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

STOMATOLOŠKI GLASNIK SRBIJE

SERBIAN DENTAL JOURNAL

Vol. 65 • Number 2 • April-June 2018

http://www.stomglas.org.rs

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

STOMATOLOŠKI GLASNIK SRBIJE

SERBIAN DENTAL JOURNAL

Vol. 65 • Number 2 • April-June 2018

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

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

Cene pretplate za 2018. godinu su: 2.400 dinara za pojedince, 4.800 dinara za ustanove i 50 evra za čitaoce van Srbije. Pretplata se može uplatiti Srpskom lekarskom društvu, ul. Džordža Vašingtona 19, 11000 Beograd, na tekući račun 205-8041-21 (Komercijalna banka AD, Beograd), sa pozivom na broj 04/1710, imenom časopisa i godinom za koju se pretplata uplaćuje.
Sve dodatne informacije mogu se dobiti na telefon 011/3245-149.

Subscriptions prices for the year 2018 are: 2,400 RSD for individuals, 4,800 RSD for institutions, and 50 Euros for readers outside Serbia. Subscription order: Serbian Medical Society, Džordža Vašingtona 19, 11000 Belgrade; details of payment: bank account number 205-8041-21 (Komercijalna banka AD, Belgrade), invoice number 04/1710, with the name of the journal and the year for which you subscribe; beneficiary: Serbian Medical Society.
For further information, please contact us on stomglas@bvcom.net.

Finansijsku podršku izdavanju časopisa pruža Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije i Stomatološka komora Srbije.

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

sciendo

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 Srpsko lekarsko društvo
Publisher Serbian Medical Society

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

Prelom teksta i priprema za štampu
Layout & Prepress
Jasmina Živković

Štampa
Printed by
JP „Službeni glasnik", Beograd

Broj primeraka
Number of copies
500

DE GRUYTER
OPEN

Contents / Sadržaj

Velika je nesreća kad čovek ne
zna šta hoće, a prava
katastrofa kad ne zna šta može.
Jovan Dučić

Kada se u ovom citatu oslikava mudrost pesnika, onda je to poruka za budućnost, za one koji misle, ali kada je to paradigma naše stvarnosti i „mantra" elite koja tumara našim životima, onda je to sunovrat elementarnih vidika i jedini put u bezizlaz.

Kako u ovim komentarima uglavnom govorim o problemima u nauci i obrazovanju, pokušaću da i ovog puta budem na „liniji". Povod za ovaj komentar je bio intervju predsednika Finske, države sa najuređenijim i najorganizovanijim društvenim sistemom i zemlje sa najsrećnijim i najzadovoljnijim stanovnicima. Na pitanje šta je osnovni razlog za to, on je jasno i decidirano odgovorio da je to sigurno zahvaljujući sistemu obrazovanja. Naglasio je pritom da su sistem i plan obrazovanja dugo i temeljno pripremani i da su rezultati i uspeh vidljivi posle ozbiljnog i predanog rada na njihovoj realizaciji. Moglo bi se zaključiti da je ovo normalan put i da je upravo obrazovanje ta važna „karika" koja povezuje zadovoljstvo i sreću žitelja ove skandinavske zemlje.

Naša realnost je sasvim drugačija, jer je briga o nauci i obrazovanju svedena na nivo incidenta. Zato razmišljanja o reformi našeg obrazovanja u stilu da mi sa svojim resursima možemo da dostignemo Fince i da nam je za unapređenje obrazovnog sistema potrebno manje od godinu dana mogu predstavljati samo bajku za decu pred spavanje ili ozbiljnu priču za mediokritete, za neuke i neobrazovane.

U beskrajnoj promociji primitivizma teško se stiču kulturne potrebe. A zidari fontana i drugih besmislenih „projekata" obesmišljavaju stvarnost i ruše svaki pozitivan pomak. Zahvaljujući svojoj „moći" neuki postaju sve pametniji i uspešniji u promociji svojih akademskih ideja.

Sila i strah su osnovne vrednosti koje nas vode u budućnost, a politika postaje osnovna „naučna institucija" koja trasira svekolike puteve: i u kulturi, i u nauci, i u obrazovanju, u ekonomiji i celokupnom vašaru naše stvarnosti. Ista matrica primitivizma ograničava svaki intelektualni resurs. A kada se primitivizam ne sankcioniše, onda to postaje obrazac življenja i jedini put u budućnost kojoj težimo. A kako reče veliki Branko Miljković, kada budućnost postane beskrajno ponavljanje prošlosti, onda je bezizlaz izvesniji i od najsurovije klisure.

I ovaj urednički komentar ću završiti onako kako sam i počeo, ali ovog puta citatom Duška Radovića: „Mnoge je samo glupost spasla od anonimnosti" jer je to paradigma jednog posebnog soja ljudi koji kreiraju našu stvarnost.

Prof. dr Slavoljub Živković

ORIGINAL ARTICLE
ORIGINALNI RAD

DOI: 10.2478/sdj-2018-0006
UDC: 616.314-78

Deformation of Nickel-Titanium (NiTi) rotary instruments in cyclic loading – *in vitro* study

Isidora Nešković[1,2], Igor Stojanac[1,2], Sanja Vujkov[1,2], Jovan Laban Terzija[1], Aleksandra Maletin[2]

[1]Clinic for Dentistry of Vojvodina, Novi Sad, Serbia;
[2]Novi Sad University, Faculty of Medicine, Novi Sad, Serbia

SUMMARY

Introduction Separation of instruments in the root canal is one of the challenges in endodontic treatment. More specifically, nickel-titanium (NiTi) rotary instruments usually separate without previous deformation. The aim of this pilot study was to assess the effect of torsional stress on endodontic NiTi rotary instruments separation in simulated clinical conditions.

Materials and methods Research was conducted on a sample of 20 human teeth in laboratory conditions. Experimental procedure consisted of determining canal curvatures for each root on digital radiographs and root canal treatment using endodontic NiTi rotary instruments. Out of 20 teeth (60 canals), two groups were formed with similar root canal curvatures (10 pairs of teeth) and instrumented using NiTi rotary instrument with or without torque control.

Results Wilcoxon matched pair test showed no statistically significant difference in average number of instruments use with or without torque control ($p>0.05$).

Conclusion Even though there is no statistical significance in instrument separation when instruments were used with or without torque, there is tendency to experience sudden fracture of instruments after work without torsional control even after only few uses in clinical work.

Keywords: nickel-titanium rotary instruments; torque; separation

INTRODUCTION

Cleaning and shaping of root canals (instrumentation and aseptic irrigation) are main preconditions for complete disinfection, which can determine the result of endodontic treatment. Root canal shaping needs to be performed respecting the initial morphology of the root canal. Ideally, a conical shape of canal from apical to coronal part should be maintained while apical foramen should remain in its anatomical and morphological position, with uninterrupted integrity [1]. Root canal systems are complex and usually more curved then roots especially if analyzed in 3D plane. Using inflexible, rigid endodontic instruments made of stainless steel can result in transportation and perforation of root canal walls, due to their characteristics to preserve initial shape after flexion [2].

Unlike endodontic instruments made of stainless steel, nickel-titanium (NiTi) rotary instruments are more present in clinical practice, primarily due to significantly faster shaping of root canals, technically simplified instrumentation, minimal errors in shaping and smaller number of instruments required. Numerous *in vitro* studies on extracted teeth showed that rotary NiTi instruments retain the original (initial) curvature of the root canal better, especially in the apical zone of the root [3, 4].

NiTi has superelastic feature - ability to restore its original shape (shape-memory effect) and high corrosion resistance. Also, nickel titanium is biocompatible material [5]. Superelastic feature of NiTi endodontic instruments is associated with induced phase transformation of the crystal structure of the material [6]. Shape-memory effect of this alloy allows restoring the original shape and size after temperature change. Although NiTi alloy is called superelastic this material is still susceptible to fatigue and leads to its fracture after a certain number of cycles, so we call this feature pseudoelastic. Repeated loading leads to progressive accumulation of defects in the metal structure, and consequently its fracture [7].

Breakage or separation of endodontic instruments in root canal is one of complications during endodontic treatment. Unlike nickel-titanium, classic endodontic instruments made of stainless steel are visibly deformed prior to fracture; therefore dentist can discard such instruments during clinical work before they separate. Despite of increased flexibility, the occurrence of separation of nickel-titanium instruments is significant clinical problem, because the fracture of nickel-titanium instruments happens without previous deformation or macroscopically visible irregularities on instruments. Visual inspection as a method of control of nickel- titanium instruments use is not clinically reliable and cannot be used for determining the time to discard an instrument from clinical use [8].

Several factors can influence fracture of NiTi instruments, such as the size, taper and the shape of the cross-section of instruments. On the other hand, there are views that inexperienced dentist is main factor that leads to failure in NiTi instruments use [9]. Despite the low incidence,

Address for correspondence: Isidora NEŠKOVIĆ, Dušana Vasiljeva 22, Novi Sad, Serbia; *isidora.neskovic@mf.uns.ac.rs*

fracture of endodontic instruments is a significant clinical problem. Stainless steel instruments usually deform before breaking, however NiTi instruments can be broken without any visible signs of deformation [10]. NiTi rotary instruments fracture during clinical use may be the result of cyclic fatigue, excessive torsional stress, or combination of both [11].

Cyclic fatigue occurs when the instrument rotates freely in a curved canal and fracture occurs at the site of its maximum curvature [12]. Maximum stress and strain are developed in the curved surface of the instrument. By cyclic rotation, the instrument is subjected to compression and stretching, and number of cycles is positively correlated with the fatigue of material. It is very difficult to determine the amount of stress that one instrument is getting during clinical use, but some estimates can be given based on the analysis of the curvature of root canals on the preliminary X-rays [10].

Torsional stress usually occurs when part of the instrument is screwed into the root canal wall, when the tip of the instrument is greater than diameter of the root canal, or when there is excessive pressure on the instrument during operation [13]. If the tip of the instrument in the root canal is blocked, and endo-motor that rotates the instrument continues to deliver torque, there is an accumulation of torsional stress within the material, which after exceeding the critical load points, consequently leads to plastic deformation and fracture of the instrument [14].

On the other hand, even if endodontic motor is used with torque control that prevents excessive torque loads and eliminates the occurrence of turning instrument in the root canal, inevitable fatigue due to repeated torsional stresses of material develops [15].

Numerous studies have shown that torsional stress is the primary cause of defects and failures of endodontic NiTi rotary instruments [11, 16, 17]. Many manufacturers recommend endo motors with torque control. While some studies indicate no statistically significant difference in the occurrence of deformation and separation of endodontic NiTi rotary instruments whether they are used at different speeds and with or without torque [18, 19, 20], manufacturers always emphasize the necessity of using endo-motor with torque control for safety reasons. On the other hand, some manufacturers have introduced endodontic reduction hand-pieces that can be used with different types of endodontic full rotation instruments. They don't have torsional control and controlled rotational speed, but due to the more favourable price compared to electric endo-motors, they are widely accepted in clinical practice.

The aim of this study is to assess the influence of torsional stress on separation of endodontic NiTi rotary instruments in simulated clinical conditions.

MATERIALS AND METHODS

The study was conducted on a sample of twenty human teeth in laboratory conditions. The sample consisted of the first, second and third molars of the upper and lower jaw extracted at the Department of Oral Surgery Dental Clinic in Novi Sad. The period from extraction to the beginning of test was not longer than one month. After surgical removal, the crowns and roots of the teeth were washed from blood and saliva and with surgical curette soft tissue was removed. The teeth were then immersed in a bacteriostatic / bactericidal solution (0.5% chloramine), over the next seven days at a temperature of 4 degrees Celsius. The teeth were rinsed with distilled water and left in non-ionized water (ISO 3696), on the storage temperature (4 degrees Celsius). Every 48 hours, non-ionized water was replenished with fresh water.

The procedure of the experimental work involved the following steps:

1. Formation of access cavity.
2. Establishing initial patency of the root canal.
3. Determining the working length of each canal with apex locator.
4. X-ray recording with manually placed stainless steel instrument # 10 in the canal.
5. Measurement of the curvature of each root canal.
6. Root canal endodontic treatment with NiTi rotary instruments.

The entire procedure was carried out by a student of the fifth year of dentistry at the Faculty of Medicine in Novi Sad, without previous clinical experience with mechanical endodontic instruments but with previous training and ongoing supervision of accredited manager from manufacturer Dentsply / Maillefer who had years of clinical experience.

Access cavity preparation was performed with a high sped handpiece and water-cooled bur at 300 000 rpm (W & H), carbide round bur #44 and tapered fissure bur in the set Endo Access Kittm (Dentsply Maillefer, Ballaigues, Switzerland). Initial patency of the root canal was established manually with hand K expander #10, using reciprocal movement to the apical constriction. Samples were immersed with their root part in alginate (irreversible hydrocolloid) (Zermak Co., Italy), as shown in Figure 1. Working length was determined for each root canal with hand file K Expander #10 and electronic apex locator (Propex II, Dentsply Maillefer, Ballaigues, Switzerland). Peripical x-ray was taken in bucco-lingual direction individually for each tooth with K files placed into the canals (Sirona, Heliodent Vario Digital Dental Xray "2002", 70 kV, 7mA, 120V, D3350, Germany) (Figure 1).

Determination of curvature for each root canal - angle of curvature (α) and radius of curvature (R) were determined on the x-ray for each root canal using AutoCAD software (AutoCAD 2009, Autodesk Inc., San Rafael, USA) (Figure 2).

After calculating the average curvature for each of 20 teeth, two groups with 10 teeth each were established with the most similar curvature (Table 1). Before mechanical instrumentation, glide path was achieved using hand endodontic reamers K #10, #15 and #20. Shaping and cleaning of root canals was done with NiTi rotary instruments ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) driven by endo-motor (X-Smart, Endodontic Motor, Dentsply/Maillefer, Ballaigues, Switzerland: 07927988) as

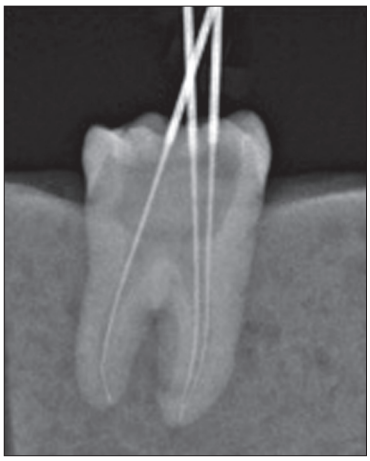


Figure 1. X rays with K file #10 taken in bucco lingual projection individually for each tooth
Slika 1. Rendgenski snimak zuba sa K turpijama #10 u kanalima u oro-bukalnom pravcu

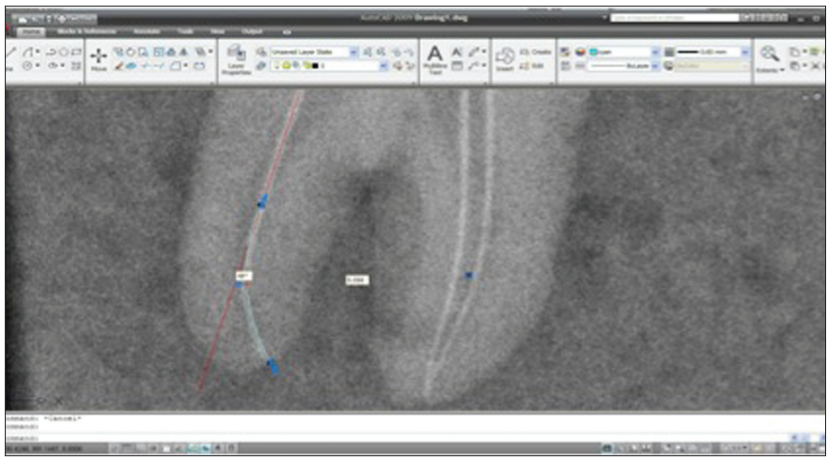
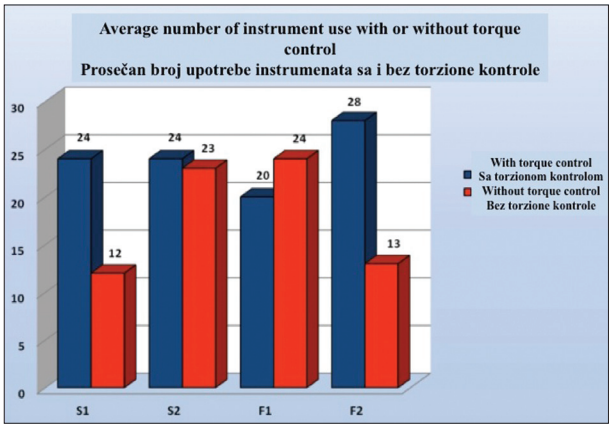


Figure 2. Determination of average curvature for each root canal
Slika 2. Određivanje prosečne zakrivljenosti kanala korena zuba



Graph 1. Average number of instruments usage in groups with and without torque control
Grafikon 1. Prosečan broj upotreba instrumenata u grupama sa torzionom kontrolom i bez nje

follows: S1, S2, F1 and F2 - a sequence of instruments recommended by the manufacturer. Throughout instrumentation copious irrigation of canals with sodium hypochlorite (1% NaOCl), lubrication Glyde File (DeTrey / Dentsply, Konstanz, Germany) and recapitulation with manual expander K #10 were done. Rotational speed of ProTaper Universal instrument was fixed at 250 rpm, as recommended by the manufacturer for using ProTaper Universal instruments in clinical conditions. The instruments were used for the root canal preparation with and without torque.

This way, two groups of teeth were formed:

First group of teeth (N = 10) was instrumented with endo-motor with set torque (3 N/cm instruments for S1, 1 N/cm for S2, 1.5 N/cm for F1 and 2 N/cm for F2 instrument, as per manufacturer recommendation.

Second group of teeth (N = 10) was treated with endo-motor without torque control; it was set to 5.2 N/cm, which is the highest adjustable value of torque.

Length of use for each tested instrument in the root canal was not longer than 10 seconds. Rotation period (10 seconds) corresponds to the time period necessary to complete the root canal instrumentation in clinical use of Ni-Ti instruments, according to researchers [21]. In both groups, instruments were used in the above sequence (S1, S2, F1, F2) and the number of usage was recorded (number of canals instrumented to the point of fracture of the instrument). After the failure of an instrument, that one was substituted with a new instrument, and others were continuously used by the time of their fracture.

Statistical analysis was carried out in two phases: in the first phase, the results presented numerical variables that were analyzed by standard procedures of descriptive statistics. Descriptive statistics were used to determine the measure of central tendency (mean, median), measures of variability (standard deviation, coefficient of variation) and the minimum and maximum values. The results are presented in tables and graphs. In the second phase, the following methods were used to compare individual characteristics, Mann-Whitney U-test to compare mean values of the two independent variables and Wilcoxon matched pairs test. Statistical analysis was performed using the software package Statistica 9.1, while the tables and graphs were done in Microsoft Office Excel 2010.

RESULTS

Table 2 presents descriptive statistic of the sample: Number of canals (N), angle and radius of curvature (Xsr), minimum and maximum value measured (min, max), standard deviation (SD) and cumulative value of average curvature of all teeth in both groups (n =10). T-test for two paired samples determined that there was no statistically significant difference in average curvatures between the groups with and without torque control ($p > 0.05$) and they could be considered as two homogeneous groups.

Table 1. Preview of 10 pairs of two teeth with similar average curvature
Tabela 1. Prikaz 10 parova od po dva zuba sa najsličnijim prosečnim zakrivljenostima

GROUP OF TEETH WITH TORSION CONTROL GRUPA ZUBA SA TORZIONOM KONTROLOM					GROUP OF TEETH WITHOUT TORSION CONTROL GRUPA ZUBA BEZ TORZIONE KONTROLE				
Tooth	kanal	R (mm)	U (°)	R*U prosek	Zub	kanal	R (mm)	U (°)	R*U prosek
1	1	17.37	25.86	597.96	1	1	29.81	21.22	562.15
	2	10.77	56.22			2	35.97	17.06	
	3	10.77	56.22			3	30.99	14	
2	4	50.99	6.94	666.04	2	4	51.04	7.22	651.65
	5	5.78	35.68			5	5.96	37.06	
	6	4.43	55.3			6	4.23	51.48	
3	7	85.29	5.94	828.63	3	7	69.90	10.66	807.70
	8	25.16	18.38			8	17.56	26.48	
	9	11.15	37			9	17.23	32.28	
4	10	122.20	3.36	911.97	4	10	37.81	18.42	876.54
	11	78.68	6.52			11	10.77	59.44	
	12	24.46	26.54			12	10.98	54.56	
5	13	103.25	6.14	976.114588	5	13	67.88	8.4	1305.70
	14	26.17	25.16			14	14.50	51.28	
	15	26.17	25.16			15	10.63	66.64	
6	16	278.42	0.84	2523.92	6	16	241.20	1.84	2271.58
	17	11.81	31.76			17	18.91	32.64	
	18	7.24	43.76			18	8.95	41.5	
7	19	33.17	14.34	537.04	7	19	41.52	9.54	499.13
	20	17.72	24.4			20	14.30	25.04	
	21	9.94	40.7			21	7.81	36	
8	22	37.65	11.86	682.35	8	22	26.41	16.84	685.16
	23	17.77	28.92			23	6.61	63.92	
	24	9.76	53.42			24	6.04	77.06	
9	25	25.41	14.5	419.51	9	25	18.20	12	468.68
	26	18.48	21.94			26	16.74	21.08	
	27	16.20	26.38			27	7.20	66.98	
10	28	5.02	31.48	316.64	10	28	2.32	42.7	255.88
	29	7.80	51.76			29	6.10	62.16	
	30	6.80	61.88			30	4.88	68.06	

Table 2. Descriptive statistics of both tested groups
Tabela 2. Deskriptivna statistika obe ispitivane grupe

Variable Varijabla	N Broj	With torque control Sa torzionom kontrolom		Without torque control Bez torzione kontrole	
		Xsr ± SD	Min–Max	Xsr ± SD	Min–Max
Angle Ugao	30	28.28 ± 17.89	0.84–61.88	35.19 ± 22.26	1.84–77.06
Radius Radijus	30	36.85 ± 54.66	4.43–278.42	28.09 ± 44.08	2.33–241.2
Average curvature Prosečna povijenost	10	846.0 ± 624.9	316.64–2523.93	838.4 ± 577.4	255.89–2271.58

The table shows data of average canal curvature in the group without torque and with torque control. The obtained values do not show statistically significant difference in curvature between the groups ($p > 0,05$).
U tabeli su prikazani podaci zbirnih srednjih vrednosti povijenosti u grupi bez torzione i u grupi sa torzionom kontrolom. Dobijene vrednosti ne govore u prilog statistički značajnoj razlici ($p > 0,05$).

Test results of the instruments usage till the moment of separation are shown in Chart 1. In the group with torque control instrument S1 separated after shaping 24 root canals (during the shaping of the 24th canal); instrument S2 separated after shaping 24 root canals (during shaping of the 25th canal) (instrument S2 was not shaping 24th canal where separation of S1 occurred); instrument F1 separated after it shaped 20 root canals (during the preparation of 20th canal), instrument F2 was not separated even after shaping of all 27 root canals. Instrument F2 was not used to shape 24th canal where S1 separation occurred, 25th canal where S2 separation occurred, or the 20th root canal where F1 separation occurred.

In the group without torque, instrument S1 separated after shaping 22 root canals (during shaping of the 22nd canal) and the new one separated after 2nd usage, during preparation of the 24th root canal. Instrument S2 separated after the 23rd usage (during the preparation of the 25th root canal). Instrument S2 did not shape the canal where S1 separation occurred (root canals number 22 and 24). Instrument F1 separated after 24 usages, during the shaping of the 27th root canal. Instrument F1 was not used for

shaping canals where S1 separation occurred (root canal number 22 and 24) and also canals where separation of S2 occurred (25th canal). Instrument F2 separated after 21 usages (during the shaping of the 21st root canal) and the second one was separated after 5 usages (during shaping of the 30th canal). The second F2 instrument was not used for shaping canals where separation of previous instruments occurred (canals number 22, 24, 25, 27).

Man-Whitney U test showed no statistically significant difference in the average usage of instruments with or without torque control ($p>0.05$). Wilcoxon matched pair test confirmed no statistically significant difference in average usage of instruments with or without torque control ($p>0.05$).

DISCUSSION

A young dentist who had no previous clinical experience with mechanical endodontic instruments did the experimental part of this study. In previous studies, it has been suggested that the experience of the clinician may significantly affect the quality of endodontic treatment. However, there were opposite findings where there was no significant difference in the quality of endodontic treatment based on clinical experience, if they follow clearly defined principles of modern endodontics with proper training and use of modern instruments and techniques [22–25].

In our study, the canal curvature was determined based on methodology proposed by Pruett's [10]. Geometrical analysis of the position of the instrument in each canal using digital radiography and AutoCAD application was performed [26]. After calculation of average curvature of each tooth, 10 pairs of teeth were formed with the most similar curvatures.

In experimental part of the study, all instruments were used at the speed of 250 rpm as recommended by the manufacturer. As for the torque, manufacturer emphasized the necessity of setting it to the value recommended for each individual instrument and these values were used in root canal instrumentation of group with torque control. There are findings in the literature that the value of torque has no effect on the number of shaping canals with NiTi instruments full rotation, which is applied in instrumentation of root canals in the group without torque [27].

To reduce the risk of instrument separation manufacturer's instructions for use should be followed carefully, and only a few rotational cycles of the instrument are safe when working in curved canals [28]. There is no consensus on recommended usage of NiTi instruments; the number of canals varies from 1-27, with an average of 11 canals [8]. Guettier suggested that rotary instruments could be reused, depending on the type of teeth that are treated, for example instruments used for anterior teeth can be reused higher number of times then in posterior teeth. Most authors recommend discarding the instrument after its in highly curved, calcified and complex root canals, and in the case of occurrence of any signs of deformation [11, 16, 29, 30]. Of course, a good knowledge of predisposing factors that lead to NiTi instruments separation is crucial in the prevention of this phenomenon.

Observing the results of this pilot study, all instruments tested with torque control were used 20 or more times until they fractured, where F2 was not separated even after 27 uses. In the group without torque control, fracture of instruments occurred after 20 or more uses, but S1 was broken after only two time use, and F2 instrument after five uses. Although there is no statistically significant difference in results between the two groups considering limitation of this pilot study, we can see a tendency that working without torque can cause unexpected breakage of instruments just after a few usage in clinical practise.

CONCLUSION

The clinical significance of this study is that when working with NiTi rotary instruments, it is important to respect manufacturer's instructions, given that there is no official recommendation on the number of use of NiTi rotary instruments. Although the analysis of the obtained data did not show statistical significance, considering the limitation of the study, it is possible to see the tendency to experience sudden fracture of instruments after work without torque control even if instruments used only few times.

REFERENCES

1. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974; 18:269–96. [PMID: 4522570]
2. Wildey WL, Senia ES, Montgomery S. Another look at root canal instrumentation. Oral Surg Oral Med Oral Pathol. 1992; 74:499–507. [DOI: 10.1016/0030- 4220(92)90303-8] [PMID: 1408028]
3. Gluskin AH, Brown DC, Buchanan LS. A reconstructed computerized tomographic comparison of Ni-Ti rotary GT files versus traditional instruments in canals shaped by novice operators. Int Endod J. 2001; 34:476–84. [DOI: 10.1046/j.1365-2591.2001.00422.x] [PMID: 11556516]
4. Schäfer E, Lohmann D. Efficiency of rotary nickel-titanium FlexMaster instruments compared with stainless steel hand K- Flexofile—Part 2. Cleaning effectiveness and instrumentation results in severely curved root canals of extracted teeth. Int Endod J. 2002; 35:514–21. [DOI: 10.1046/j.1365-2591.2002.00515.x] [PMID: 12190908]
5. Haïkel Y, Serfaty R, Wilson P, Speisser JM, Allemann C. Mechanical properties of nickel-titanium endodontic instruments and the effect of sodium hypochlorite treatment. J Endod. 1998; 24:731–5. [DOI: 10.1016/S0099-2399(98)80163-5]
6. Thompson SA. An overview of nickel-titanium alloys used in dentistry. Int Endod J. 2000; 33(4):297–310. [DOI: 10.1046/j.1365-2591.2000.00339] [PMID: 11307203]
7. Kuhn G, Tavernier B, Jordan L. Influence of structure on nickel-titanium endodontic instruments failure. J Endod. 2001; 27(8):516–20. [DOI: 10.1097/00004770-200108000- 00005] [PMID: 11501589]
8. Parashos P, Gordon I, Messer HH. Factors influencing defects of rotary nickeltitanium endodontic instruments after clinical use. J Endond. 2004; 30(10):722–5. [PMID: 15448468]
9. Yared GM, Dagher FB, Kulkarni GK. Influence of torque control motors and the operator's proficiency on ProTaper failures. Oral Surg Oral Med Oral Pathol. 2003; 96:229–33. [DOI: 10.1016/S107921040300167]

10. Pruett JP, Clement DJ, Carnes DL. Cyclic fatigue testing of nickel-titanium endodontic instruments. J Endod. 1997; 23(2):77–85. [DOI: 10.1016/S0099-2399(97)80250-6] [PMID: 9220735]
11. Sattapan B, Nervo G, Palamara J, Messer H. Defects in nickel titanium endodontic rotary files after clinical usage. J Endod. 2000; 26:161–6. [DOI: 10.1097/00004770- 200003000-00008]
12. Lopes H, Moreira E, Elias C, Almeida R, Neves M. Cyclic fatigue of ProTaper instruments. J Endod. 2007; 33(1):55–7. [DOI: 10.1016/j.joen.2006.09.003] [PMID: 17185132]
13. Bahia MG, Melo MC, Buono VT. Influence of cyclic torsional loading on the fatigue resistance of K3 instruments. Int Endod J. 2008; 41(10):883–91. [DOI: 10.1111/iej.12400] [PMID: 18699785]
14. Stojanac I, Drobac M, Petrović Lj, Atanacković T. Predicting in vivo failure of rotary nickel-titanium endodntic instruments under cyclic fatigue. Dent Mat J. 2012; 31(4):650–8. [DOI: 10.4012/dmj.2011-254] [PMID: 22864220]
15. Best S, Watson P, Pilliar R, Kulkarni GG, Yared GM. Torsional fatigue and endurance limit of a size 30 .06 ProFile rotary instrument. Int Endod J. 2004; 37:370–3. [DOI: 10.1111/j.1365-2591.2004.00814]
16. Arnes FC, Hoen MM, Steiman HR, Dietz GC Jr. Evaluation of single-use rotary nickel-titanium instruments. J Endod. 2003; 29(10):664–6. [DOI: 10.1097/00004770- 200310000-00013] [PMID: 14606792]
17. Yared G. In vitro study of the torsional properties of new and used profile nickel- titanium rotary files. J Endod. 2004; 30(6):440–2. [PMID: 15167468]
18. Patino PV, Biedma BM, Liebana CR, Cantatore G, Ghillo JG. The influence of manual glide path on the separation rate of NiTi rotary instruments. J Endod. 2005; 31(2):114–6. [PMID: 15671822]
19. Bartnick KL, Steiman HR, Ruskin A. Comparison of nickel-titanium file distortion using electric and air driven handpieces. J Endod. 2001; 27:57–9. [DOI: 10.1097/00004770-200101000-00021]
20. Yared G, Bou Dagher F, Machtou P. Failure of profile instruments used with high and low torque motors. Int Endod J. 2001; 34:471–5. [DOI: 10.1046/j.1365-2591.2001.00420]
21. Pasqualini D, Scotti N, Tamagnone L, Ellena F. Hand-operated and rotary ProTaper instruments: a comparison of working time and number of rotations in simulated root canals. J Endod. 2008; 34(3):314–7. [DOI: 10.1016/j.joen.2007.12.017] [PMID: 18291284]
22. Serene TP, Adams JD, Saxena A. Nickel-titanium instruments: applications in endodontics. St Louis, MO, USA: Ishiyaku EuroAmerica 1995.
23. Sonntag D, Delschen S, Stachniss V. Root-canal shaping with manual and rotary Ni- Ti files performed by students.Int Endod J. 2003; 36(11):715–23. [DOI: 10.1046/j.1365-2591.2003.00703.x] [PMID: 14641434]
24. Gekelman D, Ramamurthy R, Mirfarsi S, Paqué F, Peters OA. Rotary nickel-titanium GT and ProTaper files for root canal shaping by novice operators: a radiographic and micro-computed tomography evaluation. J Endod. 2009; 35(11):1584–8. [DOI: 10.1016/j.joen.2009.07.018] [PMID: 19840653]
25. Tu MG, Chen SY, Huang HL, Tsai CC. Endodontic shaping performance using nickel-titanium hand and motor ProTaper systems by novice dental students. J Formos Med Assoc. 2008; 107(5):381–8. [DOI: 10.1016/S0929-6646(08)60103-5] [PMID: 18492622]
26. Stojanac I. Ispitivanje dinamičkog zamora nikl-titanijumskih endodontskih instrumenata pune rotacije. Doktorska disertacija, Novi Sad, 2011.
27. Zarrabi MH, Javidi M, Vatanpour M, Esmaeili H. The influence of torque and manual glide path on the defect or separation rate of NiTi rotary instruments in root canal therapy. Indian J Dent Res. 2010; 21(1):107–11. [DOI: 10.4103/0970- 9290.62815] [PMID: 20427918]
28. Kuhn G, Jordan L. Fatigue and mechanical properties of nickel titanium endodontic instruments. J Endod 2002; 28:716–20. [DOI: 10.1097/00004770-200210000-00009] [PMID: 12398171]
29. Hieawy A, Haapasalo M, Zhou H, Wang Z, Shen Y. Phase Transformation Behavior and Resistance to Bending and Cyclic Fatigue of ProTaper Gold and ProTaper Universal Instruments. J Endod. 2015; 41(7):1134–8. [DOI: 10.1016/j.joen.2015.02.030]
30. Fereirra F, Adeodato C, Barbosa I, Aboud L, Scelza P, Zaccaro Sceleza M. Movement kinematics and cyclic fatigue of NiTi rotary instruments: a systematic review. Int Endod J. 2017; 50:143–52. [DOI: 10.1111/iej.12613] [PMID: 25841955]

Received: 17.01.2018 • Accepted: 8.5.2018

Deformacije nikl-titanijumskih mašinski pokretanih instrumenata pune rotacije u cikličnom opterećenju – *in vitro* studija

Isidora Nešković[1,2], Igor Stojanac[1,2], Sanja Vujkov[1,2], Jovana Laban Terzija[1], Aleksandra Maletin[2]

[1]Klinika za stomatologiju Vojvodine, Novi Sad, Srbija;
[2]Univerzitet u Novom Sadu, Medicinski fakultet, Novi Sad, Srbija

KRATAK SADRŽAJ

Uvod Separacija ili lom endodontskih instrumenata u kanalu korena zuba je jedna od težih komplikacija u toku endodontske terapije. Separacija nikl-titanijumskih instrumenata je značajan klinički problem, jer do loma nikl-titanijumskih instrumenata dolazi bez prethodne deformacije. Cilj rada je bio da se proceni uticaj torzione kontrole na pojavu separacije endodontskih NiTi instrumenata pune rotacije u klinički simuliranim uslovima.

