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Contents / Sadržaj

„Postoji samo jedan način da se
glupacima i budalama pokaže
koliko su nerazumni,
a to je da se sa njima ne razgovara“
A. Šopenhauer

U aktuelnom društvenom trenutku gde „sve pršti od viška pameti“ čini se da je jednostavno i lako odabrati ideju za urednički komentar. Međutim, u atmosferi gde je „rijaliti“ dominantan društveni i kulturni model i gde odsustvo stida i prostakluk unižava svaku normalnost, to i nije baš tako. Naime, vrlo je teško izaći iz okvira naše pseudostvarnosti i pokrenuti se iz stanja opšte „demencije“ i kolektivne depresije. U zagađenoj i kontaminiranoj medijskoj sceni istina se „kasapi“ makazama laži, a neuki izvođači „prljavih poslova“ svoj kosmopolitski duh velikodušno šire do granica sopstvenih vidika (čitaj zidova dnevne ili spavaće sobe).

Nasuprot „laboratoriji zabluda i laži“ naša stvarnost je posve drugačija. Dok „zlatno doba“ cveta samo u glavama onih sa izvitoperenim nazorima, simfonija laži se ori sa svih medija i čarobnom maglom nadkriljuje poslušnike, podanike i mediokritete nudeći „svekoliki sunovrat i bezizlaz“.

Šizofrena situacija nudi „preučene i bezlične“ na svim nivoima, koji u providnoj igri „podvalu“ vide kao jedini i najubedljiviji program. A tamo gde „normalnost“ živi u jednini i tamo gde neuki i bahati pišu ciljeve za budućnost, agonija i put u beznađe su jedino izvesni.

Aktuelnim trenutkom dominiraju „intelektualno nedovršene osobe“ sa kupljenim diplomama i plagiranim doktoratima, osobe sa moralnim erozijama i verbalnom agresijom, koje se bez imalo stida ponose svojim neznanjem. Vrhunac ove hipokrize je šizofreni odnos prema svemu (najgori oblik šizofrenije je kad se ne razlikuje stvarnost od onoga što je u sopstvenoj glavi), gde je sve moguće, pa čak i da se bude najbolji nasuprot pokazateljima i argumentima koji ukazuju na suprotno.

U takvoj medijskoj stvarnosti, gde se „vatra gasi kerozinom“, moguće je i da se zemlja graniči sama sa sobom, da na plodnoj zemlji mnogi gladuju, da je u besplatnom zdravstvu lečenje skupo, da se nešto ruši da bi se zidalo (a ne da bi tu ljudi živeli), da se metro gradi na livadi gde nema ljudi, da nezaposleni najviše rade, da sudski postupci traju duže od života, da se ratovi nikad ne završavaju, da... itd.

Beg iz ovakvog moralnog i svekolikog posrnuća je uslov svih uslova i sigurno nije lak ni jednostavan. Univerzitet i akademska odgovornost članova ove institucije moraju biti moralno svetlo i zračak koji će pokrenuti „reanimaciju“ potonulosti svega i borbom za istinu vratiti uniženu stvarnost na kolosek izvesnije budućnosti.

Odgovornost i čestitost, uz poštovanje elementarnih zakonskih, etičkih i moralnih normi, mogla bi biti iskorak iz „laboratorije zabluda i laži“ i poštenjem i hrabrošću eliminisati ravnodušnost i moralnu eroziju aktuelnog trenutka. Odlučnost obrazovanih i ljudi od znanja mora biti najsvetija obaveza za buđenje iz „besvesti“ i iskorak iz društvene kaljuge i medijskog galimatijasa naše realnosti.

Primitivizam, neukus, poltronstvo i bahatost su realnosti sunovrata, a znanje, stručnost, hrabrost i sloboda mišljenja i izražavanja osnovni preduslovi ne samo slobodnog nego i uspešnog društva. Nadarenost učenih ljudi da kritički misle i odgovorno stvaraju mora biti inicijalna, ali i neiscrpna energija za promenu izvitoperene stvarnosti i najsvetlija putanja za spas sopstvenog života iz kandži bezizlaza.

Završiću citatom velikog pisca Ernesta Hemingveja: „Moramo se na ovo navići: na najvažnijim raskrsnicama života ne nailazimo na znakove“ jer je to paradigma naše stvarnosti i trenutak kada lična odluka i odgovornost mogu biti jedini putokaz i izlaz iz bespuća sopstvene inferiornosti.

Prof. dr Slavoljub Živković

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Photogrammetric analysis of postextraction space closure

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SUMMARY

Introduction When planning orthodontic treatment, it is sometimes necessary to apply the extraction of individual teeth, in order to achieve proper occlusion and an acceptable aesthetic appearance. Clinicians give the greatest advantage to elastic chains as a method for post-extraction space closure during treatment with fixed orthodontic appliances. When closing post-extraction spaces, it is necessary to measure them in order to adjust the treatment plan. One of the most acceptable methods is photogrammetry.

The aim of this study was to analyze, using a photogrammetric method, the efficacy of post-extraction space closure with elastic chains during orthodontic treatment with fixed orthodontic appliances.

Material and Methods The total sample in study consisted of 38 post-extraction spaces in 19 patients who were indicated for first premolars extraction and use of fixed orthodontic appliances in order to achieve treatment goal. Elastic chains were used to close post-extraction spaces. Post-extraction sites were monitored for 6 months with follow-up examinations every 4 weeks. Mechanisms were activated at controlled examinations, and measurements of the width of post-extraction spaces were performed by photogrammetry and digital caliper.

Results The results showed that average reduction of post-extraction space width was 1.00 mm per month by photogrammetric measurement, while the average values of measurements with a digital caliper were 1.02 mm. The average values were measured in six time intervals and a statistically significant change in average intervals of post-extraction spaces during 6 months was determined.

Conclusion The elastic chain has proven to be a very effective mechanism for closing post-extraction space, and photogrammetry as a simple and precise method for monitoring results of treatment. Since the difference in relation to measurements with a digital caliper is minimal, photogrammetry can be routinely applied in everyday practice.

Keywords: photogrammetry; elastic chain; post-extraction space

INTRODUCTION

When planning orthodontic treatment, it is sometimes necessary to apply extraction of individual teeth, in order to achieve proper occlusion and an acceptable aesthetic appearance. The first premolar is usually the tooth of choice in extraction treatment with fixed orthodontic appliances. Closing the post-extraction space is performed by different methods, and two basic ones are sliding mechanism and methods without friction using loops [1]. The use of a sliding mechanism for post-extraction space closure is very common in clinical practice due to its simplicity. Studies show that clinicians give the greatest advantage to elastic chains as a method for this type of treatment [2, 3].

Although they were introduced in practice in the 1960s, elastic chains remained a traditional method for tooth retraction and space closure in general. Even today, they are one of the most commonly used techniques for closing space, due to easy application, patient and therapist comfort [4, 5]. They are primarily composed of polyesters or polyethers formed by the polymerization of rubbers with multiple molecular structures linked by a series of urethane bonds [6]. The advantage of elastic chains is that they are not expensive, easy to use and can be applied to various clinical cases. However, they must be changed every 4 to 6 weeks due to plaque retention, difficult hygiene and expected decrease in strength [7]. Therefore, it is necessary to monitor the closure of post-extraction space at control examinations in order to summarize achieved results and correctly direct treatment plan.

By introducing dental photography as an integral part of dental treatment documentation, it is possible to show condition at the beginning and the end, the process and its phases. This way, photographs can be used for various purposes, such as communication with patient, case presentation, diagnosis and treatment plan [8]. Along with

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development of digital photography, there was an innovation in the field of dentistry called photogrammetry. This method is using geometric properties of objects that can be determined from photographs and this proved its usefulness in orthodontics for studying three-dimensional occlusion of dental arches, teeth and their dimensions. Chadwick defines photogrammetry as the art, science, and technology of obtaining reliable information about physical objects through the processes of capturing, measuring, and interpreting photographic images [9].

Due to its simplicity, economy and without the danger of radiation, photogrammetry on standardized extra oral and intraoral photographs is used in everyday orthodontic practice [10, 11, 12].

The aim of this study was to analyze using a photogrammetric method the efficacy of post-extraction space closure with elastic chains during orthodontic treatment with fixed orthodontic appliances.

MATERIAL AND METHODS

The research was conducted at the Faculty of Medicine - study program of Dentistry in Banja Luka, with the consent of the Ethics Committee of the Department of Dentistry. The total sample consisted of 38 post-extraction spaces in 19 patients who were indicated for the extraction of the first premolars in order to conduct orthodontic treatment. The age of patients at the beginning of treatment was 12-20 years, who did not have contraindications for orthodontic treatment and who had no other extractions (except for the first premolars). Subjects who had poor oral hygiene, who came for check-ups irregularly and did not follow the instructions given at the beginning of treatment, were excluded from the study.

After extraction of first premolars, fixed orthodontic appliance was applied to the subjects (Dentaurum, Discovery, Roth prescription, slot 0.022 in), and then, initial leveling with round and rectangular NiTi arches was performed, before the placement of steel rectangular arches. A rectangular steel arch wire of 0.019×0.025 in was left in brackets slots for at least 4 weeks, to become passive, and then elastic chains were applied. The elastic chain was placed to connect the hook on the tube of the first molar and the hook of the bracket on the canine, whereby it is stretched to approximately twice the initial length, and on control examinations it was replaced with a new one (Figure 1).

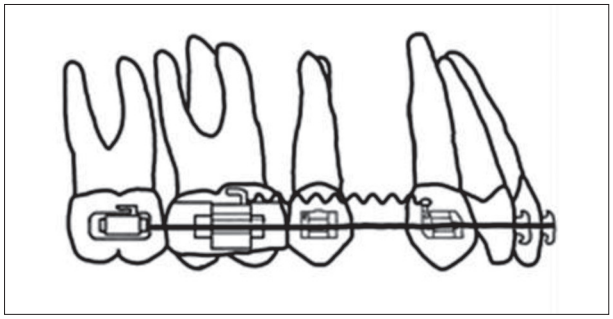


Figure 1. Method for placement of the elastic chain
Slika 1. Metoda postavljanja elastičnog lanca

Post-extraction spaces were monitored for 6 months from the beginning of the application of elastic chains at intervals of one month (T_0-T_6). Control examinations were performed every 4 weeks and it was checked whether there was damage to applied mechanisms and their activation.

For the photogrammetric method, a Canon camera (EOS 750D Body) with macro lens (EF 100 mm / 2.8 IS USM) and a ring-shaped flash (macro Ring Lite MR-14 EXII), a flat occlusal mirror and a retractor for occlusal photography with millimeter scale were used. During regular check-ups (T_0-T_6), standardized occlusal photographs of the upper and lower dental arch were obtained. When photographing, the mirror rested on the opposite dental

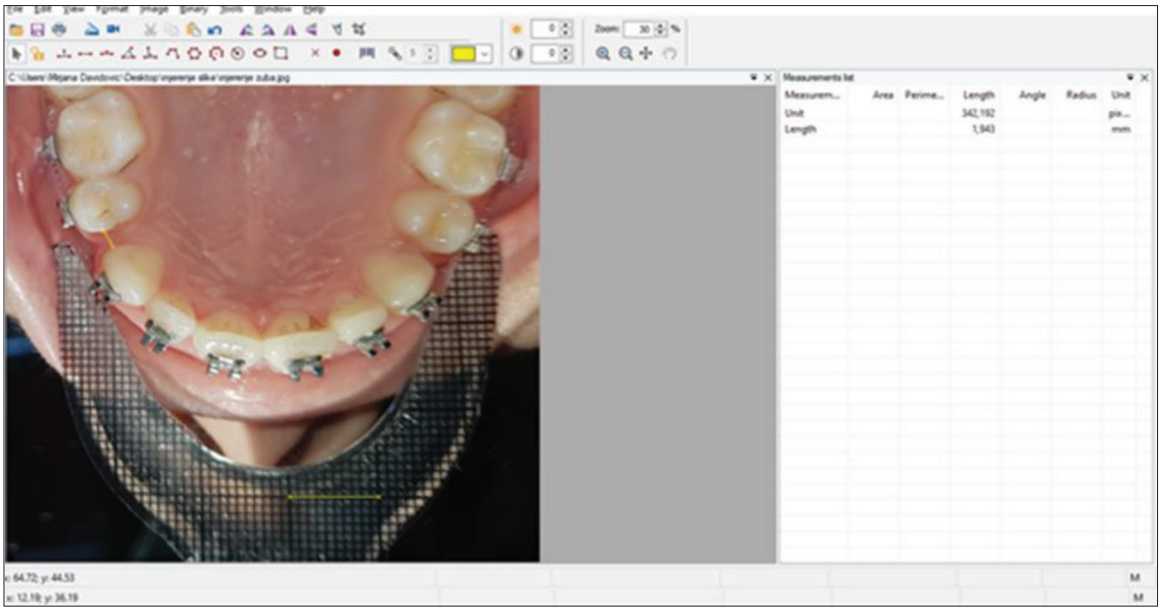


Figure 2. Photogrametry measurement of postextraction space
Slika 2. Merenje postekstrakcionog prostora fotogrametrijom

arch, while the retractor was placed parallel to the dental arch being photographed.

The millimeter scale on the retractor enabled the measurement results to be recognized by software with the computer program Digimizer for photo analysis and processing. Using this program, linear measurements in pixels were obtained. Then, the number of pixels in one centimeter that was on the retractor with a millimeter scale was read. This way, one centimeter of a segment of a photograph, measured in pixels, was used as a parameter to convert the number of pixels in a real photograph into centimeters. All measurements in pixels were converted to millimeters through a computer program. The shortest distance from the distal surface of the canine to the mesial surface of the second premolar was measured. Measurements were performed 3 times alternately, and the reference value represented the mean value of these 3 measurements (Figure 2).

In order to establish the accuracy of this method, measurements were also performed using a digital caliper with an accuracy of 0.01 mm. The direct distance from the distal surface of the canine to the mesial surface of the second premolar was measured by direct method. These measurements were performed for each post-extraction space 3 times alternately. The reference value was the mean of these 3 measurements.

RESULTS

For measuring the efficiency of the elastic chain, the photogrammetry method was used. The Tukey test was used to test whether there was a difference between all time intervals measuring the space between teeth by this method. This test showed that a statistically significant difference exists between all time intervals. The average distance between the teeth decreased over time, and the average distance of post-extraction space at the beginning of the measurement (T_1) was 4.03 ± 1.44 mm, while at the final measurement (T_6) it was 0.44 ± 0.57 mm (Table 1).

Using one-factor analysis of Repeated Measure ANOVA, it was examined whether there was a statistically significant change in the average values of post-extraction spaces when using the elastic chain method measured by photogrammetry. Mean values were measured at six time intervals and a statistically significant change in the average intervals of post-extraction spaces over 6 months was found (Wilks' lambda = 0.019, F = 103.98, p = 0.000). The influence of the elastic chain as a mechanism of post-extraction spaces closure was also examined. The value of the Wilks lambda of 0.01-small influence, 0.06-moderate influence and 0.14-big influence, and the obtained η^2 of 0.98, indicates a very large influence of the elastic chain as a mechanism of post-extraction space closure (Table 2). The graph shows the reduction of the average values of post-extraction spaces measured by the method of photogrammetry, under the action of an elastic chain (Figure 3). Control measurements were performed by a direct method using digital caliper. The average distance of the post-extraction space at the beginning of the measurement (T_1) was 4.14 ± 1.47 mm, and at the end (T_6) 0.46 ± 0.59 mm (Table 3).

A statistically significant difference was found in the average intervals of post-extraction spaces during 6 months (Wilks' lambda = 0.006, F = 322.06, p = 0.000). The influence of the elastic chain, as a mechanism of space closure between the teeth, was also examined. In this case, the obtained η^2 is 0.99, which indicates a very large influence of the elastic chain as a mechanism of reducing space between the teeth (Table 4). Figure 4 graphically shows the average values of post-extraction space width, that is, the maximum distance between the teeth when using an elastic chain measured with a digital caliper.

Table 1. Average values of maximum distance (mm) between teeth measured by photogrammetry
Tabela 1. Prosečne vrednosti maksimalnog rastojanja (mm) među zubima merenog fotogrametrijom

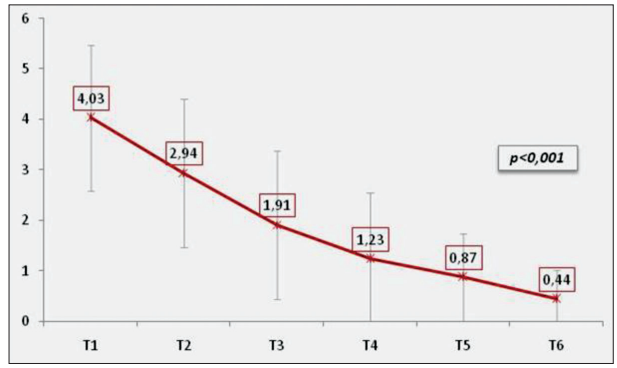
	N	Min	Max	M	SD	Percentage of reduction Procenat smanjenja
T_1 photogrammetry T_1 fotogrametrija	38	1.85	6.67	4.03	1.44	
T_2 photogrammetry T_2 fotogrametrija	38	0.88	5.75	2.94	1.47	-27.04
T_3 photogrammetry T_3 fotogrametrija	38	0	4.93	1.91	1.47	-52.60
T_4 photogrammetry T_4 fotogrametrija	35	0	3.83	1.23	1.32	-69.47
T_5 photogrammetry T_5 fotogrametrija	24	0	2.49	0.87	0.87	-78.41
T_6 photogrammetry T_6 fotogrametrija	15	0	1.46	0.44	0.57	-89.08

N – number of subjects; Min – minimum value on the sample; Max – maximum value on the sample; M – arithmetic mean; SD – standard deviation;
N – broj ispitanika; Min. – minimalna vrednost na uzorku; Max. – maksimalna vrednost na uzorku; M – aritmetička sredina; SD – standardna devijacija

Table 2. Differences in values of maximum distance (mm) between teeth measured by a photogrammetry in six time intervals
Tabela 2. Razlike u vrednostima maksimalnog rastojanja (mm) među zubima merenog fotogrametrijom u šest vremenskih intervala

Wilks' Lambda	F	P	η^2
0.019	103.98	0.000	0.981

F – ANOVA of repeated measurements; p – statistical significance; η^2 – squared Eta;
F – ANOVA ponovljenih merenja; p – statistička značajnost; η^2 – kvadrirana Eta



Slika 3. Graphic representation of average values for maximum distance (mm) between teeth measured by photogrammetry
Slika 3. Grafički prikaz prosečnih vrednosti maksimalnog rastojanja (mm) među zubima merenog fotogrametrijom

Table 3. Average values of maximum distance (mm) between teeth measured by a digital caliper
Tabela 3. Prosečne vrednosti maksimalnog rastojanja (mm) među zubima merenog digitalnim kaliperom

	N	Min	Max	M	SD	Percentage of reduction Procenat smanjenja
T_1 digital caliper T_1 digitalni kaliper	38	1.84	6.83	4.14	1.47	/
T_2 digital caliper T_2 digitalni kaliper	38	1.01	5.77	3.07	1.47	-25.84
T_3 digital caliper T_3 digitalni kaliper	38	0	4.99	1.97	1.49	-52.41
T_4 digital caliper T_4 digitalni kaliper	35	0	3.87	1.26	1.34	-69.56
T_5 digital caliper T_5 digitalni kaliper	24	0	2.66	0.93	0.91	-77.53
T_6 digital caliper T_6 digitalni kaliper	15	0	1.58	0.46	0.59	-88.88

N – number of subjects; Min – minimum value on the sample; Max – maximum value on the sample; M – arithmetic mean; SD standard deviation;
N – broj ispitanika; Min. – minimalna vrednost na uzorku; Max. – maksimalna vrednost na uzorku; M – aritmetička sredina; SD – standardna devijacija

Table 4. Differences in values of maximum distance (mm) between teeth measured with a digital caliper in six time intervals
Tabela 4. Razlike u vrednostima maksimalnog rastojanja (mm) među zubima merenog digitalnim kaliperom u šest vremenskih intervala

Wilks' Lambda	F	P	η^2
0.006	322.06	0.000	0.994

F – ANOVA of repeated measurements; p – statistical significance; η^2 – squared Eta;
F – ANOVA ponovljenih merenja; p – statistička značajnost; η^2 – kvadrirana Eta

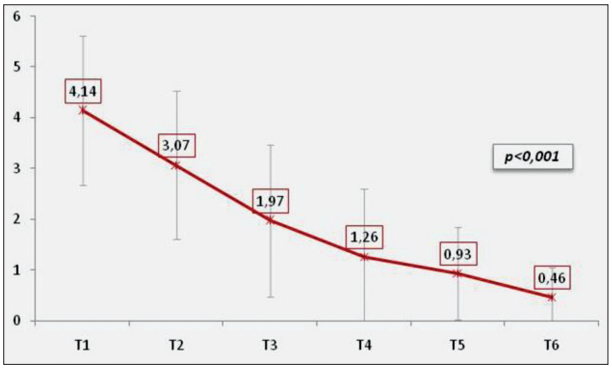


Figure 4. Graphic representation of average values of maximum distance (mm) between teeth measured with a digital caliper
Slika 4. Grafički prikaz prosečnih vrednosti maksimalnog rastojanja (mm) među zubima merenog digitalnim kaliperom

DISCUSSION

It has been shown that among clinicians, sliding mechanics is the most commonly used method for the post-extraction space closure [13]. The possibility of quick and easy reactivation with minimal bending of the wire and saving time are the advantages that make sliding mechanism the method of choice during treatment of extraction spaces closure [14]. The results of research conducted in Brazil by Monnini et al. confirmed that most specialists (63.81%) prefer a technique based on sliding mechanics, while elastic chains are among the most used methods [2]. In a similar study in Great Britain, they came to the conclusion that loops are practically not used for space closure, and the sliding technique was used in 98% of cases [3].

Chitra and Prakash analyzed the use of photogrammetry in orthodontic diagnosis and treatment planning. They found that occlusal photogrammetric analysis could be used as an adjunct to the analysis of study models and to assess treatment progress. In cases where appliances for expansion were used, photogrammetric measurement of intercanine distance, anterior and posterior widths could be used periodically for quantitative monitoring to determine the change during treatment [12]. They can also be used to measure the mesiodistal dimension of the tooth and to calculate the Bolton mismatch, as well as to plan the correction of deviations from the midline [13].

