixation of fractures. Further, thick cortical bone of the symphysis ensures secure subcortical placement and rigid fixation (Ram et.al.,2017). A significant handicap in the management of symphyseal fractures is the high degree of torsional stress (Budhreja et. al.,2018). One screw was reported to be insufficient to prevent the rotational movement of

the fracture fragments and the fragments may undergo torsion and shear forces. In the present study, we placed 2 screws in opposite directions in the horizontal plane, to prevent rotation, as recommended in the literature (Booth et al., 2003).

The use of SG-HCCSs in maxillofacial surgery appears to be focused mainly on condylar head fractures, with limited indications (Kozakiewicz, 2018). To the best of our knowledge, only a few studies have described the use of SG-HCCSs in the treatment of mandibular symphysis fractures. El-Mahallawy et al. reported that the fixation provided by HCCSs was a successful and minimally invasive treatment modality for the management of anterior mandibular fractures (El-Mahallawy & Al-Mahalawy, 2018). Sheep cadaveric mandibles are commonly used in such studies due to their similarity in thickness and size to the human mandibles (Haug et al., 2002). Van Hareen et al. reported there were no changes in the mechanical properties of preserved cadaveric animal bones which had been frozen and treated with 10% formaldehyde, and reported that they could be used safely in mechanical tests for up to one year of storage (van Haaren et al., 2008). We preferred to use sheep cadaveric mandibles because of their advantages and all samples were kept at -15°C in 10% formaldehyde solution throughout the study. Faran et al. compared the compressive forces of Herbert and HCCS on cancellous bone discs transected from fresh human cadavers and found no significant difference statistically but mathematically the resistance to tensile forces was found 42% higher in the HCCS group (Faran et al., 1999). They concluded that HCCS could be used preferably to Herbert screw in the young population, considering the correlation between cortical density and the compression of the screw. In contrast, Adla et al. compared 3.0 mm Herbert and 2.0 mm HCCS on cancellous bone models and found no significance between the compressions of the screws (Adla et al., 2005). This may be a result of the large difference in the screws' diameters. We aimed to examine the screws' biomechanical properties as objectively as possible by choosing their diameters closer to each other. Despite their relatively smaller diameter, HCCS exhibited statistically higher MF, MD, and MS values in STU and FEA than Herbert screws. The fully threaded design and profile of HCCS may be the cause of this difference.

In vivo studies were reported to be insufficient for fully understanding of the biomechanical effects of the inherent properties of the mandible, such as elasticity and density, and the vector of masticatory forces, including magnitude

and direction (Shyam Sundar et al., 2012). To assess the fixation unit *ex vitro*, biomechanical experimental and hypothetical techniques can be used. STU and FEA were reported to be the most common analysis methods for strain and stress analysis of different types of fixation systems (Atalı et al., 2014). In the biomechanical test units, the most challenging part is realistically performing the masticatory forces (Adla et al., 2005).

2 methods can be used to assess the displacement and maximum force that the fixation unit can withstand without deforming: applying predetermined forces or applying an incremental force with a constant acceleration, starting from 0 N and stopping when deformation occurs. In this study, similar to previous studies, a 100 N predetermined force was applied to the FEMs in FEA, as in a previous study (Bayram et al., 2009), while an incremental force with a constant acceleration (starting from 0 N and stopping when deformation occurs) was applied in STU (Peterson et al., 2005).

FEA was reported to be a reliable and convenient method for assessing stress distribution and clinical performance of complex geometric systems. A definite correlation between *ex vitro* studies and FEA studies using mandible models has been reported in many studies. In FEA, the analysis becomes easier to perform, as the object becomes simpler and vice versa. When it comes maxillofacial structures, the analysis can be challenging due to the complex nature. Hence, the modeling step is important in FEA for maxillofacial surgery (Bayram et al., 2009). The accuracy of FEA results relies on the similarity between the original biological structure and FEM, the quantity of nodes and the clearly defined boundary conditions. In the present study, the models were meshed into 132053 tetrahedral finite elements and 213500 nodes to obtain the proximate results. Since the element and node values of the FEM created in this study are close or higher than those of similar studies (Castaño et al., 2002) it was not necessary to make a convergence test for the models.

This study was limited by several factors. In STU, only one type loading protocol were used. Although the sample size was determined based on a previous study (Ram et al., 2017), larger samples could potentially yield more comprehensive results. Furthermore, it is important to consider that the anatomical and physical characteristics of the sheep cadaveric mandibles differ from those of humans. Besides, the absence of muscle attachments in the cadaveric mandibles could have been altered the biomechanical characteristics of the fixation unit comprising

the screw and bone. An experimental setting that closely imitates the human mandible with its surrounding soft tissues and masticatory muscles may be useful for a better understanding.

Modeling human structures is extremely difficult because of their complex anatomy. Given the incomplete understanding of the mechanical behaviors of these structures and the uncertainty in the model's ability to describe the physics of the system, it is inevitable that some assumptions will be accepted. It should be considered that the boundary conditions used for bone and biomaterials in FEA, are predetermined average values and the confidence of the analysis depends on the well-defined boundary conditions.

CONCLUSION

Both STU and FEA analysis revealed that the required force for failure of the fixation system was statistically higher in HCCS than in Herbert screw. Within the limits of this experimental study, the findings suggested that biomechanical competency of both SG-HCCSs can be promising in the management of mandibular symphysis fractures with the help of the suitable anatomy of the region. The study may also be helpful for the evaluation and comparison of different fixation systems in virtual environments using FEA, but further clinical studies are needed in this area.

Statements & Declarations

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

All authors contributed to the study conception and design. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics Approval

This study was carried out in accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Animal Care and Use Committee of Marmara University (Istanbul,

Turkey) with the approval number: 07.2014.mar dated 20.02.2014.

Consent to Participate

The study does not involve human subjects, no informed consent was needed.

Consent to Publish

The study does not contain any individual person's data in any form.

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The Effects of Different Surface Preparation Techniques on Enamel Surface Properties and Bond Strength

Farklı Yüzey Hazırlama Tekniklerinin Mine Yüzey Özelliklerine ve Bağlanma Dayanımına Etkisi

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ABSTRACT

Objectives: The purpose of this study was to investigate the morphological and chemical changes and bond strength on enamel surfaces subjected to different surface preparation.

Material and Methods: The samples were evaluated in *in vitro* tests with 7 different groups (acid etching, Er:YAG laser QSP mode, and Er:YAG laser MSP mode, Air-Flow, and combinations with acid). Surface profilometer and AFM were used to evaluate the surface roughness. After the surface treatment, the chemical changes were analyzed using SEM-EDS. The effects of preparation technique on the bond strength to the enamel surface were evaluated by using micro tensile and shear bond strength tests.

Results: The values obtained the surface roughness evaluation of surface profilometer and AFM were compatible with each other. The highest roughness value was found in QSP when all groups were compared. Ca/P ratios of the surfaces were evaluated as a result of SEM-EDS analysis and it was observed that Ca/P ratio increased in all groups except Acid. It was seen that the results obtained for all groups of micro tensile and shear bond strength tests were consistent with each other.

Conclusion: In conclusion, it is considered the use of Er:YAG laser QSP settings with acid can effect the long-term success of restorations clinically.

Keywords: AFM; Enamel; SEM-EDS; Surface Preparation.

ÖZ

Amaç: Bu çalışmanın amacı, farklı yüzey hazırlığına tabi tutulan mine yüzeylerdeki morfolojik ve kimyasal değişimler ile bağlanma mukavemetinin araştırılmasıdır.

Gereç ve Yöntemler: Örnekler *in vitro* testlerde kullanılmak üzere 7 farklı gruba (asit dağlama, Er:YAG lazer QSP modu ve Er:YAG lazer MSP modu, Air-Flow ve asitle kombinasyonlar) ayrıldı. Yüzey pürüzlülüğünü değerlendirmek için yüzey profilometresi ve AFM kullanıldı. Yüzey işleminden sonra

kimyasal değişiklikler SEM-EDS kullanılarak analiz edildi. Preparasyon tekniğinin mine yüzeyine bağlanma dayanımı üzerindeki etkileri mikro gerilim ve makaslama bağlanma dayanımı testleri kullanılarak değerlendirildi.

Bulgular: Yüzey profilometresi ve AFM'nin yüzey pürüzlülüğü değerlendirmesinden elde edilen değerler birbiriyle uyumluydu. Tüm gruplar karşılaştırıldığında en yüksek pürüzlülük değeri QSP'de bulundu. SEM-EDS analizi sonucunda yüzeylerin Ca/P oranları değerlendirilmiş ve Asit dışındaki tüm gruplarda Ca/P oranının arttığı görülmüştür. Mikro gerilim ve makaslama bağlanma dayanımı testlerinde tüm gruplar için elde edilen sonuçların birbiriyle uyumlu olduğu görüldü.

Sonuç: Sonuç olarak, Er:YAG lazer QSP ayarlarının asitle birlikte kullanılmasının klinik olarak restorasyonların uzun vadeli başarısını etkileyebileceği düşünülmektedir.

Anahtar kelimeler: AFM; Mine; SEM-EDS; Yüzey Hazırlığı

INTRODUCTION

The eruption of the permanent dentition occurs at an early age (~6 years), when the first permanent molar erupts, and is almost complete by ~12 years, with the eruption of the second molars. The teeth are often at highest risk to caries during this process, as the enamel is not fully matured, parents are often unaware of the newly erupting teeth, and cleaning difficulties can arise, due to tender gums. It may also be a challenge for children to brush all surfaces of the new erupting teeth, effectively, as molars exhibit a complex morphology, with pits and fissures covering 12% of the tooth surface (Subramaniam, Konde & Mandanna, 2008).

Occlusal pits and fissures vary morphologically, therefore, they are often irregular and narrow allowing the accumulation of bacteria and debris. This may cause caries due to demineralization of the occlusal surfaces. Currently, minimal restorative intervention aimed at the protection

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of healthy tooth structure as much as possible is used for the treatment of occlusal caries. The progress in adhesive dentistry and understanding of the caries process allow the successful restoration (Tyas & Burrow, 2004).

Various restorative materials have been used to date. Today, composite resins are the most preferred clinically among minimally invasive approaches. The most important factor affecting the clinical success of composite resin restorations is the quality of the adhesion between the dental hard tissues and the restorative materials, and herewith long-term retention. The quality of retention and adhesion is directly related to the etching technique (Matei, Popescu & Suci, 2014).

Phosphoric acid is utilized conventionally for conditioning of enamel surface. However, this method is time-consuming and has an unacceptable taste for children, requires technical precision and hereby caused evolving new alternative methods which increase the surface intensity of enamel. One of these alternative methods, the air-polishing system carries out a mechanical abrasive effect removing the organic debris when applied to the enamel surface. It has been reported that it can be used to etch the enamel surface prior to the restoration (Burnett, Shinkai & Eduardo C de, 2004).

The laser has a widespread clinical use in paediatric dentistry as well as contemporary dentistry. Laser treatment that is increasingly used in dentistry is considered as an enamel surface conditioning technique in recent years (Sagır, Usumez, Ademci & Usumez, 2013; Karandish, 2014).

The properties of sound enamel tissue must first be known for understanding caries, one of the common health problems nowadays. The inorganic part of enamel consists of hydroxyapatite crystals, which are a special form of calcium and phosphate substantially. The inorganic components of enamel also include calcium, phosphate, sodium and magnesium. Other inorganic components exist on lower proportions are; iron, zinc, strontium, fluorine, rubidium, bromide, vanadium, copper, manganese, gold, silver, chromium, cobalt (Weatherell, Robinson & Hallsworth, 1974).

The filler particle size in composite resin materials affects the character of the material. The flowable composite resins are used successfully in paediatric dentistry because of low viscosity, easy adaptation of the cavity shape, and easy application (Jackson & Morgan, 2000).

It is frequently preferred for restoration of pit and fissure caries due to the fact that the shape of the cavity is not ideal and, therefore, penetration into the cavity and prevents the

polymerization shrinkage. The efficient bonding depends on the wettability of the tooth tissues on which the adhesive is applied. Accordingly, the wettability of enamel, which is composed of hydroxyapatite crystals with high surface energy, is high and the adhesion to enamel is more successful. The earliest accepted method is the total-etch approach, which is based on the principle of completely removing the smear layer. Firstly, the etching of the dental hard tissue is performed. Three-step ethanol-water based total-etch adhesives are considered the gold standard in terms of bond strength (De Munck et al., 2005).

The bond strength of composite resin materials to enamel tissue can be influenced by various factors. The enamel surface must be prepared before treatment to ensure that the restorative material is adhered to the enamel surface. Thus, the surface energy of enamel is improved. Depending on the different preparation techniques and the adhesive system used, the surface properties of the dental tissue can affect the bond strength (Sattabanasuk, Vachiramon, Qian & Armstrong, 2007; Firat, Gurgan & Gutknecht, 2012).

In vitro tests are frequently used for the investigation of newly developed materials and methods (Van Meerbeek et al., 2003). Various methods are used to evaluate the morphological and chemical effects of different dental treatments. The use of bond strength analysis as well as surface roughness and chemical composition analyzes allows for leading of the clinical success of the materials and techniques.

Nowadays, different methods are used to improve the adhesion between the dental hard tissues and the composite resins frequently used clinically. In this respect, researchers have been interested in the use of laser, which have been increasingly used in dentistry recently, as a method of the enamel etching.

Based on this information, it was aimed to investigate the morphological and chemical changes of the enamel surfaces on which prepared with different etching techniques and the bond strength with a flowable composite resin *in vitro*. The purpose of this study was to compare the conventional (acid) and novel (air-polishing and laser) enamel etching techniques. The initial hypothesis was admitted that the use of QSP setting of Er: YAG laser for the enamel etching was statistically significant in terms of surface roughness and bond strength in the study.

MATERIALS AND METHODS

Ethical committee approval for the study was obtained from the Faculty of Dentistry Ethics Committee (2016/011).

This study was conducted in two processes *in vitro*. Various tests were applied to evaluate the effects of different surface preparation techniques on the enamel composition and bond strength.

Firstly, the evaluation of the surface roughness of enamel before and after etching was done using Atomic Force Microscopy and Surface Profilometer. The structural changes of enamel samples after etching were examined by Scanning Electron Microscopy. Subsequently, the changes in the mineral content of the enamel that was prepared by different etching techniques were evaluated by Energy Diffraction X-Ray Spectroscopy.

Secondly, the effects of preparation technique on the bond strength between the flowable composite resin with total-etch adhesive and the enamel surface were evaluated by using micro tensile and shear bond strength tests.