Materijal i metode Ispitivanje je izvršeno na uzorku od dvadeset ekstrahovanih humanih zuba u laboratorijskim uslovima. Postupak je podrazumevao merenje povijenosti kanala korena na digitalnim rendgengrafijama svakog pojedinačnog korena zuba, obradu kanala NiTi instrumentima pune rotacije. Nakon izračunavanja prosečne povijenosti svakog od 20 zuba (60 kanala), napravljeno je deset parova od po dva zuba sa najsličnijim prosečnim zakrivljenostima. Na taj način su formirane dve grupe zuba.

Rezultati Vilkoksonovim testom parova (Wilcoxon matched pair test) potvrđeno je da ne postoji statistički značajna razlika u prosečnom broju upotreba instrumenata sa torzionom kontrolom i bez nje ($p > 0,05$).

Zaključak Iako analiza dobijenih podataka nije pokazala statističku značajnost, s obzirom na limitiranost studije može se uvideti tendencija da pri radu bez torzione kontrole može doći iznenadnog loma instrumenata posle samo nekoliko upotreba u kliničkom radu.

Ključne reči: NiTi; puna rotacija; zamor materijala; obrtni momenat; separacija

UVOD

Čišćenje i oblikovanje kanalnog prostora zuba, odnosno instrumentacija i antiseptična irigacija, ključni su preduslovi potpune dezinfekcije kanalnog prostora, od čega umnogome zavisi ishod endodontske terapije. Preoblikovanje endodontskog prostora se mora sprovesti poštujući inicijalnu morfologiju kanala korena zuba. Osnovni zahtevi oblikovanja kanalnog prostora su: konični oblik preparacije od najšireg koronarnog do najužeg apikanog dela kanala, kanalna preparacija mora zadržati inicijalni oblik kanala korena i apikalni foramen treba da ostane na svojoj anatomo-morfološkoj poziciji, nenarušenog integriteta [1]. Kanalni sistemi znatno su povijeniji od korenova zuba u kojima su smešteni i prostiru se u trodimenzionalnoj ravni. Korišćenje nefleksibilnih, krutih endodontskih instrumenata od nerđajućeg čelika u instrumentaciji kanala može rezultirati transportacijom (izmeštanjem) i perforacijom (probijanjem) kanala korena, zbog svojstva ovog instrumenta da se nakon savijanja ispravlja i vraća u svoj inicijalni oblik [2].

Za razliku od endodontskih instrumenata od nerđajućeg čelika, nikl-titanijumski instrumenti pune rotacije su sve više zastupljeni u kliničkoj praksi, prvenstveno zbog značajno bržeg oblikovanja kanala korena zuba, tehnički pojednostavljene instrumentacije, a moguće greške lekara su svedene na minimum zahvaljujući superelastičnosti nikl- titanijumskih instrumenata i manjem broju instrumenata potrebnom za oblikovanje kanala korena. Brojne *in vitro* studije na ekstrahovanim zubima, pokazale su da se upotrebom nikl-titanijumskih instrumenata pune rotacije bolje prati originalna (inicijalna) povijenost kanala korena, posebno u apikalnoj zoni korena zuba, u odnosu na endodontske instrumenate izrađene od nerđajućeg čelika [3, 4].

Legura nikl-titanijuma (NiTi) poseduje svojstvo superelastičnosti, sposobnost vraćanja prvobitnog oblika (*shape-memory effect*) i visok stepen otpornosti na koroziju [5]. Superelastičnost nikl-titanijumskih endodontskih instrumenata je povezana sa indukovanom faznom transformacijom kristalne strukture samog materijala [6]. *Memory effect* je sposobnost legure za ponovno uspostavljanje prvobitnog oblika i dimenzija nakon promene temperature. Materijal je ipak osetljiv na zamor i dolazi do njegovog loma nakon određenog broja ciklusa opterećenja, iako je NiTi legura superelastična. Naime, ponavljana opterećenja dovode do progresivne akumulacije defekata u strukturi metala, što sledstveno dovodi do njegovog loma [7].

Lom ili separacija endodontskih instrumenata u kanalu korena zuba je jedna od težih komplikacija u toku endodontske terapije. Za razliku od nikl-titanijumskih, klasični instrumenti izrađeni od nerđajućeg čelika se vidljivo deformišu pre pucanja, tako da terapeut može da odbaci ovakve instrumente tokom kliničkog rada i spreči separaciju u toku endodontskog zahvata. Endodontski instrumenti pune rotacije izrađeni od nikl-titanijumske legure poseduju superelastična svojstva i mogu se savijati značajno više od klasičnih instrumenata od nerđajućeg čelika. Međutim, i pored povećane fleksibilnosti, pojava separacije nikl-titanijumskih instrumenata je značajan klinički problem, jer do loma nikl- titanijumskih instrumenata dolazi bez prethodne deformacije, odnosno, makroskopski uočljivih iskrivljenosti i/ili nepravilnosti instrumenta. Vizuelna inspekcija kao metod kontrole korišćenih nikl-titanijumskih instrumenata nije klinički pouzdana te se ne može koristiti u svrhu determinisanja trenutka odbacivanja instrumenta iz dalje kliničke upotrebe [8].

Više faktora može uticati na pojavu loma NiTi instrumenata, a to su veličina, konična i oblik poprečnog preseka instrumenata, kao i obučenost samog terapeuta. S druge strane, postoje stavovi da je neobučeni terapeut osnovni negativni faktor koji dovodi do neuspeha pri korišćenju NiTi instrumenata [9]. Uprkos niskoj incidenciji, lom endodontskih instrumenta je značajan klinički problem. Instrumenti od nerđajućeg čelika se obično deformišu pre lomljenja, međutim NiTi instrumenti se mogu slomiti bez bilo kakvih vidljivih znakova deformacije [10]. Lom NiTi instrumenata pune rotacije tokom kliničke upo-

trebe može biti rezultat cikličnog zamora materijala, prekomernog torzionog opterećenja ili kombinacije oba [11].

Ciklični zamor nastaje kada se instrument slobodno rotira u zakrivljenom kanalu, pri čemu do loma dolazi na mestu njegove maksimalne povijenosti [12]. Maksimalno naprezanje i deformacija se razvijaju na površini povijenog instrumenta. Pri rotiranju u uslovima zakrivljenosti, instrument podleže cikličim kompresijama i istezanjima, gde je broj ciklusa u pozitivnoj korelaciji sa zamaranjem materijala. Veoma je teško odrediti količinu naprezanja koje instrument trpi tokom kliničke upotrebe, ali se mogu napraviti određene procene pri analizi povijenosti kanala korena na preliminarnom rtg snimku [10].

Torziono preopterećenje se obično događa kada se deo instrumenta uvrće u zid kanala tj. kada je vrh instrumenta veći od promera kanala korena, ili kada se vrši prekomeran pritisak na instrument u toku rada [13]. Ukoliko je vrh instrumenta blokiran u kanalu korena, a endo-motor, koji rotira instrument, nastavi da isporučuje obrtni momenat, dolazi do akumulacije torzionog stresa unutar materijala, što nakon prekoračenja kritične tačke opterećenja, dovodi prvo do plastične deformacije, a posledično i loma instrumenta [14].

S druge strane, i kada se koristi endodontski motor sa torzionom kontrolom, koji sprečava prekomerno torziono opterećenje i eliminiše pojavu ušrafljivanja instrumenta u kanalu korena, ipak dolazi do zamora materijala zbog neminovnih ponavljanih torzionih naprezanja materijala koji se javljaju pri radu instrumenta [15].

Na osnovu brojnih studija, torzioni zamor je primarni uzrok pojave defekata i lomova endodontskih NiTi instrumenata pune rotacije [11, 16, 17]. Upotreba električnih endo-motora sa torzionom kontrolom je preporučena od strane mnogih proizvođača. Iako neka istraživanja ukazuju da ne postoji statistički značajna razlika u pojavi deformacije i separacije endodontskih NiTi instrumenata pune rotacije ukoliko se koriste pri različitim brzinama i sa torzionom kontrolom ili bez nje [18, 19, 20], proizvođači uvek naglašavaju neophodnost upotrebe gorepomenutih endo-motora zbog sigurnosti u radu. S druge strane, pojedini proizvođači su predstavili endodontske redukcione kolenjake koji se mogu koristiti sa različitim tipovima endodontskih instrumenata pune rotacije. Ovi endodontski kolenjaci ne poseduju torzionu kontrolu i kontrolisanu brzinu rotiranja, ali su zbog povoljnijeg finansijskog momenta u odnosu na električne endo-motore široko zastupljeni u kliničkoj praksi.

Cilj ovog rada bio je da se ispita uticaj torzione kontrole na pojavu separacije endodontskih NiTi instrumenata pune rotacije u klinički simuliranim uslovima.

MATERIJAL I METODE

Ispitivanje je izvršeno na uzorku od dvadeset humanih zuba u laboratorijskim uslovima. Uzorak se sastojao od prvih, drugih i trećih molara gornje i donje vilice, izvađenih na odeljenju Oralne hirurgije Klinike za stomatologiju Vojvodine u Novom Sadu. Period od vađenja zuba do upotrebe u ispitivanju nije bio duži od mesec dana. Posle hirurškog vađenja, sa krunice i korena zuba isprani su krv i saliva fiziološkim rastvorom, i hirurškom kiretom uklonjeni zaostali delovi mekih tkiva. Potom su zubi potopljeni u bakteriostatični/baktericidni rastvor (0,5% hloramin), tokom narednih sedam dana na temperaturi od 4 stepena Celzijusa. Zubi su isprani destilovanom vodom i ostavljeni u nejonizovanoj vodi (ISO 3696), na temperaturi čuvanja od četiri stepena Celzijusa. Svakih 48 sati nejonizovana voda je kompletno zamenjena svežom.

Postupak eksperimentalnog rada podrazumevao je sledeće:
- formiranje pristupnog kaviteta na zubima koji su činili uzorak
- uspostavljanje inicijalne prohodnosti kanala korena zuba
- određivanje radne dužine svakog kanala apeks lokatorom
- rendgenografsko snimanje zuba sa postavljenim ručnim kanalnim proširivačima od nerđajućeg čelika #10
- merenje zakrivljenosti kanala svakog pojedinačnog korena
- obradu kanala korenova zuba endodontskim NiTi instrumentima pune rotacije

Celokupan postupak je realizovan od strane stomatologa bez prethodnog kliničkog iskustva u radu sa mašinskim endodontskim instrumentima, uz prethodnu obuku i stalni nadzor akreditovanog rukovodioca endodontskih kurseva za proizvode firme Dentsply/Maillefer sa višegodišnjim kliničkim iskustvom.

Formiranje pristupnog kaviteta vršeno je visokoturažnom bušilicom sa vodenim hlađenjem 300000 o/min. (W&H), i karbidnim okruglim svrdlom #4 koničnim fisurnim borerom iz seta EndoAccess Kittm (Dentsply Maillefer, Ballaigues, Switzerland). Uspostavljanje inicijalne prohodnosti kanala korena zuba vršeno je ručnim K proširivačima #10, recipročnim pokretima do apeksnog suženja. Uzorci su korenskim delom uronjeni u ireverzibilni hidrokoloid alginat (Zermak Co., Italy). Posle toga je izvršeno određivanje radne dužine svakog kanala korena ručnim K proširivačima #10 elektronskim apeksnim lokatorom (ProPex II, Dentsply Maillefer, Ballaigues, Switzerland). Radiografsko snimanje je vršeno u vestibulo-oralnoj projekciji pojedinačno za svaki zub, za ispitivanje korišćena je rendgen jedinica za digitalnu radiografiju (Sirona, Heliodent Vario Digital Dental Xray "2002" X-ray 1 YR WARR; 70 KV, 7MA, 120V, D3350, Germany). Neposredno pre snimanja zuba u svaki kanal korena zuba je plasirana po jedna K turpija #10, na prethodno određenu radnu dužinu (Slika 1).

Određivanje povijenosti svakog kanala korena – ugao zakrivljenosti (α) i radijus zakrivljenosti (R) – urađeno je na digitalnim rendgengrafijama svakog pojedinačnog kanala korena zuba pomoću aplikacije AutoCad (AutoCAD 2009, Autodesk Inc., San Rafael, USA), što se vidi na Slici 2, odnosno matematički je određena prosečna povijenost kanala svakog zuba (Slika 2).

Posle izračunavanja prosečne povijenosti svakog od 20 zuba, napravljeno je 10 parova od po dva zuba sa najsličnijim prosečnim povijenostima (Tabela 1). Neposredno pre mašinske instrumentacije svi kanali su obrađeni ručnim endodontskim K proširivačima #10, #15 i #20. Zatim je urađena mašinska obrada kanala korena svakog zuba endodontskim NiTi instrumentima pune rotacije ProTaperUniversal (Dentsply Maillefer, Ballaigues, Switzerland) pokretanih endo-motorom (X-Smart, Endodontic Motor, Dentsply/Maillefer, Ballaigues, Switzerland, sn:07927988) i to: prvo instrument S1, zatim S2, pa F1 i na kraju F2 – što predstavlja sekvencu korišćenja instrumenata po preporuci proizvođača. Brzina rotacije je fiksirana na 250 obrt/min. Celokupna instrumentacija je urađena uz obilnu irigaciju kanala rastvorom natrijum-hipohlorita (1% NaOCl), lubrifikacija preparatom Glyde File (DeTrey/Dentsply, Konstanz, Germany) i rekapitulacija ručnim kanalnim proširivačem #10. Instrumenti su korišćeni za obradu kanala korenova zuba sa torzionom kontrolom i bez nje.

Na taj način su formirane dve grupe zuba:

1) Grupa zuba (N = 10) koji su obrađivani instrumentima sa torzionom kontrolom; po preporuci proizvođača vrednost torzije, pri kojoj se blokira dalji rad endo-motora i rotiranje instrumenata u kanalu, bila je podešena na 3 Ncm za instrumente S1, 1 Ncm za instrumete S2, 1,5 Ncm za instrumete F1 i 2 Ncm za instrumete F2.

2) Grupa zuba (N = 10) koji su obrađivani instrumentima bez torzione kontrole; vrednost torzije za sve instrumete, pri kojoj se blokira dalji rad endo-motora i rotiranje instrumenata u kanalu, bila je podešena na 5,2 Ncm, što je i najviša podesiva vrednost korišćenog električnog aparata.

Dužina upotrebe svakog ispitivanog instrumenta pri instrumentaciji kanala korena zuba nije bila duža od 10 sekundi. Period rotacije (10 sekundi) odgovara periodu potrebnom za kompletnu instrumentaciju kanala korena zuba pri jednoj kliničkoj upotrebi Ni-Ti instrumenta, prema rezultatima istraživanja Pasqualinija i sar. [21]. U obe grupe instrumenti su korišćeni u gorepomenutoj sekvenci (S1, S2, F1, F2) i beležio se broj upotreba (broj obrađenih kanala do momenta loma instrumenta), s tim što se posle loma nekog instrumenta taj instrument zamenjivao novim, a ostali su nastavljali da se koriste do momenta njihovog loma.

Statistička analiza je sprovedena u dve faze: u prvoj fazi rezultati su prikazali numeričke varijable koje su analizirane standardnim procedurama deskriptivne statistike. Deskriptivne statistike su korišćene da se utvrdi mera centralne tendencije (srednja vrednost, medijana), mere promenljivosti (standardna devijacija, koeficijent varijacije) i minimalne i maksimalne vrednosti. Rezultati su prikazani u tabelama i grafikonima. U drugoj fazi za upoređivanje pojedinačnih karakteristika korišćeni su Mann–Whitney U-test za upoređivanje srednje vrednosti dve nezavisne varijable i Vilkoksonov test parova. Statistička analiza izvršena je korišćenjem softverskog paketa Statistica 9.1, a tabele i grafikoni su urađeni u programu Microsoft Office Excel 2010.

REZULTATI

U Tabeli 2 prikazana je deskriptivna statistika uzorka obe ispitivane grupe: broj kanala (N), ugao i radijus zakrivljenosti kanala (Xsr), minimalna i maksimalna vrednost, standardna devijacija (SD), kumulativna vrednost srednje zakrivljenosti kanala u obe grupe (n = 10). T-testom za dva sparena uzorka utvrđeno je da ne postoji statistički značajna razlika u prosečnim zakrivljenostima između grupa sa torzionom kontrolom i bez nje ($p > 0.05$), tj. utvrđeno je da se može smatrati da su dve grupe homogene.

Rezultati ispitivanja broja uporeba instrumenata do pojave loma prikazani su na Grafikonu 1.

U grupi sa torzionom kontrolom:

Instrument S1 – polomljen je posle 24 upotrebe (pri obradi 24. kanala korena). Instrument S2 – polomljen je posle 24 upotrebe (pri obradi 25. kanala korena). * Instrument S2 nije obrađivao 24. kanal u kome se slomio S1.

Instrument F1 –polomljen je posle 20 upotreba (pri obradi 20. kanala korena). Instrument F2 – nije polomljen ni posle 27 upotreba (obradio je 27. kanal).

* Instrument F2 nije obrađivao kanale u kojima su se slomili instrumenti S1 (24. kanal), S2 (25. kanal) i F1 (20. kanal) zato što se oni koriste pri obradi kanala pre njega.

U grupi bez torzione kontrole:

Instrumenti S1 – prvi je polomljen posle 22 upotrebe (pri obradi 22. kanala korena), a drugi (nov) odmah posle dve upotrebe (pri obradi 24. kanala).

Instrument S2 – polomljen je posle 23 upotrebe (pri obradi 25. kanala korena).

* Instrument S2 nije obrađivao kanale u kojima su slomljeni S1 instrumenti (kanal 22 i kanal 24).

Instrument F1 – polomljen je posle 24 upotrebe (pri obradi 27. kanala korena).

* Instrument F1 nije obrađivao kanale u kojima su pukli S1 (kanal 22, kanal 24) i kanal u kome je pukao S2 (kanal 25).

Instrument F2 – prvi je polomljen posle 21 upotrebe (pri obradi 21. kanala korena), a drugi posle pet upotreba (pri obradi 30. kanala).

* Drugi instrument F2 nije obrađivao kanale u kojima su slomljeni prethodni instrumenti (kanale 22, 24, 25 i 27)

Man–Whitney U test nije pokazao statistički značajnu razliku u prosečnoj upotrebi instrumenata sa kontrolom torzionog stresa ili bez kontrole torzionog stresa ($p > 0,05$). Vilkoksonov test parova nije potvrdio statistički značajnu razliku u prosečnoj upotrebi instrumenata sa kontrolom ili bez kontrole torzionog stresa ($p > 0,05$).

DISKUSIJA

Eksperimentalni deo ovog rada urađen je od strane stomatologa bez prethodnog kliničkog iskustva u radu sa mašinskim endodontskim instrumentima. U dosadašnjim radovima postoje stavovi da iskustvo kliničara može značajno uticati na kvalitet endodontske terapije. Međutim, postoje i stavovi da ne postoji značajna razlika u kvalitetu sprovedenog endodontskog tretmana kada je u pitanju dužina radnog iskustva lekara, ukoliko se poštuju jasno definisani savremeni principi endodoncije uz pravilnu obuku i upotrebu savremenih instrumenata i tehnika rada [22–25].

U ovom radu je korišćen precizan metod definisanja parametara zakrivljenosti instrumenata u kanalima, kao što je predloženo od strane Pruetta.[10], geometrijskom analizom položaja instrumenta u svakom kanalu, odnosno preciznim definisanjim vrednosti ugla i radijusa krivine instrumenta, aplikacijom AutoCAD na osnovu digitalnih rendgengrafija [26]. Posle izračunavanja prosečnih zakrivljenosti svakog pojedinačnog zuba formirano je 10 parova od po dva zuba sa najsličnijim prosečnim zakrivljenostima, kako bi uzorak u obe grupe bio što homogeniji, odnosno kako bi nalazi instrumentacije svakog ispitivanog instrumenta (broj upotreba do pojave loma) bili uporedivi.

U eksperimentalnom delu svi ispitivani instrumenti korišćeni su pri brzinama rotiranja od 250 obrtaja u minuti, preporučenim od strane proizvođača. Što se tiče torzione kontrole, proizvođač naglašava neophodnost podešavanja njene vrednosti pri radu za svaki pojedinačni instrument i te vrednosti su korišćene u instrumentaciji kanala korenova zuba kontrolne grupe (grupa sa torzionom kontrolom). Postoje stavovi da vrednost torzione kontrole nema uticaj na životni vek NiTi instrumenata pune rotacije, što je i primenjeno u instrumentaciji kanala korenova zuba u eksperimentalnoj grupi (grupa bez torzione kontrole) [27].

Da bi se smanjila opasnost od loma instrumenta, uputstva proizvođača za korišćenje treba maksimalno poštovati, a samo nekoliko rotacionih ciklusa instrumenta je potpuno bezbedno pri radu u veoma zakrivljenim kanalima [28]. Ne postoji zvaničan stav o preporučenom broju korišćenja NiTi instrumenata pune rotacije; taj broj varira od 1 do 27 kanala, sa prosekom od 11 kanala [8]. Guettier [29] je predložio da se instrument može ponovno koristiti, u zavisnosti od vrste zuba koji se tretiraju, s većim brojem korišćenja kod prednjih i manjim brojem korišćenja kod bočnih zuba. Većina autora preporučuje odbacivanje instrumenta (čak i potpuno novih) nakon korišćenja u oštro zakrivljenim, kalcifikovanim i složenim kanalima korena, i u slučajevima pojave bilo kakvih znakova plastične deformacije [11, 16, 29, 30]. Naravno, dobro poznavanje predisponirajućih faktora koji dovode do frakture NiTi instrumenata pune rotacije je od presudnog značaja u prevenciji ove pojave.

Posmatrajući rezultate ove studije, svi ispitivani instrumenti u grupi sa torzionom kontrolom su upotrebljeni 20 i više puta do momenta loma, uz napomenu da instrument F2 nije polomljen ni posle 27 upotreba. U grupi bez torzione kontrole, takođe je do loma instrumenata došlo nakon 20 i više upotreba, ali je jedan instrument S1 polomljen posle samo dve upotrebe, a jedan instrument F2 posle pet upotreba. Iako statistička obrada dobijenih rezultata nije pokazala statističku značajnost, s obzirom na limitiranost studije može se uvideti tendencija da pri radu bez torzione kontrole može doći do iznenadnog loma instrumenata posle samo nekoliko upotreba u kliničkom radu, što će biti cilj obimnijeg istraživanja koje sledi posle ove pilot studije.

ZAKLJUČAK

Klinički značaj ove studije ogleda se u tome da je pri radu sa NiTi instrumentima pune rotacije najvažnije pridržavati se uputstva proizvođača, s obzirom na to da ne postoji zvaničan stav o preporučenom broju korišćenja NiTi instrumenata pune rotacije. Iako analiza dobijenih podataka nije pokazala statističku značajnost, s obzirom na limitiranost studije može se uvideti tendencija da pri radu bez torzione kontrole može doći do iznenadnog loma instrumenata posle samo nekoliko upotreba u kliničkom radu.

ORIGINAL ARTICLE
ORIGINALNI RAD

DOI: 10.2478/sdj-2018-0007
UDC: 616.314.16-08

The application of MTA as apical plug for root canal obturation – *in vitro* study

Ivan Matović, Dragan V. Ilić, Renata Petrović, Dejan Ostojić

University of Belgrade, Faculty of Dental Medicine, Department for Restorative Odontology and Endodontics, Belgrade, Serbia

SUMMARY

Introduction Prognosis of endodontically treated tooth is directly correlated to the quality of apical obturation. Modern concept of endodontics in particular way points out the quality of apical filling. The aim of this study was to assess the quality of root canal obturation with MTA apical plug using the method of gas (argon) penetration.

Material and Methods Sixty-six freshly extracted single rooted (single canal) teeth were divided into the two experimental (30 teeth) and one control group (6). All canals were instrumented using hand and rotary files in step-back technique and copious irrigation of 1%NaOCl. In the first experimental group teeth were obturated using different sealers: Gutta Flow (Roeko), AH Plus (DeTrey), Acroseal (Septodont) and mono gutta-percha cone (10 canals each). In the second experimental group obturation involved 3 mm of MTA-Angelus apical plug while the remaining canal space was filled with the same three sealers as in the first group. The rate of gas permeability by Leak detector-Edwards LD 416 was measured in all teeth.

Results The best seal was found in teeth obturated with Gutta Flow and MTA plug with average diffusion rate of 264.4 sec while the worst quality of obturation was found with Acroseal (178.5 sec-the highest gas permeability). All samples with MTA plug exhibited significantly lower leakage than the samples filled without MTA apical plug.

Conclusion Root canals filled with MTA apical plug exhibited statistically significant lower gas permeability in comparison to the ones filled with sealer and guttapercha cones only.

Keywords: MTA; sealer; apical obturation; Gutta Flow; calcium silicate; gas permeability

INTRODUCTION

Adequately done endodontic treatment supports and stimulates reparative processes in apical periodontal tissues. Up to date doctrine of endodontic treatment is based on biomechanical canal instrumentation and irrigation [1]. The idea about optimal apical hermetic sealing with biologic properties forced many investigators to find ideal obturation material that could also prevent overfilling [2, 3]. This material needed to be biocompatible, adhesive and physico-chemically stable to perform obturation [4, 5]. Mineral trioxide aggregate (MTA) material fulfills many of required characteristics [5]. Torabinejad and Asgary were the first ones to use MTA *in vitro* and then *in vivo* studies in restorative and endodontic procedures in the nineties of the past century [5]. It was invented to improve and satisfy appropriate hardness, low solubility and short setting time as obturation material. The first dark-gray variant of MTA was mostly based on hydroxyapatite particles [4], similar to the original Portland cement (PC) formulation. It has been examined through the series of physicochemical and biological tests for use in dentistry as cheaper bioactive dentine replacement material besides expensive MTA [5–8]. Up to nowadays, many variants of CS cements showed impressive results as endodontic sealers, pulp-capping agents, apical retrograde fillings [9, 10] apical obturation sealers [11, 12], perforation healing liners [13], as well as propelling agent during apexogenesis/apexification [12, 13]. One of CS preparations, an improved MTA cement, iRoot cement (iR) as root canal sealer is confirmed to kill E. *faecalis* in bacterial medium [14]. It is considered bioactive material but with high toxicity and certain antibacterial properties [15, 16]. Methods for evaluation of apical hermeticity are numerous but diffusion of dye is the one most frequently used, whether by vacuum system or without. Similar methods were used at the end of past century, but with more precision, displaying apical permeability through the function of time [17, 18].

The aim of this study was to assess the canal filling hermeticity of MTA apical plug using the method of gas diffusion.

MATERIAL AND METHODS

The study involved sixty-six extracted single-rooted teeth grouped into the two experimental groups of 30 teeth each and one control group of six teeth. The used endodontic sealers were: Gutta Flow (Colthane /Whaledent, Germany), AH Plus (DeTrey, Germany) and Acroseal (Septodont, France). Standardized gutta-percha cones of 2% taper were used for obturation (Pearl Endopia, Pearl Dent Co.). In the first group (A) canals were obturated with single gutta-percha cone and sealer. The second group (B) had canals obturated with apical MTA plug and rest of the canal with gutta-percha and sealer. The roots of teeth had similar diameter and volume of apical portion without any defect along the root. The coronal part of the teeth was removed from the root at the cement-enamel junction using high-speed hand-piece and

Address for correspondence: Ivan MATOVIĆ, Faculty of Dental Medicine, Department for Restorative Odontology and Endodontics, 11000 Belgrade, Serbia; *ivan.matovic@gmail.com*

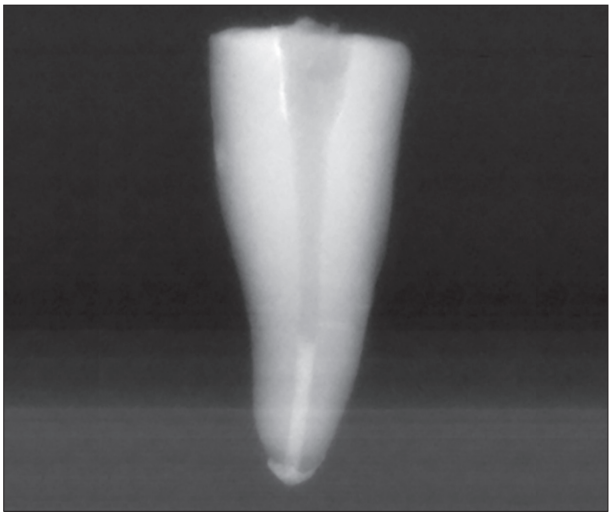


Figure 1. X ray of the root canal after the placement of apical filling (plug) using MTA cement
Slika 1. Kontrolna radiografija korena posle punjenja apeksnog dela kanala MTA cementom

fissure diamond bur enabling direct access to the canal. After the initial patency (Kerr files #10 and #15), preoperative radiograms were performed. Pulp tissue was removed using barbed broach. Working length was determined by insertion of hand file into the canal until it goes out through the apex and then subtraction for 1 mm and taking xray. Canals were prepared to the WL (#15 do #40) and then by step-back technique up to the coronal third of canal using copious irrigation (1% NaOCl) and lubricant (Canal +, Septodont, France). Instrumentation was completed with hand Ni-Ti reamers and files (Sybron, Germany).