The results of this study showed that post-extraction spaces were closed by an average of 1.00 mm per month when measurements were performed by photogrammetry. Control measurements with a digital caliper gave average values of 1.02 mm per month. Both methods confirmed the high efficiency of elastic chains in post-extraction space closure.

Numerous authors have analyzed post-extraction space closure in different ways [14, 15]. Direct measurement with a digital caliper has proven to be the simplest method for both the patient and the therapist. The biggest advantage is that the measurement results are obtained immediately, which can be of great importance for assessing the success so far and treatment planning. This method was used by Dixon et al., who used elastic chains in 10 patients and found that the space was closed by 0.58 mm per month [4]. A similar study was conducted by Chaudhari and Tarvade observing the closure of postextraction spaces in 20 patients. During 4 months, measurements were performed using a digital caliper from the tip of the canine to the tip of the mesiobuccal cusp on the first permanent molar, and they found that this value decreased by 0.62 mm per month [16]. Direct measurement was used by both Kanuru et al. when examining the amount of space closure by moving the canines using 4 different elastic chains over 6 weeks. They measured the distance from the hook of the bracket on the canine to the hook of the tube on the first molar. After 3 weeks, the measured values for space closure ranged from 0.75 mm to 1.12 mm, while after 6 weeks these values ranged from 1.47 mm to 2.07 mm [17]. However, the biggest disadvantage of this method is the correct positioning of the caliper arms, because the measurement is performed in a limited space in a humid environment, so it can happen that wrong results occur.

Indirect measurements involve taking impressions at check-ups, which allows the orthodontist greater comfort for analysis and measurement. This method was used by Talwar and Bath who also examined the efficiency of elastic chains. Impressions were taken at the beginning and at the end of the observed 12-week period. Measurements were performed on study models from the tip of the canine to the tip of the mesiobuccal cusp on the first permanent molar. The average values were 1.62 ± 0.14 mm per month [18]. Fang et al. conducted a similar study, but the measurement points were located at the tip of the canine and

in the middle of the central fissure of the second premolar, while the space was closed by 0.52 mm per month [19].

Sabrina et al. investigated the closure of post-extraction spaces in self-ligating and conventional locks using an elastic chain in 11 patients over 8 weeks. At the control examinations, the arches were removed, and the prints were taken through brackets that were protected with wax. Measurements were performed indirectly on the obtained study models, from the distal surface of the canine to the mesial surface of the second premolar using a digital caliper. The average value for conventional brackets was 0.75 mm, and for self-ligating 0.48 mm per month [20].

A similar split-mouth study was conducted by Mezomo et al. comparing conventional and self-ligating brackets, and as a sliding mechanism an elastic chain. Impressions were taken at the monthly controls, and measurements were performed by the indirect method with digital caliper. The results showed that the space closure with conventional brackets takes place at a rate of 0.84 mm per month; while for self-ligating locks this value was 0.90 mm per month [21]. The biggest disadvantage of indirect measurement is that the time of the control inspection is extended, and the inadvertent detachment of the brackets can contribute to that even more, which requires additional time planning.

Bokas and Woods observed the closure of 12 post-extraction spaces by sliding mechanics using elastic chains. Control examinations were performed at 28-day intervals and impressions were taken for study models which were then scanned. Measurements were performed on digital photographs obtained by occlusal scanning using the appropriate software. The results showed that elastic chains closed spaces by 1.68 mm per month [22]. Scanning models and analyzing their 3D replicas gives the orthodontist the ability to measure in three dimensions, and software manipulation allows monitoring and prediction of treatment results. However, properly analyzing and measuring scanned models requires practice and a good knowledge of the capabilities provided by the software.

Like previous methods, photogrammetry has its advantages and disadvantages. The advantage is first of all that you avoid taking impressions. The record obtained by this method is in color and faithfully depicts the area of measurement, but also the structures around it. Another advantage of digital photos is that the image can be repeated immediately if it is not satisfactory, and the measurements can be done later without hastle. In addition to a certain inconvenience when taking photos, the biggest drawback of this method is the lack of a third dimension. Therefore, it is necessary that the picture taking conditions be standardized.

CONCLUSION

The elastic chain has proven to be a very effective mechanism for closing the post-extraction space, and photogrammetry is a simple and precise method for monitoring treatment results. Since the difference in relation to measurements with a digital caliper is minimal, photogrammetry can be routinely applied in everyday practice.

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Fotogrametrijska analiza zatvaranja postekstrakcionog prostora

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KRATAK SADRŽAJ

Uvod Prilikom planiranja ortodontske terapije ponekad je potrebno primeniti ekstrakciju pojedinih zuba kako bi se postigla pravilna okluzija i prihvatljiv estetski izgled. Kliničari najveću prednost daju elastičnim lancima kao metodi za zatvaranje postekstrakcionih prostora u toku terapije fiksnim ortodontskim aparatima. Kod zatvaranja postekstrakcionih prostora neophodno je njihovo merenje kako bi se prilagodio plan terapije. Jedna od najprihvatljivijih metoda je fotogrametrija.
Cilj ovog rada je bio da se fotogrametrijskom metodom analizira efikasnost zatvaranja postekstrakcionog prostora sa elastičnim lancima u okviru terapije fiksnim ortodontskim aparatima.
Materijal i metode Ukupan uzorak u istraživanju činilo je 38 postekstrakcionih prostora kod 19 pacijenta kojima je indikovana ekstrakcija prvih premolara i primena fiksnog ortodontskog aparata u cilju provođenja terapije. Za zatvaranje postekstrakcionih prostora primenjeni su elastični lanci. Postekstrakcioni prostori su praćeni tokom šest meseci sa kontrolnim pregledima svake četiri sedmice. Na kontrolnim pregledima su aktivirani mehanizmi, a merenja širine postektrakcionih prostora su obavljana fotogrametrijom i digitalnim nonijusom.
Rezultati Rezultati istraživanja pokazuju da je prosečno smanjenje širine postekstrakcionog prostora iznosilo 1,00 mm mesečno merenjem fotogrametrijskom metodom, dok je prosečna vrednosti kontrolnih merenja digitalnim kaliperom iznosila 1,02 mm. Prosečne vrednosti merene su u šest vremenskih intervala i utvrđena je statistički značajna promena u prosečnim razmacima postekstrakcionih prostora tokom šest meseci.
Zaključak Elastični lanac se pokazao kao veoma efikasan mehanizam za zatvaranje postekstrakcionog prostora, a fotogrametrija kao jednostavna i precizna metoda za praćenje rezultata terapije. S obzirom da je razlika u odnosu na merenja digitalnim kaliperom minimalna, fotogrametrija se može rutinski primenjivati u svakodnevnoj praksi.
Ključne reči: fotogrametrija; elastični lanac; postekstrakcioni prostor

UVOD

Prilikom planiranja ortodontske terapije, ponekad je potrebno primeniti ekstrakciju pojedinih zuba kako bi se postigla pravilna okluzija i prihvatljiv estetski izgled. Zub izbora u ekstrakcionoj terapiji fiksnim ortodontskim aparatima najčešće je prvi premolar. Zatvaranje postekstrakcionog prostora se provodi različitim metodama, a dve osnovne su klizni mehanizmi i metode bez trenja pomoću omči [1]. Primena kliznog mehanizma za zatvaranje postekstrakcionog prostora je veoma česta u kliničkoj praksi zbog svoje jednostavnosti. Istraživanja pokazuju da kliničari najveću prednost daju elastičnim lancima kao metodi za ovu vrstu terapije [2, 3].

Iako su u praksu uvedeni šezdesetih godina prošlog veka, elastični lanci su ostali tradicionalna metoda za retrakciju zuba i uopšte za zatvaranje prostora. I danas su jedna od najčešće primenjivanih tehnika za zatvaranje prostora zahvaljujući lakoj aplikaciji, komfornosti pacijenta i terapeuta [4, 5]. Prvenstveno su sastavljeni od poliestera ili polietera nastalih polimerizacijom guma s višestrukim molekularnim strukturama povezanim nizom uretanskih veza [6]. Prednost elastičnih lanaca je ta što nisu skupi, lako se koriste i mogu se primeniti na različite kliničke slučajeve. Međutim, moraju se menjati svakih 4 do 6 sedmica zbog zadržavanja plaka, otežanog održavanja higijene i očekivanog opadanja sile [7]. Zbog toga je neophodno na kontrolnim pregledima pratiti zatvaranje postekstrakcionog prostora kako bi se sumirali postignuti rezultati i pravilno usmerio plan terapije.

Uvođenjem dentalne fotografije kao sastavnog dela dokumentacije stomatološke terapije, stvorena je mogućnost da se prikaže stanje na početku i na kraju, proces i njene faze. Na ovaj način fotografije se mogu koristiti u razne svrhe, kao što je komunikacija sa pacijentom, prezentacija slučaja, dijagnostika i plan terapije [8]. Uz razvoj digitalne fotografije, pojavila se i inovacija u oblasti stomatologije koja se naziva fotogrametrija, kroz koju se geometrijska svojstva predmeta mogu odrediti iz fotografija i koja je dokazala svoju korisnost u ortodonciji za proučavanje trodimenzionalne okluzije zubnih lukova, zuba i njihovih dimenzija. Fotogrametriju Chadwick definiše kao umetnost, nauku i tehnologiju dobijanja pouzdanih informacija o fizičkim objektima kroz procese snimanja, merenja i interpretacije fotografskih slika [9].

Zbog jednostavnosti, ekonomičnosti i bez opasnosti od zračenja, fotogrametrija se na standardizovanim ekstraoralnim i intraoralnim fotografijama koristi u svakodnevnoj ortodontskoj praksi [10, 11, 12].

Cilj ovog rada je bio da se fotogrametrijskom metodom analizira efikasnost zatvaranja postekstrakcionog prostora sa elastičnim lancima u okviru terapije fiksnim ortodontskim aparatima.

MATERIJAL I METODE

Istraživanje je sprovedeno na Medicinskom fakultetu – studijski program stomatologija, u Banjaluci, uz saglasnost Etičkog komiteta Zavoda za stomatologiju. Ukupan uzorak u istraživanju činilo je 38 postekstrakcionih prostora kod 19 pacijenta kojima je indikovana ekstrakcija prvih premolara u cilju provođenja ortodontske terapije. Uzrast ispitanika na početku terapije, kod kojih nisu postojale kontraindikacije za ortodontsku terapiju i koji nisu imali druge ekstrakcije (osim prvih premolara), iznosio je

od 12 do 20 godina. Iz istraživanja su isključeni ispitanici koji su imali lošu oralnu higijenu, koji neredovno dolaze na kontrole i ne pridržavaju se datih uputstava na početku terapije.

Posle ekstrakcije prvih premolara ispitanicima je postavljen fiksni ortodontski aparat (*Dentaurum, Discovery, Roth preskripcija, slot 0,022 in*), nakon čega je izvršena početna nivelacija sa NiTi lukovima okruglog i četvrtastog preseka, pre postavljanja čeličnih četvrtastih lukova. Četvrtasti čelični luk preseka 0,019 × 0,025 in je stajao u slotovima bravica najmanje četiri sedmice, da bi postao pasivan, nakon čega su aplicirani elastični lanci. Elastični lanac je postavljan tako da povezuje kukicu na tubi prvog molara i kukicu bravice na očnjaku, pri čemu je rastegnut na približno dvostruku početnu dužinu, a na kontrolnim pregledima je zamenjen novim (Slika 1).

Postekstrakcioni prostori su praćeni šest meseci od početka primene elastičnih lanaca u intervalima od mesec dana (T_0–T_6). Kontrolni pregledi su obavljani svake četiri sedmice i na njima je proveravano da li je došlo do oštećenja apliciranih mehanizama i izvršena njihova aktivacija.

Za fotogrametrijsku metodu korišćen je fotoaparat Canon (EOS 750D Body), makroobjektiv (EF 100 mm/2,8 IS USM) i blic u obliku prstena (macro Ring Lite MR-14 EXII), ravno okluzalno ogledalo i retraktor za okluzalno fotografisanje sa milimetarskom skalom. Fotografisanjem na kontrolnim pregledima (T_0–T_6) dobijene su standardizovane okluzalne fotografije za gornji i donji zubni luk. Prilikom fotografisanja ogledalo se oslanjalo na suprotni zubni luk, dok je retraktor bio postavljen paralelno sa zubnim nizom koji se fotografiše.

Milimetarska skala na retraktoru je omogućila da se rezultati merenja softverski očitaju kompjuterskim programom Digimizer za analizu i obradu fotografije. Pomoću ovog programa dobijeno je linearno merenje u pikselima. Zatim je očitan broj piksela u jednom centimetru koji se nalazio na retraktoru sa milimetarskom skalom. Na ovaj način jedan centimetar segmenta fotografije, meren u pikselima, koristio se kao parametar da se broj piksela na realnoj fotografiji konvertuje u centimetre. Sva merenja u pikselima su se kroz kompjuterski program konvertovala u milimetre. Mereno je najkraće rastojanje od distalne površine očnjaka do mezijalne površine drugog premolara. Merenja su obavljana tri puta naizmenično, a referentna vrednost je predstavljala srednju vrednost ova tri merenja (Slika 2).

Kako bi se ustanovila preciznost ove metode, uporedo su obavljana merenja i digitalnim nonijusom preciznosti 0,01 mm. Direktnom metodom je izmereno maksimalno rastojanje od distalne površine očnjaka do mezijalne površine drugog premolara. Ova merenja su obavljana za svaki postekstrakcioni prostor tri puta naizmenično. Referentna vrednost je predstavljala srednju vrednost ova tri merenja.

REZULTATI

Prilikom merenja efikasnosti elastičnog lanca korišćena je metoda fotogrametrije. Testom za višestruka poređenja (Tukey test) testirano je da li postoji razlika između svih vremenskih intervala u kojima je prostor između zuba meren ovom metodom. Ovaj test je pokazao da statistički značajna razlika postoji između svih vremenskih intervala. Prosečno rastojanje između zuba smanjuje se tokom vremena, a prosečan razmak postekstrakcionog prostora na početku merenja (T_1) bio je 4,03 ± 1,44 mm, dok je na poslednjem merenju (T_6) iznosio 0,44 ± 0,57 mm (Tabela 1).

Primenom jednofaktorske analize varijanse ponovljenih merenja (Repeated Measure ANOVA) ispitano je da li je došlo do statistički značajne promene u prosečnim vrednostima postekstrakcionih prostora kada se koristi metoda elastičnog lanca merena fotogrametrijom. Prosečne vrednosti merene su u šest vremenskih intervala i utvrđena je statistički značajna promena u prosečnim razmacima postekstrakcionih prostora tokom šest meseci (Vilksova lambda = 0,019, F = 103,98, p = 0,000). Ispitano je i koliki je uticaj elastičnog lanca kao mehanizma za zatvaranje postekstrakcionih prostora. Vrednost Vilksove lambde od 0,01 – mali uticaj, 0,06 – umeren uticaj i 0,14 – veliki uticaj i dobijena η^2 koja iznosi 0,98 ukazuju na veoma veliki uticaj elastičnog lanca kao mehanizma zatvaranja postekstrakcionog prostora (Tabela 2).

Grafičkim prikazom je predstavljeno smanjivanje prosečnih vrednosti postekstrakcionih prostora merenih metodom fotogrametrije, pod dejstvom elastičnog lanca (Slika 3).

Kontrolna merenja su obavljana direktnom metodom pomoću digitalnog nonijusa. Prosečan razmak postekstrakcionog prostora na početku merenja (T_1) iznosio je 4,14 ± 1,47 mm, a na kraju (T_6) 0,46 ± 0,59 mm (Tabela 3).

Utvrđena je statistički značajana promena u prosečnim razmacima postekstrakcionih prostora tokom šest meseci (Vilksova lambda = 0,006, F = 322,06, p = 0,000). Ispitano je i koliki je uticaj elastičnog lanca kao mehanizma zatvaranja prostora među zubima. U ovom slučaju dobijena η^2 iznosi 0,99, što ukazuje na veoma veliki uticaj elastičnog lanca kao mehanizma smanjenja prostora među zubima (Tabela 4).

Na Slici 4 grafički su prikazane prosečne vrednosti širine postekstrakcionog prostora, odnosno maksimalnog rastojanja među zubima kod upotrebe elastičnog lanca, merene digitalnim kaliperom.

DISKUSIJA

Pokazalo se da među kliničarima klizna mehanika predstavlja najčešće korišćenu metodu za zatvaranje postekstrakcionog prostora [13]. Mogućnost brze i jednostavne reaktivacije uz minimalno savijanje žice i uštedu vremena su prednosti zbog kojih klizni mehanizam predstavlja metodu izbora u toku terapije zatvaranja postekstrakcionih prostora [14]. Rezultati istraživanja koje su u Brazilu sproveli Monnini i saradnici potvrđuju da većina specijalista (63,81%) preferira tehniku zasnovanu na kliznoj mehanici, dok su elastični lanaci među najviše korišćenim metodama [2]. U sličnoj studiji u Velikoj Britaniji došli su do rezultata da se omče praktično ne koriste za zatvaranje prostora, a klizna tehnika je korišćena u 98% slučajeva [3].

Chitra i Prakash su analizirali upotrebu fotogrametrije u ortodontskoj dijagnostici i planiranju terapije. Ustanovili su da se okluzalna fotogrametrijska analiza može koristiti kao dodatak analizi studijskih modela i za procenu napretka lečenja. U slučajevima kada se koriste aparati za širenje, fotogrametrijsko merenje interkaninog rastojanja, prednje i zadnje širine mogu se periodično koristiti za kvantitativno praćenje da bi se utvrdila promena u toku lečenja [12]. Mogu se takođe primeniti i za merenje meziodistalne dimenzije zuba i u izračunavanju Boltonove

nepodudarnosti, kao i za planiranje korekcije odstupanja od srednje linije [13].

Rezultati ovog istraživanja pokazuju da se postekstrakcioni prostori zatvaraju prosečno za 1,00 mm mesečno kada su merenja obavljana fotogrametrijom. Kontrolna merenja digitalnim kaliperom daju prosečne vrednosti od 1,02 mm mesečno. I jedna i druga metoda potvrđuju veliku efikasnost elastičnih lanaca kod zatvaranja postekstracionog prostora.

Brojni autori su analizirali zatvaranje postekstrakcionog prostora na različite načine [14, 15]. Kao najjednostavnija metoda i za pacijenta i za terapeuta pokazalo se direktno merenje digitalnim kaliperom. Najveća prednost je u tome što se rezultati merenja dobiju odmah, što može biti od velikog značaja za procenu dosadašnjeg uspeha i planiranja terapije. Upravo ovu metodu su koristili Dixon i saradnici, koji su primenom elastičnih lanaca kod 10 pacijenata utvrdili da se prostor zatvara za 0,58 mm mesečno [4]. Slično istraživanje su sproveli Chaudhari i Tarvade posmatrajući zatvaranje postekstrakcionih prostora kod 20 pacijenata. U toku četiri meseca merenja su izvršena pomoću digitalnog kalipera od vrha kvržice na očnjaku do vrha meziobukalne kvržice na prvom stalnom molaru, pri čemu su ustanovili da se ta vrednost smanjuje za 0,62 mm mesečno [16]. Direktno merenje su koristili i Kanuru i saradnici kada su ispitivali iznos zatvaranja prostora pomeranjem očnjaka koristeći četiri različita elastična lanca tokom šest sedmica. Merili su rastojanje od kukice bravice na očnjaku do kukice tube na prvom molaru. Nakon tri sedmice izmerene vrednosti za zatvaranje prostora su iznosile od 0,75 mm do 1,12 mm, dok su posle šest sedmica te vrednosti iznosile od 1,47 mm do 2,07 mm [17]. Međutim, najveći nedostatak ove metode je u pravilnom pozicioniranju krakova kalipera, jer se merenje obavlja u ograničenom prostoru u vlažnoj sredini, pa se može desiti da zbog toga dođe do pogrešnih rezultata.

Indirektna merenja podrazumevaju uzimanje otisaka na kontrolnim pregledima, što omogućava ortodontu veći komoditet za analizu i merenje. Ovu metodu su koristili Talwar i Bath, koji su takođe ispitivali efikasnost elastičnih lanaca. Otisci su uzeti na početku i na kraju posmatranog perioda od 12 sedmica. Merenje su se obavljala na studijskim modelima od vrha kvržice na očnjaku do vrha meziobukalne kvržice na prvom stalnom molaru. Prosečne vrednosti su iznosile 1,62 ± 0,14 mm mesečno [18]. Fang i saradnici su sproveli slično istraživanje, ali su se merne tačke nalazile na vrhu kvržice očnjaka i sredini centralne fisure drugog premolara, dok se prostor zatvarao za 0,52 mm mesečno [19].

Sabrina i saradnici su ispitivali zatvaranje postekstrakcionih prostora kod samoligirajućih i konvencionalnih bravica pomoću elastičnog lanca kod 11 pacijenata tokom osam sedmica. Na kontrolnim pregledima su uklanjani lukovi, a otisci su se uzimali preko bravica koje su bile zaštićene voskom. Merenja su se vršila indirektno na dobijenim studijskim modelima, od distalne površine očnjaka do mezijalne površine drugog premolara pomoću digitalnog kalipera. Prosečna vrednost za konvencionalne bravice je iznosila 0,75 mm, a za samoligirajuće 0,48 mm mesečno [20].

Sličnu split-mouth studiju je sproveo i Mezomo sa saradnicima poredeći konvencionalne i samoligirajuće bravice, a kao klizni mehanizam elastične lance. Na mesečnim kontrolama su uzimani otisci, a merenja su izvršena indirektnom metodom sa digitalnim nonijusom. Rezultati su pokazali da se zatvaranje prostora konvencionalnim bravicama odvija brzinom od 0,84 mm mesečno, dok je za samoligirajuće bravice ova vrednost iznosila 0,90 mm mesečno [21]. Najveći nedostatak indirektnog merenja je u tome što se produžava vreme kontrolnog pregleda, a tome još više može da doprinese nehotično odlepljivanje bravica, što zahteva dodatno planiranje vremena.

