Stom Glas S COBISS. SR-ID 8417026 UDC 616.31 ISSN 0039-1743

STOMATOLOŠKI GLASNIK SRBIJE

SERBIAN DENTAL JOURNAL

Vol. 70 • Number 4 • October-December 2023

http://www.stomglas.org.rs

Stom Glas S COBISS. SR-ID 8417026 UDC 616.31

STOMATOLOŠKI GLASNIK SRBIJE

SERBIAN DENTAL JOURNAL

Vol. 70 • Number 4 • October-December 2023

www.stomglas.org.rs

Adresa uredništva
Srpsko lekarsko društvo
Kraljice Natalije 1
11000 Beograd
Srbija

Telefon: +381 (0)11 409 27 76
Email: stomglas@bvcom.net

Address of the Editorial Office
Serbian Medical Society
Kraljice Natalije 1
11000 Belgrade
Serbia

Phone: +381 11 409 27 76
Email: stomglas@bvcom.net

Časopis izlazi četiri puta godišnje.
The journal is published four times a year.

Finansijsku podršku izdavanju časopisa pružaju Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije i Stomatološka komora Srbije.

The publishing of the Journal is financially supported by The Ministry of Science, Technological Development and Innovation of the Republic of Serbia and Serbian Dental Chamber.

ISSN 0039-1743
ISSN Online 1452-3701
COBISS. SR-ID 8417026
UDC 616.31

www.stomglas.org.rs

Stomatološki glasnik Srbije
Serbian Dental Journal

Izdavač / **Publisher**
Srpsko lekarsko društvo
Serbian Medical Society

Osnivač / **Founder**
Stomatološka sekcija Srpskog lekarskog društva
Dental Section of the Serbian Medical Society

Contents / Sadržaj

ORIGINAL ARTICLE
ORIGINALNI RAD
DOI: https://doi.org/10.2298/SGS2304163S
UDC: 616.314.6-073

Evaluation of the root canal morphology variations of maxillary premolars using cone-beam computed tomography

Antonije Stanković[1], Jelena Popović[1,2], Marija Daković-Bjelaković[3], Nenad Stošić[1,2], Marija Nikolić[1,2], Aleksandar Mitić[1,2], Radomir Barac[1,2], Aleksandra Milovanović[1]

[1]University of Niš, Faculty of Medicine, Niš, Serbia;
[2]Clinic of Dental Medicine, Department of Restorative Dentistry and Endodontics, Niš, Serbia;
[3]University of Niš, Faculty of Medicine, Department of Anatomy, Niš, Serbia

SUMMARY

Introduction Maxillary premolars often undergo endodontic treatment, which requires detailed knowledge of their canal morphology. The aim of this study was to determine the most common number of roots of maxillary premolars by analyzing CBCT images, as well as to determine the most common root canal configuration in maxillary premolars in the population of Southeast Serbia using the new system for classifying root canal morphology by Ahmed et al.

Material and methods 55 CBCT images of male and 63 CBCT images of female patients were analyzed, which included 223 maxillary first premolars and 207 maxillary second premolars. The analysis was performed in the program Galileos. The number of roots of these teeth was determined and the canal morphology was classified in relation to the gender and side of maxilla.

Results The maxillary first premolars most often had two roots and configuration type $^{2}TNB^{1}P^{1}$, while the most maxillary second premolars had one root and configuration type $^{1}TNB^{1}$. No significant difference was observed in the number of roots and type of configuration between male and female, as well as between left and right sides.

Conclusion The classification of the tooth canal system according to Ahmed et al. emphasizes the advantage of simultaneous classification of the number of roots and the number of canals. Although most premolars do not pose a problem for treatment, there have been registered canal configurations of maxillary premolars that can be a challenge for endodontic treatment. A detailed analysis of the canal configuration can be performed using CBCT.

Keywords: endodontics; canal configuration; maxillary premolars; CBCT

INTRODUCTION

Missed root canals, which have not been endodontically treated, represent a source of infection that can compromise the outcome of the treatment and potentially endanger the entire organism. If canal system is incompletely instrumented and obturated, endodontic treatment is considered not successful [1]. Successful endodontic treatment is impossible without detailed knowledge of the number and position of the roots and canals. The exact localization of the entrance to the root canals dictates the preparation of the access cavity - an important phase of endodontic treatment. The preparation of access cavities in teeth covered with a crown requires extreme precision to avoid possible damage to the crown itself. Removal of ceramics, more than necessary, due to not knowing the exact localization of the root canal, can result in crown cracking [2]. The analyzes of variations in canal configuration within a population can provide clinicians with useful guidelines when planning and performing endodontic treatment on individual teeth. The need-to-know possible variations of the root canal configuration has contributed to the constant work on finding universal classifications, which would consider all possible combinations of tooth root canal configurations caused by the separation and fusion of the canals. Many authors tried to classify complex morphology of root canals by describing dozens of types of canal configurations [3]. In addition to already well-known classification according to Vertucci [4], the classification of canal configurations according to Ahmed [5], presented in 2017, stood out as useful. With its help, it is possible to identify canal configurations that were not documented or described in the literature.

Although any tooth can be a challenge to treat, maxillary premolars are one of the more demanding groups of teeth to perform endodontic treatment. The study that aimed to collect information on endodontic treatment carried out by Belgian dentists, indicated a much higher number of post-endodontic complications in premolars than incisors and canines [6]. According to the study by Zaatar et al. [7], maxillary premolars are teeth often subjected to endodontic treatment.

The aim of our study was to determine the most common number of roots of maxillary premolars by analyzing CBCT images, as well as to determine the most common configuration of canals in maxillary premolars in the population of Southeast Serbia using the new system for classifying root canal morphology by Ahmed et al. [5].

Address for correspondence: Antonije STANKOVIĆ, University of Niš, Faculty of Medicine, Blvd. Dr Zorana Đinđića 81, Niš, Serbia; *stankovicantonije@gmail.com*

Table 1. Proposal of code formulas that can be used to mark the configurations of the canals of single-rooted, two-rooted, and three-rooted premolars according to Ahmed et al. [5]
Tabela 1. Predlog formula kodova kojima se mogu obeležiti konfiguracije kanala jednokorenih, dvokorenih i trokorenih premolara po Ahmedu i saradnicima [5]

$^{1}TN^{O\text{-}C\text{-}F}$	Single-rooted teeth, as indicated by the superscript in front of the tooth number (TN) Jednokoreni zubi, na šta ukazuje superskripta ispred broja zuba
$^{2}TN\ B^{O\text{-}C\text{-}F}\ P^{O\text{-}C\text{-}F}$	Double-rooted teeth, as indicated by the superscript in front of the tooth number (TN) Dvokoreni zubi, na šta ukazuje superskripta ispred broja zuba
$^{3}TN\ MB^{O\text{-}C\text{-}F}\ DB^{O\text{-}C\text{-}F}\ P^{O\text{-}C\text{-}F}$	Three-rooted teeth, as indicated by the superscript in front of the tooth number (TN) Trokoreni zubi, na šta ukazuje superskripta ispred broja zuba

TN – tooth number; O – number of openings on the floor of the pulp chamber; C – number of canals; F – number of foramina; B – buccal root; P – palatal root; MB – mesiobuccal root; DB – distobuccal rootTN – broj zuba; O – broj otvora na podu pulpne komore; C – broj kanala; F – broj foramena; B – bukalni koren; P – palatinalni koren; MB – meziobukalni koren; DB – distobukalni koren

MATERIALS AND METHODS

The research was approved by the Ethical Committee of the Clinic for Dental Medicine in Niš (01-728/23). 118 CBCT images of patients at the Clinic for Dental Medicine in Niš (55 images of male and 63 images of female patients) were analyzed in the program Galileos (Sirona, Germany) with 223 maxillary first premolars and 207 maxillary second premolars included. The analysis was performed by two experienced clinicians, who determined the number of roots of maxillary premolars and classified the configuration of their canals according to Ahmed et al. [5]. Table 1 shows the code formulas that helped marking the configurations of the canals of maxillary premolars. Table 2 shows the codes, according to Ahmed et al. [5] for the configurations of the canals of maxillary premolars recorded in the literature and used in our research.

RESULTS

The highest number of maxillary first premolars had two roots. The analysis of the results showed that there was no statistically

Table 2. Codes marking premolar canal configurations according to Ahmed et al. [5] in this research
Tabela 2. Kodovi kojima su obeležene konfiguracije kanala premolara po Ahmedu i saradnicima [5] u ovom istraživanju

$^{1}T^{N}1$	Maxillary premolar with one root and one canal (Figure 1A) Gornji premolar sa jednim korenom i jednim kanalom (Slika 1A)
$^{1}TN^{1\text{-}2}$	Maxillary premolar with one root and one canal dividing into two canals (Figure 1B) Gornji premolar sa jednim korenom i jednim kanalom koji se grana (Slika 1B)
$^{1}TN^{1\text{-}2\text{-}1}$	Maxillary premolar with one root and one canal divinding into two canals and then reuniting into a single canal (Figure 1C) Gornji premolar sa jednim korenom i sa jednim kanalom koji se grana, a potom ponovo spaja u jedan kanal (Slika 1C)
$^{1}TN^{1\text{-}2\text{-}1\text{-}2}$	Maxillary premolar with one root and one canal divinding into two canals, then reuniting into one canal to finally separate into two canals (Figure 1D) Gornji premolar sa jednim korenom i sa jednim kanalom koji se grana, potom ponovo spaja u jedan kanal, da bi se naposletku odvojio u dva kanala (Slika 1D)
$^{1}TN^{2}$	Maxillary premolar with one root and two canals (Figure 1E) Gornji premolar sa jednim korenom i dva kanala (Slika 1E)
$^{1}TN^{2\text{-}1}$	Maxillary premolar with one root and two canals, merging into a single canal (Figure 1F) Gornji premolar sa jednim korenom i dva kanala, koja se spajaju (Slika 1F)
$^{1}TN^{2\text{-}1\text{-}2}$	Maxillary premolar with one root and two canals, which merge into one, and then separate into two canals (Figure 1G) Gornji premolar sa jednim korenom i dva kanala, koja se spajaju u jedan, koji se potom grana (Slika 1G)
$^{2}TN^{1}B^{1}P^{1}$	Maxillary premolar with the root which splits into two roots, and one canal from the floor of the chamber, which splits into two canals, one in each root (Figure 1H) Gornji premolar, čiji se koren razdvaja u dva korena; sa poda komore polazi jedan kanal, koji se razdvaja u dva kanala, po jedan u svakom korenu (Slika 1H)
$^{2}TNB^{1}P^{1}$	Maxillary premolar with two roots and two canals, one in the palatal root and the other in the buccal root (Figure 1J) Gornji premolar sa dva korena i dva kanala, jednim u palatinalnom korenu i drugim u bukalnom korenu (Slika 1J)
$^{2}TNB^{1\text{-}2}P^{1}$	Maxillary premolar with two roots and two canals, one in the palatal root and one in the buccal root, which divides into two canals (Figure 1K) Gornji premolar sa dva korena i dva kanala, jednim u palatinalnom korenu i drugim u bukalnom korenu, koji se grana (Slika 1K)
$^{3}TNMB^{1}DB^{1}P^{1}$	Maxillary premolar with three canals, one in each root (Figure 1L) Gornji premolar sa tri kanala, jednim u svakom korenu (Slika 1L)

TN – maxillary premolar (14, 24, 15, 25); B – buccal root; P – palatal root; MB – mesiobuccal root; DB – distobuccal root
TN – gornji premolar (14, 24, 15, 25); B – bukalni koren; P – palatinalni koren; MB – meziobukalni koren; DB – distobukalni koren

Table 3. Frequency distribution of the number of the maxillary first premolar roots according to gender and tooth position
Tabela 3. Distribucija frekvencije broja korenova gornjeg prvog premolara prema polu i poziciji zuba

	Maxillary first premolar Gornji prvi premolar	Single-rooted Jedan koren	Double-rooted Dva korena	Three-rooted Tri korena	Total Ukupno	Chi square Hi kvadrat
Gender Pol	Male / Muškarci	28 (27.2%)	74 (71.8%)	1 (1%)	103 (100%)	$\chi^2 = 1.25$; p = 0.53
	Female / Žene	35 (29.2%)	85 (70.8%)	0 (0.0%)	120 (100%)	
Tooth position Pozicija zuba	Right (14) / Desna (14)	33 (29.2%)	79 (69.9%)	1 (0.9%)	113 (100%)	$\chi^2 = 1.11$; p = 0.57
	Left (24) / Leva (24)	30 (27.3%)	80 (72.7%)	0 (0.0%)	110 (100%)	
	Total / Ukupno	63 (28.3%)	159 (71.3%)	1 (0.4%)	223 (100%)	

χ^2 – Chi square test value; p – the value of the probability of the Chi-square test
χ^2 – vrednost testa χ^2; p – vrednost verovatnoće testa χ^2

Table 3. Frequency distribution of the number of the maxillary first premolar roots according to gender and tooth position
Tabela 3. Distribucija frekvencije broja korenova gornjeg prvog premolara prema polu i poziciji zuba

	Maxillary first premolar Gornji prvi premolar	Single-rooted Jedan koren	Double-rooted Dva korena	Three-rooted Tri korena	Total Ukupno	Chi square Hi kvadrat
Gender Pol	Male / Muškarci	28 (27.2%)	74 (71.8%)	1 (1%)	103 (100%)	$\chi^2 = 1.25$; $p = 0.53$
	Female / Žene	35 (29.2%)	85 (70.8%)	0 (0.0%)	120 (100%)	
Tooth position Pozicija zuba	Right (14) / Desna (14)	33 (29.2%)	79 (69.9%)	1 (0.9%)	113 (100%)	$\chi^2 = 1.11$; $p = 0.57$
	Left (24) / Leva (24)	30 (27.3%)	80 (72.7%)	0 (0.0%)	110 (100%)	
	Total / Ukupno	63 (28.3%)	159 (71.3%)	1 (0.4%)	223 (100%)	

χ^2 – Chi square test value; p – the value of the probability of the Chi-square test
χ^2 – vrednost testa χ^2; p – vrednost verovatnoće testa χ^2

Table 4. Frequency distribution of the number of the maxillary second premolar roots according to gender and tooth position
Tabela 4. Distribucija frekvencije broja korenova gornjeg drugog premolara prema polu i poziciji zuba

	Maxillary second premolar Gornji drugi premolar	Single-rooted Jedan koren	Double-rooted Dva korena	Three-rooted Tri korena	Total Ukupno	Chi square Hi kvadrat
Gender Pol	Male / Muškarci	69 (74.2%)	24 (25.8%)	0 (0.0%)	93 (100%)	$\chi^2 = 0.60$; $p = 0.44$
	Female / Žene	79 (69.3%)	35 (30.7%)	0 (0.0%)	114 (100%)	
Tooth position Pozicija zuba	Right (15) / Desna (15)	78 (72.7%)	30 (27.8%)	0 (0.0%)	108 (100%)	$\chi^2 = 0.06$; $p = 0.81$
	Left (25) / Leva (25)	70 (70.7%)	29 (29.3%)	0 (0.0%)	99 (100%)	
	Total / Ukupno	148 (71.5%)	59 (28.5%)	0 (0.0%)	207 (100%)	

χ^2 – Chi square test value; p – the value of the probability of the Chi-square test
χ^2 – vrednost testa χ^2; p – vrednost verovatnoće testa χ^2

Table 5. Frequency distribution of maxillary premolars canal configuration according to tooth position
Tabela 5. Distribucija frekvence konfiguracije kanala gornjih premolara prema poziciji zuba

		Maxillary first premolar Gornji prvi premolari			Maxillary second premolar Gornji drugi premolari		
		14	15	Total Ukupno	24	25	Total Ukupno
Canal configuration types Tipovi konfiguracije kanala	$^{1}TN^{1}$	3 (2.7%)	8 (7.3%)	11 (4.9%)	40 (37.0%)	42 (42.4%)	82 (39.6%)
	$^{1}TN^{1-2}$	6 (5.3%)	3 (2.7%)	9 (4.0%)	8 (7.4%)	6 (6.1%)	14 (6.8%)
	$^{1}TN^{1-2-1}$	5 (4.4%)	3 (2,7%)	8 (3.6%)	5 (4.6%)	1 (1.0%)	6 (2.9%)
	$^{1}TN^{1-2-1-2}$	4 (3.5%)	0 (0.0%)	4 (1.8%)	3 (2.8%)	0 (0.0%)	3 (1.4%)
	$^{1}TN^{2}$	6 (5.3%)	8 (7.3%)	14 (6.3%)	9 (8.3%)	12 (12.1%)	21 (10.1%)
	$^{1}TN^{2-1}$	9 (8.0%)	8 (7.3%)	17 (7.6%)	8 (7.4%)	5 (5.1%)	13 (6.3%)
	$^{1}TN^{2-1-2}$	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (4.6%)	4 (4.0%)	9 (4.3%)
	$^{2}TN^{1}B^{1}P^{1}$	5 (4.4%)	10 (9.1%)	15 (6.7%)	1 (0.9%)	3 (3.0%)	4 (1.9%)
	$^{2}TNB^{1}P^{1}$	74 (65.5%)	70 (63.6%)	144 (64.6%)	29 (26.9%)	26 (26.3%)	55 (26.6%)
	$^{2}TNB^{1-2}P^{1}$	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	$^{3}TNMB^{1}DB^{1}P^{1}$	1 (0.04%)	0 (0.0%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Total Ukupno	113 (100%)	110 (100%)	223 (100%)	108 (100%)	99 (100%)	207 (100%)
	Chi square test Test χ^2	$\chi^2 = 10.86$; $p = 0.21$			$\chi^2 = 8.02$; $p = 0.43$		

TN – maxillary premolar; B – buccal root; P – palatal root; MB – mesiobuccal root; DB – distobuccal root; χ^2 – Chi square test value; p – the value of the probability of the Chi-square test
TN – gornji premolar; B – bukalni koren; P – palatinalni koren; MB – meziobukalni koren; DB – distobukalni koren; χ^2 – vrednost testa χ^2; p – vrednost verovatnoće testa χ^2

significant difference in the number of roots between the left and right maxillary first premolars. Analysis of the number of roots of maxillary first premolars in relation to gender did not reveal a statistically significant difference between male and female patients (Table 3).

A single root was observed in most maxillary second premolars. No statistically significant difference was found in the number of roots between left and right maxillary second premolars. Also, the difference in the number of roots of maxillary premolars between male and female patients was not statistically significant (Table 4).

The most common canal configuration in the maxillary first premolars, according to Ahmed et al. [5], can be marked with the code $^{2}TNB^{1}P^{1}$, while in the maxillary second premolars the most common code was $^{1}TN^{1}$. No statistically significant difference was found in the canal configuration between the left and right premolars (Table 5). The analysis of the canal morphology of the maxillary premolars in relation to gender did not show a statistically significant difference between men and women (Table 6). Figures 2–5 show some of the CBCT images, which were analyzed in the research.

DISCUSSION

Although periapical radiographs are common during endodontic treatment, this way it is not always possible to fully see the canal morphology due to the complex three-dimensional

Table 6. Frequency distribution of maxillary premolars canal configuration according to gender
Tabela 6. Distribucija frekvence konfiguracije kanala gornjih premolara prema polu

		Maxillary first premolar Gornji prvi premolari			Maxillary second premolar Gornji drugi premolari		
		Male / Muškarci	Female / Žene	Total / Ukupno	Male / Muškarci	Female / Žene	Total / Ukupno
Canal configuratin types Tipovi konfiguracije kanala	$^{1}TN^{1}$	6 (5.8%)	5 (4.2%)	11 (4.9%)	38 (40.9%)	44 (38.6%)	82 (39.6%)
	$^{1}TN^{1-2}$	5 (4.9%)	4 (3.3%)	9 (4.0%)	5 (5.4%)	9 (7.9%)	14 (6.8%)
	$^{1}TN^{1-2-1}$	5 (4.9%)	3 (2.5%)	8 (3.6%)	0 (0.0%)	6 (5.3%)	6 (2.9%)
	$^{1}TN^{1-2-1-2}$	1 (1.0%)	3 (2.5%)	4 (1.8%)	0 (0.0%)	3 (2.6%)	3 (1.4%)
	$^{1}TN^{2}$	4 (3.9%)	10 (8.3%)	14 (6.3%)	15 (16.1%)	6 (5.3%)	21 (10.1%)
	$^{1}TN^{2-1}$	7 (6.8%)	10 (8.3%)	17 (7.6%)	6 (6.5%)	7 (6.1%)	13 (6.3%)
	$^{1}TN^{2-1-2}$	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (5.4%)	4 (3.5%)	9 (4.3%)
	$^{2}TN^{1}B^{1}P^{1}$	10 (9.7%)	5 (4.2%)	15 (6.7%)	2 (2.2%)	2 (1.8%)	4 (1.9%)
	$^{2}TNB^{1}P^{1}$	64 (62.1%)	80 (66.7%)	144 (64.6%)	22 (23.7%)	33 (28.9%)	55 (26.6%)
	$^{2}TNB^{1-2}P^{1}$	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	$^{3}TNMB^{1}DB^{1}P^{1}$	1 (1.0%)	0 (0.0%)	1 (0.4%)	0 (0.0%)	0 (0,0%)	0 (0,0%)
	Total / Ukupno	103 (100%)	120 (100%)	223 (100%)	93 (100%)	114 (100%)	207 (100%)
	Chi square test Test χ^2	χ^2 = 7,99; p = 0,21			χ^2 = 14,85; p = 0,06		

TN – maxillary premolar; B – buccal root; P – palatal root; MB – mesiobuccal root; DB – distobuccal root; χ^2 – Chi square test value; p – the value of the probability of the Chi-square test
TN – gornji premolar; B – bukalni koren; P – palatinalni koren; MB – meziobukalni koren; DB – distobukalni koren; χ^2 – vrednost testa χ^2; p – vrednost verovatnoće testa χ^2

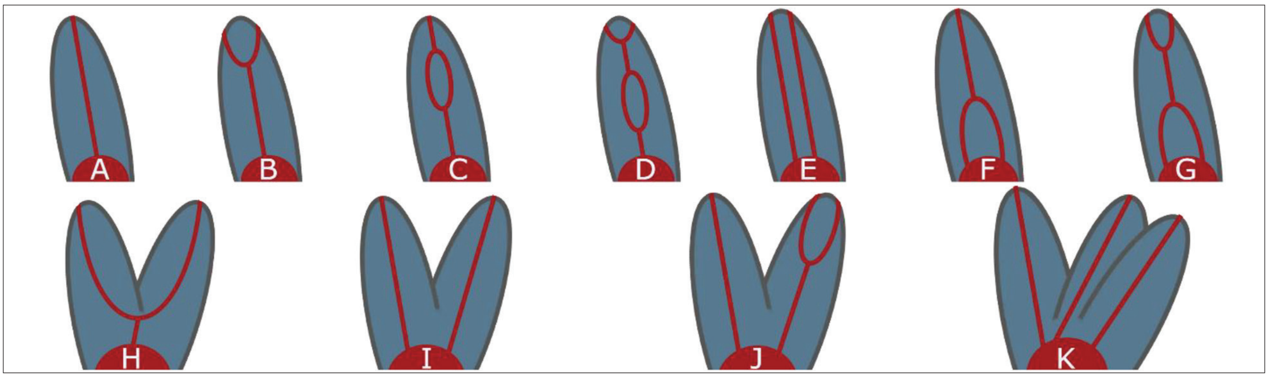

Figure 1. Schematic representations of maxillary premolar canal configurations, according to Ahmed et al. [5] are labeled as follows: **A** $^{1}TN^{1}$; **B** $^{1}TN^{1-2}$; **C** $^{1}TN^{1-2-1}$; **D** $^{1}TN^{1-2-1-2}$; **E** $^{1}TN^{2}$; **F** $^{1}TN^{2-1}$; **G** $^{1}TN^{2-1-2}$; **H** $^{2}TN^{1}B^{1}P^{1}$; **I** $^{2}TNB^{1}P^{1}$; **J** $^{2}TNB^{1-2}P^{1}$; **K** $^{3}TNMB^{1}DB^{1}P^{1}$
Slika 1. Šematski prikazi konfiguracija kanala premolara koje su prema Ahmedu i saradnicima [5] obeleženi na sledeći način: **A** $^{1}TN^{1}$; **B** $^{1}TN^{1-2}$; **C** $^{1}TN^{1-2-1}$; **D** $^{1}TN^{1-2-1-2}$; **E** $^{1}TN^{2}$; **F** $^{1}TN^{2-1}$; **G** $^{1}TN^{2-1-2}$; **H** $^{2}TN^{1}B^{1}P^{1}$; **I** $^{2}TNB^{1}P^{1}$; **J** $^{2}TNB^{1-2}P^{1}$; **K** $^{3}TNMB^{1}DB^{1}P^{1}$

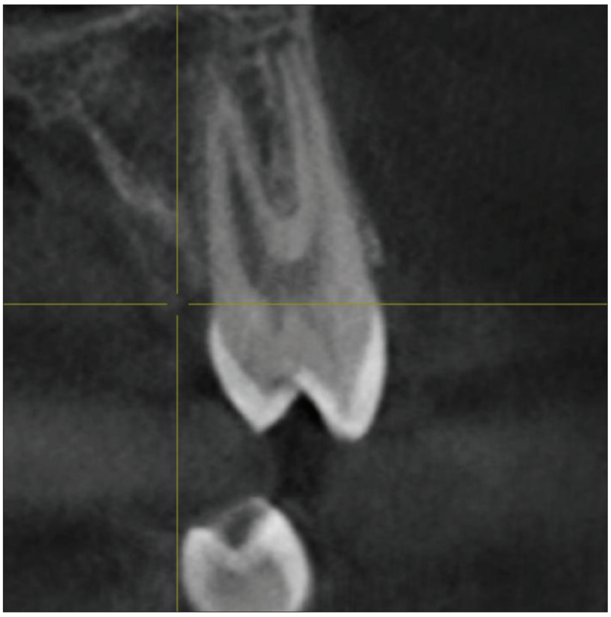

Figure 2. The most common canal configuration of the maxillary first premolar: $^{2}14B^{1}P^{1}$
Slika 2. Najčešća konfiguracija kanala gornjeg prvog premolara: $^{2}14B^{1}P^{1}$

structure of the tooth root canal. The superimposition of buccal and palatal roots on two-dimensional images prevents an adequate assessment of the number and position of the canals, making it difficult to plan therapeutic procedures in endodontics. This difficulty can be solved by analyzing images made by the cone beam computed tomography (CBCT) method [8]. These images provide a three-dimensional insight into the bone structures and tooth morphology, which eliminates the problems of superimposition on two-dimensional images. In addition to its wide clinical use, the analysis of CBCT images is recognized in the literature as extremely useful in many studies, which deal with the examination of morphological variations of individual teeth in different populations [9, 10]. Using this method, a larger number of teeth are available for examination, compared to research on extracted teeth, which limit the analysis to teeth extracted for certain orthodontic or prosthetic reasons.

During classification of maxillary premolars canal configurations according to Vertucci [4], many authors faced a problem, since this type of classification does not provide insight into the number of roots. This means that, based on the classification itself, it is not possible to conclude how many roots a

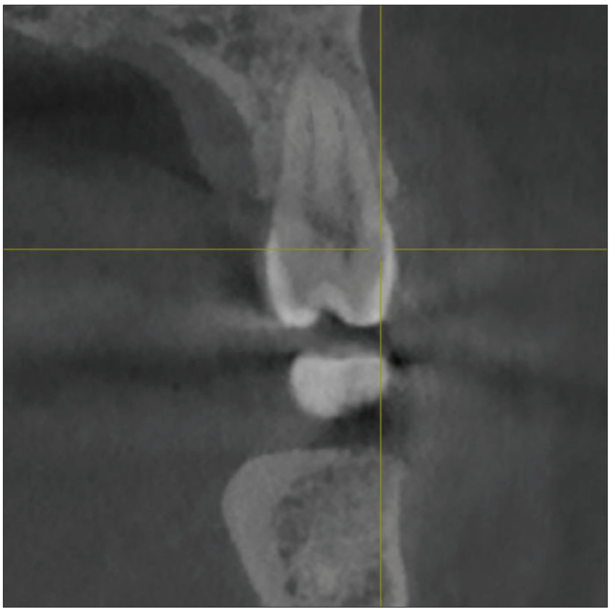

Figure 3. Canal configurations of the maxillary first premolar: $^{1}14^{2}$
Slika 3. Jedna od konfiguracija kanala gornjeg prvog premolara: $^{1}14^{2}$

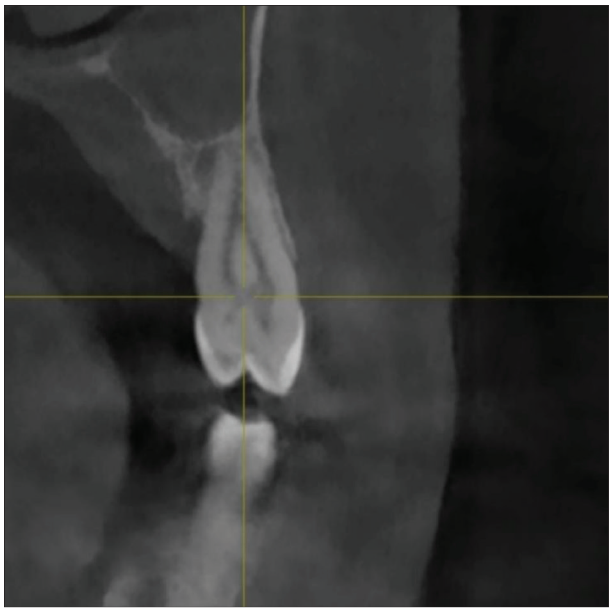

Figure 4. Rarer canal configurations of the maxillary first premolar: $^{1}14^{2-1}$
Slika 4. Jedna od ređih konfiguracija kanala gornjeg prvog premolara: $^{1}14^{2-1}$

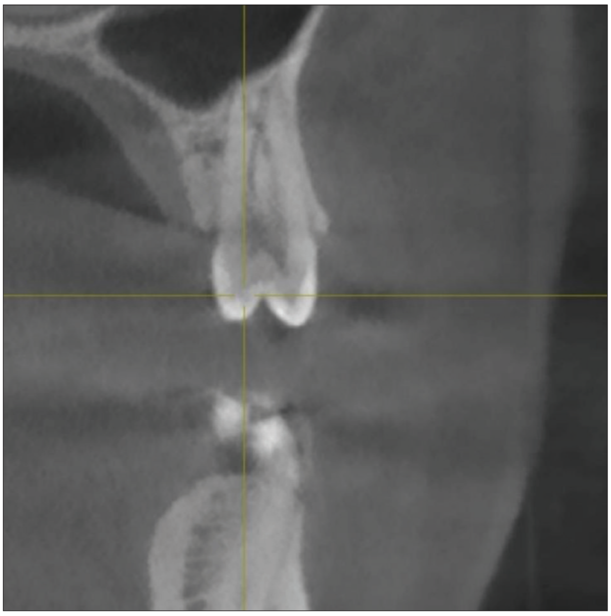

Figure 5. Rarer canal configurations of the maxillary first premolar: $^{1}14^{2-1-2}$
Slika 5. Jedna od ređih konfiguracija kanala gornjeg prvog premolara: $^{1}14^{2-1-2}$

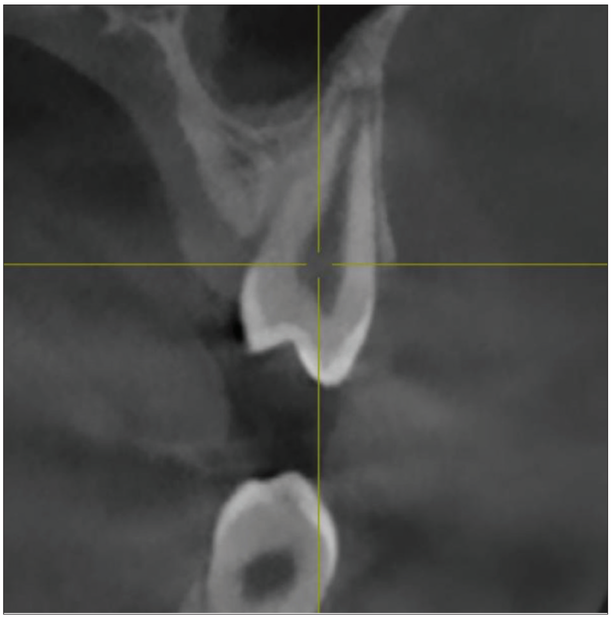

Figure 6. The most common canal configuration of the maxillary second premolar: $^{1}25^{1}$
Slika 6. Najčešća konfiguracija kanala gornjeg drugog premolara: $^{1}25^{1}$

particular tooth has [5]. Also, the progress of technology and the emergence of systems that allow three-dimensional representation of teeth have detected certain variations of canal systems, which due to their complexity could not be classified into already existing categories according to Vertucci. In the study by Filpo-Perez et al. [11], 13% of the distal roots that were examined could not be classified into any of the types of Vertucci's calcification. In 2017, Ahmed et al. [5] proposed a very thorough type of canal configuration classification, which is universal and can be applied to any tooth, regardless of the number of roots, the number of canals in the root, mutual connections, and separations of the canals in the roots.