Preparation of teeth to be used for in vitro study

A total of 322 impacted human third molars were collected from the patients referred to Department of Oral and Maxillofacial Surgery with the verbal and written consent for this *in vitro* study. The teeth were cleaned of organic debris and stored in distilled water at room temperature.

Preparation of Teeth for the Investigation of Surface Properties

The root portions of the teeth were separated from the crown portions by the precision sectioning device under water cooling (Isomet 1000, Buehler Lake Bluff, IL, USA). Then, the buccal surfaces of the crown parts of the teeth were formed into smooth surfaces under water cooling with silicone carbide waterproof sandpaper (600, 1000, 1200 grit). The samples were checked with a x40 magnification under the stereomicroscope in terms of defect presence and the appearance of dentin tissue. Subsequently, the samples with the buccal surfaces exposed were placed on a plastic cylinder mold with an internal diameter of 10 mm and a height of 2 mm and over a red wax, and the plastic molds were filled with the self-curing acrylic resin (Panacryl, Arma, Istanbul, Turkey). The samples removed from the molds were checked for surface parallax. The surfaces of the specimens were

marked as 2 equal parts, and one side was subjected to etching while the other side was not processed. 'T' indicating 'tested' was written on the etching side and 'C' indicating 'controlled' was written on the non-processed side.

Preparation of Teeth for the Investigation of Bond Strength

The sample preparation was performed same as the investigation of surface properties. The only difference was that the plastic molds used had an inside diameter of 10 mm and a height of 20 mm.

A total of 154 specimens were prepared for surface profilometer, AFM and SEM-EDS studies. A total of 168 specimens were prepared for micro tensile and shear bond strength tests. The samples were kept in glass bottles with distilled water at room temperature until the testing time. The samples were randomly divided into 7 groups according to enamel surface preparation techniques.

Surface preparation procedures

Acid etching

The samples were first washed and dried. The surface was then prepared with 37% phosphoric acid (N-etch, Kerr Italia, S.R.L., Scafati, Salerno, Italy) in accordance with the manufacturer's instructions for 20 seconds. The surface was washed with water for 20 seconds to remove the acid and air-dried for 10 seconds.

Laser etching

The samples were prepared with the cylindrical sapphire tip attached to H14C for 15 seconds with horizontal movements at a distance of 1 mm from the surface and perpendicular to the surface using two different settings (QSP mode and MSP mode at 10 Hz, 1.2W, 120 mJ) of Er:YAG laser (LightWalker AT, Fotona, Slovenia).

Air-polishing etching

The samples were prepared with Air-Flow Master Piezon (EMS, Nyon, Swiss) device and Air-flow Classic Powder for 30 seconds with horizontal movements at a distance of 2 mm from the surface with pressure air and water (33.2 ± 1.7 mL/min and 10.8 L/min).

The Implementation of Restorative Material to The Samples

A conventional adhesive system and a nanohybrid composite were applied to the surface of etched enamel specimens which was prepared for use in micro tensile and shear bond strength tests.

The samples were dried slightly for 3 seconds, Prime in OptiBond FL (Kerr Italia, S.r.l., Scafati, Salerno, Italy) kit was applied to the surface with a small brush for 15 seconds. Afterwards, low-pressure air was applied for 5 seconds. Then, Adhesive was applied with a small brush for 15 seconds and thinned for 3 seconds by low pressure air to spread to the enamel surface. Subsequently, it was polymerized for 20 seconds.

Standard teflon molds with 3 mm diameter and 4 mm height were placed on the enamel surfaces where the adhesive system was applied. Tetric N-Flow (Ivoclar-Vivadent, Schaan, Liechtenstein, a nanohybrid flowable composite, was applied to these cavities in 2 mm layers and polymerized for 20 seconds. The mold was carefully removed and polymerized for 20 seconds.

Surface Roughness Analysis

Twenty samples from each group were used for the surface roughness analysis. The evaluations were made on two different surfaces, one of which was the controlled and tested portions of each sample. SurfTest SJ-210 (Mitutoyo Corporation, Tokyo, Japan) was used to measure the surface roughness of the samples. The device calibration before each measurement was made in accordance with the manufacturer's recommendations. The surface roughness was measured from randomly selected three different points and each measurement was repeated 3 times (0.5 mm/sec). Then, the obtained values are recorded in micrometers. The evaluations were made by taking the arithmetic mean of these 3 values (Ra = Roughness average).

AFM Analysis

One sample from each group was used for the AFM analysis. The evaluations were made on two different surfaces, one of which was the controlled and tested portions of each sample. The surface topography of the samples was studied with AFM XE-100 (PSIA Corp, Sang – Daewon-dong, Korea) in non-contact mode. For each sample, the sample surface was scanned at two randomly chosen 10

$\mu\text{m} \times 10 \mu\text{m}$ areas (0.5 Hz). Three-dimensional images and numerical surface roughness (Ra) of the scanned areas were obtained.

SEM-EDS Analysis

One sample from each group was used for the SEM-EDS analysis. The evaluations were made on two different surfaces, one of which was the controlled and tested portions of each sample. SEM-EDS examinations of samples were performed with SEM SU-1510 (Hitachi High Technologies Corporation, Tokyo, Japan). The samples were fixed on discs with double sided carbon adhesive. For SEM evaluations, samples were first coated with gold-palladium on a Denton Vacuum Desk V Cold Sputter / Etch Unit (Desk V Cold Sputter/Etch Unit, Denton Vacuum LLC, NJ, USA) with a thickness of 50 Å for 60 seconds (30 mA, 0,05 torr). Digital images were obtained at different magnification ratios (x2000 and x5000). EDS analysis of the same samples were carried out in order to determine mineral content and weight as %. Ca% P% Na% and O% were calculated by surface element analysis on both sides of the enamel surface by evaluating randomly selected 6 different points of each surface. All the obtained values were recorded in written form.

Shear Bond Strength Test

Twenty samples from each group were analyzed by universal test device (Shimadzu AGSX, Shimadzu Corporation, Tokyo, Japan) for shear bond strength. The samples were fixed on the auxiliary metal pieces. The rounded separator tip, 0.5 mm thickness, was placed perpendicular to the connection surface between enamel and composite resin. The separator tip was applied at a crossing speed of 0.5 mm / min until the bonding failure occurred (Jafari, Shahabi, Chiniforush & Shariat, 2013). The obtained values were recorded with the computer connected to the device as Newton and later converted to Megapascal (mPa). Afterwards, the specimens were examined with a stereomicroscope at x40 magnification in order to determine the type of failures (adhesive, cohesive, mixed).

Micro Tensile Bond Strength Test

First, 1 x 1 x 4 mm sticks were prepared under water cooling with the precision sectioning device. Microtensile Test Device MTD-500 (SD Mechatronic MTD 500,

Germany) was used for the test. The sticks were fixed on the metal holding part of the device with a cyanoacrylate based adhesive. The tensile strength was applied to the specimens at a speed of 1 mm / min until the bonding failure occurred (Phrukkannon, Burrow & Tyas, 1998). The results were recorded in Newtons, then converted to mPa. The specimens were examined by stereomicroscope (Leica Stereo Explorer, Leica Microsystems Ltd, Heerbrugg, Swiss) to determine the failure types.

Statistical Evaluation

Statistical evaluations of all obtained data were performed with the SPSS 21.0 program (SPSS, Chicago, USA). One-way ANOVA was used to determine whether there was a difference between the groups if each variable had a normal distribution, and the Bonferroni test was used for the binary comparison of the groups. Kruskal-Wallis and Mann-Whitney U tests were used for non-normal distribution variables. The descriptive statistics; arithmetic mean, standard deviation, median, minimum and maximum values were shown. Statistical significance was set at $p < 0.05$.

RESULTS

The initial hypothesis was accepted based on the results of the study. The results were presented in the following headings.

Results of Surface Roughness Analysis

The descriptive statistics values of all groups are shown in Table 1. The highest Ra values were obtained in QSP, while the lowest Ra values were observed in the control groups.

The roughness values of the ‘control’ subgroups of all groups were found statistically significantly lower than the ‘test’ subgroups. Moreover, the effect of surface preparation on the roughness values was statistically considerable. The increase in surface roughness values between ‘control’ and ‘test’ subgroups of Acid, Air-Flow and Air-Flow + Acid were not statistically significant while the values between ‘control’ and ‘test’ subgroups of MSP, QSP, MSP+Asit ve QSP+Asit were significant.

Table 1. Surface roughness analysis for all groups.

Groups	N	R _{max}	R _{min}	R _{medium}	R _a ± SD	
Acid	Control	20	0,319	0,293	0,302	0,304±0,01
	Test		0,582	0,384	0,408	0,436±0,12
MSP	Control	20	0,365	0,276	0,299	0,316±0,04
	Test		8,773	5,881	8,198	7,438±0,40
QSP	Control	20	0,699	0,376	0,459	0,496±0,16
	Test		9,610	8,702	8,992	9,045±0,43
Air-Flow	Control	20	0,643	0,341	0,438	0,471±0,14
	Test		2,153	0,780	1,028	1,283±0,79
MSP+Acid	Control	20	0,296	0,203	0,243	0,253±0,03
	Test		8,058	6,817	7,097	7,257±0,67
QSP+Acid	Control	20	0,880	0,585	0,766	0,748±0,08
	Test		8,091	6,706	7,336	7,346±0,53
Air-Flow+Acid	Control	20	0,300	0,196	0,271	0,259±0,02
	Test		0,892	0,684	0,814	0,798±0,05

*Bonferroni test
MSP: Medium-Short Pulse
QSP: Quantum-Square Pulse

Results of AFM Analysis

The dark areas denoted pits and the light areas signified hills on the images. The highest surface roughness values were observed in QSP while the lowest values were monitored in the control groups similarly to the results of the surface roughness analysis (Table 2). There was also created three-dimensional image of the surface enamel. The effect of surface preparation on the increase of surface roughness values in all groups was found statistically significant.

Table 2. AFM analysis for all groups.

Groups	Average		
	R _a	R _q	
Acid	Control	16,552	20,472
	Test	28,013	60,601
MSP	Control	13,311	16,748
	Test	311,210	344,045
QSP	Control	37,260	48,577
	Test	332,012	398,321
Air-Flow	Control	23,873	30,390
	Test	36,565	46,377
MSP+Acid	Control	19,845	26,894
	Test	123,373	139,845
QSP+Acid	Control	19,598	24,266
	Test	195,074	243,901
Air-Flow+Acid	Control	121,925	145,438
	Test	196,733	218,983

*Bonferroni test
MSP: Medium-Short Pulse
QSP: Quantum-Square Pulse

The investigation of the samples in ‘control’ groups with AFM revealed that the enamel crystals were arranged on the surface in a shallow and regular manner. The enamel crystals were arranged irregularly and the regional cavities were monitored due to the dissolution of the crystals on the ‘test’ samples of Acid group (Fig. 1a).

It was observed the irregular slight depths on the images of the ‘test’ samples of MSP and QSP groups. In addition, the micro-cracks were found on the samples etched with only laser. The ‘test’ samples of Air-Flow group showed an irregular and non-uniform structure (Fig. 1b, 1c, 1d).

The ‘test’ samples of MSP + Acid and QSP + Acid groups showed more regular texture than Acid group. It was observed less irregularity on the ‘test’ samples of Air-Flow + Acid groups than laser groups but more amorphous than Air-Flow group (Fig. 1e, 1f, 1g).

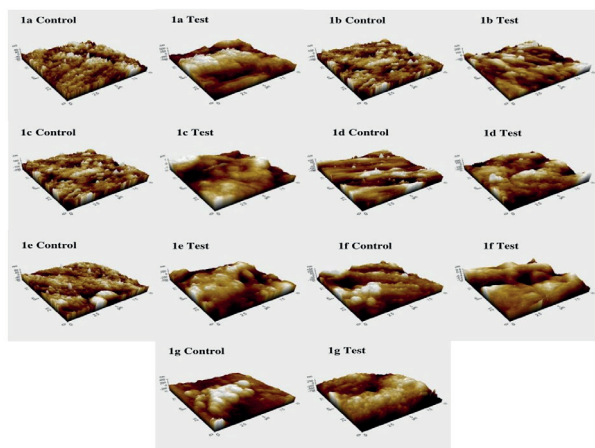


Figure 1: 1a control: AFM images of ‘Control’ enamel sample of Acid group. 1a test : AFM images of ‘Test’ enamel sample of Acid group. 1b control: AFM images of ‘Control’ enamel sample of MSP group. 1b test: AFM images of ‘Test’ enamel sample of MSP group. 1c control: AFM images of ‘Control’ enamel sample of QSP group. 1c test: AFM images of ‘Test’ enamel sample of QSP group. 1d control: AFM images of ‘Control’ enamel sample of Air-flow group. 1d test: AFM images of ‘Test’ enamel sample of Air-flow group. 1e control: AFM images of ‘Control’ enamel sample of MSP+Acid group. 1e test: AFM images of ‘Test’ enamel sample of MSP+Acid group. 1f control: AFM images of ‘Control’ enamel sample of QSP+Acid group. 1f test: AFM images of ‘Test’ enamel sample of QSP+Acid group. 1g control: AFM images of ‘Control’ enamel sample of Air-flow+Acid group. 1g test: AFM images of ‘Test’ enamel sample of Air-flow+Acid group

Results of SEM Analysis

The mean values of EDS analysis applied to examine the amount and distribution of the minerals on the surface of the specimens evaluated by SEM were shown in Table 3. Different morphological changes were observed on the enamel surfaces etched with different procedures on the SEM images. The honeycomb appearance was clearly visible on the surface of the ‘test’ samples in Acid group. It was present that the dissolution of the crystals and the gaps between enamel crystals (Fig. 2a).

The SEM images of the ‘test’ specimens in MSP and QSP groups showed that the obstruction of the gaps and the formation of irregular craters (Fig. 2b, 2c).

The smear layer was observed on the SEM images of the ‘test’ samples in Air-Flow group due to the ingredient of Air-flow Classic Powder (Fig. 2d).

The SEM images of the ‘test’ specimens in MSP+Acid and QSP+Acid groups showed that the obstruction of the gaps and the formation of irregular craters with the honeycomb appearance (Fig. 2e,2f).

The smear layer with the irregular honeycomb appearance was observed on the SEM images of the ‘test’ samples in Air-Flow group due to the ingredient of Air-flow Classic Powder (Fig. 2g).