Bokas i Woods su posmatrali zatvaranje 12 postekstrakcionih prostora kliznom mehanikom primenom elastičnih lanaca. Kontrolni pregledi su obavljani u intervalima od 28 dana, i na njima su uzimani otisci za studijske modele koji su zatim skenirani. Merenja su izvršena na digitalnim fotografijama dobijenim okluzalnim skeniranjem pomoću odgovarajućeg softvera. Rezultati pokazuju da su elastični lanci zatvarali prostore za 1,68 mm mesečno [22]. Skeniranje modela i analiza njihovih 3D replika pruža ortodontu mogućnost merenja u tri dimenzije, a softverska manipulacija omogućava praćenje i predviđanje rezultata terapije. Međutim, pravilno analiziranje i merenje skeniranih modela zahteva uvežbanost i dobro poznavanje mogućnosti koje pruža softver.

Kao i prethodne metode, fotogrametrija ima svoje prednosti i nedostatke. Prednost je pre svega u tome što se izbegava uzimanje otisaka. Zapis koji se dobije ovom metodom je u boji i verno oslikava i područje merenja, ali i strukture oko njega. Još jedna prednost koju nose digitalne fotografije je to što se snimak može odmah ponoviti ukoliko nije zadovoljavajući, a merenja obaviti kasnije bez žurbe. Pored određene neprijatnosti kod fotografisanja, najveća mana ove metode je nedostatak treće dimenzije. Zato je neophodno da uslovi fotografisanja budu standardizovani.

ZAKLJUČAK

Elastični lanac se pokazao kao veoma efikasan mehanizam za zatvaranje postekstrakcionog prostora, a fotogrametrija kao jednostavna i precizna metoda za praćenje rezultata terapije. S obzirom na to da je razlika u odnosu na merenja digitalnim kaliperom minimalna, fotogrametrija se može rutinski primenjivati u svakodnevnoj praksi.

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Investigation of the radiopacity and cytotoxicity of ALBO-DENT – novel strontium carbonate incorporated calcium silicate based dental cement

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SUMMARY

Introduction Calcium silicate (CS) dental cements have numerous clinical indications in dentistry including pulp capping, root end surgery, perforation repair and apexification/apexogenesis treatment.

Materials and methods Novel CS based dental cement with incorporation of $SrCO_3$ radiopacifier named ALBO-DENT was used as an experimental cement material while Portland cement (Aalborg, Denmark) and ProRoot MTA (Tulsa Dental, USA) were used as controls. The radiopacity evaluation was performed using digital Trophy Radiographic system with an intention to precisely determine the minimum of radiopaque agent needed to confer to ISO radiopacity requirement. Thereafter, biocompatibility of material was tested in *in vitro* conditions in mouse fibrosarcoma L929 cell culture treated with materials' extracts. Cell morphology was observed using phase-contrast microscopy, while cell viability was measured using crystal violet (CV) and 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium bromide (MTT) assays.

Results Radiopacity evaluation revealed that 30%wt addition of $SrCO_3$ was necessary to achieve satisfactory radiopacity (3.45 mm Al). Cytotoxicity analysis using CV and MTT assays revealed that pure extracts of ALBO-DENT presented superior biocompatibility when compared to PC and MTA controls while serial dilutions of experimental cements' extracts as well as that of PC and MTA did not influence L929 cell viability.

Conclusions Novel formulation of CS cement – ALBO-DENT presented satisfactory radiopacity and adequate biocompatibility.

Keywords: calcium silicate; strontium carbonate; radiopacity; dental materials biocompatibility; endodontics

INTRODUCTION

Calcium silicate (CS) dental cements have revolutionized many regenerative endodontic procedures such as root end surgery, apexification/apexogenesis, perforation repair and direct pulp capping [1]. The very first commercial CS-based dental cement - ProRoot MTA (Tulsa Dental, OK, US) has shown significant clinical outcomes [2] and it is composed of type 1 ordinary Portland cement (PC) (with fineness in the range of 4500–4600 cm^2/g) and bismuth oxide (Bi_2O_3) added for radiopacity, in the proportion of 4:1 [2]. However, it has been shown that Bi_2O_3 addition increases cement solubility, reduces its mechanical resistance and causes tooth discoloration [3]. Therefore, researchers use different alternatives aiming to meet the ISO 6876 requirement for radiopacity. The following radiopaque agents are employed previously: barium sulphate ($BaSO_4$) [4, 5], titanium dioxide (TiO_2) [4], gold (Au) [4, 5], calcium tungstate ($CaWO_4$) [6, 7], zirconium dioxide (ZrO_2) [8, 9, 10], ytterbium fluoride (YbF_3) [9], tantalum pentoxide (Ta_2O_5) [10] and niobium pentoxide (Nb_2O_5) [11, 12].

Our research group has demonstrated the satisfactory properties of two novel CS formulations: one consisting of CS, nano-particulated hydroxyapatite (nano-hydroxyapatite, nHA) and $BaSO_4$ – ALBO $MPCA_1$ and another composed of CS, calcium carbonate ($CaCO_3$) and Bi_2O_3 – ALBO $MPCA_2$. Their mechanical properties and *in vivo* safety, after both acute and sub-chronic administration, are documented previously [13–19]. These materials have shown satisfactory setting time, increased pH value, adequate biocompatibility and enhanced neutralization of the bacterial biofilm [20, 21]. It was confirmed that CS enriched with nHA was associated with YbF_3 as radiopacifiers leading to adequate physicochemical and biological characteristics [9, 19].

This study generally served to further improve the quality of ALBO MPCA cements by incorporating the potentially bioactive radiopacifier – strontium carbonate

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($SrCO_3$). The idea is rooted in proofs of numerous beneficial effects of strontium (Sr) on bone and dental tissue, among which are: osteoproliferative and odontoproliferative effects, stimulation of bone formation and angiogenesis, inhibition of cell differentiation and activity of osteoclasts and induction of human dental pulp stem cells by promoting their odontogenic differentiation, proliferation and mineralization [22, 23, 24]. The aim of this study was to determine the minimal ratio of $SrCO_3$ capable to satisfy ISO required radiopacity standard and investigate the biocompatibility of this material in L929 cell culture.

MATERIALS AND METHODS

Synthesis of inorganic phases

The novel experimental cement – ALBO-DENT was composed of the following components: calcium silicate, zirconium oxide, strontium carbonate, magnesium silicate, mesosilica and hexaphosphate. Silicate active phase was synthesized from calcium chloride pentahydrate ($CaCl_2 \cdot 5H_2O$) (Merck, Germany) and silica sol obtained by hydrothermal treatment. Aluminium acetate ($Al(CH_3COO)_3$) was added to the mixture to provide the production of a small amount (3.01 %) of active tricalcium aluminate (C_3A) phase. Detailed procedure of used CS synthesis is given in investigations of Jokanović et al. [14, 15]. $SrCO_3$ (Sigma-Aldrich, St. Louis, Missouri, USA) was added into the mixture at 10%, 20% and 30% wt. ratio. PC (Aalborg, Denmark) and MTA+ (thereafter referred to as MTA) (Cerkamed, StalowaWola, Poland) served as control.

Specimen preparation

All experimental cements and PC were hand-mixed at a powder/liquid ratio of 1 g cement/0.3 ml distilled water, while MTA preparation was performed in accordance with manufacturer's instructions, using glass mixing pad and stainless steel spatula for cement mixing. The specimens were made using polytetrafluoroethylene (PTFE) ring molds incorporating a cavity of various internal diameter and height depending on the used test. Molds were filled to a level surface with mixed cement.

Radiopacity assessments

Radiopacity was determined in accordance with ISO 6876 [25]. Specimens (n=5) measuring 8 mm in diameter and 1 mm thickness were placed alongside an aluminum step-wedge (99.6 % pure) varying in thickness from 1 to 10 mm in increments of 1 mm each and radiographed by CCD sensor and X-ray unit (Trophy Radiology, Cedex, France) operating at 65 kV, 7 mA, for 0.07 s and at the focus to target distance of 35 cm. Image J for Windows software (National Institutes of Health (NIH), Bethesda, MD, USA) was used to calculate the gray scale values of each specimen and of each aluminium step-wedge thickness. The mean grey scale values were plotted against the number of aluminum steps, the plots were linearly regressed and regressions were used to convert mean grey scale values into millimeters of aluminum.

Cell viability analysis

Preparation of the materials extracts

Cell viability was carried out in accordance with the ISO Standard 10993-5/2005 [26]. Cements were manipulated under sterile conditions. Immediately after mixing, materials were placed into pre-sterilized PTFE molds (12 mm in diameter and 2 mm thick) to set for 24 h in a humidified atmosphere. Thereafter, discs were sterilized by ultraviolet irradiation for 2 h, then immersed in 1 ml complete medium – Dulbecco's modified Eagle medium (DMEM; Gibco, Thermo Fisher Scientific, Inc., Waltham, MA, USA) supplemented with 5 % fetal bovine serum (FBS), 2 mM L-glutamine and penicillin/streptomycin (all from Capricorn Scientific, Ebsdorfergrund, Germany) and incubated for 24 h at 37° C. To prepare eluents for treatment, extracts were diluted with complete culture medium that was used for cultivation of control/non-treated cells.

Cell culture and treatment

The mouse fibrosarcoma L929 cell line (European Collection of Animal Cell Cultures, Salisbury, UK) was cultivated in complete medium and maintained at 37°C, in a humidified atmosphere with 5% CO_2. Cells were prepared for experiments using the conventional trypsinization procedure with trypsin/EDTA and seeded in 96-well flat-bottom plates (5×10^3 cells/well) for the cell viability assessment. Cells were treated 24 h post-seeding with pure extract (1) and serial dilutions (1:2, 1:4, 1:8, 1:16 and 1:32 (v:v)). Cell viability was assessed after 24, 48 and 72 h treatment.

Cell viability assessment

The number of adherent cells was determined using crystal violet (CV) while mitochondrial dehydrogenase activity was assessed using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium bromide (MTT) test. The CV assay was based on the inability of dead cells to remain adherent. After treatment, the adherent, viable cells were fixed with methanol and stained with 10 % CV solution for 15 min at room temperature. CV dye was dissolved in 33 % acetic acid after rigorous washing with water. MTT test measures mitochondrial-dependent reduction of MTT to formazan by metabolically viable cells. MTT solution was added to the cell cultures in the final concentration of 0.5 mg/ml and cells were incubated for an additional hour. Subsequently, the solution was removed and cells were lysed by dimethyl sulfoxide. The absorbance of dissolved CV dye, corresponding to the number of adherent (viable) cells and the conversion of MTT to formazan, corresponding to the number of cells with an active mitochondria were measured in automated micro-plate reader at 570 nm (Sunrise; Tecan, Dorset, UK). The results were

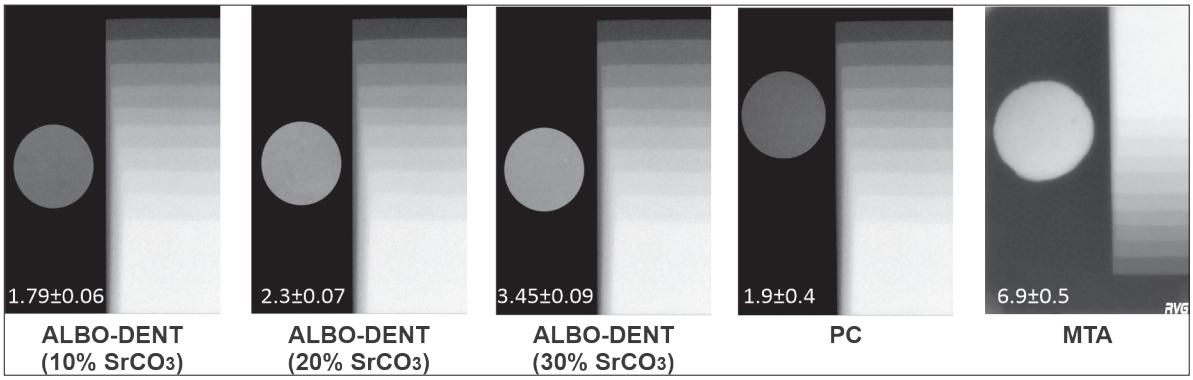

Figure 1. Radiopacity of investigated cements as measured with digital radiography. Digital radiographs of the representative disc-shaped cements' specimens alongside an aluminum step wedge ethalone. Note the increase of the radiopacity with greater percentage of $SrCO_3$ addition. $SrCO_3$ – strontium carbonate; PC – Portland cement; MTA – mineral trioxide aggregate
Slika 1. Rendgenkontrasnost ispitivanih cemenata merena digitalnom radiografijom. Digitalni radiogrami reprezentativnih uzoraka cemenata u obliku diska zajedno sa aluminijumskim etalonom. Primetiti povećanje kontrastnosti sa većim postotkom prisutnog SrCO3. SrCO3 – stroncijum-karbonat; PC – cement Portland; MTA – mineralni trioksidni agregat

presented as percentage of viability relative to untreated, control cultures, considered as 100 % viable. The experiments were performed in triplicates.

Phase contrast microscopy analysis

Morphological changes in mouse fibrosarcoma L929 cell line were observed and cells photographed under Leica DCF320 phase contrast microscope (Leica Microsystems DMIL, Wetzlar, Germany) equipped with Leica Microsystems DFC320 camera and Leica Application Suite software (version 2.8.1), with 20× magnification.

Statistical analysis

The SPSS software program (ver. 20, IBM Corp., Armonk, NY, USA) was employed for statistical analysis. The Shapiro-Wilk test was used to check the normality of data distribution. Afterwards, one-way ANOVA with Bonferroni post-hoc tests was employed to compare obtained radiopacity and cytotoxicity outcomes ($p<0.05$).

RESULTS

The Shapiro-Wilk test for normality found that data were normally distributed and thus they were subjected to one-way ANOVA analysis followed by Bonferroni test.

The results of the radiopacity evaluations are presented in Figure 1. One-way ANOVA revealed that the addition of different percentage of radiopacifiers statistically influenced the obtained values of radiopacity. The lowest value of radiopacity was found in PC that was not statistically different when compared with CS+10%$SrCO_3$ addition, while it was statistically different that all other investigated cements. On the other hand, MTA presented the greatest radiopacity value, statistically higher than in all other cements. Results revealed that 30% wt addition of $SrCO_3$ conferred the ALBO-DENT radio-density of 3.45±0.09 mm Al that was in accordance with ISO 6876 requirement, while 10 % addition and 20 % addition of $SrCO_3$ did not conform with ISO standard for 3 mm Al (1.79±0.06 mmAl, 2.3±0.07 mmAl, for 10 % and 20 %, respectively).

Cytotoxicity data are given in Figure 2 and Figure 3, while representative phase-contrast images of the cells treated with extracts of investigated materials are presented in Figure 4. For CV assay (Figure 2), one-way ANOVA showed the statistical difference among tested cements after 24 h (pure extracts, 1:2 and 1:4), 48 h (pure extracts, 1:2 and 1:4) and 72 h (pure extracts and 1:2) ($p<0.05$). For MTT assay (Figure 3), one-way ANOVA showed the statistical difference for all time points for pure, 1:2 and 1:4 dilutions ($p<0.05$), while significance was not found for 1:8, 1:16 and 1:32 dilutions ($p>0.05$). The results obtained for CV and MTT assays are highly complementary. Pure extract of ALBO-DENT presented lower cytotoxicity than PC and MTA for all time points, showed by both CV and MTT assays. For 1:2 dilution, MTA presented significant proliferative potential after 24h. Similarly, treatment with 1:2 and 1:4 dilutions of PC extract exerted statistically higher proliferative potential after 48 h. The rest of dilutions (1:8, 1:16 and 1:32) had no effect on cell viability.

Consistent with results obtained using cell viability assays, treatment of L929 cells with ALBO-DENT pure extract for 24 h had no effect on cell morphology, but slightly decreased cell proliferation. Contrary, MTA and PC pure extracts triggered morphological changes typical for cell death, cell shrinkage and rounding and detachment of cells from bottom well (Figure 4).

DISCUSSION

This study showed that $SrCO_3$ might be a radiopacifying agent in CS-based dental cement. It has been shown that 30 % wt addition of $SrCO_3$ has met ISO requirement for radiopacity and at the same time cement mixture enriched with 30 % wt $SrCO_3$ showed satisfactory biocompatibility properties.

The idea and reason behind adding $SrCO_3$ into CS-based cement formulation originate from two reasons.

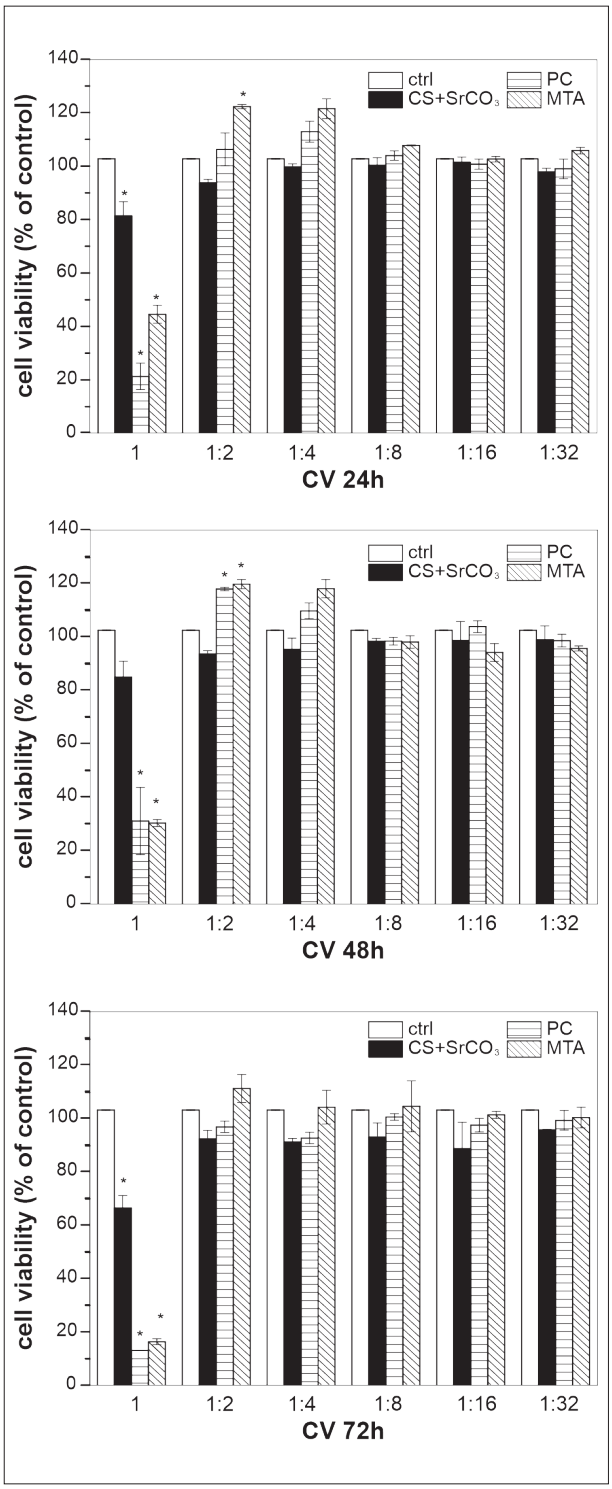

Figure 2. Cell viability (%) evaluated by the crystal violet (CV) assay after 24 h, 48 h and 72 h exposure of L929 cells to the cements' eluents – pure extract (1) and different serial dilutions (1:2, 1:4, 1:8, 1:16, 1:32 (v:v)). The data are presented as mean ± standard deviation (SD) values of triplicates from one representative of three independent experiments. Columns with * are statistically different in comparison to control ($p < 0.05$). $SrCO_3$ – strontium carbonate; PC – Portland cement; MTA – mineral trioxide aggregate

Slika 2. Vijabilnost ćelija (%) izmerena kristal violet (KV) testom posle 24 h, 48 h i 72 h izlaganja ćelija L929 na eluate cemenata – čisti ekstrakt (1) i sa serijom razblaženja (1 : 2, 1 : 4, 1 : 8, 1 : 16, 1 : 32 (v : v)). Rezultati su predstavljeni kao srednja vrednost i standardne devijacije (SD) triplikata kultura iz jednog od tri nezavisna eksperimenta. Kolone sa oznakom * su statistički značajne u poređenju sa kontrolnom grupom ($p < 0,05$). SrCO3 – stroncijum-karbonat; PC – cement Portland; MTA – mineralni trioksidni agregat

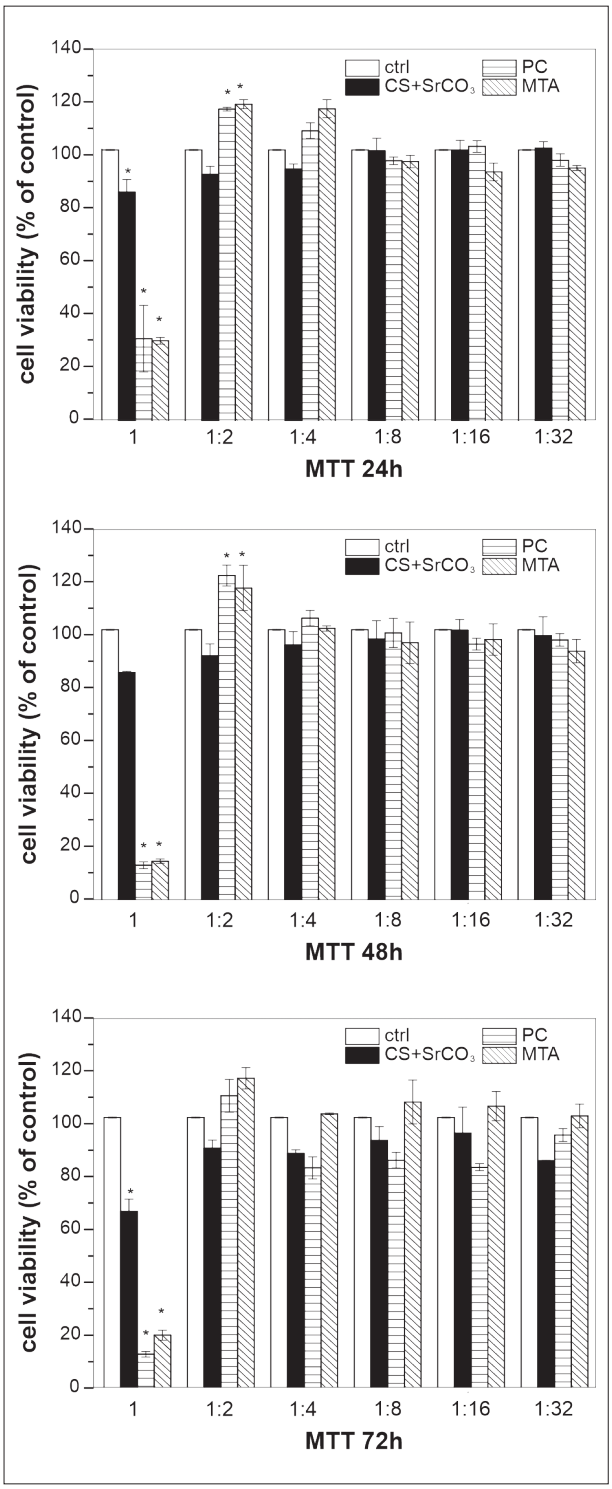

Figure 3. Cell viability (%) evaluated by the MTT test after 24 h, 48 h and 72 h exposure of L929 cells to the cements' eluents – pure extract (1) and different serial dilutions (1:2, 1:4, 1:8, 1:16, 1:32 (v:v)). The data are presented as mean ± standard deviation (SD) values of triplicates from one representative of three independent experiments. Columns with * are statistically different in comparison to control ($p < 0.05$). $SrCO_3$ – strontium carbonate; PC – Portland cement; MTA – mineral trioxide aggregate