Experimental groups

Upon canal preparation (apical matrix of #40 size) root canals were obturated with three sealers and single gutta-percha cone (groups A1, B1 and C1) or with previously inserted MTA plug by pluggers for vertical condensation (Maillefer, Swiss) and then sealer and gutta-percha cone in the groups A2, B2 and C2. Obturation was performed using Lentulo spiral and guttapercha cones in combination with endodontic sealers: Gutta Flow, Acroseal and AH Plus (DeTray, Germany). Gutta Flow was inserted using dispensing gun (Coltene/Whaledent, Swiss).

Apical plug was 3 mm long where periapical radiographs from two directions confirmed the quality of apical MTA filling (Figure 1). Access cavities were temporary filled with Cavit (Premier, Dental Products, Germany).

Control group involved six canals that were obturated only with gutta-percha cones to show that argon (Ar) is capable of going only through the apical foramen and root canal filling material. The teeth of experimental and control group were kept for 7 days at 37°C in the area of absolute humidity to allow definite hardening of sealers.

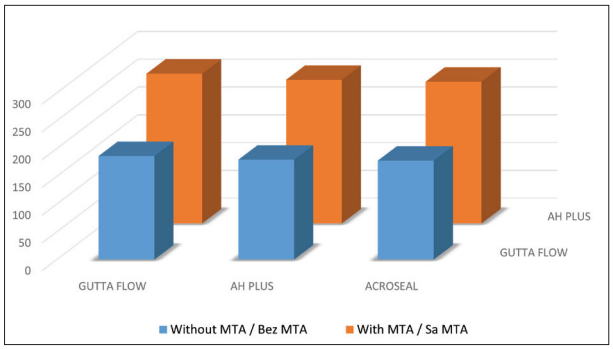
Gas diffusion marking

Quantification of visual information was done using VegaCam device (Edwards LD, 416, UK) and detector device by added software program (Argon Leak Detector, Edwards, UK). The quality of root canal obturation was assessed using the technique of gas permeability system [18]. Ar concentration was measured using argon-leak detector (Edwards LD 416, UK) [18]. Obturated teeth were fixed in prospecting detectors for stability. Argon gas was introduced by a special micro-cannula placed in the coronal part of canal when the measurement chamber was vacuumed. The time (sec) needed for gas penetration through the apex was measured using the timer [19]. The quality of obturation was expressed as the time interval needed for Ar to penetrate through the apex whereby longer time meant better obturation.

Statistical analysis was performed using ANOVA test for differences between the means of experimental groups using confidentiality level of p=0.01. Newman-Keuls test was used to compare differences between the groups.

RESULTS

In the group of teeth that were obturated with apical MTA plug, the lowest gas permeability was shown by combined obturation with Gutta Flow and MTA apical plug (269.4 sec), then AH Plus and MTA plug (258.5 sec) while the highest gas permeability was with Acroseal and MTA plug (255.2 sec). The differences among them were statistically insignificant (p > 0.01) (Table 1, Graph 1).



Graph 1. Comparative values of the time (sec) required for argon diffusion from coronal part of restoration to the apex (groups of teeth with sealer and gutta-percha without MTA plug and groups with sealer and gutta-percha and MTA plug)
Grafikon 1. Uporedne vrednosti vremena (sek.) potrebne za difuziju argona od kruničnog dela ispuna do apeksa kod grupe A1, B1 i C1 prema grupama A2, B2 i C2

Table 1. Average time needed for argon diffusion (sec) throughout the root canal filling
Tabela 1. Srednja vrednost brzine prodora argona (sek.) kroz kanalsko punjenje

Material Materijal	Sample Uzorak	Variance Varijansa	Mean value of Ar diffusion rate (sec) Srednja vrednost brzine prodora argona (sek.)
A_1 – Gutta flow	10	21.35	186.7
A_2 – Gutta flow + MTA	10	27.02	269.4
F = 0.73, p < 0.01			
B_1 – AH Plus	10	21.85	179.9
B_2 – AH Plus + MTA	10	41.23	258.5
F = 1.50, p < 0.01			
C_1 – Acroseal	10	31.24	178.5
C_2 – Acroseal + MTA	10	33.54	255.2
F = 1.87, p < 0.01			

In the group of teeth that were obturated with no apical MTA plug, the lowest gas permeability was recorded in Gutta Flow samples (186.7 sec) then AH Plus (179.9sek) and the highest permeability in the Acroseal paste samples (178.5 sec). The differences among them were statistically insignificant ($p > 0.01$). The MTA samples showed statistically significant lower argon leakage in comparison to the ones obturated only with sealer and gutta-percha cones without MTA plug ($p < 0.05$).

DISCUSSION

MTA has characteristics of bioactive material and it is known for its use as an apical plug with good physico-chemical properties exhibiting good adherence to dentin, compressive strength and push-out forces [4, 7, 8, 20, 21]. Moreover, its positive biological properties such as biostimulative, osteoconductive and antimicrobial effects have been confirmed either on animal model or in clinical conditions (pulp capping, pulpotomy, root perforations) [4, 6, 7, 8, 19, 20].

Several methods have been used for the evaluation of apical hermeticity such as bacterial penetration [21], electric currency [22], dye diffusion [2] and radioactive agents [23]. Gas permeability method has good value in assessing the quality of canal obturation. Due to the use of different gases in this method (Ar, O_2, N_2, CO_2, noble gases, organic gases), comparison of the results with different gas nature or different experimental models may not be possible [18, 19]. Argon as the noble element was chosen for our study due to its inactivity to endodontic sealers [18, 19]. However, this method only allows assessing overall permeability without showing the path of its diffusion. In addition, combined argon diffusion with optical analysis (XRD and spectrophotometry) could possibly explain physical phenomenon of leakage events [18, 24].

MTA was chosen as most commonly used cement in several investigations [4–9, 15, 25, 26] and due to its biocompatibility, high alkalinity and low solubility [2, 27]. Our satisfying results obtained by MTA-plug could be explained by its low solubility due to water absorption and minimal expansion that was confirmed in several studies [8, 9, 12, 23, 27, 28].

The use of iR as sealer or filler and for reparation of canal-wall perforation presented satisfactory results [27] due to missing alumina particles and resemblance to white MTA. iR is considered appropriate for root canal filling material due to its viscosity [28] and could be used as sealer-filler with or without gutta-percha cones [29].

The advantage of combination of MTA apical plug and sealer over sealer only samples in the current study may be explained by its expansion in the first several hours during setting and water absorption when MTA exposed weight increase around 12% upon submerging for 24 h [30].

Low solubility and good adherence to the canal walls of Gutta Flow and AH Plus paste has been shown in several studies [17, 18, 31, 32]. Our results are consistent with the results of the study of Bracket et al. [33] and Bouillaguet et al. after 12 months follow-up [34]. Bouillaguet et al. explained that in single-cone obturation technique the volume of sealer is higher than the volume of gutta-percha, and this ratio promotes void formation and reduces the quality of seal due to the contraction phenomenon. Use of single-cone technique also allowed comparison of the performance of all materials under relatively standardized conditions. Leakage of AH-Plus may have resulted from inadequate bonding between sealer and gutta-percha cone allowing fluid to flow at the interface. This finding is in agreement with the results from Sagsen et al. [29]. Bouillaguet et al. also considered that gun pressure for sealer injection created better adhesion of Guta Flow than AH Plus to the canal walls and consequently lower micro-leakage. Martin et al. based of bacterial canal penetration confirmed better sealability in AH Plus cases than when Gutta Flow paste was used as obturation material [35].

Acroseal as calcium-hydroxide based sealer showed inadequate (poor) hermeticity and that finding is also in accordance with several studies [34, 36]. As per Mc Michen et al. AH Plus was more stable than Acroseal that was also confirmed in the current study [37].

The explanation for better apical hermeticity in canals obturated by MTA apical plug than in samples without MTA plug was demonstrated in the study of Guven et al. [38]. They explained this finding by the nanosphere structure of MTA particles that allows the material to penetrate into dentinal tubules and interact with moisture inside the tubules for final setting. This creates mechanical bond with dentin upon setting and renders the material with exceptional dimensional stability. In addition, many MTA brands provided either water or hydrosoluble gel to improve its washout resistance.

Nowadays, more improved MTA-based sealers (BioRoot ™ –RCS, MTA caps^R, iR^R, iR- BP PlusMTA-Fillapex^R [27], Biodentine™ [27], Bioaggregate^R [38], ProRoot MTA^R [39]) are more insoluble than original MTA formula *in vivo* and *in vitro*. For their safe clinical use further research is required.

CONCLUSIONS

Root canal obturation with different sealers, gutta-percha and MTA apical plug demonstrated significantly lower gas penetration compared to standard technique that included gutta-percha and sealer without MTA plug.

REFERENCES

1. Oliver CM, Abbott PV. Correlation between clinical success and apical dye penetration. Int Endod J. 2001; 34(8):637–44. [DOI: 10.1046/j.1365-2591.2001.00442] [PMID: 11762501]
2. Murphy WM. The testing of endodontic materials in vitro. Int Endod J. 1988; 21(2):170–7. [DOI: 10.1111/j.1365-2591.1988.tb00971.x] [PMID: 3268553]
3. Fogel BB. A comparative study of five materials for use in filling root canal spaces. Oral Surg Oral Med Oral Pathol. 1977; 43(2):284–99. [PMID:64952]
4. Asgary S, Shahabi S, Jafarzadeh T, Amini S, Kheirieh S. The properties of a new endodontic material. J Endod. 2008; 34(8):990–3. [DOI: 10.1016/j.joen.2008.05.006] [PMID: 18634932]
5. Torabinejad M, Watson TF, Pitt Ford TR. Sealing ability of a mineral trioxide aggregate when used as a root end filling material. J Endod. 1993; 19(12):591–5. [DOI: 10.1016/S0099-2399(06)80271-2] [PMID: 8151252]
6. De Deus G, Ximenes R, Gurgel-Filho ED, Plotkowski MC, Coutinho-Filho T. Cytotoxicity of MTA and Portland cement on human ECV 304 endothelial cells. Int Endod J. 2005; 38(9):604–9. [DOI: 10.1111/j.1365-2591.2005.00987] [PMID: 16104973]

7. Torabinejad M, Parirokh M. Mineral trioxide aggregate: a comprehensive literature review-part II: leakage and biocompatibility investigations. J Endod. 2010; 36(2):190–202. [DOI: 10.1016/j.joen.2009.09.010] [PMID: 20113774]
8. Parirokh M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review-Part I: chemical, physical, and antibacterial properties. J Endod. 2010; 36(1):16–27. [DOI: 10.1016/j.joen.2009.09.006] [PMID: 20003930]
9. Watson TF, Atmeh AR, Sajini S, Cook RJ, Festy F. Present and future of glass-ionomers and calcium-silicate cements as bioactive materials in dentistry: biophotonics-based interfacial analyses in health and disease. Dent Mater. 2014; 30(1):50–61. [DOI: 10.1016/j.dental.2013.08.202] [PMID: 24113131]
10. Biočanin V, Antonijević Đ, Poštić S, Ilić D, Vuković Z, Milić M, et al. Marginal Gaps between 2 Calcium Silicate and Glass Ionomer Cements and Apical Root Dentin. J Endod. 2018; 44(5):816–21. [DOI: 10.1016/j.joen.2017.09.022] [PMID: 29336880]
11. Kadić S, Baraba A, Miletić I, Ionescu A, Brambilla E, Ivanišević Malčić A, et al. Push-out bond strength of three different calcium silicate-based root-end filling materials after ultrasonic retrograde cavity preparation. Clin Oral Investig. 2018; 22(3):1559–65. [DOI: 10.1007/s00784-017-2244-6] [PMID: 29063381]
12. Bosso-Martelo R, Guerreiro-Tanomaru JM, Viapiana R, Berbert FL, Basso Bernardi MI, Tanomaru-Filho M. Calcium silicate based cements associated with micro and nanoparticle radiopacifiers: physicochemical properties and bioactivity. Int Sch Res Notices. 2015; 2015:874283. [DOI: 10.1155/2015/874283] [PMID: 27347552]
13. Lemos MSS, Gabardo MC, Castiglia Gonzaga C, Dias Morais N, Baratto-Filho F, Correr Nolasco GM, et al. Bond strength of self-adhesive resin cement to different root perforation materials. J Endod. 2016; 42(12):1819–21. [DOI: 10.1016/j.joen.2016.08.019] [PMID: 27769677]
14. Dawood AE, Parashos P, Wong RHK, Reynolds EC, Manton DJ. Calcium silicate-based cements: composition, properties, and clinical applications. J Investig Clin Dent. 2017; 8:2. [DOI: 10.1111/jicd.12195] [PMID: 26434562]
15. Zhaofei L, Cao L, Fan M, Xu Q. Direct pulp capping with calcium hydroxide or Mineral Trioxide Aggregate: A Meta-analysis. J Endod. 2015; 41(9):1412–7. [DOI: 10.1016/j.joen. 2015.04.012] [PMID: 25990198]
16. De-Deus G, Canabarro A, Alves GG, Marins JR, Linhares AB, Granjeiro JM. Cytocompatibility of the ready-to-use bioceramic putty repair cement iRoot BP Plus with primary human osteoblasts. Int Endod J. 2012; 45(6):508–13. [DOI: 10.1111/j.1365-2591.2011.02003] [PMID: 22364572]
17. Parirokh M, Torabinejad M, Dummer PMH. Mineral trioxide aggregate and other bioactive endodontic cements: an updated overview-part I: vital pulp therapy. Int Endod J. 2018; 51(2):177–205. [DOI: 10.1111/iej.12841] [PMID: 28836288]
18. Djordjević M, Lapcević A, Jovanić P, Jevremović DP, Puskar T, Jovanić PB. Hydroxyapatite activation analysis using x ray diffraction FT-IR spectroscopy and SEM. Healthmed. 2012; 6(7):2537–42.
19. Matović I, Teodorović N, Marjanović M. Evaluation of root canal obturation using gas permeability method. Stom Glas S. 2013; 60(2):63–8. [DOI: 10.2298/SGS1302063M]
20. Torabinejad M, Chivian N. Clinical applications of mineral trioxide aggregate. J Endod. 1999; 25(3):197–205. [DOI: 10.1016/S0099-2399(99)80142-3] [PMID: 10321187]
21. Schwartz RS, Mauger M, Clement DJ, Walker WA. Mineral trioxide aggregate: a new material for endodontics. J Am Dent Assoc. 1999; 130(7):967–75. [PMID: 10422400]
22. Sisodia R, Ravi KS, Shashikiran ND, Singla S, Kulkarni V. Bacterial penetration along different root canal fillings in the presence or absence of smear layer in primary teeth. J Clin Pediatr Dent. 2014; 38(3):229–34. [PMID: 25095317]
23. Aydemir H, Ceylan G, Tasdemir T, Kalyoncuoglu E, Isildak I. Effect of immediate and delayed post space preparation on the apical seal of root canals obturated with different sealers and techniques. J Appl Oral Sci. 2009; 17(6):605–10. [PMID: 20027435]
24. Puppala R, Hegde A, Munshi AK. Laser and light cured composite resin restorations: in-vitro comparison of isotope and dye penetrations. J Clin Pediatr Dent. 1996; 20(3):213–8. [PMID: 8634208]
25. Singh S, Podar R, Dadu S, Kulkarni G, Purba R. Solubility of a new calcium silicate-based root-end filling material. J Conserv Dent. 2015; 18(2):149–53. [DOI: 10.4103/0972-0707.153053] [PMID: 25829696]
26. Guneser MB, Akbulut AU, Eldeniz MB. Effect of various endodontic irrigants on push-out bond strength of Biodentine and conventional root perforation repair materials. J Endod. 2013; 39(3):380–4. [DOI: 10.1016/j.joen.2012.11.033] [PMID: 23402511]
27. Parirokh M, Torabinejad M. 10 Calcium Silicate–Based Cements. Pocket Dentistry. Available at: https://pocketdentistry.com/10-calcium-silicate-based-cements/
28. Nagas E, Uyanik MO, Eymirli A, Cehreli ZC, Vallittu PK, Lassila LV, et al. Dentin moisture conditions affect the adhesion of root canal sealers. J Endod. 2012; 38(2):240–4. [DOI: 10.1016/j.joen.2011.09.027] [PMID: 22244645]
29. Sagsen B, Ustün Y, Demirbuga S, Pala K. Push-out bond strength of two new calcium silicate-based endodontic sealers to root canal dentine. Int Endod J. 2011; 44(12):1088–91. [DOI: 10.1111/j.1365-2591.2011.01925] [PMID: 21895700]
30. Camilleri J. The physical properties of accelerated Portland cement for endodontic use. Int Endod J. 2008; 41(2):151–7. [DOI: 10.1111/j.1365-2591.2007.01330] [PMID: 17931386]
31. Guimarães BM, Vivan RR, Piazza B, Alcalde MP, Bramante CM, Duarte MAH. Chemical-physical Properties and apatite-forming ability of Mineral Trioxide Aggregate flow. J Endod. 2017; 43(10):1692–96. [DOI: 10.1016/j.joen.2017.05.005] [PMID: 28735787]
32. Razmi H, Parvizi S, Khorshidian A. Comparison of AH26 physicochemical properties with two AH26/antibiotic combinations. Iran Endod J. 2010; 5(1):6–10. [PMID: 23130022]
33. Brackett MG, Martin R, Sword J, Oxford C, Rueggeberg FA, Tay FR, et al. Comparison of seal after obturation techniques using a polydimethylsiloxane-based root canal sealer. J Endod. 2006; 32(12):1188–90. [DOI: 10.1016/j.joen.2006.07.009] [PMID: 17174680]
34. Bouillaguet S, Shaw L, Barthelemy J, Krejci I, Wataha JC. Long-term sealing ability of Pulp Canal Sealer, AH-Plus, GuttaFlow and Epiphany. Int Endod J. 2008; 41(3):219–26. [DOI: 10.1111/j.1365-2591.2007.01343] [PMID: 18005042]
35. Martin RL, Monticelli F, Brackett W, Loushine RJ, Rockman RA, Ferrari M, et al. Sealing properties of mineral trioxide aggregate orthograde apical plugs and root fillings in an in vitro apexification model. J Endod. 2007; 33(3):272–5. [DOI: 10.1016/j.joen.2006.11.002] [PMID: 17320712]
36. Eldeniz AU, Ørstavik D. A laboratory assessment of coronal bacterial leakage in root canals filled with new and conventional sealers. Int Endod J. 2009; 42(4):303–12. [DOI: 10.1111/j.1365-2591.2008.01509] [PMID: 19220520]
37. McMichen FR, Pearson G, Rahbaran S, Gulabivala K. A comparative study of selected physical properties of five root-canal sealers. Int Endod J. 2003; 36(9):629–35. [PMID: 12950578]
38. Hashem AA, Wanees Amin SA. The effect of acidity on dislodgement resistance of mineral trioxide aggregate and bioaggregate in furcation perforations: an in vitro comparative study. J Endod. 2012; 38(2):245–9. [DOI: 10.1016/j.joen.2011.09.013] [PMID: 22244646]
39. Guven Y, Tuna EB, Dincol ME, Ozel E, Yilmaz B, Aktoren O. Long-term fracture resistance of simulated immature teeth filled with various calcium silicate-based materials. Biomed Res Int. 2016; 2016:2863817. [DOI: 10.1155/2016/2863817] [PMID: 27382564]

Received: 01.03.2018 • Accepted: Prihvaćen 21.05.2018

Primena MTA kao apeksnog čepa u opturaciji kanala korena zuba – *in vitro* studija

Ivan Matović, Dragan V. Ilić, Renata Petrović, Dejan Ostojić

Univerzitet u Beogradu, Stomatološki fakultet, Klinika za restaurativnu odontologiju i endodonciju, Beograd, Srbija

KRATAK SADRŽAJ

Uvod Prognoza uspeha endodontski treatiranih zuba je u direktnoj korelaciji sa kvalitetom opturisanog endodontskog prostora. Savremena koncepcija endodontskog tretmana poseban akcenat stavlja na kvalitet preparacije i opturacije apeksnog dela kanala. Cilj ovog rada je bio da se metodom merenja gasne propustljivosti (argona) proveri kvalitet opturacije kanala korena zuba nakon primene mineral-trioksid agregata (MTA) kao apeksnog čepa.

Materijal i metod U istraživanje je uključeno 66 jednokorenskih-jednokanalskih zuba razvrstanih u dve grupe (po 30 zuba), dok je šest zuba korišćeno kao kontrola. Preparacija svih kanala je urađena ručnim instrumentima i primenom step-back tehnike uz obilnu irigaciju 1% NaOCl. U prvoj grupi zuba je opturacija realizovana silerima uz pomoć gutaperka konusa Gutta Flow-Roeko (10), AH Plus-DeTrey (10) i Acroseal-Septodont (10). Drugu grupu su činili zubi kod kojih je u apeksnom delu kanala aplikovan MTA, a potom su kanali ispunjeni primenom tri silera kao u prvoj grupi. Svi zubi iz obe grupe su podvrgnuti metodi merenja brzine gasne propustljivosti pomoću aparata Argon Leak Detector, Edwards LD 416.

Rezultati Najbolju hermetičnost su pokazali uzorci kanala ispunjeni primenom Gutta Flow+MTA sa prosečnom brzinom (264,4 sek.), a najslabiji kvalitet opturacije sa Acroseal silerom (najveća gasna propustljivost 178,5 sek.). Svi uzorci druge grupe sa MTA čepom su pokazali statistički značajno manju propustljivost nego oni u prvoj grupi sa silerom i gutaperkom bez MTA čepa.

Zaključak Opturacija kanala sa postavljenim MTA apeksnim čepom pokazala je značajno manju propustljivost gasa u poređenju sa uzorcima ispunjenim endodontskim silerom i gutaperka konusima.

Ključne reči: MTA; siler; apeksna opturacija; Gutta Flow; kalcijum-silikat; propustljivost gasa

UVOD

Uspešan endodontski tretman značajno utiče na tok reparatornih procesa u apeksnom periodoncijumu. Savremeni aspekt endodontskog lečenja bazira se na adekvatnoj biomehaničkoj kanalskoj instrumentaciji odnosno apeksnoj medikaciji kao njen značajni faktor [1]. Ideju o optimalnoj apeksnoj hermetičnosti punjenja sa biološkim svojstvima forsiraju mnogi istraživači jer bi materijal u vidu čepa trebalo da, između ostalog, spreči prebačaj materijala u periapeksne strukture [2, 3]. U tom smislu se koriste materijali koji poseduju biokompatibilnost, dobru adhezivnost, kao i ostale stabilne fizikohemijske parametre važne za opturaciju kanala korena [4, 5]. Torabinejad i Asgary su u in vitro [4] a zatim in vivo [5] radovima prvi put primenili novi materijal, mineral-trioksid agregat (MTA), vrstu kalcijum-silikatnog cementa (KS) [4, 5] devedesetih godina prošlog veka. Uveden je sa ciljem da poboljša i zadovolji čvrstoću, nizak nivo rastvorljivosti i kratko vreme očvršćavanja kao materijal za opturaciju. Prva tamnosiva varijanta MTA je uglavnom bila sa česticama hidroksiapatita [4], slična Portland cementu (PC). Ovaj novi obećavajući materijal počinje da biva predmet istraživanja u vezi sa fizikohemijskim i biološkim osobinama za primenu u stomatologiji kao jeftiniji materijal u odnosu na MTA [5–8]. Sve do danas, varijante KS cemenata su pokazale ohrabrujuće rezultate kao endodontski sileri, sredstva za prekrivanje pulpe, kao apeksni retrogradni ispuni [9, 10], kao sredstva za slučajeve perforacija zida kanala, kao lajneri [11] ili ubrzavajući faktor apeksogeneze/apeksifikacije [12, 13]. Potvrđeno je čak da je jedna od MTA preskripcija (iRoot cement), kao endodontski siler, sposoban da uništi *E. faecalis* u bakterijskom medijumu [14]. On se smatra bioaktivnim materijalom [15, 16] ali sa visokom citotoksičnošću i izvesnim antibakterijskim osobinama. Metode za procenu hermetičnosti su brojne, pri čemu je metoda difuzije boje jedna od najčešćih, bilo da se koristi u vakuumu ili u normalnim uslovima. Sličan metod, koji je takođe vrlo precizan, korišćen je krajem prošlog veka i bazira se na apeksnoj gasnoj propustljivosti u funkciji vremena [17, 18].

Iz tog razloga je cilj ovog rada bio da se metodom gasne propustljivosti proveri kvalitet hermetičnosti kanalskog punjenja nakon primene MTA kao apeksnog čepa.

MATERIJAL I METOD

U istraživanju je korišćeno 66 ekstrahovanih jednokorenih zuba podeljenih u dve eksperimentalne grupe (po 30), dok je šest zuba korišćeno za kontrolu. Kao endodontski sileri su korišćeni: Gutta Flow-Colthane/Whaledent, Germany; AH Plus, De Trey, Germany; Acroseal, Septodont, France za opturaciju. Pri opturaciji su standardizovani gutaperka kočići koniciteta 2% (Pearl Endopia, Pearl Dent Co., Vietnam). U grupi A su bili kanali ispunjeni silerom i gutaperka kočićima, a u grupi B oni ispunjeni prvo MTA apeksnim čepom, a preostali deo silerom i gutaperka kočićima. Korenovi zuba su bili približno sličnog dijametra i volumena apeksne trećine korena bez ikakvog defekta duž korena zuba. Krunični deo zuba je odsečen od korena na gleđno-cementnoj granici korišćenjem visokoturažne bušilice i fisurnog dijamantskog svrdla omogućavajući direktan pristup kanalu. Posle inicijalne prohodnosti (Kerr turpije #10 i #15) urađen je preoperativni radiogram. Pulpno tkivo je uklonjeno pulpekstirpatorom. Radna dužina za sve zube je određena umetanjem proširivača u kanal i radiografisanjem sa endodontskim proširivačem na 1 mm kraće od anatomskog foramena. Apeksna matrica je formirana na tom nivou serijskim proširivanjem #15 do #40, a zatim *step back* tehnikom do krunične trećine kanala uz obilnu irigaciju. Za kanalsku insrumentaciju korišćeni su ručni NiTi proširivači (Sybron, Germany) uz irigaciju 1% NaOCl i lubrikant (Canal +, Septodont, France).

Eksperimentalne grupe

Posle apeksne preparacije veličine #40 kanali su opturisani primenom tri silera i gutaperka konusa bilo kao standardna kombinacija (grupe A1, B1 i C1) ili sa prethodno umetnutim MTA čepom kompakterima za vertikalnu kompakciju (Maillefer, Swiss) u grupama (A2, B2 i C2). Opturacija je sprovedena korišćenjem Lentulo spirale i gutaperka konusa kombinovanog sa endodontskim silerom Gutta Flow (Roeco, Germany), Acroseal (Septodont, France) i AH Plus (DeTray, Germany). Gutta Flow siler je aplikovan pištoljem (Coltene/Whaledent dispensing gun, Swiss). Apeksni MTA čep je bio debljine 3 mm, pri čemu je retroalveolarnim snimkom iz dva pravca proveren kvalitet ispuna (Slika 1). Pristupni kaviteti su privremeno zatvarani ispunom Cavit (Premier, Dental Products, Germany).

Kontrolnu grupu je činilo šest zuba, kod kojih su kanali opturisani samo gutaperka konusima sa ciljem da pokažu da je argon (Ar) sposoban da prođe samo kroz masu kanalskog ispuna i apeks. Zubi eksperimentalnih i kontrolnih grupa su stajali sedam dana na 37°C u sredini apsolutne vlažnosti da omoguće definitivno očvršćavanje silera.

Markiranje difuzije gasa

Sistem za kvantifikaciju vizuelnih informacija sastojao se od kamere (VegaCam, Edwards LD 416, UK) i detektorskog uređaja sa odgovarajućim softverskim programom (Argon Leak Detector, Edwards, UK). Kvalitet kanalne opturacije je kontrolisan tehnikom provodljivosti gasa Ar [18]. Njegova koncentracija je merena korišćenjem aparata za detektovanje propustljivosti (Argon Leak Detector Edwards LD 416, UK) [18]. Zubi su fiksirani u komorici pomoću držača radi stabilnosti, gde je Ar uveden specijalnom mikrokanilom plasiranom u krunični deo kanala zuba, posle čega je komora aparata vakuumirana. Vreme (sek.) koje je potrebno da gas prodre kroz apeks je mereno tajmer-detektorom (Argon LD 416, UK) [19]. Kvalitet hermetičnosti je izražen kao vreme potrebno da Ar prodre kroz sve slojeve kanalskog punjenja, pri čemu je duži interval vremena za pojavu gasa u apeksu označavao bolji kvalitet opturacije i obratno.

Statistička obrada je podrazumevala analizu varijanse ANOVA za procenu srednjih vrednosti među eksperimentalnim grupama sa nivoom poverenja p = 0,01. Test Neweman–Keuls je služio za poređenje razlika između grupa.

REZULTATI

Dobijeni rezultati su prikazani u Tabeli 1 i na Grafikonu 1. Najbolje rezultate pokazala je kombinacija apeksnog čepa i Gutta Flow silera sa prosečnom brzinom prodora gasa od 269,4 sek., potom paste AH Plus i MTA čepa (258,5 sek.), dok je najveća gasna propustljivost uočena primenom Acroseal silera i MTA (255,2 sek.). Ova razlika nije bila statistički značajna ($p > 0.01$).

U grupi u kojoj je opturacija urađena bez apeksnog čepa MTA cementom najmanja gasna propustljivost je zabeležena posle primene paste Gutta Flow (186,7sek.), potom kod paste AH Plus (179,9 sek.), a najveća propustljivost je uočena posle korišćenja paste Acroseal (178,5 sek.). Razlika takođe nije bila statistički značajna ($p > 0.01$).

Uzorci sa MTA čepom pokazali su statistički znatno manju vrednost difuzije Ar u odnosu na grupe čiji su kanali napunjeni samo endodontskim silerom bez MTA čepa ($p < 0.01$).

DISKUSIJA

Kako se kalcijum-silikatni MTA materijal smatra bioaktivnim materijalom, on je u ovom istraživanju izabran kao apeksni čep jer ispoljava dobre fizičko-hemijske osobine: zadovoljavajuća adherentnost za dentin, pritisna čvrstoća i povoljna sila smicanja [4, 7, 8, 20, 21]. Osim toga, potvrđena su njegova biološka svojstva: biostimulativnost, osteokonduktivnost i antimikrobnost kako na animalnom modelu tako i u kliničkim uslovima (prekrivanje pulpe, pulpotomija, perforacije korena zuba) [4, 6, 7, 8, 19, 20].

Među brojnim metodama za otkrivanje i procenu propustljivosti kanalskog ispuna (metod bakterijske propustljivosti [21], električne struje [22], difuzije boje [2] i radioaktivnih čestica [23]), gasna propustljivost se takođe pokazala kao veoma precizan postupak u proceni kvaliteta opturacije. U literaturi se mogu naći radovi sa primenom različitih gasova (Ar, O_2, N_2, CO_2, drugi plemeniti gasovi, organski gasovi) [18, 19], što ponekad može otežati poređenje dobijenih rezultata.

Argon kao plemeniti gas izabran je u ovoj studiji zbog svoje hemijske inertnosti prema ispitivanim materijalima za opturaciju [18, 19].

Nedostatak metode gasne propustljivosti je u tome što prikazuje samo integralnu sveukupnu propustljivost markirnog agensa (Ar), ali ne i puteve njegovog prolaska. Kombinacija ove metode sa optičkom analizom uz pomoć XRD i spektrofotometrije mogla bi lakše i preciznije objasniti fenomen curenja [18, 24].