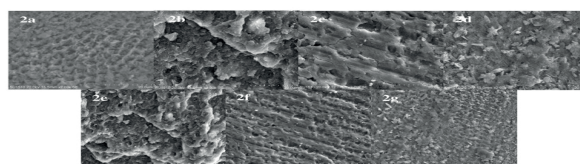


Figure 2: 2a. SEM images of ‘Test’ enamel sample of Acid group. 2b: SEM images of ‘Test’ enamel samples MSP group. 2c: SEM images of ‘Test’ enamel samples QSP group. 2d: SEM images of ‘Test’ enamel samples Air-flow group. 2e: SEM images of ‘Test’ enamel samples MSP+Acid group. 2f: SEM images of ‘Test’ enamel samples QSP+Acid group. 2g: SEM images of ‘Test’ enamel samples Air-flow+Acid group

Wilcoxon test, a nonparametric test, was performed on the data that had no normal distribution. The weight and atomic percentages of the elements (Ca, O, P, Na) and Ca / P ratios in all groups were compared with the ‘control’ and ‘test’ groups and the difference between them was evaluated (Table 3).

There was no statistical difference between the ‘control’ and ‘test’ samples in Acid, Air-Flow, MSP+Acid, QSP+Acid,

Table 3. Ca/P ratio and weight percentages of mineral distributions of enamel samples.

Groups	Subgroups	Weight %				
		Calcium	Phosphate	Oxigen	Sodium	Ca/P
Acid	Control	21,82±2,30	11,58±0,97	62,79±3,06	1,14±0,15	1,88±0,09
	Test	23,55±2,19	13,02±0,50	65,45±3,86	0,63±0,15	1,80±0,12
MSP	Control	26,34±1,10	14,77±1,03	58,14±1,47	0,69±0,14	1,78±0,05
	Test	23,93±0,19	12,36±1,55	62,28±0,68	0,44±0,05	1,93±0,07
QSP	Control	22,94±0,78	12,01±1,33	64,38±0,89	0,70±0,13	1,89±0,14
	Test	20,80±0,81	9,44±0,65	66,45±1,13	0,59±0,08	2,43±0,29
Air-Flow	Control	23,38±1,23	12,51±1,09	63,18±0,96	1,08±0,33	1,84±0,03
	Test	21,47±1,04	11,62±1,05	65,66±0,46	0,93±0,19	1,86±0,04
MSP+Acid	Control	21,56±1,02	12,25±0,63	65,43±0,49	0,70±0,11	1,73±0,02
	Test	21,00±1,15	12,12±0,60	66,17±0,19	0,75±0,09	1,76±0,03
QSP+Acid	Control	21,92±0,77	12,15±0,68	67,30±0,22	0,77±0,02	1,80±0,07
	Test	20,75±0,28	11,19±0,49	65,15±0,18	0,76±0,02	1,85±0,09
Air-Flow+Acid	Control	21,79±0,58	11,99±0,26	65,37±0,65	0,83±0,09	1,81±0,01
	Test	21,17±0,21	11,15±0,70	65,53±0,67	1,22±0,24	1,89±0,03

*Wilcoxon test

MSP: Medium-Short Pulse

QSP: Quantum-Square Pulse

Air-Flow+Acid groups in terms of EDS analysis (Chart). The increase in Ca / P ratio was found to be statistically higher than the other groups comparing the ‘control’ and ‘test’ samples in MSP and QSP groups.

Results of Microtensile and Shear Bond Strength Analysis

The ‘test’ samples of QSP+Acid group yielded the highest shear bond strength while the ‘test’ samples of Air-Flow exhibited the lowest values. The descriptive statistics of shear bond strength values of all groups are given in the Table 4.

Table 4. Descriptive statistics of shear bond strenght values.

Groups	N	Min (mPa)	Max (mPa)	Mean(mPa) ± Standard Deviation
Acid	20	4,25	8,11	5,86 ± 2,00
MSP	20	4,76	6,66	5,45 ± 1,05
QSP	20	4,99	7,17	6,19 ± 1,10
Air-Flow	20	3,37	3,98	3,72 ± 0,31
MSP+Acid	20	4,52	7,47	6,25 ± 1,54
QSP+Acid	20	7,06	8,99	8,07 ± 0,96
Air-Flow+Acid	20	4,26	6,13	5,1 ± 0,94

*Shapiro-Wilk analysis, one-way ANOVA, Bonferroni test

MSP: Medium-Short Pulse

QSP: Quantum-Square Pulse

Shapiro-Wilk analysis resulted in the assumption of normality (p> 0.05). The difference between Air-Flow and QSP + Acid group (p <0,05) was significant based on one-way ANOVA, but no significant difference was observed between the other groups. It was seen that the results of the microtensile bond strengths were in compatible with the shear bond strength. The descriptive statistics of microtensile bond strength values are given in the Table 5.

Shapiro-Wilk analysis resulted that the data had normal distribution (p> 0.05). There was a significant difference between all groups according to the one-way ANOVA and Bonferroni’s multiple comparison analysis.

Table 5. Descriptive statistics of microtensile bond strenght values.

Groups	N	Min (mPa)	Max (mPa)	Mean(mPa) ± Standard Deviation
Acid	10	5,63	10,36	7,61 ± 0,01
MSP	10	5,84	10,71	6,92 ± 0,02
QSP	10	5,74	10,93	7,73 ± 0,23
Air-Flow	10	4,25	7,95	5,45 ± 0,14
MSP+Acid	10	6,42	12,31	10,11 ± 0,06
QSP+Acid	10	6,10	12,64	11,82 ± 0,45
Air-Flow+Acid	10	4,36	8,85	6,84 ± 0,09

*Shapiro-Wilk analysis, one-way ANOVA, Bonferroni test

MSP: Medium-Short Pulse

QSP: Quantum-Square Pulse

DISCUSSION

This study was planned in order to investigate the surface properties, composition and bond strength of enamel etched with several procedures and thus, to increase the success of restorations.

The pits and fissures are the most sensitive surface to caries (Cehreli, Gungor & Karabulut, 2006). The most important issue in clinical evaluation is to decide whether the restoration is necessary for suspected fissure. Various restoration materials have been used in paediatric dentistry. The widespread use of composite resins and the adoption of minimally invasive approaches have resulted in more satisfactory results both in esthetics and function. The role of adhesive systems in bonding of composite resins is precious. Adhesive systems are classified as total-etch, self-etch and glass ionomer adhesive systems according to the effects on the smear layer. These systems form the basis of adhesives (Unlu, Ermis, Sener, Kucukyilmaz & Cetin, 2010). The adhesive system used in current study was a three-step total-etch adhesive that requires the separate etching and washing steps. This process was followed by primer and adhesive resin application.

Several studies exist in the literature reporting that the traditional three-step total-etch adhesive systems exhibit more successful results than the newly developed, simplified adhesive systems in laboratory tests (De Munck et al., 2003; Shirai et al., 2005; Imai et al., 2017). The results of these studies confirm that the three-step total-etch adhesive systems can be used as a gold standard in assessing the clinical performance of newly developed adhesives (De Munck et al., 2003). A number of laboratory studies has been reported that providing stronger bond to enamel with total-etch adhesive systems (Pashley & Tay, 2001; Perdigo & Swift, 2006; Kalra, Suprabha, Rao, Shenoy & Lewis, 2015; Schwendicke, Doméjean, Ricketts & Peters, 2015).

Kalra et al. (2015) applied three different surface treatments (total-etch and self-etch adhesive systems, only acid etching) to the enamel surfaces with initial caries lesions, before performing the resin-based fissure sealant. It was noticed that the highest bond strength values were obtained in the total-etch adhesive system group.

Schwendicke et al. (2015) implemented composite resin restorations with three different self-etch and total-etch adhesive to the extracted human teeth. In the study, it was assessed the integrity of restorations, microleakage and resistance to fracture and attained statistically higher values

in total-etch groups. In our study, Optibond FL, a total-etch adhesive system, was used based on the literature.

The improvements in modern dentistry facilitate the essential function and aesthetic with minimal loss of dental tissue. The use of flowable composites is one of the major advances for dental material technology (Bonilla, Yashar & Caputo, 2003).

The use of flowable composites in paediatric dentistry is encouraged due to the low viscosity, consistency, easy adaptation and application (Jackson & Morgan, 2000). It was investigated the radiopacity of six different flowable composite resins. The supreme values were indicated in Tetric N Flow and Clearfil Majesty Flow groups. It has been suggested that the radiopacity of the composite resins is considerable for detecting new caries formation (Ergücü, Türkün, Onem & Güneri, 2010). Therefore, Tetric N-Flow, a nanohybrid composite, was preferred for our study (Jackson & Morgan, 2000; Baroudi & Rodrigues, 2015).

The intent of the enamel surface conditioning is to create a proper tooth surface for chemical and micro-mechanical bonding of the adhesive systems (Espinosa et al., 2010). In our study, the acid etching, a standard and recognized method, was used based on the literature. However, it has led to search for alternative methods that would further increase the enamel surface energy because of the unpleasant taste and technical sensitivity. For this purpose, it was considered that different methods such as laser and air polishing systems could be used besides acid (Boyde, 1984; Usumez & Aykent, 2003).

Agrawal and Shigli (2012) prepared the occlusal surfaces of the teeth with only brush, brush with prophylactic paste, burs, air-polishing, air-abrasion and acid etching with time extension methods before applying resin-based fissure sealant. In this study in which microleakage was evaluated, the lowest values were observed in the groups that burs, air-abrasion and air-polishing systems were used respectively while there was no statistically difference between the groups.

Brocklehurst, Joshi, and Northeast (1992) evaluated the effectiveness of different cleaning methods such as prophylactic paste, only water, air-polishing systems prior to fissure sealant on the success of restoration. It has been reported that the use of air-polishing system increases the depth of penetration of the resin to the enamel surface. In our study, it was intended to compare with the studies in

the literature using the only air-polishing and combination with acid.

Nowadays, erbium lasers are preferred for the enamel etching while Nd:YAG and CO₂ lasers have been used in the past. Er:YAG laser can be absorbed at high rate by the water and hydroxyapatite of dental tissue (Karandish, 2014).

Keller and Hibst (1993) prepared the bovine enamel prepared with acid and Er:YAG laser at different energy levels for SEM observations and bond strength of a composite resin. The acid and laser etched surfaces demonstrated similar morphological changes on SEM images. There was no statistically significant difference between acid and laser groups in terms of bond strength of the composite resin.

Sagir et al. (2013) investigated the bond strength of the orthodontic brackets to the enamel etched with acid and Er:YAG laser at MSP and QSP settings. Significant differences were not observed between the laser MSP and QSP settings while higher bond strength values were obtained in both laser groups than the acid group.

In another study, it was investigated the bond strength of the orthodontic brackets to the enamel etched with different methods (acid, Er:YAG laser MSP and QSP settings). The use of QSP etching with self-etch adhesive system has been reported to exhibit the highest statistical values (Akin, Veli, Erdur, Aksakalli & Uysal, 2016).

The outcomes of studies in which used Er:YAG laser etching may differ slightly (Gurgan et al., 2008). The conflict on this issue is considered depend on the variable parameters of laser used in the studies (Firat et al., 2012). In current study, it was evaluated the effect of two different settings of Er:YAG laser and conventional acid etching to the success of composite resins. In literature review, it has not been observed any study investigating the conventional and novel etching techniques together.

Different surface conditioning methods can induce changes in content and structure of the enamel. The solubility and permeability of the enamel may also vary if the ratios between the organic and inorganic components of the enamel change. Hence, the alternative etching methods should have minimal effect on the structure and surface properties of the enamel (Rohanizadeh, LeGeros, Fan, Jean & Daculsi, 1999).

Clinical trials are the most effective method to demonstrate the long-term success of adhesive systems and composite resin restorations. Nevertheless, the fact

that clinical trials are difficult and time-consuming, and the results are not determinable when considering ethical reasons. However, *in vitro* tests give more accurate results with shorter time and lower cost (Van Meerbeek et al., 2003). Our study was conducted as *in vitro* because of controlling variables and resulting in a short time.

The teeth used in the current study were collected among the impacted third molars intended to imitate the immature permanent teeth. The plane of teeth used in the laboratory studies may affect the results. The buccal surfaces of teeth are commonly used because the thickness of occlusal enamel differs. Based on this information, the impacted third molar teeth were used for the current study and stored in distilled water until the test time.

The surface roughness is a substantial parameters used to assess the success of composite resins *in vitro* (Mikulewicz, Szymkowski & Matthews-Brzozowska, 2007). Contact and non-contact profilometers are used for the evaluation of surface roughness (Wan Bakar & McIntyre 2008; Barkmeier, Erickson, Kimmes, Latta & Wilwerding, 2009; Ganss, Lussi, Sommer, Klimek & Schlueter, 2010). In the present study, we used the contact profilometer performing precise measurements and “Ra” values was used. In this respect, there is an opportunity to compare with other studies (Silva & Zuanon, 2006). Kim et al. (2007) examined the enamel surfaces of premolar teeth with a surface profilometer and obtained Ra values of $0,45 \pm 0,52 \mu\text{m}$. It is also compatible with the results of our study that the individual differences in Ra values exist.

Barkmeier et al. (2009) investigated the surface roughness of the enamel (prepared with total-etch and self-etch adhesives) with profilometer, and the bond strength of a composite resin. The total-etch adhesive group exhibited the highest values in all respect.

AFM enables to investigate the surface roughness in micro and nano levels. AFM was preferred for our study due to the reliability on the monitoring of surface changes (White et al., 2010). AFM ensures a three-dimensional image of dental surfaces. The most commonly used parameter for the evaluation of the data obtained with AFM is Rq values (Raposo, Ferreira & Ribeiro, 2007).

The morphological and structural changes on the enamel surfaces etched with Er: YAG laser by AFM and SEM-EDS were evaluated in a study. It was observed the triangular recesses on the laser etched surfaces (Rodriguez-Vilchis, Contreras-Bulnes, Olea-Mejia, Sánchez-Flores

& Centeno-Pedraza, 2011). In our study, AFM images consistent with the literature were obtained.

In dentistry, SEM is often used as a supporting analysis in studies. EDS serves to analyze the chemical composition of a structure. In our study, it was observed regular and small pores on the enamel surfaces of Acid group while irregular and various sized pores on the enamel surfaces of laser groups. The results of AFM and SEM analysis were compatible with each other. EDS analysis was performed to standardize the mineral content of the specimens prior to the surface preparation and there was no statistically significant difference between the groups (de-Melo et al., 2011). It has been reported that various etching methods may change the mineral ratios of enamel surface (Rodriguez-Vilchis et al., 2011; Keinan, Mass & Zilberman, 2010).