Analysis of CBCT images in this study showed that the largest number of maxillary first premolars have two roots (71.3%). This is in agreement with the results of studies, which examined morphology on extracted maxillary premolars [12]. A similar prevalence of double-rooted maxillary first premolars was observed in a study conducted in the Polish population [10]. The study by Neelakantan et al. [13] showed that double-rooted first premolars dominated in the population of India in a significantly higher percentage compared to the results of our study. In contrast, the study by Tian et al. [14] showed a higher prevalence of single-rooted first premolars in Chinese population. Such differences in morphology can be explained by data from the literature that indicate that during tooth root development, genes that differ between populations play a key role and are responsible for such population differences [15]. Within each population, a rare occurrence of three-rooted first premolars was observed, which was also shown by the results of this study [10, 14].

The results of our study showed a higher prevalence of single-rooted maxillary second premolars (71.5%) compared to two-rooted (28.5%). A similar ratio in the root morphology of the maxillary second premolars was observed in a CBCT study, which investigated the number of roots of these teeth in the population of Saudi Arabia [9].

Internal morphology of teeth largely follows the external morphology [4]. However, the results of this study showed that a significant number of teeth, despite having one root, had two canals, which was observed in 11.7% of male and 16.6% female. This is in agreement with the results of the study that analyzed extracted teeth and found that after preparation of the access cavity in single-rooted maxillary premolars, two canals are more often observed than one [16].

The results of our study showed great variability of the canal system of maxillary premolars, which is reflected in the fact that almost all types of configurations were found in these teeth. The largest number of examined maxillary first premolars (64.6%) was marked with the code $^{2}TNB^{1}P^{1}$ according to Ahmed's classification, which suggests that they have two roots with one canal each. This is in agreement with studies, that classified the canal system of maxillary first premolars this way [10, 15, 17]. Maxillary premolars that have two roots with one canal each, but also those that have one root with two canals, are classified according to Vertrucci [4] in the fourth type. In studies that classified the canal system according to Vetrucci, the largest number of maxillary first premolars had a fourth type canal configuration. This classification does not provide information on whether these premolars had one or two roots, but indicates that they had two canals that started from the floor of the pulp chamber, which was certainly the case in our examination [9, 18]. Two openings on the floor of the chamber were observed in the largest number of maxillary first molars in a study by AlZubaidi et al. [19], who evaluated the configuration of maxillary premolars using CBCT.

The largest number of maxillary second premolars in our study had a canal system that can be marked with the code $^{1}TN^{1}$, which is in agreement with the study by Olczak et al. [20], who marked the morphology of the maxillary second premolars in Polish population according to Ahmed's classification. This data shows that one root with a single canal was observed in these teeth, which is in agreement with research, where the most common type of canal system of these teeth was type one according to Vertuucci [18]. A quarter of the maxillary second premolars in our study were coded $^{2}TNB^{1}P^{1}$, which indicates teeth that have two roots with one canal each.

In our study, 5.4% of maxillary first premolars and 8.6% of maxillary second premolars had the most demanding canal systems for endodontic treatment, which includes canals that branch and reunite ($^{1}TN^{1-2-1}$, $^{1}TN^{1-2-1-2}$, $^{1}TN^{2-1-2}$). Teeth with such canal configuration, despite adequate diagnostics, can represent a challenge for endodontic treatment, which must be carried out with great caution since there is a risk of rotary endodontic instrument breakage during canal treatment due to overcoming resistance to cyclic fatigue when working in curved canals [21].

Analysis of the external morphology of the roots of the first and second premolars in relation to gender did not reveal a statistically significant difference in the number of roots between men and women, which is in agreement with the results of studies conducted in the Polish population [10, 20]. A significant difference between left and right sides in terms of the number of roots and configuration of the root canal was not observed, which may be of importance to therapists when endodontically treating the same group of teeth on the contralateral side in the same patients.

CONCLUSION

The classification of the tooth canal system according to Ahmed et al. emphasizes the advantage of the simultaneous classification of the number of roots and the number of canals, thus overcoming the ambiguities in this area. Most of the maxillary first premolars had two roots, while most of the second had one root. Due to the complexity of the canal morphology, every seventh maxillary premolar can be a challenge for endodontic treatment, so the analysis of the radiograph before endodontic intervention is imperative. This analysis can be performed in a very reliable way through CBCT images.

ACKNOWLEDGMENT

This research was supported by the scientific research project of the Faculty of Medicine of the University of Niš, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia (451-03-47/2023-01/200113).

REFERENCES

1. Costa FFNP, Pacheco-Yanes J, Siqueira JF, Oliveira ACS, Gazzaneo I, Amorim CA, et al. Association between missed canals and apical periodontitis. Int Endod J. 2019;52(4):400–6. [DOI: 10.1111/iej.13022] [PMID: 30284719]
2. Abusteit OE, Hosney S, ElSheshtawy AS, Zapata RO. Outcome of Endodontic Treatment through Existing Full Coverage Restorations: An Endodontic Practice Case Series. J Endod. 2022;48(3):388–95. [DOI: 10.1016/j.joen.2021.11.008] [PMID: 34843799]
3. Karobari MI, Parveen A, Mirza MB, Makandar SD, Nik Abdul Ghani NR, Noorani TY, et al. Root and Root Canal Morphology Classification Systems. Int J Dent. 2021;6682189. [DOI: 10.1155/2021/6682189] [PMID: 33679981]
4. Vertucci FJ. Root canal morphology and its relationship to endodontic procedures. Endod Topics. 2005;10(1):3–29. [DOI: 10.1111/j.1601-1546.2005.00129.x]
5. Ahmed HMA, Versiani MA, De-Deus G, Dummer PMH. A new system for classifying root and root canal morphology. Int Endod J. 2017;50(8):761–70. [DOI: 10.1111/iej.12685] [PMID: 27578418]
6. Slaus G, Bottenberg P. A survey of endodontic practice amongst Flemish dentists. Int Endod J. 2002;35(9):759–67. [DOI: 10.1046/j.1365-2591.2002.00564.x] [PMID: 12449027]
7. Zaatar EI, Al-Kandari AM, Alhomaidah S, Al Yasin IM. Frequency of endodontic treatment in Kuwait: Radiographic evaluation of 846 endodontically treated teeth. J Endod. 1997;23(7):453–6. [DOI: 10.1016/S0099-2399(97)80302-0]
8. Mazzi-Chaves JF, Camargo RV, Borges AF, Silva RG, Pauwels R, Silva-Sousa YTC, et al. Cone-Beam Computed Tomography in Endodontics—State of the Art. Curr Oral Health Rep. 2021;8(2):9–22. [DOI: 10.1007/s40496-021-00292-8]

9. Mirah MA, Bafail A, Baik A, Abu Zaid B, Hakeem M, Ghabbani H. Root Canal Morphology of Premolars in Saudis. Cureus. 2023;15(9):e45888. [DOI: 10.7759/cureus.45888] [PMID: 37885565]
10. Olczak K, Pawlicka H, Szymański W. Root form and canal anatomy of maxillary first premolars: a cone-beam computed tomography study. Odontology. 2022;110(2):365–75. [DOI: 10.1007/s10266-021-00670-9] [PMID: 34714481]
11. Filpo-Perez C, Bramante CM, Villas-Boas MH, Húngaro Duarte MA, Versiani MA, Ordinola-Zapata R. Micro–computed Tomographic Analysis of the Root Canal Morphology of the Distal Root of Mandibular First Molar. J Endod. 2015;41(2):231–6. [DOI: 10.1016/j.joen.2014.09.024] [PMID: 25447505]
12. Atieh MA. Root and canal morphology of maxillary first premolars in a Saudi population. J Contemp Dent Pract. 2008;9(1):46–53. [PMID: 18176648]
13. Neelakantan P, Subbarao C, Ahuja R, Subbarao CV. Root and canal morphology of Indian maxillary premolars by a modified root canal staining technique. Odontology. 2011;99(1):18–21. [DOI: 10.1007/s10266-010-0137-0] [PMID: 21271321]
14. Tian YY, Guo B, Zhang R, Yu X, Wang H, Hu T, et al. Root and canal morphology of maxillary first premolars in a Chinese subpopulation evaluated using cone-beam computed tomography. Int Endod J. 2012;45(11):996–1003. [DOI: 10.1111/J.1365-2591.2012.02059.x] [PMID: 22551454]
15. Saber SEDM, Ahmed MHM, Obeid M, Ahmed HMA. Root and canal morphology of maxillary premolar teeth in an Egyptian subpopulation using two classification systems: a cone beam computed tomography study. Int Endod J. 2019;52(3):267–78. [DOI: 10.1111/iej.13016] [PMID: 30225932]
16. Nikolić M, Mitić A, Gašić J, Popović J, Barac R, Dačić S, et al. First premolar variations in number of roots, root canals and tooth length. Glasnik Antropoloskog drustva Srbije. 2014;(49):37–41. [DOI: 10.5937/gads1449037N]
17. Khanna S, Jobanputra L, Mehta J, Parmar A, Panchal A, Mehta F. Revisiting Premolars Using Cone-Beam Computed Tomography Analysis and Classifying Their Roots and Root Canal Morphology Using Newer Classification. Cureus. 2023;15(5):e38623. [DOI: 10.7759/cureus.38623] [PMID: 37284378]
18. Erkan E, Olcay K, Eyüboğlu TF, Şener E, Gündoğar M. Assessment of the canal anatomy of the premolar teeth in a selected Turkish population: a cone-beam computed tomography study. BMC Oral Health. 2023;23(1):403. [DOI: 10.1186/s12903-023-03107-7] [PMID: 37337200]
19. Al-Zubaidi SM, Almansour MI, Al Mansour NN, Alshammari AS, Alshammari AF, Altamimi YS, et al. Assessment of root morphology and canal configuration of maxillary premolars in a Saudi subpopulation: a cone-beam computed tomographic study. BMC Oral Health. 2021;21(1):397. [DOI: 10.1186/s12903-021-01739-1] [PMID: 34389013]
20. Olczak K, Pawlicka H, Szymański W. Root and canal morphology of the maxillary second premolars as indicated by cone beam computed tomography. Aust Endo J. 2023;49(1):92–103. [DOI: 10.1111/aej.12624] [PMID: 35502481]
21. Sobotkiewicz T, Huang X, Haapasalo M, Mobuchon C, Hieawy A, Hu J, et al. Effect of canal curvature location on the cyclic fatigue resistance of reciprocating files. Clin Oral Investig. 2021;25(1):169–77. [DOI: 10.1007/s00784-020-03348-8] [PMID: 32488488]

Received: 2.10.2023 • Accepted: 14.12.2023

Evaluacija varijacija u morfologiji kanala korena gornjih premolara pomoću kompjuterizovane tomografije konusnog zraka

Antonije Stanković[1], Jelena Popović[1,2], Marija Daković-Bjelaković[3], Nenad Stošić[1,2], Marija Nikolić[1,2], Aleksandar Mitić[1,2], Radomir Barac[1,2], Aleksandra Milovanović[1]

[1]Univerzitet u Nišu, Medicinski fakultet, Niš, Srbija;
[2]Klinika za dentalnu medicinu, Odeljenje za bolesti zuba i endodonciju, Niš, Srbija;
[3]Univerzitet u Nišu, Institut za anatomiju, Medicinski fakultet, Niš, Srbija

KRATAK SADRŽAJ

Uvod Gornji premolari se često podvrgavaju endodontskom tretmanu, što zahteva detaljno poznavanje njihove kanalne morfologije. Cilj ove studije je bio da se analizom snimaka napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT) odredi najčešći broj korenova gornjih premolara, kao i da se pomoću novog sistema za klasifikaciju kanalne morfologije autora Ahmeda i saradnika odredi najčešća konfiguracija kanala kod gornjih premolara u populaciji jugoistočne Srbije.

Materijal i metode U studiji je analizirano 55 CBCT snimaka muškaraca i 63 CBCT prikaza žena, u kojima su obuhvaćena 223 gornja prva premolara i 207 gornjih drugih premolara. Analiza je obavljena u programu Galileos. Određen je broj korenova ovih zuba i izvršena je klasifikacija unutrašnje morfologije u odnosu na pol i stranu gornje vilice.

Rezultati Gornji prvi premolari su imali najčešće dva korena i tip konfiguracije $^{2}TNB^{1}P^{1}$, dok su gornji drugi premolari imali najčešće jedan koren i tip konfiguracije $^{1}TNB^{1}$. Nije uočena statistički značajna razlika u broju korenova i tipu konfiguracije između muškaraca i žena, kao i između leve i desne strane.

Zaključak Klasifikacija kanalnog sistema zuba po Ahmedu i saradnicima ističe prednost istovremene klasifikacije broja korenova i broja kanala. Iako većina premolara ne predstavlja problem za lečenje, registrovane su konfiguracije kanala gornjih premolara koje mogu biti izazov za endodontsko lečenje. Detaljna analiza kanalne konfiguracije se može izvršiti pomoću CBCT.

Ključne reči: endodoncija; konfiguracija kanala; gornji premolari; CBCT

UVOD

Neidentifikovani kanali korena, koji nisu endodontski tretirani, predstavljaju izvor infekcije koji može da kompromituje ishod lečenja i da ugrozi ceo organizam. Ukoliko je tokom endodontskog lečenja zuba kanalni sistem nepotpuno obrađen i opturisan, endodontski tretman se ne smatra uspešnim [1]. Iz ovog proizilazi da je efikasan endodontski tretman zapravo nemoguć bez detaljnog poznavanja broja i pozicije korenova i kanala zuba. Tačna lokalizacija ulaza u kanale korena diktira preparaciju pristupnog kaviteta – važnu fazu endodontskog tretmana. Formiranje pristupnih kaviteta kod zuba prekrivenih krunom zahteva izuzetnu preciznost kako bi se izbeglo eventualno oštećenje same krune. Uklanjanje keramike, više nego što je neophodno, usled nepoznavanja tačne lokalizacije kanala korena može rezultirati pucanjem krune [2]. Ispitivanja varijacija konfiguracija kanala u okviru neke populacije može kliničarima pružiti korisne smernice tokom planiranja i izvođenja endodontskog tretmana na pojedinim zubima. Težnja ka poznavanju mogućih varijacija konfiguracije kanala korena zuba je doprinela konstantnom radu na pronalaženju univerzalnih klasifikacija, koje bi sagledale sve moguće kombinacije kanalnih konfiguracija korena zuba izazvane razdvajanjem i spajanjem kanala. Veliki broj autora je pokušao da klasifikuje kompleksnu morfologiju kanala korena opisujući na desetine tipova kanalnih konfiguracija [3]. Pored već dobro poznate klasifikacije po Vertučiju [4], klasifikacija kanalnih konfiguracija po Ahmedu [5], predstavljena 2017. godine, izdvojila se kao izuzetno korisna. Posebno se istakla zbog specifičnosti da se uz pomoć nje identifikuju konfiguracije kanala koje do tada nisu bile dokumentovane niti opisane u literaturi.

Iako svaki zub može da predstavlja izazov za lečenje, gornji premolari predstavljaju jednu od zahtevnijih grupa zuba za izvođenje endodontskog tretmana. Istraživanje čiji je cilj bio prikupljanje informacija o endodontskom tretmanu, koje su sproveli belgijski stomatolozi, ukazalo je na mnogo veći broj postendodontskih komplikacija kod premolara nego sekutića i očnjaka [6]. Prema studiji koju su sproveli Zaatar i saradnici [7], gornji premolari predstavljaju zube koji se veoma često podvrgavaju endodontskom tretmanu, s obzirom na to da je pomenuto istraživanje zabeležilo da je svaki treći endodontski lečeni zub u gornjoj vilici bio premolar.

Cilj ove studije je bio da se analizom CBCT snimaka odredi najčešći broj korenova gornjih premolara, kao i da se pomoću novog sistema za klasifikaciju kanalne morfologije autora Ahmeda i saradnika [5] odredi najčešća konfiguracija kanala kod gornjih premolara u populaciji jugoistočne Srbije.

MATERIJAL I METODE

Istraživanje je odobreno od strane Etičkog odbora Klinike za dentalnu medicinu u Nišu (01-728/23). U studiji je analizirano 118 CBCT snimaka pacijenata Klinike za dentalnu medicinu u Nišu (55 snimaka muškarca i 63 snimka žena). Snimci su analizirani u programu Galileos (Sirona, Germany). U studiji su analizirana 223 gornja prva premolara i 207 gornjih drugih premolara. Analiza je urađena od strane dvoje iskusnih kliničara, koji su posmatrajući CBCT prikaze određivali broj korenova gornjih premolara i klasifikovali konfiguraciju kanala gornjih premolara prema klasifikaciji Ahmeda i saradnika [5]. U Tabeli 1 su prikazane formule kodova, uz pomoć kojih bi prema primenjenoj klasifikaciji mogle da se označe konfiguracije kanala gornjih premolara. U Tabeli 2 su prikazani kodovi uz pomoć kojih se po Ahmedu i saradnicima [5] mogu označiti konfiguracije kanala gornjih premolara koje su zabeležene u literaturi i u skladu sa tim korišćene u ovom istraživanju.

REZULTATI

Najveći broj gornjih prvih premolara je imao dva korena. Analiza rezultata je pokazala da nije utvrđena statistički značajna razlika u broju korenova između levih i desnih gornjih prvih premolara. Analizom broja korenova gornjih prvih premolara u odnosu na pol nije utvrđena statistički značajna razlika između muških i ženskih pacijenata (Tabela 3).

Kod većine gornjih drugih premolara uočen je jedan koren. Nije utvrđena statistički značajna razlika u broju korenova između levih i desnih gornjih drugih premolara. Takođe, razlika u broju korenova gornjih drugih premolara između muških i ženskih pacijenata nije bila statistički značajna (Tabela 4).

Najzastupljenija konfiguracija kanala kod gornjih prvih premolara se po Ahmedu i saradnicima [5] može označiti kodom $^{2}TNB^{1}P^{1}$, dok je kod gornjih drugih premolara najzastupljeniji kod bio $^{1}TN^{1}$. Nije utvrđena statistički značajna razlika u kanalnoj konfiguraciji između premolara leve i desne strane (Tabela 5). Analiza kanalne morfologije gornjih premolara u odnosu na pol nije pokazala statistički značajnu razliku između muškaraca i žena (Tabela 6). Na slikama 2–5 prikazani su neki od CBCT snimaka koji su analizirani u istraživanju.

DISKUSIJA

Iako su retroalveolarni radiološki snimci uobičajeni prilikom endodontskog lečenja, na ovaj način nije uvek moguće potpuno sagledati kanalnu morfologiju zbog kompleksne trodimenzionalne strukture kanala korena zuba. Superponiranje bukalnih i palatinalnih korenova na dvodimenzionalnim snimcima onemogućava adekvatnu procenu broja i pozicije kanala, otežavajući planirane terapijske procedure u endodonciji. Ova poteškoća može da se reši analizom snimaka napravljenih metodom CBCT [8]. Na ovim snimcima omogućen je trodimenzionalni uvid u koštane strukture i morfologiju zuba, što otklanja probleme superponiranja na dvodimenzionalnim snimcima. Pored široke kliničke upotrebe, analiza CBCT snimaka je u literaturi prepoznata kao izuzetno korisna u mnogim istraživanjima koja se bave ispitivanjem morfoloških varijacijama pojedinih zuba u različitim populacijama [9, 10]. Pomoću ove metode ispitivanju je dostupan veći broja zuba, u poređenju sa istraživanjima na ekstrahiranim zuba, koja ograničavaju analizu na zube ekstrahovane iz određenih ortodontskih ili protetskih razloga.

Prilikom klasifikacije konfiguracija kanala gornjih premolara po Vertučiju [4], mnogi autori su se suočili sa problemom, s obzirom na to da ovaj vid klasifikacije ne pruža uvid u broj korenova zuba. Ovo znači da, na osnovu same klasifikacije, nije moguće zaključiti koliko korenova određeni zub ima [5]. Takođe, napredak tehnologije i pojava sistema koji omogućavaju trodimenzionalni prikaz zuba otkrili su određene varijacije kanalnih sistema, koje zbog svoje kompleksnosti nisu mogle da se svrstaju u već postojeće kategorije po Vertučiju. U studiji koju su sproveli Filpo-Perez i saradnici [11] 13% distalnih korenova koji su bili ispitivani nije moglo da se svrsta ni u jedan od tipova Vertučijeve klasifikacije. Ahmed i saradnici [5] predložili su 2017. godine veoma temeljan vid klasifikacije konfiguracije kanala, koji je univerzalan i može da se primeni na bilo kom zubu, bez obzira na broj korenova, broj kanala u korenu, međusobna spajanja i razdvajanja kanala u korenovima.

Analiza CBCT snimaka u ovoj studiji je pokazala da najveći broj gornjih prvih premolara ima dva korena (71,3%). Ovo je u saglasnosti sa rezultatima studija koje su ispitivanje morfologije vršile na ekstrahovanim gornjim premolarima [12]. Slična zastupljenost dvokorenih gornjih prvih premolara je uočena u istraživanju sprovedenom u populaciji Poljske [10]. U studiji koju su sproveli Neelakantan i sar. [13] dokazano je da su dvokoreni prvi premolari dominirali u populaciji Indije u značajno većem procentu u odnosu na rezultate naše studije. Suprotno tome, studija koju su sproveli Tian i sar. [14] na populaciji Kine pokazala je veću zastupljenost jednokorenih prvih premolara. Ovakve razlike u morfologiji se mogu objasniti podacima iz literature koji ukazuju da tokom razvoja korena zuba ključnu ulogu igraju geni koji se razlikuju među populacijama, i koji su zaslužni za ovakve populacione razlike [15]. U okviru svake populacije je uočena retka pojava trokorenih prvih premolara, što su pokazali i rezultati ove studije [10, 14].

Rezultati ove studije su pokazali veću zastupljenost jednokorenih gornjih drugih premolara (71,5%) u odnosu na dvokorene (28,5%). Sličan odnos u korenskoj morfologiji gornjih drugih premolara uočen je u CBCT studiji koja se bavila ispitivanjem broja korenova ovih zuba u populaciji Saudijske Arabije [9].

Unutrašnja morfologija zuba u najvećoj meri prati spoljašnju morfologiju [4]. Međutim, rezultati ove studije su pokazali da je značajan broj zuba, uprkos jednom korenu, imao dva kanala, što je zapaženo kod 11,7% muških ispitanika i 16,6% ženskih ispitanika. Ovo je u saglasnosti sa rezultatima ispitivanja u kojima je analizom ekstrahovanih zuba zaključeno da se nakon formiranja pristupnog kaviteta kod jednokorenih gornjih premolara češće uočavaju dva kanala nego jedan [16].

Rezultati ove studije su pokazali veliku varijabilnost kanalnog sistema gornjih premolara, koja se ogleda u podatku da su kod ovih zuba pronađeni skoro svi tipovi konfiguracija. Najveći broj ispitivanih gornjih prvih premolara (64,6%) označen je kodom $^{2}TNB^{1}P^{1}$ po Ahmedovoj klasifikaciji, što sugeriše da imaju dva korena sa po jednim kanalom. Ovo je u saglasnosti sa studijama koje su kanalni sistem gornjih prvih premolara klasifikovali na ovaj način [10, 15, 17]. Gornji premolari koji imaju dva korena sa po jednim kanalom, ali i oni koji imaju jedan koren sa dva kanala, u klasifikaciji po Vertučiju [4] svrstavaju se u četvrti tip. U studijama koje su klasifikovale kanalni sistem po Vertučiju najveći broj gornjih prvih premolara je imao konfiguraciju kanala tip IV. Klasifikacija na ovaj način ne daje podatak da li su ti premolari imali jedan ili dva korena, ali ukazuje da su kod njih pronađena dva kanala koja su krenula sa poda komore, što je svakako bio slučaj i u našem ispitivanju [9, 18]. Dva otvora na podu komore su uočena kod najvećeg broja gornjih prvih molara u studiji AlZubaidija i saradnika [19], koji su procenjivali konfiguraciju gornjih premolara korišćenjem CBCT.

Najveći broj gornjih drugih premolara u ovoj studiji je imao kanalni sistem koji se može obeležiti kodom $^{1}TN^{1}$, što je u saglasnosti sa studijom koju su sproveli Olczak i saradnici [20], koji su po Ahmedovoj klasifikaciji označavali morfologiju gornjih drugih premolara u populaciji Poljske. Ovakav podatak pokazuje da je kod ovih zuba uočen jedan koren sa jednim kanalom, što je u saglasnosti i sa istraživanjima u kojima je najčešći tip kanalnog sistema ovih zuba bio tip I po Vertučiju [18]. Četvrtina gornjih drugih premolara u ovoj studiji je označena kodom $^{2}TNB^{1}P^{1}$, kojim se označavaju zubi koji imaju dva korena sa po jednim kanalom.

U ovoj studiji 5,4% gornjih prvih premolara i 8,6% gornjih drugih premolara imalo je najzahtevniji kanalni sistem za endodontski tretman, koji podrazumeva kanale koji se granaju pa spajaju ($^{1}TN^{1-2-1}$, $^{1}TN^{1-2-1-2}$, $^{1}TN^{2-1-2}$). Zubi sa ovakvom konfiguracijom kanala i pored adekvatne dijagnostike mogu predstavljati izazov za endodontski tretman, koji se mora sprovoditi uz veliki oprez budući da i tokom mašinske obrade kanala postoji opasnost od pucanja instrumenta usled prevazilaženja otpornosti na ciklični zamor prilikom rada u zakrivljenim kanalima [21].

Analizom spoljašnje morfologije korenova prvih i drugih premolara u odnosu na pol nije uočena statistički značajna razlika u broju korenova između muškaraca i žena, što je u saglasnosti sa rezultatima studija sprovedenim u populaciji Poljske [10, 20]. Značajna razlika između leve i desne strane u pogledu broja korenova i konfiguracije kanala korena nije uočena, što može biti od značaja terapeutima prilikom endodontskog tretiranja iste grupe zuba na kontralateralnoj strani kod istih pacijenata.

ZAKLJUČAK

Klasifikacija kanalnog sistema zuba po Ahmedu i saradnicima ističe prednost istovremene klasifikacije broja korenova i broja kanala, prevazilazeći time nejasnoće u ovoj oblasti. Većina gornjih prvih premolara je imala dva korena, dok je većina drugih imala jedan koren. Zbog kompleksnosti kanalne morfologije, svaki sedmi gornji premolar može biti izazov za endodontsko lečenje, tako da analiza radiološkog snimka pre endodontske intervencije predstavlja imperativ. Ova analiza se na veoma pouzdan način može ostvariti putem CBCT snimaka.

ZAHVALNICA

Istraživanje je podržano od strane naučnoistraživačkog projekta Medicinskog fakulteta Univerziteta u Nišu, koji finansira Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije (451-03-47/2023-01/200113).

ORIGINAL ARTICLE
ORIGINALNI RAD
DOI: https://doi.org/10.2298/SGS2304173D
UDC: 616.314-089.23

Comparative analysis of root canal length determination using cone-beam computerized tomography and apex locator

Aleksandra Đeri[1], Irena Radman Kuzmanović[1], Adriana Arbutina[2], Renata Josipović[1], Saša Marin[3], Mirjana Umićević-Davidović[2]

[1]University of Banja Luka, Faculty of Medicine, Department of Dental Diseases, Banja Luka, Republika Srpska;
[2]University of Banja Luka, Faculty of Medicine, Department of Orthodontics, Banja Luka, Republika Srpska;
[3]University of Banja Luka, Faculty of Medicine, Department of Oral Surgery, Banja Luka, Republika Srpska

SUMMARY

Introduction Determining the length of the root canal is one of the key factors that can affect the outcome of endodontic therapy. Incorrectly determined working length results in underfilled or overfilled canal.
The aim of this work was to verify the effectiveness of cone-beam computerized tomography (CBCT) and apex locators in determining working length of the root canal.

Material and method Endodontic procedure was performed according to established endodontic protocol on 98 teeth. Teeth were divided into two groups: single-rooted and multi-rooted teeth. In both groups, working length was measured with an apex locator (Woodpex III) and CBCT (Planmeca Viso). In multi-rooted teeth, the canals were classified according to their morphological position into the groups Lingvomesial (LM), Buccomesial (BM), Bucodistal (BD), Palatal (P) and Distal (D) canals. Root canal length was determined by a dentist using apex locator at the University of Banja Luka while CBCT analysis was performed by a radiology engineer at the 3DENT radiology center in Banja Luka.

Results CBCT odontometry had small deviations from apex locator odontometry. The mean value of the absolute difference between CBCT measurement and apex locator measurement was the smallest in the group of linguomesial canals (0.284 mm), and the largest in the group of distal canals of the lower molars (1.939 mm). Based on the results of the Mann-Whitney U test, it was concluded that there was no statistically significant difference ($p > 0.05$) in measured length of the root canal between the two methods in all groups of roots of multi-rooted teeth as well as in the group of single-rooted teeth.

Conclusion CBCT odontometry is as reliable as apex locator odontometry.

Keywords: root canal length; CBCT diagnostics in dentistry; odontometry

INTRODUCTION

Today's dental procedures inevitably involve the use of digital technologies. CBCT can be used for digitized determination of the length of the root canal. In CBCT odontometry, the patient is exposed to a minimal level of X-ray radiation while scanning the inside of the tooth root canal (endodontium). The CBCT device emits conical X-ray radiation while detectors collect information about the way X-rays pass through dental and surrounding structures. After scanning, collected data is used to reconstruct a three-dimensional image of dental structures [1, 2]. Image processing software allows endodontists to make precise measurements of the root canal length. However, due to exposure to X-ray radiation, the use of CBCT is performed with caution and in accordance with strictly controlled clinical indications, especially when endodontic protocol is carried out in children [3, 4, 5].

Decision to use CBCT in dental treatment is usually made based on the need for accurate diagnostic information and treatment planning. Although odontometric devices, also known as apex locators, are useful in determining the exact length of the root during endodontic treatments, there are several potential disadvantages or challenges that can arise with their use [6].

Apex locators use electrical impedance or sound signals to determine the length of a root canal. However, various factors, such as the presence of fluid or bleeding in the canal, the presence of metal fillings or a curved root canal, can lead to inaccurate results. This can lead to suboptimal treatment, including over- or under-instrumentsation and obturation [7, 8]. Correct use of the apex locator requires a skilled operator. Incorrect placement or use of the device can result in inaccurate measurements. Apex locators are not recommended in certain situations, such as the presence of metal crowns or if the patient has an implanted pacemaker, and the use of low-frequency current could disrupt the rhythm of pacemaker. Proximity of mandibular canal should also be taken into account during endodontic protocol on the lower posterior teeth, because inadequate odontometry can lead to injury to the mandibular canal if it is in the immediate vicinity of the

Address for correspondence: Aleksandra ĐERI, Bulervar Vojvode Petra Bojovića 21a, 78 000 Banja Luka, Republika Srpska; *aleksandra.djeri@med.unibl.org*

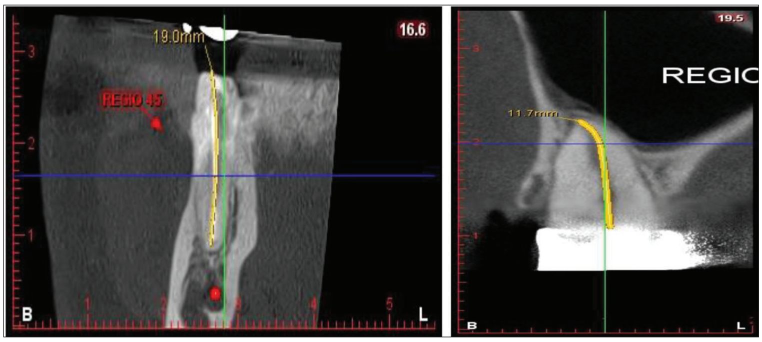

Figure 1. CBCT odontometry – Software compensation of the curved part of the canal
Slika 1. CBCT odontometrija – Softverska kompenzacija zakrivljenog dela kanala

Figure 2. Apex locator
Slika 2. Apeksni lokator

apical foramen. In such cases, it is recommended to use CBCT odontometry as an alternative method [9–12].