MTA kao predstavnik KS cementa je izabran na osnovu činjenice da je favorizovan u mnogim radovima [4–9, 15, 25, 26], ali i zbog svoje biokompatibilnosti, visoke alkalnosti i slabe rastvorljivosti [2, 27]. Dobri rezultati dobijeni primenom MTA kao apeksnog čepa u našoj studiji mogli bi se objasniti njegovom malom rastvorljivošću usled upijanja vode i neznatnom ekspanzijom, što potvrđuju i drugi radovi [8, 9, 12, 23, 27, 28].

Primena iRoot (iR) cementa za punjenje kanala (kao filer i siler), kao i za reparaciju perforacija korenskog zida, pokazala je zadovoljavajuće rezultate [27] jer on ne sadrži aluminijumske čestice a sličan je varijanti belog MTA. iRoot se smatra pogodnim za punjenje kanala korena zbog svoje viskoznosti [28] pa se može koristiti kao siler-filer sa gutaperka kočićem ili bez njega [29].

Prednost kvaliteta opturacije gde se koristi MTA kao apeksni čep mogla bi se objasniti njegovom ekspanzijom prvih nekoliko sati nakon mešanja jer tada MTA pokazuje porast težine za oko 12% nakon potapanja u vodu u toku jednog dana [30].

Niska rastvorljivost i dobra adhezija za kanalske zidove Gutta Flow silera i paste AH Plus su potvrđene u nekim ispitivanjima [17, 18, 31, 32]. Slične rezultate sa nalazima ovog istraživanja potvrđuju i Bracket sa sar. [33], kao i Bouillaguet i sar. [34], ali tek posle 12 meseci. Bouillaguet i sar. [34] smatraju da je kod monokone tehnike opturacije zapremina silera mnogo veća od same mase gutaperke pa ovaj nepovoljan odnos utiče na stvaranje praznih prostora usled kontrakcije. Ovi autori smatraju da je za lošu adherenciju i veću propustljivost silera AH-Plus odgovorna neadekvatna veza između silera i gutaperka kočića,

koja dozvoljava fluidnu filtraciju na njihovom međuspoju. Oni smatraju da pritisak postolja takođe doprinosi boljoj adherenciji Gutta Flow od paste AH plus pa time i manjoj apeksnoj mikropropustljivosti.

Martin RL [35] ispituje bakterijsku penetraciju u kanalima i nalazi bolje zaptivanje silera AH Plus nego kod uzoraka ispunjenih pastom Gutta Flow. On to objašnjava boljim adhezivnim osobinama paste AH Plus.

Acroseal $Ca(OH)_2$ siler je pokazao u našem eksperimentu neadekvatno odnosno najslabije zaptivanje, što je u saglasnosti sa sličnim studijama [34, 36]. Objašnjenje daju Mc Michen i sar. [37] u vezi sa stepenom rastvorljivosti koji pokazuje da AH Plus ima bolje osobine vezane za nerastvorljivosti od pasti na bazi $Ca(OH)_2$. Slično tome, i u našem ispitivanju je Acroseal pokazao slabiju apeksnu hermetičnost u odnosu na AH Plus preparat. Objašnjenje za bolju apeksnu hermetičnost primećenu kod kanala ispunjenih MTA čepom u odnosu na one opturisane samo silerom i gutaperkom se može naći u studiji Guvena i sar. [38]. Oni smatraju da nanostrukture kod mineral-trioksidnog agregata dozvoljavaju da materijal penetrira u dentinske tubule i interreaguje sa vlagom unutar njih kako bi se ostvarilo završno očvršćavanje. Time se ostvaruje mehanička veza sa dentinom, a materijal poprima izvanrednu dimenzionu stabilnost. U tom smislu fabrikovane su razne varijante MTA preparata, koje su se pripremale bilo sa vodom, bilo sa hidrosolubilnim gelom kako bi se poboljšala otpornost na ispiranje.

Danas usavršeni endodontski sileri na bazi MTA preskripcije (BioRoot™ – RCS, MTA caps®, iR®, iR-BP Plus®, MTA-Fillapex®, Biodentine™, Bioaggregate®, ProRoot MTA®) pokazuju veću otpornost na rastvaranje nego originalni MTA preparat, što pokazuju kako in vivo, tako i in vitro eksperimenti za retrogradno punjenje kanala korena zuba [27, 38, 39]. Za njihovu sigurniju primenu u praksi još uvek nedostaju opsežni klinički rezultati.

ZAKLJUČAK

Dobijeni rezultati su pokazali da je u svim uzorcima u kojima je MTA bio prethodno postavljen kao apeksni čep uočena značajno manja difuzija gasa u odnosu na uzorke opturisane standardnom tehnikom opturacije gutaperka kočićima bez apeksnog čepa.

Serbian Dental Journal, vol. 65, N° 2, 2018

ORIGINAL ARTICLE
ORIGINALNI RAD

DOI: 10.2478/sdj-2018-0008
UDC: 616.31-07:528.7; 616.314-089.23

Photogrammetry based space analysis measurements in orthodontic diagnosis

Marijana Arapović-Savić[1], Mihajlo Savić[2], Mirjana Umićević-Davidović[1], Adriana Arbutina[1], Nenad Nedeljković[3], Branislav Glišić[3]

[1]University of Banja Luka, Faculty of Medicine, Department of Orthodontics, Banja Luka, Republic of Srpska, Bosnia and Herzegovina;
[2]University of Banja Luka, Faculty of Electrical Engineering, Banja Luka, Republic of Srpska, Bosnia and Herzegovina;
[3]University of Belgrade, Faculty of Dental Medicine, Department of Orthodontics, Belgrade, Serbia

SUMMARY

Introduction Lundstrom segmental analysis is often used analysis in orthodontic diagnosis. It includes measurements of available and needed space in the arch in order to determine whether there is a lack or excess of space for proper teeth alignment. Measurements are traditionally performed on plaster study models, but with recent developments of computer-based systems, there is an increase in use of digital models in measuring process. The aim of this study was to present a photogrammetry based measurement approach that requires no specialized and expensive hardware and compare results with ones obtained on 3D scanned models.

Material and method On 50 plaster study models measurements of 24 teeth, widths of 12 segments and Lundstrom segmental analysis were performed. 3D scanned study models were analyzed in the photogrammetry software OrthoPhoto4D on the set of four photographs of the study model in custom made measurement apparatus. The software corrects for finite distance of the camera and corrects errors due to perspective distortion.

Results Statistical analysis performed on obtained measurements provided Bland-Altman plots that strongly suggested high degree of correspondence between the two measurements methods. Discrepancies for maxilla for individual segments were under 0.25 mm with standard deviation of up to 0.16 mm, and less than 1 mm and deviation of up to 0.4 mm for complete arch. For mandible the differences were up to 0.27 mm for segments with 0.15 mm deviation and 0.6 mm for complete arch with up to 0.24 mm deviation. Correlation coefficient was over 0.985 in all cases.

Conclusions Both analyzed methods can be equally used in clinical practice.

Keywords: orthodontics; digital models; photogrammetry; diagnosis; therapy

INTRODUCTION

Orthodontic study models have multiple uses and represent an invaluable part of orthodontic documentation. Aside from clinical examinations, intraoral and extraoral radiographic images, plaster study models represent an irreplaceable diagnostic tool in orthodontic diagnosis. Direct measurements on the study models have advantages, however there are several limiting factors such as: ideal positioning of the measurement tools on the models requires significant time, errors due to involuntary movements of the hand produce errors in results, complicated use of measurement instruments, for example calipers in Korkhaus analysis, as well as issues related to storing, durability and mobility of plaster models [1, 2].

In order to determine correct orthodontic and dentofacial diagnosis and plan the treatment, radiological images and functional analyses are used. The aim of these techniques is to correctly replicate or describe anatomical and physiological facts and properly show the 3D anatomy with precision. Photography is one of auxiliary diagnostic methods. Orthodontists routinely use 2D techniques in order to record craniofacial anatomy. Depth of the structure cannot be obtained and localized from 2D images and that is one of their limits. Development of information technologies and widespread use of generating 2D and 3D models that appropriately depict real world objects has lead to using aforementioned technologies in dentistry and orthodontic practice [3, 4].

3D modeling is gaining more popularity in orthodontics and in definition of certain orthodontic parameters [5]. Contemporary technologies and more frequent use of computers in orthodontics enabled simulations of orthodontic and surgical interventions that helped patients preparing for surgical procedures [6, 7]. A number of diagnostic methods for visualization of face and teeth structures were developed. Currently, most commonly used methods of 3D recording are computerized tomography (CT), cone beam computerized tomography (CBCT), 3D laser and 3D face morphology (3DFM). 3D techniques provide detailed information even in difficult cases in soft and hard tissues [8–12]. Digital models have numerous advantages, from simpler storage, over more efficient exchange of data to automation of certain processes. How-

Address for correspondence: Marijana ARAPOVIĆ-SAVIĆ, Save Mrkalja 14, 78000 Banja Luka, Republika Srpska, Bosna i Hercegovina; *marijana.arapovic-savic@med.unibl.org*

ever, question often raised is whether these models truthfully depict study models orthodontic therapy is based on. Aside from this, real world obstacle to wider use is also the cost of high quality 3D scanners and software packages required for quality work [13, 14, 15].

Other than 3D scanning, during the measurement process, it is possible to use digital photographs through the process called photogrammetry. Today, photogrammetry implies modeling based on a set of photographs, although the term itself is derived from "measuring from photographs" [16]. Modeling based on photographs through the use of photogrammetry is considered one of the most advanced techniques of image processing that provides accurate data and detailed 3D information. This method allows precision and reliability of data tied to the image and control points (CP) that represent locations of corresponding points in two or more digital images and can be used to connect images. Therefore, there is a requirement of at least two images in order to recreate 3D information through the use of projection and perspective geometry [17]. In order for a set of photographs to be a basis for photogrammetry, there needs to be an overlap between the images. This means that each geometric element that we want to locate must be present in at least two photographs [16, 17].

The aim of this paper was to describe an alternative approach in measuring process during space analysis based on the use of photogrammetry in custom developed OrthoPhoto4D software. This program calculates and corrects errors due to perspective distortion.

MATERIAL AND METHODS

Fifty sets of plaster study models were used in the study. All study models were with permanent dentition, without caries lesions with adequate restorations. In the first

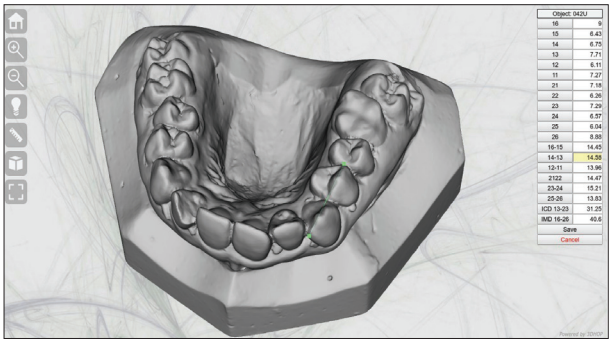


Figure 1. Measurement module in OP4D
Slika 1. Modul za merenja u OP4D

phase, the study models were scanned with Steinbichler L3D 5M industrial scanner. We created the software package OP4D shown in Figure 1. The main characteristic of this program is that it is Internet based and as such requires no additional software to be installed, except any Internet browser (Google Chrome, Mozilla Firefox, etc). It is based on 3DHOP package and supports working with digital models in PLY (Polygon File Format / Stanford Triangle Format) and NXS (Nexus) formats [18, 19]. The measurement process requires choosing the object we want to measure as well as the type of measurement we want to perform. The system allows an arbitrary number of measurements of the same or different types on any of the objects. Performing different types of measurements enables carrying out multiple analyses, while repeating the same type of measurement allows future studies, such as reliability or repeatability studies. After the measuring is completed, the data were saved to database and stored in JSON format [20]. This format enabled significant flexibility as it had dynamic structure and support presenting data as scalars, vectors, maps and other hierarchical data structures.

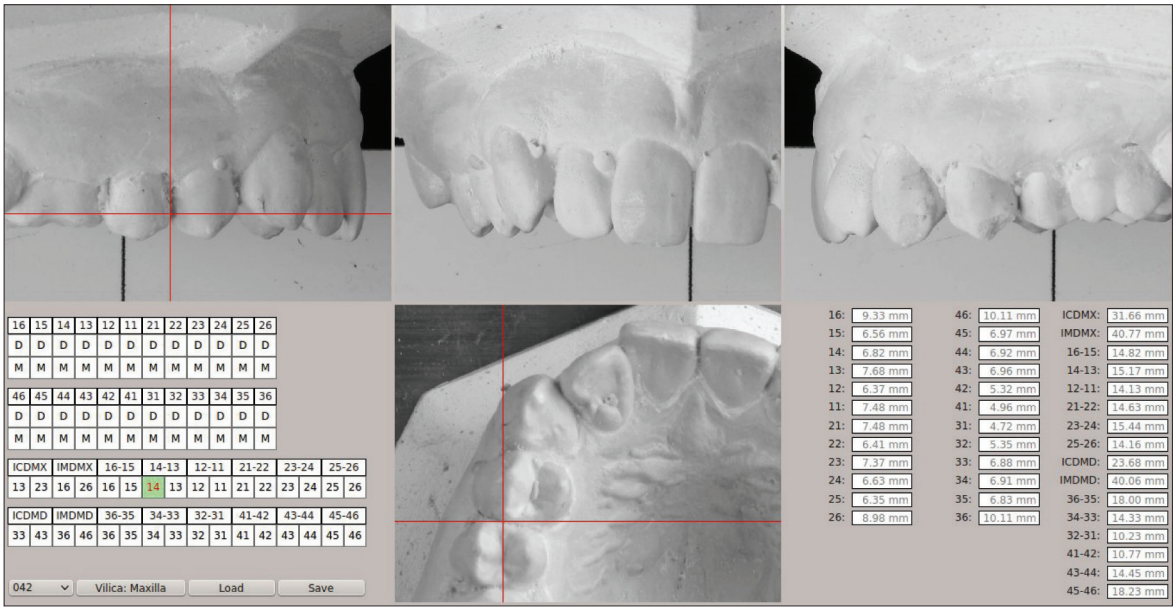


Figure 2. OrthoPhoto4D measurement module user interface
Slika 2. Izgled modula za merenja u OP4D

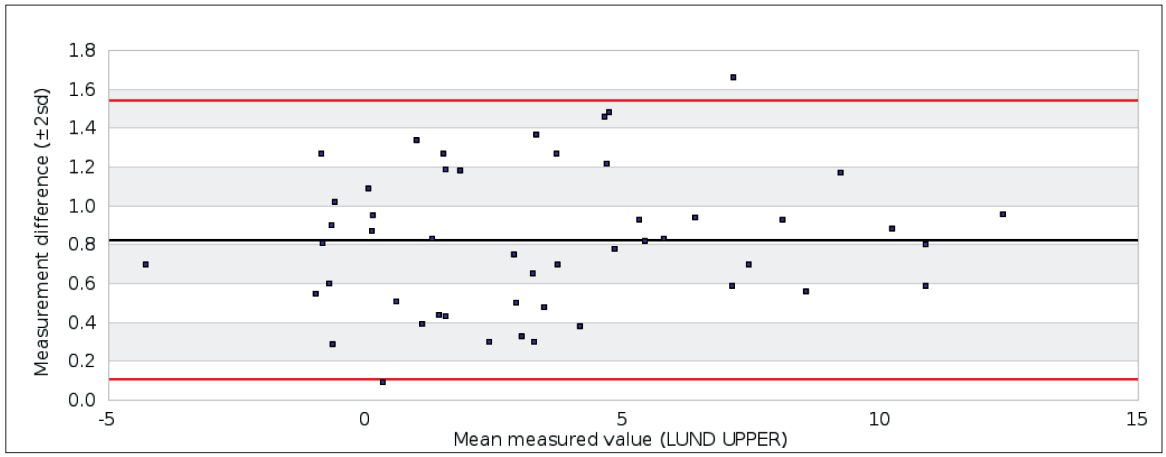


Figure 3. Bland–Altman plot for Lundstrom analysis in maxilla.
Slika 3. Bland–Altman plot za Lundstromovu analizu u gornjoj vilici

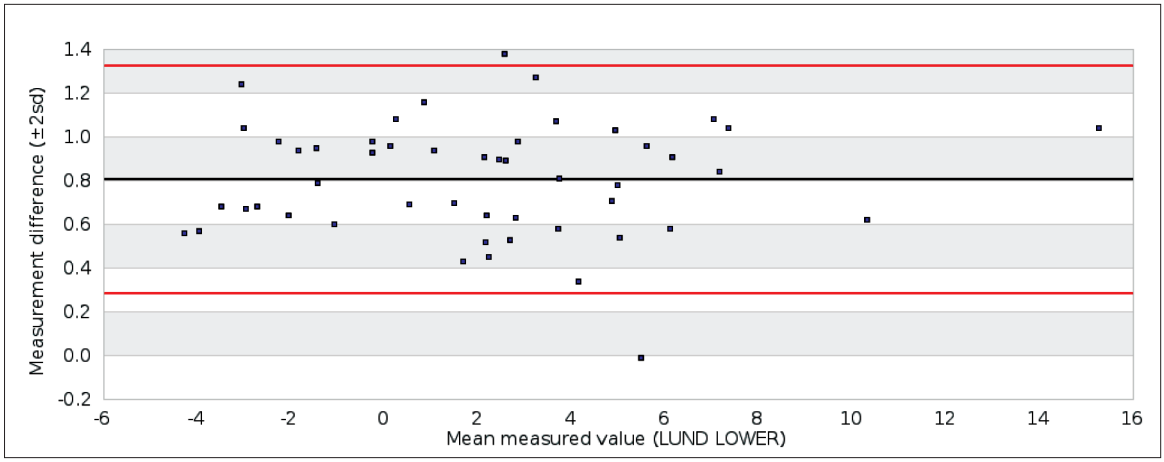


Figure 4. Bland–Altman plot for Lundstrom analysis in mandible
Slika 4. Bland–Altman plot za Lundstromovu analizu u donjoj vilici

In the second phase of the study, plaster study models were photographed from the front, left, right and upper side in measurement apparatus that enables simple positioning of the model in required orientations. The camera was mounted on the firm and sturdy tripod and was triggered by a wireless remote in order to minimize accidental movement of the camera during operation. In order to provide sufficient field depth, aperture was set to f/22 and lens was set to focal length of 200 mm. Lighting was provided by 30 × 30 cm white LED source positioned on the left and matte reflecting surface on the opposing side. Light sources were positioned in such way to provide soft and sufficiently uniform lighting of the object while providing enough shadow to detect the details of the model. Additional problems in using photographs in measurements are related to perspective distortion as well as issues with measuring distances not parallel to the imaging plane.

In order to increase the accuracy of measurements, we designed a measurement apparatus that consists of a stand and a model mount, while the measurements were made on the set of four photographs for each model. The stand was permanently fixed to the stable surface and could not be moved relatively to the camera during photographing. It consisted of base plate, back plate and front plate. The base plate was made in such way to allow the operator to position the back and front plates in required locations and facilitate simple placing of the model mount in all four required states. The apparatus contained central marker lines in order to ease proper positioning of the camera. Models were fixed by a screw with rubber top in order to minimize damages to models. Model mount also contained QR codes that denoted the side of the model currently being photographed: T for top, F for front, R for right and L for left. Models were also marked by QR codes that help identifying the model and automating the procedure.

After the model or multiple models have been photographed, the photographs were analyzed and camera parameters derived from photographs in OrthoPhoto4D software. This process consisted of five major steps:

1. Converting photographs to grayscale representation and eliminating chromatic aberrations by using green channel as a base.
2. Identifying QR codes and processing their contents by the Zbar library [21]. This step provides information on distances between markers, photographed side and identification of the model.

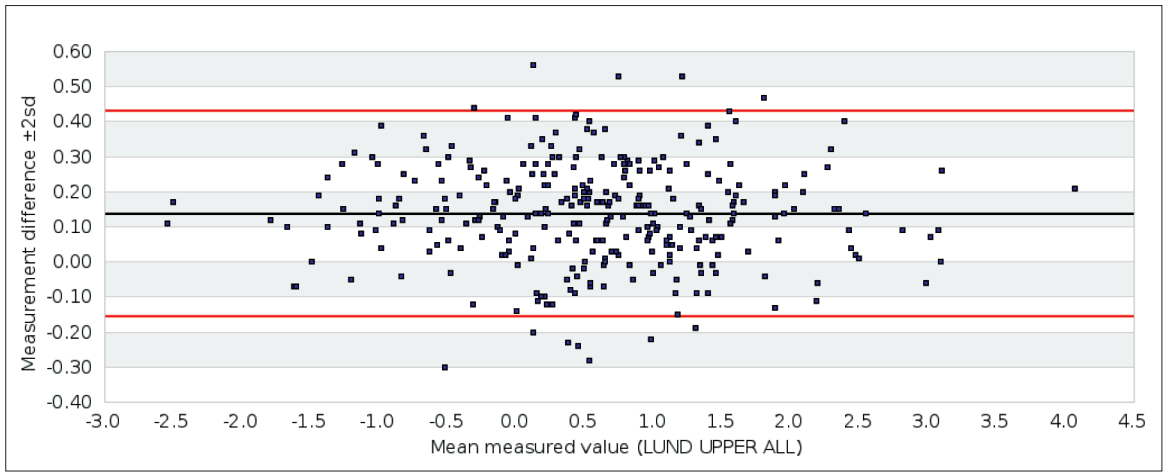


Figure 5. Bland–Altman plot for Lundstrom analysis for all segments in maxilla
Slika 5. Bland–Altman plot za Lundstromovu analizu svih segmenata u gornjoj vilici

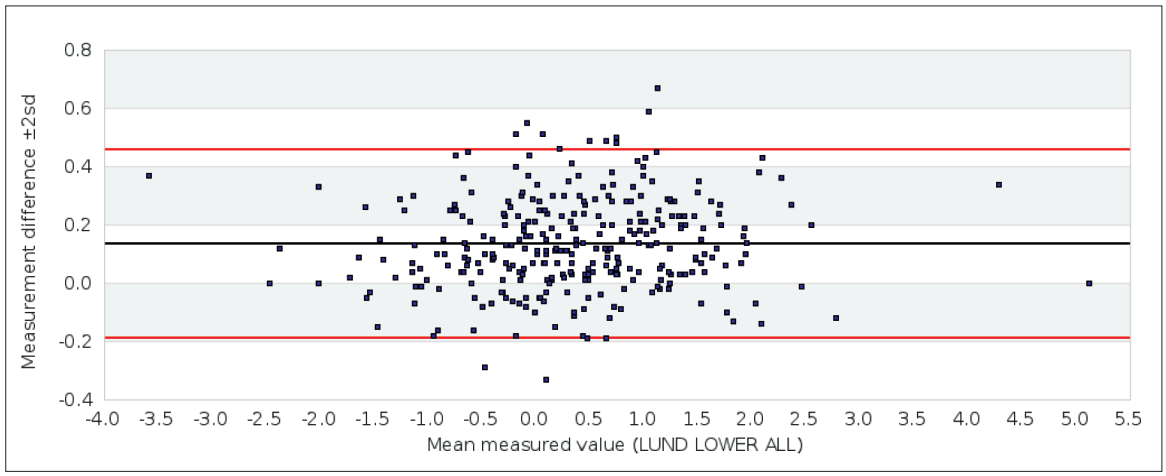


Figure 6. Bland–Altman plot for Lundstrom analysis for all segments in mandible
Slika 6. Bland–Altman plot za Lundstromovu analizu svih segmenata u donjoj vilici

3. Identifying measurement markers by Open CV library [22].
4. Deriving the camera-object distance and perspective parameters based on measured distances of markers on the back and front plates. This step was crucial as data derived here were used to correct the perspective errors.
5. The final step consisted of cropping the image to the area defined by the front plate markers and saving the file to defined case directory. All data derived during the process were stored in JSON format in a field within EXIF structure of the JPEG file that provided simple and efficient storage and transfer of data. Case directories as determined from data in QR codes and in our case was numerical identification of the model where letter L was for mandible and U for maxilla, for example, file named "cases/001U/T.jpg" denoted processed photograph of the top projection of maxilla of the model number 001.

Measurement user interface view of OrthoPhoto4D consists of six components in a grid consisting of two rows and three columns. Front, left and right model view are placed on the top row, the top model view is in the middle of the bottom row. Bottom left section contains the list of possible measurements and the operator can choose between tooth width, segment width, inter-canine and inter-molar width. Due to the fact that we can display only one arch at the time, model views will automatically update if the operator selects a point from currently hidden arch. This section also contains model chooser and "Save" and "Load" buttons. Measured values are presented in a three-column grid in the bottom right section.

For each measurement, the operator has to select corresponding measurement button and one of the two end points, for example 14-13 segment and 14 point. The operator can translate and enlarge the views that are automatically synchronized, in order to select the point in at least two views. As an example, the operator can select the location of the point in "top" and "left" views. This requirement is mandatory in order to locate the point in 3D space and there is insufficient information in location in just one projection. The first selected point is used to calculate two coordinates while the second location is used only for the third coordinate (Z axis in this case). Once the operator locates both ends of the measured length the program will calculate the length in 3D space and display the value

in the value field section. Each completed measurement is denoted by green background color with measurements in progress being red or orange depending on the current phase of measurement. Measurement values obtained on 3D models and photographs were subsequently statistically processed and the mean values and standard deviations were calculated, as well as correlation coefficients and paired t-test.

RESULTS

Table 1 contains the results of statistical analysis of the maxilla measurements. Mean value of difference for individual segments was under 0.25 mm with standard deviation of under 0.16 mm while the mean difference for the whole arch was under 1 mm and deviation under 0.4 mm. Correlation coefficient was over 0.98 for each segment and over 0.99 for the arch, while p values of t-test were under required 0.05 in all cases ($p<0.0001$).

Table 2 contains the results of statistical analysis of the mandible measurements. In this case, the mean value of difference for individual segments was under 0.27 mm with standard deviation under 0.15 mm while the mean difference for the whole arch was under 0.6 mm and deviation was under 0.24 mm. Correlation coefficient was over 0.98 for each segment and over 0.99 for the whole arch. Except in the case of 43-44 segment, the p value of t-test were under required 0.05, while in the case of 43-44 segment the recorded mean difference was under 0.1 mm and clinically insignificant.

Images 3 to 6 show Bland-Altman plots for values obtained by both analysed methods [23]. Mean of each pair of measurements is presented on X axis while the difference is plotted on Y-axis. Black line represents mean difference for all samples, while red lines denote two standard deviations above and below the mean. Interval containing 95% of samples is 1.96 standard deviations above and below the mean.

Majority of measurements is concentrated around the mean and falls within the red line interval, regardless of the measured value. Such Bland-Altman plot suggests the high level of correlation between the two measurements methods.

DISCUSSION

Due to the advantages of digitization of the study models, in the recent years the increase of the computer use in dentistry can be observed. In several papers authors present the comparisons of mesiodistal widths of teeth and segments between the plaster study models and digital representations. Two of the most widely used digital representations are 3D scanned models and digital photographs of the models. Available literature contains studies comparing measurements and analyses on study models and their digital surrogates, but there is a notable lack of analyses on indirect values calculated from the measurements. One of such analyses is Lundstrom segment analysis that was presented in this paper. As a set of three individual measurements for each two-teeth segment, width of the each tooth and segment were used, it was required to analyze both individual measurements as well as indirectly calculated values. This is especially significant when working with complete arch since we used a set of 18 individual measurements.

The aim of the study done by Quimby et al. was to determine accuracy, repeatability and efficacy of the measurements made on digital models. Dentoform and plaster models were used as a "gold standard." Measured parameters were divided into the seven groups, two of which

Table 1. Statistical analysis of results obtained for maxilla
Tabela 1. Statistička analiza podataka za gornju vilicu

Lundstrom – Maxilla Lundstrom – Gornja vilica							
Segment	16-15	14-13	12-11	21-22	23-24	25-26	Arch
E_{mean} [mm]	-0.1294	-0.0794	-0.2342	-0.1784	-0.0680	-0.1316	-0.8210
E_{sd} [mm]	0.1211	0.1331	0.1275	0.0975	0.1580	0.1636	0.3588
Correlation Korelacija	0.9892	0.9879	0.9910	0.9967	0.9888	0.9864	0.9952
T	7.4776	4.1760	12.8548	12.8141	3.0131	5.6295	16.0153
p	0.0000	0.0001	0.0000	0.0000	0.0041	0.0000	0.0000

Table 2. Statistical analysis of results obtained for mandible
Tabela 2. Statistička analiza podataka za donju vilicu

Lundstrom – Mandible Lundstrom – Donja vilica							
Segment	36-35	34-33	32-31	41-42	43-44	45-46	Arch
E_{mean} [mm]	-0.2370	-0.1764	-0.0486	-0.0684	-0.0088	-0.2654	-0.5676
E_{sd} [mm]	0.1473	0.1292	0.1123	0.1142	0.1436	0.1274	0.2384
Correlation	0.9880	0.9926	0.9905	0.9929	0.9924	0.9872	0.9977
T	11.2638	9.5600	3.0298	4.1914	0.4291	14.5833	21.6366
p	0.0000	0.0000	0.0039	0.0001	**0.6697**	0.0000	0.0000

were available and needed width of the segment. They used digital callipers for plaster model measurements and a standard computer mouse to select points on digital models. Measurements were repeated after two weeks. Repeatability was high for both measurements on plaster models as well as on digital models. Efficacy was also similar regardless of the method of measurement. Recorded differences for arch were 0.54 mm for available and 2.23 mm for needed space in maxilla and 2.88 mm for available and 0.21 mm for needed space in mandible. Statistically significant difference was found only in the case of needed space in mandible. Conclusion of the study was that digital models could be used as clinically acceptable alternative to plaster models [24]. Although the authors did not analyze the difference between needed and available space, from the published results one can see that the method presented in our paper has comparable or significantly lower differences and we did not find any statistically significant differences when analyzing complete arches.

In the study performed by Leifert et al., the authors compared the measurements done by two orthodontists on mesiodistal widths of the teeth and arch lengths on plaster study models and 3D virtual models. Difference in measurements for missing space in maxilla was 0.424 mm and 0.384 mm in mandible. Paired t-test showed statistically significant differences in measurements in maxilla. It is worth noting that differences between the two orthodontists were up to 0.408 mm and were comparable to differences between the two measurements methods, therefore the study concluded that differences between methods are acceptable in clinical practice [25]. In our case our method has comparable or lower differences with absence of statistically significant difference on analyzed values. Recorded differences for segments of under 0.3 mm are not clinically significant, while discrepancies of under 0.8 mm on the level of arch are also clinically insignificant.

Yoon et al. examined usability of intraoral scanners by comparing measurements obtained on plaster study models and 3D scanned study models. Results were statistically analyzed using paired t-test. One of the observed measurements was the missing space for the whole arch and they obtained differences between plaster and 3D scanned models of up to 0.58 mm for maxilla with statistically significant differences and up to 0.63 mm for mandible also with statistically significant difference. Differences between plaster and intraorally scanned models were up to 0.86 mm for maxilla and 0.55 mm for mandible with statistically significant differences. Authors concluded that recorded differences are not clinically significant and that all three methods can be used in practice, regardless of the severity of crowding [26]. Comparison of these results and results presented in our paper indicates that recorded discrepancies between methods are comparable, with the note of no statistically significant difference being present in our results for complete arches.

Liang et al. examined usability of 3Shape™ D800 scanner in clinical practice by comparing the measurements on digital model and plaster study models. Models were divided into the three groups based on the severity of crowding. Presented results strongly suggested that the use of 3D scanned models in clinical practice is justified since the measurement differences for available and needed space were under 0.3 mm with no significant statistical difference found. Statistically significant difference was found when authors analyzed the results by severity of crowding [27]. Aforementioned conclusions of the authors are in accordance with our findings as our measurements differences for segments fall within the same intervals, while the differences for the whole arch are somewhat larger but still acceptable in clinical practice.

CONCLUSIONS

Measurements performed by presented photogrammetry method are comparable to measurements made on 3D scanned plaster study models. Recorded measurement differences fall within the intervals acceptable in clinical practice with a very high coefficient of correlation and with no statistically significant differences found in Lundstrom analysis for arches. Presented results strongly suggest that the use of the presented method is justified in the diagnosis of orthodontic irregularities.