Alcantara-Galeana et al. (2017) examined the structural and morphological changes on the deciduous teeth etched with acid, Er: YAG laser and self-etch adhesive system with SEM-EDS. It has been reported that Er:YAG laser etching increased the mineral ratios.

This study aims at the integrated evaluation of the different surface conditioning techniques all in one which is not covered in the previously reviewed literature. The SEM-EDS results of this study are consistent with the research performed by Rodriguez-Vilchis et al. (2011) and Kwon, Kwon, Kim, and Kim (2003) The distribution of minerals in the enamel are influenced by the different surface conditioning techniques. It was observed that Ca / P ratio increased in all groups except the Acid group. The increase in MSP and QSP groups was significant while the increase in the other groups was not significant.

The most essential consideration in the success of composite resins is the adhesion between the dental hard tissue and material. The bond strength tests are often preferred used to evaluate the success of resin-based dental materials (Heintze & Zimmerli, 2011). In our study, micro tensile and shear bond strengths were performed.

Sasaki et al. (2008) investigated the micro tensile bond strength of the composite resin material to the enamel surface on which etched with acid, Er:YAG laser and combined. It has been reported that the highest bond strength values were obtained with the combined use of acid and Er:YAG laser.

Firat et al. (2012) evaluated the micro tensile bond strength of the composite resin and a total-etch adhesive system to the enamel and dentin on which etched with acid and Er:YAG laser at the different pulse duration and energy

level. It was stated the bond strength values were decreased as the pulse duration increased in the laser etched groups. However, it has indicated that the use of laser with acid etching increased the bond strength.

In our study, it was observed that the use of Er:YAG laser QSP setting with acid significantly increased the micro tensile and shear bond strength in concordance with the literature (Akin et al., 2016; Altunsoy, Botsali, Korkut, Kucukyilmaz & Sener, 2014; Buyukhatipoglu, Ozsevik, Secilmis & Usumez, 2016).

CONCLUSION

It was predicted that besides the conventional acid etching, the use of laser, air-polishing systems, and the combination with acid may be alternative promising methods in terms of the increase for the bond strength. The use of Er:YAG laser QSP setting was prompted to be a method for improving the success of the restorations as it has increased the Ca / P ratio and bond strength. The fact remains that these *in vitro* studies need to be supported by *in vivo* studies for the effectiveness.

Conflict of Interest

The authors declare that they have no conflict of interest related to this

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Authors' contributions

BA performed the literature review and collected the data. YS created the study design. YS consulted on idea and hypothesis. BA carried out the laboratory study and wrote the manuscript. YS critically revised the manuscript. All authors have made substantive contribution to this study and manuscript, and all have reviewed the final paper prior to its submission.

Disclosure statement

The authors declare that they have no conflict of interest.

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Investigation of Serotonin 2A Receptor Gene 5-HTR2A rs6311 Polymorphism in Trigeminal Neuralgia Disease

Trigeminal Nevralji Hastalığında Serotonin 2A Reseptör Geni 5-HTR2A rs6311 Polimorfizminin Araştırılması

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ABSTRACT

Objectives: Trigeminal neuralgia (TN) is a disease that occurs in the distribution region of the trigeminal nerve and is frequently recurrent pain. Serotonin (5-HT) acts on neurotransmitters in the central nervous system. The study aims to examine the relationship between sensitivity and pain intensity of the serotonin receptor gene (5-HTR2A) and rs6311 polymorphism in patients by examining TN genetically.

Materials and Methods: The study consisted of 10 TN patients and 10 healthy individuals. Genotyping of 5-HTR2A rs6311 polymorphism using DNA isolated from blood, Real-Time

PCR in StepOnePlus device, and TaqMan SNP Genotyping Tests were performed by manufacturers' protocols.

Results: In 5HTR2A rs6311 analysis, 3 of 10 TN patients were found to have CC, 5 had CT and 2 had TT genotype. In the control group, CC genotype was detected in 4 individuals, CT genotype in 4 individuals, and TT genotype in 2 individuals.

Conclusion: It was found that the TN genotype and allelic frequency differences between the patient and control groups were not significant. However, the CT genotype was found to be more common.

Keywords: Trigeminal neuralgia, polymorphism, serotonin, serotonin receptor

ÖZ

Amaç: Trigeminal nevralkji (TN), trigeminal sinirin dağılım bölgesinde ortaya çıkan ve sıklıkla tekrarlayan ağrılarla karakterize bir hastalıktır. Serotonin (5-HT), merkezi sinir sistemindeki nörotransmitterlere etki eder. Çalışmada, TN'yi genetik olarak inceleyerek hastalarda serotonin reseptör geni (5-HTR2A) duyarlılığı ve ağrı şiddeti ile rs6311 polimorfizmi arasındaki ilişkiyi araştırmak amaçlanmıştır.

Gereç ve Yöntem: Çalışmada 10 TN hastası ve 10 sağlıklı birey yer almıştır. 5-HTR2A rs6311 polimorfizminin genotiplemesi kanlardan izole edilen DNA ile StepOnePlus cihazında Real-Time PCR ve TaqMan SNP Genotipleme Testleri kullanılarak üretici protokolüne uygun olarak yapılmıştır.

Bulgular: 5HTR2A rs6311 analizinde, 10 TN hastasından 3'ünde CC, 5'inde CT ve 2'sinde TT genotipinin varlığı tespit edildi. Kontrol grubunda ise 4 kişide CC genotipi, 4 kişide CT genotipi ve 2 kişide TT genotipi tespit edildi.

Sonuç: Hasta ve kontrol grupları arasındaki TN genotipi frekans farklılıklarının anlamlı olmadığı görüldü. Ancak CT genotipinin diğerlerine göre daha yaygın olduğu görüldü.

Anahtar Kelimeler: Trigeminal nevralkji, polimorfizm, serotonin, serotonin reseptörü

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INTRODUCTION

Trigeminal neuralgia (TN) is a disease that has sudden, usually unilateral, short-term, stabbing, and recurrent pain that occurs in the distribution area of the branches of the trigeminal nerve (McMillan R, 2011). This pain originating from the trigeminal nerve, responsible for facial sensation, is in the form of sudden and severe attacks. The duration of the pain can be a few seconds or a few minutes. It mostly occurs on one side of the face, teeth, and jaw (Maarbjerg et al., 2017). To diagnose the disease, at least three of the four factors created according to the International Association for the Study of Pain (IASP) must be present. TN has been examined in many ways by several studies, however, there is no consensus on the causes and treatment yet (Küçük Kurt et al., 2019).

Serotonin (5-hydroxytryptamine, 5-HT) is a hormone that regulates neurotransmitters in the central nervous system and also has psychological effects. It is one of the most important neuromodulators in the central nervous system. In previous studies, it has been found that serotonin plays a crucial role in many physiological processes such as cell division, neuronal migration, and differentiation (Paredes et al., 2019). In addition, 5-HT is an effective factor in pain disorders originating from the trigeminal system. The 5-HT receptor family is divided into seven subfamilies (5-HT₁, 5-HT₂, 5-HT₃, 5-HT₄, 5-HT₅, 5-HT₆, 5-HT₇) consisting of 14 receptor subtypes. Serotonin 2A receptor (5-HTR2A) can be found in almost all organs. They are effective in wound healing and blood coagulation, as well as taking part in many neural events in the central nervous system. Besides 5-HTR2A is effective in mental disorders and processes such as learning and memory, and also in the production of nerve cells (Ebdrup et al., 2011).

The study aims to examine the relationship between pain content and responses of the expanded 5-HTR2A by examining the genetic aspects of trigeminal neuralgia.

MATERIALS AND METHODS

Study Group

The study consisted of 10 individuals diagnosed with trigeminal neuralgia (TN group) and 10 healthy individuals without TN (C group). The study protocol was prepared by the Helsinki Declaration 2 (2015) guidelines and was approved by Marmara University Ethics Committee (protocol code: 09.2021.323).

Study inclusion criteria: TN diagnosis by a neurologist, maxilla/mandible attacks, unilateral neuralgia in 2nd/3rd trigeminal branches, no genetic disease in family/self, age 18-65. Exclusion criteria: Presence of organic factors such as tumors or other brain lesions (eg multiple sclerosis), presence of atypical facial pain with symptoms similar to TN, presence of a genetic disease in the family, not being 18-65 years old range.

DNA Isolation and Genotyping

For genomic DNA isolation, 200 µL peripheral blood samples were collected in the EDTA-containing tubes and a PureLink DNA isolation kit (Invitrogen, Van Allen Way Carlsbad, CA, USA) was used for isolation, as previously stated (Kazancı et al., 2021). All the samples were isolated at the same day, and the isolated DNAs were kept at -20°C until the genotyping process was carried out.

Real Time – PCR Analyses

Genotyping of the 5-HTR2A rs6311 polymorphism was performed using Real-Time PCR on the StepOnePlus (Thermo Fisher Scientific, Inc.) instrument. Commercially available TaqMan SNP Genotyping Assays genotyping kits were used according to manufacturers' protocols (cat. no. 4371355, Thermo Fisher Scientific, Inc.).

Statistical Analysis

Statistical analyses of the results were performed using the SPSS 25.0 program and by the χ^2 (chi-square) test. The P-value of less than 0.05 was regarded as statistically significant.

RESULTS

Genotype and allele distributions of individuals with and without TN disease are given in Table 1 and 2, respectively. In the 5-HTR2A rs6311 analysis, 3 (30%) TN patients had CC, 5 (50%) CT, and 2 (20%) TT genotypes (Table 1). When the distributions of alleles were examined, it was seen that it was 55% for the C allele and 45% for the T allele (Table 2). In the C group, 4 individuals were CC, 4 were CT and 2 were TT genotype. When the distributions of alleles were examined, it was seen that it was 60% for the C allele and 40% for the T allele.

The quantitative Real-Time PCR amplification of the 5-HTR2A rs6311 polymorphism in the CC, CT, and TT genotypes is shown in Fig. 1. FAM (blue curve) indicates the T allele, while VIC (green curve) indicates the C allele. (A) The

single green curve shows the homozygous genotype of CC (Fig. 1A), the green and blue curves show the heterozygous genotype of CT (Fig. 1B), and the single blue curve shows the homozygous genotype of TT (Fig. 1C).

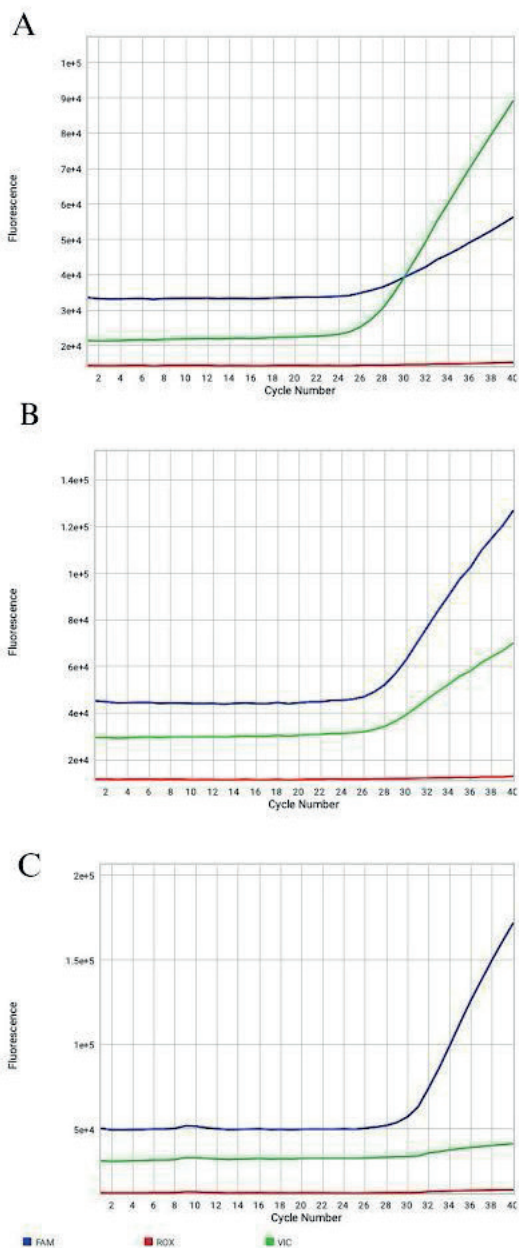


Figure 1. Real Time – PCR image of 5-HTR2A rs6311 polymorphism. Genotype A is CC homozygous. For this genotype, a high fluorescence signal is observed in the FAM channel and a low fluorescence signal in the VIC channel. Genotype B is CT heterozygous. For this genotype, a moderate fluorescence signal is observed in FAM and VIC channels. Genotype C is TT homozygous. For this genotype, a low fluorescence signal is observed in the FAM channel and a high fluorescence signal in the VIC channel.

Table 1. Genotype distributions of individuals with and without TN disease.

	Genotype			P value
	CC	CT	TT	
TN (n=10)	3	5	2	0.8807
Percentage	30%	50%	20%	
C (n=10)	4	4	2	
Percentage	40%	40%	20%	

TN: Trigeminal neuralgia group. C: Control group

Table 2. Allele distributions of individuals with and without TN disease.

	Allelic Frequency		P value
	C	T	
TN (n=10)	11	9	0.7491
Percentage	55%	45%	
C (n=10)	12	8	
Percentage	60%	40%	

TN: Trigeminal neuralgia group. C: Control group

DISCUSSION

Serotonin is a neurotransmitter that regulates neural activity and plays important roles both in the brain and many parts of the body through its receptors (Berger et al., 2017). Serotonin and its receptors have also been associated with the development of several diseases such as Alzheimer’s disease (Thome et al., 2001), Parkinson’s disease (Lee et al., 2012), migraine (Naito et al., 2010, Yücel et al., 2016), schizophrenia (Golimbet et al., 2007) and temporomandibular pain disorders (Cui et al., 2014) in humans and animal models, but the mechanisms by which they induce pain remain unclear.