Apex locators require maintenance and calibration to be accurate. Improper maintenance or malfunctions of the device can lead to inaccurate measurements. Quality apex locators can represent an investment for a dental practice. On the other hand, apex locators are usually not a source of ionizing radiation like X-ray machines, but use electrical signals or sound waves. Nevertheless, the issue of patient exposure to electromagnetic radiation remains a topic of concern and research. The above shows the need for a new, more modern method of odontometry [13, 14, 15].

The aim of this work was to verify the effectiveness of cone-beam computed tomography (CBCT) and apex locators in determining working length of the root canal.

MATERIAL AND METHODS

The research was carried out within the project of the Faculty of Medicine of the University of Banja Luka at the Department of Dental Medicine under the auspices of the Ministry of Science, Technological Development and Information Systems of the Government of the Republika Srpska (project no. 19/6-020/961-48/18) as a retrospective study in the period 2019–2022. The study included 196 root canals of teeth that were indicated for endodontic treatment. Measurements of the length of the tooth root canal were performed on the complete sample – odontometry using the CBCT method (Planmeca ProMax 3D Classic (Planmeca, Finland) with a voxel size of 0.2 mm and a field of view of 4 × 4 cm) and determining the length of the root canal with the apex locator Woodpex III (Woodpecker Medical Instrument Co, Guilin, China).

There were six groups formed to measure root canal length:

1st group: Palatal canals of upper multi-rooted teeth – 24

2nd group: Bucomesial canals of upper and lower multi-rooted teeth – 49

3rd group: Bucodistal canals of upper multi-rooted teeth – 24

4th group: Linguomesial canals of lower multi-rooted teeth – 25

5th group: Distal canals of lower multi-rooted teeth – 25

6th group: Canals of single-rooted teeth of the upper and lower jaw – 49

1. CBCT odontometry

By analyzing the CBCT section, we first determined the position of the anatomical apical foramen, which represents the first reference point. Then, linear measurements were made to another reference point (determined arbitrarily – incisal edge, cusp tip or curved surface) (Figure 1). Linear measurements were parallel to the vertical axis of the tooth and were made from one reference point to another, where the axial cross-section allowed drawing a straight line from the anatomical foramen to the tip of the cusp or the incisal edge of the tooth. The measurement was more reliable as it was performed on both the mesio-distal and vestibulo-oral sections, after which the mean value of the measurement was calculated and taken as the working length. In the case of curved canals, it was suggested to use segmented linear measurements that form a certain angle with each other. The disadvantage of this method of odontometric measurements is that the reference points for measurement are set according to the curved path of the canal, which can affect repeatability of measurements. 3D Endo-software (Planmeca Viso, Helsinki Finland) has an innovative feature to detect the semi-automatic path of the root canal, after scanning the entrance to the canal, thus minimizing the possibility of subjective operator error. The software also compensates for curved surfaces and unevenness or depressions in the interior giving more reliable measured size (Figure 2).

2. Odontometry with apex locator

Electronic determination of the working length using the apex locator is based on fact that resistance between the tip of endodontic instrument that is in contact with the periodontium and oral mucosa is approximately constant and amounts to 6.5 kΩ. Soft tissues are conductors of low-frequency alternating current and contact of the endodontic instrument with the periodontal tissue closes the current circuit, which is read on the display of the apex locator. At the moment when it is observed on the display that we are in the area of the apical foramen (first reference point), the rubber stopper is placed in the position that determines the second reference point. After that, endodontic instrument is removed from the canal and the distance between the first and second reference points is measured. The obtained value is the working length of the tooth root canal (Figure 3).

RESULTS

For multi-rooted teeth (molar region), measurements are shown individually for the buccomesial (BM), linguomesial (LM), palatal (P) and distal (D) canal (Tables 1–3). Based on the results of the Mann-Whitney U test, it was concluded that there was no statistically significant difference $p > 0.05$ in the measured length of the tooth root canal between the two methods in all groups of multi-rooted teeth.

Table 1. Odontometry measured with apex locator
Tabela 1. Odontometrija izmerena apeksnim lokatorom

Root Koren	N	Minimum Minimum	Maximum Maksimum	Average value Srednja vrednost	Standard deviation Standardna devijacija
BM	49	14.00	21.00	17.9184	1.81242
BD	24	16.00	22.00	18.2083	1.64129
P	24	18.00	24.00	20.9167	1.90917
D	25	16.00	24.00	20.4800	1.93907
LM	25	16.00	22.00	17.8000	1.65831

Table 2. Odontometry measured by the CBCT method
Tabela 2. Odontometrija izmerena metodom kompjuterizovane tomografije konusnog zraka (CBCT)

Root Koren	N	Minimum Minimum	Maximum Maksimum	Average value Srednja vrednost	Standard deviation Standardna devijacija
BM	49	13.80	21.20	17.9137	1.82871
BD	24	15.80	21.80	18,1042	1.66145
P	24	17.80	23.70	20.8958	1.79183
D	25	17.00	23.50	20.5160	1.81284
LM	25	15.70	21.20	17.9500	1.48111

For single-rooted teeth, measurements of root canal length using apex locator and CBCT are shown in s 4-6. Based on the results of the Mann-Whitney U test, it was concluded that there was no statistically significant difference $p > 0.05$ in the measured root length between the two methods in single-rooted teeth.

Table 3. Comparison of apex locator odontometry and CBCT method in multi-rooted teeth
Tabela 3. Poređenje odontometrije apeksnim lokatorom i metodom kompjuterizovane tomografije konusnog zraka (CBCT) kod višekorenih zuba

Root Koren	Measurement_Method Metoda merenja	N	Average value Srednja vrednost	p
BM	MEASUREMENT WITH APEX LOCATOR MERENJE APEKSNIM LOKATOROM	49	48.64	0.767
	CBCT MEASUREMENT CBCT MERENJE	49	50.36	
	Total Ukupno	98		
BD	MEASUREMENT WITH APEX LOCATOR MERENJE APEKSNIM LOKATOROM	24	24.90	0.849
	CBCT MEASUREMENT CBCT MERENJE	24	24.10	
	Total Ukupno	48		
P	MEASUREMENT WITH APEX LOCATOR MERENJE APEKSNIM LOKATOROM	24	24.04	0.826
	CBCT MEASUREMENT CBCT MERENJE	24	24.96	
	Total Ukupno	48		
D	MEASUREMENT WITH APEX LOCATOR MERENJE APEKSNIM LOKATOROM	25	25.42	0.973
	CBCT MEASUREMENT CBCT MERENJE	25	25.58	
	Total Ukupno	50		
LM	MEASUREMENT WITH APEX LOCATOR MERENJE APEKSNIM LOKATOROM	25	23.28	0.284
	CBCT MEASUREMENT CBCT MERENJE	25	27.72	
	Total Ukupno	50		

Table 4. Odontometry with apex locator
Tabela 4. Odontometrija apeksnim lokatorom

	N	Minimum Minimum	Maximum Maksimum	Average value Srednja vrednost	Standard deviation Standardna devijacija
Root canal length Dužina kanala korena	49	13.07	21.07	17.0812	1.74013

Table 5. Odontometry using the CBCT method
Tabela 5. Odontometrija metodom kompjuterizovane tomografije konusnog zraka (CBCT)

	N	Minimum Minimum	Maximum Maksimum	Average value Srednja vrednost	Standard deviation Standardna devijacija
Root canal length Dužina kanala korena	49	14.00	22.00	17.6735	1.77233

The mean value of the absolute difference between the CBCT measurement and the apex locator measurement was the smallest in the group of linguomesial canals and was 0.284 mm, and the largest in the group of distal canals of the lower molars was 1.939 mm. Based on the results of the Mann-Whitney U test, it was concluded that there was no statistically significant difference $p > 0.05$ in the measured length of root canals between the two methods in all groups of roots of multi-rooted teeth as well as in the group of single-rooted teeth

Table 6. Comparison of odontometry with apex locator and CBCT method
Tabela 6. Poređenje odontometrije apeksnim lokatorom i metodom kompjuterizovane tomografije konusnog zraka (CBCT)

	Measurement Method Metoda merenja	N	Average value Srednja vrednost	p
Root canal length Dužina kanala korena	MEASUREMENT WITH APEX LOCATOR MERENJE APEKSNIM LOKATOROM	49	50.66	0.685
	CBCT MEASUREMENT CBCT MERENJE	49	48.34	
	Total Ukupno	98	100	

DISCUSSION

By applying CBCT, endodontics gets a new diagnostic tool in different stages of endodontic therapy. Odontometry is one of the phases of the endodontic protocol, which determines the working length at which the chemomechanical instrumentation of the root canal is performed. Apex locators are successfully used for odontometry, however, the presence of serous, purulent or hemorrhagic fluid in the canal can interfere with the measurement and give wrong results. On the other hand, in patients who have an implanted pacemaker, the use of an apex locator is contraindicated. Recently, CBCT has been described as new endodontic tool for measuring the length of the root canal [16].

This innovative digital method showed that there is a high correlation between the image of the histological sections of the teeth and the analog CBCT image. The analysis of the results of our research showed that CBCT odontometry requires segmentation of the endodontic space and gives very precise measurements that have small deviations compared to apex locator measurements. In the group of single-rooted teeth, this deviation has no statistical significance ($p = 0.685$). The smallest length measured by the apex locator was 13.07 mm, while the smallest length measured by CBCT was 14 mm. By segmenting the CBCT image, we separated the endodontium from the surrounding tissue - dentin and tooth root cementum [17]. Initial reference points were marked on the incisal edge for anterior teeth and on the top of the vestibular cusp for posterior teeth. The final reference point in both groups was the physiological apical foramen 0.5 mm from the anatomical foramen.

In our study, neither in the group of single-rooted nor in the group of multi-rooted teeth, there was a statistically significant difference between measuring the working length by apex locator and CBCT imaging and that is in agreement with numerous studies [17, 18, 19]. However, there are studies that are suggest that CBCT odontometry is an unreliable method for determining working length [20].

Considering that there are larger number of studies with results that indicate reliability of using CBCT for endodontics, the reasons for the opposite findings could be misinterpretation of the results. In the interpretation of the radiographic image, a significant difference was observed between different observers. For this reason, the results of this research were interpreted by a radiology engineer.

In support that CBCT odontometry is a very new and precise method of determining the working length are also the results of our study in which wax models with extracted teeth were used to perform odontomery manually. Access cavities were prepared on the extracted teeth, after which expanders number 08, 10 and 15 were introduced into the canal until the tip of the expander appeared at the anatomical apical foramen. The working length was measured from the stopper positioned on the incisal edge of anterior teeth or on the top of the cusps of lateral teeth, while the second reference point was the anatomical apical foramen. Using the same positions of the reference points, the measurements were repeated by CBCT. The results showed that deviations of CBCT measurements from manual measurements were less than 1 mm, which had no significant difference [10].

Determination of the working length by CBCT imaging and the ability to manually adjust the path of the line drawn from reference point 1 to reference point 2 is one of the most creative features of Romexis software. This reduces the possibility of error to a minimum. In addition to the length, the therapist gets an insight into the path of the canal system of the root [21, 22].

Current study aimed to correlate the quality of an objective CBCT image with the relatively simple task of estimating the length of a tooth's root canal with an apex locator. The length was scaled in intervals and very suitable for statistical analysis, which confirmed the assumption that the CBCT method is a highly accurate method for determining root canal length. The only ethical obstacle for indicating CBCT odontometry is the amount of radiation. A key principle in radiation protection refers to the optimization of exposure in terms of the well-known principle "as low as reasonably possible" (ALARA). Therefore, knowing what quality is sufficient for a specific diagnostic or treatment task is essential for adopting this principle of radiation protection [23, 24].

REFERENCES

1. Paterson A, Franco V, Patel S, Foschi F. Use of preoperative cone-beam computed tomography to aid in establishment of endodontic working length: A systematic review and meta-analysis. Imaging Sci Dent. 2020;50(3):183–92. [DOI: 10.5624/isd.2020.50.3.183] [PMID: 33005575]
2. Decurcio DA, Bueno MR, Silva JA, Loureiro MAZ, Damião Sousa-Neto M, Estrela C. Digital planning on guided endodontics technology, Braz Dent J. 2021;32(5):23–33. [DOI: 10.1590/0103-6440202104740] [PMID: 34877975]
3. Moazzy I. Almansour, Saad M. Al-Zubaidi, Abdulmjeed S. Enizy and Ahmed A. Madfa: Comprehensive evaluation of root and root canal morphology of mandibular second molars in a Saudi subpopulation evaluated by cone-beam computed tomography. BMC Oral Health. 2022;22(1):267. [DOI: 10.1186/s12903-022-02305-z] [PMID: 35778729]
4. Van Gorp G, Lambrechts M, Jacobs R, Declerck D. Does clinical experience with dental traumatology impact 2D and 3D radiodiagnostic performance in paediatric dentists? An exploratory study. BMC Oral Health. 2022;22(1):245. [DOI: 10.1186/s12903-022-02281-4] [PMID: 35725397]

5. Sisli S, Gülen O. Root canal length measurement of molar teeth using cone-beam computed tomography (CBCT): comparison of two-dimensional versus three-dimensional methods. Eur Oral Res. 2021;55(2):94–8. [DOI: 10.26650/eor.20210124] [PMID: 34250476]
6. Mahmoud O, Awad Abdelmagied MH, Dandashi AH, Jasim BN, Tawfik Kayali HA, Al Shehadat S. Comparative Evaluation of Accuracy of Different Apex Locators: Propex IQ, Raypex 6, Root ZX, and Apex ID with CBCT and Periapical Radiograph–In Vitro Study. Int J Dent. 2021;2021:5563426. [DOI: 10.1155/2021/5563426] [PMID: 34054960]
7. Lo Giudice R, Nicita F, Puleio F, Alibrandi A, Cervino G, Lizio AS, et al. Accuracy of Periapical Radiography and CBCT in Endodontic Evaluation. Int J Dent. 2018;2018:2514243. [DOI: 10.1155/2018/2514243] [PMID: 30410540]
8. Kofler B, Jenetten L, Runge A, Degenhart G, Fischer N, Hörmann R, et al. ALADA Dose Optimization in the Computed Tomography of the Temporal Bone: The Diagnostic Potential of Different Low-Dose CT Protocols. Diagnostics. 2021;11(10):1894. [DOI: 10.3390/diagnostics11101894] [PMID: 34679601]
9. Lucena C, López JM, Martín JA, Robles V, González-Rodríguez MP. Accuracy of working length measurement: electronic apex locator versus cone-beam computed tomography. Int Endod J. 2014;47(3):246–56. [DOI: 10.1111/iej.12140] [PMID: 23772839]
10. Đeri A, Radman-Kuzmanović I, Čavić M, Vujaković I, Arbutina A, Uzelac T, et al. Root canal working length determination using Cone-Beam Computed Tomography. Stom Glas S. 2019;66(2):57–65. [DOI: 10.2478/sdj-2019-0006]
11. Đeri A, Brestovac N, Subotić S, Radman Kuzmanović I, Arbutina A, Marin S. CBCT analysis of apical distance between second lower-premolars, first and second lower molars and mandibular canal. Stom Glas S. 2021;68(3):122–7. [DOI: 10.2298/SGS2103122D]
12. Marin S, Đeri A, Vidović H, Trtić N, Arbutina A, Pavlić V. Cone-beam computed tomography assessment of the buccal bone thickness in anterior maxillary and mandibular teeth. Med Pregl. 2021;74(11–12):362–7. [DOI: 10.2298/MPNS2112362M]
13. Jafarzadeh H, Beyrami M, Forghani M. Evaluation of Conventional Radiography and an Electronic Apex Locator in Determining the Working Length in C-shaped Canals. Iran Endod J. 2017;12(1):60–3. [DOI: 10.22037/iej.2017.12] [PMID: 28179926]
14. Shibin J, Prathima GS, Suganya M, Nandhakumar S, Sanguida A, Kavitha M. Evaluation of the working length determination accuracy by cone-beam computed tomography in primary teeth. Int J Clin Pediatr Dent. 2022;15(Suppl 1):S92–S96. [DOI: 10.5005/jp-journals-10005-2330] [PMID: 35645504]
15. Wolf TG, Fischer F, Schulze RKW. Correlation of objective image quality and working length measurements in different CBCT machines: An ex vivo study. Sci Rep. 2020;10(1):194. [DOI: 10.1038/s41598-020-76424-4] [PMID: 33173072]
16. Jeger FB, Janner SF, Bornstein MM, Lussi A. Endodontic working length measurement with preexisting cone-beam computed tomography scanning: a prospective, controlled clinical study. J Endod. 2012;38(7):884–8. [DOI: 10.1016/j.joen.2012.03.024] [PMID: 22703648]
17. Connert T, Hülber-J M, Godt A, Löst C, ElAyouti A. Accuracy of endodontic working length determination using cone beam computed tomography. Int Endod J. 2014;47(7):698–703. [DOI: 10.1111/iej.12206] [PMID: 24134733]
18. Yılmaz F, Kamburoğlu K, Şenel B. Endodontic Working Length Measurement Using Cone-beam Computed Tomographic Images Obtained at Different Voxel Sizes and Field of Views, Periapical Radiography, and Apex Locator: A Comparative Ex Vivo Study. J Endod. 2017;43(1):152–6. [DOI: 10.1016/j.joen.2016.09.019] [PMID: 27986097]
19. Faraj BM. Preoperative Estimation of Endodontic Working Length with Cone-Beam Computed Tomography and Standardized Paralleling Technique in comparison to Its Real Length. Biomed Res Int. 2020;2020:7890127. [DOI: 10.1155/2020/7890127] [PMID: 33102594]
20. Lucena C, López JM, Martín JA, Robles V, González-Rodríguez MP. Accuracy of working length measurement: electronic apex locator versus cone-beam computed tomography. Int Endod J. 2014;47(3):246–56. [DOI: 10.1111/iej.12140] [PMID: 23772839]
21. Hilgenfeld T, Juerchott A, Deisenhofer UK, Weber D, Rues S, Rammelsberg P, et al. In vivo accuracy of tooth surface reconstruction based on CBCT and dental MRI-A clinical pilot study. Clin Oral Implants Res. 2019;30(9):920–7. [DOI: 10.1111/clr.13498] [PMID: 31257638]
22. Janner SF, Jeger FB, Lussi A, Bornstein MM. Precision of endodontic working length measurements: a pilot investigation comparing cone-beam computed tomography scanning with standard measurement techniques. J Endod. 2011;37(8):1046–51. [DOI: 10.1016/j.joen.2011.05.005] [PMID: 21763892]
23. Paterson A, Franco V, Patel S, Foschi F. Use of preoperative cone-beam computed tomography to aid in establishment of endodontic working length: A systematic review and meta-analysis. Imaging Sci Dent. 2020;50(3):183–92. [DOI: 10.5624/isd.2020.50.3.183] [PMID: 33005575]
24. Zidan M, Schwindling FS, Juerchott A, Mente J, Gehrig H, Nittka M, et al. Endodontic working length measurements of premolars and molars in high-resolution dental MRI: a clinical pilot study for assessment of reliability and accuracy. Clin Oral Investig. 2022;26(11):6765–72. [DOI: 10.1007/s00784-022-04636-1] [PMID: 35861757]

Received: 5.10.2023 • Accepted: 15.12.2023

Uporedna analiza određivanja dužine kanala korena zuba pomoću kompjuterizovane konusne tomografije i apeksnog lokatora

Aleksandra Đeri[1], Irena Radman Kuzmanović[1], Adriana Arbutina[2], Renata Josipović[1], Saša Marin[3], Mirjana Umićević-Davidović[2]

[1]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za bolesti zuba, Banja Luka, Republika Srpska;
[2]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za ortodonciju, Banja Luka, Republika Srpska;
[3]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za oralnu hirurgiju, Banja Luka, Republika Srpska

KRATAK SADRŽAJ

Uvod Određivanje dužine kanala korena zuba je jedan od ključnih faktora koji mogu uticati na ishod endodontske terapije. Pogrešno određena radna dužina rezultira nedovoljno napunjenim kanalom ili prepunjenim kanalom.

Cilj ovog rada je bio da se proveri efikasnost primene kompjuterizovane konusne tomografije (CBCT) i apeksnog lokatora u određivanju radne dužine kanala korena zuba.

Materijal i metode Endodontska procedura je sprovedena po endodotskom protokolu *lege artis* na 98 zuba. Zub su podeljeni u grupe jednokorenih i višekorenih zuba. U obe grupe radna dužina je izmerena apeksnim lokatorom (Woodpex III) i CBCT merenjem (Planmeca Viso). Kod višekorenih zuba kanali su prema morfološkom položaju svrstani u sledeće grupe: lingvomezijalni (LM), bukomezijalni (BM), bukodistalni (BD), palatinalni (P) i distalni (D) kanali. Odontometrija apeksnim lokatorom je vršena na licu mesta od strane operatera Univerzitet u Banjaluci, a CBCT analiza je vršena od strane inženjera radiologije u radiološkom centru 3DENT u Banjaluci.

Rezultati CBCT odontometrija je imala mala odstupanja od odontometrije apeksnim lokatorom. Srednja vrednost apsolutne razlike između CBCT merenja i merenja apeksnim lokatorom bila je najmanja u grupi lingvomezijalnih kanala i iznosila je 0,284 mm, a najveća u grupi distalnih kanala donjih molara – 1,939 mm. Na osnovu rezultata Man–Vitnijevog U testa došlo se do zaključka da nije postojala statistički značajna razlika ($p > 0,05$) u izmerenoj dužini kanala korena zuba između dve metode kod svih grupa korenova višekorenih zuba, kao ni u grupi jednokorenih zuba.

Zaključak CBCT odontometrija je jednako pouzdana kao i odontometrija apeksnim lokatorom.

Ključne reči: dužina kanala korena zuba; CBCT dijagnostika u stomatologiji; odontometrija

UVOD

Današnja stomatološka procedura neizostavno uključuje upotrebu digitalizovanih stomatoloških aparata. Za digitalizovano određivanje dužine kanala korena zuba može da se koristi konusna dentalna tomografija (cone beam conus tomography – CBCT). U CBCT odontometriji pacijent se izlaže minimalnom nivou rendgenskog zračenja dok se vrši skeniranje unatrašnjosti kanala korena zuba, endodoncijuma. CBCT uređaj emituje konusno rendgensko zračenje, a detektori prikupljaju informacije o načinu prolaska RTG zraka kroz zubne i okolne strukture. Nakon skeniranja, prikupljeni podaci se koriste za rekonstrukciju trodimenzionalne slike zubnih struktura [1, 2]. Softver za obradu slike omogućava endodontima da izvrše precizna merenja dužine kanala korena zuba. Međutim, zbog izloženosti pacijenta rendgenskom zračenju, upotreba CBCT-a se obavlja s oprezom i u skladu sa strogo kontrolisanim kliničkim indikacijama, pogotovo kada se endodontski protokol sprovodi kod dece [3, 4, 5].

Odluka o korišćenju CBCT-a u stomatološkom tretmanu obično se donosi na osnovu potreba za preciznim dijagnostičkim informacijama i planiranjem tretmana. Iako su odontometrijski aparati, poznati i kao apeksni lokatori, korisni u određivanju tačne dužine korena zuba tokom endodontskih tretmana, postoji nekoliko mogućih nedostataka ili izazova koji se mogu javiti pri njihovoj upotrebi [6].

Apeksni lokatori se baziraju na električnoj impedanci ili zvučnim signalima kako bi odredili dužinu kanala korena zuba. Međutim, različiti faktori, kao što su prisustvo tečnosti ili krvarenje u kanalu, prisustvo metalnih ispuna ili zakrivljen kanal korena, mogu dovesti do netačnih rezultata. To može dovesti do suboptimalnog lečenja, uključujući prekomerno ili nedovoljno čišćenje i preparaciju kanala [7, 8]. Tačna upotreba apeksnog lokatora zahteva veštog operatera. Pogrešno postavljanje ili korišćenje aparata može rezultirati netačnim merenjima. Apeksni lokatori se ne preporučuju u određenim situacijama, kao što je prisustvo metalnih krunica ili kad pacijent ima ugrađen pejsmejker, te bi upotreba niskofrekventne stuje mogla poremetiti ritam pejsmejkera. Takođe treba voditi računa o blizini mandibularnog kanala kod endodontskog protokola na donjim bočnim zubima jer neadekvatna odontometrija može dovesti do povrede mandibularnog kanala ukoliko je u neposrednoj blizini foramena apikale. U takvim slučajevima je preporuka da se koristi CBCT odontometrija kao alternativna metoda [9–12].

Apeksni lokatori zahtevaju održavanje i kalibraciju kako bi bili tačni. Neodgovarajuće održavanje ili kvarovi u aparatu mogu dovesti do netačnih merenja. Zatim, kvalitetni apeksni lokatori mogu predstavljati investiciju za stomatološku praksu. S druge strane, apeksni lokatori obično nisu izvor jonizirajućeg zračenja kao rendgenski aparati, ali koriste električne signale ili zvučne talase. Ipak, pitanje izloženosti pacijenta elektromagnetnom zračenju ostaje tema zabrinutosti i istraživanja. Iz navedenog se uočava potreba za novom, savremenijom metodom odontometrije. Cilj ovog rada bio je da ispita pouzdanost digitalizovanog merenja dužine kanala korena zuba pomoću CBCT odontometrije [13, 15].

MATERIJAL I METODE

Istraživanje je sprovedeno u okviru projekta Medicinskog fakulteta Univerziteta u Banjaluci na Odseku dentalne medicine pod pokroviteljstvom Ministarstva za nauku, tehnološki razvoj i informacione sisteme Vlade Republike Srpske (br. projekta 19/6-020/961-48/18) kao retrospektivna studija u periodu 2019–2022. godine. U istraživanje je uključeno 196 kanala korenova zuba koji su bili indikovani za endodontsku terapiju. Na kompletnom uzorku su izmerene dužine kanala korena zuba – odontometrija metodom CBCT (Planmeca ProMax 3D Classic (Planmeca, Finland) sa veličinom voksela od 0,2 mm i vidnog polja 4 × 4 cm) i određene dužine kanala korena zuba apeksnim lokatorom Woodpex III (Woodpecker Medical Instrument Co, Guilin, China).

Formirano je šest grupa za merenje odontometrije:

1. grupa: Palatinalni kanali gornjih višekorenih zuba – 24
2. grupa: Bukomezijalni kanali gornjih i donjih višekorenih zuba – 49
3. grupa: Bukodistalni kanali gornjih višekorenih zuba – 24
4. grupa: Lingvomezijalni kanali donjih višekorenih zuba – 25
5. grupa: Distalni kanali donjih višekorenih zuba – 25
6. grupa: Kanali jednokorenih zuba gornje i donje vilice – 49

1. CBCT odontometrija

Analizom CBCT preseka prvo smo utvrdili poziciju anatomskog foramena apikale, koji predstavlja prvu referentnu tačku. Potom su vršena linijska merenja do druge referentne tačke (određene proizvoljno – incizalna ivica, vrh kvržice ili zakrivljena površina) (Slika 1). Linijska merenja su paralelna sa aksijalnom osovinom zuba i vrše se od jedne do druge referentne tačke, pri čemu treba izabrati onaj aksijalni presek koji omogućava povlačenje ravne linije od anatomskog foramena do vrha kvržice ili incizalne ivice zuba. Merenje je pouzdanije ukoliko se izvrši i na meziodistalnim i na vestibulooralnim presecima, nakon čega se izračunava srednja vrednost merenja i uzima kao radna dužina. Kod zakrivljenih kanala se predlaže korišćenje segmentiranih linijskih merenja koja međusobno čine određeni ugao. Nedostatak ovakve metode odontometrijskog merenja je taj da se referentne tačke za merenje postavljaju prema zakrivljenoj putanji kanala, što može da utiče na ponovljivost merenja. 3D Endo-softwer (Planmeca Viso, Helsinki, Finland) ima inovativnu osobinu da detektuje poluautomatsku putanju kanala korena zuba, nakon skeniranja ulaza u kanal, tako da se minimizira mogućnost subjektivne greške operatera. Softver takođe kompenzuje zakrivljene površine i neravnine ili udubljenja u unutrašnjosti kanala, što daje pouzdaniju izmerenu veličinu (Slika 2).

2. Odontometrija apeksnim lokatorom

Elektronsko određivanje radne dužine korišćenjem apeksnog lokatora je bazirano na činjenici da je otpor između vrha endodontskog instrumenta koji je u kontaktu sa parodontom i oralne mukoze otprilike konstantan i iznosi 6.5 kΩ. Meka tkiva su provodnici niskofrekventne naizmenične struje, tako da se kontaktom endodontskog instrumenta sa parodontalnim tkivom zatvara strujni krug, što se očitava na displeju apeksnog lokatora. U trenutku kada je na displeju uočeno da se nalazimo u području foramena apikale (prva referentna tačka), gumeni graničnik se postavlja u poziciju koja određuje drugu referentnu tačku. Nakon toga se endodontski instrument uklanja iz kanala i meri se distanca između prve i druge referentne tačke. Dobijena vrednost je radna dužina kanala korena zuba (Slika 3).

REZULTATI

Kod višekorenih zuba (molarna regija) merenja su prikazana pojedinačno za bukomezijalni (BN), lingvomezijalni (LM), palatinalni (P) i distalni (D) kanal. Na osnovu rezultata Man–Vitnijevog U testa došlo se do zaključka da nije postojala statistički značajna razlika ($p > 0,05$) u izmerenoj dužini kanala korena zuba između dve metode kod svih grupa višekorenih zuba i u izmerenoj dužini korena između dve metode kod jednokorenih zuba.

Srednja vrednost apsolutne razlike između CBCT merenja i merenja apeksnim lokatorom bila je najmanja u grupi lingvomezijalnih kanala i iznosila je 0,284 mm, a najveća u grupi distalnih kanala donjih molara – 1,939 mm. Na osnovu rezultata Man–Vitnijevog U testa došlo se do zaključka da nije postojala statistički značajna razlika ($p > 0,05$) u izmerenoj dužini kanala korena zuba između dve metode kod svih grupa korenova višekorenih zuba, kao ni u grupi jednokorenih zuba.

DISKUSIJA

Primenom dentalnog CT-a endodoncija dobija novo dijagnostičko sredstvo u različitim fazama endodontske terapije. Odontometrija je jedna od faza endodontskog protokola kojom se određuje radna dužina na kojoj se vrši mehaničko-medikamentozna obrada kanala korena zuba. Apeksni lokatori se uspešno koriste za odontometriju, međutim prisustvo serozne, gnojne ili hemoragijske tečnosti u kanalu može da ometa merenje i daje pogrešne rezultate. S druge strane, kod pacijenata koji imaju ugrađen pejsmejker, kontraindikovana je upotreba apeksnog lokatora. Nedavno je CBCT opisan kao zanimljiv endodontski alat za merenje dužine kanala korena zuba, tj. određivanje odontometrije [16].

Ova inovativna digitalna metoda je pokazala da postoji visoka korelacija između slike histoloških preseka zuba i analogne CBCT slike. Analiza rezultata ovog istraživanja je pokazala da CBCT odontometrija zahteva segmentaciju endodontskog prostora i daje veoma precizna merenja, koja imaju mala odstupanja u odnosu na merenja apeksnim lokatorom. U grupi jednokorenih zuba to odstupanje nema statističku značajnost ($p = 0,685$). Najmanja izmerena dužina apeksnim lokatorom je 13,07 mm, dok je najmanja izmerena dužina CBCT snimanjem 14 mm. Segmentacijom CBCT slike odvajamo endodoncijum od okolnog tkiva-dentina i cementa korena zuba [17]. Početne referentne tačke su markirane na incizalnoj ivici kod frontalnih zuba i na vrhu vestibularne kvržice kod bočnih zuba. Završna referentna tačka u obe grupe bio je fiziološki foramen apikale 0,5 mm od anatomskog foramena.