ACKNOWLEDGEMENTS

The research leading to these results was co-funded by the European Commission under the H2020 Research Infrastructures contract no. 675121 (project VI-SEEM).

REFERENCES

1. Rheude B, Lionel Sadowsky P, Ferriera A, Jacobson A. An evaluation of the use of digital study models in orthodontic diagnosis and treatment planning. Angle Orthod. 2005; 75(3):300–4. [DOI: 10.1043/0003-3219(2005)75[300:AEOTUO]2.0.CO;2] [PMID: 15898364]
2. Zilberman O, Huggare J, Parikakis KA. Evaluation of the validity of tooth size and arch width measurements using conventional and three-dimensional virtual orthodontic models. Angle Orthod. 2003; 73(3):301–6. [DOI: 10.1043/0003-3219(2003)073<0301:EOTVOT>2.0.CO;2] [PMID: 12828439]
3. Karatas OH, Toy E. Three-dimensional imaging techniques: A literature review. Eur J Dent. 2014; 8(1):132–40. [DOI: 10.4103/1305-7456.126269] [PMID: 24966761]
4. Hajeer MY, Millett DT, Ayoub AF, Siebert JP. Current Products and Practices: Applications of 3D imaging in orthodontics: Part I. J Orthod. 2004; 31(1):62–70. [DOI: 10.1179/146531204225011346]
5. Majstorović NV, Mačužić J, Glišić B. Referent geometric entities in orthodontics on 3D models. Stom Glas Srb. 2014; 61(2):102–12. [DOI: 10.2298/SGS1402102M]
6. Milutinović J, Nedeljković N, Nikolić P. The possibilities of computer simulation of the orthognatic surgical procedure in the treatment of class II malocclusion. Stom Glas Srb. 2008; 55(3):147–53. [DOI: 10.2298/SGS0803147M]
7. Grbović A, Mihajlović D. Practical aspects of finite element method applications in dentistry. Balk J Dent Med. 2017; 21(2):69–77. [DOI: 10.15157BJDM/2017/0011]
8. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc. 2006; 72(1):75. [PMID: 16480609]

9. Ritman EL. Micro-computed tomography-current status and developments. Annu Rev Biomed Eng. 2004; 6:185–208. [DOI: 10.1146/annurev.bioeng.6.040803.140130g] [PMID: 15255767]
10. Paddock SW, Eliceiri KW. Laser scanning confocal microscopy: History, applications, and related optical sectioning techniques. Methods Mol Biol. 2014; 1075:9-47. [DOI: 10.1007/978-1-60761-847-8_2] [PMID: 24052346]
11. Fechteler P, Eisert P, Rurainsky J. Fast and high resolution 3D face scanning. (III-4).ICIP. 2007; 3:III–81. [DOI: 10.1109/ICIP.2007.4379251]
12. Ilić DV, Stojanović L. Application of digital radiography for measuring in clinical dental practice. Srp Arh Celok Lek. 2015; 143(1-2):16–22. [DOI: 10.2298/SARH1502016I] [PMID: 25845247]
13. Todorović A, Lisjak D, Lazić V, Špadijer-Gostović A. Possible errors during the optical impression procedure. Stom Glas Srb. 2010; 57(1):30–7. [DOI: 10.2298/SGS1001030T]
14. Stewart MB. Dental models in 3D. Orthod Prod. 2001; 21–4. [DOI: 10.2319/071117-460.1]
15. Redmond WR. Digital models: a new diagnostic tool. J Clin Orthod. 2001; 35(6):386–7. [PMID: 11494942]
16. Kasser M, Egels Y. Digital photogrammetry. London: Taylor & Francis; 2002. pp. 300–9.
17. Linder W. Digital photogrammetry. Springer, 2009.
18. Potenziani M, Callieri M, Dellepiane M, Corsini M, Ponchio F, Scopigno R. 3DHOP: 3D heritage online presenter. Comput Graph. 2015; 52:129–41. [DOI: 10.1016/j.cag.2015.07.001]
19. paulbourke.net [Internet]. P. Bourke, PLY - Polygon File Format c2018 [cited 2018 March 8]. Available from: http://paulbourke.net/dataformats/ply/.
20. rfc-editor.org [Internet]. Bray T. The JavaScript Object Notation (JSON) data interchange format c2018 [cited 2018 March 8]. Available from: https://www.rfc-editor.org/info/rfc8259.
21. zbar.sourceforge.net [Internet]. ZBar bar code reader c2018 [cited 2018 March 8]. Available from: http://zbar.sourceforge.net/.
22. opencv.org [Internet]. OpenCV library c2018 [cited 2018 March 8]. Available from: https://opencv.org/.
23. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999; 8(2):135–60. [DOI: 10.1177/096228029900800204] [PMID: 10501650]
24. Quimby ML, Vig KW, Rashid RG, Firestone AR. The accuracy and reliability of measurements made on computer-based digital models. Angle Orthod. 2004; 74(3):298–303. [DOI: 10.1043/0003-3219(2004)074<0298:TAAROM>2.0.CO;2] [PMID: 15264638]
25. Leifert MF, Leifert MM, Efstratiadis SS, Cangialosi TJ. Comparison of space analysis evaluations with digital models and plaster dental casts. Am J Orthod Dentofacial Orthop. 2009; 136(1):16–e1. [PMID: 19577140] [DOI: 10.1016/j.ajodo.2008.11.019]
26. Yoon JH, Yu HS, Choi Y, Choi TH, Choi SH, Cha JY. Model Analysis of Digital Models in Moderate to Severe Crowding: In Vivo Validation and Clinical Application. Biomed Res Int. 2018; 2018:8414605. [DOI: 10.1155/2018/8414605] [PMID: 29568766]
27. Liang YM, Rutchakitprakarn L, Kuang SH, Wu TY. Comparing the reliability and accuracy of clinical measurements using plaster model and the digital model system based on crowding severity. J Chin Med Assoc. 2018; pii: S1726-4901(17)30380-5. [DOI: 10.1016/j.jcma.2017.11.011] [PMID: 29395944]

Received: 08.02.2018 • Accepted: Prihvaćen 16.05.2018

Primena fotogrametrije za prostorne analize u ortodontskoj dijagnostici

Marijana Arapović-Savić[1], Mihajlo Savić[2], Mirjana Umićević-Davidović[1], Adriana Arbutina[1], Nenad Nedeljković[3], Branislav Glišić[3]

[1]Univerzitet u Banjoj Luci, Medicinski fakultet, Katedra za ortopediju vilica, Banja Luka, Republika Srpska, Bosna i Hercegovina;
[2]Univerzitet u Banjoj Luci, Elektrotehnički fakultet, Banja Luka, Republika Srpska, Bosna i Hercegovina;
[3]Univerzitet u Beogradu, Stomatološki fakultet, Katedra za ortopediju vilica, Beograd, Srbija

KRATAK SADRŽAJ

Uvod Najčešća prostorna analiza koja se koristi u ortodontskoj dijagnostici je Lundstromova segmentna analiza. Na osnovu dobijenih rezultata merenja upoređuje se potreban i raspoloživ prostor u zubnom nizu i dobijaju informacije o višku ili manjku prostora za pravilan smeštaj zuba. Merenja se tradicionalno vrše na gipsanim studijskim modelima, ali je usled razvoja računarskih sistema sve prisutnija upotreba digitalnih reprezentacija modela u procesu merenja. Cilj ovog rada je bio da se predstavi fotogrametrijski pristup merenjima koji ne zahteva specijalizovan i skup hardver i dobijeni rezultati uporede sa merenjima na skeniranim 3D modelima.

Metod Na 50 studijskih modela su merene meziodistalne širine 24 zuba, te širine 12 segmenata i izvršena je Lundstromova prostorna analiza. Merenja su vršena na 3D skeniranom modelu studijskim modelima i u fotogrametrijskom programu OrthoPhoto4D na osnovu četiri fotografije modela u namenski projektovanom držaču modela. Program uzima u obzir konačnu udaljenost kamere od modela i vrši korekcije grešaka nastalih usled perspektivne distorzije.

Rezultati Provedena statistička analiza na prikupljenim merenjima i priloženi Bland–Altman grafici snažno sugerišu da postoji visok stepen saglasnosti između dva metoda merenja. Odstupanja za maksilu za pojedinačne segmente su iznosila do 0,25 mm sa standardnom devijacijom od 0,16 mm, za celu vilicu manje od 1 mm uz devijaciju od 0,4 mm, za mandibulu odstupanja za segmente iznose ispod 0,27 mm uz devijaciju od 0,15 mm, te za celu vilicu do 0,6 mm uz devijaciju od 0,24 mm. Koeficijenti korelacije su preko 0,985 u svim slučajevima.

Zaključak Fotogrametrijski metod se može opravdano koristiti u kliničkoj praksi za dijagnostiku ortodontskih nepravilnosti.

Ključne reči: ortodoncija; digitalni modeli; fotogrametrija; dijagnoza; terapija

UVOD

Ortodontski studijski modeli imaju više namena i predstavljaju neophodan deo ortodontske dokumentacije. Pored kliničkog ispitivanja, intraoralnih i ekstraoralnih radiografskih snimaka, studijski modeli predstavljaju nezamenjivo dijagnostičko sredstvo u ortodontskoj dijagnostici.

Direktno merenje na studijskim modelima, pored prednosti, nosi sa sobom i ograničavajuće faktore jer idealno postavljanje mernih instrumenata na modele zahteva dosta vremena, greške nastale zbog slučajnih pokreta rukom rezultiraju greškama u rezultatima, upotreba mernih instrumenata (npr. šestara po Korkhausu) vrlo je komplikovana, a problem su i nedostaci u pogledu skladištenja, izdržljivosti i prenosivosti [1, 2].

Za postavljanje pravilne ortodontske i dentofacijalne dijagnostike i planiranje lečenja koriste se RTG snimci i funkcionalne analize. Ove tehnike treba tačno da replikuju ili opišu anatomske i fiziološke činjenice i da trodimenzionalnu (3D) anatomiju prikažu precizno. Fotografija je jedan od pomoćnih dijagnostičkih metoda. Ortodonti rutinski koriste 2D statičke tehnike snimanja kraniofacijalne anatomije. Dubine struktura se ne mogu dobiti i lokalizovati sa 2D slikama i to predstavlja njihov glavni nedostatak. Razvoj informacionih tehnologija i sve šira upotreba generisanja dvodimenzionalnih i trodimenzionalnih modela koji verno opisuju realne objekte doveli su do upotrebe navedenih tehnologija u stomatologiji pa tako i u ortodontskoj praksi [3, 4].

3D modeliranje nalazi sve veću primenu u ortodontskoj praksi i definisanju određenih ortodontskih parametara [5]. Savremene tehnologije i sve češća upotreba računara u ortodonciji omogućavaju i simulacije ortodontsko-hirurških intervencija, što olakšava pacijentima odluke oko prihvatanja hirurškog zahvata [6, 7].

Razvijen je veliki broj dijagnostičkih metoda za prikaz struktura lica i zuba. Najčešće korišćene aktuelne metode su tehnike 3D snimanja – kompjuterizovana tomografija CT, kompjuterizovana tomografija Cone Beam CBCT, 3D laser, te 3D morfometrija lica 3DDFM. 3D tehnike omogućavaju detaljne i problematične informacije o mekim i tvrdim tkivima [8–12].

Digitalni modeli imaju brojne prednosti, od jednostavnijeg čuvanja, preko efikasnije razmene podataka do automatizacije određenih procesa. Međutim, postavlja se pitanje da li tako dobijeni modeli dobro opisuju realne studijske modele na kojima se bazira ortodontska terapija. Osim navedenog problema, realna prepreka široj upotrebi u ortodontskoj dijagnostici su i relativno visoki troškovi kvalitetnih trodimenzionalnih skenera i pratećeg softvera neophodnih za kvalitetan rad [13, 14, 15].

Osim 3D skeniranja, u procesima merenja studijskih ortodontskih modela moguća je i upotreba digitalne fotografije pristupom koji se zove fotogrametrija. Danas se pod fotogrametrijom podrazumeva modelovanje na osnovu više slika, iako je termin fotogrametrija složenica koja je izvedena iz sintagme „merenje sa slike“ [16].

Modeliranje zasnovano na slikama korišćenjem fotogrametrije smatra se jednom od najboljih tehnika obrada podataka o slici, koja pruža tačne podatke i detaljne 3D informacije. Ova tehnika dozvoljava određivanje preciznosti i pouzdanosti podataka, a parametri iz merenih tačaka vezanih za sliku i kontrolne tačke (CP), koje predstavljaju lokaciju odgovarajuće / korespondentne tačke u dva ili više susednih digitalnih slika, mogu se koristiti za povezivanje slike. Zbog toga su potrebne dve slike, a zatim 3D informacije mogu biti izvedene primenom projektivne i perspektivne geometrije [17].

Da bi niz fotografija mogao da bude baza za fotogrametrijsko modelovanje, neophodno je da postoji „preklapanje fotografija“.

To znači da svaki geometrijski element čiji se položaj želi da odredi mora da bude vidljiv bar na dve fotografije [16, 17].

Cilj ovog rada je bio da se prikaže alternativni pristup u merenju prostornih analiza, zasnovan na upotrebi fotogrametrije u namenski razvijenom sofveru OrthoPhoto4D, gde program izračunava greške nastale kao posledica perspektivne distorzije.

MATERIJAL I METODE

Za potrebe ovog istraživanja korišćeno je 50 studijskih gipsanih modela. Svi gipsani studijski modeli su bili sa stalnom denticijom, a zubi bez karijesa i sa adekvatno urađenim ispunima.

U prvoj fazi studijski modeli su skenirani industrijskim *Steinbichler L3D 5M* skenerom. Kreiran je programski paket OP4D (Slika 1). Osnovna karakteristika ovog sistema je da je veb baziran i da nije potrebna instalacija nikakvog posebnog softvera na računaru, osim jednog od savremenih programa za pristup vebu (Google Chrome, Mozilla Firefox i slični). Zasnovan je na 3DHOP paketu, a podržan je rad sa digitalnim modelima u PLY (Polygon File Format / Stanford Triangle Format) [18] i NXS (Nexus) [19] formatima. Sam proces merenja podrazumeva odabir objekta na kojem se vrše merenja. Sistem ja napravljen tako da je moguće izvršiti proizvoljan broj merenja na svakom od objekata (istih ili različitih vrsta). Sprovođenje različitih vrsta merenja omogućava da se na istom modelu uradi više analiza, dok višestruka merenja iste vrste omogućavaju buduću obradu rezultata, bilo u vidu srednje dobijenih vrednosti (npr. ukoliko merenja vrši isti korisnik) ili analize merenja od različitih operatera. Posle izvršenog merenja modela podaci se čuvaju u bazi podataka i kodirani su upotrebom JSON formata [20]. Ovaj format omogućava veliku fleksibilnost jer ima dinamičnu strukturu i podržava predstavljanje podataka u obliku skalara, vektora, mapa, te drugih hijerarhijski organizovanih struktura.

U drugoj fazi israživanja gipsani studijski modeli su fotografisani sa anteriorne, leve i desne bukalne strane, te gornje, odnosno donje okluzalne strane u pozicioneru koji je omogućavao jednostavno fiksiranje modela u potrebnim položajima.

Kamera je postavljena na čvrst i stabilan stativ i aktivira se putem bežičnog daljinskog upravljača u cilju sprečavanja slučajnog kretanja fotoaparata u radu. Da bi se obezbedila dovoljna dubina polja, otvor objektiva je podešen na vrednost f/22, a zum objektiva je postavljen na maksimalnih 200 mm. Osvetljenje obezbeđuje 30 × 30 cm LED izvor svetlosti postavljen na levoj strani i mat bela reflektujuća površina postavljena na suprotnoj strani. Izvori svetlosti postavljeni su na takav način da se obezbedi mekano i prilično jednoobrazno osvetljenje objekta, uz obezbeđivanje dovoljno senke da bi se mogli raspoznati detalji modela.

Posebne probleme u upotrebi fotografija u merenjima predstavljaju perspektivna distorzija te problem pri merenju dužina koje su normalne na ravan slike.

Sa ciljem povećanja tačnosti merenja, napravljen je merni uređaj koji se sastoji od postolja i nosača modela, a merenja su vršena na osnovu skupa od četiri fotografije za svaki model. Postolje je fiksirano na stabilnu površinu i ne može da se kreće u odnosu na fotoaparat tokom fotografisanja. Sastoji se od osnovne ploče, zadnje ploče i prednje ploče. Osnovna ploča sadrži niz ureza i vodilja koji omogućavaju fleksibilno pozicioniranje zadnje i prednje ploče, kao i stabilno pozicioniranje držača modela. I zadnja i prednja ploča sadrže i linije vodilje koje omogućavaju pravilno pozicioniranje kamere. Modeli su fiksirani na nosač modela pomoću jednog zavrtnja sa mekanom gumenom podlogom kako bi se izbeglo oštećenje modela. Nosač modela poseduje QR kod i oznaku slova na svakoj od četiri strane namenjene fotografisanju: T –gornja, F – frontalna, R – desna i L – leva. Važno je napomenuti i da svaki model sadrži i QR marker koji sadrži identifikaciju modela i omogućava jednostavnu automatizovanu proceduru obrade i klasifikacije u procesu obrade fotografija.

Kada su model ili više modela fotografisani, fotografije se obrađuju i parametri fotoaparata se izračunavaju automatski pomoću namenski razvijenog softvera. Obrada fotografija uključuje sledeći niz koraka:

1. Pretvaranje boje u sivu skalu i uklanjanje hromatskih aberacija korišćenjem zelenog kanala kao osnove.
2. Identifikovanje QR markera i tumačenje njihovog sadržaja korišćenjem Zbar biblioteke [21]. Ovaj korak pruža informacije o rastojanjima markera, fotografisanoj strani i identifikaciji modela.
3. Pronalaženje mernih markera korišćenjem OpenCV biblioteke [22].
4. Izračunavanje rastojanja fotoaparata i perspektivnih parametara od detektovanih lokacija markera na zadnjoj i prednjoj ploči. Ovaj korak je ključan jer omogućava ispravke grešaka usled perspektivne distorzije prisutne na fotografijama.
5. Na kraju, slika se iseca na upotrebljivu površinu koja je definisana centrima markera prednje ploče i snima se pod definisanim imenom u odgovarajući direktorijum slučaja. Svi izračunati parametri se čuvaju kao JSON kodirani dokument unutar datoteke u EXIF polju. Ovo omogućava jednostavniji i efikasniji prenos i razmenu dokumenata. Direktorijum slučaja se određuje na osnovu podataka iz QR kodova i u našem slučaju je numerička identifikacija modela povezana sa slovom „L“ za mandibulu ili „U“ za maksilu; na primer, fajl naziva „cases/001U/T.jpg“ sadrži obrađenu fotografiju gornje projekcije maksile modela broj 001.

Glavni ekran OrthoPhoto4D je podeljen na šest glavnih komponenti postavljenih u mrežu sa tri kolone i dva reda. Prvi red sadrži slike koje prikazuju prednji i bočne prikaze, dok je gornji prikaz u srednjem delu drugog reda. Donja leva sekcija sadrži listu mogućih mernih veličina, omogućavajući operateru odabir merenja individualne širine zuba, širine segmenta dva zuba, kao i interkanine i intermolarne širine. Pošto se u jednom trenutku može prikazati samo maksila ili mandibula, slike modela će se ažurirati kada korisnik izabere željeno merenje. U ovom odeljku nalazi se padajuća lista koja omogućava odabir modela koji se meri, kao i dugmad za snimanje ili ponovno učitavanje podataka merenja. Donji desni deo sadrži izračunate merne vrednosti u tri kolone.

Za svaku merenu dužinu korisnik mora da odabere veličinu za merenje i jedan od dva kraja, na primer 14–13 i tačku 14. Korisnik može da pomera i uvećava prikaze, koji se pomeraju sinhronizovano, dok željena tačka nije vidljiva bar u dva prikaza. Na primer, korisnik može odabrati tačku u „gornjem“ i „levom“ prikazu. Ovo je neophodno jer programu potrebna 3D pozicija tačke i izbor u samo jednoj slici neće proizvesti dovoljno podataka. Važno je napomenuti da se prva odabrana tačka koristi kao

osnova za izračunavanje tako da korisnik mora samo odabrati odgovarajuću poziciju po nedostajućoj osi na drugoj slici (u našem slučaju samo Z osa). Kada se proces završi na oba kraja linije, softver izračunava rastojanje u 3D prostoru i popunjava odgovarajuće polje u odeljku merenih veličina. Sve završene mere imaju zelenu boju pozadine, dok je trenutno izabrana tačka crvena ili narandžasta, u zavisnosti od faze merenja.

Vrednosti dobijene merenjima na 3D modelima i na fotografijama modela su posle toga statistički obrađene i izračunate su srednje vrednosti i standardne devijacije, te faktori korelacije, a nakon toga je proveden i upareni dvostrani T-test.

REZULTATI

U Tabeli 1 su prikazani rezultati statističke obrade podataka za maksilu. Kao što se iz vrednosti može videti, srednja greška za pojedinačne segmente ne prelazi 0,25 mm sa standardnom devijacijom manjom od 0,16 mm, dok je sumarna srednja greška za celu vilicu ispod 1 mm sa standardnom devijacijom manjom od 0,4 mm. Koeficijent korelacije je preko 0,98 za svaki segment i veći od 0,99 za celu vilicu, dok je p vrednost t-testa ispod zadanih 0,05 u svim slučajevima.

U Tabeli 2 su dati rezultati statističke analize za mandibulu. I u ovom slučaju su srednja odstupanja po segmentima manja od 0,27 mm sa standardnom devijacijom manjom od 0,15 mm, dok je srednje odstupanje za celu vilicu manje od 0,6 mm sa standardnom devijacijom manjom od 0,24 mm. Koeficijent korelacije je u svim posmatranim slučajevima veći od 0,98, dok je na nivou cele mandibule veći od 0,99. Osim u slučaju segmenta 43–44, p vrednosti su ispod 0,05, dok je u slučaju segmenta 43–44 odstupanje u merenjima manje od 0,1 mm i nema značaj u kliničkoj praksi.

Na slikama (slike 3–6) prikazani su Bland–Altman grafici za vrednosti dobijene upotrebom oba ispitivana metoda [23]. Na apscisi se nalaze srednje vrednosti oba merenja, dok je na ordinati predstavljeno odstupanje između dva metoda merenja. Crna linija predstavlja srednju vrednost odstupanja za sva obuhvaćena merenja, dok crvene linije označavaju odstupanje od po dve standardne devijacije u odnosu na srednje odstupanje. Odstupanje od 1,96 standardnih devijacija podrazumeva interval koji obuhvata 95% ispitivanih uzoraka.

Sa slika je vidljivo da većina merenja pripada intervalu između crvenih linija standardnih devijacija i da su vrednosti grupisane oko srednje vrednosti odstupanja, bez obzira na iznos merene veličine. Ovakav izgled Bland–Altman grafika sugeriše visok stepen saglasnosti između dva metoda merenja.

DISKUSIJA

Zahvaljujući prednostima digitalizacije studijskih modela, poslednjih godina zabeležen je porast primene računara u stomatološkoj praksi. U brojnim dostupnim radovima poređeni su rezultati merenja meziodistalnih širina zuba i segmenata zuba na gipsanim studijskim modelima i na digitalnim reprezentacijama modela. Dve najčešće korišćene digitalne reprezentacije su 3D skenirani modeli i digitalne fotografije modela. U literaturi su prisutna poređenja i analize vršene na direktnim merenjima na gipasnim modelima i njihovim digitalnim reprezentacijama, ali je primetan manjak analiza vršenih na indirektnim vrednostima računatim na osnovu merenja. Jedna od takvih analiza je i Lundstromova analiza, koja je obrađena u ovom radu. Usled upotrebe tri pojedinačna merenja za svaki segment od dva zuba, širina segmenta i dve zasebne širine zuba, neophodno je pored analiza pojedinačnih merenja izvršiti i analize na indirektnim računatim vrednostima. Ovaj značaj je naročito izražen kod računanja nedostatka prostora za pravilan smeštaj zuba za celu vilicu jer se u tom slučaju koristi 18 pojedinačnih merenja.

Cilj studije koju su radili Quimby i saradnici bio je da se utvrdi tačnost, ponovljivost i efikasnost merenja izvedenih na digitalnim modelima. Dentoform i gipsani studijski modeli poslužili su kao zlatni standard. Merene parametre su podelili u sedam grupa, od kojih su dve grupe bile raspoloživa i potrebna širina zubnog segmenta. Za merenja na gipsanim modelima korišćen je digitalni šestar, a standardnim kompjuterskim mišem tačke su označene na digitalnim modelima. Merenja su ponovljena i posle dve sedmice. Ponovljivost je bila visoka za merenja izvedena na i gipsanim i digitalnim modelima. Efikasnost je takođe bila slična bez obzira na način merenja. Merna odstupanja između digitalnih i gipsanih modela za celu vilicu su iznosila 0,54 mm za raspoloživi i 2,23 mm za potrebni prostor u maksili, te 2,88 mm za raspoloživi i 0,21 mm za potrebni prostor u mandibuli. Statistički značajna razlika je pronađena samo u slučaju potrebnog prostora u mandibuli. Zaključak studije je da se digitalni modeli mogu koristiti kao klinički prihvatljiva alternativa konvencionalnim gipsanim modelima [24]. Iako autori nisu sproveli analize na razlici potrebne i dostupne širine, iz objavljenih vrednosti je vidljivo da metod merenja predstavljen u našem radu ima uporediva ili bitno manja merna odstupanja, te da nisu pronađene statistički značajne razlike na nivou celih vilica.

U studiji koji su radili Leifert i saradnici poređena su merenja izvršena od strane dva ortodonta na meziodistalnim širinama zuba i dužinama zubnih lukova na gipsanim modelima i trodimenzionalnim virtuelnim 3D modelima. Razlike u merenjima na gipsanim i digitalnim modelima za nedostatak prostora je iznosio do 0,424 mm u maksili i 0,384 mm u mandibuli. Upareni t-test je pokazao statistički značajnu razliku za merenja u maksili. Vredi napomenuti da su razlike u merenjima između dva ortodonta iznosila do 0,408 mm i uporediva su sa razlikama između dva načina merenja, te su zaključci studije da su ova odstupanja prihvatljiva u kliničkoj praksi [25]. I u ovom slučaju naš metod merenja ima uporediva ili manja odstupanja uz odstustvo statistički značajnih razlika na analiziranim vrednostima. Pronađene razlike po segmentima su manje od 0,3 mm i nisu klinički značajne, dok odstupanje na nivou cele vilice od 0,8 mm takođe nije značajno u praksi.

Yoon i saradnici su ispitivali upotrebljivost intraoralnih skenera za vršenje merenja poredeći dobijene rezultate sa rezultatima dobijenim ručnim merenjima na gipsanim studijskim modelima, te merenjem 3D skeniranih studijskih modela. Dobijeni rezultati su statistički obrađeni, a izvršen je i upareni t-test. Jedna od merenih veličina je bila nedostatak prostora za celu vilicu i dobijena prosečna odstupanja između merenja na gipsanom modelu i skeniranom modelu su za maksilu iznosila do 0,58 mm uz statistički značajnu razliku, a za mandibulu do 0,63 mm, takođe uz statistički značajnu razliku. Pri poređenju merenja na gipsanom modelu i intraoralno skeniranom modelu dobijena prosečna odstupanja su iznosila do 0,86 mm za mak-

silu i 0,55 mm za mandibulu, uz pronađene statistički značajne razlike. Autori zaključuju da razlike u merenjima nisu klinički značajne i da je moguća upotreba sva tri metoda u kliničkoj praksi bez obzira na stepen teskobe [26]. Poredeći navedene rezultate sa rezultatima prezentovanim u ovom radu, vidljivo je da su odstupanja približno istih vrednosti, uz razliku da u našem slučaju nije pronađena statistički značajna razlika za cele vilice.

Liang i saradnici su ispitivali upotrebljivost 3Shape™ D800 skenera u kliničkoj praksi poredeći rezultate merenja na digitalnom modelu sa merenjima na gipsanim studijskim modelima. Modeli su bili podeljeni u tri grupe prema stepenu teskobe. Prezentovani rezultati snažno sugerišu da je opravdana klinička upotreba 3D skeniranih modela jer su prosečna odstupanja merenja za dostupan i potreban prostor bila ispod 0,3 mm, bez pronađene statistički značajne razlike. Statistički značajna razlika je pronađena pri poređenju dobijenih rezultata po stepenima teskobe [27]. Navedeni zaključci autora su u skladu sa nalazima ove studije, jer su naša odstupanja po segmentima u istim okvirima, dok je odstupanje na nivou vilice nešto većih vrednosti ali i dalje u okviru klinički prihvatljivih odstupanja.

ZAKLJUČAK

Merenja izvršena opisanim fotogrametrijskim metodom su uporediva sa merenjima izvršenim na 3D skeniranim gipsanim studijskim modelima. Pronađena odstupanja u merenjima su u okvirima prihvatljivim u kliničkoj praksi uz vrlo visok stepen korelacije i bez pronađenih statistički značajnih razlika u Lundstromovoj prostornoj analizi vilica. Navedeni rezultati snažno sugerišu opravdanost upotrebe opisanog modela u dijagnostici ortodontskih nepravilnosti.

ORIGINAL ARTICLE
ORIGINALNI RAD

DOI: 10.2478/sdj-2018-0009
UDC: 613.65:616.31-051(497.7); 616.7:616.31-051(497.7)

Work related muskuloskeletal disorders among dentists at the university dental clinic in Skopje

Vasilka Rendžova, Sonja Apostolska, Marina Eftimoska, Biljana Džipunova, Vesna Filipovska
Ss. Cyril and Methodius University, Faculty of Dental Medicine, Skopje, R Macedonia

SUMMARY

Introduction Musculoskeletal disorders (MSDs) are one of the most common types of work-related diseases that affect health workers, especially dentists. The aim of our study was to examine the presence of musculoskeletal disorders among dentists at the university dental clinic in correlation with risk factors.

Materials and methods A questionnaire survey was carried out among 78 dental practitioners aged between 20 to 60 years old, employed at the university dental clinic. Questions included data on physical and psychosocial workload, perceived general health and occurrence of musculoskeletal complaints in the past 12 months, chronic complaints, frequency and length of breaks, exercising habits as well as medical care seeking.

Results Pain in the back, neck and shoulders (84.6% / 85.9%) was the most common complaint among the majority of respondents, while reduced range of movement was noticed among significantly fewer subjects, mostly between 40-60 years of age. Prolonged statistic position was considered to be one of the main causes of MSDs (82.05%) while 73.08% of respondents stated at least two more reasons beside this one.

Conclusion The percentage of MSDs prevalence among dentists in public health sector is high. More extensive surveys should be undertaken to cover larger group of dentists from both private and public sector, in order to obtain complete analysis of the prevalence of occupational disorders in our country.

Keywords: dentists; ergonomics; musculoskeletal disorders

INTRODUCTION

According to the US department of Safety and Health Administration musculoskeletal disorders (MSDs) develop as a result of imbalance between the level of demand of physical effort at the workplace and physical capacity of worker [1]. Despite having physical and psychological effects, professional disorders can impact worker's economic state and wellbeing on a larger scale, which contributes to more frequent absence from work and early retirement [2]. Some of professional hazards in dentistry are exposure to chemical substances, radiation, dangerous biological materials and inadequate body positioning during work. Based on data received from the Occupational Information Network and US Department of Labour database, dentistry was ranked as profession that has the worst impact on the health of workers [3].

Musculoskeletal disorders are one of the most common types of work-related diseases that affect health workers, especially dentists. There are multiple factors that contribute to development of musculoskeletal disorders among dentists [4]: continuous movements, insufficient lighting, improper body position during work, psychological stress, genetics, physical conditions, age and weight [5, 6].