In the study examining the effects of drugs targeting specific serotonin receptors on different diseases, it was stated that more than one serotonin receptor is expressed in all regions of the brain and that neurons can express multiple serotonin receptors (Berger et al., 2017). Di Stefano et al. (2020) conducted a genetic analysis of neuronal TN, suggesting that trigeminal neurons respond rapidly to stimuli in their study, in which they systematically described the clinical features of TN patients with the same characteristics. As a result of the study, it was pointed out that these patients displayed genetic variations in the genes responsible for voltage-gated ion channels and transient receptor channels. Besides, the study comparing the expressions of Nav1.3, Nav1.7, and Nav1.8 in TN patients with healthy individuals, the relationship between sodium channels and

acute and chronic neuropathic pain was evaluated and it was reported that Nav1.7 causes insensitivity to pain syndromes (Siqueria et al., 2009). This channel is referred to as Nav1.8. Nav1.3 is an embryonic channel expressed in neurons in neuropathic conditions and after injury. This study points to the expression of these molecules in individuals suffering from chronic pain. In the study examining the relationship between the serotonin transporter gene 5-HT and rs25531 polymorphism and pain severity in TN patients, it was determined that the genotype distribution of 5-HTTLPR between patients and healthy individuals was different and that the short-short genotype was higher in patients than in controls. However, it was suggested that the rs25531 polymorphism was not associated with TN susceptibility and/or pain severity (Cui et al., 2014).

Genetic variations play an important role in the diagnosis and treatment of chronic pain. In the case of chronic pain conditions like fibromyalgia, low back pain, migraine, and TN, it has been found that the serotonin transporter gene affects the release of neurotransmitters into the synaptic cleft and regulates neurotransmission (Knezevic et al., 2018). HTR2A gene c.102T> C (rs6313) and 1438A>G (rs6311) variants affect impulse control and the formation of repetitive behaviors. The T allele, which is associated with increased receptor expression, is linked to impulsivity and repetitive behaviors in diseases such as Parkinson's disease. The genetic influence leading to these behaviors significantly increases in the low levodopa equivalent dose groups, which raises the risk of developing the disease in CT and TT carriers by 2.8 and 6.9 times, respectively (Lee et al., 2012). Regina et al. (2007) determined the frequency and linkage disequilibrium for – 1438A/G, – 1420C/T, and – 783A/G in their study on promoter single nucleotide polymorphisms, and significant linkage disequilibrium was pointed between SNPs and – 1438A/G (rs6311) and – 783A/G (rs6312). Also, no significant difference in promoter activity between the A – and G-alleles of the – 1438 locus was seen when expressed with the – 1420C/T and – 783A/G major alleles. It was observed that the mRNA expression of the 5-HT2A receptor in the human fibroblast cell line, and the – 783A/G polymorphism significantly changed the effects of the – 1438A/G single nucleotide polymorphism.

CONCLUSION

In our study, no difference was found between genotype ($p=0.8807$) and allelic ($p=0.7491$) frequencies between TN

patients and the control group. Accordingly, we found that the CT genotype was more common in the patients. In light of this information, we think that the rs6311 polymorphism in the 5-HTR2A gene may be effective in TN patients, but more effective results can be obtained by increasing the study group.

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Limitation of the study: Since the sample collection phase of the study coincided with the COVID-19 pandemic, patients' arrival at the clinic was disrupted. For this reason, the number of individuals remained below the planned.

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Sert Damak Defektli Diyabetik Hastanın İmplant Destekli Hareketli Protez ile Protetik Rehabilitasyonu: Vaka Sunumu

Prosthetic Rehabilitation of a Diabetic Patient with Palatal Defect with Implant Supported Removable Prosthesis: Case Report

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ÖZ

Çene yüz protezleri konjenital sebepler, tümör ve travma sonrası meydana gelen defektler sonucunda bozulan stomatognatik sistem bütünlüğünün rehabilitasyonu amacıyla uygulanan protetik yaklaşımlardır. Damak defekti bulunan hastalarda kaybedilen doku kaynaklı fonksiyon, fonasyon ve estetik problemler meydana gelmektedir. Uygulanacak protezler, defekti kapatmalı ayrıca estetik ve fonasyonun rehabilitasyonunu sağlamalıdır. Damak defekti bulunan hastaların protetik tedavisinde tedavi yaklaşımlarında konvansiyonel ve implant destekli protezlerden faydalanılabilir. Tümör kaynaklı damak defekti bulunan 65 yaşında erkek hasta, damak defektinin tedavisi amacıyla Marmara Üniversitesi Diş Hekimliği Fakültesi'ne başvurmuştur. İntrooral ve radyolojik değerlendirme sonrasında hastanın protetik planlaması yapılmıştır. Protetik planlama sonucu hastanın üst çenesi 4 adet topuz ataşman üzeri implant destekli hareketli protez, dişsiz alt çenesi ise tam protez ile rehabilite edilmiştir. 3 yıllık kullanım sonrasında hasta; fonksiyon, fonasyon ve estetik açıdan protezlerinden memnun olduğunu bildirmiştir.

Anahtar Kelimeler: Sert damak defekti, topuz ataşman, implant, diabetes mellitus

ABSTRACT

Maxillofacial prostheses are prosthetic techniques used to restore integrity that has been compromised by congenital causes, tumors, or post-traumatic abnormalities. Loss of tissue-related function, phonation and aesthetic problems are inevitable in patients with palate defects. Prostheses to be applied to patients with palate defect should close the defect area and also prevent aesthetic and phonation problems. Conventional and implant supported prostheses can be used for the prosthetic palatal defect patient's. A 65-year-old male with palatal deformity was referred to the Faculty of Dentistry at Marmara University. After intraoral and radiographic assessment, the patient's prosthetic treatment plan was determined. As a result of prosthetic planning, the patient's maxilla was rehabilitated with an implant-supported removable prosthesis on 4 ball attachments, and toothless mandible was rehabilitated with a complete denture. The patient reported that was satisfied with prostheses in terms of function, phonation and aesthetics during three-year-recall evaluation.

Keywords: Palatal defect, ball attachment, implant, diabetes mellitus

GİRİŞ

Kazanılmış defektlere sahip bireylerin protetik tedavisinde amaç estetik, fonksiyonel ve fonetik rehabilitasyonun yanında; deformitelerin sebep olduğu olası psikolojik etkileri de ortadan kaldırmaktır. Maksillofasiyal defekte sahip hastalarda; dikey boyut kaybı sonrasında gelişen azalmış yüz desteği, TME rahatsızlıkları, konuşma bozuklukları, estetik kayıp, çiğneme fonksiyonunda yetersizlik gibi fiziksel ve fonksiyonel eksiklikler görülebilmektedir (Hickey & Salter, 2006).

Diabetes mellitus öyküsü bulunan yaşlı erişkinlerin artan prevalansı, önemli bir sosyal yük haline gelmiştir. Diabetes mellitus tedavisi için yeni terapötik ajanlar tedavi

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seçeneklerimizi genişletmiş olsa da, hastaların sağlığı için dengeli beslenme ve düzenli egzersiz şarttır. Düzensiz beslenme kaynaklı hiperglisemi ve hipoglisemi gibi komplikasyonlar yaşlı erişkinlerde kognitif bozukluk ve kan şekeri regülasyonu için risk faktörü oluşturmaktadır. Modern diyet tedavisinin amacı sadece glisemik kontrolü düzgün bir şekilde yönetmek değil, aynı zamanda her hasta için en uygun tıbbi bakımı sağlamaktır (Tamura ve ark., 2020). Diabetes mellitus gibi sistemik sıkıntısı bulunan damak defektine sahip hastaların protetik tedavisi, yutkunma ve konuşma sırasında yumuşak damak ve faringeal duvarlar arasında etkin kapanma meydana getirilmesinin ve beslenme rehabilitasyonunun sağlanabilirliğinin zorluğu nedeniyle dikkat gerektiren bir işlemdir. Farklı şekillerde ortaya çıkabilen palatofaringeal eksiklikler etiyojisine göre doğuştan, sonradan veya gelişimsel defektler olarak sınıflandırılabilir (Ysunza ve ark., 2015; Buğurman ve Türker, 2007).

Maksillofasiyal defekte sahip bireylerin tedavisinde defektin büyüklüğü ve hastanın sosyo-ekonomik durumu oldukça etkilidir (Reisberg, 2000). Damak defektine sahip yetişkin hastaların tedavisinde protetik obtüratörler yapılır. Obtüratör yardımı ile yiyecek ve sıvı yetersizliği (regürjitasyonu) önlenmekte ve konuşma daha anlaşılır bir hale gelmektedir (Varghese, 2014). Obtüratör yapımı ve protetik rehabilitasyon, tam dişsiz hastalarda destek alınabilecek dişlerin olmaması ve yumuşak doku desteğinin defekt varlığı sebebiyle azalmasından ötürü zorlaşmaktadır. Bu gibi durumlarda, gerekli protez stabilitesinin ve tutuculuğunun elde edilebilmesi için implantlardan faydalanılabilir. İmplant tutuculu/destekli hareketli protezler genellikle 2 veya 4 implant üzerine uygulanan protezlerdir. Protezlerin planmasından önce implantların sayısı, lokalizasyonu, ataşman seçimi gibi faktörler değerlendirilmelidir. Birbirlerine paralel olarak uygulanmış implantlar üzerine yerleştirilen bar, topuz, locator ya da magnet ataşmalar impant tutuculu/destekli hareketli protezlerin tutuculuk ve stabilizasyonun sağlanmasında kullanılabilir (Özkan, 2012).

Bu çalışmanın amacı, tip 1 diabetes mellitus öyküsü bulunan damak defektine sahip erkek hastanın topuz başlı ataşmanlı implant tutuculu bir obtüratör yardımı ile rehabilitasyonunun anlatılmasıdır.

VAKA SUNUMU

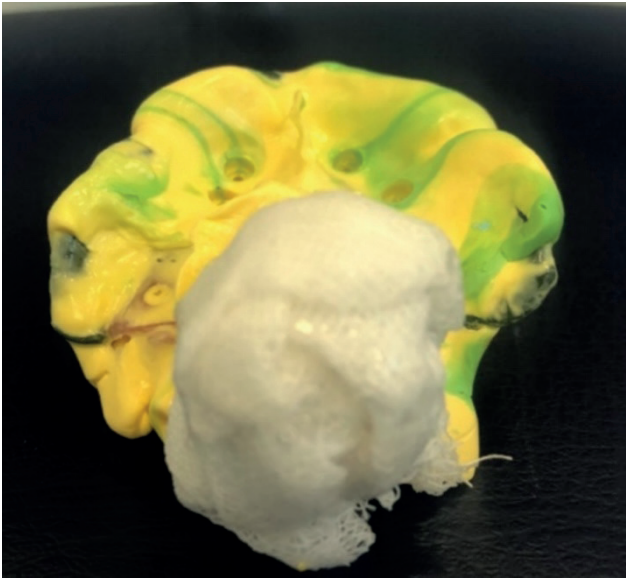
Üst çenesinde damak defekti bulunan 65 yaşındaki erkek hasta, konuşma, beslenme ve estetik bozuklukların rehabilitasyonu için Marmara Üniversitesi Diş Hekimliği Fakültesi'ne başvurdu. Uygulanacak tedavi ile ilgili hastaya gerekli bilgilendirmeler anlatılarak, hastanın yazılı ve sözlü onamı alındı. Alınan anamnezde sert damaktaki defektin 15 yıl önce kanser kaynaklı bir operasyon sonrasında meydana geldiği öğrenildi. Hasta, cerrahi işlem sonrasında eksik dişlerinin tedavisi için 15 yıl önce implant tedavisi uygulandığını ve üzerine implant destekli tam protez yapıldığını belirtti.

Sistemik anamnez sorgulandığında, tip 1 diabetes mellitus öyküsü bulunan hastanın etken maddesi insülin glarjin, insülin aspartat ve metformin hidroklorür olan ilaçları kullandığı, sigara ve alkol tüketimi olmadığı tespit edildi. Konuşma bozukluğunun yanı sıra mevcut protezlerinin uyumsuzluğu sebebiyle beslenme yetersizliği bulunan hastada beslenme bozukluğuna bağlı olarak kan şekeri düzensizliğinin var olduğu belirlendi.

Hastanın ağız içi muayenesinde, sert damaktan yumuşak damağa kadar devam eden defekt tespit edildi (Şekil 1). Hastanın teşhis modelleri elde edilerek protez planlaması yapıldı. Kaybedilmiş estetik ve çiğneme fonksiyonunun rehabilitasyonu için, mevcut olan 4 implant üzerine yapılacak hareketli bir protezle defekt bölgesinin protetik olarak kapatılmasına karar verildi. Teşhis modeli üzerine bireysel kaşık yapıldı. Ölçü aşamasında, üst çene için defekt bölgesine ölçü maddesinin kaçmasını engellemek amacı ile uygulanmış steril gaz tamponlar defekt içerisine yerleştirildi. Hermetik kapamanın sağlanabilmesi için kenar şekillendirilmesinde termoplastik stenç materyali (Kerr Company, SpofaDental, Markova, Çek Cumhuriyeti) kullanıldı. Kenar şekillendirme işlemi tamamlandıktan sonra polieter ölçü maddesi ile (Hydrorise Monophase, Zhermack, Badia Polesine, İtalya) ölçü alındı (Şekil 2). Alt çenenin ölçüsü için ise hazırlanan bireysel kaşıklardan kenar şekillendirme işlemi yapıldıktan sonra çinko oksit ojenol (SS White, Gloucester, İngiltere) ölçü materyali kullanıldı. Ana model üzerinden hazırlanan mum duvarlarla hastanın vertikal ve horizontal ilişkileri yarı ayarlanabilir artikülator (AmannGirrbach Artex Type CPR, Herrschaftswiesen Koblach, Avusturya) kullanılarak kaydedildi (Şekil 3). Seçilen uygun boyuttaki yapay dişlerle (VITA, Vitapan, Bad Sackingen, Almanya) dişli prova aşaması tamamlandıktan sonra protezin bitim aşaması tamamlandı.