U našoj studiji ni u grupi jednokorenih ni u grupi višekorenih zuba nema statistički značajne razlike između merenja radne dužine apeksnim lokatorom i CBCT snimanjem, što je u saglasnosti sa brojnim studijama [17, 18, 19]. Ipak, postoje studije koje su eksplicitne u tvrdnji da je CBCT odontometrija nepouzdan metod određivanja radne dužine [20].

S obzirom na to da je mnogo veći broj studija sa rezultatima koji ukazuju na pouzdanost korišćenja CBCT za endodonciju, za suprotne nalaze treba tražiti razloge u pogrešnoj interpretaciji rezultata. U interpretaciji radiografske slike primećena je značajna zavisnost između tačnosti kod različitih posmatrača. Iz tog razloga rezultati ovog istraživanja interpretirani su od strane jednog inženjera radiologije.

U prilog potvrdi da je CBCT odontometrija veoma pozdan i precizan metod određivanja radne dužine ukazuju i rezultati naše studije, u kojoj su korišćeni voštani modeli sa ekstrahovanim zubima na kojima je odontometrija urađena ručno. Na ekstrahovanim zubima su preparisani pristupni kaviteti, nakon čega su proširivači broj 08, 10 i 15 uvođeni u kanal do pojave vrha proširivača na anatomskom foramenu apikale. Radna dužina je merena od „stopera" pozicioniranog na incizalnoj ivici frontalnih zuba ili na vrhu kvržice bočnih zuba, dok je druga referentna tačka anatomski foramen apikale. Koristeći iste pozicije referentnih tačaka, merenja su ponovljena CBCT snimanjem. Rezultati su pokazali da su odstupanja CBCT merenja od ručnog merenja manja od 1 mm, što apsolutno nema klinički značaj [10].

Određivanje radne dužine CBCT snimanjem i mogućnost ručnog podešavanja putanje linije koja se povlači od referentne tačke 1 do referentne tačke 2 jedna je od najkreativnijih karakteristika softvera Romexis. Time se mogućnost greške svodi na minimum. Pored radne dužine, terapeut dobija uvid u putanju kanalnog sistema pulpe korena [21, 22].

Ovo istraživanje je imalo za cilj da poveže kvalitet objektivne CBCT slike sa relativno jednostavnim zadatkom procene dužine kanala korena zuba apeksnim lokatorom. Dužina je skalirana u intervalima i veoma pogodna za statističku analizu, koja je potvrdila pretpostavku da je CBCT metoda visoko precizna metoda za određivanje odontometrije. Jedina etička prepreka za indikovanje CBCT odontometrije je količina zračenja. Ključni princip u zaštiti od zračenja odnosi se na optimizaciju izloženosti u smislu dobro poznatog principa „nisko koliko je razumno moguće" (ALARA). Dakle, saznanje koji je kvalitet dovoljan za određeni dijagnostički ili tretmanski zadatak je od suštinskog značaja za usvajanje ovog principa zaštite od zračenja [23, 24].

ORIGINAL ARTICLE
ORIGINALNI RAD
DOI: https://doi.org/10.2298/SGS2304181K
UDC: 615.46:616.314-77(73)"2010/2014"; 616.314-089.28

Bonding of orthodontic ceramic brackets: optimal conditioning method of lithium disilicate restorations

Stefan Kuzmanovski[1], Cvetanka Bajraktarova Mishevska[2], Aneta Mijoska[1], Natasha Stavreva[1], Emilija Bajraktarova Valjakova[1]

[1]University „Ss Cyril and Methodius“, Faculty of Dentistry, Department of Prosthodontics, Skopje, Republic of North Macedonia;
[2]University „Ss Cyril and Methodius“, Faculty of Dentistry, Department of Orthodontics, Skopje, Republic of North Macedonia

SUMMARY

Introduction According to the data obtained from the American Orthodontic Society survey conducted in 2015, the number of adult patients that requested orthodontic treatment increased from 14% to 27% between 2010 and 2014. Because of the increased age of the patients, fixed orthodontic treatment is expected to be performed on restored teeth, including all ceramic restorations. The objectives of the present study were to evaluate the influence of different surface treatments on the bond strength of ceramic brackets to lithium disilicate ceramic and to determine the mode of fracture.

Material and method 45 ceramic rectangular specimens were obtained from lithium disilicate CAD/CAM blocks which were divided in five groups according to the performed surface conditioning method: 1. grinding with a fine diamond bur (control group); 2. sandblasting with 29 µm alumina (Al_2O_3); 3. etching with 4% hydrofluoric acid (HF); 4. sandblasting followed by conditioning with a universal primer – silanization (Al_2O_3 + S); 5. HF acid etching followed by silanization (HF + S). Shear bond strength test was performed after storing the samples in water bath for 7 days. All of the fractured samples were analyzed with optical microscope to determine the type of fracture.

Results HF acid etching followed by silanization performed the highest bond strength of 8.03 MPa, while sandblasting followed by silanization – 6.69 MPa. Mechanical surface conditioning with either HF acid etching or sandblasting resulted in significantly lower bond strength (2.65 MPa and 1.51 MPa respectively). Mainly adhesive mode of fractures was noticed after sandblasting and silanization, indicating minor chance of damaging the ceramic restoration after debonding, at the end of the orthodontic treatment, unlike the ceramic specimens in the Group 5 (HF + S) with 42.8% mixed and 14.4% cohesive fractures; 100% adhesive fractures were observed after mechanical treatments.

Conclusion According to the SBS test results and fracture type, sandblasting followed by the application of a universal primer can be considered as an adequate method for conditioning the lithium disilicate ceramic restorations before the bonding of ceramic orthodontic brackets.

Keywords: ceramic bracket; conditioning methods; lithium disilicate restoration; sandblasting; hydrofluoric acid; universal primer

INTRODUCTION

According to the data obtained from the survey of the American Orthodontic Society conducted in 2015, the number of adult patients that requested orthodontic treatment increased from 14% to 27% between 2010 and 2014; this means that the number of adult orthodontic patients has doubled in just 4 years [1]. Therefore, in daily clinical practice, treatment with orthodontic brackets can be expected to be performed on a dentition previously treated with fixed-prosthetic restorations – metal-ceramic or all-ceramic crowns or veneers. On the other hand, debonding of the brackets during the orthodontic treatment is an often problem, resulting in patients' frustration and dental appointments that are scheduled more frequently, with performing of the entire procedure for re-bonding the brackets. Obtaining an adequate bonding of the brackets to the restorations is of a great importance for the successful orthodontic treatment. However, the bond strength should not be too strong in order to avoid damage of the ceramic restorations during the debonding process of the brackets at the end of the orthodontic treatment [1].

The introduction of glass ceramics as restorative materials in prosthodontics, as well as the advantages of adhesive cementation, contributed to the development of the concept of ceramic etching with hydrofluoric acid (HFA). However, HFA possesses corrosive potential causing burns and necrosis of the tissue at the contact site, while if absorbed into the bloodstream, fluoride ions are distributed to all organs and tissues, provoking potential life-threatening systemic toxicity and organs failure. All this imposes an extraordinary caution and great awareness of health consequences when HF acid is used intraorally [2]: exposure of the oral mucosa to a concentration of 0.1%

Address for correspondence: Stefan KUZMANOVSKI, University „Ss Cyril and Methodius“, Faculty of Dentistry, Department of Prosthodontics, Skopje, Republic of North Macedonia; *s.kuzmanovski@hotmail.com*

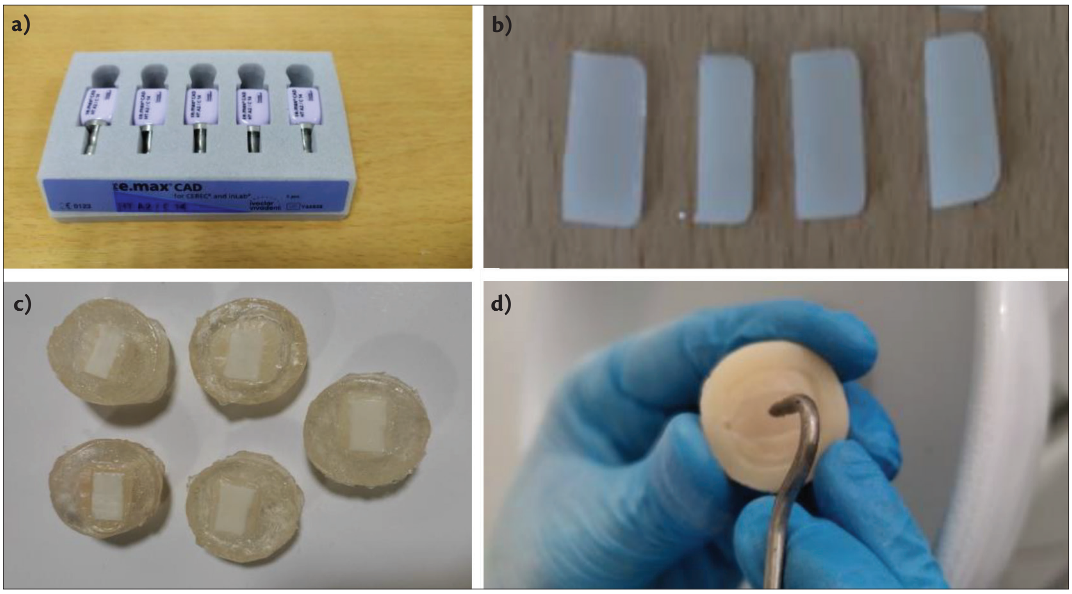

Figure 1. a) Lithium disilicate presintered CAD/CAM blocks; b) Ceramic samples after sintering; c) Prepared acrylic molds with ceramic samples; d) Air abrasion

Slika 1. a) Litijum-disilikatni presinterovani CAM/CAM blokovi; b) Keramički uzorci nakon sinterovanja; c) Pripremljeni akrilni kalupi sa keramičkim uzorcima; d) Vazdušna abrazija

Figure 2. a) Etching the samples with 4% HFA; b) Prepared samples from group 4; c) Prepared samples from group 5

Slika 2. a) Nagrizanje četvoroprocentnom fluorovodoničnom kiselinom; b) Pripremljeni uzorci Grupe 4; c) Pripremljeni uzorci Grupe 5

HFA can lead to mucosal necrosis [3]. When etching glass ceramics with 9.6% HFA, a double reaction occurs: primary - between the acid and the ceramic glass phase, and secondary – between the acid and the crystalline phase, leaving the larger crystals intact. In this way, an irregular surface is created with microscopic pores that enable the micromechanical interlocking of the adhesive resin. The more the crystalline phase is present, and the less the glass phase in the composition of the material, the greater is resistance of the ceramic to the acid [4].

Sandblasting using aluminum oxide (Al_2O_3) particles is another method for mechanical conditioning of the bonding surface of ceramic restorations causing an irregularity, which is required for micromechanical retention of the bonding agent. However, air abrasion may cause irreversible damage of the ceramic restorations. Therefore, it is recommended that Al_2O_3 sandblasting should be performed under low pressure (1-2 bars), using grain size less than 50 µm and at a distance of 10 mm perpendicular to the ceramic surface [5].

After mechanical treatment, in order to achieve an optimal bond with the composite luting cement, chemical conditioning with primers that contain silane is recommended. The silane molecule has two different functional groups: the -SiOH group that bonds to the silicon dioxide molecules and another organic functional group that bonds to the methacrylate resin of the composite cement [6].

The aim of the present study was to evaluate the influence of different surface conditioning methods on the bond strength of ceramic brackets to lithium disilicate ceramic and to determine the mode of fracture.

MATERIAL AND METHOD

Ceramic sections (2 mm thick) were obtained from presintered lithium disilicate CAD/CAM blocks IPS e. max CAD (Ivoclar Vivadent, Schaan Liechtenstein) with a diamond blade (Figure 1a) using a Minitom precise cutting machine (Struers, Denmark) (Figure 1b); cutting was performed with permanent water cooling to prevent overheating of the ceramic material that may cause microcracks. All the ceramic sections were sintered in a ceramic furnace Programat EP 5000 (Ivoclar Vivadent, Shaan Liechtenstein). Sintered ceramic sections were immersed in the middle of the metal ring molds (d = 30 mm) filled with freshly mixed cold-polymerizing acrylate polymethyl metahacrylate – PoliTEMP (PoliDent, Slovenia), with an exposed ceramic surface that was used as a bonding surface for the ceramic brackets (Figure 1c). After that, the

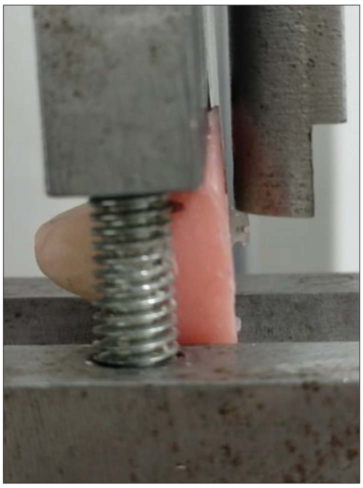

Figure 3. Shear bond strength test
Slika 3. Ispitivanje čvrstoće veze na smicanje

bonding surface of all ceramic samples was grinded with a fine diamond bur. All ceramic samples were randomly divided into 5 groups according to surface treatment:

1. Control group = no further treatment;
2. Al_2O_3: the bonding surfaces were sandblasted with 29-μm Al_2O_3 particles – Sandman (Innovative Micro Dentistry, Poland), perpendicular to the bonding surface, for 10 seconds, under a pressure of 1 bar and at 10 mm distance (Figure 1d). Surfaces were cleaned with air blowing for 5 sec.
3. HF: the bonding surfaces were etched with 4% hydrofluoric acid – IPS Ceramic etching gel (Ivoclar Vivadent, Shaan Liechtenstein) for a period of 20 seconds. Surfaces were thoroughly rinsed with water for 60 sec to remove the residual acid and dried with compressed air (Figure 2a).
4. Al_2O_3 + S: the bonding surfaces were sandblasted with 29-μm Al_2O_3 particles using a blasting procedure as in Group 2. After that, a universal primer – Monobond Plus (Ivoclar Vivadent, Shaan Liechtenstein) was applied in a thin coat and left to react for 60 seconds (Figure 2b). Any remaining excess was dispersed with a gentle stream of air.
5. HF + S: the bonding surfaces were etched with 4% hydrofluoric acid for 20 s, rinsed and dried. A universal primer – Monobond Plus was applied and left to react for 60 seconds (Figure 2c).

Bonding procedure

After surface treatment, ceramic brackets for maxillary central incisors – Cosmetic 20/40 UR Central (American Orthodontics, USA) were bonded to a treated surfaces using orthodontic composite luting cement No Mix:30™ One step Adhesive – (American Orthodontics, USA) with a constant vertical load of 1 kg, for 1 min. The composite cement was left to set in its self-curing mode. The samples were stored in distilled water at 37°C for 7 days – Biobase Water Tank WT-42 (Biobase Biodustry, Shandong, China) thus imitating the conditions in the oral cavity (moisture and temperature).

Shear bond strength test

The shear bond strength test (SBS) was carried out using a universal testing machine – Shimadzu AGS-X (Shimadzu Co., Japan), at a speed of 0.5 mm/min, for determining bond strength between orthodontic brackets and ceramic surfaces (Figure 3). The SBS was expressed in MPa, derived by dividing the imposed force (N) at the time of fracture by the bonding area of the ceramic bracket (mm^2) ($MPa = N/mm^2$).

Mode of fracture

The mode of fracture (adhesive, cohesive in luting cement or ceramic bracket or mixed) for each specimen was determined using a light microscopy – Levenhuk Zeno Cash ZC6 (Levenhuk Inc., USA) at a magnification of 60 ×.

Statistical Analysis

The analysis of categorical variables was done by determining coefficient of relationships, proportions and rates. Continuous variables were analyzed with measures of central tendency (mean, median, minimum and maximum values), as well as with measures of dispersion (standard deviation). Shapiro-Wilk W test was used to determine the normality of the frequency distribution of the studied variables. Pearson Chi square test was used to determine the association between certain attributive dichotomous features.

RESULTS

The SBS results after different surface treatments are recorded in Figure 4 and Table 1. The highest bond strength, 8.04±0.61 MPa, was recorded when ceramic brackets were bonded to ceramic surfaces that were etched with hydrofluoric acid followed by silanization (Group 5).

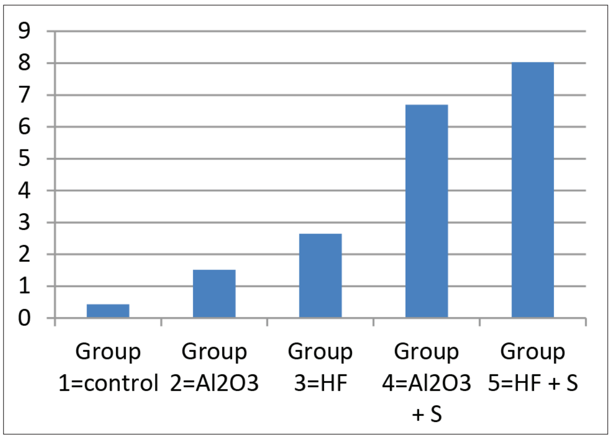

Figure 4. Mean SBS (MPa) after different conditioning treatments
Slika 4. Srednje vrednosti SBS-a (MPa) posle različitih metoda kondicioniranja površine

Insignificantly lower bond strength (p = 0.1477) was achieved when sandblasting the bonding surfaces with 29-μm Al_2O_3 followed by silanization (Group 4) – 6.69 ± 1.20 MPa. When mechanical treatments were performed only, HF acid etching (Group 3) or sandblasting (Group 2), the bond strength was significantly lower, 2.65 ± 0.84 MPa and 1.52 ± 0.43 MPa, respectively. The lowest SBS was recorded after grinding the ceramic surfaces with fine diamond burr (control group), 0.43 ± 0.23 MPa.

Adhesive fractures after debonding were exclusively present in the first three groups (100%), whereas in the Group 4 it showed dominant presence (71.4%). Mixed and cohesive modes of fracture in ceramic brackets were found only in the Groups 4 and 5 (Table 1).

Table 1. Mode of fracture after debonding
Tabela 1. Tip frakture nakon debondiranja

	Mode of fracture Tip frakture		
	Adhesive Adhezivni (%)	Cohesive Kohezivni (%)	Mixed Pomešani (%)
Group 1 Grupa 1	100	/	/
Group 2 Grupa 2	100	/	/
Group 3 Grupa 3	100	/	/
Group 4 Grupa 4	71.4	14.3	14.3
Group 5 Grupa 5	42.8	14.4	42.8

DISCUSSION

The aim of the present study was to evaluate the influence of different surface treatments over the bonding efficacy of ceramic brackets to the lithium disilicate ceramic. The results showed that the most efficient treatments were mechanical treatments when followed by chemical conditioning: sandblasting or etching with hydrofluoric acid, followed by conditioning with a primer ie. silanization. Low bond strength was achieved when using mechanical alteration methods only (air abrasion or etching with hydrofluoric acid), without primer conditioning. The lowest bond strength was observed in the control group, meaning that if the ceramic bonding surfaces are ground with a diamond burr only, a sufficient bond strength cannot be expected.

According to Yang et al. [7] air abrasion used as a sole treatment achieved low bond strength. On the other hand, primer conditioning performed after sandblasting provided an adequate bond strength to composite cements. However, when primer was used as the only conditioning method, initially adequate bond strength with the composite cement was achieved, but the bond was proved to be non-water resistant, which resulted in drastically decreased bond strength over time. Hence, the authors concluded that although chemical conditioning methods (primers) are responsible for building the bond with ceramics, such a bond can only be made after previously conducted mechanical conditioning of the bonding surface. In the process of air abrasion, the ceramic surface roughness increases, it gets cleaned of organic molecules and becomes receptive for a connection with chemical agents [7].

In the literature, the application of hydrofluoric acid when bonding the brackets, is described in combination with silanization (a silane-based primer) as a method of conditioning ceramic surfaces, which results in both micromechanical and chemical retention of orthodontic brackets. Hydrofluoric acid dissolves the glass matrix at the bonding surface of the ceramic restoration, resulting in irregular, and pronounced surface micromorphology. However, due to the high toxicity and corrosive effects of hydrofluoric acid, its use in *in vivo* conditions is limited [8]. Mehmeti et al. concluded that the use of hydrofluoric acid to roughen the surface of zirconium dioxide or lithium disilicate ceramics did not lead to a significantly stronger bond compared to orthophosphoric acid followed by primer application. Furthermore, hydrofluoric acid can weaken the surface structure of ceramics, and considering the corrosive and toxic effect on the oral mucosa, the authors believe that hydrofluoric acid is not the optimal method for conditioning lithium disilicate or zirconium dioxide ceramics [9].

Schmage et al. suggested that bond strength between 6 and 10 MPa of orthodontic brackets to ceramic restorations is sufficient. The conditioning method that provides higher bond strength may lead to damage during the process of debonding; in some cases, if the bond strength exceeds 13 MPa, fracture of the ceramic restoration may be expected [10].

Determining optimal conditioning treatment for lithium disilicate ceramic restorations is largely dependent on the analysis of the fractured surfaces after brackets debonding and determination of the fracture mode. The adhesive type of fracture usually occurs when weaker bond is built between orthodontic brackets and ceramic restorations. Sample analysis with light microscopy showed no residue of the bonding cement on the ceramic bonding surfaces. On the other hand, cohesive or mixed mode of fracture is more prevalent if higher bond strength is achieved and a residue of the bonding cement is detected on the ceramic bonding surface. In some samples, fragments of the fractured ceramic brackets that remained bonded to the ceramic surfaces were observed. In this study, adhesive mode of fractures was exclusively represented in the groups where treatment consisted of mechanical conditioning methods only (sandblasting or etching with hydrofluoric acid), without silanization. Contrary, cohesive or mixed mode of fractures were present in the groups with mechanical and chemical conditioning of the bonding ceramic surfaces (sandblasting or hydrofluoric acid etching followed by silanization) (Table 1).

Conditioning method that provides the strongest bond strength of the brackets to ceramic restorations is not always considered as optimal conditioning method due to the appearance of cohesive fractures after debonding of the orthodontic brackets. Removing the fractured bracket or residual luting cement (which remains adherent to the ceramic surface) may result in irreversible damage of the prosthetic restoration.

CONCLUSION

Considering the corrosive and toxic effects that hydrofluoric acid has on the oral mucosa, as well as dominantly cohesive and mixed mode of fractures after debonding, the authors suggest that sandblasting with 29-µm Al2O3 followed by silanization may be considered as an optimal conditioning method for lithium disilicate ceramic restorations before bonding the orthodontic ceramic brackets.

REFERENCES

1. Alzainal HA, Shehab Majud A, Al-Ani MA, Mageet OA. Orthodontic bonding: Review of the literature. Int J Dent. 2020;2020:8874909. [DOI: 10.1155/2020/8874909] [PMID: 32733564]
2. Bajraktarova Valjakova E, Korunoska Stevkovska V, Georgieva S, Ivanovski K, Bajraktarova Misevska C, Mijoska A, et al. Hydrofluoric Acid: burns and systemic toxicity, protective measures, immediate and hospital medical treatment. Open Access Maced J Med Sci. 2018;6(11):2257–69. [DOI: 10.3889/oamjms.2018.429] [PMID: 30559898]
3. Harvard University DoCaCB. Guidelines for the Safe Use of Hydrofluoric Acid. Cambridge, MA, USA: Harvard University; 2013.
4. Yucel MT, Aykent F, Akman S, Yondem I. Effect of surface treatment methods on the shear bond strength between resin cement and all-ceramic core materials. J Non-Crystalline Solids. 2012;358(5):925–30. [DOI: 10.1016/j.jnoncrysol.2012.01.006]
5. Lung CY, Liu D, Matinlinna JP. Silica coating of zirconia by silicon nitride hydrolysis on adhesion promotion of resin to zirconia. Mater Sci Eng C Mater Biol Appl. 2015;46: 103–10. [DOI: 10.1016/j.msec.2014.10.029] [PMID: 25491965]
6. Xie H, Li Q, Zhang F, Lu Y, Tay FR, Qian M, et al. Comparison of resin bonding improvements to zirconia between one-bottle universal adhesives and tribochemical silica coating, which is better. Dent Mater. 2016;32(3):403–11. [DOI: 10.1016/j.dental.2015.12.014] [PMID: 26754430]
7. Yang B, Barloi A, Kern M. Influence of air-abrasion on zirconia ceramic bonding using an adhesive composite resin. Dent Materials. 2010;26(1):44–50. [DOI: 10.1016/j.dental.2009.08.008] [PMID: 19766300]
8. Wolf DM, Powers JM, O'Keefe KL. Bond strength of composite to etched and sandblasted porcelain. Am J Dent. 1993;6(3):155–8. [PMID: 8240779]
9. Mehmeti B, Kelmendi J, Ilijazi D, Bleron Azizi S, Jakovljević S, Haliti F, et al. Comparison of Shear Bond Strength Orthodontic Brackets Bonded to Zirconia and Lithium Disilicate Crowns. Acta Stomatol Croat. 2019;53(1):17–27. [DOI: 10.15644/asc53/1/2] [PMID: 31118529]
10. Schmage P, Nergiz NV, Herrmann W, Ozcan M, Nergiz I. Influence of various surface-conditioning methods on the bond strength of metal brackets to ceramic surfaces. Am J Orthod Dentofacial Orthop. 2003;123(5):540–6. [DOI: 10.1067/mod.2003.S0889540602569110] [PMID: 12750673]

Received: 25.9.2023 • Accepted: 11.12.2023

Bondiranje ortodontskih keramičkih breketa: optimalna metoda kondicioniranja litijum-disilikatnih restauracija

Stefan Kuzmanovski[1], Cvetanka Bajraktarova Miševska[2], Aneta Mijoska[1], Nataša Stavreva[1], Emilija Bajraktarova Valjakova[1]

[1]Univerzitet „Sv. Kiril i Metodij", Stomatološki fakultet, Katedra stomatološke protetike, Skoplje, Republika Severna Makedonija;
[2]Univerzitet „Sv. Kiril i Metodij", Stomatološki fakultet, Katedra ortodoncije, Skoplje, Republika Severna Makedonija

KRATAK SADRŽAJ

Uvod Prema podacima dobijenim iz istraživanja Američkog ortodontskog društva sprovedenog 2015. godine, broj odraslih pacijenata koji su zatražili ortodontski tretman povećan je sa 14% na 27% u periodu od 2010. do 2014. godine. Zbog povećanja starosti pacijenata očekuje se izvođenje fiksnog ortodontskog tretmana na restauriranim zubima, uključujući i bezmetalne keramičke nadoknade. Ciljevi ovog istraživanja bili su da se evaluira uticaj različitih površinskih tretmana na čvrstoću veze keramičkih breketa sa litijum-disilikatnom keramikom i da se utvrdi tip frakture nakon debondiranja breketa.

Materijal i metod Dobijeno je 45 keramičkih uzoraka iz litijum-disilikatnih CAD/CAM blokova koji su prema izvršenoj metodi kondicioniranja podeljeni u pet grupa: 1. brušenje finim dijamantskim borerom (kontrolna grupa); 2. peskarenje sa 29 µm aluminijum-oksida (Al_2O_3); 3. jetkanje sa četvoroprocentnom fluorovodoničnom kiselinom (HF); 4. peskarenje praćeno kondicioniranjem univerzalnim prajmerom – silanizacija (Al_2O_3 + S); 5. jetkanje HF kiselinom praćeno silanizacijom (HF + S). Ispitivanje čvrstoće bondiranja je izvršeno nakon čuvanja uzoraka u vodenom kupatilu sedam dana. Svi slomljeni uzorci su analizirani optičkim mikroskopom da bi se odredio tip preloma.

Rezultati Jetkanje HF kiselinom praćeno silanizacijom ima najveću snagu bondiranja, od 8,03 MPa, dok peskarenje praćeno silanizacijom ima 6,69 MPa. Mehaničko kondicioniranje površine bilo HF kiselinom ili peskarenjem rezultiralo je značajno nižom čvrstoćom bondiranja (2,65 MPa i 1,51 MPa). Nakon peskarenja i silanizacije uočen je uglavnom adhezivni tip preloma, što ukazuje na manju mogućnost oštećenja keramičke nadoknade nakon debondiranja, za razliku od keramičkih uzoraka u Grupi 5 (HF + S) sa 42,8% mešovitih i 14,4% kohezivnih preloma. Uočeni su 100% adhezivni prelomi nakon mehaničkih tretmana.

Zaključak Prema rezultatima SBS testa i vrsti preloma, peskarenje sa nanošenjem univerzalnog prajmera može se smatrati adekvatnim metodom za kondicioniranje litijum-disilikatnih keramičkih nadoknada pre bondiranja keramičkih ortodontskih breketa.

Ključne reči: keramički breketi; metode kondicioniranja; litijum-disilikatne restauracije; vazdušna abrazija; fluorovodonična kiselina; univerzalni prajmer

UVOD

Prema rezultatima dobijenim anketom Američkog ortodontskog društva sprovedenom 2015. godine, broj odraslih pacijenata koji su zatražili ortodontski tretman povećan je sa 14% na 27% između 2010. i 2014. godine, što znači da se broj odraslih ortodontskih pacijenata udvostručio za samo četiri godine [1]. Zbog toga se u svakodnevnoj kliničkoj praksi može očekivati da se ortodontski tretman ortodontskim breketama izvodi na zubima koji su prethodno tretirani fiksno-protetskim restauracijama – metal-keramičkim ili potpuno keramičkim krunama ili fasetama. S druge strane, debondiranje breketa je čest problem, zbog čega se pregledi kod ortodonta češće zakazuju i povezuju se sa ponovnim sprovođenjem celokupne procedure za rebondiranje breketa. Od primarne važnosti za uspešan ortodontski tretman je postizanje adekvatnog vezivanja breketa za protetske nadoknade. Pri tome, čvrstoća veze ne bi trebalo da bude ni previše jaka kako bi se izbeglo oštećenje keramičkih površina tokom procesa debondiranja breketa na kraju ortodontskog tretmana [1].

Uvođenje staklokeramike kao restaurativnog materijala u stomatološku protetiku, kao i dokazane prednosti adhezivnog cementiranja doprineli su razvoju koncepta jetkanja fluorovodoničnom kiselinom (HFA). Međutim, HFA poseduje korozivni potencijal koji izaziva opekotine i nekrozu tkiva na mestu kontakta, a ako se apsorbuje u krvotok, joni fluora se distribuiraju u sve organe i tkiva, izazivajući moguću sistemsku toksičnost opasnu po život i otkazivanje organa. Sve ovo nameće izuzetan oprez i svest o zdravstvenim posledicama kada se HF kiselina primenjuje intraoralno [2]: izlaganje oralne sluzokože u koncentraciji od 0,1% HFA može dovesti do nekroze sluzokože [3]. Prilikom jetkanja staklokeramike sa 9,6% HFA dolazi do dvostruke reakcije: primarna – između kiseline i staklene faze, i sekundarna – između kiseline i kristalne faze, ostavljajući veće kristale intaktnima. Na ovaj način se stvara nepravilna površina sa mikroskopskim porama koje omogućavaju mikromehaničko retiniranje adhezivne smole. Što je više zastupljena kristalna faza a manje staklena faza u sastavu materijala, veća je otpornost keramike na dejstvo kiseline [4].

Vazdušna abrazija aluminijum-oksida (Al_2O_3) još je jedna metoda za mehaničko kondicioniranje bondiranih površina keramičkih restauracija koja uzrokuje iregularnost površine, koja je neophodna za mikromehaničko retiniranje vezivnog sredstva. Sa druge strane, vazdušna abrazija može izazvati ireverzibilno oštećenje keramičkih restauracija. Zbog toga se preporučuje da se peskarenje izvodi pod niskim pritiskom (1-2 bara), korišćenjem zrna aluminijum-oksida veličine manje od 50 µm i na udaljenosti od 10 mm od površine keramike [5].

Nakon mehaničke pripreme keramičke bondirane površine, a da bi se postigla optimalna veza sa kompozitnim cementom, od suštinskog je značaja hemijsko kondicioniranje prajmerima koji sadrže silan u svom sastavu. Molekul silana ima dve različite funkcionalne grupe: -SiOH grupu koja se vezuje za molekule silicijum-dioksida i drugu organsku funkcionalnu grupu koja se vezuje za metakrilatnu smolu kompozitnog cementa [6].