Slika 3. Vijabilnost ćelija (%) izmerena MTT testom posle 24 h, 48 h i 72 h izlaganja L929 ćelija na eluate cemenata – čisti ekstrakt (1) i sa serijom razblaženja (1 : 2, 1 : 4, 1 : 8, 1 : 16, 1 : 32 (v : v)). Rezultati su predstavljeni kao srednja vrednost i standardne devijacije (SD) triplikata kultura iz jednog od tri nezavisna eksperimenta. Kolone sa oznakom * su statistički značajne u poređenju sa kontrolnom grupom ($p < 0,05$). SrCO3 – stroncijum-karbonat; PC – cement Portland; MTA – mineralni trioksidni agregat

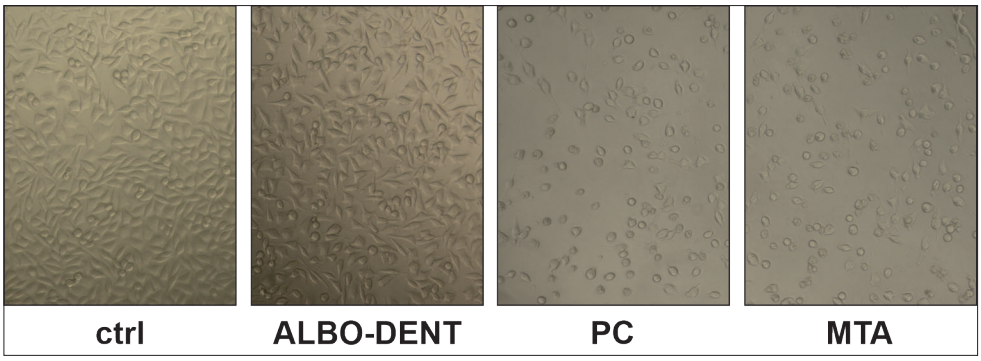

Figure 4. Effects of ALBO-DENT, MTA and PC on mouse fibrosarcoma cell line L929 morphology. L929 cell were grown in medium (A) and in presence of pure extracts of ALBO-DENT (B), MTA (C) and PC (D) for 24 h. Cell morphology was observed using phase contrast microscopy (magnification 20×).
Slika 4. Uticaj ALBO-DENTA, MTA i PC na morfologiju ćelijske linije mišjeg fibrosarkoma L929. Ćelije L929 su gajene u medijumu (A) i u prisustvu čistog ekstrakta ALBO-DENT (B), MTA (C) i PC (D) tokom 24 h. Ćelijska morfologija je posmatrana pomoću fazno kontrastnog mikroskopa (uveličanje 20×).

Firstly, Sr is nowadays accepted as a bioactive constituent of many dental materials and biomaterials used in orthopaedic surgery. In addition, modern strategies for bio-activation of the surfaces of titanium implants include their coating with Sr incorporated layers. Secondly, Sr is intentionally used in the form of carbonates since the addition of calcium carbonate ($CaCO_3$) into CS cements decreases setting time, as it was achieved in Biodentine (Septodont, France) [27].

The results of radiopacity have shown that 30 % wt addition of $SrCO_3$ was necessary to satisfy the radiopacity of ALBO-DENT. The radiopacity of ALBO-DENT was lower than previously found for CS+30%Bi_2O_3 (~11 mm Al) and CS+25%Bi_2O_3 (6.9 mm Al) [28]. The results demonstrated for radiopacity of MTA (6.9 mm Al) corroborate findings of previous studies: 4.86, 6.74, 7.0, 7.5 and 8.0mm Al [28–31]. The PC did not meet the ISO radiopacity requirement that is in line with previous studies (~0.9 mm Al) [28, 29]. The influence of $SrCO_3$ on the radiopacity of endodontic ceramics has not been previously mentioned in the literature. The variations in radiopacity come as a consequence of the difference in the atomic number between the constituents [32]. Namely, atomic number of the compounds is directly proportional to the absorption of x-rays. The atomic number of Sr (Z=40) is lower than that in Bi (Z=83) and therefore higher percentage of $SrCO_3$ is needed to meet ISO radiopacity standard. This is not playing a negative role in the case of $SrCO_3$ such as with other radiopacifiers addition (i.e. Bi) because Sr may be considered not only as biologically safe, but also biologically active constituent.

Biological safety of dental materials is of paramount importance. Therefore, *in vitro* and *in vivo* tests are routinely performed to evaluate material's biocompatibility before it can be used in clinical practice. The cytotoxicity assessment was performed for the mixture with adequate radiopacity value (30% wt addition of $SrCO_3$). ISO 10993-5 stipulates that material can be considered as not cytotoxic if it causes less than 30% cells to die in *in vitro* assays. In our study, two cytotoxicity tests were used: MTT that measures mitochondrial activity of the metabolically active cells and CV that determines the number of the adherent, viable cells. It was demonstrated that novel experimental cement ALBO-DENT performed satisfactory behavior in cell culture, comparable to that of PC and MTA. Presented results showed significantly lower percentage of viable cells in MTA/PC treatments than those found in some studies (80-150%) [7, 33, 34], but they are in agreement with other studies [35, 36]. For PC/MTA 1:2 and 1:4 eluents, the CV and MTT tests showed similar outcomes and are in rough agreement with data documented in the literature [7, 37]. The differences of cell viability results in different studies could arise from variations in specimens' size (5×3 mm [37], 5×2 mm [12] and 5×1 mm [29]). The toxic potential of PC and MTA pure elute may be a matter of debate, but it is presumably the consequence of its high alkalinity in the closed *in vitro* cell viability assessment system. It may be speculated that *in vivo*, where the constant fluid uptake is ensured, these materials may not present negative effect on the surrounding tissue. In any case, novel cement mixture ALBO-DENT presented superior characteristics than widely commercially used ProRoot MTA.

From the clinical point of view, new CS-based experimental material has certain advantages since Sr incorporation may enhance the bone healing during root end canal surgery by activating osteoblasts for improved bone synthesis [22, 23, 24]. In addition, if used for pulp capping procedures, it may stimulate odontoblasts for faster formation of tertiary dentine. These assumptions should be confirmed in the future state of the art researches.

CONCLUSION

Newly synthesized CS-based dental cement with 30% wt addition of $SrCO_3$ as radiopacifying agent meets ISO standard for radiopacity. Biocompatibility of newly synthesized cement, assessed by analysis of cell viability via measurement of the number of adherent, viable cells and viable cells with active mitochondria, is satisfactory and indicates its biological safety.

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Ispitivanje rendgenkontrastnosti i citotoksičnosti ALBO-DENTA – novog kalcijum-silikatnog cementa sa dodatkom stroncijum-karbonata

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KRATAK SADRŽAJ

Uvod Kalcijum-silikatni (KS) dentalni cementi se koriste u brojnim kliničkim indikacijama u stomatologiji koje uključuju direktno prekrivanje pulpe, retrogradnu hirurgiju korena zuba, lečenje perforacija i apeksogenezu/apeksifikaciju.

Materijali i metode U istraživanju je korišćen novosintetisani cement na bazi KS sa dodatkom $SrCO_3$ kao kontrastnog agensa ALBO-DENTA, dok su kao kontrola korišćeni cement Portland (PC, Aalborg, Denmark) i ProRoot MTA (MTA, Tulsa Dental, USA). Rendgenokontrasnost je ispitivana digitalnom radiografijom primenom aparata Trophy, sa namerom da se precizno odredi minimum kontrastnog agensa koji zadovoljava zahteve standarda ISO za rendgenkontrastnost. Biokompatibilnost materijala je ispitana *in vitro*, u kulturi ćelija mišjeg fibrosarkoma L929 tretiranoj ekstraktima ispitivanih materijala. Ćelijska morfologija je praćena upotrebom fazno-kontrastne mikroskopije, dok je vijabilnost ćelija utvrđivana kristal violet (KV) i 3-(4,5-dimetiltiazol-2-yl)-2,5-difenfl-tetrazolium bromid (MTT) esejima.

Rezultati Ispitivanje rendgenkontrastnosti je pokazalo da dodatak 30% $SrCO_3$ dovodi do zadovoljavajućeg kontrasta materijala (3,45 mm Al). Analiza citotoksičnosti KV i MTT metodom je pokazala da čisti ekstrakt ALBO-DENTA pokazuje bolju biokompatibilnost u poređenju sa PC i MTA, dok serijska razblaženja ekstrakta ispitivanog cementa, kao i PC i MTA, nisu uticala na vijabilitet ćelija L929.

Zaključci Novi cement na bazi KS – ALBO-DENT pokazao je zavodovoljavajuću rendgenkontrastnost i odgovarajuću biokompatibilnost.

Ključne reči: kalcijum-silikat; stroncijum-karbonat; rendgenkontrast; citotoksičnost; endodoncija

UVOD

Kalcijum-silikatni (KS) dentalni cementi doveli su do revolucije u mnogim endodontskim regenerativnim zahvatima kao što su endodontska apeksna hirurgija, apeksifikacija/apeksogeneza, reparacija perforacija, kao i direktno prekrivanje pulpe [1]. Prvobitno sintetisani komercijalni KS cement, ProRoot MTA (Tulsa Dental, OK, SAD) pokazao je značajne kliničke rezultate, a sastojao se od tipa 1 standardnog cementa Portland (PC) (sa finoćom u rangu od 4500 do 4600 cm^2/g) i dodatog bizmut-oksida (Bi_2O_3) kao radiokontrastnog sredstva u razmeri 4 : 1 [2]. Međutim, primećeno je da dodatak Bi_2O_3 utiče na povećanu rastvorljivost cementa, redukuje mehaničku otpornost i dovodi do diskoloracije zuba [3]. Iz tog razloga istraživači primenjuju različite alternative u cilju zadovoljavanja ISO 6876 zahteva za radiokontrast. Kao rendgenkontrasti korišćeni su barijum-sulfat ($BaSO_4$) [4, 5], titanijum-dioksid (TiO_2) [4], zlato (Au) [4, 5], kalcijum-volframat ($CaWO_4$) [6, 7], cirkonijum-dioksid (ZrO_2) [8, 9, 10], iterbijum-fluorid (YbF_3) [9], tantal-pentoksid (Ta_2O_5) [10] i niobijum-pentoksid (Nb_2O_5) [11, 12].

Naša istraživačka grupa došla je do zadovoljavajućih osobina dva nova KS preparata: jedan se sastojao od KS, nanočestičnog hidroksiapatita (nHA) i $BaSO_4$ – ALBO $MPCA_1$, dok se drugi sastojao od KS, kalcijum-karbonata ($CaCO_3$) i Bi_2O_3 – ALBO $MPCA_2$. Njihove mehaničke osobine kao i bezbednost u živom organizmu (*in vivo* safety), posle akutne i subhronične primene, dokumentovane su u prethodnim radovima [13–19]. Ovi preparati su pokazali zadovoljavajuće vreme očvršćavanja, povećanu pH vrednost, pogodnu biokompatibilnost i pojačanu neutralizaciju bakterijskog biofilma [20, 21]. Potvrđeno je da je KS obogaćen nHA uz dodatak YbF_3 kao radiokontrasta doveo do adekvatnih fizikohemijskih i bioloških karakteristika [9, 19].

Opšti cilj ove studije bio je da se dodatno poboljša kvalitet cementa ALBO MPCA dodavanjem potencijalno bioaktivnog radiokontrasta – stroncijum-karbonata ($SrCO_3$). Ideja je ukorenjena u dokazima brojnih povoljnih efekata stroncijuma (Sr) na kost i zubna tkiva, među kojima su osteoproliferativni i odontoproliferativni efekati, stimulacija formiranja kosti i angiogeneza, inhibicija ćelijske diferencijacije i osteoklastne aktivnosti, odnosno indukcija humanih stem ćelija zubne pulpe promocijom njihove odontogene diferencijacije, proliferacije i mineralizacije [22, 23, 24]. Cilj ovog istraživanja je bio da utvrdi minimalni udeo $SrCO_3$ kao rendgenkontrastnog sredstva koji zadovoljava zahteve ISO u dentalnim cementima i da proveri biokompatibilnost ovog materijala u kulturi ćelija L929.

MATERIJAL I METODE

Sinteza neorganskih faza

Novi eksperimentalni cement ALBO-DENT sačinjen je od sledećih sastojaka: kalcijum-silikata, cirkonijum-oksida, stroncijum-karbonata, magnezijum-silikata, mezosilike i heksafosfata. Aktivna silikatna faza je sintetisana od kalcijum-hlorida pentahidrata ($CaCl_2 \cdot 5H_2O$) (Merk, Nemačka) i silicijumske sol faze dobijene hidrotermalnim postupkom. Aluminijum-acetat ($Al(CH_3OO)_3$) dodat je u mešavinu da obezbedi formiranje male

količine (3,01%) aktivne trikalcijumaluminatne faze (C_3A). Detaljna procedura sinteze korišćenog KS je opisana u istraživanjima Jokanovića i saradnika [14, 15]. $SrCO_3$ (Sigma-Aldrich, St. Louis, Missouri, SAD) dodat je u mešavinu kao 10%, 20% i 30% težinski postotak. PC (Aalborg, Danska) i MTA+ (kasnije navođen kao MTA) (Cerkamed, StalowaWola, Poljska) služili su kao kontrola.

Priprema uzoraka

Svi eksperimentalni cementi i PC su ručno zamešani; odnos praha i tečnosti je bio 1 g cementa i 0,3 ml destilovane vode, dok je MTA pripremljen prema uputstvu proizvođača, metalnom špatulom za mešanje cemenata na staklenoj pločici. Uzorci su napravljeni korišćenjem politetrafluoroetilenskih (PTFE) kalupa čiji je dijametar šupljine varirao u zavisnosti od korišćenog testa. Kalupi su bili do vrha ispunjeni cementnom masom.

Određivanje rendgenkontrastnosti

Rendgenkontrastnost je utvrđivana u skladu sa standardom ISO 6876 [25]. Uzorci (n = 5) dijametra 8 mm i debljine 1 mm postavljeni su zajedno sa aluminijumskim etalonom (99,6% čistoće), čija je debljina varirala od 1 mm do 10 mm sa postepenim povećanjem od 1 mm, i radiografisani su uz pomoć CCD sensora i izvora x-zraka (Trophy Radiology, Cedex, Francuska) radeći pri sledećim parametrima: 65 kV, 7 mA, 0,07 s i rastojanju između izvora zračenja i objekta radiografisanja od 35 cm. Image J za program Windows (National Institutes of Health (NIH), Bethesda, MD, SAD) primenjen je za izračunavanje stepena sivo-bele skale svakog uzorka i svake debljine aluminijumskog etalona. Srednje vrednosti sivo-bele skale su plotovane sa debljinom aluminijuma, a izvedena linearna zavisnost i regresija korišćene su da se stepen sivo-bele skale pretvori u milimetre aluminijuma.

Analiza ćelijskog vijabiliteta

Priprema ekstrakata materijala. Analiza ćelijskog vijabiliteta je urađena u skladu sa ISO standardom 10993-5/2005 [26]. Cementi su pripremani u sterilnim uslovima. Neposredno posle mešanja materijali su stavljani u sterilisane PTFE kalupe (12 mm širine i 2 mm debljine) da očvrsnu tokom 24 sata u atmosferi zasićenoj vodenom parom. Dobijeni diskovi su zatim sterilisani ultravioletnim zračenjem u trajanju od 2 h, nakon čega su uronjeni u 1 ml kompletnog medijuma – Dulbecco modifikovani Eagle medijum (DMEM; Gibco, Thermo Fisher Scientific, Inc., Waltham, MA, SAD), obogaćenog 5% fetalnim telećim serumom (FBS), 2 mM L-glutaminom i penicilinom/streptomicinom (Capricorn Scientific, Ebsdorfergrund, Nemačka) i inkubirani 24 sata na 37° C. Kako bi se pripremili eluati za tretman ćelija, ekstrakti su razblaženi kompletnim medijumom koji je korišćen za kultivaciju kontrolnih/netretiranih ćelija.

Ćelijska kultura i tretman. Ćelijska linija mišjeg fibrosarkoma L929 (Evropska zbirka animalnih ćelijskih kultura, Salisbury, UK) kultivisana je u kompletnom medijumu i održavana na 37° C, u atmosferi zasićenoj vodenom parom, sa 5% CO_2. Ćelije su pripremljene za eksperiment korišćenjem konvencionalne procedure tripsinizacije sa tripsin/EDTA i zasejavane za testove ćelijskog vijabiliteta u polistirenske ploče sa 96 bunara sa ravnim dnom u gustini 5×10^3 ćelija po bunaru. Ćelije su 24 sata posle zasejavanja tretirane čistim ekstraktom (1) i njegovim serijskim razblaženjima (1 : 2, 1 : 4, 1 : 8, 1 : 16 i 1 : 32 (v : v)). Vijabilitet ćelija je procenjen posle 24, 48 i 72 sata.

Merenje vijabiliteta ćelija. Broj adherentnih ćelija utvrđen je kristal violet (KV) testom, dok je aktivnost mitohondrijalne dehidrogenaze merena testom 3-(4,5-dimetiltiazol-2-il)-2,5 difeniltetrazolijum-bromid (MTT). Kolorimetrijski test KV se zasniva na činjenici da adherentne ćelije koje podležu ćelijskoj smrti gube sposobnost adherencije i odlepljuju se od podloge, tako da je količina boje koju ćelije u kulturi vežu direktno proporcionalna broju živih ćelija. Nakon završetka tretmana iz ploče je odliven medijum, a bunari su isprani PBS-om i na taj način su odstranjene odlepljene, mrtve ćelije. Adherentne ćelije su fiksirane metanolom u trajanju od 15 minuta na sobnoj tempeaturi, a zatim su bojene 1% rastvorom kristal violeta u PBS-u, takođe 15 minuta na sobnoj temperaturi. Boja koja se nije vezala ispirana je vodom, a boja ugrađena u ćelije je rastvorena 33% rastvorom sirćetne kiseline u vodi.

MTT je tetrazolijumska so žute boje koja se u metabolički aktivnim ćelijama redukuje pomoću mitohondrijskih dehidrogenaza do ljubičastih nesolubilnih kristala formazana. Formazan se rastvara rastvorom DMSO i intenzitet dobijene ljubičaste boje je direktno proporcionalan aktivnosti mitohondrija, što odgovara broju živih ćelija. Po završetku kultivacije ćelija medijum je odlivan i ćelije su isprane PBS-om. Ćelije su zatim inkubirane jedan sat na 37° C sa rastvorom MTT boje (0,5 mg/ml). Nakon inkubacije boja je odlivena sa ćelija, a kristali formazana su rastvoreni pomoću DMSO. Intenzitet dobijenih boja je meren na automatskom čitaču ploča za mikrotitraciju (Sunrise; Tecan, Dorset, UK) na talasnoj dužini od 570 nm. Vijabilnost tumorskih ćelija izražena je kao procenat netretirane kontrole, kojoj je arbitrarno dodeljena vrednost 100%. Eksperimenti su urađeni u triplikatima.

Fazno-kontrastna mikroskopija

Morfološke promene mišje fibrosarkomske ćelijske linije L929 su analizirane i ćelije su fotografisane nakon 24 sata tretmana pomoću mikroskopa Leica DCF320 (Leica Microsystems DMIL, Wetzlar, Nemačka) opremljenog kamerom Leica Microsystems DFC320 i softverom Leica Application Suite (verzija 2.8.1), pri čemu je izabrano uveličanje od 20×.

Statistička analiza

Softverski program SPSS (ver. 20, IBM Corp., Armonk, Njujork, SAD) primenjen je za statističku analizu. Šapiro-Vilkov test je korišćen za proveru normalnosti raspodele podataka. Nakon toga je primenjena jednosmerna analiza varijanse (ANOVA) sa Bonferonijevim post-hok testom za poređenje dobijenih vrednosti radiokontrastnosti i citotoksičnosti ($p < 0,05$).

REZULTATI

Primena Šapiro-Vilkovog testa normalnosti je pokazala da su dobijeni podaci normalno distribuirani te su podvrgnuti jednosmernoj analizi varijanse (ANOVA) praćenoj Bonferonijevim testom.

Rezultati procene rendgenkontrastnosti su predstavljeni na Slici 1. Primena ANOVA testa pokazala je da je dodavanje različitog procenata rendgenkontrastnog sredstva uticalo na stepen rendgenkontrastnosti. Najniža vrednost rendgenkontrastnosti izmerena je u PC i nije se statistički razlikovala od cementa sa dodatkom CS + 10% $SrCO_3$, ali se statistički razlikovala od svih ostalih ispitivanih cementa. S druge strane, vrednost rendgenkontrastnosti MTA bila je statistički veća od svih ostalih cementa. Rezultati su pokazali da je 30% težinskog dodatka $SrCO_3$ obezbedilo cementu ALBO-DENT rendgenkontrastnost od 3,45 ± 0,09 mm Al, što je u skladu sa zahtevima ISO 6876 standarda, dok dodavanje 10%, odnosno 20% $SrCO_3$ nije bilo u skladu sa zahtevima ISO standarda od 3 mm Al (1,79 ± 0,06 mm Al, 2,3 ± 0,07 mm Al, za 10%, odnosno 20%).