Şekil 1: Defekt bölgesinin ağız içi görünümü

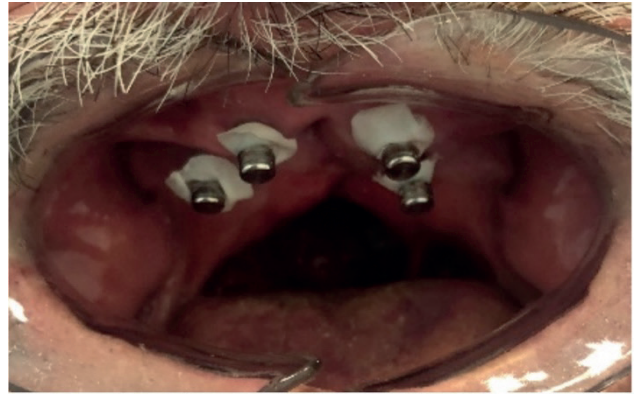


Şekil 2: Defekt ve implantların ölçüsü



Şekil 3: Alt çene ölçüsü

Çapları belirlenen topuz başlı ataşmanlara uygun dişi parçaları, ağız içerisinde uyumları kontrol edildikten sonra otopolimerizan rezin (Ufi Gel P, Voco, GmbH, Almanya) materyali ile protez içerisine adapte edildi. Uyumlama işlemi sonrası doku düzenleyici materyali (Viscogel, Dentsply, GmbH, Almanya) ile defektin nihai ölçüsü elde edildi. (Şekil 4A/B). Defekt sınırlarının doğru tespiti için yutkunma ve konuşma hareketlerinden faydalanıldı. Tekrarlanan su içme hareketi yardımı ile velofarengal kapamanın sağlandığından emin olundu. Hastaya 1 gün boyunca kullanılan protezin defekt bölgesine bakan iç yüzeyi laboratuvarında daimi yumuşak astar materyali (Molloplast B, Detax, GmbH & Co. KG, Ettlingen, Almanya) ile astarlandı (Şekil 5).



Şekil 4: A) İmplant dişi parçalarının uyumlanması B) Defekt bölgesinin Viscogel ile ölçüsünün alınması



Şekil 5: Defekt bölgesinin Molloplast ile düzenlenmiş hali

Bitmiş protezlerin ağız içerisinde oklüzal temas ilişkileri bilateral balanslı oklüzyona uygun olacak şekilde ayarlandı ve doku ile uyumları kontrol edilerek hastaya teslim edildi (Şekil 6).



Şekil 6: Bitim

TARTIŞMA

Damak defektli hastaların tedavilerinde multidisipliner yaklaşım söz konusudur. Damak defektinin rehabilitasyon sürecinin karmaşık ve kapsamlı olması sebebi ile planlama detaylı bir şekilde yapılmalı, hasta memnuniyeti ve rehabilitasyonu sağlanmalıdır (Meşe & Özdemir, 2008).

Tedavinin son basamağı olan protetik rehabilitasyon sürecinde pek çok tedavi yaklaşımı bulunmaktadır. Hastaya uygun olan tedavi seçeneğinin belirlenmesinde; daha önceden herhangi bir tedavi uygulanmış olup olmaması, hastanın yaşı ve sosyo-ekonomik durumu etkilidir. Naranyhaopeta ve arkadaşları tam dişsizliğe sahip damak defektli bulunan hastanın protetik tedavisinde topuz ataşmanlı implant destekli hareketli protez ile tamamlamışlar ve dental implantların defektli vakalarda stabilite ve konforu arttırdığını ve protetik rehabilitasyon aşamasında topuz ataşman kullanımının daha kolay ve ekonomik bir alternatif olduğunu bildirmişlerdir (Narayanraopeta ve ark., 2020) İlgili literatüre paralel olarak vaka çalışmamızda damak defektli hastamızın tedavisinde topuz ataşmanlar üzerine uygun diş parçalar kullanılarak implant destekli maksiller obtüratörlü protez yapılmıştır.

Tuna ve arkadaşları, yumuşak ve sert damak defektli bulunan tam dişsiz hastalarında obtüratörün protezin tutuculuğunu arttırmak amacı ile posterior uzantıya sahip çift taraflı bar ataşmandan yararlanmışlardır. Dudak damak defektine sahip hastaların tedavisinde deneyim ve yaratıcılığın önemini vurgulamışlar ve iyi planlanmış bir protetik planlama ile daha tatmin edici fonksiyonel ve estetik sonuçlar elde edileceğini bildirmişlerdir (Tuna ve ark., 2009). Vaka çalışmamızda hastanın sosyo-ekonomik durumunun yetersizliği sebebiyle bar tipi ataşman yerine var olan topuz başlı ataşmanların kullanılması tercih edilmiştir.

Gümüş ve Tuna, bilateral dudak damak defektli bulunan kısmi dişsiz hastalarının protetik tedavisi için bar ataşman ve diş destekli hareketli protez uygulamışlardır. Obtütatör protezleri ile fonksiyonel, estetik ve fonasyonel beklentilerin sağlanmasında en kritik aşamanın alt yapı dizaynının belirlenmesi olduğunu bildirmişlerdir. Protez ağırlığındaki azalmanın stabilizasyon ve tutuculuğu arttırdığını ve ayrıca hasta adaptasyonunu kolaylaştırdığını belirtmişlerdir (Gümüş & Tuna, 2009). Ok ve arkadaşları çift taraflı dudak damak defektli bulunan hastaların protetik rehabilitasyonunda hareketli protez uygulamayı tercih etmişlerdir. Geniş defekt alanı bulunan hastada ağızda

var olan tek dişi tutuculuğu arttırması amacı ile protez planlamasına dahil etmişlerdir. Dudak damak defektine sahip hastaların tedavisinde multidisipliner bir yaklaşım gerektiğini, fakat cerrahi tedavi endikasyonu bulunmayan veya cerrahi tedaviyi kabul etmeyen hastalarda iyi bir protez planlaması ile tatmin edici sonuçların hedefleneceğini belirtmişlerdir (Ok ve ark., 2016). Vakamızda ise tam dişsizliğe sahip olan hastanın protezin tutuculuğunun sağlanmasında implantlar üzerine yerleştirilen topuz ataşmanlardan faydalanılmıştır.

SONUÇ

Diabetes mellitus öyküsüne sahip hastalarda tedavinin etkin olabilmesi için kullanılan ilaçlar kadar düzenli beslenme de önemlidir. Damak defektli hastaların beslenmesinin ve kan şekeri regülasyonunun sağlanması için var olan defektin protetik yaklaşımla rehabilite edilmesi gerekmektedir. Damak defekti tedavisi multidisipliner bir tedavi yaklaşımı gerektirir. Defekt bölgesinin kapatılmasında cerrahi yaklaşımların yetersiz olduğu ya da hastanın cerrahi operasyon için rızasının olmadığı durumlarda; çiğneme ve konuşma fonksiyonunun tamamlanmasında implant destekli hareketli protezlerden faydalanılabilir. Yıllık kontrolleri yapılan hastamızın 3 yıllık takibi sürecinde estetik, fonksiyon ve fonasyon açısından herhangi bir komplikasyonla karşılaşılmaştır.

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Evaluation of a Postanesthetic Palatal Ulceration with an Autofluorescence Screening Method: A Case Report and a Brief Literature Review

Postanesteziik Palatal Ülserasyonunun Otofloresan Görüntüleme Yöntemi ile Değerlendirilmesi: Bir Olgu Sunumu ve Kısa Bir Literatür Taraması

Yeliz GÜNEŞ¹, Melisa ÖÇBE², Mehmet Oğuz BORAHAN³, Asım DURLU⁴, Şebnem ERÇALIK YALÇINKAYA⁵

ABSTRACT

The use of local anesthesia applications in dentistry is a well-established and reliable practice. However, complications such as ulceration, necrosis, and mucosa sloughing may occur due to the firm and dense structure of the palatal mucosa after anesthesia. These complications may lead to a misdiagnosis of oral cancer. This case report aims to evaluate the suspicious lesion that developed after local anesthesia in a 45-year-old female patient who presented to the dental clinic with acute pulpitis pain using the VELscope® (Visually Enhanced Lesion Scope) autofluorescence screening method.

Autofluorescence screening can be used as an adjunctive method as it is a simple, inexpensive and non-invasive complementary examination method. Although its specificity is controversial, it has a high sensitivity value, so it can be useful in evaluating suspicious lesions during intraoral examination.

Keywords: fluorescence, local anesthesia, oral ulcer, squamous cell carcinoma

ÖZ

Diş hekimliğinde lokal anestezi uygulamaları yaygın ve güvenilir uygulamalardır. Ancak palatinal mukozanın sıkı ve yoğun yapısı nedeniyle anestezi sonrası bazen ülserasyon, nekroz ve mukozal dökülmesi gibi komplikasyonlar ortaya çıkabilmektedir. Bu komplikasyonlar ağız kanseri olarak yanlış teşhis konulmasına sebep olabilir. Bu olgu sunumunda, akut pulpitis ağrısıyla diş hekimi kliniğine başvuran 45 yaşındaki kadın hastada, lokal anestezi sonrası gelişen şüpheli lezyonun, VELscope® otofloresan inceleme yöntemi ile değerlendirilmesi amaçlanmıştır.

Otofloresans görüntüleme basit, uygun maliyetli ve non-invaziv bir yardımcı inceleme yöntemidir. Spesifikliği tartışmalı olsa da duyarlılık değeri yüksek olduğundan ağız içi muayene sırasında şüpheli lezyonların değerlendirilmesinde faydalı olabilmektedir.

Anahtar Kelimeler: floresan, lokal anestezi, oral ülser, skuamöz hücreli karsinom

INTRODUCTION

Local anesthesia applications are used in a variety of dental procedures. It is used to ensure the comfort of both the patient and the dentist. However, sometimes local anesthesia can lead to a number of unexpected consequences. Various complications can occur such as allergy, trismus, edema, infections, hematoma, prolonged pain, paralysis, postanesthetic intraoral lesions and tissue necrosis (Jastak & Yagiela, 1981; Bennet, 1990). Palatal tissues are prone to mucosal lesions after the application of local anesthetics due to their dense, firm and adherent structure (Gogna et al., 2015). Local anesthetic injections should be administered carefully to avoid putting pressure on blood vessels which can lead to ulceration and necrosis.

Autofluorescence screening technology is used in endoscopic devices for skin evaluation, esophageal

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examination, colonoscopy and bronchoscopy. Recently, it has been used as an adjunct to conventional intraoral examination for non-invasive evaluation of the oral mucosa. Autofluorescence is facilitated by fluorochromes found in the submucosa and epithelial cell lining, such as nicotinamide adenine dinucleotide, oxidized flavine adenine dinucleotide, collagen, elastin, and keratin, which can be excited at different wavelengths. Because of absorption and scattering, the typical intrinsic pattern of autofluorescence is changed. It has been claimed that this technique, as an aid, can detect early dysplastic changes (Erçalık Yalçınkaya, 2013).

The VELscope® (LED Dental, Burnaby, British Columbia, Canada) can be used as an aid method to differentiate benign lesions and potentially malignant oral lesions from oral cancer and to determine the appropriate biopsy site for incision as it was also recommended by the World Health Organization (Shashidara et al., 2014). VELscope® works by emitting light with a wavelength of 400–460 nm, which stimulates the fluorophores in the oral epithelium using a digital camera. Healthy epithelial tissue appears green, while dysplastic tissue appears darker than surrounding fields due to loss of fluorescence (Farah et al., 2012; Erçalık Yalçınkaya, 2013; Cicciù et al., 2017).

This case report describes a postanesthetic oral ulcer in a 45-year-old female patient. The patient was referred to our clinic with a preliminary diagnosis of oral squamous cell carcinoma (OSCC).

CASE REPORT

A 45-year-old woman with no past medical history was referred to the Outpatient clinic of Oral and Maxillofacial Radiology with a complaint of a painful ulcer on the right palatal mucosa of 10 days duration. The patient's history revealed that she had visited the dentist with severe pain due to acute pulpitis of the right maxillary second molar. Local anesthesia was applied to the buccal and palatal mucosa of the second molar area for pain relief. The patient reported that the palatal mucosa suddenly became very swollen immediately after the administration of local anesthetic. The patient stated that she had visited several dental clinics due to the non-healing and painful lesion. In addition, the patient reported that dentists suspected oral cancer and immediately referred her for further investigation.

Intraoral examination revealed a single ovoid ulcer covered by a pseudo-membrane with well-defined

erythematous swollen margins on the right posterior palatal mucosa (Fig. 1a). The lesion was painful and the patient stated that the pain increased on palpation. The lesion was approximately two centimeters (cm) in diameter and one cm deep. Extraoral examination showed no evidence of lymphaneopathy. The VELscope® autofluorescence method was used and it showed reduced peripheral and superficial autofluorescence compared to healthy palatal tissue (Fig. 1b).

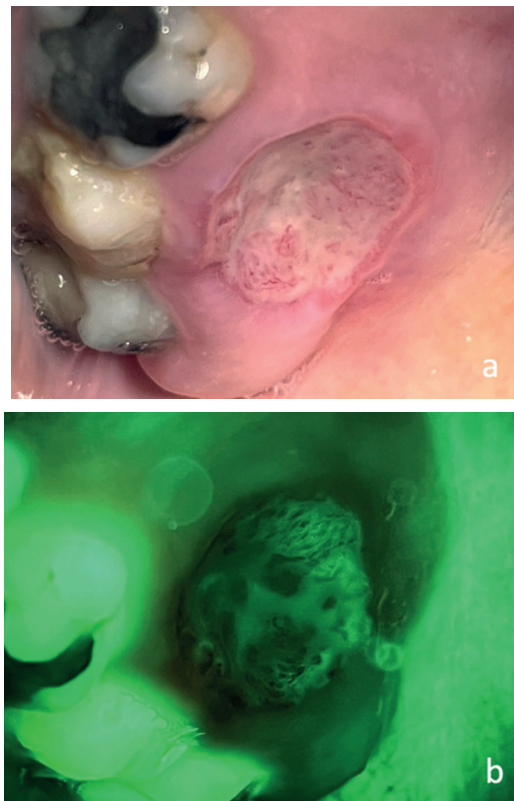


Figure 1: Intraoral examination (a) and VELscope® examination (b) of the lesion. Please note the reduced peripheral and superficial autofluorescence.

Symptomatic treatment and clinical follow-up of the lesion at regular intervals were decided upon the lesion was examined intraorally once a week. The patient was prescribed naproxen sodium as a non-steroidal anti-inflammatory drug and dexpanthenol for epithelialization. The healing process was recorded and the pain was significantly reduced one week after the symptomatic medication (Fig. 2). The autofluorescence of the lesion was similar to that of the healthy palatal tissue at the second follow-up (Fig. 3). Significant epithelialization was observed at the fourth follow-up visit (Fig. 4). Complete healing was observed after approximately 2 months (Fig. 5).

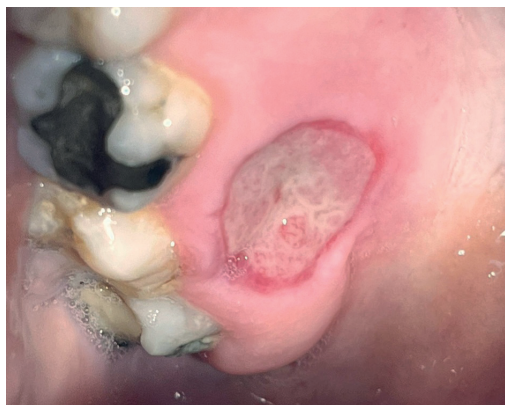


Figure 2: Intraoral examination of the lesion after the symptomatic medication.