Ergonomics is a science about design of products and regulations that assure maximal utility and safety during work. It also studies relationship between workers, equipment and work environment. The implementation of ergonomic conditions and principles in the work place is important element in the prevention of musculoskeletal disorders and improvement of productivity and effectiveness of dentist for a longer period of time [7].

The aim of our study was to examine the presence of musculoskeletal disorders among dentists at the university dental clinic in Skopje in correlation with work- related risk factors.

MATERIAL AND METHOD

This study examined 78 dental practitioners aged between 20 to 60 years old, employed at the public health institution Dental Clinic Centre. They were given a Standard Nordisk Questionnaire consisting of two parts [8]. The first part consisted of questions regarding the gender and age, years of working experience, average working hours per day and per week, number and length of their breaks and position of their bodies while working.

The second part (Standard Nordisk Questionnaire) consisted of questions addressing the musculoskeletal disorders, the presence of genetic predisposition, the frequency of painkiller usage and questions regarding diagnosis and request for medical help among patients with these disorders.

In addition to the Standard Nordisk questionnaire, another questionnaire was distributed. This questionnaire

Address for correspondence: Vasilka RENDŽOVA, Faculty of Dental Medicine, Ss. Cyril and Methodius University, Majka Tereza 17, 1000 Skopje, R. Macedonia; *rendzova@yahoo.com*

addressed frequency and length of breaks, position of body during work, exercising habits, wearing orthopedic shoes and utilization of alternative methods for improving health. The obtained results were analyzed with descriptive statistical analysis.

RESULTS

The research was conducted on 79.59% (79/98) of the total number of dental employees at the University dental clinic, Skopje. Employees that did not participate in the research were absent due to illness, lack of time or other subjective reasons. The sample consisted of specialists 87.18% (oral surgeons, prosthodontists, orthodontists, pedodontists, periodontologists and endodontologists) and 12.82% general dentists. Most of the participants held a postgraduate degree (MSc, PhD).

Gender distribution among the participants was not equal. 73.08% of respondents were female at age 20-60, with an average working experienceof 16.9 years. The average working experience of male participants was 17.24 years. Furthermore, the amount of effective working hours among 82.05% of the respondents was 30 hours per week, while 17.95%, out of which were mainly male respondents, worked effectively for 40 hours per week.

Table 1 shows work related reasons that caused musculoskeletal disorders or discomfort. 57.69% of respondents showed genetic predisposition. 82.05% of respondents spent significant amount of time in the same position while working, 52.56% respondents reported that their work required investing lot of strength, 62.82% reported their work required repetition of movements. Furthermore, 66.67% of the respondents reported exposure to constant machine vibrations as a part of their every day work, while 73.08% described two or three work-related conditions at the same time.

Another part of our research focused on pain and other complaints related to the musculoskeletal system (Table 2), where 66 respondents (84.61%) reported pain in the lower back, out of which 33.33% reported back pain in the last 12 months. Upper back pain was noticed among 60.26% of respondents, of which 19.23% have been experiencing pain in the last 12 months. 14.10% of respondents had reduced movements, all of the age group of 40-60 years with an average length of working experience, 22.5 years. None of the respondents from the age group of 20-40 years reported presence of upper back pain. The majority of respondents (85.9%) of both age groups reported the presence of shoulder and neck pain. Moreover, 28 (35.9%) examinees reported pain in hand fingers, while 14% of examinees experienced reduced hand strength, while holding instruments. All subjects had multiple musculoskeletal conditions. 47.44% of respondents used painkillers often and 33.33% of respondents used painkillers on occasional basis. However, despite the high prevalence of complaints among respondents related to pain in different parts of the MS system, only 37.18% sought professional help and have been diagnosed with MSD.

The results further showed that 51.28% of respondents were familiar with ergonomic principles of work, while 43.59% were more informed. Partial application of ergonomic principles was noticed among 55.13% of respondents and only 14 respondents (17.95%) fully applied them during work. Another finding was that most of respondents (67.97%) worked in both positions, seating

Table 1. Work related reasons that cause musculoskeletal disorders or discomfort
Tabela 1. Razlozi vezani za rad, koji uzrokuju poremećaje muskuloskeletnih organa ili nelagodnost

Variables **Promenljive**	**Number (%)** **Broj (%)**
Total number of respondents Ukupan broj ispitanika	78
Average age Prosečna starost	41.56 ± 2.1
Men Muškarci	26.92%
Women Žene	73.8%
Average working experience - men Prosečno radno iskustvo – muškarci	17.24 years
Average working experience - women Prosečno radno iskustvo – žene	16.9 years
Effective working hours ≥ 30 hours per week Efektivno radno vreme ≥ 30 sati nedeljno	64 (82.05 %)
Effective working hours ≥ 40 hours per week Efektivno radno vreme ≥ 40 sati nedeljno	14 (17.95%)
Genetic predisposition Genetska predispozicija	45 (57.69%)
Specialists Specijalisti	68 (87.18%)
Continuous body positioning Dugotrajan isti položaj tela	64 (82.05%)
Repeated movements Ponovljeni pokreti	49 (62,82%)
Vibrations from machines and instruments Vibracije od mašina i instrumenata	52 (66.67 %)
Usage of force Upotreba sile	41 (52.56%)
Two or more characteristics Dve ili više karakteristika	57 (73.08 %)

Table 2. Prevalence of musculoskeletal complaints among dentists
Tabela 2. Prevalenca mišićno-skeletnih tegoba kod stomatologa

Variables **Promenljive**	**Number (%)** **Broj (%)**
Pain in the lower back Bol u donjem delu leđa	66 (84.61%)
Experiencing pain in the last 12 months Bol u donjem delu leđa u poslednjih 12 meseci	26 (33.33 %)
Pain in the upper back Bol u gornjem delu leđa	47 (60.26%)
Experiencing pain in the last 12 months Bol u gornjem delu leđa u poslednjih 12 meseci	15 (19.23%)
Reduced ability to move Smanjena sposobnost kretanja	11 (14.10%)
Pain in the neck and shoulders Bol u vratu i ramenima	67 (85.9%)
Pain in the hand and fingers Bol u ruci i prstima	28 (35.9%)
Have been diagnosed with MSDs and sought medical help Dijagnostikovano je MSDs i tražilo medicinsku pomoć	37.18%
Have been taking proper medications/ painkillers Uzimali lekove protiv bolova	37 (47.44%)

Table 3. Application of ergonomic principles and exercise
Tabela 3. Primena ergonomskih principa i vežbanja

Variables Promenljive	Number (%) Broj (%)
Familiar with the ergonomic principles of work Upoznati sa ergonomskim principima rada	40 (51.28%)
Partial knowledge regarding ergonomic principles of work Delimično upoznati sa ergonomskim principima rada	34 (43.59%)
Partial application of the ergonomic principles of work Delimična primena ergonomskih principa rada	43 (55.13%)
Full application of the ergonomic principles of work Potpuna primena ergonomskih principa rada	14 (17.95%)
Combined work (sitting and standing) Kombinovani rad (sedenje i stajanje)	53 (67.97%)
Working while sitting Rad u sedećem položaju	5 (6.41%)
Physical therapy (occasional) Fizikalna terapija (povremena)	40 (51.28%)
Massage (occasional) Masaža (povremena)	32 (41.03%)
Exercising (frequent) Vežbanje (često)	26 (33.33%)
Exercising (occasional) Vežbanje (povremeno)	38 (48 %)

and standing and only 6.41% of the respondents (mostly from the group of 20-40 years) were working in seating position (Table 3).

Almost all respondents were familiar that exercise, massage, physical therapy and other alternative methods affect musculoskeletal system and reduce the occurrence of musculoskeletal disorders, but only 40 (51.28%) occasionally went to physical therapy and 41.03% occasionally got massages. Only 26 (33.33%) respondents exercised frequently while 48% exercised occasionally even though exercise (strength and muscle stretching) is one of the most important factors for the preservation of the musculoskeletal system health (Table 3).

DISCUSSION

The term MSDs refers to injuries that affect soft tissues such as muscles, tendons, ligaments, joints, cartilage and nervous system. These conditions most often affect arms and back and are known as cumulative disorders caused by trauma, repetitive movements, stress, or as a syndrome of occupational overload. MSDs develop gradually within weeks, months and years and in a longer period of time may cause disabilities [9].

Several studies have examined the relationship between the occurrence of MSDs and type of profession. Dentists belong to vulnerable group constantly exposed to the threat of occupational disorders due to their static activity while working continuously for a longer period of time. Other factors that contribute to the presence of MSDs are lack of small breaks, constant repetitive movements of the arms and wrists and use of force while working [10, 11]. Another important factor that influences the occurrence of musculoskeletal disorders is working environment. According to Custodio, the positions recommended by ISO and FDI, for patient and dentist (for example, the patient is in laying position and at the "9 o'clock" orientation to the dentist) are rarely observed due to the limited workspace [12]. In their study, Burke, Main and Freeman have come to the conclusion that approximately one third of dentists are forced to retire early because of work-related difficulties [13]. A number of dental studies reported that on average, two out of three dentists experienced musculoskeletal pain [14, 15]. Most commonly reported disorders of this kind occur around spinal area, shoulders and wrist that can result in lower back pain, neck pain, brachial pain, shoulder tendonitis, carpal tunnel syndrome etc. [16, 17, 18].

Sartorio et al. indicated higher presence of MSDs (54–93%) among dental staff in Italy and significantly higher risk of exposure among senior and female dentists [19]. This study further showed that backbone, shoulder, elbow and arm were most affected.

Our research was conducted in order to investigate the prevalence of musculoskeletal disorders among dentists in the largest public health institution in our country. Seventy-eight dentists aged 20 to 60 years participated in the study. Both female and male participants were involved, specializing in different dental areas and most of them held a postgraduate degree (Master's or Doctoral Degree).

The pain in the back, neck and shoulders was the most common complaint among the majority of respondents, while reduced range of movement was noticed among significantly fewer subjects, mostly between 40-60 years of age. An interesting finding was that all examinees experienced more than one musculoskeletal disorder. Furthermore, hand pain was present with significantly lower percentage compared to the pain in the back, neck and shoulders that was connected and dependent on the area of specialty. Our examination included respondents from different dental areas of specialty that share similar positioning of neck, shoulders and spine while working. The application of force at work and vibrations is related to only few dental areas that require use of hands and fingers and that explains low percentage of complaints related to hand and finger disorders.

The results of our research agree with the results presented by several authors. Legg and Smith surveyed 285 Australian dentists, out of which 90% practiced general dentistry, and most of complaints were related to neck, shoulder, and back. About 37.5% of dentists needed medical care, while 25% reached the point of disability and 9% required prolonged absence from their practice [20]. Alexopoulos EC et al. concluded that hand/wrist complaints (46% / 60%) were one of the most important occupation related musculoskeletal disorder and ergonomic and educational interventions could hold a prominent role in its prevention [21]. Several authors pointed out that position of dental chair needed to be adjusted according to the height of the dentist, together with the light source, in order to prevent the occurrence of MSDs [22]. Furthermore, the results show high percentage of lower back pain that can be related to working conditions as large number of respondents had long work experience or inability to apply ergonomic principles of work (defective workplace, poor lighting, inability to work in a seating position, etc.).

Prolonged statistic position is considered to be one of the main causes of MSDs and should be addressed properly in order for dentists to practice preventive measures [23, 24]. These findings correspond with data obtained from our survey where 82.05% of respondents reported prolonged static posture as a cause for disorders and 73.08% of respondents reported at least two more reasons beside this one.

Recently, several studies have highlighted other factors such as obesity and physical inactivity in the development of chronic MSDs among dentists. Moreover, due to exhaustion and fatigue, caused by heavy workload and long working hours, dentists avoid physical exercise and activities [25, 26]. Published literature points out the important role of physical activity (pilates, aerobics) as a preventative ergonomic measure. Aerobic exercise improves the flow of oxygen in tissues, thereby increasing efficiency. Stretching exercises are effective measure for relaxing and reducing muscle tension caused by improper posture [27]. It is well known that prolonged static posture requires contraction of 50% of body's muscles explain the need for stretching.

Even though all respondents from our research were aware that regular exercise is of exceptional importance to the musculoskeletal health, only one third of respondents exercised regularly, while 48% exercised only occasionally. The percentage of respondents who were utilizing alternative methods such as massage or spa centers was even lower. Besides the high percentage of musculoskeletal complaints among respondents, only 37.18% sought professional help and only 47% took medication to reduce pain, which comes as a result either from the respondent's negligence or the frivolous approach to this issue.

This study covered only dentists employed in the public sector. Further studies are advised to examine dentists from private dental institutions, where working conditions impose more complex schedule of work, fewer breaks and free time as well as fewer absences from work.

CONCLUSION

The percentage of MSDs prevalence among dentists in public health sector is high. More extensive surveys should be undertaken to cover larger group of dentists from both private and public sector, in order to get complete analysis of the prevalence of occupational disorders in our country. Consequently, appropriate measures should be taken in order to inform and educate dentists regarding MSD. Awareness should be raised pointing out that dentistry, as a profession, is susceptible to high risk of occupational disorders and injuries. Ignorance and avoidance of the MSDs symptoms could lead to early career ending and therefore it is important to have a knowledge regarding its prevention.

REFERENCES

1. Gupta A, Ankola AV, Hebbal M. Dental Ergonomics to Combat Musculoskeletal Disorders: A Review. Int J Occup Saf Ergon. 2013; 19(4):561–71. [DOI: 10.1080/10803548.2013.11077005]
2. Fulton-Kehoe D, Franklin G, Weaver M, Cheadle A. Years of productivity lost among injured workers in Washington State: Modeling disability burden in workers' compensation. Am J Ind Med. 2000; 37:656–62. [PMID: 10797509]
3. Natalie R. La Rochelle. Virginia Commonwealth University. Work-Related Musculoskeletal Disorders Among Dentists and Orthodontists. http://scholarscompass.vcu.edu/etd
4. Stewart WF, Ricci JA, Chee E, Morganstein D, Lipton R. Lost productive time and cost due to common pain conditions in the US workforce. JAMA. 2003; 290:2443–54. [DOI: 10.1001/jama.290.18.2443] [PMID: 14612481]
5. Smith DR, Wei N, Zhang YJ, Wang RS. Musculoskeletal complaints and psychosocial risk factors among physicians in mainland China. Int J Ind Ergon. 2006; 36:599–603. [DOI: 10.1093/occmed/kqh117]
6. De Sio S, Traversini V, Rinaldo F, Colasanti V, Buomprisco G, Perri R, et al. Ergonomic risk and preventive measures of musculoskeletal disorders in the dentistry environment: an umbrella review. PeerJ. 2018; 15(6):e4154. [DOI: 10.7717/peerj.4154] [PMID: 29362689]
7. Sarkar PA, Shigli AL. Ergonomics in General Dental Practice. People's Journal of Scientific Research. 2012; 5(1):56–60.
8. Kuorinka I, Jonsson B, Kilborn A et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics. 1987; 18(3):233–7. [PMID: 15676628]
9. Ergonomics: The Study of Work U.S. Department of Labour Occupational Safety and Health Administration. 2000 Available from: https://www.osha.gov/Publications/osha3125.pdf.
10. Szeto GP, Ho P, Ting AC, Poon JT, Cheng SW, Tsang RC. Work-related musculoskeletal symptoms in surgeons. J Occup Rehabil. 2009; 19:175–84. [DOI: 10.1007/s10926-009-9176-1] [PMID:19381790]
11. Stomberg MW, Tronstad SE, Hedberg K et al. Work-related musculoskeletal disorders when performing laparoscopic surgery. Surg Laparosc Endosc Percutan Tech. 2010; 20:49–53. [DOI: 10.1097/SLE.0b013e3181cded54] [PMID: 20173622]
12. Custodio RA, Silva CE, Brandão JG. 2012. Ergonomics work analysis applied to dentistry, a Brazilian case study. Work 41 (Suppl 1): 690-7. [DOI: 10.3233/WOR-2012-0227-690] [PMID:22316802]
13. Burke FJ, Main JR, Freeman R. The practiceof dentistry: an assessment of reasons for premature retirement. Br Dent J. 1997; 182(7):250-4. [PMID: 9134812]
14. Rucker LM. Technology meets ergonomicsin the dental clinic: new toys for old games? J Am Coll Dent. 2000; 67(2):26–9. [PMID: 10941230]
15. Bedi HS, Moon NJ, Bhatia V, Sidhu GK, Khan N. Evaluation of Musculoskeletal Disorders in Dentists and Application of DMAIC Technique to Improve the Ergonomics at Dental Clinics and Meta-Analysis of Literature. J Clin Diagn Res. 2015; 9(6):ZC01–3. [DOI: 10.7860/JCDR/2015/14041.6126] [PMID: 26266205]
16. Morse T, Bruneau H, Dussetschleger J. Musculoskeletal disorders of the neck and shoulder in the dental professions. Work. 2010; 35(4):419–29. [DOI: 10.3233/WOR-2010-0979] [PMID: 20448321]
17. Tirgar A, Javanshir K, Talebian A, Amini F, Parhiz A. Musculoskeletal disorders among a group of Iranian general dental practitioners. J Back Musculoscelet Rehab 2015; 28(4):755–9. [DOI: 10.3233/BMR-140579] [PMID: 25547232]
18. Biswas R, Sachdev V, Jindal V, Ralhab S. Musculoskeletal disorders and ergonomic risk factors in dental practice. Ind J Dent Sci. 2012; 4(1):70–4.
19. Sartorio F, Vercelli S, Ferriero G, D'Angelo F, Migliario M, Franchignoni M. Work-related musculoskeletal diseases in dental professionals. Prevalence and risk factors. G Ital Med Lav Ergon. 2005; 27(2):165–9. [PMID: 16124525]
20. Leggat PA, Smith DR. Musculo skeletal disorders self reported by dentists in Queensland, Australia. Aust Dent J. 2006; 51(4):324–7. [PMID: 17256307]
21. Alexopoulos EC, Stathi IC, Charizani F. Prevalence of musculoskeletal disorders in dentists. BMC Musculoskelet Disord. 2004; 5:16. [DOI: 10.1186/1471-2474-5-16] [PMID: 15189564]
22. Gosavi SS, Gosavi SY, Jawade RS. Posturedontics: reducing the stress in dentistry. World J Dent. 2012; 3(4):335–9. [DOI: 10.5005/jp-journals-10015-1185]

23. Peros K, Vodanovic M, Mestrovic S, Rosin-Grget K, Valic M. Physical fitness course in the dental curriculum and prevention of low back pain. J Dent Educat. 2011; 75(6):761–7. [PMID: 21642521]
24. Roberts S, Gallardo F, Brown R. Cat of month. Critically appraised topics. Dentists's awareness of posture in reducing pain in musculoskeletal disorders. Tex Dent J. 2014; 131(4):296.
25. Harutunian K, Gargallo-Albiol J, Figueiredo R, Gay-Escoda C. Ergonomics and Musculo skeletal pain among postgraduate students and faculty members of the school of dentistry of the university of Barcellona (Spain). A cross sectional study. Med Oral Patol Oral Cir Bucal. 2011; 16(3):e425–9. [PMID: 20711125]
26. Thakar S, Shivlingesh K, Jayaprakash K, Gupta B, Gupta N, Anand R, et al. High levels of physical inactivity amongst dental professionals: a questionnaire based cross sectional study. J Clin Diagn Res. 9(1):ZC43–6. [DOI: 10.7860/JCDR/2015/10459.5466] [PMID: 25738085]
27. Kumar DK, Rathan N, Mohan S, Begum M, Prasad B, Prasad ER. Exercise prescription to prevent musculoskeletal disorders in dentists. J Clin Diagn Res. 2014; 8(7): ZE13–16. [DOI: 10.7860/JCDR/2014/7549.4620] [PMID: 25177661]

Received: 26.02.2018 • Accepted: 18.05.2018

Muskuloskeletna oboljenja kod stomatologa na stomatološkoj klinici u Skoplju

Vasilka Rendžova, Sonja Apostolska, Marina Eftimoska, Biljana Džipunova, Vesna Filipovska

Univerzitet „Sv. Ćirilo i Metodije", Stomatološki fakultet, Skoplje, Makedonija

KRATAK SADRŽAJ

Uvod Muskuloskeletni poremećaji su jedno od najčešćih oboljenja koja nastaju kao posledica rada kod većine zdravstvenih radnika, a naročito stomatologa. Cilj ovog rada je bio da se proveri prisustvo muskuloskeletnih poremećaja kod stomatologa zaposlenih na Univerzitetskoj stomatološkoj klinici u Skoplju i napravi korelacija sa faktorima rizika.

Materijal i metode Ispitivanje je sprovedeno kod 78 stomatoloških praktičara u dobi između 20 i 60 godina, koji su zaposleni na univerzitetskoj stomatološkoj klinici. Pitanja su uključivala podatke o fizičkom i psihosocijalnom opterećenju, opštem zdravlju i pojavi mišićno-skeletnih bolesti u poslednjih 12 meseci, hroničnim bolestima, učestalosti i dužini odmora, radnim navikama i traženju medicinske pomoći.

Rezultati Bol u leđima, vratu i ramena (84,6% / 85,9%) bio je najčešći problem kod većine ispitanika, dok je smanjen opseg kretanja primećen kod znatno manjeg broja ispitanika, uglavnom između 40i 60 godina starosti. Dugotrajna statička pozicija se smatra jednim od glavnih uzroka muskuloskeletnih poremećaja (MSD) (82,05%), dok je 73,08% ispitanika navelo više od dva razloga kao uzrok.

Zaključak Procenat prevalencije MSD kod zubara u sektoru javnog zdravstva je visok. Potrebno je poduzeti obimnija istraživanja kako bi se pokrila veća grupa stomatologa iz privatnog i javnog sektora, da bi se dobila potpuna analiza prevalencije profesionalnih poremećaja u našoj zemlji.

Ključne reči: zubari; ergonomija; mišićno-skeletni poremećaji

UVOD

Prema američkom odeljenju za bezbednost i zdravstvenoj administraciji, mišićno-skeletni poremećaji nastaju kao rezultat neravnoteže između fizičkog napora na radnom mestu i fizičkog kapaciteta radnika [1].

Profesionalne bolesti, pored fizičkih, psiholoških i socijalnih bolesti, imaju ekonomske i sigurnosne posledice kada počnu direktno da utiču na radne kapacitete, do sve češćeg odsustva sa posla i prevremenog penzionisanja [2]. Neke profesionalne opasnosti u stomatologiji vezane su za izloženost hemijskim supstancama, zračenju, opasnim biološkim materijalima i neadekvatan položaj tela tokom rada. Na osnovu podataka dobijenih iz baze podataka o profesionalnoj informativnoj mreži i baze podataka Ministarstva rada SAD, stomatologija je rangirana kao profesija sa visokim rizikom po zdravlje radnika [3].

Muskuloskeletni poremećaji su jedno od najčešćih oboljenja koje nastaje kao posledica rada kod većine zdravstvenih radnika, a naročito stomatologa. Postoji više faktora koji dovode do muskuloskeletnih poremećaja kod stomatologa [4]: neprekidno kretanje, nedovoljno osvetljenja, nepravilno držanje tela tokom rada, psihološki stres, genetika, fizički uslovi, starost i težina [5, 6].

Ergonomija je nauka koja se bavi dizajnom opreme za rad i propisima koji osiguravaju maksimalnu efikasnost i sigurnost tokom rada. Takođe ispituje odnos između radnika, opreme i radnog okruženja. Primena ergonomskih uslova i principa na radnom mestu je važan element u prevenciji muskuloskeletnih poremećaja i poboljšanju produktivnosti i efikasnosti stomatologa na duži period [7].

Imajući ovo u vidu, cilj ovog rada je bio da proveri prisustvo muskuloskeletnih poremećaja kod stomatologa zaposlenih na Univerzitetskoj stomatološkoj klinici u Skoplju i napravi korelaciju sa faktorima rizika vezanim za rad.

METODOLOGIJA

Ispitivanje je sprovedeno kod 78 stomatologa praktičara u dobi između 20 i 60 godina, zaposlenih u javnoj zdravstvenoj ustanovi Stomatološki klinički centar. Ispitanici su dobili standardni upitnik za Nordisk koji se sastoji od dva dela [8]. Prvi deo sadrži pitanja koja se tiču pola i starosti ispitanika, godina radnog iskustva, prosečnog radnog vremena (dnevno i nedeljno), broja i dužine njihovih pauza tokom rada i položaja tela tokom rada.

Drugi deo (Standardni Nordijski upitnik) sastojao se od pitanja koja se odnose na mišićno-skeletne poremećaje, prisustvo genetske predispozicije, učestalost upotrebe lekova protiv bolova i pitanja vezanih za dijagnostikovana MSD i zahteve za medicinskom pomoći.

Pored standardnog upitnika, dat je i još jedan upitnik koji je sadržao pitanja o frekvenciji i dužini pauze, o položaju tela tokom rada, nošenju ortopedske obuće, navikama za vežbanje, istezanju mišića tokom radnog dana i korišćenju alternativnih metoda zdravstvene zaštite kao što su centri za masažu, odnosno poznavanju ergonomskih principa rada i njihove primene. Dobijeni rezultati su analizirani deskriptivnom statističkom analizom.

REZULTATI

Istraživanje je sprovedeno na 79,59% (79/98) od ukupnog broja stomatologa na Univerzitetskoj stomatološkoj klinici u Skoplju. Razlozi zbog kojih ostali zaposleni nisu bili deo istraživanja bili su odsustvo zbog bolesti, nedostatka vremena i drugih subjektivnih razloga. Uzorak se sastojao od 87,18% specijalista (iz oblasti oralne hirurgije, protetike, ortodoncije, dečje stomatologije, parodontologije i endodoncije) i 12,82% opštih stomatologa. Većina učesnika je imala završene postdiplomske studije (magistarske ili doktorske studije).

Položaj među našim učesnicima nije bio ravnopravan. Ženskog pola je bilo 73,08% ispitanika, sa prosečnim radnim iskustvom od 16,9 godina. Prosečno radno iskustvo muških učesnika bilo je 17,24 godine. Osim toga, broj efektivnog radnog vremena kod 82,05% ispitanika je iznosio 30 sati nedeljno, dok je 17,95% (uglavnom muškarci) radilo efektivno i 40 sati nedeljno.

Tabela 1 prikazuje razloge vezane za rad koji uzrokuju poremećaje mišićno-skeletnog sistema ili neugodnost. U opisu posla, 82,05% je izjavilo da provode dugi period u istoj poziciji, 52,56% je prijavilo da je njihov rad povezan sa istezanjem, kod 62,82% ispitanika to su ponavljajući pokreti. Da su vibracije mašinskih instrumenata sastavni deo njihovog rada izjavilo je 66,67% ispitanika, dok se 73,08% ispitanika u opisu rada odlučilo za dve ili više ponuđenih karakteristika.

Još jedan deo našeg istraživanja fokusirao se na bol i druge žalbe vezane za mišićno-skeletni sistem (Tabela 2) – 66 ispitanika (84,61%) prijavilo je bol u donjem delu leđa, od čega 33,33% u zadnjih 12 meseci. Bol u donjem delu leđa je primećen kod 60,26% ispitanika, od kojih se u 19,23% bol javio u poslednjih 12 meseci. Smanjen raspon pokreta imalo je 14,10% ispitanika (starosne grupe od 40 do 60 godina sa prosečnom dužinom radnog iskustva od 22,5 godina). Nijedan od ispitanika iz starosne grupe od 20 do 40 godina nije prijavio bolove u leđima. Većina ispitanika (85,9%) obe starosne grupe prijavilA je bol u ramenima i vratu. Štaviše, 28 (35,9%) ispitanika je prijavilo bol u prstima ruke, dok je 14% ispitanika doživelo gubitak osetljivosti tokom rada. Svi su imali višestruke muskuloskeletne tegobe. Što se tiče upotrebe lekova protiv bolova, 47,44% ispitanika ih vrlo često koristi, dok ih 33,33% ispitanika koristi povremeno. Međutim, uprkos visokoj prevalenciji pritužbi među ispitanicima, samo 37,18% je tražilo stručnu pomoć i imalo dijagnostikovano MSD.

Rezultati su dalje pokazali da je 51,28% ispitanika upoznato sa ergonomskim principima rada, dok je ostalih 43,59% samo delimično upoznato. Delimična primena ergonomskih principa primećena je kod 55,13% ispitanika, a samo 14 ispitanika (17,95%) potpuno ih primenjuje tokom rada. Još jedan od zaključaka je bio da većina ispitanika (67,97%) radi kombinovano (sedeći i stojeći), a samo 6,41% ispitanika (uglavnom iz grupe od 20 do 40 godina) radi u sedećem položaju (Tabela 3).

Gotovo svi ispitanici smatraju da vežbanje, masaža, fizikalna terapija i druge alternativne metode utiču na mišićno-skeletni sistem i smanjuju pojavu mišićno-skeletnih poremećaja, ali samo 40 (51,28%) ponekad ide na fizikalnu terapiju, a 41,03% povremeno na masaže. Vežbanje i vežbe istezanja mišića, kao neke od najvažnijih faktora za očuvanje zdravlja mišićno-skeletnog sistema kod stomatologa, često praktikuje samo 26 (33,33%) ispitanika, dok 48% vežba samo povremeno (Tabela 3).

DISKUSIJA

Termin MSD odnosi se na povrede koje utiču na meka tkiva kao što su mišići, tetive, ligamenti, zglobovi, hrskavica i nervni sistem. To su kumulativni poremećaji uzrokovani traumom, ponavljajućim pokretima, stresom ili kao sindrom profesionalnog preopterećenja. Generalno se razvijaju postepeno tokom nekoliko nedelja, meseci i godina i obično su bolni i mogu onesposobiti pacijenta [9].

Nekoliko studija je ispitivalo odnos između pojave MSD i vrste profesije. Stomatolozi pripadaju ranjivoj grupi koja je stalno izložena pofesionalnim oboljenjima zbog statičke pozicije, kontinuirano duži period. Drugi faktori koji doprinose prisustvu MSD su nedostatak malih pauza, stalno ponavljajući pokreti ruku i zglobova i istezanje tokom rada [10, 11]. Još jedan važan faktor koji utiče na pojavu mišićno-skeletnih poremećaja je radno okruženje. Custodio smatra da se pozicije koje preporučuju ISO i FDI, kako za pacijenta, tako i za zubara (tj. ležeća pozicija pacijenta i postavljanje zubara na poziciju „devet sati“) retko primenjuju zbog ograničenih radnih prostora [12]. U svojoj studiji, Burke, Main i Freeman su došli do zaključka da je otprilike jedna trećina stomatologa prisiljena da se ranije penzioniše zbog poteškoća vezanih za rad [13]. Brojne stomatološke studije kažu da su u proseku dva od tri stomatologa doživela muskuloskeletni bol [14, 15]. Najčešće prijavljeni poremećaji kod zubara su poremećaji kičme, ramena i zgloba, koji mogu dovesti do bolova u leđima, bolu u vratu, brahijalnom bolu, tendinitisa na ramenima, sindroma karpalnog tunela itd. [16, 17, 18].

Sartorio, Vercelli, Ferriero i sar. ukazuju na veće prisustvo MSD (54–93%) među stomatološkim osobljem u Italiji i značajno veći rizik od izloženosti kod starijih i ženskih stomatologa [19]. Ova studija je dalje pokazala da su najviše pogođeni kičma, ramena, lakat i ruke.

Naše istraživanje je obavljeno kako bi se videla prevalencija mišićno-skeletnih poremećaja kod zubara u najvećoj javnoj zdravstvenoj ustanovi u zemlji. Ispitivanje je obuhvatilo 78 stomatologa starosti od 20 do 60 godina, oba pola i iz različitih specijalnosti, a većina ih je sa postdiplomskim studijama (magistarske ili doktorske studije).

Bol u leđima, vratu i ramenima najčešći je problem među većinom ispitanika, dok je smanjen opseg kretanja primećen kod značajno manjeg broja ispitanika, uglavnom između 40 i 60 godina života. Zanimljiv je podatak da su svi ispitanici prijavili više od jednog mišićnoskeletnog poremećaja.