Cilj ove studije bio je da se evaluira jačina bondiranja keramičkih breketa vezanih za litijum-disilikatne keramike nakon različitih metoda kondicioniranja keramičke površine i određivanje tipa preloma nakon debondiranja breketa.

MATERIJAL I METOD

Keramički uzorci (debljine 2 mm) dobijeni su od presinterovanih litijum-disilikatnih CAD/CAM blokova IPS e.max CAD (Ivoclar Vivadent, Schaan Liechtenstein) (Slika 1a) korišćenjem precizne mašine za sečenje Minitom (Struers, Danska) (Slika 1b). Sečenje je izvedeno uz kontinuirano vodeno hlađenje kako bi se sprečilo pregrevanje keramičkog materijala koje može izazvati mikropukotine. Svi keramički uzorci su sinterovani u keramičkoj peći Programat EP 5000 (Ivoclar Vivadent, Schaan Liechtenstein). Uzorci sinterovane keramike bili su potopljeni u sredinu metalnih prstenastih kalupa (d = 30 mm) ispunjenih hladno-polimerizujućim akrilatom – PoliTEMP (PoliDent, Slovenija), sa eksponiranom keramičkom površinom koja će biti korišćena kao površina za vezivanje keramičkih breketa (Slika 1v). Nakon toga, površina za vezivanje svih keramičkih uzoraka je izbrušena finim dijamantskim borerom. Svi keramički uzorci su podeljeni u pet grupa prema površinskom tretmanu:

1. Kontrolna grupa = direktno bondiranje ortodontskih breketa.
2. Al_2O_3: keramički uzorci su peskareni sa 29-μm Al_2O_3 česticama – Sandman (Innovative Micro Dentistry, Poland), u trajanju od 10 sekundi, pod pritiskom od jednog bara i na udaljenosti od 10 mm (Slika 1g).
3. HF: keramičke površine su nagrizane četvoroprocentnom fluorovodoničnom kiselinom – IPS Ceramic etching gel (Ivoclar Vivadent, Shaan Liechtenstein) u trajanju od 20 sekundi. Površine su temeljno ispirane tokom 60 s sa ciljem da se ukloni zaostala kiselina, a nakon toga osušene komprimovanim vazduhom (Slika 2a).
4. Al_2O_3 + S: keramički uzorci su peskareni sa 29-μm Al_2O_3 česticama postupkom peskarenja kao u Grupi 2. Nakon toga je u tankom sloju nanet univerzalni prajmer – Monobond Plus (Ivoclar Vivadent, Shaan Liechtenstein) i ostavljen da deluje 60 sekundi, nakon čega je sledilo bondiranje breketa (Slika 2b).
5. HF + S: bondirane površine su nagrizane četvoroprocentnom fluorovodoničnom kiselinom tokom 20 s, isprane i osušene. Univerzalni prajmer Monobond Plus je nanet i ostavljen da deluje 60 sekundi nakon, čega je sledilo bondiranje breketa (Slika 2v).

Postupak bondiranja

Nakon tretmana bondiranih površina, keramičke brekete za maksilarne centralne sekutiće – Cosmetic 20/40 UR Central (American Orthodontics, USA) zalepljene su na tretiranu površinu korišćenjem ortodontskog kompozitnog cementa No Mix:30™ One step Adhesive (American Orthodontics, USA) sa konstantnim vertikalnim opterećenjem od 1 kg u trajanju od 1 min. Nakon procesa bondiranja, uzorci su čuvani u vodenom kupatilu na 37°C sedam dana – Biobase Water Tank WT-42 (Biobase Biodustry, Shandong, China) imitirajući uslove u usnoj šupljini (vlaga i temperatura).

Ispitivanje čvrstoće veze na smicanje (shear bond strenght test – SBS)

SBS je izveden na univerzalnoj mašini za ispitivanje – Shimadzu AGS-X (Shimadzu Co., Japan), brzinom od 0,5 mm/min., u cilju određivanja čvrstoće veze između ortodontskih breketa i keramičkih površina (Slika 3). SBS je izražen u MPa, izveden deljenjem sile (N) u trenutku preloma sa vezivnom površinom keramičkog breketa (mm^2) (MPa = N/mm^2).

Tip preloma

Tip preloma (adhezivni, kohezivni u nivou cementa ili breketa ili mešovit) za svaki uzorak određen je pomoću svetlosne mikroskopije – Levenhuk Zeno Cash ZC6 (Levenhuk Inc., USA) pri uvećanju od 60 puta.

Statistička analiza

Analiza kategoričkih varijabli urađena je utvrđivanjem koeficijenta odnosa, proporcija i stopa. Kontinuirane varijable su analizirane merama centralne tendencije (srednja, medijana, minimalne i maksimalne vrednosti), kao i merama disperzije (standardna devijacija). Za određivanje normalnosti frekvencijske distribucije proučavanih varijabli korišćen je Šapiro–Vilkov test. Pirsonov χ^2 test je korišćen da se utvrdi povezanost između određenih atributivnih dihotomnih karakteristika.

REZULTATI

Rezultati SBS-a nakon različitih tretmana keramičkih površina prikazani su na Slici 4 i u Tabeli 1. Najveća čvrstoća veze, 8,04 ± 0,61 MPa, zabeležena je kada su keramičke brekete bondirane na keramičke površine koje su nagrizane fluorovodoničnom kiselinom, a zatim je usledila silanizacija (Grupa 5). Nesignifikantno niža čvrstoća veze (p = 0,1477) postignuta je peskarenjem bondiranih površina sa 29-μm Al_2O_3, praćenom silanizacijom, 6,69 ± 1,20 MPa. Kada su vršeni samo mehanički tretmani, jetkanje HF kiselinom ili peskarenje, jačina veze je bila značajno niža, 2,65 ± 0,84 MPa i 1,52 ± 0,43 MPa. Najniža vrednost SBS-a je zabeležena u kontrolnoj grupi, 0,43 ± 0,23 MPa.

Adhezivni tip preloma nakon debondiranja bio je isključivo prisutan u prve tri grupe (100%), dok je u Grupi 4 bio dominantno prisutan (71,4%). Mešoviti i kohezivni tip preloma konstatovani su samo u Grupi 4 i Grupi 5 (Tabela 1).

DISKUSIJA

Cilj ove studije bio je da se evaluira uticaj različitih površinskih tretmana na efikasnost vezivanja keramičkih breketa za litijum-disilikatnu keramiku. Iz dobijenih rezultata može se uočiti da je visoka jačina bondirane sile postignuta u grupama u kojima su sprovedene mehaničko-hemijske metode za alteraciju keramičkih bondiranih površina (vazdušna abrazija ili jetkanje fluorovodoničnom kiselinom, u kombinaciji sa nanošenjem prajmera). Manja jačina bondirane sile je postignuta kod uzoraka koji su podvrgnuti samo metodama mehaničke alteracije (vazdušna abrazija ili jetkanje fluorovodoničnom kiselinom), bez kondicioniranja prajmerom. Najniže srednje vrednosti za jačinu bondirane sile zabeležene su u kontrolnoj grupi, što znači da ako se keramičke bondirane površine ne alteriraju i ne kondicioniraju, onda se ne može očekivati dovoljna jačina bondirane sile.

Autori Yang i saradnici [7] smatraju da vazdušna abrazija bez upotrebe prajmera postiže značajno nisku jačinu bondirane sile. Sa druge strane, vazdušna abrazija keramike praćena kondicioniranjem prajmerom obezbeđuje adekvatnu jačinu bondirane sile za kompozitne cemente. Autori su u istom istraživanju dokazali da kad su prajmeri korišćeni kao jedinstvena metoda kondicioniranja keramike u početku, dobijena je adekvatna jačina bondiranja sa kompozitnim cementom, ali se pokazalo da ona nije vodootporna, što je rezultiralo drastičnom smanjenju jačine bondirane sile tokom vremena. Stoga, autori su zaključili da iako su hemijske metode kondicioniranja (prajmeri) odgovorne za stvaranje veze sa keramikom, takva veza se može ostvariti samo nakon prethodnog mehaničkog kondicioniranja keramičke površine. U procesu vazdušne abrazije povećava se hrapavost površine, ona se čisti od organskih molekula i postaje prijemčiva za stvaranje veze sa hemijskim agensima [7].

U literaturi je opisana primena fluorovodonične kiseline u ortodontske svrhe u kombinaciji sa silanizacijom (prajmer na bazi silana) kao metodom kondicioniranja keramičkih površina, što rezultira i mikromehaničkim i hemijskim retiniranjem ortodontskih breketa. Fluorovodonična kiselina rastvara staklenu matricu keramičke restauracije, zbog čega tretirana površina postaje iregularna, sa izraženom mikromorfologijom. Istovremeno, zbog visoke toksičnosti i korozivnog dejstva fluorovodonične kiseline u kontaktu sa oralnim tkivom i mogućnosti brze nekroze, njena upotreba u *in vivo* uslovima je ograničena [8]. Mehmeti i saradnici zaključili su da upotreba fluorovodonične kiseline u cilju jetkanja površine cirkonijum-dioksida ili litijum-disilikatne keramike nije dovela do značajno jače veze u poređenju sa ortofosfornom kiselinom, nakon čega je usledila primena prajmera. Nadalje, fluorovodonična kiselina može oslabiti površinsku strukturu keramike, a s obzirom na korozivno i toksično dejstvo na oralnu sluzokožu, autori smatraju da fluorovodonična kiselina nije najbolja metoda za kondicioniranje keramike litijum-disilikata i cirkonijum-dioksida [9].

Schmage i saradnici sugerišu da je jačina bondirane sile od 6 do 10 MPa dovoljna da obezbedi adekvatnu vezu između ortodontskih breketa i keramičkih restauracija. Metoda kondicioniranja keramičke površine koja istovremeno obezbeđuje najjaču bondiranu silu može dovesti do njenog oštećenja tokom debondiranja; ako je jačina bondirane sile veća od 13 MPa, može se očekivati fraktura keramičke površine [10].

Određivanje optimalnog tretmana kondicioniranja za litijum-disilikatne keramičke restauracije u velikoj meri zavisi od određivanja načina preloma. Adhezivni tip preloma se obično javlja kada se između ortodontskih breketa i keramičkih nadoknada izgradi slabija veza. Analiza uzoraka svetlosnom mikroskopijom nije pokazala ostatke vezivnog cementa na keramičkim vezivnim površinama. S druge strane, kohezivni ili mešoviti način loma je preovlađujući ako se postigne veća čvrstoća veze i ako se otkrije ostatak vezivnog cementa na keramičkoj površini. U nekim uzorcima uočeni su fragmenti frakturisanih keramičkih breketa koji su ostali vezani za keramičke površine. U ovoj studiji, adhezivni način preloma bio je isključivo zastupljen u grupama u kojima se tretman sastojao samo od mehaničkih metoda kondicioniranja (peskarenje ili nagrizanje fluorovodoničnom kiselinom), bez silanizacije. Suprotno tome, kohezivni ili mešoviti načini preloma bili su prisutni u grupama sa mehaničkim i hemijskim kondicioniranjem vezivnih keramičkih površina (peskarenje ili jetkanje fluorovodoničnom kiselinom, praćeno silanizacijom) (Tabela 1).

Metoda kondicioniranja koja obezbeđuje najjaču čvrstoću bondiranja breketa za keramičke nadoknade ne smatra se uvek optimalnom metodom kondicioniranja, zbog pojave kohezivnih preloma nakon debondiranja ortodontskih breketa. Uklanjanje slomljenog breketa ili zaostalog cementa (koji ostaje na keramičkoj površini) može dovesti do nepovratnog oštećenja protetske nadoknade.

ZAKLJUČAK

Uzimajući u obzir korozivne i toksične efekte koje fluorovodonična kiselina ima na oralnu sluzokožu, kao i dominantno kohezivni i mešoviti tip preloma nakon debondiranja, autori sugerišu da se peskarenje sa 29-µm Al_2O_3, praćeno silanizacijom, može smatrati optimalnom metodom kondicioniranja litijum-disilikatnih keramičkih restauracija pre bondiranja ortodontske keramičke brekete.

ORIGINAL ARTICLE
ORIGINALNI RAD
DOI: https://doi.org/10.2298/SGS2304189K
UDC: 615.916:546.815; 616.311.2-099

The influence of lead on gingiva and periodontal tissue

Irena Kuzmanović Radman[1], Adriana Arbutina[2], Renata Josipović[1], Saša Marin[3], Mirjana Umićević-Davidović[2], Radmila Arbutina[1], Nataša Trtić[4], Verica Protić Berić[5], Aleksandra Đeri[1]

[1]University of Banja Luka, Faculty of Medicine, Department of Dental Diseases, Banja Luka, Republika Srpska, Bosnia and Herzegovina;
[2]University of Banja Luka, Faculty of Medicine, Department of Jaw Orthopedics, Banja Luka, Republika Srpska, Bosnia and Herzegovina;
[3]University of Banja Luka, Faculty of Medicine, Department of Oral Surgery, Banja Luka, Republika Srpska, Bosnia and Herzegovina;
[4]University of Banja Luka, Faculty of Medicine, Department of Periodontology and Oral Medicine, Banja Luka, Republika Srpska, Bosnia and Herzegovina;
[5]ZU „Prizma Dent“, Banja Luka, Bosnia and Herzegovina

SUMMARY
Introduction Exposure to lead (Pb) can have harmful effects on the general state of the body, including oral health. The aim of this study was to examine the prevalence of changes in gingiva and periodontal tissue in adult rats intoxicated with lead acetate by histological analysis.
Material and methods The study was conducted on 42 Wistar rats. Intoxication of rats with lead acetate was carried out through drinking water ad libitum. The first group (A1) consisted of 16 rats that received lead-acetate in water at a concentration (1500 ppm) for 14 days, and the second group (A2) consisted of 16 rats that received lead-acetate in water at the same concentration for 30 days.
Results Gingivitis and periodontitis in the first group of rats (A1) were observed in 41.7% of cases, and in the second group (A2) in 84% of cases. A statistically significant difference was found between the investigated groups ($\chi^2 = 6.955$; $p < 0.018$).
Conclusion Since changes in the gingiva and periodontium have been observed in rats intoxicated with lead for a long period of time, it is necessary to propose a preventive program for patients exposed to lead, which includes dental procedures such as oral hygiene training and regular visits to the dentist.
Keywords: lead-acetate, gingivitis; periodontitis; rats

INTRODUCTION

Toxic elements are found in the body at different concentrations due to contamination from the environment (aluminum, mercury, cadmium, lead, bismuth, silver). Among them, lead (Pb) stands out as one of the most important, toxic and prevalent heavy metals in the world. The presence of lead in the environment increases with human activity. Excessive lead concentration can be toxic to human body because it affects the blood flow, nervous, gastrointestinal, cardiovascular and musculoskeletal system [1, 2]. Long-term exposure to lead can cause cheilitis, ulcers and epithelial desquamation of the tongue, palate and other parts of the oral mucosa, damage to the gums, periodontal ligaments and alveolar bone tissue [3]. More recent studies have indicated that lead can also cause oxidative stress in many tissues and organs, including salivary glands. A disorder in the salivary glands also leads to caries, gingivitis and periodontitis, which is later attributed to tooth loss [4, 5].

The results of one of the studies conducted on rats indicated that elevated lead concentration led to decreased salivary flow by 30-40%, which accelerates formation of caries due to insufficient washing of the tooth surface with saliva, and leads to inflammation of gingiva and periodontium [6]. Periodontitis is one of the most common dental diseases. It is a chronic disease of gingiva which, if not treated, leads to the spread of inflammation in the surrounding structures of the tooth, changing bone homeostasis, later destroying supporting and surrounding structures, causing tooth loss [7].

Lee et al. found an association between increased blood lead concentrations and oxidative stress in adults that releases reactive oxygen species (ROS) [8]. ROS can also cause protein and DNA damage, as well as lipid peroxidation, and its increased value can lead to damage to gingival, periodontal ligament and alveolar bone tissue. Although biological link between lead exposure and periodontal disease has not been sufficiently investigated, ROS has been identified as a parameter for lead intoxication, because it is formed in contact with it and causes oxidative stress [9,10]. The level of lead in the teeth is related to the level of lead in the blood. Therefore, teeth are considered a good biological indicator of exposure to environmental lead pollution [11].

Address for correspondence: Irena KUZMANOVIĆ RADMAN, University of Banja Luka, Faculty of Medicine, Department of Dental Diseases, Banja Luka, Republika Srpska, Bosnia and Herzegovina; *irena.kuzmanovic.radman78@med.unibl.org*

Children tend to absorb more lead in the body than adults because their metabolism is accelerated, and children's gastrointestinal organs are underdeveloped and absorb substances more easily. Some of the studies found that elevated lead concentration in the blood is associated with gingival diseases and plaque deposition in children [12].

Similarly, another study reported that gingivitis was the most common condition among school children living near a shipyard area known to be contaminated with lead. Almost 98% of them had gingivitis. Gingivitis may be a consequence of increased prevalence of *Aggregatibacter actinomycetemcomitans* (17%) in children with high blood lead concentration [7, 13].

According to the study by El-Said et al., which focuses on the risk of gingivitis in workers exposed to lead, the occurrence of gingivitis was found to be associated with lead sulfide, a product of the reaction between lead and hydrogen sulfide during food fermentation, which can cause gingival irritation and gingivitis [14].

Lead intoxication can be determined in the oral cavity by the presence of Burton's lines (purple-blue lead-sulphide deposits at the border between the gums and teeth), which occur when lead in the blood and saliva reacts with sulfur ions released by the action of oral microorganisms [15]. There may be more than one underlying mechanism for the development of Burton's line or Gubler's sign. Various foods and vegetables contain large amounts of sulfates. Oral bacteria modify these sulfates into sulfur compounds e.g. hydrogen sulfide (H2S) [16].

The aim of this study was to examine the prevalence of changes in the gingiva and periodontium in adult rats intoxicated with lead acetate by histological analysis.

MATERIAL AND METHODS

The study was conducted after the approval of the Ethical Committee of the University Clinical Center in Banja Luka (Bosnia and Herzegovina). The sample consisted of 42 Wistar rats. The animals were two months old, with a body weight of 150–200 g. They were kept in group cages made of Plexiglas, with 12 hours of light (07:00 - 19:00), at an air temperature of 22°C (± 2) and a humidity of 60 ± 10%, with free access to food and water during experiment. At the beginning of the experiment, the rats were separated into the corresponding test groups. They were given a 15-day adaptation period. After adaptation, they were divided into two experimental groups (A1 and A2). The first (A1) and second (A2) groups consisted of 16 rats each [17].

Intoxication of adult rats with lead-acetate in a concentration of 1500 ppm was carried out through drinking water ad libitum. Lead poisoning lasted 14 days in the A1 group, and 30 days in the A2 group. All animal procedures, care, experimental treatment, pain-free and stress-free sacrifice were performed in accordance with the Guidelines for the Care of Animals in Experimental Research.

Rats from the first group (A1) were sacrificed after 14 days, and from the second group (A2) after 30 days. For histological analysis, the bones of the upper jaws together with the teeth (after 48 hours of fixation in 10% neutral buffered formalin) were decalcified in nitric acid solution (no longer than 90 minutes). Decalcified samples were then washed under running water and processed in an automated tissue processor Leica TP 1020 (Leica Byosistems) according to a standard protocol: dehydration in increasing concentrations of ethyl alcohol (70%, 96%, 100%), washing in xylene, impregnation with liquid paraffin, after which selected tissue samples were molded into paraffin blocks. For histological analysis, after cooling, paraffin blocks were cut on a sliding microtome (Leica SM 2000R, Leica Byosistems) into sections 4–5 µm thick, and cross-sections of the supporting apparatus were collected on appropriate glass slides and dried at 60°C. In an automatic staining processor (Leica ST4040 Linear stainer, Leica Byosistems), tissue sections were deparaffinized, rehydrated and rinsed in distilled water. After that, they were stained with the standard hematoxylin-eosin (HE) method. Definitive preparations were analyzed with a light microscope (Leica DM 2500, Leica Byosistems) and photographed with a camera connected to the microscope [18].

RESULTS

In the first experimental group (A1), periodontitis and gingivitis were recorded in 41.7% of cases (Table 1). In the second experimental group (A2), periodontitis and gingivitis were recorded in 84% of cases (Table 1, Figure 2). A statistically significant difference was found between the examined groups ($\chi^2 = 6.955$; $p < 0.018$) (Table 1).

Table 1. Periodontitis and gingivitis in the studied groups
Tabela 1. Parodontitis i gingivitis u ispitivanim grupama

			Gingivitis and periodontitis Gingivitis i parodontitis		Total Ukupno
			No / Ne	Yes / Da	
Group Grupa	Pb 14 days Pb 14 dana (A1)	N	7	5	12
		%	58.3%	41.7%	100%
	Pb 30 days Pb 30 dana (A2)	N	4	21	25
		%	16%	84.0%	100%
Everything Sve		N	11	26	37
		%	29.7%	70.3%	100%

DISCUSSION

Lead is one of the most important and widespread environmental pollutants in terms of global contamination and health impact [7, 19]. Children tend to absorb more lead than adults due to their higher metabolic rate, as well as their physical tendency to inhale lead from polluted air. In fact, children's gastrointestinal organs are underdeveloped and absorb lead more easily, leading to many diseases in the body and teeth [20].

Many studies have examined the effects of lead on the oral health of adults. However, the relationship between lead and oral health in children is insufficiently investigated, as is its influence on the gingiva and periodontium [21, 22].

Considering the data that children absorb much more lead and that this issue is insufficiently investigated, especially by

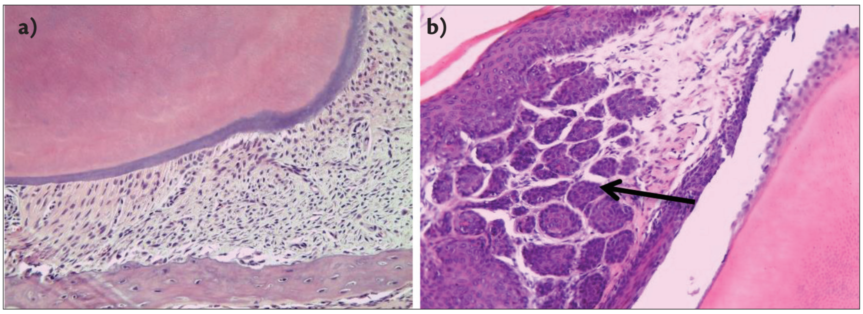

Figure 1. a) Section of a tooth – periodontal ligament, cementum and dentin are observed without morphological changes (H&E, 400×); b) Section of the teeth of rats that received lead for 30 days – in the periapical area chronic inflammation around the teeth (chronic periodontitis) is observed (H&E, 400×).
Slika 1. a) Presek zuba – uočavaju se periodontalni ligament, cement i dentin bez morfoloških promena (H&E, 400×); b) Presek zuba pacova koji su primali olovo 30 dana – u periapikalnom području se uočava hronično zapaljenje u okolini zuba (hronični parodontitis) (H&E, 400×).

histological analysis, our study was conducted on two-month-old rat pups that were intoxicated with lead in drinking water for 14 and 30 days, in order to examine the changes on the gingiva and periodontium of the same. The results of our study indicated a significantly higher incidence of gingivitis and periodontitis in rat pups that drank water with lead for a longer period of time- 30 days (Group A2) in 84% of cases compared to pups that received lead for only 14 days (Group A1) in 41.7% of cases. Our results support the theory that lead is a contributing factor in the development of periodontal disease in humans. Our results are consistent with the results of previous studies that dealt with similar issues in children. One of them was conducted by Youravong et al. among the children of Thailand who live in the industrial zone of the shipyard. The results indicated a significant positive correlation between high blood lead concentration and periodontal diseases, especially deep periodontal pockets [7]. Borany et al. aimed to investigate the relationship between blood lead levels (BLL) and oral health in South Korean children. The examination was based on blood analysis and dental examinations of children with determination of gingival index and plaque index. They found that high blood lead concentration was associated with oral health problems in South Korean children, including plaque deposition and gingival disease, which is consistent with the results of our study [23].

A large number of authors studied the relationship between the influence of lead and inflammation of the tooth's supporting tissue, because in addition to many clinical manifestations, lead-intoxicated patients (including children and young adults) have an increased risk of periodontitis. Periodontitis is a chronic disease of gingiva which, if not treated, leads to the spread of inflammation in the surrounding tooth structures, changing bone homeostasis and destroying the supporting and surrounding structures, causing tooth loss [12, 20, 24].

Periodontitis is primarily caused by an aggravated immune-inflammatory response of the host, which has many triggers, one of them being lead and cadmium, which in higher concentrations stimulate the production of reactive oxygen species (ROS), which can be a potential cause of periodontitis progression [25]. Browar et al. examined the correlation between exposure to cadmium and lead in relation to periodontal diseases using the immunohistochemical method in experimental rats. In their study, male rats received subcutaneous injections of lead and cadmium (0.6 mg/kg/day) for a period of 12 weeks. They came to the result that cadmium and lead have a significant negative effect on the periodontium of rat teeth, which is in agreement with our study, which was also performed using the immunohistochemical method on rats [26].

Determination of lead concentration in teeth is considered a good biological indicator of lead exposure in the environment and at the workplace. This was confirmed by a study by El-Said et al. which indicated that 97.2% of workers in a factory for the production of lead batteries had gingivitis, which was the most prevalent of all periodontal diseases [14]. Lead in blood, saliva, plaque, and food debris can react with oral hydrogen sulfide (produced by fermentation of food deposited in the mouth) to form lead sulfide. This can cause irritation, discoloration and bleeding gums [14, 27].

Exposure to lead mainly comes from informal recycling and manufacturing of batteries, electronic waste, emissions from factories that process ores rich in heavy metals, and excessive intake of foods and spices that contain high concentrations of lead. This was confirmed by one of the studies conducted by Ericson et al. where lead concentration in the blood of children in 34 countries was measured in order to determine the presence of lead in 1,300 million children. They found that 48.5% of children (632 million) had blood lead levels above 5 μg/dL [28].

Some of the studies indicated that the influence of lead affects reduced secretion of saliva in rats by about 30-40%. However, there have been no human studies. The effect of lead on the reduction of saliva can partially explain our study in which rats were intoxicated with lead. Lead reduced the production of saliva in the salivary glands and thus prevented its complete function of protecting and moisturizing gingiva, leading to gingivitis and periodontitis, and this was confirmed by our results [29].

By conducting education on protective measures at workplaces (smelters, battery factories and heavy industries, etc.) by avoiding areas contaminated with lead, as well as the intake of food and water from that area and adopting a healthy lifestyle, the intake of lead in the body and thus dental and mouth diseases will be reduced. Fluoridation of drinking water, salt and milk can help prevent the prevalence of oral diseases caused by lead exposure [30].

CONCLUSION

In the group of rats, that were intoxicated with lead for a longer period of time -30 days, compared to the group, which was intoxicated with lead for a shorter period of 14 days, a significantly higher prevalence of changes in gingiva and periodontium (gingivitis and periodontitis) was observed. The results of our study indicate a connection between the influence of lead and periodontal diseases, which is why it is necessary to introduce a preventive program and measures for patients and especially for children. This includes educating children from a young age about the importance of maintaining oral hygiene and regular visits to the dentist, which can reduce the presence of dental plaque, soft and hard dental deposits, and enable detection and treatment of initial pathological changes in periodontium.

REFERENCES

1. Tinkov AA, Filippini T, Ajsuvakova OP, Skalnaya MG, Aaseth J, Bjørklund G, et al. Cadmium and atherosclerosis: a review of toxicological mechanisms and a meta-analysis of epidemiologic studies. Environ Res. 2018;162:240–60. [DOI: 10.1016/j.envres.2018.01.008] [PMID: 29358116]
2. Mehrotra N, Singh S. Periodontitis. In: StatPearls. StatPearls Publishing, Treasure Island (FL); 2022. [DOI: //www.ncbi.nlm.nih.gov/books/NBK541126/]
3. Kamberi B, Koçani F, Dragusha E. Teeth as Indicators of Environmental Pollution with Lead. J Environment Analytic Toxicol. 2012;2:1–5. [DOI: 10.4172/2161-0525.1000118]
4. Yetkin-Ay Z, Cadir B, Uskun E, Bozkurt FY, Delibas N, Gultepe FM, et al. The periodontal status of indirectly lead-exposed apprentices working in autorepair workshops. Toxicol Ind Health. 2007;23(10):599–606. [DOI: 10.1177/0748233708090906] [PMID: 18717518]
5. Chakraborty S, Tewari S, Sharma RK, Narula SC, Ghalaut PS, Ghalaut V. Impact of iron deficiency anemia on chronic periodontitis and superoxide dismutase activity: a cross-sectional study. J Periodontal Implant Sci. 2014;44(2):57–64. [DOI: 10.5051/jpis.2014.44.2.57] [PMID: 24778899]
6. Khalid M, Abdollahi M. Role of lead in dental diseases. J Environ Sci Health C Toxicol Carcinog. 2020;38(4):329–61. [DOI: 10.1080/26896583.2020.1834313] [PMID: 33382012]
7. Youravong N, Teanpaisan R. The periodontal health of lead-exposed children living in a shipyard industrial area. Toxicol Ind Health. 2015;31(5):459–66. [DOI: 10.1177/0748233712472529] [PMID: 23406954]
8. Watson GE, Davis BA, Raubertas RF, Pearson SK, Bowen WH. Influence of maternal lead ingestion on caries in rat pups. Nat Med. 1997;3(9):1024–5. [DOI: 10.1038/nm0997-1024] [PMID: 9288731]
9. Lee DH, Lim JS, Song K, Boo JDR Jr. Graded associations of blood lead and urinary cadmium concentrations with oxidative-stress-related markers in the US population: results from the third National Health and nutrition examination survey. Environ Health Perspective. 2006;114(3):350–4. [DOI: 10.1289/ehp.8518] [PMID: 16507456]
10. Khalid M, Abdollahi M. Epigenetic modifications associated with pathophysiological effects of lead exposure. J Environ Sci Health Part C: Environ Carcinog Ecotoxicol Rev. 2019;37(4):235–87. [DOI: 10.1080/10590501.2019.1640581] [PMID: 31402779]
11. Tarakji B, Umair A, Prasad D, Alsakran Altamimi M. Diagnosis of oral pigmentations and malignant transformations. Singapore Dent J. 2014;35C(1):39–46. [DOI: 10.1016/j.sdj.2014.03.001] [PMID: 25496584]
12. Shishniashvili TE, Suladze NN, Margvelashvili VV. Primary teeth and hair as indicators of environmental pollution. J Clin Pediatr Dent. 2016;40(2):152–5. [DOI: 10.17796/1053-4628-40.2.152] [PMID: 26950818]
13. American Academy of Pediatrics Committee on Environmental Health. Lead exposure in children: prevention, detection, and management. Pediatrics. 2005;116(4):1036–46. [DOI: 10.1542/peds.2005-1947] [PMID: 16199720]
14. El-Said KF, El-Ghamry AM, Mahdy NH, El-Bestaw NA. Chronic occupational exposure to lead and its impact on oral health. J Egypt Public Health Assoc. 2008;83(5–6):451–66. [PMID: 19493512]
15. Verma S, Santhosh AP, Shukla S, Gupta P, Mandavdhare HS, Dutta U, et al. Gastrointestinal: An oral clue to an unusual cause of abdominal pain: Burton's line. J Gastroenterol Hepatol. 2019;34(4):629. [DOI: 10.1111/jgh.14519] [PMID: 30450668]
16. Cleymaet R, Collys K, Retief DH, Michotte Y, Slop D, Taghon E, et al. Relationship between lead in surface tooth enamel, blood, and saliva from children residing in the vicinity of a non-ferrous metal plant in Belgium. Br J Ind Med. 1991;48(10):702–9. [DOI: 10.1136/oem.48.10.702] [PMID: 1931730]
17. Kuzmanović Radman I, Arbutina A, Josipović R, Marin S, Umićević-Davidović M, Arbutina R, et al. Examination of the presence of periodontitis and gingivitis in rats with induced diabetes mellitus. Dental Gazette of Serbia. 2023;70(3):131–7. [DOI: 10.2298/SGS2303131K]
18. Kuzmanović Radman I, Đeri A, Gajanin R, Arbutina A, Josipović R, Živković S. Expression of a fibronectin in the dental pulp of lead intoxicated rats with experimentally induced diabetes mellitus. Srp Arh Celok Lek. 2021;149(3–4):136–41. [DOI: 10.2298/SARH191022102K]
19. Metryka E, Chibowska K, Gutowska I, Falkowska A, Kupnicka P, Barczak K, et al. Lead (Pb) exposure enhances the expression of factors associated with inflammation. Int J Mol Sci. 2018;19(6):1813. [DOI: 10.3390/ijms19061813] [PMID: 29925772]
20. Gemmel A, Tavares M, Alperin S, Soncini J, Daniel D, Dunn J, et al. Blood lead level and dental caries in school-age children. Environ Health Perspect. 2002;110(10):A625–30. [DOI: 10.1289/ehp.021100625] [PMID: 12361944]
21. Vandal V, Noorani H, Shivaprakash P, Walikar B. Salivary lead concentration in dental caries among normal and children with cerebral palsy. J Indian Soc Pedodontics Preventive Dent. 2018;36(4):381–5. [DOI: 10.4103/JISPPD.JISPPD_200_16] [PMID: 30324929]
22. Cenić-Milošević D, Mileusnić I, Kolak V, Pejanović D, Ristić T, Jakovljević A, et al. Environmental lead pollution and its possible influence on tooth loss and hard dental tissue lesions. Vojnosanit Pregl. 2013;70(8):751–6. [DOI: 10.2298/vsp1308751c] [PMID: 24069824]
23. Borany T, Youn-Hee C, Eun-Kyong K, Yun-Sook J, Mina H, Keun-Bae S, et al. Lead exposure may affect gingival health in children. BMC Oral Health. 2018;18(1):79. [DOI: 10.1186/s12903-018-0547-x] [PMID: 29728081]
24. Dommisch H, Kuzmanova D, Jönsson D, Grant M, Chapple I. Effect of micronutrient malnutrition on periodontal disease and periodontal therapy. Periodontol 2000. 2018;78(1):129–53. [DOI: 10.1111/prd.12233] [PMID: 30198127]
25. Alomary A, Al-Momani IF, Obeidat SM, Massadeh AM. Levels of lead, cadmium, copper, iron, and zinc in deciduous teeth of children living in Irbid, Jordan by ICP-OES: some factors affecting their concentrations. Environ Monit Assess. 2013;185(4):3283–95. [DOI: 10.1007/s10661-012-2790-y] [PMID: 22851195]
26. Browar AW, Koufos EB, Wei Y, Leavitt LL, Prozialeck WC, Edwards JR. Cadmium exposure disrupts periodontal bone in experimental animals: implications for periodontal disease in humans. Toxics. 2018;6(2):32. [DOI: 10.3390/ toxics6020032] [PMID: 29899258]
27. Craan A, Nadon G, P'an AYS. Lead flux through kidney and salivary glands of rats. Am J Phys. 1984;247(5 Pt 2):F773–83. [DOI: 10.1152/ajprenal.1984.247.5.F773] [PMID: 6496745]
28. Ericson B, Hu H, Nash E, Ferraro G, Sinitsky J, Taylor MP. Blood lead levels in low-income and middle-income countries: a systematic review. Lancet Planet Health. 2021;5(3):e145–53. [DOI: 10.1016/S2542-5196(20)30278-3] [PMID: 33713615]
29. Levy SM. An update on fluorides and fluorosis. J Can Dent Assoc. 2003;69(5):286–91. [PMID: 12734021]
30. Petersen PE, Lennon MA. Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. Community Dent Oral Epidemiol. 2004;32(5):319–21. [DOI: 10.1111/j.1600-0528.2004.00175.x] [PMID: 15341615]