Figure 5: Intraoral examination of the lesion and complete recovery after 2 months.

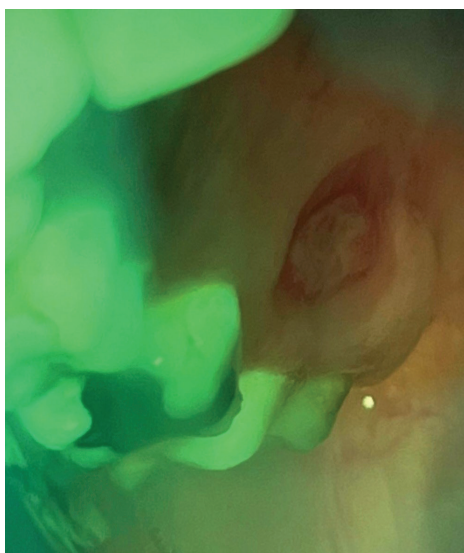


Figure 3: VELscope® examination of the lesion at the second follow-up. Please note the similar autofluorescence of the lesion and healthy mucosa.



Figure 4: Intraoral examination of the lesion with significant epithelization.

DISCUSSION

The dense, constricted and rigid nature of the palatal mucosa can lead to ulceration and necrosis after rapid and compressive injections. The lesion may be observed and initially diagnosed as OSCC or other oral malignancies.

OSCC is an invasive malignant epithelial neoplasia and the mortality rate increases with delay in early diagnosis (Llewellyn et al., 2004). According to recent studies, approximately 60% of patients with oral cancer are diagnosed at stages III and IV. Early diagnosis of oral squamous cell carcinoma, which is critical for prognosis, can be achieved by using various materials and methods in addition to intraoral screening. Cytological examination, molecular biological techniques, PCR tests, and autofluorescence techniques can be used as adjunctive methods (Jemal et al., 2005). However, histopathological examination is the gold standard for definitive of OSCC (Neville et al., 1995).

New and popular approaches to oral cancer screening include autofluorescence techniques, such as VELscope®. It provides a rapid and non-invasive preliminary diagnosis. It can also be used in daily clinical practice (Balasubramaniam et al., 2015). The principle of the device is based on the detection of biochemical changes. Biochemical changes often precede obvious morphological changes so this method can detect oral potentially malignant disorders at an early stage (Kumar & Krishna, 2019).

In a previous study by Cănjău et al. (Cănjău et al., 2018), VELscope® images were evaluated and areas of visual fluorescence loss were detected. They reported that the normal vascularisation of the tissue, the presence of

infection, potentially malignant oral lesions and OSCC may involve loss of autofluorescence. In the present case report, the loss of autofluorescence was detected in a benign ulceration of the palatal mucosa (Fig. 1b). However, at the second follow-up, the autofluorescence of the lesion was similar to that of the healthy oral mucosa (Fig. 3). It is crucial to reevaluate any oral mucosal lesion within 14 days to determine whether the lesion has healed or persisted. VELscope® method can be used as an adjunctive chair-side screening device with clinical follow-up in association with the knowledge and experience of the clinician (Erçalık Yalçınkaya, 2013).

The specificity and sensitivity of this technique have been investigated in many studies with varying results. In a study by Sharma et al. (Sharma et al., 2022), 250 patients with suspicious oral lesions were examined with VELscope®. The autofluorescence findings of these patients were compared with histopathological examination. The aforementioned showed that VELscope® had a sensitivity of 75% and a specificity of 61%. Wang et al. (Wang et al., 2022) evaluated 59 potentially malignant oral lesions with VELscope® and compared them with the histopathological findings. The subjective sensitivity and specificity were found to be 76% and 64%, respectively. However, the results of the objective method showed a sensitivity of 64% and a specificity of 82%. It was concluded that the objective fluorescence method can be also used even in low-risk lesion detection.

Vibhute et al. (Vibhute et al., 2021) evaluated 30 patients with potentially malignant oral lesions using the

VELscope® method. Histopathological results showed 90% sensitivity and 44% specificity. Above study concluded that the VELscope® method can be used as a complementary diagnostic tool but cannot replace the conventional method. Similar to this study, Amirchaghmaghi et al. (Amirchaghmaghi et al., 2018) examined 45 patients with potentially malignant oral lesions and evaluated the VELscope® method. Their research showed that the VELscope® method had a sensitivity of 90% and a specificity of 15%. In addition, the authors suggested that the VELscope device could used to increase the sensitivity of conventional intraoral examination. Erçalık Yalçınkaya et al. (Erçalık Yalçınkaya et al., 2015) suggested that the use of the VELscope® device together with the oral conventional examination may be helpful in the diagnosis of malignant lesions. However, due to the low specificity values, VELscope® screening is still not considered a definite method to differentiate between oral benign and malignant oral lesions.

Cânjău et al. (Cânjău et al., 2018) evaluated 18 patients with suspicious lesions of the oral mucosa. They demonstrated VELscope®'s 94% sensitivity and 100% specificity. Compared to other studies, the specificity rate was found to be significantly higher and the authors concluded that the VELscope® method is a useful and effective complementary method. As a result of the evaluation of VELscope® studies, it was found that the rate of sensitivity ranged from 64% to 94%; however, the rate of specificity ranged from 15% to 100% (Table 1).

Table 1. Selected previous studies evaluating the sensitivity and specificity of the VELscope® screening method

Researchers	Year	Lesion	Sample Size	Sensitivity(%)	Specificity(%)
Sharma et al.	2022	Suspicious oral mucosal lesions	250	75	61
Wang et al.	2022	Potentially malignant oral lesions (subjective assessment)	59	76	50
		Potentially malignant oral lesions (objective assessment)	59	64	82
Vibhute et al.	2021	Suspicious oral lesions	30	90	44
Amirchaghmaghi et al.	2018	Suspected OSCC and dysplasia	45	90	15
Cânjău et al.	2018	Oral potentially malignant lesions	18	94	100

CONCLUSION

In conclusion, the VELscope® method is a simple, cost-effective, non-invasive adjunctive tool with relatively high sensitivity. The device provides real-time guidance and can be also used intraoperatively to identify surgical tumor margins or incisional biopsy margins. Still, it may give false negative and/or false positive results during the evaluation of oral lesions; therefore, this situation should be taken into consideration when using it as an adjunctive method.

Patient Consent:

The patient was informed and a consent form was obtained for the use of their data.

Acknowledgments: None

Conflict of Interest: None

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An Overview of Three Dimensional Printing Captured by Three Dimensional Imaging

Üç Boyutlu Görüntüleme ile Elde Edilmiş Üç Boyutlu Baskı Teknolojilerine Genel Bir Bakış

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ABSTRACT

Modern manufacturing techniques such as 3D printing allow products to be made quickly and accurately from anything. Thanks to recent advances in 3D printing technology in dentistry, dental professionals can now custom design and print temporary and permanent crowns and bridges, implants, surgical drill guides and orthodontic appliance. This review discusses the different 3D printing technologies that can be used in dentistry and evaluates the materials printed.

Keywords: Printing, Three-Dimensional, Computer-Aided Design, Computer-Aided Manufacturing, three-dimensional image, Image-Guided Surgery

ÖZ

Üç boyutlu baskı gibi modern üretim teknikleri, plastikten metale birçok materyalden yapılmış ürünlerin hızlı ve doğru bir şekilde üretilmesini sağlar. Diş hekimleri üç boyutlu baskı teknolojisindeki son gelişmeler sayesinde artık cerrahi kılavuzları, geçici ve kalıcı kuronlar ve köprüler, ortodontik apareyler ve implantlar için özel tasarımlar yapabilmektedir. Bu derlemede diş hekimliğinde kullanılabilecek çeşitli üç boyutlu baskı teknolojileri ve baskı malzemeleri ele alınmıştır.

Anahtar Kelimeler: Printing, üç boyutlu, bilgisayar yardımlı tasarım, bilgisayar yardımlı imalat, 3-boyutlu görüntü, görüntü kılavuzluğunda cerrahi

INTRODUCTION

Three-dimensional (3D) printing is a rapidly evolving technology. It is now widely used in the dental industry. 3D printing has benefits for process engineering as compared to conventional and subtractive methods. The production of materials such polymers, metals, and ceramics can be done utilizing a variety of methods. 3D printing was first developed around thirty years ago. It is frequently referred to as the main technology of the upcoming industrial revolution and is currently undergoing rapid development as a result of the expiration of numerous patents (Sturb et al., 2006). The transfer from its laboratory to clinical use in dentistry depends heavily on the materials possible; these materials must not only offer the requisite precision but also the required physical and biological qualities (Sturb et al., 2006; Wang & Leon, 2006)

Over the past few decades, the use of computer-aided manufacturing (CAM) and computer-aided design (CAD) in dentistry has advanced significantly. It has inspired the creation of entirely new material courses, as well as the digitisation and automation of many work processes. In dentistry, CAM and subtractive manufacturing were synonymous until recently. (Wang & Leon, 2006; Kessler et al., 2020; Soriano et al., 2017).

This review's objective is to offer a current summary of many printing techniques, including digital light processing, stereolithography, selective laser sintering, photopolymer jetting, material jetting, selective laser melting and fused filament fabrication. Special consideration is given to materials used in dentistry and their clinical applications. Thus, this review article also discusses the production stages at which 3D printing technology is used in specific dental fields, existing 3D printing technologies and the materials utilized in these 3D printing technologies and their properties (Sturb et al., 2006; Wang & Leon, 2006; Kessler et al., 2020).

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3D Printing Techniques used in Digital Dentistry

Stereolithography Printers

The first commercially available 3D printing technology is stereolithography (SLA). Using highly cross-linked polymers, this manufacturing technique uses photoinduced polymerization to produce multilayer structures (Fig. 1), (Fan et al., 2020). This technology can be categorised into different groups based on the type of platform movement and laser movement. Regardless of these classifications, printing involves three main steps: exposure to light or laser, platform movement, and resin refilling. The typical example of additive manufacturing, which makes use of layer-by-layer modeling, is stereolithography. The SLA equipment completes the printed object under the direction of a 3D digitized model that serves as a template for the fabrication process. When resin is exposed to ultraviolet light, which causes the resin monomers to undergo free radical polymerization (FRP), the layers are joined from the bottom up. As each layer is polymerised, the resin platform descends by a distance equal to the thickness of one layer, building up the next layer until the 3D digital model is printed (Sakly et al., 2014; Jain et al., 2013; Lipson & Kurman 2013).



Figure 1: Creality Halot-One SLA Printer

Digital Light Processing Printers

The Digital Light Processing is a photocuring technology which is similar to SLA process. The materials used are liquid photosensitive resins that go through photocuring

and then layer by layer build the 3D printed item. The initial layer forms on the build platform. The build platform may be moving upward or downward depending on where the UV source is located. Subsequent layers are constructed above the preceding layer. The DLP 3D printer uses a digital projector screen to flash the image of the current layer across the build platform or the preceding layer through a transparent bottom or top of the resin tank. The construction platform moves up or down in accordance with the thickness of a layer after each layer has dried to complete the portion (Fig. 2) (Sakly et al., 2014; Jain et al., 2013; Cuan-Urquizo et al., 2019).

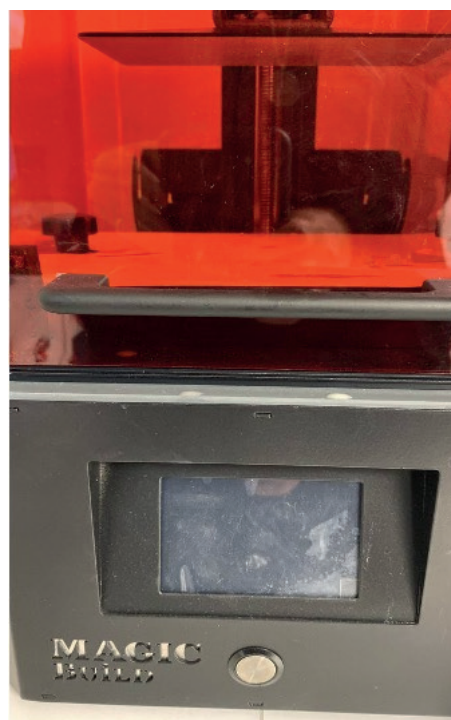


Figure 2: Magic Build DLP Printer

Fused Deposition Modeling Printers

The term “fused deposition modelling”, sometimes known as “fused filament fabrication”, refers to a procedure for softening metal alloys, composite materials, and polymers that was developed more than 20 years ago. FDM is the second most popular 3D printing method after SLA (Jain et al., 2013). This method is significantly less expensive than the other additive manufacturing techniques (Cuan-Urquizo et al., 2019). The strand extrusion principle serves as the basis for this method, which involves delivering the required type of thermoplastic material to the extruder in the form of

strands. Layer by layer, the heated viscous plastic is placed by an extrusion head after softening, producing the digital model (Soriano et al., 2017; Taylor et al., 2017). The most widely used FDM filaments are thermoplastic polymers and their composites, including low melting temperature metal alloys like bronze metal filament and acrylonitrile-butadiene-styrene, polycarbonates, and polysulfones (Cuan-Urquizo et al., 2019). To make (nano)composite filament, polymers may be loaded with metal nanoparticle reinforcement to enhance various characteristics, such as thermal resistance and mechanical qualities.

Selective Laser Sintering

In the process known as selective laser sintering (SLS), the fusing of the raw material powder is induced using a laser beam. The platform will be lowered to allow room for the laser to sinter the subsequent layer of powder after the laser has made a solid layer out of the powder. Because the surrounding powder acts as support, this particular kind of structure construction eliminates the need for extra material support during printing (Olananmi et al., 2015). SLS can be used to produce metal frameworks, multipurpose study models, and drilling and cutting guides. The utilization of autoclavable materials, mechanical functionality of the printed object, and a decrease in production cost with an increase in production volume are all benefits of SLS. The health risk connected with inhaling the raw material's powder, the initial high cost of setup, and the requirement for additional supplies like compressed air for SLS to function properly are the drawbacks of this printing technology (Tolochko et al., 2002).