Pored toga, bol u ruci je zastupljen sa značajno nižim procentom u odnosu na bol u leđima, vratu i ramenima, koji je povezan i zavisi od vrste specijalnosti. Naše ispitivanje je obuhvatilo ispitanike iz različitih područja specijalnosti, kod kojih je zajedniccko pozicioniranje vrata, ramena i kičme tokom rada. Istezanje i vibracije tokom rada su karakteristični za određene specijalnosti kojima je zajedničko korišćenje ruku i prstiju, što je razlog za nizak procenat žalbi povezanih sa poremećajima ruku i prstiju.

Rezultati našeg istraživanja poklapaju se sa rezultatima koje je iznelo nekoliko autora. Legg i Smith ispitali su 285 australijskih stomatologa, od kojih je 90% praktikovalo opštu stomatologiju, a većina njihovih problema je povezana sa vratom, ramenima i leđima. Oko 37,5% stomatologa tražilo je medicinsku pomoć, dok je 25% dostiglo tačku invalidnosti, a 9% je zatražilo produženo odsustvo iz svoje prakse [20]. Alekopoulos i saradnici su zaključili da su problemi sa rukama / zglobovima (46% / 60%) od najvećeg značaja za profesionalne mišićno-skeletne poremećaje, a ergonomske i obrazovne intervencije mogu imati značajnu ulogu u njihovoj prevenciji [21].

Nekoliko autora ističe da položaj stomatološke stolice treba prilagoditi prema visini zubara, zajedno sa izvorima svetlosti, kako bi se sprečila pojava MSD [22].

Nadalje, rezultati pokazuju visok procenat bolova u donjem delu leđa, koji se mogu odnositi na uslove rada, odnosno veće

prisustvo ispitanika sa dugogodišnjim radnim iskustvom ili nemogućnost primene ergonomskih principa rada (neispravno radno mesto, loše osvetljenje, nesposobnost rada u sedištu i dr.).

Dugotrajna statička pozicija se smatra jednim od glavnih uzroka MSD i trebalo bi da bude fokus procene rizika od strane profesionalnih doktora kako bi se olakšao razvoj efikasnih preventivnih strategija [23, 24]. Ovi nalazi su u skladu sa podacima dobijenim iz našeg istraživanja, u kojem je 82,05% navelo produženi statički položaj kao uzrok poremećaja, a 73,08% ispitanika navelo je još dva razloga.

Nedavno je nekoliko istraživanja ukazalo da i drugi faktori, kao što su gojaznost i fizička neaktivnost, utiču na razvoj hroničnog MSD kod stomatologa. Štaviše, zbog iscrpljenosti i zamora, uzrokovanih velikim opterećenjem i dugim radnim vremenom, zubari izbegavaju fizičke vežbe i aktivnosti [25, 26].

Objavljena literatura ističe fizičku aktivnost (pilates, aerobik) kao važnu preventivnu ergonomsku meru. Ove vežbe poboljšavaju protok kiseonika u tkivima, čime povećavaju efikasnost. Vežbe istezanja su efikasna mera za opuštanje i smanjenje napetosti mišića uzrokovanih nepravilnim držanjem [27]. Poznato je da produženi statički položaj zahteva kontrakciju 50% telesnih mišića, što ukazuje na potrebu za istezanjem.

Iako svi ispitanici iz našeg istraživanja smatraju da je redovno vežbanje od izuzetnog značaja za mišićno-skeletno zdravlje, samo jedna trećina ispitanika redovno vežba, a 48% vežba samo povremeno. Procenat koji ukazuje na korišćenje drugih alternativnih metoda kao što su masaža ili spa centri je još niži. Pored visokog procenta mišićno-skeletnih bolesti među ispitanicima, samo 37,18% je zatražilo stručnu pomoć, a svega 47% uzimaju lekove za smanjivanje bolova, što može biti rezultat nehata ispitanika ili neodgovoran pristup po ovom pitanju.

Ova studija pokazuje stanje zdravlja doktora stomatologije u javnom sektoru. Ostaje da se istraže položaji lekara iz privatnih stomatoloških ustanova, gde borba za pacijente i njihovo očuvanje nameće složeniji raspored rada, manje pauza i slobodnog vremena, kao i ređe odsustvo s posla.

ZAKLJUČAK

U zaključku se može reći da je procenat zastupljenosti MSD kod zubara u javnom sektoru zdravstva visok. Potrebno je preduzeti opsežnija istraživanja kako bi se pokrila veća grupa stomatologa iz privatnog i javnog sektora i dobila potpuna slika o postojanju profesionalnih oboljenja u našoj zemlji. Shodno tome, trebalo bi preduzeti odgovarajuće mere informisanja, edukovanja i podizanja svesti kod zubara o činjenici da stomatologija nosi visok rizik od profesionalnih oboljenja i povreda, a samim tim i potencijalno ranog završetka karijere, i načinima na koje da se to spreči.

CASE REPORT
PRIKAZ IZ PRAKSE

DOI: 10.2478/sdj-2018-0010
UDC: 616.314.3-001.5-053.2; 616.314-089.87-053.2

Traumatic extraction of upper central incisors

Svjetlana Janković[1], Aleksandra Žuža[2], Bojana Davidović[1], Ivana Simić[3], Lado Davidović[2,1]

[1]University of East Sarajevo, Faculty of Medicine, Department of Children and Preventive Dentistry and Orthodontics, Foča, Republika Srpska, Bosnia and Herzegovina;
[2]University of East Sarajevo, Faculty of Medicine, Department of Dental Pathology, Foča, Republika Srpska, Bosnia and Herzegovina;
[3]University of East Sarajevo, Faculty of Medicine, Department of Oral Rehabilitation, Foča, Republika Srpska, Bosnia and Herzegovina

SUMMARY

Introduction Tooth and other oral tissue damage can occur at any time of life. Traumatic extraction is a complex traumatic injury characterized by complete dislodgement of the tooth from its alveolus. The diagnosis of traumatically injured teeth includes X-rays and a detailed clinical examination.

Case report A twelve-year-old boy reported at the dental clinic of the Faculty of Medicine due to the injury in the anterior maxillary region. It was a sport injury. The time elapsed since the accident was 2 hours and 20 minutes. According to the clinical examination and X-rays the diagnosis was: The teeth 11 and 21 – Complete traumatic dental avulsion and fracture; 22- Hypodontia and chin contusion and laceration. The teeth were brought in physiological solution. After applying local anesthetic, soft tissue was cleaned, the teeth positioned back in their alveoli and an immobilizing splint of fiberglass fibers placed. The patient was administered antibiotics and recommended tetanus prophylaxis. Seven days after the injury, teeth were treated endodontically. After one month, the immobilizing splint was removed. The tooth 21 was definitely obturated and composite buildups were done on both teeth. Calcium hydroxide dressing was left in the canal of the tooth 11. One month and 3 weeks after the injury, a fistula appeared above the tooth 11, and the treatment was finally completed after seven months.

Conclusion Traumatic tooth injuries, of any kind, require urgent treatment as time loss usually reduces chances for successful treatment. One year after the injury, the patient had no symptoms and the result was functional and aesthetically acceptable.

Keywords: avulsion; trauma; teeth extraction; immobilization splint

INTRODUCTION

Traumatic injuries of teeth and other oral tissues can occur at any time of life. They happen usually between 1-3 years in primary and 8-11 years in permanent dentition [1, 2]. The most commonly affected teeth are upper central and lateral maxillary incisors that are more exposed to injuries due to anterior position [3]. Injuries of anterior teeth can lead to phonetic, functional, aesthetical problems as well as disorders in occlusion [1]. Preliminary studies suggest that boys are more prone to trauma [4–8].

Traumatic tooth extraction (Avulsio completa, Extrusio completa, Luxatio completa dentis, Exarticulatio completa) is a complete loss of a tooth from the alveolus and it is one of the most serious tooth injuries. Although clinically visible alveolus is easily detected, the diagnosis of traumatic tooth injuries is only established after the X-ray examination. Differential diagnostic considerations are tooth inntrusion (Intrusio dentis) and root fracture with the loss of crown (Fractura radicis dentis). The main cause of traumatic extraction in primary dentition is fall, while in permanent dentition it is direct (frontal) stroke of the tooth. The frequency of these injuries in primary dentition is 7%, while in permanent dentition it is lower and about 0.9% of all tooth injuries [9].

Traumatic tooth injuries of any kind require immediate treatment as any loss of time reduces the chances of successful treatment. In the case of tooth avulsion, the success of tooth replantation, posttraumatic period, as well as the possibility and the rate of complications, depends on numerous factors [10]. The most important are: the time between the injury and the time of tooth replantation, the way tooth is kept during this time period, the stage of development of the root, the condition of alveolar bone, the preliminary condition of the crown of the tooth, pulp and periodontal ligament, the existence of possible orthodontic irregularities as well as the replantation procedure itself [11]. Although long-term prognosis for retaining tooth in the jaw is not certain, due to the importance of preserving the height of alveolar ridge, function, phonetics and esthetics, it is always important to try replantation if there are adequate conditions for it.

The aim of this paper was to show the procedure, the treatment and complications after the tooth avulsion.

Address for correspondence: Svjetlana JANKOVIĆ, Vojvode Pubnika br. 1, 7300 Foča, Bosna i Hercegovina;
svjetlanajankovic@yahoo.com

CASE REPORT

A 12-year-old boy visited nearest dental clinic in Visegrad due to a tooth injury in the upper jaw after falling during sport activity. Patient gave a history of the fall and he did not show any signs or symptoms of neurological damage. Due to the lack of material for the immobilization splint, the boy was sent to a dental clinic at the Faculty of Medicine in Foca. After obtaining accident history and performed clinical examination (Figure 1) and X-ray (Figure 2), the following diagnosis was made: The teeth 11 and 21 – Complete traumatic dental avulsion; 22- Hypodontia; 11 – Traumatic tooth fracture class I; 21 - Traumatic tooth fracture class II as well as chin contusion and laceration.

The teeth were transported in a glass bottle with physiological solution (Figure 3). The available treatment options were explained to the parents. After 2 hours and 20 minutes, the replantation procedure was performed as per recommendation of The International Association of Dental Traumatology – IADT [12]. Local anesthesia was administered. In order to remove impurities and blood clots, injured region was cleaned with sterile gauze soaked with saline. Removal of soft deposits from adjacent teeth on which the splint was to be placed was performed. 37% orthophosphoric acid was applied for 30 seconds (Figure 4). After rinsing and drying (Figure 5), an adhesive was placed. During this time, the avulsed teeth were removed from the transport medium, carefully rinsed with saline and on the vestibular surface of the crown the same procedure of etching with the acid (Figure 6) and adhesive was performed. The alveoli were rinsed with saline and avulsed teeth were slowly replanted using digital pressure only. An immobilizing splint was installed (Figure 7). The time elapsed from the moment of injuries to the completion of replantation was 2 hours and 45 minutes. Tetanus prophylaxis was recommended, tetracycline antibiotics prescribed for 5 days and analgesics as needed. Patient was advised to take soft diet and maintain good oral hygiene. The postop checkup was scheduled 7 days after.

At the first checkup, the replanted teeth were mostly firm and stable on mild palpation. After clinical and radiographical evaluation root canal was performed on both teeth 11 and 21 according to the standard procedure. After copious irrigation with physiological solution and drying the canal with paper points, the teeth were filled with calcium hydroxide (*Calcipulpe®Septodont, Cedex, France*) and patient was scheduled for the next checkup in 7 days. At the second checkup, 15 days after the injury, the re-

Figure 1. Traumatic dental avulsion of teeth 11, 21
Slika 1. *Avulsio completa dentes traumatic* zuba 11, 21

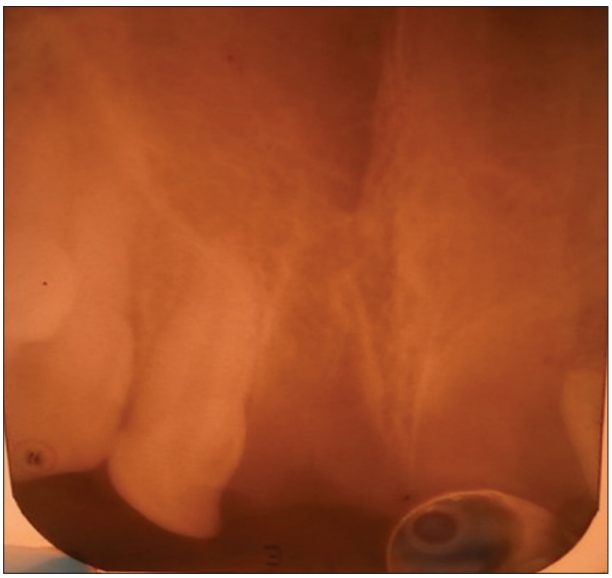


Figure 2. X ray of the teeth 11, 21
Slika 2. RTG snimak zuba 11, 21

Figure 3. Glass jar with a physiological solution in which the teeth 11 and 21 were transported
Slika 3. Staklena teglica sa fiziološkim rastvorom u kojoj su doneseni zubi 11, 21

Figure 4. Orthophosphoric acid application on adjacent teeth
Slika 4. Postavljanje ortofosforne kiseline na susedne zube

Figure 5. The teeth after rinsing orthophosphoric acid
Slika 5. Izgled zuba posle nagrizanja kiselinom

Figure 6. Orthophosphoric acid applied on avulsed teeth
Slika 6. Tretiranje izbijenih zuba ortofosfornom kiselinom

Figure 7. Immobilization splint in situ
Slika 7. Izgled imobilizacionog splinta

planted teeth were not completely firm to palpation, while on the mild vertical and horizontal percussion they were sensitive, especially the tooth 11. Taking into account the size of the injured area, hypodontia of the tooth 22, the time that elapsed from the moment of injury to teeth replantation, the immobilizing splint was kept in place for another two weeks. One month after the injury, calcium hydroxide dressing was removed, canals irrigated with 2% sodium hypochlorite solution and physiological solution. The X ray examination was done. Due to the satisfactory clinical and radiological findings the tooth 21 was finally obturated while calcium hydroxide was placed back in the canal of the tooth 11. In the same visit, the immobilization splint was removed. Then after, the teeth that were in the splint were treated with *Fluorogal®Forte Gel, Galenika A.D. Belgrade*. The patient was scheduled for another visit in three days. After 1 month and 3 days, composite buildups were done on both teeth, 11 and 21. The tooth 21 was definitely obturated (Gutaperka points and pastes for definitive obturation) while on the tooth 11 root canal treatment continued until all symptoms of chronic infection were gone. After 1 month and 3 weeks, a fistula appeared above the root of the tooth 11. Calcium hydroxide was replenished every month, and seven months after the injury, the tooth 11 was definitely obturated. One year after the injury, the patient did not have any subjective sympthoms, and the result achieved was functionally and aesthetically acceptable (Figure 8). However, X ray showed the initial signs of internal resorption of the tooth 21 (Figure 9). The patient has been monitoring on regular checkups scheduled every six months patient for up to 5 years.

Figure 8. Composite buildups on the teeth 11, 21
Slika 8. Urađene kompozitne nadogranje na zubima 11, 21

Figure 9. Definitive root canal obturation on teeth 11, 21 after one year
Slika 9. Definitivno punjenje korenskih kanala 11, 21 posle godinu dana

DISCUSSION

It has been recommended in some studies that every avulsed tooth should be replanted regardless of the time between the accident and replantation [9]. Considering

the age of the patient, the size of injured area, the way the teeth were kept in saline, and hypodontia of the tooth 22, replantation was also chosen in our case. The parents were presented with options and minimal chances for successful treatment of teeth replantation. Also they understood posttraumatic period and possible complications.

Extraalveolar time can be short (less than 20 min), medium (20-60 min) and long (more than 60 min). Although for our patient extraalveolar time was long (2 hours and 20 minutes after the injury), avulsed central incisors were replanted and the immobilization splint was placed. It is believed that periodontal ligament maintains its vitality within the first 20 minutes of the injury [12, 13, 14]. The teeth replanted within that time frame have the best prognosis and the greatest possibility for healing of periodontal ligaments [12]. However, the literature presents cases of tooth restoration even after 36 hours of injury [15]. Ideally, avulsed tooth is to be returned to the alveolus immediately after the injury occurs. If this is not done, it is necessary to put the tooth in the transport medium and, as soon as possible, refer patient to the dentist. The type of media in which the tooth is stored determines the long-term prognosis of the replanted tooth. Ideal medium should preserve most of functional capabilities of periodontal ligament cells [14]. The tooth must not be dried or transported in dry, which occurs when wrapping in wipes and gauze or similar things. This leads to dehydration of still preserved cells on the surface of root that start to die in dry medium. There are various media for storing avulsed teeth that are widely available (water, saliva, saline, milk, ...) as well as specialized media. Water can protect the tooth from dehydration but if it is used for more than 20 minutes it leads to rapid deterioration of periodontal ligament cells [16].

Saliva is easily accessible and favorable storage medium if used for less than one hour. Research has shown that saline as an environment for storing avulsed teeth can also be harmful to periodontal ligament cells if used for more than two hours because there are not enough essential nutrients such as magnesium, calcium and glucose, which are important for the metabolic needs of periodontal cells [17]. Modern research suggests that milk is an excellent storage medium for up to 6 hours because it does not have bacteria and has pH and osmolality compatible with those of the periodontal ligament cell and has nutrients such as amino acids, carbohydrates and vitamins [9, 18, 19]. There are several types of special media for transportation of avulsed teeth: Hank's Balanced Saline Solution (HBSS), DentoSafe and ViaSpan media for tissue and organ transplantation [3, 19]. Today, DentoSafe (Dentosafe GmbH, Iserlohn, Germany) is considered to be the most appropriate media for preserving and transporting avulsed tooth [16], and therefore DentoSafe vials should be available in all places at risk of dental trauma such as schools, daycares, children's playgrounds and sport fields.

Endodontic treatment of injured teeth, in our patient, started after seven days. Some authors point out that, in order to prevent necrosis of the pulp of the avulsed tooth, it is necessary to start the root canal treatment for 7-10 days from avulsion [14], which is in accordance with our procedure. Any further delay greatly increases the risk of post-implantation necrosis and loss of teeth [16]. Post-dental trauma complications can occur in pulp, periodontal ligament, and surrounding structures. The most common are pulp necrosis [20] and root resorption [10, 21]. One month and 3 weeks after the injury a fistula appeared above one replanted tooth (11) in our case. There was also palpation and percussion sensitivity on the same tooth. Some authors suggest that optimal length of having the immobilization splint, for regeneration of periodontal ligament is two weeks [12, 16]. Due to the size of traumatic field and hypodontia of the tooth 22 our patient wore a splint longer than recommended time. In our case the patient had two avulsed teeth even though the most common is just one affected tooth [3].

Trauma has serious aesthetical, functional, psychological and economic consequences for patients and their parents [16, 22]. Our patient and his parents were unaware that teeth can be replanted back to their place until dentist suggested such an intervention. Other studies conducted on this topic have also shown that parents' knowledge of tooth injuries and possible treatment is inadequate [22, 23]. Everyone involved in childcare should be properly educated in prevention and treatment of all kinds of dental trauma. Replantation of avulsed tooth in children is not important only from functional point, but it also has great psychological, emotional and social significance both for the child and parents.

CONCLUSION

Early tooth loss has a negative impact on child's psychosocial development. It is therefore important to educate parents and all childcare personnel (educators, teaching staff, trainers) about injury prevention, urgent treatment, possibilities of replantation of avulsed teeth, as well as the procedure and possible way of transporting avulsed teeth. Transporting mediums for avulsed teeth should be available in all daycares, schools and sports clubs. In addition children involved in sport activities should be wearing sport guards.

REFERENCES

1. Sari ME, Ozmen B, Koyuturk AE, Tokay U, Kasap P, Guler D. A retrospective evaluation of traumatic dental injury in children who applied to the dental hospital, Turkey. Niger J Clin Pract. 2014; 17(5):644–8. [DOI: 10.4103/1119-3077.141438] [PMID: 25244279]
2. Bücher K, Neumann C, Hickel R, Kühnisch J. Traumatic dental injuries at a German university clinic 2004-2008. Dent Traumatol. 2013; 29(2):127–33. [DOI: 10.1111/j.1600-9657.2012.01149.x] [PMID: 22613081]
3. Karayilmaz H, Kirzioglu Z, Erken Gungor O. Aetiology, treatment patterns and long-term outcomes of tooth avulsion in children and adolescents. Pak J Med Sci. 2013; 29(2):464–8. [PMID: 24353557]
4. Hasan AA, Qudeimat MA, Andersson L. Prevalence of traumatic dental injuries in preschool children in Kuwait-a screening study. Dent Traumatol. 2010; 26(4):346–50. [DOI: 10.1111/j.1600-9657.2010.00891.x] [PMID: 20662888]

5. Zaleckiene V, Peciuliene V, Brukiene V, Drukteinis S. Traumatic dental injuries: etiology, prevalence and possible outcomes. Stomatologija. 2014; 16(1):7–14. [PMID: 24824054]
6. Schuch HS, Goettems ML, Correa MB, Torriani DD, Demarco FF. Prevalence and treatment demand after traumatic dental injury in South Brazilian schoolchildren. Dent Traumatol. 2013; 29(4):297–302. [DOI: 10.1111/edt.12003] [PMID: 23067235]
7. Abukabbos H, Al Sineedi F, Guelmann M. Management of complications after traumatic injuries to immature permanente maxillary incisors: a five years follow up case report. Oral Health Dent Manag. 2014; 13(2):429–34 [PMID: 24984660]
8. Lam R. Epidemiology and outcomes of traumatic dental injuries: a review of the literature. Aust Dent J. 2016; 61:S4–20. [DOI: 10.1111/adj.12395] [PMID: 26923445]
9. Šurdilović D, Apostolović M, Igić M, Kostadinović Lj, Tričković Janjic O. Therapy of the patient having traumatic extraction of permanent upper central incisors. Acta Stomatologica Naissi 2008; 24:833–40.
10. Niikuni N, Seki N, Sato K, Nasu D, Shirakawa T. Traumatic injury to permanent tooth resulting in complete root resorption: a case report. J Oral Sci. 2007; 49(4):341–4. [DOI: 18195520] [PMID: 18195520]
11. Beloica D, Vulović M, Duggal M, Dimitrijević B. Povrede zuba. Stomatološki fakultet, Univerzitet u Beogradu. 2007.
12. Flores MT, Andersson L, Andreasen JO, Bakland LK, Malmgren B, Barnett F, et al. Guidelines for the management of traumatic dental injuries. II. Avulsion of permanent teeth. Dent Traumatol. 2007; 23(3):130–6. [DOI: 10.1111/j.1600-9657.2007.00605.x] [PMID: 17511833]
13. Panzarini SR, Trevisan CL, Brandini DA, Poi WR, Sonoda CK, Luvizuto ER, et al. Intracanal dressing and root canal filling materials in tooth replantation: a literature review. Dent Traumatol. 2012; 28(1):42–8. [DOI: 10.1111/j.1600-9657.2011.01023.x] [PMID: 22230725]
14. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 4. Factors related to periodontal ligament healing. Endod Dent Traumatol. 1995; 11(2):76–89. [PMID: 7641622]
15. Adil NF, Ahmed SS, Jindal MK, Arshad SH. Delayed replantation of avulsed teeth. J Indian Soc Pedod Prev Dent. 2007; 25:17–9. [PMID: 17921635]
16. Škrinjarić I, Škrinjarić T, Goršeta K, Čuković-Bagić I, Verzak Ž. Hitni i preventivni postupci kod trauma zuba u djece. Paediatr Croat. 2010; 54 (Supl 1):154–62.
17. Pohl Y, Tekin U, Boll M, Filippi A, Kirschner H. Investigations on a cell culture medium for storage and transportation of avulsed teeth. Aust Endod J. 1999; 25(2):70–5. [PMID: 11411083]
18. Blomlof L. Milk and saliva as possible storage media for traumatically exarticulated teeth prior to replantation. Swed Dent J. 1981; (Supl 8):1–26. [PMID: 6942523]
19. Trope M, Friedman S. Periodontal healing of replanted dog teeth stored in ViaSpan, milk, Hanks balanced salt solution. Endodon Dent Traumatol. 1992; 8(5):183–8. [PMID: 1302677]
20. Wang SH, Chung MP, Su WS, Cheng JC, Shieh YS. Continued root formation after replantation and root canal treatment in an avulsed immature permanent tooth: a case report. Dent Traumatol. 2010; 26(2):182–5. [DOI: 10.1111/j.1600-9657.2010.00864.x] [PMID: 20486947]
21. Donaldson M, Kinisons MJ. Factors affecting the time of onset of resorption in avulsed and replanted incisor teeth in children. Dent Traumatol. 2001; 17(5):205–9. [PMID: 11678538]
22. Ozer S, Yilmaz EI, Bayrak S, Tunc ES. Parental knowledge and attitudes regarding the emergency treatment of avulsed permanent teeth. Eur J Dent. 2012; 6(4):370–5. [PMID: 23077415]
23. Fujita Y, Shiono Y, Maki K. Knowledge of emergency management of avulsed tooth among Japanese dental students. BMC Oral Health. 2014; 14:34. [DOI: 10.1186/1472-6831-14-34] [PMID: 24712491]

Received: 08.01.2018 • Accepted: 05.04.2018

Traumatska ekstrakcija gornjih centralnih sekutića

Svjetlana Janković[1], Aleksandra Žuža[2], Bojana Davidović[1], Ivana Simić[3], Lado Davidović[2]

[1]Univerzitet u Istočnom Sarajevu, Medicinski flakultet Foča, Katedra za dječiju i preventivnu stomatologiju sa ortodoncijom, Foča, Republika Srpska, Bosna i Hercegovina;
2Univerzitet u Istočnom Sarajevu, Medicinski fakultet Foča, Katedra za dentalnu patologiju, Foča, Republika Srpska, Bosna i Hercegovina;
3Univerzitet u Istočnom Sarajevu, Medicinski flakultet Foča, Katedra za oralnu rehabilitaciju, Foča, Republika Srpska, Bosna i Hercegovina

KRATAK SADRŽAJ

Uvod Povrede zuba i drugih oralnih tkiva mogu nastati u bilo kom periodu života. Traumatska ekstrakcija zuba je potpuno izbijanje zuba iz alveole. Dijagnoza traumatski izbijenih zuba postavlja se tek posle analize rendgen snimka, kao i detaljnog kliničkog pregleda. **Prikaz slučaja** Pacijent uzrasta 12 godina javio se na Stomatološku kliniku Medicinskog fakulteta u Foči zbog povrede u frontalnoj regiji maksile. Uzrok povrede je pad u toku sportskih aktivnosti. Vreme proteklo od povrede je dva sata i 20 minuta. Kliničkim pregledom i rendgen snimkom dijagnostikovano je: 11 i 21 – *Avulsio completa dentes traumatica et Fractura dentes traumatica*; 22 – *Hypodontia dentis* i *Vulnus laceratio contusus mentae*. Zubi su doneseni u fiziološkom rastvoru. Posle obrade rane i date anestezije zubi su vraćeni u alveolu i postavljen je imobilizacioni splint od fiberglas vlakana. Pacijentu su prepisani antibiotici i preporučena antitetanus zaštita. Sedam dana od povrede zubi su endodontski tretirani. Mesec dana od povrede uklonjen je splint, zub 21 je definitivno napunjen i na oba zuba urađene su kompozitne nadogradnje. U zubu 11 ostavljeno je punjenje kalcijum-hidroksidom. Mesec dana i tri sedmice od povrede pojavila se fistula iznad zuba 11. Endodontsko lečenje ovog zuba je završeno posle sedam meseci. **Zaključak** Traumatske povrede zuba, bilo koje vrste, zahtevaju hitan tretman. Svaki gubitak vremena umanjuje verovatnoću da će lečenje biti uspešno. Godinu dana od povrede pacijent nema nikakvih subjektivnih smetnji, a postignut rezultat je funkcionalno i estetski prihvatljiv.

Ključne reči: avulzija; trauma; ekstrakcija zuba; imobilizacioni splint

UVOD

Traumatske povrede zuba i drugih oralnih tkiva mogu nastati u bilo kom periodu života. Javljaju se uglavnom između prve i treće godine u mlečnoj i osme i jedanaeste godine u stalnoj denticiji [1, 2]. Najčešće zahvaćeni zubi su gornji centralni i lateralni maksilarni incizivi, koji su zbog anteriorne pozicije i najosetljiviji na povrede [3]. Povrede prednjih zuba mogu dovesti do fonetičkih, funkcionalnih i estetskih problema, kao i do poremećaja u okluziji [1]. Prethodne studije ukazuju da su traumama skloniji dečaci [4–8].

Traumatska ekstrakcija zuba (*Avulsio completa, Extrusio completa, Luxatio completa dentis, Exarticulatio completa*) potpuno je izbijanje zuba iz alveole i istovremeno predstavlja jednu od najtežih povreda zuba. Iako se klinički lako uočava prazna alveola, dijagnoza traumatski izbijenih zuba postavlja se tek posle analize rendgen snimka. Diferencijalno dijagnostički u obzir dolazi utisnuće zuba (*Intrusio dentis*), kao i prelom korena sa gubitkom kruničnog dela zuba (*Fractura radicis dentis*). Osnovni uzrok traumatske ekstrakcije kod mlečnih zuba je pad, dok je kod stalnih zuba direktni (frontalni) udarac u zub. Učestalost ove povrede u mlečnoj denticiji je 7%, dok je u stalnoj denticiji nešto ređa i kreće se oko 0,9% od svih povreda zuba [9].

Traumatske povrede zuba, bilo koje vrste, zahtevaju hitan tretman jer svaki gubitak vremena umanjuje verovatnoću da će lečenje biti uspešno. Kada je avulzija zuba u pitanju, uspešnost replantacije zuba, posttraumatski period, kao i mogućnost i brzina nastanka komplikacija, zavise od brojnih faktora [10]. Najvažniji su: vreme koje je proteklo od traumatske ekstrakcije do replantacije, način čuvanja zuba od trenutka izbijanja do replantacije, stepen razvoja korena izbijenog zuba, stanje alveolrane kosti, prethodno stanje krunice zuba, pulpe i parodoncijuma, postojanje eventualne ortodontske nepravilnosti, kao i postupak pri samoj replantaciji [11]. Iako dugoročna prognoza da će zub ostati u vilici nije sigurna, zbog važnosti očuvanja visine alveolarnog grebena, funkcije, fonetike ali i estetike, uvek treba pokušati uraditi replantaciju ako za to postoje adekvatni uslovi.

Cilj ovoga rada bio je da prikaže postupak, terapiju i komplikacije posle avulzije zuba.

PRIKAZ SLUČAJA

Dvanaestogodišnji dečak javio se u najbližu stomatološku ambulantu u Višegradu zbog povrede zuba u gornjoj vilici posle pada tokom treniranja fudbala. Anamnestički podaci ukazuju da pacijent nije pokazivao znake i simptome neurološkog oštećenja. Zbog nedostatka materijala za postavljanje imobilizacionog splinta, dečak je upućen na Stomatološku kliniku Medicinskog fakulteta u Foči. Posle uzete anamneze, urađenog kliničkog pregleda (Slika 1) i RTG snimka (Slika 2) postavljena je sledeća dijagnoza: 11 i 21 – *Avulsio completa dentes traumatica*; 22 – *Hypodontia dentis.* Takođe je dijagnostikovano: 11 – *Fractura dentis traumatica* I klase; 21 – *Fractura dentis traumatica* II klase i *Vulnus laceratio contusus mentae*.