Rezultati citotoksičnosti prikazani su na Slici 2 (KV) i Slici 3 (MTT), a reprezentativne fotografije ćelija tretiranih čistim ekstraktima ispitivanih materijala posmatranih fazno-kontrastnom mikroskopijom prikazane su na Slici 4. Jednosmerna analiza varijanse je pokazala da za podatke dobijene KV testom postoji statistička razlika između ispitivanih materijala nakon 24 sata (čisti ekstrakti, 1 : 2 i 1 : 4), 48 sata (čisti ekstrakti, 1 : 2 i 1 : 4) i 72 sata (čisti ekstrakti i 1 : 2) ($p < 0,05$). Za podatke dobijene MTT testom ista analiza je pokazala statističku razliku u svim vremenskim tačkama za čist ekstrakt, kao i 1 : 2 i 1 : 4 razblaženja ($p < 0,05$), dok značajnost nije uočena za 1 : 8, 1 : 16 i 1 : 32 razblaženja ($p > 0,05$). Rezultati dobijeni KV i MTT testovima su izuzetno komplementarni. Čisti ekstrakt cementa ALBO-DENT je pokazao značajno manju citotoksičnost u poređenju sa PC i MTA, u svim praćenim vremenima. Razblaženje MTA 1 : 2 je pokazalo proliferativni potencijal nakon 24 sata. Razblaženje PC 1 : 2 i 1 : 4 je potenciralo proliferaciju ćelija nakon 48 sata, dok ostala razblaženja (1 : 8, 1 : 16 i 1 : 32) nisu pokazala statistički značajan uticaj na ćelijsku vijabilnost.

U skladu sa rezultatima dobijenih testova za ispitivanje ćelijskog vijabiliteta, tretman ćelija L929 sa čistim ekstraktom cementa ALBO-DENT tokom 24 sata nije uticao na morfologiju ćelija, ali je blago inhibirao ćelijsku proliferaciju. S druge strane, čisti ekstrakti MTA i PC izazvali su morfološke promene koje su karakteristične za ćelijsku smrt – ćelije su u njihovom prisustvu izgubile volumen, zaokruglile se i odvojile od podloge.

DISKUSIJA

Ova studija je pokazala da se $SrCO_3$ može koristiti kao rendgenkontrastno sredstvo kod KS dentalnih cemenata. Pokazano je da 30% težinskog dodatka $SrCO_3$ zadovoljava ISO standarde rendgenkontrastnosti i u isto vreme ova mešavina obogaćena sa 30% $SrCO_3$ pokazuje zadovoljavajuću biokompatibilnost.

Ideja i razlog dodavanja $SrCO_3$ u KS dentalne cemente proizilazi iz dva razloga. Prvo, stroncijum danas predstavlja široko prihvaćeni bioaktivni sastojak mnogih stomatoloških materijala, kao i biomaterijala u ortopedskoj hirurgiji. Takođe, savremene strategije za povećanje bioaktivnosti površina titanijumskih implantata uključuju njihovo presvlačenje filmovima na bazi stroncijuma. Drugo, stroncijum je sa razlogom odabran u formi karbonata jer dodavanje kalcijum-karbonata u KS cemente skraćuje vreme očvršćavanja, što je postignuto kod biodentina (Septodont, Francuska) [27].

Rezultati rendgenkontrastnosti su pokazali da je 30% dodatka $SrCO_3$ neophodno da se postigne željena rendgenkontrastnost ALBO-DENTA. Rendgenkontrastnost ALBO-DENTA je bila niža nego što je prethodno pronađeno za CS+30% Bi_2O_3 (~11 mmAl) i CS+25%Bi_2O_3 (6,9 mmAl) [28]. Rezultati istraživanja u vezi sa MTA (6,9 mmAl) slažu se sa prethodnim istraživanjima: 4,86, 6,74, 7,0, 7,5 i 8,0 mmAl [28–31]. PC nije ispunio ISO standard rendgenkontrastnosti, što je u saglasnosti sa prethodnim studijama (~0,9 mmAl) [28, 29]. Uticaj dodataka $SrCO_3$ na rendgenkontrastnost endodontske keramike nije do sada pominjan u literaturi. Razlike u rezultatima dobijenih vrednosti rendgenkontrastnosti potiču od različitih atomskih brojeva sastojaka [32]. Naime, atomski broj sastojaka je u direktnoj vezi sa apsorpcijom x-zraka. Atomski broj stroncijuma (Z = 40) niži je od atomskog broja bizmuta (Z = 83) i zbog toga je neophodno dodati više $SrCO_3$ kako bi se zadovoljili zahtevi ISO standarda. Ovo nema negativnu ulogu u slučaju $SrCO_3$ kao kod drugih dodatih rendgenkontrastnih sredstava (na primer bizmut) jer se stroncijum može smatrati ne samo biološki bezbednim već i biološki aktivnim sastojkom.

Biološka bezbednost stomatoloških materijala je od izuzetne važnosti. Zbog toga se *in vitro* i *in vivo* testovi rutinski primenjuju za ispitivanje citotoksičnosti materijala pre njihove upotrebe u kliničkoj praksi. Testovi citotoksičnosti su izvedeni na mešavini koja je pokazala odgovarajuću vrednost rendgenkontrastnosti (30% težinski dodatka $SrCO_3$). ISO 10993-5 propisuje da se material može smatrati necitotoksičnim ukoliko uzrokuje smrt manje od 30% ćelija u *in vitro* uslovima. U ovoj studiji korišćena su dva testa za ispitivanje citotoksičnosti: MTT, koji meri mitohondrijalnu aktivnost ćelija i KV, koji određuje broj adherentnih živih ćelija. Pokazano je da novi eksperimentalni cement ALBO-DENT pokazuje zadovoljavajuće ponašanje u ćelijskoj kulturi, uporedljivo sa PC i MTA. Dobijeni rezultati pokazuju značajno niži procenat živih ćelija kod tretmana MTA/PC-om nego u drugim istraživanjima (80–150%) [7, 33, 34], ali su u saglasnosti sa rezultatima drugih studija [35, 36]. Kod 1 : 2 i 1 : 4 razblaženja PC/MTA, KV i MTT testovi pokazali su slične rezultate i takođe su u saglasnosti sa podacima koji se navode u literaturi [7, 37]. Razlike u ćelijskoj vijabilnosti u različitim studijama mogu da proisteknu iz razlika u veličini korišćenih uzoraka (5 × 3 mm [37], 5 × 2 mm [12] i 5 × 1 mm [29]). Niže vrednosti za čiste ekstrakte PC i MTA mogu da budu predmet debate, ali su najverovatnije posledica visoke alkalnosti eluata u zatvorenom *in vitro* ćelijskom sistemu. Može se pretpostaviti da u situacijama u kojima je obezbeđen dotok tečnosti ovi materijali ne bi pokazali negativan efekat na okolno tkivo. U svakom slučaju, novosintetisani cement ALBO-DENT je pokazao superiornije osobine u odnosu na komercijalno dostupni ProRoot MTA.

Sa kliničke tačke gledišta, novi eksperimentalni materijal na bazi KS može da ima izvesne prednosti budući da dodatak stroncijuma može da poboljša zaceljenje koštanog tkiva nakon periapeksnog hirurškog zahvata aktivirajući osteoblaste [22, 23, 24]. Takođe, ukoliko se koristi za direktno prekrivanje pulpe, on može da stimuliše osteoblaste u smislu bržeg formiranja tercijarnog dentina. Ove pretpostavke bi trebalo da se potvrde upotrebom savremenih procedura koje su trenutno u toku.

ZAKLJUČAK

Novosintetisani cement na bazi KS sa 30% težinskim dodatkom $SrCO_3$ kao rendgenkontrastnog sredstva zadovoljava zahteve standarda ISO za kontrastnost. Biokompatibilnost novosintetisanog cementa na osnovu analize ćelijskog vijabiliteta merenjem broja adherentnih ćelija i aktivnosti mitohondrijalne dehidrogenaze je zadovoljavajuća i ukazuje na njegovu biološku bezbednost.

ZAHVALNICA

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Oral health status in 12 and 15-year-old schoolchildren

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SUMMARY

Introduction Dental caries is, along with periodontitis, the most frequent oral disease and represents a chronic, progressive, multifactorial process that leads to loss of hard dental tissues. The oral health status analysis and caries risk factors assessment in early childhood and adolescence are necessary for creating strategies in oral health promotion and preventive treatment.

The aim of the present study was to evaluate caries prevalence in 12 and 15-year-old schoolchildren in Cukarica, a municipality of Belgrade.

Material and method The retrospective study included 409 schoolchildren of both genders. The oral health status was registered using the Klein-Palmer DMFT system (D – Decayed, M – Missing, F – Filled teeth). The methods of descriptive statistics were performed and p-values lower than 0.05 were considered statistically significant.

Results The younger group included 214 children (52.3%) and the older group 195 (47.7%). Individual caries rate was higher in 15-year-old children (81.02%) comparing to 12-year-old (57%). The mean value of decayed teeth for all participants was 2.43 and of total DMFT was 8.99%.

Conclusions Oral health promotion programs gave positive results. Moreover, it is important to implement them in the underdeveloped regions of Serbia with an improvement of the oral health literacy of parents and raising awareness of oral diseases.

Keywords: oral health; health promotion; dental caries assessment; risk factors; education

INTRODUCTION

Oral diseases have been identified as one of the global public health issues related to health, psychosocial and economic aspects [1]. Tooth decay is, along with periodontal disease, the most frequent oral disease and represents a chronic, progressive, multifactorial process that leads to loss of dental hard tissues. Its etiology is complex and includes several factors, predominantly the presence of fermentable carbohydrates, host factors, and cariogenic microbial flora [2, 3] However, there are also 'micro factors' that are related to individual level and family and 'macro factors' that are referred to social, economic, and cultural features of the country [4]. Caries shares common risk factors with some chronic, non-communicable diseases such as obesity, diabetes, cardiovascular and cerebrovascular disorders [3].

Childhood is a period of constant learning and social, cognitive, emotional, and educational development. Consequently, it is essential to embrace positive habits and attitudes towards oral health and oral hygiene in schoolchildren population. Caries prevalence, strategies for its prevention and diagnosis, treatment, and potential complications of caries lesions are subjects of many epidemiological and clinical studies [2].

Literature data indicate that some European countries and the United States of America have achieved significant results in caries prevention due to effective preventive programs and oral health education. Also, it has been shown that dental caries affects unequally countries with different socioeconomic status, with a higher prevalence in areas with a poorer socioeconomic indicator [5].

Caries prevention programs have the most efficient and long-term results. It is very important to analyze oral health status and identify potential risk factors for caries development in early childhood and adolescence. Obtained epidemiological data is indispensable for creating specific strategies in oral health promotion and preventive treatment [2]. Some authors suggest that the highest caries prevalence in permanent dentition is between 15 and 19 years [6]. Oral health status in 12-year-old children is considered a referent caries indicator in the population and is globally used in different research for evaluation of the success of preventive programs and comparison of the results [3].

The aim of the present study was to evaluate caries prevalence in 12 and 15-year-old schoolchildren in Cukarica, a municipality of Belgrade.

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MATERIAL AND METHOD

The retrospective study included 409 schoolchildren of both genders, from two elementary schools located in Cukarica, one of the municipalities of Belgrade. They were all patients of Community health center Sremcica where a specialist in preventive and pediatric dentistry performed regular dental examinations. Their dental charts were analyzed and oral status characteristics gathered and registered using the Klein-Palmer DMFT system (D – Decayed, M – Missing, F – Filled teeth) [7].

Data were analyzed using SPSS Statistics 22 software (SPSS Inc., Chicago, IL, USA). The methods of descriptive statistics and testing statistical hypotheses were performed. For testing statistical significance among numeric variables, t-test was used, while for categorical variables chi-square test was done. P-values lower than 0.05 were considered statistically significant.

RESULTS

The present study included 409 schoolchildren located in Cukarica, one of the municipalities of Belgrade. In the 12-year-old group there were 214 children (52.3%) and in the 15-year-old group 195 (47.7%). Gender distribution in the younger group was 113 males and 101 females and in the older group 104 males and 91 females (Figure 1).

In total, 31.54 % of children were caries-free (DMFTscore 0) and 68.46% had cavitated caries lesions on the permanent teeth. In 12-year-old schoolchildren, the percentage of children with decayed teeth was 57%. Number of males with all healthy teeth was 48, and females 44. On the other hand, number of children with caries lesions was higher, 65 males and 57 females (Figure 2). In 15-year-old schoolchildren, only 19.2% of them had all healthy teeth and 82.3% had cavitated caries lesions on their permanent teeth. Number of children with all healthy permanent teeth was similar in males and females, 19 and 18, respectively. Number of schoolchildren with decayed permanent teeth was 85 males and 73 females (Figure 3).

Individual caries rate, as one of the most important caries prevalence indicators, was higher in 15-year-old children (81.02%) comparing to 12-year-old (57%) and this was statistically significant ($p<0.001$). Separated analysis in each group showed that in 12-year-old children, individual caries rate was higher in males (57.52%) comparing to females (56.44%), without statistical significance ($p=0.839$). Similar findings were in the other group; it was also higher in males (81.73%) than in females (80.22). This difference was statistically significant ($p=0.026$).

The mean value of total DMFT was 8.99%. This value was higher in 15-year-old schoolchildren (11.06%) comparing to 12-year-old children (6.40%). DMFT gender distribution was different between groups, in younger schoolchildren group, this value was slightly higher in males (6.43%) comparing to females (6.35%) and in the older group it was lower in males (10.65%) than females (12.79%). The mean value of decayed teeth for all

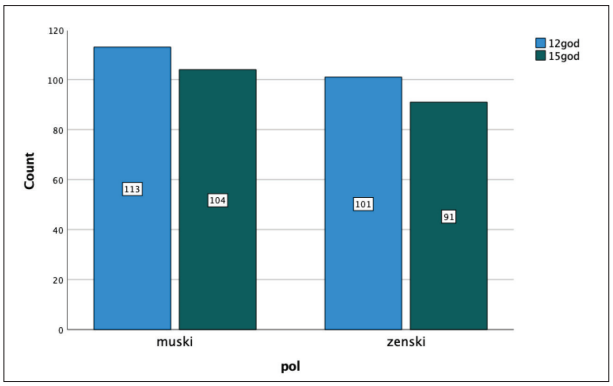

Figure 1. Distribution of children according to gender and age
Slika 1. Podela dece po polu i starosti

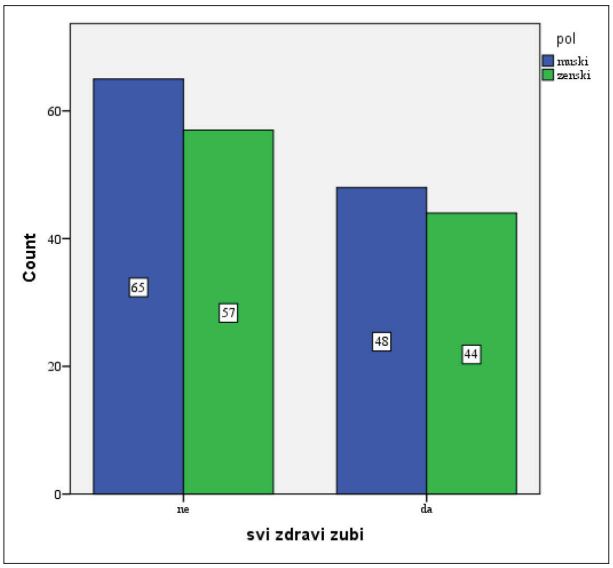

Figure 2. Distribution of healthy teeth between male and female of 12 year old

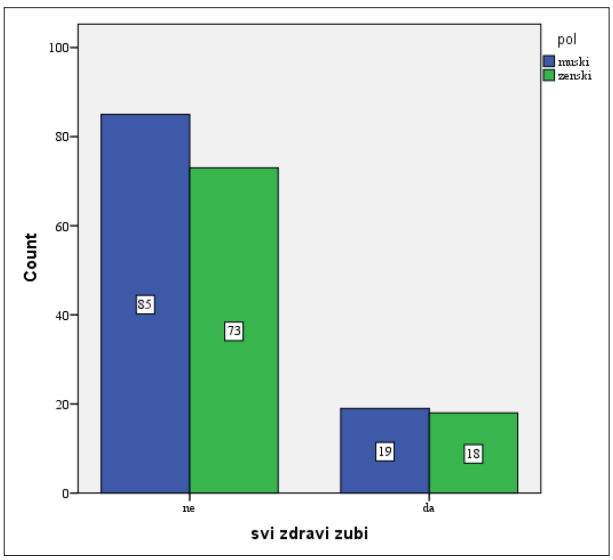

Figure 3. Distribution of healthy teeth between male and female of 15 year old
Slika 3. Podela zdravih zuba po polu kod petnaestogodišnjaka

participants was 2.43. In 12-year-old children, the mean value of decayed teeth was 1.66 and in the older group it was higher (3.26), and this was found to be statistically significant (t=-6.346, p<0.001). In 12-year-old females the mean value of decayed teeth was 1.65 and males 1.67. In the other schoolchildren group, it was 3.58 for females and 2.98 for males.

The mean value of DMFT in 15-year-old females was significantly higher compared to the 12-yer-old females (t=-4.836, p<0.001). The decayed (D) component of the DMFT index was dominant among other variables (52.08%). The percentage of filled teeth was 37.80% and the percentage of extracted teeth due to caries complications was 6.3%. Decayed permanent teeth were more present in the older group (62.60%) compared to the 12-year-old schoolchildren (42.50%), and it was statistically significant (chi-square=16.420, p<0.001). Even though obtained DMFT values were higher in 15-year-old females than 12-year-old females with statistically significant difference (t=-4.836, p<0.001), that difference was not found in the number of missing teeth among these two groups of schoolchildren even though 15-year-old children had more extracted teeth (13.3%) compared to 12-year-old children (9.8%).

The percentage of filled teeth (F) was higher in the older schoolchildren group (48.7%) than younger group (29.4%) and this difference was statistically significant (chi-square=15.995, p<0.001).

DISCUSSION

This study, conducted in the scope of the Belgrade municipality of Cukarica, included schoolchildren aged 12 and 15. Oral status of 12-year-olds has been the subject of many studies around the world since, according to the recommendation of the World Health Organization (WHO), children of this age are considered a standardized group for monitoring oral health, both due to the presence of permanent dentition and the fact that habits of preserving oral health are already formed [7]. In order to understand epidemiological situation of oral health better, it was important that children aged 15 were included in this research as the consequences of bad habits can already be noticed at this age [8]. Of the total number of children examined, 31.54% had all healthy teeth present. This data coincides with the research conducted on the territory of our country, that analyzed the state of oral health in children and youth [3].

If these results are compared with those in developed countries of Europe, such as Germany (ACI only 0.5 and with the tendency to decrease), Spain, where the value of the ACI index for 12-year-olds is 0.82, and for 15-year-olds 1.38, that is, countries in Asia, e.g. China (1.14), and Malaysia (1.36), it is quite clear that the Republic of Serbia is still in the group of countries with a high distribution rate of caries. [9.10] Among the countries with low values, the ACI particularly singles out Nigeria with a score of 0.16 [11]. However, it should be noted that compared to the countries in the environment, Serbia is showing significant progress. The average value of ACI in Montenegro is 3.43, in Bosnia and Herzegovina it is 4.89 in urban areas, and up to 6.74 in rural areas of BiH [12, 13]. Also among the countries with high values of the average caries index is Poland with a value of 4.2 and Iran with 3.35 [14, 15].

The Average Caries Index (ACI) for both age groups was 2.43, which indicates that caries in our area is permanently present and that fact represents a serious social and medical problem affecting the country.

If we compare these results obtained in the scope of one Belgrade municipality (2.43) with those recorded in the southern Serbia (4.22), it can be concluded that there is a difference between the caries index in children living in urban areas and children from rural areas [16]. It should be taken into account that many measures have been taken in the past decade to improve oral health of children in Serbia, especially in the field of prevention [17]. WHO expectations were that by 2020, the value of ACI in twelve-year-olds would be below 1.5 [18]. Our results obtained from the systematic review of the 2019/2020 school year, indicated that we are approaching the achievement of the set goal and that the average values of the caries index, in respondents aged 12, was 1.66.

WHO's study on the health behavior of young people aged 11, 13 and 15 (Health Behavior in School-aged Children; HBSC) was implemented in 49 countries around the world, including Serbia. According to the data for Serbia from 2018, 70.9% of the respondents stated that they brush their teeth more than once a day (82.6% girls and 59.9% boys), which goes in favor of schoolchildren in Serbia who have higher level of brushing culture compared to their peers from other countries in our region [19].

CONCLUSION

The results of this retrospective study showed that the presence of caries in schoolchildren aged 12 and 15 years was found in two-thirds of respondents (68.46%). In the group of 12 years, caries was present in 122 subjects (57%), while in 15-year-old children it was found in 158 subjects (82.3%).

The strategy of education, promotion of oral health, as well as the application of preventive and prophylactic measures should be implemented in less developed parts of Serbia. Intensive education of young parents is necessary for raising health awareness to achieve the same level of oral health as in developed countries of the world.