Cone Beam Computed Tomography

This part will specifically focus on cone beam computed tomography and how it is used in conjunction with 3D printers. Although conventional radiography is still widely used today, converting the morphology of three-dimensional hard structures into two-dimensional radiographs may lead to inadequate examination and inaccurate diagnosis. These shortcomings prompted researchers to improve three-dimensional imaging systems. Cone Beam Computed Tomography imaging system was used for the first time for radiotherapy, angiography and mammography in 1982. Since the 1990s, it has been possible to add three-dimensional imaging to the existing 2D imaging system. The use of cone beam computed tomography (CBCT) in dentistry has seen

a significant surge. Its applications include the diagnosis and treatment of anatomical and pathological structures within the oral and maxillofacial area, evaluation of the temporomandibular joint, implant design, and several other matters. (Karslıoğlu et al., 2022; Windisch et al., 2007).

The use of CBCT in dentistry has rapidly changed radiodiagnostics in dentistry, allowing dentists to make three-dimensional diagnoses. The CBCT units currently in use are capable of three-dimensional imaging of hard tissues in the head and neck region with excellent high resolution (Karslıoğlu et al., 2022).

USAGE OF 3D PRINTERS IN FIELD OF ORTHODONTICS

The developing use of 3D printers has also led to great developments in the field of orthodontics. One of the most important of these developments is the use of technology that will change the concept of orthodontic appliances with 3D printers. With this technique; one can produce orthodontic instruments used in active orthodontic treatment such as various removable orthodontic appliances (hawley etc.), dental arch expansion appliances, space holders, arch wires, clear aligners, brackets, transfer trays for orthodontic treatment for indirect bonding, lingual bracket systems. In addition, it offers opportunities to make orthodontic treatment applications fast and easy by providing models produced for treatment planning and diagnosis and the production of surgical splints and surgical guides for orthognathic surgery patients (Suryajaya et al., 2021).

Obtaining a Dental Model

In orthodontics, where dental models and impressions are widely used, the traditional method of impression-taking has begun to give way to intraoral scanning devices and 3D digital model-taking technology. The production of models makes treatment faster, easier and more comfortable for both the dentist and the patient. Advantages of digital models; no need for physical storage, easy access to data, digital diagnosis or treatment simulations, patient comfort, ability to send to laboratory, no risk of breakage, wear, deterioration or loss, less labour required (Suryajaya et al., 2021).

Orthodontic Appliances

There are many processes involved in the manufacture of orthodontic appliances, both in the clinic and in the laboratory. The production of appliances using traditional methods consists of long, challenging and less comfortable stages for both the patient and the clinician. Recently, 3D printer application in the production of orthodontic appliances has brought benefits such as rapid treatment planning, easier planning and patient comfort. Digital applications open up new possibilities for indirect bonding (IDB) (Dong et al., 2020).

Orthodontic Treatment Provided by Clear Aligners

The first clear aligners were developed for the final stages of orthodontic treatment or simply to treat minor irregularities in tooth position. As a result of developments in the field of clear aligners, they have also begun to be used in the treatment of moderate to severe malocclusions. Many materials have been used in the manufacture of clear aligners, but limited work has been done to introduce new materials. The manufacturing process of 3D printing technology bypasses physical creation of the dental model and the clear aligner can be created directly from electronically stored 3D data (Zinelis et al., 2022).

3D Printed Photocurable Shape Memory Resin for Clear Aligners

Direct 3D printing of aligners has been developed to overcome the disadvantages of the traditional vacuum thermoforming manufacturing process. The photocurable resin TC85, a novel material for 3D printing of clear aligners, was compared with the thermo-mechanical and viscoelastic properties of a thermoplastic known as polyethylene terephthalate glycol. Dynamic mechanical analysis was carried out to investigate the mechanical behaviour of the two materials at 37°C and 80°C respectively. In addition, a U-bend test was used to assess the shape memory properties of the two materials and the shape recovery ratio was calculated for 60 min at 37 °C (Melkos, 2005).

Recently, attempts have been made to directly 3D print clear aligners using a biocompatible material in order to solve the challenges that come with traditional production methods. This approach requires less time and effort and produces fewer geometric errors. Numerous studies have evaluated the accuracy, fit and clinical viability of direct

3D printed clear aligners. However, few studies have investigated the mechanical and physical properties of the 3D printed materials (Fig.3), (Melkos, 2005).

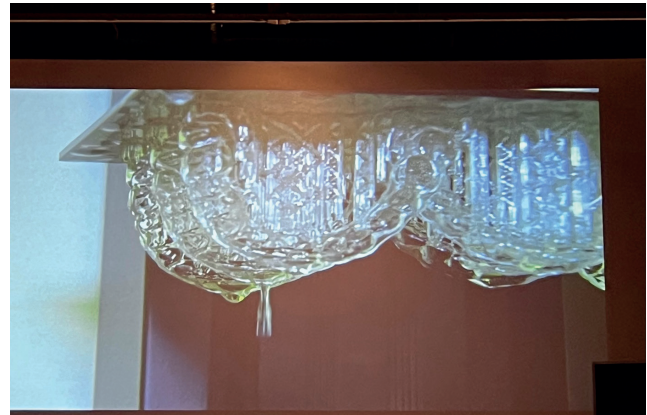


Figure 3: Graphy Shape Memory Clear Aligner printing stage

In order to enhance the predictability of clear aligner performance and treatment results, it is critical to understand the viscoelastic properties of creep and stress relaxation in addition to physical parameters such as static mechanical properties. Force degradation occurs when clear aligners are worn for extended periods of time and are frequently placed in the mouth. The clear aligners are made of viscoelastic polymers, which have properties halfway between elasticity and viscosity (Dupaix et al., 2005). As a result, the behaviour of clear aligners changes significantly over time under constant load (Fig. 4), (Fang et al., 2013).



Figure 4: Graphy Shape Memory Clear Aligner curing stage

3D PRINTERS IN ORAL SURGERY

As technology develops, three-dimensional software and printing technologies are being used in the surgical field of dentistry, as well as in many other fields. Three-dimensional

printing technology, particularly cone beam computed tomography (CBCT), has been developed alongside advanced 3D imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT), and can be used in all areas of dentistry. This technology reduces the risk of complications that can occur during and after surgical procedures by providing guidance during surgery, as well as superior diagnosis and treatment planning. (Windisch et al., 2007)

Preoperative Planning

The use of anatomical models is of great importance in preoperative planning, especially in orthognathic surgery applications. Orthognathic surgery is defined as surgical procedures performed in conjunction with orthodontics for correction of dentofacial deformities in patients with severe skeletal mismatch as a result of congenital or acquired deformities and who have completed their growth development (Oberoi et al., 2018; Bayramov et al., 2022).

Surgical Education and Simulation

Anatomical models produced by three-dimensional printers can also be used for training purposes and can be shared between specialists for information exchange (Windisch et al., 2007). Models can be used to evaluate complex anatomy and to test new manipulation and surgical techniques. They can be used as a tool in obtaining informed consent for surgery by making it easier for the patient to understand the surgical procedures and have a positive effect on patient satisfaction (Windisch et al., 2007).

Surgical Operation Instruments Used in Preoperative Surgical Planning

The use of three-dimensional printers in the treatment of tissue loss due to trauma or tumour surgery, or in reconstruction procedures for plastic surgery, has brought many benefits. For example, functional planning and execution can be achieved when restoring an anatomically complex area. In particular, the use of three-dimensional anatomical models in the evaluation of the bone defect for grafting, together with the identification of the ideal donor site, can provide an excellent match for the graft material (Thankappan et al., 2008). Another advantage of anatomical models is that they allow appropriate reconstruction plates

to be shaped on the model prior to surgery (Windisch et al., 2007; Thankappan et al., 2008)

Instruments Used During Surgery

Anatomical models or surgical instruments produced by three-dimensional printers can be used both preoperatively and intraoperatively, thus contributing in many ways to the treatment process. Although a wide variety of 3D printers and printing materials are used to produce anatomical models and surgical instruments, it is recommended that sterilisable materials are used so that the model can be used for guidance during surgery (Thankappan et al., 2008; Schmauss et al., 2013; Ursan et al., 2013).

3D PRINTERS IN ENDODONTICS

Educational Use of 3D Printed Models

The use of 3D printing in dentistry can produce high-resolution resin models, with a resolution range of 16-32 µm for each layer, automatically and by layering. Rapid prototyping of replicas of natural teeth is very promising and has particular potential for inclusion in endodontic training. It also allows standardisation of specimens, which is important for laboratory studies such as root canal instrumentation, filling and retreatment (Patel et al., 2019).

Guided Non-Surgical Endodontics

Pulp canal obliteration is a gradual narrowing of the canals and a more apical position of the roots as a result of caries, orthodontic treatment, systemic disease, trauma or increased dentin production due to age. As a result of pulp canal obliteration, perforations of calcified canals during access and canal preparation increase by up to 75% (Anderson et al., 2018). 3D-printed guides may be useful for canal localisation during nonsurgical endodontic treatment, where there is a significant risk of procedural errors, including root perforation, which can seriously compromise the outcome of treatment (Cvek et al., 1982; Amir et al., 2001).

Guided Surgical Endodontics

The effective performance of endodontic microsurgery (EMS) necessitates the precise implementation of

osteotomy and root tip resection, which should be guided by anatomical landmarks and preoperative radiographs or measurements obtained using cone beam computed tomography. The osteotomy may deviate from the ideal due to operator failures in clinical scenarios where proper orientation, angulation and preparation depth are difficult. Advances in magnification systems and materials have made EMS a predictable procedure (Syngcuk et al., 2006).

3D PRINTERS IN PROSTHODONTICS

The prosthetic rehabilitation of teeth and jaws is influenced by 3D technology at every stage. The development of intra-oral scanners allows digital optical impressions to be taken of the patient's dental arches, significantly reducing chair-side time. The dentist can now interact with a dental laboratory by digitally exchanging patient data or printing the required prosthesis or component in the office, thanks to the evolving trends of the digital revolution. (Vasamsetty et al., 2020; Lee et al., 2017)

Fixed Prosthetic Restorations

A 3D temporary bridge and crown resin must not only be biocompatible, but also have mechanical properties that can withstand the high occlusal forces. To achieve sufficient polymerisation and the ideal mechanical performance of the material as designed by the manufacturer, an ideal post-polymerisation process is required in which the photosensitive resin receives the necessary UV light at the right wavelength. It has been observed that the biological, mechanical and degree of polymerisation of the final printed resin improves with post-curing time and temperature. (Vasamsetty et al., 2020; Bayarsaikhan et al., 2022)

Removable Dental Prostheses

Recent advances in digital dentistry have enabled the successful use of digital technology to produce removable prostheses. Prosthesis manufacturing methods, materials and processes have been modernised and made more efficient with 3D printing. (Aanadioti et al., 2020) Dentca created the first 3D printed denture in 2015. The dentist can send a digital or traditional impression, together with details of the jaw relationship, to the dental laboratory during the working day. The prosthesis base is created using CAD design software with the teeth in occlusion. A printed try-in prosthesis is an option and clinical modifications can

be made by grinding the acrylic and then rescanning. The finished prosthesis and teeth are fabricated separately and then bonded together. Dental professionals can also print prosthesis internally as open source softwares and printers become more cost-effective. (Aanadioti et al., 2020)

Dental Models

The use of additive manufacturing techniques can be used to create custom models. This model can also be used as a reference model. At the same time, additive manufacturing techniques can be used to create educational models for the medical and dental fields. The models produced can be used for research and teaching. They are colourful and clearly illustrate the anatomy. A study compared dental models made using the SLA method with traditional stone casts. It was claimed that the accuracy of the SLA model was inferior to that of the traditional method (Alshawaf et al., 2018). Demiralp et. al. compared the prosthetic teeth made using heat curing, milling, and 3D printing techniques after thermal aging for flexural bond strength and fracture toughness. (Demiralp et al., 2021)

APPLICATIONS OF 3D PRINTING IN RESTORATIVE DENTISTRY

Indirect Composite Resin Restorations: Inlay and Onlay

In recent times, there has been a growing acceptance of 3D printed composites as feasible materials for the purpose of single tooth restorations. Studies comparing the efficiency of these restorations with subtractive procedures in terms of fatigue, time and cost are lacking. There are also no studies on marginal adaptation, which is crucial because many clinical failures, such as stain retention, recurrent caries and water absorption, which affect the quality of the restoration, begin or are noticed at the transition between tooth and restoration. (Daher et al., 2022)

As they offer acceptable marginal adaptation with time and cost advantages, three-dimensional printed composites may be a suitable material for long-term temporary restorations. (Daher et al., 2022)

APPLICATIONS OF 3D PRINTING IN PERIODONTOLOGY

Periodontal Splint

The masticatory function of mobile anterior mandibular teeth can be enhanced with periodontal splinting, which also lowers the possibility of unintentional extraction.

Instead of ceramics and metal, polyetherketoneketone, a high-performance thermoplastic resin, has also been used. In a previous study, the antibacterial properties of PEKK and the accuracy and efficiency of digital technology ensured that the splint had no negative impact on oral hygiene or periodontal maintenance during two years of follow-up (Qian et al., 2023). The procedure provided a personalised, biocompatible and aesthetically pleasing method of stabilising mobile teeth. Qian et al. found that the PEKK splint functioned well clinically, with good stability and retention two years after delivery (Qian et al., 2023). Plaque buildup, composite resin fracture, complicated prosthodontic fabrication processes for partial dentures, or difficulty modifying or adjusting metal splints intraorally are all downsides of periodontal splints of various designs and materials (Qian et al., 2023; Patel et al., 2017).

Surgical Guide for Crown Lengthening (Gingivectomy and Bone Resection)

Crown lengthening is a procedure used to expose the tooth structure, in order to restore the proper biological width that corresponds to the physiological dimension from the junctional epithelium and connective tissue attachment to the alveolar crest or for esthetic purposes. By using digital workflow, a surgical guide is designed digitally with a software program to perform crown lengthening. A digital design of the new tooth shape and a cone beam computed tomography scan are used to create standard tessellation language (STL) files, which are then converted from DICOM files to the STL format. Surgical planning of the crown-lengthening procedure is done by superimposing these files (Bayarsaikhan et al., 2022; Polat et al., 2022).

Based on the above-mentioned recent literature review, it appears that 3D technologies will play a popular role in future dental practices. It is obvious that 3D printing technology will be more widely used in dentistry in line with developments in artificial intelligence and technological improvements by overcoming barriers such as current R&D costs, user unfamiliarity with the products and higher financial costs of materials.