Received: 9.10.2023 • Accepted: 13.12.2023

Uticaj olova na gingivu i potporni aparat zuba

Irena Kuzmanović Radman[1], Adriana Arbutina[2], Renata Josipović[1], Saša Marin[3], Mirjana Umićević-Davidović[2], Radmila Arbutina[1], Nataša Trtić[4], Verica Protić Berić[5], Aleksandra Đeri[1]

[1]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za bolesti zuba, Banja Luka, Republika Srpska, Bosna i Hercegovina;
[2]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za ortopediju vilica, Banja Luka, Republika Srpska, Bosna i Hercegovina;
[3]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za oralnu hirurgiju, Banja Luka, Republika Srpska, Bosna i Hercegovina;
[4]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za parodontologiju i oralnu medicinu, Banja Luka, Republika Srpska, Bosna i Hercegovina;
[5]ZU „Prizma Dent", Banja Luka, Bosna i Hercegovina

KRATAK SADRŽAJ

Uvod Izloženost olovu (Pb) može imati štetne efekte na opšte stanje organizma, uključujući i oralno zdravlje. Cilj ove studije je bio da se histološkom analizom ispita zastupljenost promena na gingivi i parodoncijumu kod adultnih pacova koji su intoksikovani olovo-acetatom.

Materijal i metode Studija je sprovedena na 42 pacova soja vistar. Intoksikacija pacova olovo-acetatom je vršena putem vode za piće *ad libitum*. Prvu grupu (A1) činilo je 16 pacova koji su 14 dana dobijali olovo-acetat u vodi u koncentraciji od 1500 ppm, a drugu grupu (A2) činilo je 16 pacova koji su 30 dana dobijali olovo-acetat u vodi u istoj koncentraciji.

Rezultati Gingivitis i parodontitis u prvoj grupi pacova (A1) uočeni su u 41,7% slučajeva, a u drugoj u grupi (A2) u 84% slučajeva. Između ispitivanih grupa utvrđena je statistički značajna razlika ($\chi^2 = 6{,}955$; $p < 0{,}018$).

Zaključak S obzirom na to da je kod pacova koji su intoksikovani olovom duži vremenski period uočena promena na gingivi i parodoncijumu, neophodno je predložiti preventivni program za pacijete izložene olovu, koji obuhvata stomatološke procedure kao što su obuke održavanja oralne higijene i redovne posete stomatologu.

Ključne reči: olovo-acetat; gingivitis; periodontitis; pacovi

UVOD

Toksični elementi se u organizmu nalaze u različitim koncentracijama usled kontaminacije iz okoline (aluminijum, živa, kadmijum, olovo, bizmut, srebro). Među njima se posebno izdvaja olovo (Pb) kao jedan od najvažnijih, najtoksičnijih i najzastupljenijih teških metala u svetu. Prisustvo olova u okolini se povećava sa ljudskom aktivnošću. Prekomerna koncentracija olova može biti toksična za čovekov organizam jer utiče na krvotok, nervni, gastrointestinalni, kardiovaskularni i mišićno-skeletni sistem [1, 2]. Dugotrajno izlaganje olovu može izazvati nastanak heilitisa, ulkusa i epitelne deskvamacije jezika, nepca i drugih delova oralne sluznice, oštećenja gngive, parodontalnih ligamenta i alveolarnog koštanog tkiva [3]. Novije studije su ukazale da olovo takođe može izazvati oksidativni stres u mnogim tkivima i organima, uključujući i pljuvačne žlezde. Poremećaj u pljuvačnim žlezdama dovodi i do karijesa, gingivitisa i parodontitisa, kojem se kasnije pripisuje gubitak zuba [4, 5].

Rezultati jedne od studija sprovedene na pacovima ukazali su na to da je povišena koncentracija olova dovela do smanjenog protoka pljuvačke za 30-40%, što ubrzava nastanak karijesa usled nedovoljnog ispiranja površine zuba pljuvačkom, te dovodi do upale gingive i parodoncijuma [6]. Parodontitis je jedno od najčešćih oboljenja zuba. To je hronična bolest gingive koja ako se ne leči, dovodi do širenja upale u okolne strukture zuba, menjajući homeostazu kostiju, kasnije razara potporne i okolne strukture uzrokujući gubitak zuba [7].

Lee i autori su pronašli povezanost između povećane koncentracije olova u krvi i oksidativnog stresa kod odraslih, koji oslobađa reaktivnu vrstu kiseonika (ROS) [8]. ROS takođe može uzrokovati oštećenje proteina i DNK, kao i peroksidaciju lipida, a njegova povećana vrednost može dovesti do oštećenja gingivalnog, parodontalnog ligamenta i alveolarnog koštanog tkiva. Iako biološka veza između izloženosti olovu i parodontoloških oboljenja nije dovoljno ispitana, ipak je ROS označen kao parametar za intoksikaciju olovom, jer nastaje u kontaktu sa njim i uzrokuje oksidativni stres [9, 10].

Nivo olova u zubima je povezan sa nivoom olova u krvi. Zbog toga se zubi smatraju dobrim biološkim indikatorom izloženosti zagađenju okoline olovom [11].

Deca imaju tendenciju da apsorbuju više olova u organizmu nego odrasli jer je kod njih ubrzan metabolizam, a dečji gastrointestinalni organi su nedovoljno razvijeni i lakše apsorbuju supstance. Neke od studija su utvrdile da je povišena koncentracija olova u krvi povezana sa bolestima gingive i taloženjem plaka kod dece [12].

Slično tome, druga studija je objavila da je upala gingive najčešće stanje među školskom decom koja žive u blizini područja brodogradilišta, za koje se zna da je kontaminirano olovom. Skoro 98% njih je imalo zapaljenje gingive. Gingivitis može biti posledica povećane prevalencije bakterije *Aggregatibacter actinomycetemcomitans* (17%) kod dece sa visokom koncentracijom olova u krvi [7, 13].

Prema studiji koju su sproveli El-Said i saradnici, koja se fokusira na rizik od gingivitisa kod radnika izloženih olovu, uvrđeno je da je pojava gingivitisa povezana sa olovnim sulfidom, proizvodom reakcije između olova i sumporovodika tokom fermentacije hrane, što može izazvati iritaciju gingive i gingivitis [14].

Intoksikacija olovom se može utvrditi u usnoj šupljini prisustvom Burtonovih linija (ljubičasto-plavih naslaga olovo-sulfida na granici između desni i zuba), koje nastaju kada olovo u krvi i pljuvački reaguje sa jonima sumpora koji se oslobađaju delovanjem oralnih mikroorganizama [15]. Može postojati više od jednog osnovnog mehanizma za razvoj Burtonove linije ili Gublerovog znaka. Razna hrana i povrće sadrže velike količine sulfata. Oralne bakterije modifikuju ove sulfate u jedinjenja sumpora, npr. sumporovodik (H2S) [16].

Cilj ove studije je bio da se histološkom analizom ispita zastupljenost promena na gingivi i parodoncijumu kod adultnih pacova koji su intoksikovani olovo-acetatom.

MATERIJAL I METODE

Studija je sprovedena posle odobrenja Etičkog odbora Univerzitetskog kliničkog centra u Banjoj Luci (Bosna i Hercegovina). Uzorak se sastojao od 42 pacova soja vistar. Životinje su bile stare dva meseca, telesne težine 150–200 g. Čuvane su u grupnim kavezima od pleksiglasa, na 12 sati svetlosti (07.00 – 19.00 časova), na temperaturi vazduha od 22°C (± 2) i vlažnosti od 60% ± 10%, pri čemu su imali slobodan pristup hrani i vodi tokom eksperimenta. Na početku eksperimenta pacovi su razdvojeni u odgovarajuće testne grupe. Dobili su 15-dnevni period adaptacije. Posle adaptacije podeljeni su u dve eksperimentalne grupe (A1 i A2). Prvu (A1) i drugu (A2) grupu činilo je po 16 pacova [17].

Intoksikacija odraslih pacova olovo-acetatom u koncentraciji od 1500 ppm izvedena je putem vode za piće *ad libitum*. Trovanje olovom je trajalo 14 dana u grupi A1, a 30 dana u grupi A2. Sve procedure na životinjama, negovanje, eksperimentalni tretman, žrtvovanje bez bola i stresa izvedeni su u skladu sa Smernicama za brigu o životinjama u eksperimentalnim istraživanjima.

Pacovi iz prve grupe (A1) žrtvovani su posle 14 dana, a iz druge grupe (A2) posle 30 dana. Za histološku analizu su kosti gornjih vilica zajedno sa zubima (posle 48 sati fiksacije u 10% neutralnom puferovanom formalinu) dekalcifikovane u rastvoru azotne kiseline (ne duže od 90 minuta). Dekalcifikovani uzorci su zatim isprani tekućom vodom i obrađeni u automatizovanom tkivnom procesoru Leica TP 1020 (Leica Byosistems) po standardnom protokolu: dehidracija u rastućim koncentracijama etil-alkohola (70%, 96%, 100%), ispiranje u ksilolu, impregnacija tečnim parafinom, nakon čega su odabrani uzorci tkiva ukalupljeni u parafinske blokove. Za histološku analizu parafinski blokovi su nakon hlađenja sečeni na kliznom mikrotomu (Leica SM 2000R, Leica Byosistems) na preseke debljine 4–5 μm, a poprečni preseci potpornog aparata sakupljani su na odgovarajuća predmetna stakalca i sušeni na 60°C. U procesoru za automatsko bojenje (Leica ST4040 Linear stainer, Leica Byosistems) tkivni preseci su deparafinisani, rehidrirani i ispirani u destilovanoj vodi. Nakon toga su obojeni standardnom metodom hematoksilin-eozina (HE). Definitivni preparati su analizirani svetlosnim mikroskopom (Leica DM 2500, Leica Byosistems) i fotografisani kamerom povezanom sa mikroskopom [18].

REZULTATI

U prvoj eksperimentalnoj grupi (A1) parodontitis i gingivitis su zabeleženi u 41,7% slučajeva (Tabela 1). U drugoj eksperimentalnoj grupi (A2) parodontitis i gingivitis su zabeleženi u 84% slučajeva (Tabela 1, Slika 2). Između ispitivanih grupa utvrđena je statistički značajna razlika ($\chi^2 = 6{,}955$; $p < 0{,}018$) (Tabela 1).

DISKUSIJA

Olovo je jedan od najvažnijih i najrasprostranjenijih zagađivača u životnoj sredini u smislu globalne kontaminacije i uticaja na zdravlje [7, 19].

Deca imaju tendenciju da apsorbuju više olova u organizam nego odrasli zbog veće stope metabolizma, kao i fizičke sklonosti da udišu olovo iz zagađenog vazduha. U stvari, dečji gastrointestinalni organi su nedovoljno razvijeni i lakše apsorbuju olovo, dovodeći do mnogih oboljenja u organizmu i zubima [20].

Mnoge studije su se bavile ispitivanjem uticaja olova na oralno zdravlje odraslih osoba. Međutim, odnos olova i oralnog zdravlja kod dece je nedovoljno ispitan, kao i njegov uticaj na gingivu i parodoncijum [21, 22].

S obzirom na podatke da deca mnogo više apsorbuju olovo i da je ova problematika nedovoljno istražena, posebno histološkom analizom, naša studija je sprovedena na mladuncima pacova starim dva meseca koji su intoksikovani olovom u vodi za piće 14 i 30 dana, u cilju da se ispitaju promene na njihovoj gingivi i parodoncijumu. Rezultati naše studije su ukazali na značajno veću zastupljenost gingivitisa i parodontitsa kod mladunaca pacova koji su pili vodu sa olovom duži vremenski period (30 dana) (Grupa A2) – 84% slučajeva, u odnosu na mladunce koji su olovo dobijali samo 14 dana (Grupa A1) – 41,7% slučaja. Ovi naši rezultati podržavaju mogućnost da je olovo faktor koji doprinosi razvoju parodontalnih bolesti kod ljudi. Naši rezultati su u skladu s rezultatima prethodnih studija koje su se bavile sličnom problematikom kod dece. Jednu od njih je sproveo Youravong sa saradnicima među decom Tajlanda koja žive u industrijskoj zoni brodogradilišta. Rezultati su ukazali na značajnu pozitivnu korelaciju između visoke koncentracije olova u krvi i parodontoloških oboljenja, posebno dubokih parodontalnih džepova [7]. Borany je sa saradnicima imao za cilj da istraži vezu između nivoa olova u krvi (BLL) i oralnog zdravlja kod dece Južne Koreje. Ispitivanje je bilo bazirano na analizi krvi i stomatološkim pregledima dece uz određivanje gingivalnog indeksa i plak indeksa. Utvrdili su da se visoka koncentracija olova u krvi dovodi u vezu s problemima oralnog zdravlja kod dece Južne Koreje, uključujući taloženje plaka i bolesti gingive, što je usaglašeno sa rezultatima naše studije [23].

Veliki broj autora se bavio se proučavanjem veze između uticaja olova i inflamacije potpornog tkiva zuba, jer je pored mnogih kliničkih manifestacija kod pacijenata intoksikovanih olovom (uključujući decu i mlade odrasle osobe) povećan rizik od parodontitisa. Parodontitis je hronična bolest gingive, koja ako se ne leči dovodi do širenja upale u okolne strukture zuba, menjajući homeostazu kostiju, kasnije razarajući potporne i okolne strukture uzrokujući gubitak zuba [12, 20, 24].

Parodontitis je prvenstveno uzrokovan pogoršanim imunološko-upalnim odgovorom domaćina, koji ima mnogo pokretača, a jedan od njih su olovo i kadmijum, koji u većoj koncentraciji podstiču proizvodnju reaktivnih vrsta kiseonika (ROS), što može biti mogući uzrok progresije parodontitisa [25]. Browar je sa saradnicima ispitivao korelaciju između izloženosti kadmijumu i olovu u odnosu na parodontološka oboljenja i to imunohistohemijskom metodom kod eksperimentalnih pacova. U njihovoj studiji su mužjaci pacova dobivali supkutano injekcije olova i kadmijuma (0,6 mg/kg/dan) u periodu od 12 sedmica. Došli su do rezultata da kadmijum i olovo imaju značajan negativni uticaj na parodoncijum zuba pacova, što je usaglašeno sa našom studijom, koja je takođe rađena imunohistohemijskom metodom na pacovima [26].

Određivanje koncentracije olova u zubima smatra se dobrim biološkim pokazateljima izloženosti olovu u životnoj sredini i na radnom mestu. To je potvrdila studija koju su sproveli

El-Said i saradnici. Ona je ukazala da 97,2% radnika u fabrici za proizvodnju olovnih baterija ima gingivitis, koji je bio najzastupljeniji od svih parodontoloških oboljenja [14]. Olovo u krvi, pljuvački, plaku i ostacima hrane može stupiti u reakciju sa oralnim vodonik-sulfidom (koji nastaje fermentacijom hrane koja se taloži u ustima) da bi se formirao olovni sulfid. To može izazvati iritaciju, diskoloraciju i krvarenje desni [14, 27].

Izloženost olovu uglavnom dolazi od neformalnog recikliranja i proizvodnje baterija, elektronskog otpada, emisijom iz fabrika koje obrađuju rude bogate teškim metalima i prekomernim unosom hrane i začina koji sadrže velike koncentracije olova. To je i potvrdila jedna od studija u kojoj je Ericson sa saradnicima određivao vrednosti koncentracije olova u krvi dece u 34 zemlje kako bi se utvrdila zastupljenost olova kod 1300 miliona dece. Došli su do rezultata da je 48,5% dece (632 miliona) imalo nivo olova u krvi iznad 5 µg/dL [28].

Neke od studija su ukazale da uticaj olova utiče na smanjeno lučenje pljuvačke kod pacova čak 30-40%. Međutim, nije bilo studije sprovedene na ljudima. Uticaj olova na smanjenje pljuvačke može delimično objasniti i našu studiju u kojoj su pacovi intoksikovani olovom. Olovo je u pljuvačnim žlezdama smanjilo proizvodnju pljuvačke i tako onemogućilo njenu potpunu funkciju zaštite i vlaženja gingive, dovodeći do gingivitisa i parodontitisa, a to su potvrdili i naši rezultati [29].

Sprovođenjem edukacija o merama zaštite na radnim mestima (topionice, fabrike baterija i teške industrije itd.), izbegavanjem područja kontaminiranih olovom, kao i unosa hrane i vode sa tog područja, te usvajanjem zdravog načina života, smanjiće se unos olova u organizam i samim tim i oboljenja zuba i usta. Fluorizacija vode za piće, soli i mleka može pomoći u sprečavanju prevalencije bolesti usta uzrokovanih izloženošću olovu [30].

ZAKLJUČAK

Kod grupe pacova koja je intoksikovana olovom duži vremenski period – 30 dana, u odnosu na grupu koja je intoksikovana olovom u kraćem vremenskom periodu – 14 dana, uočena je znatno veća zastupljenost promena na gingivi i parodoncijumu (gingivitis i parodontitis) potpornog aparata zuba pacova. Rezultati ove studije ukazuju na povezanost uticaja olova i parodontalnih oboljenja, zbog čega je neophodno uvesti preventivni program i mere za pacijente, a posebno za decu. To obuhvata edukaciju dece od malih nogu o značaju održavanja oralne higijene i redovnih poseta stomatologu, koja može smanjiti zastupljenost zubnog plaka, mekih i tvrdih zubnih naslaga i omogućiti uočavanje početnih patoloških promena parodoncijuma i njihovo lečenje.

CASE REPORT
PRIKAZ BOLESNIKA
DOI: https://doi.org/10.2298/SGS2304196P
UDC: 616.314-089; 615.46:616.314

Soft Tissue Management at Delayed Implant Loading in the Aesthetic Zone – A Case Report

Aleksandra Prokić, Minja Miličić Lazić, Igor Đorđević
University of Belgrade, Faculty of Dental Medicine, Department of Prosthodontics, Belgrade, Serbia

SUMMARY
Emergence profile of implant-supported crowns is defined by the characteristics of supracrestal connective tissue (SCT), located between the implant platform and cervical soft tissue margin. This paper reflects the soft tissue contour management of implant-supported screw-retained crowns and the transfer of emergence profile using an indirectly customized impression coping.
A 27-year-old male was referred for endosseus implant placement (Straumann BLT Ø 4.1 mm × 12 mm) in a region of a maxillary right central and lateral incisor. Teeth were extracted due to a cystic formation in the mentioned region. Following the delayed implant loading protocol, implants were exposed, and provisional crowns were fabricated to support marginal mucosa and papillae and to mimic the contralateral site. During the three months of temporization, three-dimensional peri-implant soft tissue changes were validated, and temporary crowns were re-contoured every two weeks to obtain dynamic compression. When adequate soft tissue architecture was achieved, the impression for definitive crowns was taken using customized transfer technique to be able to register the emergence profile of provisional crowns.
This case report described a soft tissue management technique, where remodeling the provisional restoration allowed soft tissue to be reshaped. Individual transfer impression technique provides an accurately captured emergence profile of the soft tissue contours around implants in the aesthetic zone. This technique enables contouring of the transmucosal part of the definitive restoration according to the results obtained by individual dynamic compression, which leads to healthy soft tissue contours as well as satisfactory aesthetic results.
Keywords: supracrestal connective tissue; soft tissue management; screw-retained crowns; aesthetic zone; customized impression coping

INTRODUCTION

Besides the desired design and morphology of implant-supported crowns, soft tissue architecture plays a crucial role in biological and overall aesthetic outcomes [1]. After achieving osseointegration with delayed implant loading protocol, the final steps of remodeling the soft tissue still remain challenging. The cylindrical shape of an implant or a prefabricated healing abutment is not compatible with the gingival contour of natural teeth. Thus, additional surgery procedures are often required to obtain the desired aesthetic outcome. However, if the correct 3D implant position is provided, with an adequate thickness of the supracrestal connective tissue it is possible to create the desired emergence profile using non-invasive restorative procedures [2].

In order to establish an ideal emergence profile a vertical dimension of a minimum of 3 mm of supracrestal connective tissue is required [3]. Supracrestal connective tissue around implant differs from the gingival tissue around natural teeth primarily because of reduced vascularisation and parallelly oriented fibers of the connective peri-implant tissue. Moreover, increased permeability in comparison to the junctional epithelium of natural teeth leads to higher susceptibility to infection. Those conditions could result in mucositis and periimplantitis [4, 5]. By guided conditioning, i.e. using dynamic compression technique in peri-implant region it is possible to obtain optimal conditions for oral hygiene [6]. From the prosthodontic point, the final goal is to recreate the lost contours of the natural tooth [7, 8]. Studies show different approaches and treatment options [5, 6]. The transfer of the emergence profile using an indirectly fabricated modified impression post while focusing on the management of the gingival framework at the healed site of implant placement was the preferred method in this case report.

CASE REPORT

A 27-year-old patient visited the Department of Oral Surgery, University of Belgrade with missing anterior teeth 12 and 11. Teeth were extracted due to a cystic formation in the mentioned region. After proper treatment planning, endo-osseous implants (Straumann BLT Ø 4.1 mm × 12 mm) were placed in the position of teeth 12 and 11, using a bone xenograft (Geistlich Bio-Oss), and according to the restoratively driven implant placement. Following the delayed implant loading protocol, implants were exposed four months post-implantation (Figure 1).

The open tray technique was used to make a definitive impression for provisional crowns. The copings for open tray were connected using dental floss and an acrylic resin. Connecting the transfers assisted in ensuring the

Address for correspondence: Aleksandra PROKIĆ, Milovana Marinkovića 18, Beograd, Srbija; *aleksandra_prokic@yahoo.com*

Figure 1. Placement of gingival former
Slika 1. Postavljene kapice za zarastanje mekih tkiva

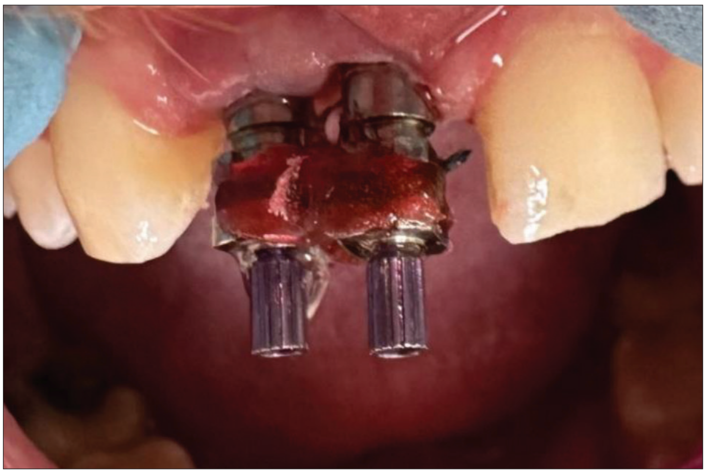

Figure 2. Connection of the impression coping
Slika 2. Povezani prenosnici

Figure 3. Impression with placed analogs
Slika 3. Realizovan jednovremeni otisak sa postavljenim replikama implantata

Figure 4. Temporary crowns
Slika 4. Privremene krunice

Figure 5. Preparation for re-contouring of temporary crowns
Slika 5. Fiksirane privremene krunice pripremljene za preoblikovanje

accuracy of the impression and cast. The impression tray was coated with adhesive and loaded with VPS (Elite HD+ Putty Soft, Zhermack). Concurrently light-body impression material (Elite HD+ Light Body, Zhermack) was expressed around the transfers to capture the morphology of the soft tissue and into the impression tray over the heavy body impression material. After the impression was taken, the analogs were tightened to copings (Figure 3).

When the provisional crowns were fabricated, the soft tissue conditioning began. The material was removed from the deep contour of the crown to obtain an adequate emergence profile. Also, the superficial contour of the crowns was developed to support marginal mucosa and papillae and to mimic the contralateral site. A provisional two-unit bridge was fabricated with functional occlusal contact with opposing teeth. During the three months of temporization, three-dimensional peri-implant soft tissue changes were validated, and the provisional restauration was re-contoured every two weeks to mold the tissue (Figures 4–7).

After completion of the temporary screw-retained crown (Mantis Cheme CAD-CAM), we started recontouring its transmucosal part (Figures 4, 5, and 6). Primarily, the material was removed from the subcritical contour of the crown to obtain an optimal emergence profile. A slightly concave shape of the subcritical contour of the crown will allow sufficient space for a stable blood clot (Figure 6). Contrary, the convex shape of the critical contour of the crown will provide support for the cervical soft tissue margin (Figure 6). During the 12 weeks of temporization,

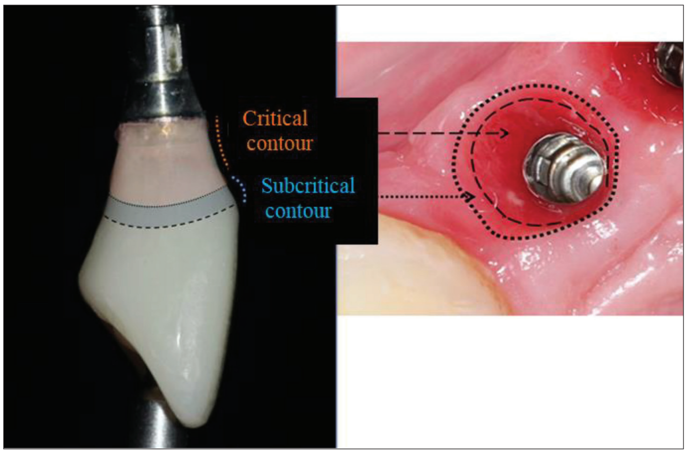

Figure 6. Remodeling of transmucosal part of temporary crown according to the characteristics of supracrestal connective tissue
Slika 6. Remodelacija transmukoznog dela privremene zubne nadoknade prema karakteristikama suprakrestalnog vezivnog tkiva

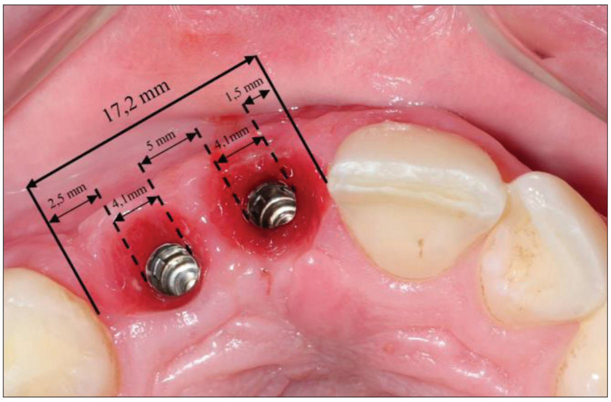

Figure 7. Mesio-distal space for final crowns
Slika 7. Raspoloživi prostor za definitivne zubne nadoknade

Figure 8. Emergence profile after 12 weeks
Figure 8. Izgled mekih tkiva nakon 12 nedelja

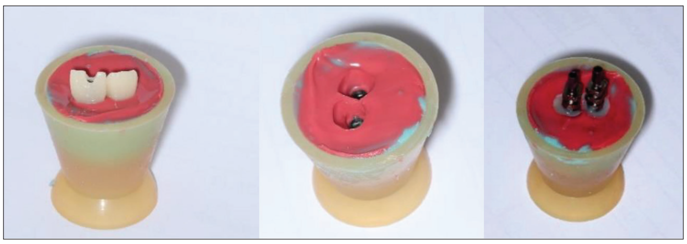

Figure 9. Registering the emergence profile of the provisional crowns
Slika 9. Registrovanje izlaznog profila privremene nadoknade u elastičnom otisnom materijalu

Figure 10. Placement of customized impression copings for open tray technique
Slika 10. Intraoralno postavljeni individualni prenosnici

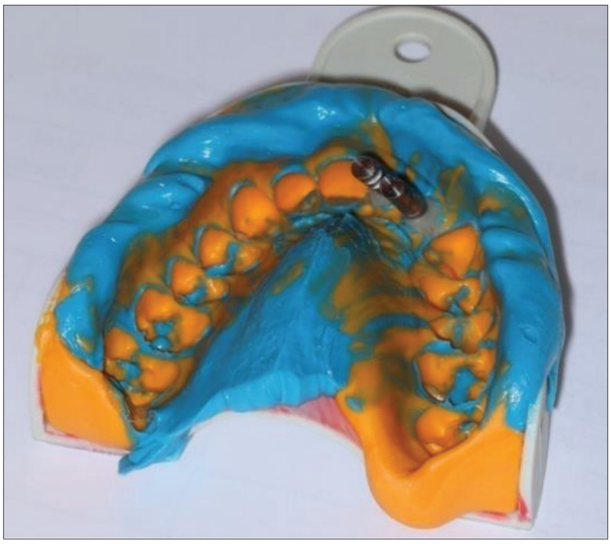

Figure 11. Definitive impression - customized impression coping technique
Slika 11. Definitivni otisak realizovan tehnikom individualizovanog prenosnika

supracrestal connective tissue was periodically re-scalloped and the three-dimensional changes were validated.