Zubi su transportovani u staklenoj bočici sa fiziološkim rastvorom (Slika 3). Roditeljima su objašnjene dostupne terapijske mogućnosti. Posle dva sata i 20 minuta pristupilo se postupku replantacije, po preporukama Internacionalne asocijacije dentalne traumatologije – IADT [12]. Aplikovana je lokalna anestezija. Da bi se uklonile nečistoće i krvni ugrušci, povređena regija je tretirana sterilnom gazom natopljenom u fiziološki rastvor. Izvršeno je uklanjanje mekih naslaga sa zuba na koje će biti postavljen imobilizacioni splint. Potom je urađeno nagrizanje 37% ortofosfornom kiselinom u trajanju od 30 sekundi (Slika 4). Posle ispiranja i posušivanja (Slika 5), postavljen je adheziv. Tokom

ovog perioda izbijeni zubi su uklonjeni iz transportnog medijuma, pažljivo isprani fiziološkim rastvorom i na vestibularnim površinama zuba ponovljena je ista procedura sa kiselinom (Slika 6) i adhezivom. Alveola je isprana sa fiziološkim rastvorom i izbijeni zubi su lagano replantirani digitalnom kompresijom. Postavljen je imobilizacioni splint (Slika 7). Vreme proteklo od momenta povređivanja do završetka replantacije je dva sata i 45 minuta. Preporučena je antitetanusna profilaksa, propisani su tetraciklinski antibiotici u trajanju od pet dana i analgetici po potrebi. Pacijentu je savetovano da jede mekanu hranu i održava oralnu higijenu. Kontrola je zakazana za sedam dana.

Na prvoj kontroli replantirani zubi su bili u velikoj meri čvrsti i stabilni na palpaciju. Posle kliničke i radiološke procene sproveden je endodontski tretman na zubima 11 i 21 po standardnoj proceduri. Zubi su napunjeni kalcijum-hidroksidom (Calcipulpe®Septodont, Cedex, France) posle obilne irigacije fiziološkim rastvorom i posušivanja papirnim poenima Naredna kontrola je zakazana za sedam dana. Na drugoj kontroli, 15 dana od povrede, replantirani zubi nisu bili potpuno čvrsti na palpaciju, dok su na blagu vertikalnu i horizontalnu perkusiju bili osetljivi, posebno zub 11. Imajući u vidu veličinu povređenog područja, urođeni nedostatak zuba 22, vreme koje je proteklo od momenta povređivanja do replantacije, odlučeno je da splint ostane još neko vreme. Na oba zuba ponovljeno je punjenje kalcijum-hidroksidom i pacijentu je zakazan kontrolni pregled za dve sedmice. Posle mesec dana uklonjeno je prethodno punjenje, izvršena obilna irigacija 2% natrijum-hipohloritom, a zatim fiziološkim rastvorom, i kanal je ponovo napunjen kalcijum-hidroksidom. Urađen je RTG snimak.

Zbog zadovoljavajućeg kliničkog nalaza zub 21 je opturisan. U istoj poseti uklonjen je imobilizacioni splint. Posle uklanjanja splinta, zubi koji su bili u splintu tretirani su *Fluorogal®Forte gelom,Galenika A.D. Beograd*. Pacijentu je zakazana naredna kontrola za tri dana. Posle jednog meseca i tri dana, na oba zuba, 11 i 21, urađene su kompozitne nadogradnje. Zub 21 bio je definitivno napunjen (gutaperka poeni i pasta za definitivnu opturaciju kanala), dok se na zubu 11 lečenje korenskog kanala nastavilo i dalje do potpunog smirivanja svih simptoma hroničnе infekcije. Polse jednog meseca i tri sedmice, iznad zuba 11 pojavila se fistula. Punjenje je menjano svakih mesec dana, a nakon sedam meseci od povrede zub 11 je definitivno zbrinut i napunjen pastom za definitivnu opturaciju kanala. Godinu dana od povrede pacijent nije imao nikakvih subjektivnih smetnji, a postignuti rezultat je funkcionalno i estetski prihvatljiv (Slika 8). Međutim, na RTG snimku oko zuba 21 uočavaju se početni znaci interne resorpcije (Slika 9). Pacijent se i dalje prati na redovnim kontrolama, koje se zakazuju na šest meseci, i biće opserviran još najmanje pet godina.

DISKUSIJA

Kada je traumatska ekstrakcija zuba u pitanju, pojedine studije pokazuju da je replantaciju zuba potrebno sprovesti bez obzira na to kada se pacijent javi [9]. S obzirom na uzrast pacijenta, veličinu povređenog polja, način na koji su zubi doneseni, kao i urođeni nedostatak zuba 22, nije preostalo ništa drugo nego da se pokuša sa replantacijom. Roditeljima je ukazano da postoje šanse, mada minimalne, da se zubi sačuvaju. Takođe su upoznati sa posttraumatskim tokom i mogućim komplikacijama.

Razlikuje se kratko (manje od 20 min.), srednje (20–60 min.) i dugo (više od 60 min.) ekstraalveolarno vreme. Iako je ekstraalveolarno vreme kod našeg pacijenta dugo (prošlo je dva sata i 20 minuta od povrede), traumatski izbijeni centralni sekutići su vraćeni u alveolu i postavljen je imobilizacioni splint. Smatra se da periodontalni ligament održava svoju vitalnost u prvih 20-ak minuta od povrede [12, 13, 14]. Zubi koji su replantirani u okviru tog vremena imaju najbolju prognozu i najveću mogućnost za ozdravljenje periodontalnog ligamenta [12]. Međutim, u literturi su opisani slučajevi vraćana zuba i nakon 36 sati od povrede [15].

Najbolja prognoza bi bila da su pacijentu zubi vraćeni u alveolu neposredno posle povrede. Kada to nije urađeno, zube je neophodno staviti u transportni medijum i što pre, zajedno sa pacijentom uputiti stomatologu.

Vrsta medija u koji se pohranjuje zub i te kako utiče na dugoročnu prognozu replantiranog zuba. Idealni medij bi trebalo da očuva većinu funkcionalnih sposobnosti ćelija periodontalnog ligamenta [14]. Zube ne bi trebalo sušiti, niti prenositi u suvom, što se događa prilikom umotavanja u maramice, gaze i slično. To dovodi do dehidratacije još uvek očuvanih ćelija na korenu, koje u suvom medijumu počinju izumirati. Postoje različiti mediji za čuvanje izbijenog zuba, kao što su široko dostupni (voda, pljuvačka, fiziološki rastvor, mleko...) i specijalizovani mediji. Voda može da štiti zub od dehidratacije, ali ako se koristi duže od 20 minuta dovodi do brzog propadanja ćelija periodontalnog ligamenta [16].

Pljuvačka je lako dostupan i povoljan medij za čuvanje ako se koristi kraće od sat vremena. Istraživanja su pokazala da je fiziološki rastvor kao sredina za čuvanje izbijenog zuba štetan za ćelije periodontalnog ligamenta ako se koristi duže od dva sata jer nema dovoljno esencijalnih hranjivih materija kao što su magnezijum, kalcijum i glukoza, koje su bitne za metaboličke potrebe periodoncijuma [17]. Savremena istraživanja navode mleko kao odličan medijum za čuvanje zuba i do šest sati jer nema bakterija, a ima pH i osmolalnost kompatibilne onima koji su kao ćelije periodontalnog ligamenta i ima hranljive materije kao što su aminokiseline, ugljeni hidrati i vitamini [9, 18, 19]. Postoji više vrsta posebnih medijuma za prenos izbijenog zuba: Hankov izbalansirani rastvor soli (HBSS – Hank's Balanced Saline Solution), DentoSafe i ViaSpan medij za transplantaciju tkiva i organa [3, 19]. Danas se smatra da je DentoSafe (Dentosafe GmbH, Iserlohn, Germany) najprikladniji medij za očuvanje i transport izbijenih zuba [16] te bi zbog toga DentoSafe bočice trebalo da budu dostupne na svim mestima rizičnim za nastanak dentalnih trauma, kao što su škole, vrtići, dečja igrališta i sportski tereni.

Pojedini autori ističu da je, u cilju prevencije nekroze pulpe avulziranog zuba, potrebno započeti korensko lečenje 7–10 dana od avulzije [14], što je u skladu sa našim postupkom. Svako dalje odlaganje povećava rizik od postreplantacione nekroze i gubitka zuba [16]. Komplikacije posle dentalne traume mogu se desiti u pulpi zuba, parodontalnom ligamentu i okolnim strukturama. Najčešće su nekroza pulpe [20] i resorpcija korena [10, 21]. Našem pacijentu konstatovana je fistula iznad zuba 11 mesec dana i tri sedmice od povrede. Postojala je i perkutorna kao i palpatorna osetljivost pomenutog zuba. Pojedini autori ističu da je optimalna dužina nošenja imobilizacionog splinta za regeneraciju periodontalnog tkiva petnaest dana [12, 16]. Naš pacijent je zbog veličine traumatskeog polja te zbog anodoncije zuba 22, kao i zbog palpatornog kliničkog nalaza, nosio splint

duže od preporučenog vremena. U ovoj studiji pacijent je imao dva avulzirana zuba. Inače se obično dešava da je kod pacijenata traumatski ekstrahovan samo jedan zub [3].

Traume dentomaksilofacijalne regije imaju ozbiljne estetske, funkcionalne, psihološke i ekonomske posledice za pacijente i njihove roditelje [16, 22]. Naš pacijent i njegovi roditelji nisu bili upoznati sa tim da je moguće da se zubi vrate u vilicu dok im stomatolog nije predložio takvu intervenciju. Inače, i druge studije rađene na tu temu pokazuju da je znanje roditelja o povredama zuba kao i mogućem lečenju neadekvatno [22, 23]. Znanje o hitnom lečenju izbijenih zuba treba povećati pružanjem edukativnih i preventivnih informacija svima koji rade sa decom. Replantacija izbijenog zuba kod dece nije važna samo s funkcionalnog pogleda već ima veliki psihološki, emocionalni i socijalni značaj kako za dete tako i za roditelje. Rani gubitak zuba može da utiče negativno na psihosocijalni razvoj deteta. Zbog toga je važno edukovati sve osobe (roditelje, vaspitače, nastavno osoblje, sportske trenere) o prevenciji povreda, prvoj pomoći povređenih, mogućnosti replantacija avulziranih zuba kao i postupku i mogućem načinu transporta povređenih zuba. Medijumi za čuvanje izbijenog zuba trebalo bi da budu dostupni u svim vrtićima, školama i sportskim klubovima. U toku izvođenja sportskih aktivnosti, kako bi se sprečile ili ublažile povrede zuba, potrebno je da deca nose štitnike za zube.

Da li ste pažljivo čitali radove?

1. Metod gasne propustljivosti se koristi:
   a) za proveru kvaliteta opturacije kanala
   b) za proveru kvaliteta preparacije kanala
   c) za proveru kvaliteta dezinfekcije kanala

2. Uzorci sa apeksnim čepom su pokazali:
   a) veću apeksnu propustljivost gasa
   b) manju apeksnu propustljivost gasa
   c) identičnu apeksnu propustljivost gasa

3. Nakon endodontskog lečenja došlo je do pojave fistule na:
   a) zubu 21
   b) zubu 11
   c) oba replantirana zuba

4. Najčešća analiza prostora u ortodontskoj dijagnostici je:
   a) BLEKOVA analiza
   b) LUNDSTROMOVA analiza
   c) MAUNTOVA analiza

5. Odstupanja za celu donju vilicu između dva metoda merenja su iznosila:
   a) do 0,6 mm
   b) preko 1 mm
   c) preko 1,2 mm

6. U metodi gasne propustljivosti korišćen je:
   a) helijum
   b) ksenon
   c) argon

7. Prosečna brzina prodora gasa u kanale ispunjene pastom GUTTA FLOW je iznosila:
   a) 264 sec.
   b) 178 sec.
   c) 322 sec.

8. Nakon endodontskog lečenja replantiranih sekutića kod oba zuba je urađena:
   a) kompozitna nadogradnja
   b) metalna nadogradnja
   c) keramička nadogradnja

9. Lundstromovom analizom se dobijaju informacije o:
   a) višku prostora za smeštaj zuba
   b) manjku prostora za smeštaj zuba
   c) višku ili manjku prostora za smeštaj zuba

10. Prevalenca muskuloskeletnih oboljenja kod stomatologa u Skoplju je:
    a) visoka
    b) niska
    c) postoji

11. U metodi gasne propustljivosti MTA je korišćen kao:
    a) pasta za opturaciju
    b) apeksni čep
    c) sredstvo za uklanjanje razmaznog sloja

12. Najveća gasna propustljivost je uočena kod:
    a) ACROSEAL PASTE
    b) GUTTA FLOW PASTE
    c) AH-PLUS PASTE

13. Lom endodontskih instrumentata u kanalu je:
    a) teška komplikacija
    b) jednostavna komplikacija
    c) beznačajan problem

14. Lundstromova analiza podrazumeva:
    a) merenja na gipsanim modelima
    b) merenja direktno u ustima
    c) merenja uz pomoć računara

15. Muskuloskeletna oboljenja su kod stomatologa:
    a) jedna od najčešćih
    b) jedna od najređih
    c) izuzetno retka

16. U istraživanju o primeni MTA kod apeksnog čepa uključeno je:
    a) 66 zuba
    b) 44 zuba
    c) 74 zuba

17. Traumatska ekstrakcija gornjih centralnih sekutića je bila kod:
    a) pacijenta uzrasta 12 godina
    b) pacijenta uzrasta 8 godina
    c) pacijenta uzrasta 15 godina

18. Lom NiTi rotirajućih instrumenata nastaje:
    a) usled vidljivog oštećenja instrumenta
    b) usled neadekvatnog odnosa metala u leguri
    c) bez prethodno vidljive deformacije

19. Fotogrametrijska merenja zahtevaju:
    a) specijalizovan hardver
    b) skup hardver
    c) merenja na osnovu fotografija modela

20. Prisustvo muskuloskeletnih oboljenja kod stomatologa je proveravano kod:
    a) privatnih stomatologa
    b) zaposlenih u državnom sektoru
    c) privatnih i državnih stomatologa

21. Primena MTA kao apeksnog čepa je realizovana kod:
    a) jednokorenih zuba
    b) višekorenih zuba
    c) višekanalskih sistema

22. Traumatska ekstrakcija zuba je bila posledica:
    a) saobraćajnog udesa
    b) zlostavljanja u porodici
    c) sportskih aktivnosti

23. Pri radu bez torzione kontrole sa NiTi rotirajućim instrumentima dolazi:
    a) do češćeg loma
    b) doređeg loma
    c) do početnih deformacija

24. Fotogrametrijski program omogućava merenja na osnovu:
    a) četiri fotografije
    b) šest fotografija
    c) deset fotografija

25. Muskuloskeletni poremećaji su proveravani:
    a) na Univerzitetskoj klinici u Skoplju
    b) na Univerzitetskoj klinici u Ohridu
    c) u domu zdravlja u Skoplju

26. U istraživanju gde je MTA korišćen kao apeksni čep preparacija kanala je urađena:
    a) ručnim instrumentima
    b) mašinskim instrumentima
    c) kombinacijom ručnih i mašinskih instrumenata

27. Vreme proteklo od traumatske ekstrakcije je iznosilo:
    a) 2 h i 20 min.
    b) 3 h i 20 min.
    c) 1 h i 20 min.

28. Uticaj torzione kontrole na lom endodontskih instrumenata je proveravan:
    a) u kliničkim uslovima
    b) u laboratorijskim uslovima
    c) u kliničkim i laboratorijskim uslovima

29. Fotogrametrijski program:
    a) vrši korekcije grešaka nastalih usled distorzije
    b) ne vrši korekcije grešaka nastalih usled distorzije
    c) samo u određenim slučajevima vrši korekcije

30. Muskuloskeletni poremećaji su proveravani kod:
    a) 78 stomatologa
    b) 58 stomatologa
    c) 108 stomatologa

31. Preparacija kanala u istraživanju gde je MTA korišćen kao čep je urađena:
    a) tehnikom *crown-down*
    b) tehnikom *step-back*
    c) tehnikom dvostrukog konusa

32. Traumatski ekstrahovani zubi su doneti:
    a) u vlažnoj maramici
    b) u fiziološkom rastvoru
    c) u alkoholu

33. Uticaj torzione kontrole je proveravan kod:
    a) 20 zuba
    b) 30 zuba
    c) 40 zuba

34. Između fotogrametrijskog i merenja na skeniranim 3D modelima:
    a) postoji visok stepen saglasnosti
    b) postoji nizak stepen saglasnosti
    c) ne postoji saglasnost

35. Pitanja koja su postavljana stomatolozima su uključivala njihovo opšte stanje zdravlja:
    a) u poslednjih 12 meseci
    b) u poslednja 24 meseca
    c) u poslednjih šest meseci

36. Opturacija kanala u istraživanju gde je MTA korišćen kao apeksni čep je urađena:
    a) primenom paste AH-26
    b) primenom paste AH-PLUS
    c) primenom jodoform cementa

37. Imobilizacioni splint kod zuba koji su vraćeni u alveolu je bio od:
    a) fiber-glas vlakana
    b) metalnog luka
    c) tečnog kompozita

38. Kod svih zuba podvrgnutih preparaciji kanala NiTi instrumentima je:
a) merena povijenost kanala
b) merena povijenost samo višekorenih zuba
c) merena samo povijenost veća od 80%

39. Odstupanja za maksilu za pojedinačne segmente između dva metoda merenja su iznosila:
a) 0,15 mm
b) 0,25 mm
c) 0,35 mm

40. Glavni razlog muskuloskeletnih poremećaja kod stomatologa je bio:
a) nedostatak odmora
b) dugotrajna statičnost
c) psihosocijalno opterećenje

41. Najbolji kvalitet opturacije u istraživanju gde je MTA korišćen kao apeksni čep je pokazala:
a) pasta GUTTA-FLOW sa MTA kao čepom
b) pasta GUTTA-FLOW bez čepa
c) pasta ACROSEAL bez čepa

42. Traumatski ekstrahovani zubi su endodontski lečeni posle:
a) tri dana od povrede
b) sedam dana od povrede
c) 14 dana od povrede

43. Razlika u prosečnom broju korišćenja NiTi rotirajućih instrumenata sa torzionom kontrolom i bez nje je bila:
a) bez statističke značajnosti
b) statistički značajna
c) značajno veća od manjeg broja korišćenja

44. Odstupanja za celu gornju vilicu između dva metoda merenja su iznosila:
a) više od 1,5 mm
b) više od 1 mm
c) manje od 1 mm

45. Dugotrajna statička pozicija je bila uzrok muskuloskeletnih poremećaja:
a) u 82,05% slučajeva
b) u 73,08% slučajeva
c) u 45,03% slučajeva

46. Najslabiji kvalitet opturacije u istraživanju gde je MTA korišćen kao apeksni čep je pokazala:
a) pasta AH-PLUS
b) pasta AH-PLUS sa apeksnim čepom
c) pasta ACROSEAL

47. Splint kod replantiranih sekutića je uklonjen:
a) posle mesec dana
b) posle dva meseca
c) posle tri meseca

48. Povijenost kanala u istraživanju o kontroli torzije NiTi instrumenata je merena:
a) pomoću nonijusa
b) digitalnom rendgenografijom
c) laserom

49. Odstupanja za mandibulu za pojedinačne segmente između dve metode merenja su iznosila:
a) ispod 0,27 mm
b) iznad 0.27 mm
c) iznad 3,2 mm

50. Na više od dva uzorka muskuloskeletnih poremećaja je ukazalo:
a) 43,07% stomatologa
b) 56,04% stomatologa
c) 73,08% stomatologa

Uputstvo autorima za pripremu rada

Stomatološki glasnik Srbije je časopis 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.

Svi rukopisi se podvrgavaju recenziji. Radove recenziraju dva anonimna stručnjaka i, ukoliko je potrebno, statističar. Konačnu odluku o prihvatanju rada za štampu donosi glavni i odgovorni urednik. Autori se obaveštavaju o prijemu ili odbijanju rada najkasnije osam nedelja od podnošenja rukopisa.

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.

Radovi se štampaju na engleskom i srpskom jeziku.

Opšta uputstva Tekst rada treba da bude otkucan u programu za obradu teksta *Word*, sa dvostrukim proredom, isključivo fontom Times New Roman i veličinom slova 12 pt. Sve margine treba podesiti na 25 mm, veličinu stranice na A4 format, a tekst kucati s levim poravnanjem i uvlačenjem svakog pasusa za 10 mm, bez deljenja reči. 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 se numerišu redom u okviru donje margine, počev od naslovne strane.

Naslovna strana Na posebnoj, prvoj strani rukopisa treba navesti sledeće: naslov rada bez skraćenica, puna imena i prezimena autora bez titula, zvaničan naziv ustanova u kojima autori rade, mesto i državu; na dnu stranice navesti ime i prezime, adresu za kontakt, broj telefona i e-mail adresu autora zaduženog za korespondenciju.

Kratak sadržaj i ključne reči Druga strana treba da sadrži kratak sadržaj rada obima 100–250 reči. Kratak sadržaj originalnog rada treba strukturirati na sledeće delove: Uvod (u okviru kojeg se navodi cilj rada), Materijal i metode rada, Rezultati i Zaključak. Navode se najvažniji rezultati, numeričke vrednosti, statističke analize i nivo značajnosti. Ispod kratkog sadržaja navesti od tri do šest ključnih reči. U izboru ključnih reči koristiti *Medical Subject Headings – MeSH* (*http://www.nlm.nih.gov/mesh*).

Struktura rada Originalni rad treba da sadrži sledeće podnaslove: Uvod (sa ciljem rada), Materijal i metode rada, Rezultati, Diskusija, Zaključak i Literatura. Prikaz iz prakse čine: Uvod, Prikaz bolesnika, Diskusija i Literatura. Ne treba koristiti imena bolesnika, inicijale ili brojeve istorija bolesti. Pregledni i informativni rad čine Uvod, odgovarajući podnaslovi, Zaključak i Literatura. Pregledni rad mogu objaviti samo autori koji su izuzetno uspešni u oblasti kojom se bave i koji navedu najmanje pet autocitata radova publikovanih u časopisima s recenzijom.

Tekst rukopisa Koristiti kratke i jasne rečenice, bez stranih reči i neadekvatnih pojmova iz prevoda iz strane literature. Za nazive lekova koristiti generička imena. Skraćenice koristiti samo kada je to neophodno, a ne koristiti ih u naslovu. Za svaku skraćenicu pun termin treba navesti pri prvom pojavljivanju u tekstu, sem ako to nije standardna jedinica mere. Decimalne brojeve u engleskom tekstu pisati sa tačkom, a u srpskom sa zarezom. Kad god je to moguće, broj zaokružiti na jednu decimalu. Sve rezultate hematoloških, kliničkih i biohemijskih merenja navoditi u metričkom sistemu prema Međunarodnom sistemu jedinica (SI).

Obim rukopisa Celokupni rukopis rada – koji čine naslovna strana, kratak sadržaj, tekst rada, spisak literature, svi prilozi, potpisi za njih i legenda (tabele, slike, grafikoni, sheme, crteži) – mora iznositi za pregledni rad do 7.000 reči, za originalni rad do 5.000 reči, a za informativni rad i prikaz iz prakse do 3.000 reči. Provera broja reči u dokumentu može se izvršiti kroz podmeni Tools–Word Count ili File–Properties–Statistics.

Tabele Tabele se označavaju arapskim brojevima prema redosledu navođenja u tekstu, a moraju biti urađene u programu *Word*, kroz meni Table–Insert–Table, uz definisanje tačnog broja kolona i redova koji će činiti mrežu tabele. Korišćene skraćenice u tabeli treba objasniti u legendi ispod tabele.

Grafikoni Grafikoni treba da budu urađeni i dostavljeni u programu *Excel*, da bi se videle prateće vrednosti raspoređene po ćelijama.

Slike Slike se označavaju arapskim brojevima prema redosledu navođenja u tekstu. Primaju se isključivo digitalne fotografije (crno-bele ili u boji) rezolucije 300 dpi i formata zapisa .tiff ili .jpg. Ukoliko autori ne poseduju ili nisu u mogućnosti da dostave digitalne fotografije, onda originalne slike treba skenirati kao Grayscale (ili u boji) u rezoluciji 300 dpi i snimiti ih u originalnoj veličini.

Sheme Sheme crtati i dostaviti u programu *CorelDraw* ili *Adobe Illustrator*. Podatke u shemi kucati fontom Times New Roman i veličinom slova 10 pt.

Zahvalnica Navesti sve one koji su doprineli stvaranju rada, ali ne ispunjavaju merila autorstva. Finansijska i materijalna pomoć u obliku sponzorstva, stipendija, poklona, opreme, lekova, materijala i drugog takođe treba da bude navedena.

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 numerisane arapskim brojevima navoditi prema redosledu citiranja u tekstu. Broj referenci u originalnim radovima ne bi trebalo da bude veći od 30, osim kod preglednih i informativnih radova, gde broj referenci nije ograničen. Izbegavati korišćenje apstrakta kao reference, a apstrakte starije od dve godine ne citirati. Reference članaka koji su prihvaćeni za štampu treba označiti kao „u štampi" (*in press*) i priložiti dokaz o prihvatanju rada.

Reference se citiraju prema Vankuverskom stilu (jednoobraznim 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, monografija, elektronskog, neobjavljenog i drugog objavljenog materijala) mogu se naći na internet-stranici *http://www.nlm.nih.gov/bsd/uniform_requirements.html*.

Propratno pismo Uz rukopis obavezno priložiti pismo koje su potpisali svi autori, a koje treba da sadrži: izjavu da rad prethodno nije publikovan i da nije istovremeno podnet za objavljivanje u drugom časopisu, te izjavu da su rukopis pročitali i odobrili svi autori koji ispunjavaju merila autorstva.

Autorstvo Autorstvo se zasniva na bitnom doprinosu koncepciji rada, dobijanju rezultata ili analizi i tumačenju rezultata, planiranju rukopisa ili njegovoj kritičkoj reviziji od znatnog intelektualnog značaja, te doprinosu u završnom doterivanju verzije rukopisa koji se priprema za štampanje. Finansiranje, sakupljanje podataka ili generalno nadgledanje istraživačke grupe sami po sebi ne mogu opravdati autorstvo.

Slanje rukopisa Rukopis rada i svi prilozi uz rad mogu se dostaviti imejlom (*stomglas@bvcom.net*), preporučenom pošiljkom ili lično, dolaskom u Uredništvo. Ukoliko se rad šalje poštom ili donosi u Uredništvo, rukopis se dostavlja odštampan u dva primerka i narezan na CD (snimljeni materijal treba da je istovetan onom na papiru).

Važna napomena Svi autori i koautori radova moraju biti članovi Srpskog lekarskog društva i pretplatnici na časopis za godinu u kojoj predaju rad za publikovanje.

Adresa:
Srpsko lekarsko društvo
Uredništvo časopisa „Stomatološki glasnik Srbije"
Ul. kraljice Natalije 1
11000 Beograd
Srbija

Telefon: +381 (0)11 409 27 76
E-mail: stomglas@bvcom.net
Internet-adresa: http://www.stomglas.org.rs

Instructions for Authors

Serbian Dental Journal is the journal of the Serbian Medical Society, founded in 1953. The journal publishes original scientific and professional papers, case reports, review articles, preliminary research reports, historical papers, book review, comments and letters to the Editor, social chronicle.

All manuscripts are peer-reviewed. Manuscripts are reviewed by two anonymous referees and, if necessary, a statistician. The final decision on paper acceptance for publishing is made by the Editor-in-Chief. Authors are informed of acceptance or rejection of the paper within eight weeks after manuscript submission.

Copyright is transferred from the author(s) to the publisher upon paper acceptance and no fees are paid for papers to be published. Manuscripts are not returned to the author. For any reproduction and repeated publishing of part or the whole paper, written consent from the publisher is requested.

The journal is published in English and Serbian.

General instructions The manuscript should be typed in MS Word, with double line spacing, only in Times New Roman font and letters size 12 pt. Page margins should be 25 mm, page size set to A4 format, and text typed aligned left with paragraph indentations of 10 mm. Words should not be hyphenated. If special symbols are used in the text, preferred font is Symbol. References should be marked with Arabic numbers in brackets, e.g. [1, 2], in the order of appearance in the text. Page numbers should be inserted at the bottom of the page, starting from the title page.

Title page The first page should contain: the title of the paper without abbreviations, authors' names without professional titles, authors' affiliations; the exact postal address of the corresponding author, telephone number and e-mail address must be given at the bottom of the title page.

Summary and keywords The second page should contain a structured summary of the paper with Introduction (with the aim), Material and Methods, Results and Conclusion with up to 250 words. Each of these segments should be written as a new paragraph with bold subtitles. Only the most important results should be indicated with the statistical level of significance. Following summary it is recommended to list 3 to 6 keywords related to the paper. Keywords should be chosen according to the Medical Subject Headings – MeSH (*http://www.nlm.nih.gov/mesh*).

Structure of the manuscript Original paper should have the following subheadings: Introduction (with the aim), Material and Methods, Results, Discussion, Conclusion and References. Case report should contain: Introduction, Case Report, Discussion, Conclusion and References. No patients' names, initials or record numbers should be indicated. Review and informative article consists of Introduction, subheadings, Conclusion and References. Only distinguished authors with at least five citations of their published papers are eligible to publish review articles.

Text of the manuscript Text should be written in short and clear sentences, avoiding foreign language words and inadequate terms and interpretation from the literature. Medications should be indicated by their generic names. For each abbreviation, full term should be indicated when first mentioned in the text, except for standard measuring units. Decimals should be separated with a comma in Serbian, and with a dot in English. Numbers should be approximated to one decimal place. All results of hematological, clinical and biochemical measurements should be quoted in the metrical system according to the International Unit System (SI).

Length of the manuscript The entire manuscript (title page, summary, the whole text, list of references, all enclosures including captions and legends) should not exceed 7,000 words for a review article, 5,000 words for an original paper, and 3,000 words for an informative article and case report. The number of words can be checked in MS Word using Tools–Word Count or File–Properties–Statistics options.

Tables Tables should be marked in Arabic numbers in the order of appearance in the text, and should be prepared in MS Word using Table–Insert–Table, with clearly defined number of columns and rows. Abbreviations used in a table should be explained in the legend under the table.

Graphs Graphs should be prepared in MS Excel, in order to maintain a clear view of all values within the cells.

Photographs Photographs should be marked in Arabic numbers in the order of appearance in the text. Only original digital photographs (black-and-white or color), resolution of 300 dpi, and .tiff or .jpg format, are acceptable. If authors do not posses or are not able to provide digital photographs, then the original photos should be scanned as Grayscale (or RGB color) with resolution of 300 dpi, and saved in original size.

Schemes Schemes should be drawn in CorelDraw or Adobe Illustrator programmes. The text in the scheme should be typed in Times New Roman, font size 10 pt.

Acknowledgment All contributors to the paper who are not named as authors should be acknowledged. Financial and other material support, like sponsorship, grants, gifts, medical supplies, etc., should also be mentioned.

References The reference list is the responsibility of the authors. Cited articles should be readily accessible to the journals readership. Therefore, following each reference, its DOI number and PMID number (if the article is indexed for MEDLINE/PubMed) should be typed.

References must be marked in Arabic numbers and cited in the order of appearance in the text. The number of references should not exceed 30, except in review and informative articles, when no limits are established. The use of abstracts as references should be avoided and an abstract more than two years old should not be quoted by any means. When citing accepted papers, these should be indicated as "in press" and a proof of acceptance should be provided.

References are cited according to the Vancouver style (*Uniform 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) could be found on the web site *http://www.nlm.nih.gov/bsd/uniform_requirements.html*.

Cover letter A cover letter should be signed by all authors and with the following content: written consent that the paper was not previously published and is not simultaneously submitted to publication in other journals, and written consent that the paper was reviewed and approved by all other co-authors.

Authorship Authorship is based only on: crucial contribution to the article conception, obtaining of results or analysis and interpretation of results; design of the manuscript or its critical review of significant intellectual value; final revision of the manuscript being prepared for publication. Funding, collection of data or general supervision of the research group alone cannot justify authorship.

Submission Manuscript and all enclosures can be sent by e-mail (*stomglas@bvcom.net*). If sent by registered mail or delivered in person at the Editorial Office in Belgrade, it should contain two printed copies and a CD with the version identical to that on paper.

Important notice All authors and co-authors must be members of the Serbian Medical Society and subscribers to the journal for the year in which the manuscript is being submitted.

Address:
Serbian Medical Society
Editorial Board of the Serbian Dental Journal
Ul. kraljice Natalije 1
11000 Belgrade
Serbia

Phone: +381 (0)11 409 27 76
E-mail: stomglas@bvcom.net
Web site: http://www.stomglas.org.rs

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