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Procena oralnog zdravlja dece uzrasta 12 i 15 godina

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KRATAK SADRŽAJ

Uvod Karijes je, pored parodontopatije, jedno od dva najučestalija oralna oboljenja i predstavlja hronično, progresivno oboljenje tvrdih zubnih tkiva kompleksne etiologije. Analiza stanja oralnog zdravlja i identifikovanje faktora rizika za nastanak karijesa u dečjem uzrastu i adolescenciji su osnove preventivnih programa.
Cilj ovog istraživanja je bio da se utvrdi učestalost karijesa kod školske dece uzrasta 12 i 15 godina na teritoriji opštine Čukarica.
Materijal i metode Retrospektivnom studijom obuhvaćeno je 409 dece, oba pola. Procena rasprostranjenosti karijesa je registrovana pomoću Klajn–Palmerovog sistema kroz KEP indeks (K– karijes, E – ekstrahovan zub, P – plombiran zub). Za analizu podataka korišćene su metode deskriptivne statistike, a statističke vrednosti su testirane na nivou statističke značajnosti od 0,05.
Rezultati Grupa dece od 12 godina obuhvatila je 214 (52,3%) ispitanika, a grupa dece od 15 godina 195 (47,7%) ispitanika. Vrednosti karijes indeks osoba (Kio) bile su veće kod dece uzrasta 15 godina (81,02%) u odnosu na uzrast od 12 godina (57%). Ukupan karijes indeks zuba (Kiz) za sve ispitanike iznosio je 8,99%, a prosečan broj obolelih stalnih zuba po jednom ispitaniku (Kip) kod svih testiranih iznosio je 2,43.
Zaključak Primenjene mere za poboljšanje i unapređenja oralnog zdravlja dece postepeno daju rezultate. Promociju oralnog zdravlja je neophodno sprovesti i u slabije razvijenim delovima Srbije uz intenzivnu edukaciju mladih roditelja radi podizanja zdravstvene svesti i očuvanja oralnog zdravlja dece.
Ključne reči: oralno zdravlje; karijes indeksi; promocija zdravlja; faktori rizika; edukacija

UVOD

Oboljenja usta i zuba su označena kao jedan od globalnih javnozdravstenih problema vezanih za zdravstveni, psihosocijalni i ekonomski aspekt [1]. Karijes je, pored parodontopatije, najučestalije oralno oboljenje i predstavlja hroničnu, progresivnu destrukciju tvrdih zubnih tkiva sa vrlo kompleksnom etiologijom. Kao primarni faktori u nastanku karijesa izdvajaju se karakteristike domaćina, specifičnosti mikroflore usne duplje i način ishrane [2, 3]. Međutim, danas se sve više pažnje posvećuje takozvanim „mikrofaktorima" koji deluju na nivou pojedinca, odnosno „makrofaktorima" koji obuhvataju uticaj zajednice i socioekonomske parametre države [4]. Faktori rizika za nastanak karijesa uglavnom su povezani sa nekim drugim hroničnim, nezaraznim bolestima kao što su gojaznost, dijabetes, kardiovaskularna i cerebrovaskularna oboljenja [3].

S obzirom na to da je detinjstvo period intenzivnog učenja i usvajanja pozitivnih navika i stavova, važno je naglasiti da je briga za oralno zdravlje neophodna tokom čitavog života, a pogotovo u najmlađoj populaciji. Učestalost karijesa i njegove potencijalne komplikacije su razlog velikog broja istraživanja koja se bave njegovom prevalencijom, merama prevencije, odnosno pravovremenom dijagnostikom i terapijom [2].

Dosadašnja istraživanja pokazuju da su pojedine zemlje Evrope, kao i Sjedinjene Američke Države, postigle značajne rezultate u prevenciji karijesa zahvaljujući pre svega kontinuiranom sprovođenju preventivnih programa i programa zdravstvenog vaspitanja. Studije su takođe pokazale da slabije razvijene zemlje imaju znatno veću učestalost karijesa u odnosu na razvijenije [5].

Preventivne mere imaju najdugoročniji efekat i zato je neophodno analizirati stanje oralnog zdravlja i identifikovati faktore rizika za nastanak karijesa u dečjem uzrastu i adolescenciji. Dobijeni epidemiološki podaci mogu predstavljati polaznu osnovu za izradu odgovarajućih preventivnih programa [2]. Istraživanja ukazuju da je najveća učestalost karijesa na stalnim zubima na globalnom nivou u periodu od 15. do 19. godine [6]. Stanje oralnog zdravlja dece uzrasta od 12 godina smatra se referentnim pokazateljem u određenoj populaciji i služi kao parametar za različita istraživanja, međunarodna poređenja, praćenje i evaluaciju preventivnih programa [3].

Cilj ovog istraživanja je bio da se utvrdi učestalost karijesa kod školske dece uzratsa 12 i 15 godina na teritoriji beogradske opštine Čukarica.

MATERIJAL I METOD

Retrospektivnom studijom obuhvaćeno je 409 dece, oba pola, iz dve osnovne škole, koja žive na teritoriji beogradske opštine Čukarica. Svi oni su redovno kontrolisani od strane dečjeg stomatologa u stomatološkoj ambulanti doma zdravlja Sremčica. Analizom podataka iz stomatoloških kartona pacijenata registrovana je rasprostranjenost karijesa. Podaci o prisutnim karijesnim, ekstrahovanim i plombiranim zubima su registrovani pomoću Klajn– Palmerovog sistema DMF (D – Decayed, M – Missing, F – Filled), koji je kod nas preveden kao KEP (K – karijes, E – ekstrahovan zub, P – plombiran zub) [7].

Za analizu podataka korišćene su metode deskriptivne statistike i metode za testiranje statističkih hipoteza. Za testiranje značajnosti razlike srednjih vrednosti numeričkih obeležja korišćen je t-test, a za utvrđivanje razlike u učestalosti kategorijskih varijabli hi-kvadrat test. Statističke vrednosti su testirane na nivou statističke značajnosti od 0,05. Za statističku obradu rezultata korišćen je softverski program SPSS Statistics 22 (SPSS Inc., Chicago, IL, USA).

REZULTATI

U istraživanju je učestvovalo 409 dece iz beogradske opštine Čukarica. Grupa dece od 12 godina obuhvatila je 214 ispitanika (52,3%), a grupa dece od 15 godina 195 ispitanika (47,7%). U grupi ispitanika od 12 godina bilo je 113 dece muškog i 101 dete ženskog pola, a u grupi od 15 godina 104 muškog i 91 ženskog pola (Grafikon 1).

Od ukupng broja ispitanika procent dece sa svim zdravim zubima iznosio je 31,54%, a sa obolelim stalnim zubima 68,46%.

U uzrastu dece od 12 godina procent dece sa svim zdravim zubima iznosio je 43%, a sa obolelim 57%. Kod muškog pola 48 dece je bilo sa svim zdravim zubima, a 65 sa obolelim stalnim zubima. Kod ženskog pola 44 ispitanika su imala sve zdrave zube, a njih 57 obolele stalne zube (Grafikon 2).

U uzrastu od 15 godina procenat dece sa svim zdravim zubima je iznosio 19,2%, a sa obolelim 82,3%. Kod muškog pola samo 19 ispitanika je bilo sa svim zdravim zubima, a 85 ispitanika sa obolelim stalnim zubima. Kod ženskog pola 18 ispitanika je imalo sve zdrave zube, a 73 ispitanika obolele stalne zube (Grafikon 3).

Vrednosti Kio, kao glavnog pokazatelja frekvence karijesa među ispitanicima, bile su veće kod dece uzrasta 15 godina (81,02%) u odnosu na uzrast od 12 godina (57%), i ta razlika je bila statistički značajna ($p < 0,001$). Odvojenom analizom unutar starosnih grupa utvrđeno je da je u grupi dece od 12 godina vrednost Kio bila veća kod dečaka (57,52%) u odnosu na devojčice (56,44%), ali bez statističke značajnosti ($p = 0,839$). Slično je bilo u grupi od 15 godina, gde je Kio bio veći kod dečaka (81,73%) nego kod devojčica (80,22%). Ova vrednost bila je statistički značajna ($p = 0,026$).

Ukupan Kiz za sve ispitanike iznosio je 8,99%. Vrednisti Kiz-a bile su veće kod petnaestogodišnjaka (11,06%) u odnosu na dvanaestogodišnjake (6,40%). U grupi dvanaestogodišnjaka vrednosti Kiz indeksa bile su neznatno veće kod dečaka (6,43%) u odnosu na devojčice (6,35%), dok su kod petnaestogodišnjaka ove vrednosti bile veće kod devojčica (12,79%) u odnosu na vrednosti kod dečaka (10,65%).

Prosečan broj obolelih stalnih zuba po jednom ispitaniku (Kip) kod svih testiranih iznosio je 2,43. Prosečna vrednost Kip-a kod dece uzrasta 12 godina iznosila je 1,66, a kod dece uzrasta 15 godina 3,26. Prosečna vrednost Kip-a dece starosti 15 godina bila je statistički značajno veća u odnosu na decu starosti 12 godina ($t = -6,346$, $p < 0,001$).

Prosečna vrednost Kip-a kod devojčica uzrasta 12 godina iznosila je 1,65, a kod dečaka 1,67, dok je kod devojčica od 15 godina ona iznosila 3,58, a kod dečaka 2,98.

Prosečna vrednost KEP-a devojčica starosti 15 godina je statistički značajno veća u odnosu na devojčice starosti 12 godina ($t = -4,836$, $p < 0,001$).

Za utvrđivanje karijesnog statusa stalnih zuba korišćen je indeks KEP (karijesni, ekstrahovani, plombirani zubi), pri čemu se nesanirani karijes (52,08%) ističe kao dominantno obeležje među varijablama indeksa KEP. Procentualna zastupljenost saniranih karijesnih lezija iznosila je 37,80%, a procenat ekstrahovanih zuba 6,3%. Nesanirane karijesne lezije bile su procentualno veće kod ispitanika uzrasta 15 godina (62,60%) u odnosu na ispitanike od 12 godina (42,5%), sa statistički značajnom razlikom (hi-kvadrat = 16,420, $p < 0,001$). Dobijene vrednosti KEP-a bile su veće kod devojčica uzrasta 15 godina u odnosu na devojčice od 12 godina i ove vrednosti su bile statistički značajne ($t = -4,836$, $p < 0,001$).

Međutim, nije postojala statistički značajna razlika u odnosu na broj ekstrahovanih zuba između dece različitog uzrasta, iako su deca uzrasta 15 godina imala nešto veći procenat izvađenih zuba (13,3%) u odnosu na decu od 12 godina (9,8%).

Procenat saniranih karijesnih lezija (P) bio je veći kod dece uzrasta 15 godina (48,7%) u odnosu na decu od 12 godina (29,4%) i ova razlika je bila statistički značajna (hi-kvadrat = 15,995, $p < 0,001$).

DISKUSIJA

U ovu studiju, sprovedenu na teritoriji beogradske opštine Čukarica, uključena su školska deca starosti 12 i 15 godina. Oralni status kod dvanaestogodišnjaka predmet je istraživanja mnogih studija širom sveta jer se prema preporuci Svetske zdravstvene organizacije (SZO) deca ovog uzrasta smatraju standardizovanom grupom za praćenje oralnog zdravlja, kako zbog prisutne stalne denticije tako i zbog činjenice da su u tom uzrastu već uveliko formirane navike koje se tiču očuvanja oralnog zdravlja. Zarad boljeg sagledavanja epidemiološke situacije oralnog zdravlja bitno je bilo uključiti u istraživanje i decu starosti 15 godina kod kojih se već mogu uočiti posledice loših navika [8]. Od ukupnog broja pregledane dece, 31,54% imaju prisutne sve zdrave zube. Ovaj podatak se podudara sa istraživanjem koje je sprovedeno na teritoriji naše zemlje, a koje se bavi stanjem oralnog zdravlja dece i omladine [3].

Prosečni Kip za obe starosne grupe ove studije iznosi 2,43, što ukazuje na to da je karijes na našim prostorima permanentno prisutan i da predstavlja ozbiljan socijalno-medicinski problem sa kojim se Republika Srbija suočava.

Ako se ovi rezultati uporede sa vrednostima Kip-a u razvijenijim zemljama Evrope, poput Nemačke (Kip svega 0,5 i sa tendencijom smanjenja), Španije, gde je vrednost Kip indeksa za dvanaestogodišnjake 0,82, a za petnaestogodišnjake 1,38, odnosno zemljama Azije, npr. Kinom (Kip 1,14), i Malezijom (Kip 1,36), sasvim je jasno da se Republika Srbija još uvek nalazi u redu zemalja sa visokom stopom rasprostranjenosti karijesa [9, 10]. Među zemljama sa niskim vrednostima Kip indeksa posebno se izdvaja Nigerija sa rezultatom od 0,16 [11]. Međutim, treba napomenuti da u poređenju sa zemljama u okruženju Srbija pokazuje značajan napredak. Prosečna vrednost Kip-a u Crnoj Gori iznosi 3,43, u Bosni i Hercegovini 4,89 u urbanim sredinama, a do 6,74 u ruralnim sredinama BiH [12, 13]. Takođe, u red zemalja sa visokim vrednostima Kip-a spadaju Poljska sa vrednošću od 4,2 i Iran sa 3,35 [14, 15].

Ako se uporede ovi rezultati dobijeni na području jedne beogradske opštine (2,43) sa onim zabeleženim u južnoj srpskoj pokrajini (4,22), može se zaključiti da postoji razlika između karijes indeksa kod dece koja žive u urbanim sredinama i dece iz ruralnih sredina i u R. Srbiji [16]. Ne treba izgubiti iz vida da su u protekloj deceniji preduzete mnoge mere zarad poboljšanja oralnog zdravlja dece u Srbiji, posebno na polju prevencije [17]. Očekivanja SZO su bila da do 2020. godine vrednost Kip-a kod dvanaestogodišnjaka bude ispod 1,5 [18]. Naši rezultati dobijeni na osnovu sistematskog pregleda školske 2019/2020. ukazuju da se bližimo ostvarenju zadatog cilja i prosečnim vrednostima karijes indeksa, kod ispitanika od 12 godina od 1,66.

Istraživanje SZO o zdravstvenom ponašanju mladih uzrasta 11, 13 i 15 godina (engl. Health Behaviour in School-aged Children; HBSC) sprovodi se u 49 zemalja sveta, među kojima je i Srbija. Prema podacima za Srbiju iz 2018. godine, 70,9% ispitanika se izjasnilo da zube pere više od jednom dnevno (82,6% devojčica i 59,9% dečaka), što govori u prilog tome da školarci u R. Srbiji poseduji viši stepen kulture pranja zuba u odnosu na svoje vršnjake iz susednih zemalja [19].

ZAKLJUČAK

Rezultati ove retrospektivne studije pokazali su da je učestalost karijesa kod školske dece uzrasta 12 i 15 godina registrovana kod dve trećine ispitanika (68,46%). U grupi od 12 godina karijes je bio prisutan kod 122 ispitanika (57%), a kod dece uzrasta 15 godina kod 158 ispitanika (82,3%).

Strategiju edukacije, promocije oralnog zdravlja, kao i primena preventivnih i profilaktičkih mera treba sprovesti i u slabije razvijenim delovima Srbije. Neophodna je intenzivna edukacija mladih roditelja radi podizanja zdravstvene svesti kako bi se postigao nivo oralnog zdravlja kao i u razvijenim zemljama sveta.

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How to prevent fracture of NiTi files

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SUMMARY

More certain therapeutic and significantly facilitated solution of everyday endodontic problems are provided by the introduction of NiTi rotary files in endodontic practice and their proper application. However, their widespread use has caused more and more frequent fractures and has become a significant frustrating factor that diminishes their numerous benefits. Torsional stress and cyclic fatigue are the main reasons for the occurrence of a fracture, and the frequency of NiTi file fractures is exactly proportional to the degree of bending of the canal, knowledge of the features of the file, ie. the skill and expertise of the therapist. The most dominant factor for the occurrence of fractures is the dentist who, in addition to manual dexterity, must have a good knowledge of the anatomy of various canal systems and file design in order to make the best choice for each individual case. Properly formed access cavity and knowledge of the working part of NiTi files enable maximum realization of endodontic skills, increased efficiency of intervention and reduced possibility of error during canal instrumentation. The special treatment of NiTi alloy and new solutions related to the design of the working part have significantly increased file flexibility and resistance to cyclic fatigue. Specific design (reduced number of threads, change of conicity, interruption of blade continuity), reduced engagement of file, ie. change of dynamics of movement in the canal (full rotation, reciprocal, eccentric, transaxial), as well as reduced number of processing files, have also significantly influenced the reduction of fracture risks.

The aim of this paper was to analyze the most common reasons for the fracture of NiTi files and emphasize measures and factors that can increase their safe use and reduce complications during canal instrumentation.

Keywords: NiTi files; fractures; file design; motion dynamics

INTRODUCTION

Endodontic treatment has become increasingly safe and effective due to new concepts and methods of "cleaning" and shaping the canal, ie. introduction of new files [1]. More certain therapeutic and significantly facilitated solutions of everyday endodontic problems are provided by the introduction of NiTi rotary files and their proper application [1, 2]. The use of these files, with limited speed and marked flexibility, significantly accelerates canal instrumentation, but unexpected and sudden fractures are still an important frustrating factor that diminishes their numerous benefits [3, 4].

NiTi files have become the standard in endodontic dental treatment over the last two decades and their widespread use has caused more frequent fractures [3, 5, 6]. It has been confirmed that due to rotating, almost all sets of NiTi files are subject to fractures, and that is more common during instrumentation of curved canals [3, 6]. The main reasons for the occurrence of fracture are torsional stress and cyclic fatigue during canal instrumentation [7–10]. Torsional stress occurs due to the friction of the files against the walls of the canal when one part of the file is screwed in the wall, and the other part continues to move, so the fracture occurs due to exceeding the elastic limit [7, 8]. Cyclic fatigue is a consequence of the cumulative effect of bending forces that are repeated in the same place (usually in the area of the curve), so the file is alternately exposed to tensile forces on the outside and compression forces on the inside [9, 10]. It has been confirmed that NiTi files that were previously exposed to torsional stress showed higher resistance to cyclic fatigue, ie that files of smaller diameter are generally more resistant to cyclic fatigue [11, 12].

Clinical studies have shown the frequency of fractures of NiTi rotary files is 0.13–10%, and 0.25–6% for hand files [13–17]. NiTi file fracture most often occurs during endodontic treatment of molars (77–89%) with a higher risk during treatment of the upper (50-55%) compared to the lower molars (25–30%) [13, 15, 16]. In the upper molars, the fracture most often occurs in the mesiobuccal canal (distal curvature of the mesial root), and the lower molars in the mesial canals due to distal and buccal curvature [13].

The frequency of NiTi file fracture is exactly proportional to the curvature of the canal (7% in straight, 35% in slightly curved and 58% in very curved canals), and most often occurs in the apical segment (41–82.7%), then in the middle third (14.8–32%) and least often in the coronal third (2.5-20%) [13, 17].

In a study that examined the frequency of NiTi file fractures in general dental and specialized endodontic surgeries, 88.8% of dentists reported fractures, which were much more common among endodontists who performed multiple interventions and generally treated more severe cases [18].

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The aim of this paper is to assess the most common reasons for the occurrence of NiTi file fractures and emphasize measures and factors that can increase the safety and reduce possible complications during canal instrumentation.

Factors that influence the occurrence of NiTi file fractures

File fractures seriously complicate and compromise endodontic treatment and its prognosis, and therefore require various precautions [13]. Numerous studies have examined factors that can affect the fracture of endodontic files with the main goal of increasing the safety and reducing possible complications during canal instrumentation [3, 6, 9, 10, 11, 14, 17].

Different factors that can be classified into four categories, affect the occurrence of NiTi file fractures: a) factors related to the therapist (skill and expertise); b) anatomical factors (access cavity and canal anatomy); c) factors related to the file (material, design, production process) and d) technical factors of instrumentation (dynamics of file movement, irrigation, reuse, sterilization) [19–22].

In order to eliminate the risk of possible fractures and deformations of NiTi rotary files during canal preparation, dental technology has developed several new strategies in creating and designing their working part (conicity, cross section, working part design), special thermomechanical procedures in alloy preparation, ie different kinetics of file movement in the canal [1, 9, 20, 21, 22].

A dentist is certainly the most important and most dominant factor influencing the appearance of defects and fractures, ie. his knowledge, expertise and clinical training. In addition to manual skills and knowledge of instrumentation techniques, the practitioner must have a good knowledge of the anatomy of different canal systems (number, arrangement, angle and diameter of canal curvature, additional canals), or file design, to make the best choice for each case [3, 16, 18]. Good planning and detailed analysis of the course of endodontic treatment are necessary for success, but also for prevention of possible fractures [16, 17].

The first and certainly the most important step in preventing fractures is the proper formation of the access cavity and adequate opening of the canals. This provides good visualization of endodontic space, facilitates the control of bending and preparation of the complex apical segment of the canal [3, 15, 16, 23]. Properly formed access cavity is the first step in preventing fracture, because it enables easier movement of the files in the canal, significantly minimizes the stress of bending and twisting, and prevents possible fractures when it comes to patients with limited mouth openings. Canal entrance processing (Gates-Gliden) and checking the patency with hand files significantly facilitate rectilinear access to the canals and reduce the cyclic fatigue of the file during movement in the canal [3, 15, 16].

Apical preparation is a special problem due to inaccessibility and inadequate diameter, reduced effect of irrigation solution and frequent existence of apical curvature that makes it difficult to reach the file to the apical narrowing. Therefore, the blade efficiency of the file and the solvent effect of irrigation are reduced in this part of the canal, and the possibility of retention of debris is increased, as well as the frequent formation of "blockage" that can cause fracture of the file [24, 25].

DESIGN OF NITI FILES

Knowledge and understanding of the design of NiTi files enables the practitioner to maximize endodontic skills, increased efficiency and reduced possibility of error during canal instrumentation [3, 26]. Cyclic fatigue and torsional stress are the most common causes of the damage and fractures during canal instrumentation and are a function of the material and design of the working part, i.e the dynamics of movement [7, 8, 9, 26]. The resistance of files to cyclic fatigue depends on numerous factors, primarily on the metallurgical features of the alloy and production process, file design (cross-sectional design, length, conicity, blade thread depth), preparation technique, irrigation, rotation speed, number of used files and of course canal curvature and dentist training [4, 8, 26, 27].

The first NiTi rotary file was introduced in 1992 (standard conicity of 2%) and was made of conventional NiTi wire (56% Ni, 44% Ti) with a "shape memory" effect (after unloading, it returns to its original shape), and with extremely biocompatible properties and corrosion resistance [1, 4, 8, 16].

A large number of different NiTi sets have been presented during the last decades (more than 160), with the basic goal of increasing their clinical efficiency and safety with innovative file design, new production processes and special treatments of NiTi alloy, ie affecting resistance to torsional loads, cyclic fatigue and flexibility [1, 8, 20]. High flexibility and shape memory are based on the fact that atoms in the alloy exist in two conformational forms (martensite and austenite), which significantly depend on the ambient temperature and stress (tension) during the movement of the files. The elasticity of the alloy increases with the change of phase, ie martensitic transformation into austenitic (in the martensitic phase the file bends with a slight force), and returns to its original shape after the cessation of stress [4, 9, 20, 26].