After 12 weeks, when adequate soft tissue architecture was achieved (Figure 8), the impression for definitive crowns was taken via individual transfer technique to register the emergence profile of the provisional crowns (Figure 9). This served as a customized impression where the transfer was tightened to analog and the gap between transfer and polyvinyl siloxane was poured with self-polymerizing acrylic resin.

In order to register and transfer the obtained emergence profile to the definitive cast, the customized impression copings were created in three steps (figure 9). The impression of the transmucosal part of temporary crowns was indexed in VPS material. This served as a precise impression where copings for the open tray technique were placed and tightened to the analogs. The space between copings and impression materials was filled with light-cured resin (Figure 9). Thus, customized copings served

Figure 12. Definitive implant-supported restorations- all ceramic screw-retained crowns
Slika 12. Definitivna nadoknada – keramički hibridne krunice

for the transfer of soft tissue architecture to the definitive cast (Figures 10 and 11). Definitive restoration was fabricated and placed a week after taking the definitive impression (Figure 10).

DISCUSSION

Delayed implant loading protocol enables the osseointegration and soft tissue maturation. This loading protocol is based on the concept that increased vertical or lateral force upon the implant during the healing process results in implant motion, abnormal healing, and fibrous tissue encapsulation [9, 10].

Soft tissue management procedures are frequently performed both simultaneously with, and post-implant placement in order to improve the aesthetic, functional, and biological outcomes of implant therapy [7, 11, 12].

Insufficient soft tissue volume can have a great impact on the final results of the implant reconstruction. Results of contemporary investigations have shown that mucosal thickness has a high influence on color changes of the mucosa [13, 14] and plays a crucial role in soft tissue aesthetics [15, 16]. Thin peri-implant soft tissue is also linked to a greater risk of developing recession [17] as well as a negative effect on marginal bone levels [18-20].

Marginal bone loss (MBL) is a parameter vital for considering the attainment and maintenance of implant osseointegration [21]. Marginal bone loss around implants is affected by different parameters such as the thickness of the peri-implant mucosa, the quality of the surrounding bone tissue, the macro- and micro design of the implant, and the design of the implant-abutment interface [21–25].

The stability of the peri-implant soft tissues is a crucial factor for a natural appearance and good rehabilitation and prevention of bone reabsorption. The healthy peri-implant mucosal interface has been linked with the conservation of marginal bone and long-term implant success [21]. In cases such as this one, where high aesthetics is of upmost importance, soft tissue management is recommended with delayed implant placement to reduce soft tissue recession [11]. Therefore, to deliver a natural-looking final restoration, the management of the transgingival region can be properly guided using provisional two-unite bridge.

CONCLUSION

This case report describes a soft tissue management technique, where remodeling the provisional restoration allows the soft tissue to be reshaped. Individual transfer impression technique provides an accurately captured emergence profile of the soft tissue contours around implants in the aesthetic zone. This method provides definitive restoration to be shaped exactly like provisional, leading to healthy soft tissue contours as well as satisfactory esthetical results.

ACKNOWLEDGEMENT

The authors express their gratitude to the dental technician Nenad Mandić.

REFERENCES

1. Al-Rethia R, Al-Dayel A. Soft Tissue Management around Implant in the Esthetic Zone: A Case Report. Int J Dent Sci Res. 2021;9(1):6–10. [DOI: 10.12691/ijdsr-9-1-2]
2. González-Martín O, Lee E, Weisgold A, Veltri M, Su H. Contour Management of Implant Restorations for Optimal Emergence Profiles: Guidelines for Immediate and Delayed Provisional Restorations. Int J Periodontics Restorative Dent. 2020;40(1):61–70. [DOI: 10.11607/prd.4422] [PMID: 31815974]
3. Kois JC, Kan JY. Predictable peri-implant gingival aesthetics: surgical and prosthodontic rationales. Pract Proced Aesthet Dent. 2001;13(9):691–8; quiz 700, 721–2. [PMID: 11862920]
4. Salvi GE, Aglietta M, Eick S, Sculean A, Lang NP, Ramseier CA. Reversibility of experimental peri-implant mucositis compared with experimental gingivitis in humans. Clin Oral Implants Res. 2012;23(2):182–90. [DOI: 10.1111/j.1600-0501.2011.02220.x] [PMID: 21806683]

5. Nemcovsky CE, Moses O. Rotated palatal flap. A surgical approach to increase keratinized tissue width in maxillary implant uncovering: technique and clinical evaluation. Int J Periodontics Restorative Dent. 2002;22(6):607–12. [PMID: 12516832]
6. Lazić V, Todorović A, Djordjević I, Milošević N, Popović D, Miletić A. Contouring the emergence profile of peri-implant soft tissue by provisionals on implants – case report. Stom Glas Srb. 2015;62(4):196–201. [DOI: 10.1515/sdj-2015-0020]
7. Thoma DS, Buranawat B, Hammerle CH, Held U, Jung RE. Efficacy of soft tissue augmentation around dental implants and in partially edentulous areas: a systematic review. J Clin Periodontol. 2014;41(Suppl 15):S77–91. [DOI: 10.1111/jcpe.12220] [PMID: 24641003]
8. Bassetti RG, Stahli A, Bassetti MA, Sculean A. Soft tissue augmentation procedures at second-stage surgery: a systematic review. Clin Oral Investig. 2016;20(7):1369–87. [DOI: 10.1007/s00784-016-1815-2] [PMID: 27041111]
9. Pardal-Peláez B, Flores-Fraile J, Pardal-Refoyo JL, Montero J. Implant loss and crestal bone loss in early loading versus delayed and immediate loading in edentulous mandibles. A systematic review and meta-analysis. J Clin Exp Dent. 2021;13(4):e397–e405. [DOI: 10.4317/jced.57966] [PMID: 33841740]
10. Pandey C, Rokaya D, Bhattarai BP. Contemporary Concepts in Osseointegration of Dental Implants: A Review. Biomed Res Int. 2022;2022:6170452. [DOI: 10.1155/2022/6170452] [PMID: 35747499]
11. Thoma DS, Cosyn J, Fickl S, Jensen SS, Jung RE, Raghoebar GM, et al. Soft tissue management at implants: Summary and consensus statements of group 2. The 6th EAO Consensus Conference 2021. Clin Oral Implants Res. 2021;32(Suppl. 21):174–80. [DOI: 10.1111/clr.13798]
12. Cairo F, Barbato L, Selvaggi F, Baielli MG, Piattelli A, Chambrone L. Surgical procedures for soft tissue augmentation at implant sites. A systematic review and meta-analysis of randomized controlled trials. Clin Implants Dent Related Res. 2019;21(6):1262–70. [DOI: 10.1111/cid.12861] [PMID: 31729830]
13. Thoma DS, Buranawat B, Hammerle CH, Held U, Jung RE. Efficacy of soft tissue augmentation around dental implants and in partially edentulous areas: A systematic review. J Clin Periodont. 2014;41(Suppl 15):S77–91. [DOI: 10.1111/jcpe.12220] [PMID: 24641003]
14. Wang II, Barootchi S, Tavelli L, Wang HL. The peri-implant phenotype and implant esthetic complications. Contemporary overview. J Esthet Restor Dent. 2021;33(1):212–23. [DOI: 10.1111/jerd.12709] [PMID: 33459483]
15. Del Amo FSL, Yu S-H, Sammartino G, Sculean A, Zucchelli G, Rasperini G, et al. Peri-implant Soft Tissue Management: Cairo Opinion Consensus Conference. Int J Environ Res Public Health. 2020;17(7):2281. [DOI: 10.3390/ijerph17072281] [PMID: 32231082]
16. Khorshed A, Vilarrasa J, Monje A, Nart J, Blasi G. Digital evaluation of facial peri-implant mucosal thickness and its impact on dental implant aesthetics. Clin Oral Investig. 2023;27(2):581–90. [DOI: 10.1007/s00784-022-04753-x] [PMID: 36260169]
17. Jung RE, Becker K, Bienz SP, Dahlin C, Donos N, Hammächer C, et al. Effect of peri-implant mucosal thickness on esthetic outcomes and the efficacy of soft tissue augmentation procedures: Consensus report of group 2 of the SEPA/DGI/OF workshop. Clin Oral Implants Res. 2022;33(Suppl 23):100–8. [DOI: 10.1111/clr.13955] [PMID: 35763020]
18. Van Brakel R, Cune MS, van Winkelhoff AJ, de Putter C, Verhoeven JW, van der Reijden W. Early bacterial colonization and soft tissue health around zirconia and titanium abutments: an in vivo study in man. Clin Oral Implants Res. 2011;22(6):571–7. [DOI: 10.1111/j.1600-0501.2010.02005.x] [PMID: 21054554]
19. Thoma DS, Naenni N, Figuero E, Hämmerle CHF, Schwarz F, Jung RE, et al. Effects of soft tissue augmentation procedures on peri-implant health or disease: A systematic review and meta-analysis. Clin Oral Implants Res. 2018;29(Suppl 15):32–49. [DOI: 10.1111/clr.13114] [PMID: 29498129]
20. Puisys A, Linkevicius T. The influence of mucosal tissue thickening on crestal bone stability around bone-level implants. A prospective controlled clinical trial. Clin Oral Implants Res. 2015;26(2):123–9. [DOI: 10.1111/clr.12301] [PMID: 24313250]
21. Thoma DS, Gil A, Hämmerle CHF, Jung RE. Management and prevention of soft tissue complications in implant dentistry. Periodontol 2000. 2022;88(1):116–29. [DOI: 10.1111/prd.12415] [PMID: 35103320]
22. Liu W, Cai H, Zhang J, Wang J, Sui L. Effects of immediate and delayed loading protocols on marginal bone loss around implants in unsplinted mandibular implant-retained overdentures: a systematic review and meta-analysis. BMC Oral Health. 2021;21(1):122. [DOI: 10.1186/s12903-021-01486-3] [PMID: 33731092]
23. Wang T, De Kok IJ, Zhong S, Vo C, Mendonça G, Nares S, et al. The Role of Implant-Tooth Distance on Marginal Bone Levels and Esthetics. Int J Oral Maxillofac Implants. 2019;34(2):499–505. [DOI: 10.11607/jomi.6809] [PMID: 30703184]
24. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: a 10-year randomized clinical study. Int J Prosthodont. 2004;17(4):401–10. [PMID: 15382775]
25. Gibbs S, Roffel S, Meyer M, Gasser A. Biology of soft tissue repair: gingival epithelium in wound healing and attachment to the tooth and abutment surface. Eur Cell Mater. 2019;38:63–78. [DOI: 10.22203/eCM.v038a06] [PMID: 31410840]

Received: 12.10.2023 • Accepted: 11.12.2023

Oblikovanje mekih tkiva pri odloženom opterećenju implantata u estetskoj regiji – prikaz slučaja

Aleksandra Prokić, Minja Miličić Lazić, Igor Đorđević
Univerzitet u Beogradu, Stomatološki fakultet, Klinika za stomatološku protetiku, Beograd, Srbija

KRATAK SADRŽAJ
Izlazni profil mekih tkiva implantatno nošenih zubnih nadoknada definisan je karakteristikama suprakrestalnog vezivnog tkiva lokalizovanog između platforme implantata i cervikalne ivice mekih tkiva. U ovom radu je opisana metoda oblikovanja izlaznog profila hibridnih krunica na implantatima uz pomoć individualizovanog prenosnika sa fokusom na usmereno preoblikovanje mekih tkiva. Kod pacijenta starog 27 godina ugrađeni su endoosealni implantati (Straumann BLT Ø 4.1 × 12 mm) u regijama koje odgovaraju pozicijama zuba 12 i 11. Navedeni zubi su prethodno izvađeni zbog cistične promene u istoimenoj regiji. Prateći protokol odloženog opterećenja, implantati su otvoreni četiri meseca nakon ugradnje i izrađene su privremene krunice kako bi se formirala estetski zadovoljavajuća marginalna gingiva i papila. Tokom tri meseca kondicioniranja mekih tkiva zabeležene su promene, a privremene krunice su remodelovane periodično oduzimanjem i dodavanjem kompozita. Otisak za definitivne krunice je realizovan tehnikom individualizovanih prenosnika formiranih pomoću izlaznih profila privremenih kruna.
Primenjena metoda obezbeđuje oblikovanje transmukoznog dela definitivne nadoknade prema rezultatima dobijenim usmerenom dinamičkom kompresijom, što dovodi do zdravih kontura mekih tkiva i do zadovoljavajućih estetskih rezultata.
Ključne reči: suprakrestalno vezivno tkivo; oblikovanje mekih tkiva; šrafom retinirane krunice; estetska zona; otisak pomoću individualizovanog prenosnika

UVOD

Pored adekvatnog dizajna i morfologije implantno nošenih zubnih nadoknada, meka tkiva igraju važnu ulogu u biološkom i sveukupnom estetskom aspektu [1]. Nakon perioda oseointegracije postignutog protokolom odloženog opterećenja implantata, završni koraci oblikovanja mekih tkiva i dalje predstavljaju izazov. S obzirom na to da se cilindričan oblik implantata i kapice za zarastananje mekih tkiva ne poklapa sa konturama prirodnog izlaznog profila oko zubne krunice, neretko se primenjuju i dodatne intervencije u domenu mukogingivalne hirurgije kako bi se postigli zadovoljavajući estetski rezultati. Ipak, ukoliko se obezbedi optimalna trodimenzionalna pozicija implantata uz prisustvo adekvatnog fenotipa mekih tkiva, moguće je restaurativnim metodama formirati željenu konturu transmukoznog dela periimplantnih tkiva [2].

Prema literaturno dostupnim podacima, da bi se obezbedili uslovi za postizanje optimalnog izlaznog profila, neophodno je da postoji 3 do 4 mm vertikalne dimenzije suprakrestalnog vezivnog tkiva koje čine vezivno tkivo i pripojni epitel [3].

Periimplantna mukoza se razlikuje od gingive prirodnih zuba pre svega zbog smanjene vaskularizacije i paralelno orijentisanih vlakana vezujućeg periimplantnog tkiva. Dodatno, veća permeabilnost u odnosu na epitelni pripoj prirodnih zuba uslovljava veću podložnost ka inflamaciji. Navedeno posledično može dovesti do gubitka koštanog tkiva uslovljenog mikrobima [4, 5]. Usmeranim oblikovanjem mekih tkiva, tj. sprovođenjem tehnike dinamičke kompresije u periimplantnoj regiji moguće je obezbediti uslove za pravilno održavanje oralne higijene uz poštovanje anatomskih struktura mekih tkiva [6]. Sa protetskog aspekta, krajnji cilj je ponovno kreiranje izgubljene mekotkivne konture prirodnog zuba. Studije pokazuju različite pristupe i procedure lečenja [7, 8].

Cilj ovog rada je bio da se prikaže klinički slučaj usmerenog kondicioniranja periimplantnih mekih tkiva rekonturiranjem privremenih krunica na implantatima u estetskoj zoni.

PRIKAZ SLUČAJA

Pacijent star 27 godina javio se na Kliniku za oralnu hirurgiju Univerziteta u Beogradu sa nedostatkom centralnog i lateralnog sekutića u gornjoj vilici sa desne strane. Zubi su prethodno izvađeni zbog cistične formacije u pomenutoj regiji. Nakon uspostavljenog terapijskog plana, endoosealni implantati (Straumann BLT Ø 4,1 × 12 mm) ugrađeni su u regijama koje odgovraju pozicijama zuba 12 i 11, sa dodatkom koštanog ksenotransplantata (Geistlich Bio-Oss). Ugradnja je izvršena prema smernicama protetskom nadoknadom vođene implantacije. Vodeći se protokolom odloženog opterećenja, implantati su otvoreni četiri meseca nakon ugradnje (Slika 1).

Dve nedelje od postavljanja kapica za zarastanje mekih tkiva, realizovan je jednovremeni otisak metodom otvorene kašike za izradu privremenih nadoknada. Kašika za otiskivanje (Miratray® Implant) prethodno je pripremljena adhezivom, a potom napunjena vinil-poliksiloksanom (Elite HD+ Putty Soft, Zhermack) gušće konzistencije. Oko prenosnika je plasiran elastomer ređe konzistencije (Elite HD+ Light Body, Zhermack). Po realizaciji otiska, analozi su pričvršćeni za prenosnike (Slika 3).

Na izrađenim privremenim krunicama od PMMA materijala (Mantis Cheme CAD-CAM) započeto je rekonturiranje (slike 4, 5 i 6). Materijal je uklonjen sa duboke konture krune da bi se dobio adekvatan izlazni profil. Formiranjem umereno konkavnog oblika duboke konture krune sa vestibularne površine obezbeđeno je prorastanje vezivnog tkiva i pripojnog epitela (Slika 6). Suprotno tome, subpovršinska kontura kruna je remodelovana dodavanjem kompozitnog materijala tako da dobije konveksan oblik koji će podržati marginalnu sluzokožu i papile (Slika 6). Nakon predaje individualno preoblikovanog privremenog rada započeto je kondicioniranje mekih tkiva. Privremene krune su izrađene tako da ostvaruju funkcionalne okluzalne kontakte sa antagonistima, prema konceptu uzajamno štićene okuzije. Tokom tri meseca temporizacije, potvrđene su trodimenzionalne promene mekog tkiva oko implantata, a privremene zubne nadoknade su rekonturirane periodično dodavanjem kompozita da bi se izvršila usmerena remodelacija mekih tkiva.

Nakon 12 nedelja, kada je postignuta adekvatna arhitektura mekog tkiva (slike 7 i 8), realizovan je otisak za definitivne krune tehnikom individualizovanog prenosnika. U cilju registracije novoformiranih izlaznih profila oko privremenih krunica, izrada individualnih prenosnika sprovedena je u tri koraka (Slika 9). Indeks transmukoznog dela privremenih kruna je zabeležen u elastičnom otisnom materijalu. Tako dobijena impresija poslužila je kao precizan otisak gde su prenosnici fiksirani za implantat replike, a prostor između prenosnika i vezanog otisnog materijala je popunjen tečnim kompozitom (Slika 9). Prilagođeni prenosnici poslužili su za transfer arhitekture mekih tkiva na definitivni radni model (slike 10 i 11). Definitivna nadoknada je predata nakon nedelju dana (Slika 12).

DISKUSIJA

Korišćeni protokol odloženog opterećenja implantata omogućava oseointegraciju i zarastanje mekog tkiva. Prednosti ovog koncepta zasnovane su na činjenici da povećana vertikalna i/ili bočna sila usmerena na implantat tokom procesa koštanog i mekotivnog zarastanja dovodi do mikropokreta, abnormalnog zarastanja i inkapsulacije fibroznog tkiva [9, 10].

Procedure oblikovanja mekih tkiva se često izvode istovremeno sa implantacijom i nakon nje kako bi se poboljšali estetski, funkcionalni i biološki ishodi implantološke terapije [7, 11, 12].

Nezadovoljavajući volumen mekog tkiva može imati veliki uticaj na konačni rezultat protetske rehabilitacije implantatima. Rezultati savremenih istraživanja su pokazali da debljina sluzokože ima veliki uticaj na promene boje sluzokože [13, 14] i da ima ključnu ulogu u estetici mekih tkiva [15, 16]. Tanko periimplantno meko tkivo je takođe povezano sa većim rizikom od razvoja recesije [17], kao i sa negativnim efektom na nivoe marginalne kosti [18, 19, 20].

Marginalni gubitak kosti je parametar od vitalnog značaja za održavanje osteointegracije implantata [21]. Na marginalni gubitak koštanog fundamenta oko implantata utiču različiti parametri, kao što su debljina periimplantatne sluzokože, kvalitet okolnog koštanog tkiva, makro i mikro dizajn implantata i dizajn veze implantat–abatment [21–25].

Stabilnost periimplantnih mekih tkiva je presudan faktor za prirodan izgled, dobru rehabilitaciju i prevenciju resorpcije kosti. Zdrava mukoza oko implantata je povezana sa očuvanjem marginalne kosti i dugoročnim uspehom implantata [21]. U slučajevima kao što je ovaj klinički prikaz, gde je visoka estetika od najveće važnosti, preporučuje se oblikovanje mekih tkiva uz odloženo postavljanje implantata kako bi se smanjila recesija mekog tkiva [11]. U cilju dobijanja konačne restauracije prirodnog izgleda, od ključnog značaja je da se usmeri zarastanje mekih tkiva u željenom pravcu.

ZAKLJUČAK

Individualna tehnika otiskivanja prenosnika obezbeđuje precizno izrađen izlazni profil kontura mekog tkiva oko implantata u estetskoj zoni. Ova metoda obezbeđuje definitivnu nadoknadu koja će biti oblikovana tačno kao privremena, što dovodi do zdravih kontura mekih tkiva i do zadovoljavajućih estetskih rezultata.

ZAHVALNICA

Autori upućuju zahvalnost zubnom tehničaru Nenadu Mandiću.

Da li ste pažljivo čitali radove?

1. Endoosealni implantati su ugrađeni na pozicijama:
   a) 11 i 12
   b) 21 i 22
   c) 31 i 32

2. Evaluacija morfologije kanala je proveravana:
   a) SEM-om
   b) CBCT-om
   c) rendgenografski

3. Određivanje radne dužine kanala proveravano je:
   a) rendgenografski i apeksnim lokatorom
   b) kompjuterizovanom tomografijom konusnog zraka (CBCT) i apeksnim lokatorom
   c) rendgenografski i kompjuterizovanom tomografijom konusnog zraka (CBCT)

4. Snaga veze posle pripreme keramike peskiranjem i silanizacijom iznosila je:
   a) 8,03 Mpa
   b) 6,69 Mpa
   c) 3,08 Mpa

5. Otvaranje implantata je urađeno posle:
   a) tri meseca
   b) četiri meseca
   c) šest meseci

6. Morfologija kanala je evaluirana kod:
   a) gornjih premolara
   b) donjih premolara
   c) gornjih molara

7. Provera radne dužine kanala realizovana je kod:
   a) 88 zuba
   b) 98 zuba
   c) 108 zuba

8. Blokovi disilikatne keramike podeljeni su u:
   a) tri grupe
   b) pet grupa
   c) osam grupa

9. Najveća razlika radne dužine kanala uočena je u grupi:
   a) mezijalnih kanala donjih molara
   b) distalnih kanala donjih molara
   c) lingvomezijalnih kanala donjih molara

10. Kondicioniranje fluorovodoničnom kiselinom rezultovalo je vezom od:
    a) 8,03 Mpa
    b) 2,65 Mpa
    c) 1,51 Mpa

11. Privremene krune na implantatima urađene su posle:
    a) tri meseca
    b) četiri meseca
    c) šest meseci

12. Konfiguracija kanala kod gornjih premolara je tumačena:
    a) po Vertućiju
    b) po Ahmedu
    c) po Bleku

13. Klasifikacija kanalnog sistema zuba po Ahmedu u odnosu na klasifikacije broja korenova i broja kanala:
    a) ima određene prednosti
    b) slične su
    c) nema nikakvih prednosti

14. Srednja vrednost razlike radne dužine kanala između kompjuterizovane tomografije konusnog zraka (CBCT) i apeksnog lokatora bila je najmanja u grupi:
    a) lingvomezijalnih kanala
    b) bukodistalnih kanala
    c) lingvodistalnih kanala

15. Priprema keramike u prvoj eksperimentalnoj grupi urađena je:
    a) brušenjem dijamantskim borerom
    b) peskiranjem aluminijum-oksidom
    c) nagrizanjem fluorovodoničnom kiselinom

16. Kondicioniranje peskiranjem rezultovalo je vezom od:
    a) 8,03 Mpa
    b) 2,65 Mpa
    c) 1,51 Mpa

17. Remodelovanje mekih tkiva privremenim krunama je realizovano:
    a) tokom tri meseca
    b) tokom četiri meseca
    c) tokom šest meseci

18. Za analizu morfologije kanala gornjih premolara korišćeno je:
    a) 55 snimaka muškaraca napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT)
    b) 45 snimaka muškaraca napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT)
    c) 85 snimaka muškaraca napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT)

19. Radna dužina je proveravana:
    a) samo kod jednokorenih zuba
    b) samo kod višekorenih zuba
    c) kod jednokorenih i višekorenih zuba

20. Uporedna analiza određivanja radne dužine kanala korena je realizovana:
    a) na Univerzitetu u Beogradu
    b) na Univerzitetu u Banjoj Luci
    c) na Univerzitetu u Foči

21. Priprema keramike u drugoj eksperimentalnoj grupi urađena je:
    a) brušenjem dijamantskim borerom
    b) peskiranjem aluminijum-oksidom
    c) nagrizanjem fluorovodoničnom kiselinom

22. Najefikasniji postupak kondicioniranja keramike je:
    a) peskiranje i silanizacija
    b) peskiranje
    c) brušenje dijamantom

23. Remodelovanje privremenih krunica je realizovano:
    a) samo oduzimanjem kompozita
    b) samo dodavanjem kompozita
    c) oduzimanjem i dodavanjem kompozita

24. Za analizu morfologije kanala gornjih premolara korišćena su:
    a) 53 snimka žena napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT)
    b) 63 snimka žena napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT)
    d) 73 snimka žena napravljenih metodom kompjuterizovane tomografije konusnog zraka (CBCT)

25. Između leve i desne strane kod premolara:
    a) nije uočena statistički značajna razlika
    b) uočena je statistički značajna razlika
    c) razlika je bila visoko statistički značajna

26. Značajna razlika u vrednostima radne dužine kanala između kompjuterizovane tomografije konusnog zraka (CBCT) i apeksnog lokatora:
    a) nije uočena
    b) uočena je samo kod jednokorenih zuba
    c) uočena je samo kod višekorenih zuba

27. Priprema keramike u trećoj eksperimentalnoj grupi urađena je:
    a) brušenjem dijamantom
    b) peskiranjem aluminijum-oksidom
    c) nagrizanjem fluorovodoničnom kiselinom

28. Uticaj olova na gingivu je proveravan kod:
    a) 32 pacova
    b) 42 pacova
    c) 52 pacova

29. Definitivni otisak za krunice na implantatima realizovan je:
    a) tehnikom individualizovanih prenosnika
    b) CAD/CAM tehnologijom
    c) otiskom pomoću gipsa

30. Morfologija kanala prvih premolara je analizirana kod:
    a) 223 premolara
    b) 253 premolara
    c) 263 premolara

31. Radna dužina kanala korena zuba je proveravana aparatom:
    a) WOOD PEX II
    b) WOOD PEX III
    c) WOOD PEX IV

32. CBCT tehnika odontometrije je:
    a) pouzdanija od postupka sa apeksnim lokatorom
    b) jednako pouzdana kao i tehnika sa apeksnim lokatorom
    c) manje pouzdana od tehnike sa apeksnim lokatorom

33. Priprema keramike u četvrtoj eksperimentalnoj grupi urađena je:
    a) brušenjem dijamantom
    b) peskiranjem aluminijum-oksidom
    c) peskiranjem i silanizacijom

34. Intoksikacija pacova olovo-austatom je urađena:
    a) vodom
    b) hranom
    c) injekcionom aplikacijom

35. Gingivitis i parodontitis u drugoj grupi pacova uočeni su u:
    a) 41,7% slučajeva
    b) 61,7% slučajeva
    c) 84% slučajeva

36. Morfologija kanala drugih premolara je analizirana kod:
    a) 107 premolara
    b) 207 premolara
    c) 307 premolara

37. Između broja korenova i tipa konfiguracije kanala gornjih premolara kod muškaraca:
    a) uočena je statistički značajna razlika
    b) nije uočena statistički značajna razlika
    c) razlika je bila visoko statistički značajna

38. U periodu od 2010. do 2014. godine broj pacijenata koji su tražili ortodontski tretman povećan je:
    a) od 10% na 15%
    b) od 14% na 27%
    c) od 15% na 30%

39. Priprema keramike u petoj eksperimentalnoj grupi urađena je:
    a) brušenjem dijamantom
    b) peskiranjem i silanizacijom
    c) nagrizanjem fluorovodoničnom kiselinom i silanizacijom

40. Prvu i drugu grupu pacova činilo je po:
    a) 10 pacova
    b) 16 pacova
    c) 20 pacova

41. Gingivitis i parodontitis u prvoj grupi pacova uočeni su u:
    a) 41,7% slučajeva
    b) 61,7% slučajeva
    c) 84% slučajeva

42. Gornji prvi premolari su imali najčešće:
    a) dva korena i dva kanala
    b) dva korena i tri kanala
    c) dva korena i četiri kanala

43. Između broja korenova i tipa konfiguracije kanala gornjih premolara kod žena:
    a) uočena je statistički značajna razlika
    b) nije uočena statistički značajna razlika
    c) razlika je bila visoko statistički značajna

44. Veza ortodontskih bravica je proveravana:
    a) na dentinu
    b) na gleđi
    c) na disilikatnoj keramici

45. Najveća snaga veze za površinu keramike ostvarena je:
    a) brušenjem dijamantom
    b) peskiranjem i silanizacijom
    c) nagrizanjem fluorovodoničnom kiselinom i silanizacijom

46. Prva grupa pacova dobijala je olovo-austat u vodi:
    a) tokom sedam dana
    b) tokom 14 dana
    c) tokom 30 dana

47. Druga grupa pacova dobijala je olovo-austat u vodi:
    a) tokom sedam dana
    b) tokom 14 dana
    c) tokom 30 dana

48. Gornji drugi premolari su najčešće imali:
    a) jedan koren i jedan kanal
    b) jedan koren i dva kanala
    c) dva korena i dva kanala

49. Kao uzorak u istraživanju o vezivanju ortodontskih bravica korišćeno je:
    a) 45 uzoraka CAD/CAM blokova
    b) 55 uzoraka CAD/CAM blokova
    c) 65 uzoraka CAD/CAM blokova

50. Snaga veze bravice za keramiku posle kondicioniranja fluorovodoničnom kiselinom i silanizacijom iznosila je:
    a) 8,03 Mpa
    b) 6,69 Mpa
    c) 3,08 Mpa

Odgovore slati na email adresu Uredništva časopisa „Stomatološki glasnik Srbije“ ili na adresu Stomatološke komore Srbije (Uzun Mirkova 3/3). Tačni odgovori na pitanja će se vrednovati u skladu s Pravilnikom o kontinuiranoj medicinskoj edukaciji zdravstvenih radnika.

UPUTSTVO AUTORIMA ZA PRIPREMU RADA

Stomatološki glasnik Srbije (SGS) časopis je Srpskog lekarskog društva osnovan 1953. godine. Časopis objavljuje originalne naučne i stručne radove, prikaze iz prakse, pregledne radove, saopštenja, istoriografske radove, prikaze knjiga, komentare i pisma uredništvu, društvenu hroniku.

Pre podnošenja rukopisa Uredništvu časopisa SGS svi autori treba da pročitaju Uputstvo za autore (Instructions for Authors), gde će pronaći sve potrebne informacije o pisanju i pripremi rada u skladu sa standardima časopisa. Ukoliko rukopis ne bude usklađen s ovim zahtevima, Uredništvo će odložiti ili odbiti njegovo publikovanje.

Za objavljene radove se ne isplaćuje honorar, a autorska prava se prenose na izdavača. Rukopisi i prilozi se ne vraćaju. Za reprodukciju ili ponovno objavljivanje nekog segmenta rada publikovanog u „Stomatološkom glasniku Srbije" neophodna je saglasnost izdavača – Srpskog lekarskog društva.

Radovi se štampaju na englekom i srpskom jeziku.

OPŠTA UPUTSTVA. SGS objavljuje radove koji do sada nisu nigde objavljeni, u celosti ili delom, niti prihvaćeni za objavljivanje. Radovi se uvek dostavljaju na engleskom i srpskom jeziku. Tekst rada kucati u programu za obradu teksta Word, fontom Times New Roman i veličinom slova 12 tačaka (12 pt). Sve četiri margine podesiti na 25 mm, veličinu stranice na format A4, a tekst kucati s dvostrukim proredom, levim poravnanjem i uvlačenjem svakog pasusa za 10 mm, bez deljenja reči (hifenacije). Ako se u tekstu koriste specijalni znaci (simboli), koristiti font Symbol. Podaci o korišćenoj literaturi u tekstu označavaju se arapskim brojevima u uglastim zagradama – npr. [1, 2], i to redosledom kojim se pojavljuju u tekstu. Stranice numerisati redom u donjem desnom uglu, počev od naslovne strane.