Files with an austenitic phase are used for instrumenting straight canals, and NiTi files with a higher share of the martensitic phase show greater flexibility and resistance to cyclic fatigue and are used for instrumenting highly bent canals [28]. An important step in improving physical and mechanical properties of NiTi files is the introduction of new design solutions and production technologies of alloys related to thermal and electrochemical treatment of the working part, as well as the procedure of ion implantation and protection of alloy with various nano coatings [1, 3, 20, 28, 29].

Electrochemical surface treatment of NiTi alloys was a key factor for increasing blade efficiency and increased resistance to cyclic fatigue [29], and the introduction of new heat-treated alloys (M-wire, CM-wire, Max-wire) significantly increased flexibility and resistance to torsional

stresses [4, 9, 30, 31]. The alloy is alternately and under controlled conditions heated and cooled by heat treatment, in order to provide its specific properties related to increased flexibility and greater resistance to cyclic fatigue [9, 28].

Knowledge of the design features of the working part of the NiTI file is one of the most important prerequisites for efficient preparation, but also a significantly lower possibility of fracture [1, 3, 26]. Resistance to cyclic fatigue mostly depends on the size of cross section, conicity, length of the working part, depth of the cutting edges, surface imperfection of the file, rotation speed, etc. [15, 17, 26, 31]. It has been observed that thinner and more flexible files are more resistant to cyclic fatigue and more sensitive to torsional loads, while thicker ones are more sensitive to cyclic fatigue, but can withstand higher torque [17, 26]. Since increased conicity is often the reason for fracture, dental technology has offered shorter files with progressive multiconicity, which significantly reduces the engagement (contact) of the file with the walls, and thus stress and the possibility of screwing, with more efficient cutting and removal of detritus from the canal [7, 8].

The specific cross-section of the file (U, S shape), ie. number and depth of blades are also factors that lead to screwing and possible fractures, so files with shallow blade edges and constant cross section shape are more resistant to fractures [3, 26]. Surface imperfections of the new NiTi files and higher speed also affect the appearance of fractures. Deformations and fractures of the file are four times more frequent at higher speeds (over 350 rpm) compared to lower speeds (160 rpm), as well as at higher torsional load ($3N/cm^2$) compared to $1N/cm^2$ [3, 11, 12].

Reduced engagement of the NiTi file in the canal can be solved by shortening the working part, reducing the number of threads, changing the conicity, interrupting the continuity of the blade, using files in correct order and changing the dynamics of movement [3, 14, 26]. Since the torque is directly proportional to the surface of engaged file in the canal, smaller torque requires higher number of revolutions and sharper blade needs less threads [3, 12, 26, 27).

Dynamics of movement of NiTi files in the canal

Frequent fractures of NiTi files in the canal influenced the introduction of new concepts of instrumentation primarily based on the change of movement dynamics, ie. reduction of the number of files for canal treatment [1, 10, 16]. Initially, only full rotation was used to start the NiTi file, and the instrumentation was most often realized with several file sets (initially with 5-6, and later with 3), while in recent years endodontics with single file has become more common, which significantly reduces the risk of fracture [2, 6, 8]. The fear of screwing (and thus fracture) in systems with full rotation influenced the introduction of systems with reciprocal movements that significantly increases the resistance to cyclic fatigue and prolongs life of files. Files with reciprocal movements are mainly represented by a single file that significantly reduces the instrumentation time, but also the stress during canal instrumentation [1, 25, 27].

Research confirms that the system with reciprocal movements is currently the most popular, because it allows greater flexibility and increased file resistance to cyclic fatigue, ie. efficient cleaning and shaping with reduced postoperative sensitivity [1, 13, 32, 33]. Reciprocal movements are based on movements of balanced forces, where rotation counterclockwise (cutting direction) and a much shorter movement in a clockwise direction significantly reduce both torsional stress and cyclic fatigue, and thus the possible screwing of the file [1, 26, 34, 35, 36]. The benefits of these files are shorter processing time, reduced possibility of cross-contamination and reduction of fear of fracture, because only one instrument is used [16, 32, 33, 34].

A system that uses a combination of full rotation and reciprocal movements (Genius system, Ultradent, USA) has been introduced in recent years, with instrumentation performed reciprocally and final instrumentation with full rotation files, which significantly increases resistance to torsional fractures [1, 34].

Some NiTi systems that use individual files rotate eccentrically (asymmetrically) in the canal and thus provide efficient canal cleaning with irregular morphology [1, 35]. Representative of these files is XP ENDO Shaper, a new generation of NiTi files, made of a special alloy (Max-wire), with a unique design of the working part (snake shape), which provides exceptional flexibility and increased resistance to cyclic fatigue. The specific design of the file also enables higher rotation speed (800 rpm), more efficient irrigation and more efficient removal of detritus from inaccessible parts of the canal [1, 35, 36].

The Self Adjusting File (SAF) has a completely different design and movement kinetics than existing NiTi systems. This NiTi file is hollow, mesh and flexible, and during transaxial movement (vibration) it enables more efficient and always fresh irrigation, that is continuously delivered to the canal via a silicone tube. This file has high resistance to fracture, adapts three-dimensionally and cleans the canal system very efficiently [1, 3, 7, 37].

In vitro studies have confirmed that prolonged clinical use of NiTi files reduces their resistance to cyclic fatigue, and therefore a single application is recommended [9, 10]. Sterilization of new or used files also reduces the resistance to cyclic fatigue and affects the occurrence of corrosion due to changes in the surface layer of titanium oxide [16, 20, 38]. The use of different lubrication gels, ie irrigation solution (NaOCl) can also have corrosive effects of NiTi alloy. It has been confirmed that NaOCl in concentration of 1% affects torsional and cyclic resistance after a cumulative exposure of 2.5 h, while longer-term exposure (18 h) also shows clear signs of corrosion [16, 38, 39]. The problem caused by immersion of files in NaOCl solution is related to metallurgical features and the occurrence of galvanic currents (handle and working part are made of two different metals) can accelerate corrosion and reduce fracture resistance [40, 41, 42].

CONCLUSION

File fracture during canal instrumentation is a serious iatrogenic complication that compromises endodontic treatment and largely depends on the therapist. Exceptional

skills and expertise are required, as fractures are more common in less experienced practitioner. Preclinical training on extracted molars is mandatory and necessary in order to provide routine and experience with NiTi files, before using them in clinical conditions. The therapist also must be well acquainted with the canal anatomy of the teeth, the number and shape of the canals, the position of the curve and must plan the whole endodontic intervention well. In addition, therapist must clearly and precisely form the access cavity and clearly shape the entrances to the root canals.

The clinician must know the design of NiTi files and material they are made of (type of alloy), and choose files with working parts that will ensure reduced engagement of the file during canal instrumentation. Also, lower speed and less torque should be used during canal instrumentation and proposed protocol must be followed. The patency of the canal should be checked with hand instruments and it is obligatory to use lubricants and abundant irrigation with solutions during canal instrumentation.

The therapist must know the dynamics of the file movement and choose a preparation technique that prevents a possible fracture. Reciprocal movements are currently the most efficient, because they significantly reduce stress and the possibility of screwing during canal instrumentation due to the specific dynamics of movement in the canal. Numerous studies have confirmed that the frequency of file fractures is extremely low in clinicians who are well aware of possible fractures.

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Kako sprečiti frakturu NiTi instrumenata

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KRATAK SADRŽAJ

Uvođenjem NiTi rotirajućih instrumenata u endodontsku praksu i njihovom pravilnom primenom obezbeđena su izvesnija terapijska rešenja i znatno je olakšano rešavanje svakodnevnih endodontskih problema. Međutim, njihova široka primena uzrokovala je sve učestalije frakture i postala značajan frustrirajući faktor koji umanjuje njihove brojne benefite. Torziono naprezanje i ciklični zamor su glavni razlozi za nastanak frakture, a učestalost loma NiTi turpija je upravo srazmerna stepenu povijenosti kanala, poznavanju karakteristika instrumenta, odnosno veštini i stručnosti terapeuta. Najdominantniji faktor za nastanak fraktura je stomatolog, koji osim manuelne spretnosti mora dobro poznavati anatomiju različitih kanalskih sistema i dizajn turpije kako bi napravio najbolji izbor za svaki pojedinačni slučaj. Pravilno formiran pristupni kavitet i poznavanje radnog dela NiTi instrumenata omogućavaju maksimalnu realizaciju endodontske veštine, povećanu efikasnost intervencije i smanjenu mogućnost greške tokom obrade kanala. Poseban tretman NiTi legure i nova rešenja vezana za dizajn radnog dela značajno su povećali fleksibilnost turpije i otpornost na ciklični zamor. Specifičan dizajn (smanjen broj navoja, promena koničnosti, prekid kontinuiteta sečiva) i smanjena angažovanost instrumenta, odnosno promena dinamike kretanja u kanalu (puna rotacija, recipročna, ekcentrična, transaksijalna) i smanjenje broja turpija za obradu, uticali su i na značajno smanjenje rizika od preloma.

Cilj ovog rada je bio da ukaže na najčešće razloge za pojavu fraktura NiTi turpija i apostrofira mere i faktore koji mogu povećati sigurnost instrumentacije i smanjiti moguće komplikacije tokom obrade kanala.

Ključne reči: NiTi turpije; frakture; dizajn turpije; dinamika kretanja

UVOD

Zahvaljujući novim konceptima i metodama „čišćenja" i oblikovanja kanala, odnosno novim instrumentima, endodontska terapija je postala sve sigurnija i efikasnija [1]. Uvođenjem NiTi rotirajućih instrumenata i njihovom pravilnom primenom obezbeđena su izvesnija terapijska rešenja i značajno je olakšano rešavanje svakodnevnih endodontskih problema [1, 2]. Primena ovih instrumenata sa ograničenim brojem obrtaja i izrazitom fleksibilnošću značajno ubrzava preparaciju kanala, ali su neočekivane i iznenadne frakture još uvek važan frustrirajući faktor koji anulira njihove brojne koristi [3, 4].

Tokom poslednje dve decenije NiTi turpije su postale standard u endodontskom lečenju zuba, pa je i njihova široka primena uzrokovala sve učestalije frakture [3, 5, 6]. Potvrđeno je da su zbog ušrafljivanja skoro svi setovi NiTi instrumenata podložni frakturama, pri čemu je ovaj problem znatno češći tokom obrade povijenih kanala [3, 6]. Glavni razlozi za pojavu frakture su torzioni stres i ciklični zamor tokom instrumentacije kanala [7–10]. Torziono naprezanje nastaje usled trenja instrumenata o zidove kanala kada u predelu krivine dođe do ušravljivanja dela instrumenta a drugi nastavlja sa kretanjem, pa usled prekoračenja granice elastičnosti dolazi do frakture [7, 8]. Ciklični zamor je posledica kumulativnog efekta sila savijanja koje se ponavljaju na istom mestu (najčešće u predelu krivine), pa je instrument tokom rotacije naizmenično izložen silama zatezanja na spoljašnjoj strani, odnosno silama kompresije na unutrašnjoj strani [9, 10]. Potvrđeno je da NiTi instrumenti koji su prethodno izloženi torzionom stresu pokazuju veću otpornost na ciklični zamor, odnosno da su instrumenti manjeg dijametra uglavnom otporniji na ciklični zamor [11, 12].

Kliničke studije pokazuju da je učestalost fraktura NiTi rotirajućih instrumenata 0,13–10%, a kod ručnih instrumenata 0,25–6% [13–17]. Do frakture NiTi turpija najčešće dolazi tokom endodontskog tretmana molara (77–89%) [13, 15, 16], pri čemu je veći rizik tokom terapije gornjih (50–55%) u odnosu na donje molare (25–30%) [13]. Kod gornjih molara fraktura se najčešće dešava u bukomezijalnom kanalu (distalna krivina mezijalnog korena), a kod donjih u mezijalnim kanalima usled distalne i bukalne povijenosti [13].

Učestalost loma NiTi turpija je upravo proporcionalna povijenosti kanala (7% kod pravih, 35% kod blago povijenih i 58% u jako povijenim kanalima), a najčešće se dešava u apeksnom segmentu (41–82,7%), potom u srednjoj trećini (14,8–32%), a najređe u kruničnoj trećini (2,5–20%) [13, 17].

U studiji koja je proveravala učestalost loma NiTi instrumenata u opštim stomatološkim i specijalizovanim endodontskim ordinacijama 88,8% stomatologa je prijavilo frakture, pri čemu su one bile mnogo češće među endodontistima koji realizuju više intervencija i uglavnom tretiraju teže slučajeve [18].

Cilj ovog rada je bio da ukaže na najčešće razloge za pojavu fraktura NiTi turpija i apostrofira mere i faktore koji mogu povećati sigurnost instrumentacije i smanjiti moguće komplikacije tokom obrade kanala.

FAKTORI KOJI UTIČU NA POJAVU FRAKTURA NITI TURPIJA

Frakture instrumenata ozbiljno komplikuju i kompromituju endodontski tretman i njegovu prognozu i zbog toga obavezuju na konstantan oprez preduzimanjem brojnih mera predostrožnosti [13]. Brojne studije su istraživale faktore koji mogu uticati na lom endodontskih turpija sa osnovnim ciljem da se poveća sigurnost instrumentacije i smanje moguće komplikacije tokom obrade kanala [3, 6, 9, 10, 11, 14, 17].

Na pojavu fraktura NiTi turpija utiču brojni faktori, koji se mogu klasifikovati u četiri kategorije: a) faktori vezani za terapeuta (veština i stručnost); b) anatomski faktori (pristupni kavitet i anatomija kanala); c) faktori vezani za instrument (materijal, dizajn, proizvodni proces) i d) tehnički faktori instrumentacije (dinamika kretanja instrumenata, irigacija, ponovna upotreba, sterilizacija).

Da bi se eliminisao rizik od mogućih fraktura i deformacija NiTi rotirajućih instrumenata tokom preparacije kanala, dentalna tehnologija je razvila nekoliko novih strategija u kreiranju

i dizajniranju njihovog radnog dela (koničnost, poprečni presek, dizajn radnog dela), posebne termomehaničke procedure u pripremi legure, odnosno različitu kinetiku kretanja instrumenta u kanalu [19–22].

Najvažniji i najdominantniji faktor koji utiče na pojavu defekata i fraktura je sigurno stomatolog, odnosno njegovo znanje, stručnost i klinička obučenost. Osim manuelnih veština i poznavanja tehnika instrumentacije, praktičar mora dobro poznavati anatomiju različitih kanalskih sistema (broj, raspored, ugao i prečnik povijenosti kanala, dodatnih kanala), odnosno dizajn turpije kako bi napravio najbolji izbor za svaki pojedinačni slučaj [3, 16, 18]. Dobro planiranje i detaljna analiza toka endodontske intervencije pre njenog otpočinjanja su takođe neophodni za uspeh, ali i za sprečavanje eventualnih fraktura [16, 17].

Prvi i sigurno najznačajniji korak u sprečavanju fraktura je pravilno formiranje pristupnog kaviteta i adekvatna obrada ulaza u kanale. Time se obezbeđuje dobra vizuelizacija endodontskog prostora, olakšava kontrola povijenosti i preparacija kompleksnog apeksnog segmenta kanala [3, 15, 16, 23]. Pravilno formiran pristupni kavitet je prvi korak u sprečavanju frakture jer omogućava olakšano kretanje instrumenta u kanalu, značajno minimalizuje stres na savijanje i uvijanje i sprečava eventualne frakture kod pacijenata sa ograničenim otvaranjem usta. Obrada ulaza u kanale (Gates-Gliden) i provera prohodnosti ručnim instrumentima značajno olakšavaju pravolinijski pristup kanalima i smanjuju ciklični zamor instrumenta tokom kretanja u kanalu [3, 15, 16].

Apeksna preparacija je poseban problem zbog nepristupačnosti i neadekvatnog dijametra, umanjenog efekta rastvora za irigaciju i, skoro uvek, postojanja apikalne povijenosti koja otežava dosezanje turpije do apikalnog suženja. Zbog toga je u ovom delu kanala smanjena sečivna efikasnost instrumenta i rastvarački efekat irigansa, a povećana mogućnost zadržavanja debrisa i često formiranje „blokade", koja može uzrokovati frakturu instrumenta [24, 25].

DIZAJN NITI INSTRUMENATA

Poznavanje i razumevanje dizajna NiTi instrumenata omogućavaju praktičaru maksimalnu realizaciju endodontske veštine, povećanu efikasnost i smanjenu mogućnost greške tokom obrade kanala [3, 26]. Ciklični zamor i torzioni napon su najčešći uzroci oštećenja i fraktura tokom instrumentacije kanala i u funkciji su materijala i dizajna radnog dela, odnosno dinamike kretanja [7, 8, 9, 26]. Otpornost instrumenata na ciklični zamor zavisi od brojnih faktora, a pre svega od metalurških karakteristika legure i proizvodnog procesa, dizajna instrumenta (dizajn poprečnog preseka, dužina, koničnost, dubina sečivnih navoja), tehnika preparacije, irigacije, brzine rotacije, broja korišćenih instrumenata i, naravno, povijenosti kanala i obučenosti stomatologa [4, 8, 26, 27].

Prvi NiTi rotacioni instrument je predstavljen 1992. g. (standardna koničnost 2%) i bio je izrađen od konvencionalne NiTi žice (56% Ni, 44% Ti) sa efektom „pamćenja oblika" (posle rasterećenja se vraća u prvobitni oblik), sa izrazitim biokompatibilnim osobinama i otpornošću na koroziju [1, 4, 8, 16].

Tokom poslednjih decenija predstavljen je veliki broj različitih setova NiTi (više od 160) sa osnovnim ciljem da se inovativnim dizajnom turpije, novim proizvodnim procesima i posebnim tretmanima NiTi legure poveća njihova klinička efikasnost i sigurnost, odnosno utiče na otpornost na torziona opterećenja, ciklični zamor i fleksibilnost [1, 8, 20]. Visoka fleksibilnost i pamćenje oblika baziraju se na činjenici da atomi u leguri postoje u dva konformaciona oblika (martenzit i austenit), koji značajno zavise od temperature okoline i stresa (napetosti) tokom kretanja instrumenata. Promenom faze, odnosno martenzitnom transformacijom u austenitnu, povećava se elastičnost legure (u martenzitnoj fazi instrument se povija uz neznatnu silu), a po prestanku stresa ponovo se vraća u originalni oblik [4, 9, 20, 26].

Instrumenti sa austenitnom fazom se koriste u obradi pravih, a NiTi instrumenti sa većim udelom martenzitne faze pokazuju veću fleksibilnost i otpornost na ciklični zamor i koriste se za obradu izrazito povijenih kanala [28]. Važan iskorak u poboljšanju fizičkih i mehaničkih svojstava NiTi turpija je uvođenje novih dizajnerskih rešenja i proizvodnih tehnologija legure vezanih za termičku i elektrohemijsku obradu radnog dela, kao i postupak jonske implantacije i zaštite legure različitim nanopremazima [1, 3, 20, 28, 29].

Elektrohemijska obrada površine NiTi legure bila je ključni faktor za povećanje sečivne efikasnosti i povećane otpornosti na ciklični zamor [29], a uvođenje novih termički tretiranih legura (M-wire, CM-wire, Max-wire) značajno je povećalo fleksibilnost i otpornost na torziona naprezanja [4, 9, 30, 31]. Termičkim tretmanom se legura naizmenično i pod kontrolisanim uslovima zagreva i hladi kako bi se obezbedila njena specifična svojstva vezana za povećanu fleksibilnost i veću otpornost na ciklični zamor [9, 28].

Poznavanje karakteristika dizajna radnog dela NiTI instrumenta je jedan od najvažnijih preduslova za efikasnu preparaciju ali i značajno manju mogućnost za pojavu frakture [1, 3, 26]. Otpornost na ciklični zamor najviše zavisi od veličine poprečnog preseka, koničnosti, dužine radnog dela, dubine sečivnih ivica, površinske nesavršenosti instrumenta, brzine rotacije i dr. [15, 17, 26, 31]. Uočeno je da su tanji i fleksibilniji instrumenti otporniji na ciklični zamor i osetljiviji na torziona opterećenja, dok su deblji osetljiviji na ciklični zamor, ali mogu izdržati veći obrtni moment (tork) [17, 26]. S obzirom na to da je povećana koničnost često razlog za pojavu loma, dentalna tehnologija je ponudila kraće turpije progresivne multikoničnosti, čime se značajno smanjuje angažovanost (kontakt) instrumenta sa zidovima, a time i stres i mogućnost ušrafljivanja, uz efikasnije sečenje i uklanjanje detritusa iz kanala [7, 8].

Specifičan poprečni presek turpije (oblik slova U, S), odnosno broj i dubina sečiva, takođe su faktori koji dovode do ušrafljivanja i mogućih fraktura, pa su zato instrumenti sa plićim sečivnim ivicama i konstantnim oblikom poprečnog preseka otporniji na prelome [3, 26]. Površinske nesavršenosti novih NiTi turpija i veća brzina takođe utiču na pojavu fraktura. Deformacije i lom instrumenta su četiri puta češći pri većim brzinama (preko 350 o/min.) u odnosu na manje brzine (160 o/min.), kao i pri većem torzionom opterećenju (3 N/cm^2) u odnosu na 1 N/cm^2 [3, 11, 12].

Smanjena angažovanost NiTi turpije u kanalu može se rešiti skraćenjem radnog dela, smanjenjem broja navoja, promenom koničnosti, prekidom kontinuiteta sečiva, pravilnim redosledom korišćenja i promenom dinamike kretanja [3, 14, 26]. S obzirom na to da je tork direktno proporcionalan površini angažovanog

instrumenta u kanalu, manji tork zahteva i veći broj obrtaja, a oštrija sečiva manje navoja [3, 12, 26, 27].