Pri pisanju teksta na engleskom jeziku treba se pridržavati jezičkog standarda American English i koristiti kratke i jasne rečenice. Za nazive lekova koristiti isključivo generička imena. Uređaji (aparati) se označavaju fabričkim nazivima, a ime i mesto proizvođača treba navesti u oblim zagradama. Ukoliko se u tekstu koriste oznake koje su spoj slova i brojeva, precizno napisati broj koji se javlja u superskriptu ili supskriptu (npr. 99Tc, IL-6, O2, B12, CD8). Ukoliko se nešto uobičajeno piše kurzivom (italic), tako se i navodi, npr. geni (BRCA1). Ukoliko je rad deo magistarske teze, odnosno doktorske disertacije, ili je urađen u okviru naučnog projekta, to treba posebno naznačiti u Napomeni na kraju teksta.

KLINIČKA ISTRAŽIVANJA. Klinička istraživanja se definišu kao istraživanja uticaja jednog ili više sredstava ili mera na ishod zdravlja. Registarski broj istraživanja se navodi u poslednjem redu sažetka.

ETIČKA SAGLASNOST. Rukopisi o istraživanjima na ljudima treba da sadrže izjavu u vidu pisanog pristanka ispitivanih osoba u skladu s Helsinškom deklaracijom i odobrenje nadležnog etičkog odbora da se istraživanje može izvesti i da je ono u skladu s pravnim standardima. Eksperimentalna istraživanja na humanom materijalu i ispitivanja vršena na životinjama treba da sadrže izjavu etičkog odbora ustanove i treba da su u saglasnosti s pravnim standardima.

IZJAVA O SUKOBU INTERESA. Uz rukopis se prilaže potpisana izjava u okviru obrasca Submission Letter kojom se autori izjašnjavaju o svakom mogućem sukobu interesa ili njegovom odsustvu. Za dodatne informacije o različitim vrstama sukoba interesa posetiti internet-stranicu Svetskog udruženja urednika medicinskih časopisa (World Association of Medical Editors – WAME; http://www.wame.org) pod nazivom „Politika izjave o sukobu interesa".

AUTORSTVO. Sve osobe koje su navedene kao autori rada treba da se kvalifikuju za autorstvo. Svaki autor treba da je učestvovao dovoljno u radu na rukopisu kako bi mogao da preuzme odgovornost za celokupan tekst i rezultate iznesene u radu. Autorstvo se zasniva samo na: bitnom doprinosu koncepciji rada, dobijanju rezultata ili analizi i tumačenju rezultata; planiranju rukopisa ili njegovoj kritičkoj reviziji od znatnog intelektualnog značaja; završnom doterivanju verzije rukopisa koji se priprema za štampanje.

Autori treba da prilože opis doprinosa pojedinačno za svakog koautora u okviru obrasca Submission Letter. Finansiranje, sakupljanje podataka ili generalno nadgledanje istraživačke grupe sami po sebi ne mogu opravdati autorstvo. Svi drugi koji su doprineli izradi rada, a koji nisu autori rukopisa, trebalo bi da budu navedeni u Zahvalnici s opisom njihovog doprinosa radu, naravno, uz pisani pristanak.

PLAGIJARIZAM. Od 1. januara 2019. godine svi rukopisi podvrgavaju se proveri na plagijarizam/autoplagijarizam preko SCIndeks Assistant – Cross Check (iThenticate). Radovi kod kojih se dokaže plagijarizam/autoplagijarizam biće odbijeni, a autori sankcionisani.

NASLOVNA STRANA. Na prvoj stranici rukopisa treba navesti sledeće: naslov rada bez skraćenica; predlog kratkog naslova rada, puna imena i prezimena autora (bez titula) indeksirana brojevima; zvaničan naziv ustanova u kojima autori rade, mesto i državu (redosledom koji odgovara indeksiranim brojevima autora); na dnu stranice navesti ime i prezime, adresu za kontakt, broj telefona, i imejl adresu autora zaduženog za korespondenciju.

SAŽETAK. Uz originalni rad, prethodno i kratko saopštenje, metaanalizu, pregled literature, prikaz slučaja (bolesnika), rad iz istorije medicine, aktuelnu temu, rad za rubriku jezik medicine i rad za praksu, na drugoj po redu stranici dokumenta treba priloži ti sažetak rada obima 100–250 reči. Za originalne radove, prethodno i kratko saopštenje, metaanalize i pregledne radove, sažetak treba da ima sledeću strukturu: Uvod/Cilj, Metode, Rezultati, Zaključak; svaki od navedenih segmenata pisati kao poseban pasus koji počinje boldovanom reči. Navesti najvažnije rezultate (numeričke vrednosti) statističke analize i nivo značajnosti. Zaključak ne sme biti uopšten, već mora biti direktno povezan sa rezultatima rada. Za prikaze bolesnika sažetak treba da ima sledeće delove: Uvod (u poslednjoj rečenici navesti cilj), Prikaz bolesnika, Zaključak; segmente takođe pisati kao poseban pasus koji počinje boldovanom reči. Za ostale tipove radova sažetak nema posebnu strukturu.

KLJUČNE REČI. Ispod Sažetka navesti od tri do šest ključnih reči ili izraza. U izboru ključnih reči koristiti Medical Subject Headings – MeSH (http://www.nlm.nih.gov/mesh).

PREVOD NA SRPSKI JEZIK. Na posebnoj stranici dokumenta priložiti naslov rada na srpskom jeziku, puna imena i prezimena autora (bez titula) indeksirana brojevima, zvaničan naziv ustanova u kojima autori rade, mesto i državu. Na sledećoj stranici dokumenta priložiti sažetak (100–250 reči) s ključnim rečima (3–6), prevod naziva priloga (tabela, grafikona, slika, shema) i celokupni tekst u njima i legendu.

STRUKTURA RADA. Svi podnaslovi se pišu velikim masnim slovima (bold). Originalni rad, metaanaliza, prethodno i kratko saopštenje obavezno treba da imaju sledeće podnaslove: Uvod (Cilj rada navesti kao poslednji pasus Uvoda), Metode rada, Rezultati, Diskusija, Zaključak, Literatura. Pregled literature čine: Uvod, odgovarajući podnaslovi, Zaključak, Literatura. Prvoimenovani autor metaanalize i preglednog rada mora da navede bar pet autocitata (kao autor ili koautor) radova publikovanih u časopisima s recenzijom. Koautori, ukoliko ih ima, moraju da navedu bar jedan autocitat radova takođe publikovanih u časopisima s recenzijom. Prikaz slučaja ili bolesnika čine: Uvod (Cilj rada navesti kao poslednji pasus Uvoda), Prikaz bolesnika, Diskusija, Literatura. Ne treba koristiti imena bolesnika, inicijale, niti brojeve istorija bolesti, naročito u ilustracijama. Prikazi bolesnika ne smeju imati više od pet autora. Priloge (tabele, grafikone, slike itd.) postaviti na kraj rukopisa, a u samom telu teksta jasno naznačiti mesto koje se odnosi na dati prilog. Krajnja pozicija priloga biće određena u toku pripreme rada za publikovanje.

SKRAĆENICE. Koristiti samo kada je neophodno, i to za veoma dugačke nazive hemijskih jedinjenja, odnosno nazive koji su kao skraćenice već prepoznatljivi (standardne skraćenice, kao npr. DNK, sida, HIV, ATP). Za svaku skraćenicu pun termin treba navesti pri prvom navođenju u tekstu, sem ako nije standardna jedinica mere. Ne koristiti skraćenice u naslovu. Izbegavati korišćenje skraćenica u sažetku, ali ako su neophodne, svaku skraćenicu objasniti pri prvom navođenju u tekstu.

DECIMALNI BROJEVI. U tekstu rada na engleskom jeziku, u tabelama, na grafikonima i drugim prilozima decimalne brojeve pisati sa tačkom (npr. 12.5 ± 3.8), a u tekstu na srpskom jeziku sa zarezom (npr. 12,5 ± 3,8). Kad god je to moguće, broj zaokružiti na jednu decimalu.

JEDINICE MERA. Dužinu, visinu, težinu i zapreminu izražavati u metričkim jedinicama (metar – m, kilogram (gram) – kg (g), litar – l) ili njihovim delovima. Temperaturu izražavati u stepenima Celzijusa (°C), količinu supstance u molima (mol), a pritisak krvi u milimetrima živinog stuba (mm Hg). Sve rezultate hematoloških, kliničkih i biohemijskih merenja navoditi u metričkom sistemu prema Međunarodnom sistemu jedinica (SI).

OBIM RADOVA. Celokupni rukopis rada – koji čine naslovna strana, sažetak, tekst rada, spisak literature, svi prilozi, odnosno potpisi za njih i legenda (tabele, slike, grafikoni, sheme, crteži), naslovna strana i sažetak na srpskom jeziku – mora iznositi za originalni rad, prethodno i kratko saopštenje, rad izistorije medicine i pregled literature do 5000 reči, a za prikaz bolesnika, rad za praksu, edukativni članak i rad za rubriku „Jezik medicine“ do 3000 reči; radovi za ostale rubrike mogu imati najviše 1500 reči.

PRILOZI RADU su tabele i slike (fotografije, crteži, sheme, grafikoni).

TABELE. Svaka tabela treba da bude sama po sebi lako razumljiva. Naslov treba otkucati iznad tabele, a objašnjenja ispod nje. Tabele se označavaju arapskim brojevima prema redosledu navođenja u tekstu. Tabele crtati isključivo u programu Word, kroz meni Table–Insert–Table, uz definisanje tačnog broja kolona i redova koji će činiti mrežu tabele. Desnim klikom na mišu – pomoću opcija Merge Cells i Split Cells – spajati, odnosno deliti ćelije. Kucati fontom Times New Roman, veličinom slova 12 pt, s jednostrukim proredom i bez uvlačenja teksta. Korišćene skraćenice u tabeli treba objasniti u legendi ispod tabele. Ukoliko je rukopis na srpskom jeziku, priložiti nazive tabela i legendu na oba jezika. Takođe, u jednu tabelu, u okviru iste ćelije, uneti i tekst na srpskom i tekst na engleskom jeziku (nikako ne praviti dve tabele sa dva jezika!).

SLIKE. Slike su svi oblici grafičkih priloga i kao „slike“ u SGS se objavljuju fotografije, crteži, sheme i grafikoni. Slike označavaju se arapskim brojevima prema redosledu navođenja u tekstu. Primaju se isključivo digitalne fotografije (crno-bele ili u boji) rezolucije najmanje 300 dpi i formata zapisa tiff ili jpg (male, mutne i slike lošeg kvaliteta neće se prihvatati za štampanje!). Ukoliko autori ne poseduju ili nisu u mogućnosti da dostave digitalne fotografije, onda originalne slike treba skenirati u rezoluciji 300 dpi i u originalnoj veličini. Ukoliko je rad neophodno ilustrovati sa više slika, u radu će ih biti objavljeno nekoliko, a ostale će biti u e-verziji članka kao PowerPoint prezentacija (svaka slika mora biti numerisana i imati legendu). Ukoliko je rukopis na srpskom jeziku, priložiti nazive slika i legendu na oba jezika.

GRAFIKONI. Grafikoni treba da budu urađeni i dostavljeni u programu Excel, da bi se videle prateće vrednosti raspoređene po ćelijama. Iste grafikone prekopirati i u Word-ov dokument, gde se grafikoni označavaju arapskim brojevima prema redosledu navođenja u tekstu. Svi podaci na grafikonu kucaju se u fontu Times New Roman. Korišćene skraćenice na grafikonu treba objasniti u legendi ispod grafikona. U štampanoj verziji članka verovatnije je da grafikon neće biti štampan u boji, te je bolje izbegavati korišćenje boja u grafikonima, ili ih koristiti različitog intenziteta. Ukoliko je rukopis na srpskom jeziku, priložiti nazive grafikona i legendu na oba jezika.

SHEME (CRTEŽI). Crteži i sheme se dostavljaju u jpg ili tiff formatu. Sheme se mogu crtati i u programu CorelDraw ili Adobe Illustrator (programi za rad sa vektorima, krivama). Svi podaci na shemi kucaju se u fontu Times New Roman, veličina slova 10 pt. Korišćene skraćenice na shemi treba objasniti u legendi ispod sheme. Ukoliko je rukopis na srpskom jeziku, priložiti nazive shema i legendu na oba jezika.

ZAHVALNICA. Navesti sve saradnike koji su doprineli stvaranju rada, a ne ispunjavaju merila za autorstvo, kao što su osobe koje obezbeđuju tehničku pomoć, pomoć u pisanju rada ili rukovode odeljenjem koje obezbeđuje opštu podršku. Finansijska i materijalna pomoć, u obliku sponzorstva, grantova, projekata treba takođe da bude pomenuta.

LITERATURA. Spisak referenci je odgovornost autora, a citirani članci treba da budu lako pristupačni čitaocima časopisa. Stoga uz svaku referencu obavezno treba navesti DOI broj članka (jedinstvenu nisku karaktera koja mu je dodeljena) i PMID broj ukoliko je članak indeksiran u bazi PubMed/MEDLINE. Reference numerisati rednim arapskim brojevima prema redosledu navođenja u tekstu. Broj referenci ne bi trebalo da bude veći od 30, osim u pregledu literature, u kojem je dozvoljeno da ih bude do 50, a u metaanalizi do 100. Broj citiranih originalnih radova mora biti najmanje 80% od ukupnog broja referenci, odnosno broj citiranih knjiga, poglavlja u knjigama i preglednih članaka manji od 20%. Ukoliko se domaće monografske publikacije i članci mogu uvrstiti u reference, autori su dužni da ih citiraju. Većina citiranih naučnih članaka ne bi trebalo dabude starija od pet godina. Nije dozvoljeno citiranje apstrakata. Reference članaka koji su prihvaćeni za štampu, ali još nisu objavljeni, treba označiti sa in press i priložiti dokaz o prihvatanju rada za objavljivanje.

Reference se citiraju prema Vankuverskom stilu (uniformisanim zahtevima za rukopise koji se predaju biomedicinskim časopisima), koji je uspostavio Međunarodni komitet urednika medicinskih časopisa (http://www.icmje.org), čiji format koriste U.S. National Library of Medicine i baze naučnih publikacija. Primeri navođenja publikacija (članaka, knjiga i drugih monografija, elektronskog, neobjavljenog i drugog objavljenog materijala) mogu se pronaći na internet-stranici http://www.nlm.nih.gov/bsd/uniform_requirements.html. Prilikom navođenja literature veoma je važno pridržavati se pomenutog standarda, jer je to jedan od najbitnijih faktora za indeksiranje prilikom klasifikacije naučnih časopisa.

PROPRATNO PISMO (SUBMISSION LETTER). Uz rukopis obavezno priložiti obrazac koji su potpisali svi autori, a koji sadrži: 1) izjavu da rad prethodno nije publikovan i da nije istovremeno podnet za objavljivanje u nekom drugom časopisu, 2) izjavu da su rukopis pročitali i odobrili svi autori koji ispunjavaju merila autorstva, i 3) kontakt podatke svih autora u radu (adrese, imejl adrese, telefone itd.). Blanko obrazac treba preuzeti sa internet-stranice časopisa (http://www.stomglas. org.rs). Takođe je potrebno dostaviti kopije svih dozvola za: reprodukovanje prethodno objavljenog materijala, upotrebu ilustracija i objavljivanje informacija o poznatim ljudima ili imenovanje ljudi koji su doprineli izradi rada.

ČLANARINA I NAKNADA ZA OBRADU ČLANKA. Da bi rad bio objavljen u časopisu Stomatološki glasnik Srbije, svi autori koji su lekari ili stomatolozi iz Srbije moraju biti članovi Srpskog lekarskog društva (u skladu sa članom 6. Statuta Društva) i izmiriti naknadu za obradu članaka (*Article Processing Charge*) u iznosu od 6000 dinara. Uplata nije garancija da će rad biti prihvaćen i objavljen u Stomatološkom glasniku Srbije.

Uz rukopis rada treba dostaviti kopije uplatnica za članarinu i naknadu za obradu članka, kao dokaz o uplatama, ukoliko izdavač nema evidenciju o tome. Časopis prihvata donacije od sponzora koji snose deo troškova ili troškove u celini onih autora koji nisu u mogućnosti da izmire naknadu za obradu članka (u takvim slučajevima potrebno je časopisu staviti na uvid opravdanost takvog sponzorstva).

SLANJE RUKOPISA. Rukopis rada i svi prilozi uz rad dostavljaju se preko službene imejl adrese.

NAPOMENA. Rad koji ne ispunjava uslove ovog uputstva ne može biti upućen na recenziju i biće vraćen autorima da ga dopune i isprave. Pridržavanjem uputstva za pripremu rada znatno će se skratiti vreme celokupnog procesa do objavljivanja rada u časopisu, što će pozitivno uticati na kvalitet članaka i redovnost izlaženja časopisa.

Za sve dodatne informacije, molimo da se obratite na dole navedene adrese i broj telefona:

ADRESA:
Srpsko lekarsko društvo
Uredništvo časopisa „Stomatološki glasnik Srbije“ Ul. kraljice Natalije 1
11000 Beograd Srbija
Telefon: + 381 (0)11 409-2776
Imejl adresa: stomglas@bvcom.rs
Internet adresa: http://www.stomglas.org.rs
ISSN Online 1452-3701
Open access

INSTRUCTIONS FOR AUTHORS

Serbian Dental Journal is the journal of the Serbian Medical Society, founded in 1953. The journal publishes following article types: original scientific papers, case reports, review articles, preliminary and short communications, history of medicine and dentistry articles, book reviews, articles for practitioners, invited commentaries, letters to the editor, editorials, congress and scientific meeting reports, personal view articles, professional news, chronicle articles from medical and dental society.

Before submitting their paper to the Editorial Office of the Serbian Dental Journal, authors should read the Instructions for Authors, where they will find all the necessary information on writing their manuscript in accordance with the journal's standards. The manuscripts that are not prepared in accordance with these standards will result in paper being delayed or rejected.

Serbian Dental Journal provides no fee for published articles. By submitting a paper for publishing consideration, authors of a paper accepted for publication in the Serbian Dental Journal grant and assign all copyrights to the publisher - the Serbian Medical Society.

The papers are published in English and Serbian.

GENERAL INSTRUCTIONS. Serbian Dental Journal publishes papers that have not been, either in their entirety or partially, previously published, and that have not been accepted for publication elsewhere. The papers are always submitted in both English and Serbian. The text of the manuscript should be typed in MS Word using the Times New Roman typeface, and font size 12 pt. The text should be prepared with margins set to 25 mm and onto A4 paper size, with double line spacing, aligned left and the initial lines of all paragraphs indented 10 mm, without hyphenation. If special signs (symbols) are used in the text, use the Symbol font. References cited in the text are numbered with Arabic numerals within parenthesis (for example: [1, 2]), in order of appearance in the text. Pages are numbered consecutively in the right bottom corner, beginning from the title page.

When writing text in English, linguistic standard American English should be observed. Write short and clear sentences. Generic names should be exclusively used for the names of drugs. Devices (apparatuses, instruments) are termed by trade names, while their name and place of production should be indicated in the brackets. If a letter-number combination is used, the number should be precisely designated in superscript or subscript (i.e., 99Tc, IL-6, O_2, B12, CD8). If something is commonly written in italics, such as genes (e.g. BRCA1), it should be written in this manner in the paper as well. If a paper is a part of a master's or doctoral thesis, or a research project, that should be designated in a separate note at the end of the text.

CLINICAL TRIALS. Clinical trial is defined as any research related to one or more health related interventions in order to evaluate the effects on health outcomes. The trial registration number should be included as the last line of the Summary.

ETHICAL APPROVAL. Manuscripts with human medical research should contain a statement that the subjects' written consent was obtained, according to the Declaration of Helsinki, the study has been approved by competent ethics committee, and conforms to the legal standards. Experimental studies with human material and animal studies should contain statement of the institutional ethics committee and meet legal standards.

CONFLICT OF INTEREST STATEMENT. The manuscript must be accompanied by a disclosure statement from all authors (contained within the Submission Letter) declaring any potential interest or stating that the authors have no conflict of interest. For additional information on different types of conflict of interest, please see World Association of Medical Editors (WAME, www.wame.org) policy statement on conflict of interest.

AUTHORSHIP. All individuals listed as authors should be qualified for authorship. Every author should have participated sufficiently in writing the article in order to take responsibility for the whole article and results presented in the text. Authorship is based only on: crucial contribution to the article conception, obtaining of results or analysis and interpretation of results; design of manuscript or its critical review of significant intellectual value; final revision of the manuscript being prepared for publication.

The authors should enclose the description of contribution to the article of every co-author individually (within the Submission Letter). Funding, collection of data or general supervision of the research group alone cannot justify authorship. All other individuals having contributed to the preparation of the article should be mentioned in the Acknowledgment section, with description of their contribution to the paper, with their written consent.

PLAGIARISM. Since January 1, 2019 all manuscripts have been submitted via SCIndeks Assistant to Cross Check (software iThenticate) for plagiarism and auto-plagiarism control. The manuscripts with approved plagiarism/autoplagiarism will be rejected and authors will not be welcome to publish in Serbian Dental Journal.

TITLE PAGE. The first page of the manuscript (cover sheet) should include the following: title of the paper without any abbreviations; suggested running title; each author's full names and family names (no titles), indexed by numbers; official name, place and country of the institution in which authors work (in order corresponding to the indexed numbers of the authors); at the bottom of the page: name and family name, address, phone number, and e-mail address of a corresponding author.

SUMMARY. Along with the original article, preliminary and short communication, review article, case report, article on history of medicine, current topic article, article for language of medicine and article for practitioners, the summary not exceeding 100-250 words should be typed on the second page of the manuscript. In original articles, the summary should have the following structure: Introduction/Objective, Methods, Results, Conclusion. Each segment should be typed in a separate paragraph using boldface. The most significant results (numerical values), statistical analysis and level of significance are to be included. The conclusion must not be generalized, it needs to point directly to the results of the study. In case reports, the summary should consist of the following: Introduction (final sentence is to state the objective), Case Outline (Outline of Cases), Conclusion. Each segment should be typed in a separate paragraph using boldface. In other types of papers, the summary has no special outline.

KEYWORDS. Below the Summary, 3 to 6 keywords or phrases should be typed. The keywords need not repeat words in the title and should be relevant or descriptive. Medical Subject Headings – MeSH (http://www.nlm.nih. gov/mesh) are to be used for selection of the keywords.

TRANSLATION INTO SERBIAN. The separate page of the manuscript should include: title of the paper in the Serbian language; each author's full name and family name (no titles), indexed by numbers; official name, place and country of the institution in which authors work. On the next page of the manuscript the summary (100-250 words) and keywords (3-6). The terms taken from foreign literature should be translated into comprehensible Serbian. All foreign words or syntagms that have a corresponding term in Serbian should be replaced by that term.

STRUCTURE OF THE MANUSCRIPT. All section headings should be in capital letters using boldface. Original articles and preliminary and short communications should have the following section headings: Introduction (objective is to be stated in the final paragraph of the Introduction), Methods, Results, Discussion, Conclusion, References. A review article and current topic include: Introduction, corresponding section headings, Conclusion, References. The firstly named author of a review article should cite at least five auto-citations (as the author or co-author of the paper) of papers published in peer-reviewed journals. Co-authors, if any, should cite at least one auto-citation of papers also published in peer-reviewed journals. A case report should consist of: Introduction (objective is to be stated in the final paragraph of the Introduction), Case Report, Discussion, References. No names of patients, initials or numbers of medical records, particularly in illustrations, should be mentioned. Case reports cannot have more than five authors. Letters to the editor need to refer to papers published in the Serbian Archives of Medicine within previous six months; their form is to be comment, critique, or stating own experiences. Publication of articles unrelated to previously published papers will be permitted only when the journal's Editorial Office finds it beneficial.

All enclosures (tables, graphs, photographs, etc.) should be placed at the end of the manuscript, while in the body of the text a particular enclosure should only be mentioned and its preferred place indicated. The final arrangement (position) of the enclosures will depend on page layout.

ABBREVIATIONS. To be used only if appropriate, for very long names of chemical compounds, or as well-known abbreviations (standard abbreviations such as DNA, AIDS, HIV, ATP, etc.). Full meaning of each abbreviation should be indicated when it is first mentioned in the text unless it is a standard unit of measure. No abbreviations are allowed in the title. Abbreviations in the summary should be avoided, but if they have to be used, each of them should be explained when first mentioned in the text of the paper.

DECIMAL NUMBERS. In papers written in English, including text of the manuscript and all enclosures, a decimal point should be used in decimal numbers (e.g. 12.5 ± 3.8), while in Serbian papers a decimal comma should be used (e.g. 12,5 ± 3,8). Wherever applicable, a number should be rounded up to one decimal place.

UNITS OF MEASURE. Length, height, weight and volume should be expressed in metric units (meter – m, kilogram – kg, gram – g, liter – l) or subunits. Temperature should be in Celsius degrees (°C), quantity of substance in moles (mol), and blood pressure in millimeters of mercury column (mm Hg). All results of hematological, clinical and biochemical measurements should be expressed in the metric system according to the International System of Units (SI units).

LENGTH OF PAPER. The entire text of the manuscript - title page, summary, the whole text, list of references, all enclosures including captions and legends (tables, photographs, graphs, schemes, sketches), title page and summary in Serbian - must not exceed 5,000 words for original articles, review articles and articles on history of medicine, and 3,000 words for case reports, preliminary and short communications, current topics, articles for practitioners, educational articles and articles for "Language of medicine", congress and scientific meeting reports; for any other section maximum is 1,500 words.

ARTICLE ENCLOSURES are tables, figures (photographs, schemes, sketches, graphs) and video-enclosures.

TABLES. Each table, with its legend, should be self-explanatory. The title should be typed above the table and any explanatory information under the table. Tables should be numbered in Arabic numerals in order of citation in the text. Use MS Word, the menu Table-Insert-Table, inserting the adequate number of rows and columns. By the right click of the mouse, use the options Merge Cells and Split Cells. Use Times New Roman, font size 12 pt, with single line spacing and no indent to draw tables. Abbreviations used in tables should be explained in the legend below each respective table.

Tables and corresponding legend should be both in Serbian and English. Also, the table cells should contain text in both languages (do not create two separate tables with a single language!).

FIGURES. Figures are all types of visual enclosures, and photographs, schemes, sketches and graphs are published as 'figures' in the Serbian Dental Journal. Figures should be numbered in Arabic numerals in order of citation in the text. Only original digital photographs (black-and-white or color), of minimum 300 dpi, and jpg or tiff format, are acceptable (small, blurry and photographs of poor quality will not be accepted for publishing!). If authors do not possess or are not able to provide digital photographs, then the original photos should be scanned in 300 dpi, and saved in original size. If a paper needs to be illustrated with a considerable number of figures, several figures will be published within the paper, and the rest will be available in the electronic version of the paper as a PowerPoint presentation (every figure needs to be numbered and be accompanied by legend). Photographs and corresponding legend should be both in Serbian and English.

GRAPHS. Graphs should be plotted in Excel in order to see the respective values distributed in the cells. The same graphs should be copied and pasted to the Word document, numbered in Arabic numerals by order of citation in the text. The text in the graphs should be typed in Times New Roman. Abbreviations used in graphs should be explained in the legend below the respective graph. In the printed versions of papers, graphs are generally published in black-and-white; therefore, it is suggested to avoid the use of colors in graphs, or to utilize colors of significant difference in brightness. Graphs and corresponding legend should be both in Serbian and English.

SCHEMES (SKETCHES). Schemes and sketches are to be submitted in jpg or tiff format. Schemes should be drawn in CorelDraw or Adobe Illustrator (programs for drawing vectors, curves, etc.). The text in the schemes should be typed in Times New Roman, font size 10 pt. Abbreviations used in schemes should be explained in the legend below the respective scheme. If the manuscript is entirely in the Serbian language, schemes and corresponding legend should be both in Serbian and English.

ACKNOWLEDGMENT. List all those individuals having contributed to preparation of the article but having not met the criteria of authorship, such as individuals providing technical assistance, assistance in writing the paper or running the department securing general support. Financial aid and support in the form of sponsorship, grants, donations, etc., should be mentioned too.

REFERENCES. The reference list is the responsibility of the authors. Cited articles should be readily accessible to the journal's readership. Therefore, following each reference, its DOI number and PMID number (if the article is indexed for MEDLINE/PubMed) should be typed. References should be numbered in Arabic numerals in order of citation in the text. The overall number of references should not exceed 30, except in review articles, where maximum of 50 is acceptable, and in meta-analysis, where up to 100 references are allowed. The number of citations of original articles must be at least 80% of the total number of references, and the number of citations of books, chapters and literature reviews less than 20%. If monographs and articles written by Serbian authors could be included in the reference list, the authors are obliged to cite them. The majority of the cited articles should not be older than five years. Use of abstracts as references is not allowed. The references of articles accepted for publication should be designated as in press with the enclosed proof of approval for publication.

The references are cited according to the Vancouver style (Uniformed Requirements for Manuscripts Submitted to Biomedical Journals), rules and formats established by the International Committee of Medical Journal Editors (http://www.icmje.org), used by the U.S. National Library of Medicine and scientific publications databases. Examples of citing publications (journal articles, books and other monographs, electronic, unpublished and other published material) can be found on the web site http://www.nlm.nih. gov/bsd/uniform_requirements.html. In citation of references, the defined standards should be strictly followed, because it is one of the essential factors of indexing for classification of scientific journals.

SUBMISSION LETTER. The manuscript must be accompanied by the Submission Letter, which is signed by all authors and includes the following: 1) statement that the paper has never been published and concurrently submitted for publication to any other journal; 2) statement that the manuscript has been read and approved by all authors who have met the criteria of authorship; and 3) contact information of all authors of the article (address, email, telephone number, etc.). Blank Submission Letter Form can be downloaded from the journal's web site (http://www.stomglas.org.rs).

Additionally, the authors should submit the following copies of all permits for: reproduction of formerly published material, use of illustrations and publication of information on known people or disclosure of the names of people having contributed to the work.

MEMBERSHIP FEE AND SUBSCRIPTION RATES. In order to publish their article in the Serbian Dental Journal, all authors and co-authors, medical doctors and doctors of dental medicine, must be members of the Serbian Medical Society (according to Article #6 of the Statute of the SMS) for the year in which the manuscript is being submitted. An Article Processing/Submission Charge for the coverage of all editing and publishing expenses of 6000 RSD is charged per an article. Please note that the payment of this charge does not guarantee acceptance of the manuscript for publication and does not influence the outcome of the review procedure, in accordance with the good publishing practice. The journal accepts donations from sponsors to create a sum for payment reductions or waivers for authors unable to cover the Article Processing/Submission Charge (a justification of the inability to pay should be provided in such cases).

Copies of deposit slips for membership and Article Processing/Submission Charge should be enclosed with the manuscript.

Foreign authors are under no obligation to be members of the Serbian Medical Society.

SUBMISSION. Please submit your manuscript and all enclosures via official e-mail. All correspondence, including notification of Editorial Office, requests for revision and Editor's decision will be sent by e-mail.

NOTE. The papers not complying with these instructions will not be reviewed and will be returned to the authors for revision. Observing the instructions for preparation of papers for the Serbian Archives of Medicine will shorten the time of the entire process of publication and will have a positive effect on the quality and timely release of the journal's issues.

For further information, please contact us via the following address:

ADDRESS:
Serbian Dental Journal
Editorial Office of Serbian Dental Journal
Kraljice Natalije 1
11000 Belgrade
Serbia
Phone: (+381 11) 409-2776
E-mail: stomglas@bvcom.net
Website: www.stomglas.org.rs
ISSN Online 1452 3701
OPEN ACCESS

OPEN ACCESS

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

616.31

STOMATOLOŠKI glasnik Srbije = Serbian
Dental Journal / glavni i odgovorni urednik
Slavoljub Živković. - God. 1, br. 1 (1955)-
. - Beograd (Džordža Vašingtona 19) :
Srpsko lekarsko društvo, 1955- (Beograd :
Službeni glasnik). - 29,5 cm

Dostupno i na: http://www.stomglas.org.rs - Tromesečno

ISSN 0039-1743 = Stomatološki glasnik Srbije
(Štampano izd.)
COBISS.SR-ID 8417026