DINAMIKA KRETANJA NITI INSTRUMENATA U KANALU

Česte frakture NiTi instrumenta u kanalu uticale su na uvođenje novih koncepata preparacije koji se baziraju pre svega na promeni dinamika kretanja, odnosno smanjenju broja instrumenata za obradu kanala [1, 10, 16]. Za pokretanje NiTi turpija je u početku korišćena samo puna rotacija, a preparacija je najčešće realizovana setovima sa više instrumenata (u početku sa 5-6, a kasnije sa 3), dok je poslednjih godina sve zastupljenija endodoncija jednom turpijom, čime se značajnije smanjuje i rizik od preloma [2, 6, 8]. Strah od ušrafljivanja (a time i loma) kod sistema sa punom rotacijom uticao je na uvođenje sistema sa recipročnim pokretima, čime se značajno povećava otpornost na ciklični zamor i produžava životni vek turpija. Dodatna prednost je što su turpije sa recipročnim pokretima uglavnom predstavljene jednom turpijom koja značajno smanjuje vreme preparacije ali i stres tokom obrade kanala [1, 25, 27].

Istraživanja potvrđuju da je sistem sa recipročnim pokretima trenutno najpopularniji jer omogućava veću fleksibilnost i povećanu otpornost instrumenata na ciklični zamor, odnosno efikasno čišćenje i oblikovanje uz smanjenu postoperativnu osetljivost [1, 13, 32, 33]. Recipročni pokreti se baziraju na pokretima balansiranih sila, gde rotacija u smeru suprotnom kretanju kazaljke na satu (sekući smer) i mnogo kraći pokret u smeru kazaljke izrazito smanjuju i torzioni stres i ciklični zamor, a time i moguće ušrafljivanje turpije [1, 26, 34, 35, 36]. Benefiti ovih turpija uključuju i kraće vreme obrade, smanjenu mogućnost unakrsne kontaminacije i redukovanje straha od loma jer se koristi samo jedan instrument [16, 32, 33, 34].

Poslednjih godina predstavljen je sistem koji koristi kombinaciju pune rotacije i recipročne pokrete (Genius sistem, Ultradent, USA), gde se instrumentacija obavlja recipročnim a finalna obrada turpijama sa punom rotacijom, čime se značajno povećava otpornost na torzione frakture [1, 34].

Pojedini NiTi sistemi koji koriste pojedinačne turpije u kanalu se rotiraju ekscentrično (asimetrično) i na taj način obezbeđuju efikasno čišćenje i kanala sa nepravilnom morfologijom [1, 35]. Predstavnik ovih turpija je XP ENDO Shaper, nova generacija NiTi instrumenata izrađena od posebne legure (Max-wire) sa jedinstvenim dizajnom radnog dela (zmijolik oblik) koji obezbeđuje izuzetnu fleksibilnost i povećanu otpornost na ciklični zamor. Specifičan dizajn turpije omogućava i veću brzinu rotacije (800 o/min.), efikasniju irigaciju i efikasnije uklanjanje detritusa iz nepristupačnih delova kanala [1, 35, 36].

Potpuno drugačiji dizajn i kinetiku kretanja od postojećih NiTi sistema ima samopodešavajuća turpija (SAF – Self Adjusting File). Ova NiTi turpija je šuplja, mrežasta i fleksibilna i tokom transaksijalnog kretanja (vibracije) omogućava efekasniju irigaciju uz uvek svež irigans koji se preko silikonske cevčice kontinuirano doprema u kanal. Ova turpija poseduje visoku otpornost na frakturu, trodimenzionalno se adaptira i vrlo efikasno čisti kanalni sistem [1, 3, 7, 37].

In vitro istraživanja su potvrdila da produžena klinička primena NiTi instrumenata smanjuje njihovu otpornost na ciklični zamor, pa se zbog toga preporučuje jednokratna primena [9, 10]. Sterilizacija novih ili korišćenih turpija takođe smanjuje otpornost na ciklični zamor i utiče na pojavu korozije usled promena na površinskom sloju titanijum-oksida [16, 20, 38]. Primena različitih gelova za lubrikaciju, odnosno rastvora za irigaciju (NaOCl), takođe može uticati na korozivne efekte NiTi legure. Potvrđeno je da koncentracija NaOCl od 1% utiče na torzionu i cikličnu otpornost nakon kumulativne izloženosti od 2,5 h, dok dugotrajnija izloženost (18 h) pokazuje i jasne znake korozije [16, 38, 39]. Problem koji nastaje potapanjem instrumenata u rastvor NaOCl vezan je metalurške karakteristike i pojavu galvanskih struja (drška i radni deo su od dva različita metala) koje mogu ubrzati koroziju i time smanjiti otpornost na frakturu [40, 41, 42].

ZAKLJUČAK

Fraktura instrumenta tokom preparacije je ozbiljna jatrogena komplikacija koja kompromituje endodontski tretman i u najvećoj meri zavisi od terapeuta. Praktičar mora posedovati izuzetnu veštinu i stručnost jer su frakture mnogo češće kod neiskusnih. Obavezan je i neophodan predklinički trening na ekstrahovanim molarima kako bi se obezbedili rutina i iskustvo sa NiTi turpijama, pa tek onda primena u kliničkim uslovima. Terapeut mora dobro poznavati kanalnu anatomiju zuba, broj i oblik kanala, položaj krivine i dobro isplanirati endodontsku intervenciju. Osim toga, mora jasno i precizno formirati pristupni kavitet i jasno predstaviti ulaze u kanale korena.

Kliničar mora poznavati dizajn NiTi instrumenata i materijal od koga je izrađen (vrsta legure) i izabrati turpije sa radnim delom koji će obezbediti smanjenu angažovanost instrumenta tokom preparacije kanala. Treba koristiti manje brzine i manji tork tokom obrade kanala i pridržavati se predloženog protokola. Prohodnost kanala treba proveriti ručnim instrumentima i obavezno koristiti lubrikante i obilnu irigaciju rastvorima tokom preparacije kanala.

Terapeut mora poznavati dinamiku kretanja instrumenta i odabrati tehniku preparacije koja prevenira moguću frakturu. Recipročni pokreti su trenutno najefikasniji jer zbog specifične dinamike kretanja u kanalu značajno smanjuju stres i mogućnost ušrafljivanja tokom instrumentacije kanala.

Brojne studije su potvrdile da je kod kliničara koji su svesni mogućih fraktura učestalost preloma turpije izuzetno niska.

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CASE REPORT
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Locally advanced basal cell carcinoma of the auricle and parotid region – a case report

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SUMMARY

Skin cancers are the most common malignant tumors in general. The most significant risk factor is exposure to UV radiation. They mainly occur in the head and neck region, and the majority of about 80% are basal cell carcinomas. Surgery is standard treatment of uncomplicated basal cell carcinomas, but a multidisciplinary approach is necessary in advanced cases.

The case report refers to a patient with locally advanced recurrent basal cell carcinoma with primary tumor localization in the right auricle and parotid region in 2012 when primary surgery was performed. Due to the local recurrence, amputation of the right auricle and trepanation of the mastoid process was done in November 2018, and after that, radiation therapy of a recurrent tumor in the area of the trepanation cavity was applied. In the course of follow-up so far, there is good local control, without signs of toxicity. The case report points to the importance of a multidisciplinary approach and the role of radiotherapy in the treatment and control of advanced basal cell carcinoma of this region.

Keywords: basal cell carcinoma; head and neck; maxillofacial region; surgery; radiotherapy

NTRODUCTION

Skin cancers have the highest incidence of all malignant tumors, and among them, the most common are basal cell carcinomas, about 80% of all skin cancers [1]. These cancers mainly occur in fair-skinned people, on parts of the body exposed to sunlight, such as the skin of the face, head and neck [2]. The most significant risk factor for the development of basal cell carcinoma is exposure to ultraviolet (UV) radiation.

The surgical approach is the most optimal way to treat these tumors. Depending on the local findings and stage of the disease, other modalities can be successful in treatment, such as electrodesiccation, curettage, cryotherapy, photodynamic therapy, topical application of 5-fluorouracil, or immunomodulators e.g. imiquimod, radiation therapy, or the use of the hedgehog inhibitor vismodegib [3, 4].

In the case of forms of basal cell carcinoma that do not provide an adequate response to the applied treatment - "difficult to treat", such as locally advanced or recurrent tumors, it is necessary to refer the patient to a tumor board and consider multidisciplinary treatment [5].

CASE REPORT

A 72-year-old patient reported to the regional hospital, because of a tumor in size about 3 cm, of the right earlobe and parotid region in March 2012 when tumor resection and parotidectomy were performed. Histopathological findings showed basal cell carcinoma that infiltrated periglandular fibrous and adipose tissue as well as periauricular connective, adipose, and muscle tissue. In October of the same year, another excision was done, due to an infraauricular local recurrence with a diameter of 6 mm. Histopathological findings confirmed basal cell carcinoma, nodular type.

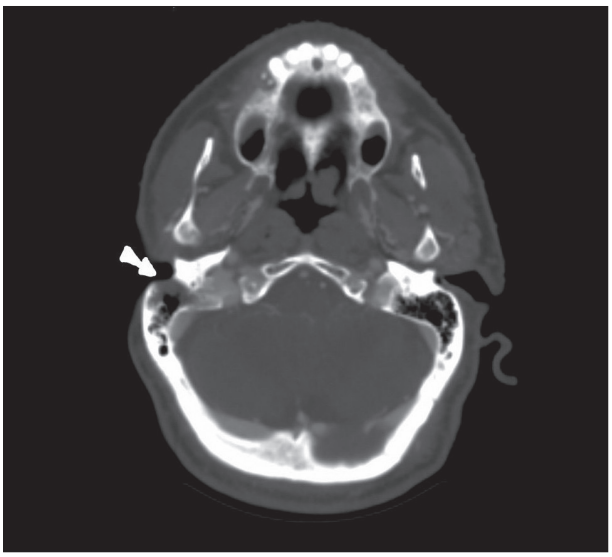

Figure 1. The tumorous mass in posttrepanation cavity.
Slika 1. Tumor u posttrepanacionom kavumu

Local recurrence appeared again in 2018. The findings of computed tomography (CT) in November 2018,

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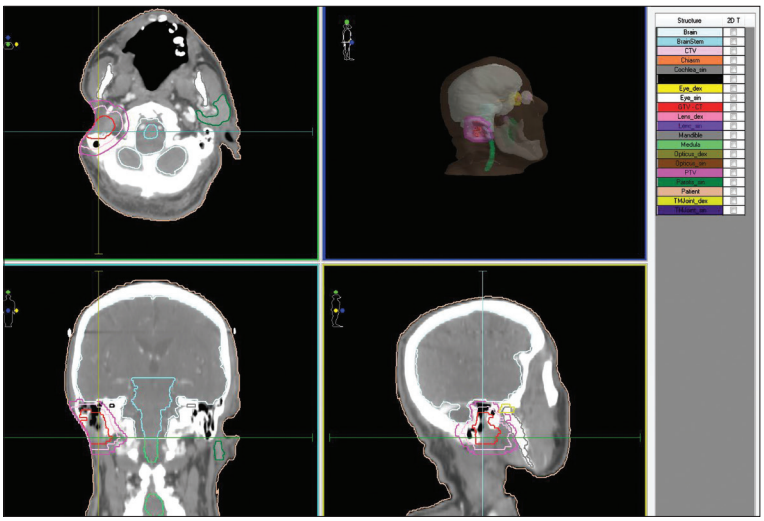

Figure 2. Target volumes and organs at risk.
Slika 2. Ciljni volumeni i organi u riziku

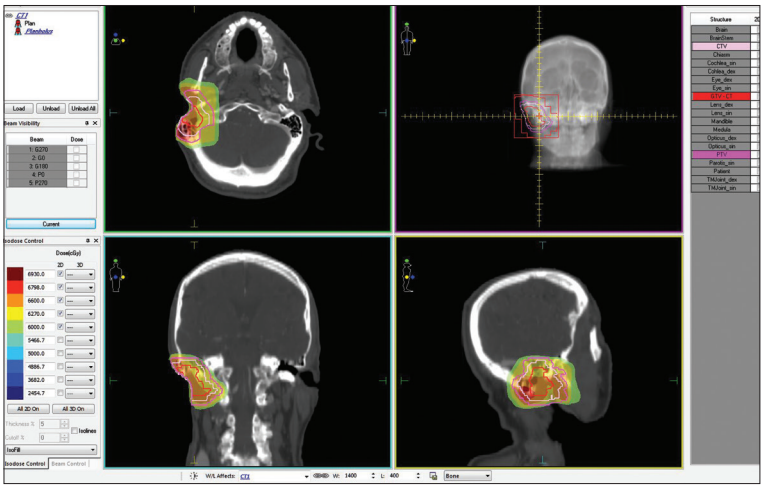

Figure 3. The treated volume and dose distribution.
Slika 3. Tretirani volumen i distribucija doze

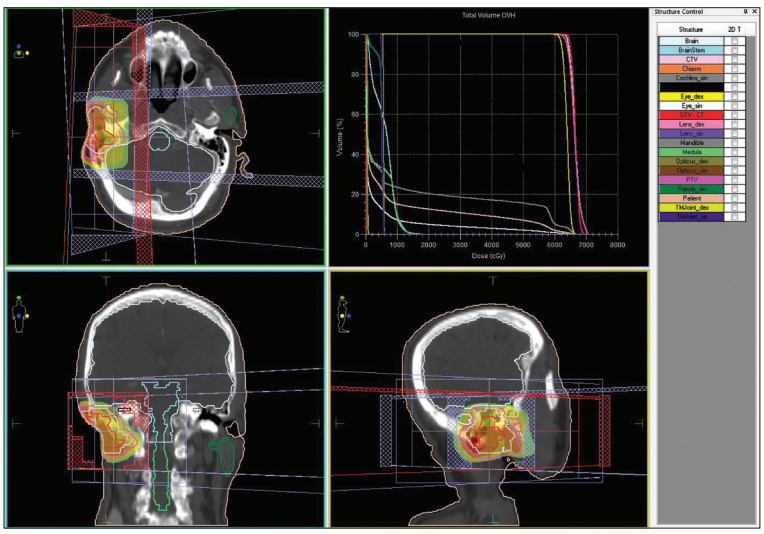

Figure 4. Field arrangement and dose volume histogram
Slika 4. Aranžman polja i DVH

showed a tumor mass in the area of the rest of the right auricle measuring 30.7 × 22.2 mm that was growing into a mastoid process. Also, on CT examination, another tumor was seen in retromandibular area on the right, near the temporomandibular joint, size 14x13 mm, without infiltration of the mandible.

The surgery was performed in November 2018 when auricle amputation, mastoid process trepanation, and defect reconstruction were performed. Postoperative histopathological findings revealed basal cell carcinoma, a pathological stage of pT3, with multiple positive edges of resection.

Progression of the local finding was observed in March 2019. At that time, CT of the head and neck indicated suspicious infiltration of mastoid cells (Figure 1), and MR examination of the neck showed a tumor in the trepanation cavity of 23×21 mm. Radiological examinations did not show enlarged lymph nodes or other signs of disease dissemination.

The patient was presented to the tumor board for skin and soft tissue cancers, and it was suggested to continue treatment with radiation therapy. Before starting radiation therapy, the patient was referred to a dentist in order to prevent oral toxicity, and the patient was thoroughly acquainted with measures to prevent acute and chronic toxicity of radiation therapy.

Radiotherapy of local recurrence was planned by 3D conformal technique (Figure 2) from three fields with TD 66 Gy in 33 fractions standard fractionation regime 2 Gy / day (Figures 3, 4). Radiation therapy was conducted in July 2019, with the development of local mucositis grade 2 of the buccal mucosa on the right and radiodermatitis grade 1 of the right buccal and surgically operated region.

The patient is now 80 years old and is regularly checked clinically and radiologically. Control MR examinations indicate stable disease and post-radiation fibrosis of the irradiated region. At the last control in March 2020, there were no signs of tumors and there was no toxicity of the treatment, without impairing the quality of life after the radiation therapy.

DISCUSSION

Basal cell carcinomas (BCCs) are the most common skin cancers. They arise from the basal layer of the epidermis or pluripotent basal cells of the adnexa and are usually found on hairy regions and parts that are most exposed to the sun.

There are several histological subtypes of BCC: nodular, superficial, pigmented, morphea, cystic, keratotic, and micronodular [6].

Clinical basal cell carcinomas have slow growth and are usually first seen as a small wound that does not heal spontaneously. Bleeding or pain occurs only when there is a significant increase in tumor size or involvement of adjacent structures. Basal cell carcinomas metastasize rarely but are characterized by infiltrative growth into the surroundings (dermis, fascia, periosteum, perichondrium, or nerve sheaths) [7].

The diagnosis of these tumors, especially lesions in the maxillofacial region, is usually not a problem due to easy visibility and availability of skin changes for biopsy or excision. However, there are some benign and malignant conditions and tumors that may mimic BCC in appearance, for example, trichoepithelioma, seborrheic hyperplasia, atypical fibroxanthomas, melanocyte nevi, Merkel cell carcinoma, and squamous cell carcinoma [7, 8]. These diseases have different biological behavior, and in some cases extremely aggressive (Merkel cell carcinoma). Therefore, the definitive diagnosis is made only after a histopathological examination. Given that these cancers show infiltrative growth, recurrence and significant local destruction can occur if treatment is not carried out in proper time [6]. Surgery is the treatment of choice for uncomplicated cases, either as Mohs surgery or extensive excision, where achieving clean resection edges are curative.

Mohs micrographic surgery is a surgical technique by which the tumor is excised horizontally, layer by layer; sections are precisely mapped and immediately examined microscopically. The process is repeated so that the edges expand only on the positive margin until completely clean edges are obtained, while at the same time healthy tissue is spared. Therefore, it is necessary for the Mohs surgeon to be an educated dermatopathologist at the same time [9]. This method achieves the best results in the treatment of non-melanoma skin cancers, especially in regions where it is important to preserve function and/or cosmetic results, such as the maxillofacial region [10]. Cryosurgery in the treatment of skin cancer is limited to well-limited, low-risk superficial lesions that are smaller than 20 mm in diameter [11]. Curettage and electrodesiccation are also reserved for properly selected low-risk tumors [12]. The use of topical preparations of 5-fluorouracil or imiquimod is also successful only in superficial tumors [4, 12]. In advanced cases, a multimodal approach should be considered.

The localization of basal cell carcinoma on the face can be a special aesthetic and functional problem. In elderly patients with localization of these tumors in the maxillofacial region, radiotherapy is recommended in the first line of treatment, which also achieves good cosmetic results. Also, advanced tumors often require the use of radiation therapy in an adjuvant or radical approach depending on the local stage [8, 13].

Target therapy with hedgehog inhibitor oral drugs has been approved in advanced cases, in a neoadjuvant and systemic approach. Sonidegib is used only in locally advanced BCC, while Vismodegib can also be used in metastatic disease [12].

Locally advanced basal cell carcinomas are rare but can be challenging to treat because of their aggressiveness, especially with localization on the head and neck, or in the maxillofacial region. In such situations, the decision on treatment must be made in a multidisciplinary team that should consist of an ENT specialist, maxillofacial surgeon, radiation oncologist and sometimes other medical specialists.

CONCLUSION

Presented case report shows the importance and role of radiotherapy in a multimodal approach in the treatment and control of advanced basal cell carcinoma of this region.

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Lokalno uznapredovali bazocelularni karcinom ušne školjke i parotidne regije – prikaz bolesnika

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KRATAK SADRŽAJ

Karcinomi kože su najčešći maligni tumori uopšte. Najznačajniji faktor rizika je izlaganje UV zracima. Uglavnom se javljaju u regiji glave i vrata, a većinu (oko 80%) čine bazocelularni karcinomi. Hirurgija je standard u lečenju nekomplikovanih bazocelularnih karcinoma, ali je kod uznapredovalih slučajeva neophodan multidisciplinarni pristup. Prikaz bolesnika se odnosi na bolesnika sa lokalno uznapredovalim rekurentnim bazocelularnim karcinomom sa primarnom lokalizacijom tumora u predelu aurikule i parotidne regije desno 2012. god., kada je pacijent primarno operisan. Zbog lokalnog recidiva je novembra 2018. urađena amputacija desne aurikule i trepanacija mastoidnog nastavka, a nakon toga je sprovedena zračna terapija rekurentnog tumora predela trepanacionog kavuma. U dosadašnjem toku praćenja postoji dobra lokalna kontrola, bez znakova toksičnosti. Prikaz bolesnika ukazuje na važnost multidisciplinarnog pristupa i ulogu radioterapije u lečenju i kontroli uznapredovalog bazocelularnog karcinoma ove regije.

Ključne reči: bazocelularni karcinom; glava i vrat; maksilofacijalna regija; hirurgija; radioterapija

PRIKAZ BOLESNIKA

Pacijent životne dobi od 72 godine javio se u regionalnu bolnicu zbog tumora desne ušne školjke i parotidne regije marta 2012. godine, kada je urađena resekcija tumora veličine oko 3 cm. Histopatološki nalaz je pokazao da se radi o BCK koji je infiltrisao periglandularno fibrozno i masno tkivo, kao i periaurikularno vezivno, masno i mišićno tkivo. Oktobra iste godine pacijent je ponovo operisan zbog infraklavikularnog lokalnog recidiva promera 6 mm. Histopatološki nalaz je potvrdio BCK, nodularni tip.

Ponovni lokalni recidiv se pojavio 2018. godine. Nalaz kompjuterizovane tomografije (KT) u novembru 2018. pokazao je tumor u predelu ostatka desne aurikule i mastoidnog nastavka dimenzija 30,7 × 22,2 mm koji urasta u mastoidni nastavak. Takođe je na pregledu KT viđena još jedna tumorska promena retromandibularno desno, u neposrednoj blizini temporomandibularnog zgloba, veličine 14 × 13 mm, bez infiltracije mandibule.

Pacijent je ponovo operisan novembra 2018. u regionalnoj bolnici, gde je urađena amputacija aurikule, trepanacija mastoidnog nastavka i rekonstrukcija defekta. Postoperativni histopatološki nalaz je pokazao da je reč o bazocelularnom karcinomu, patološkog stadijuma pT3, sa višestrukim pozitivnim ivicama resekcije.

Progresija lokalnog nalaza je uočena marta 2019. godine. Tada je KT glave i vrata (Slika 1) ukazala na suspektnu infiltraciju mastoidnih ćelija, a pregled vrata magnetnom rezonancom je pokazao tumor u trepanacionom kavumu veličine 23 × 21 mm. Na urađenim radiološkim pregledima nije bilo uvećanih limfnih čvorova niti drugih znakova diseminacije bolesti.

Pacijent je prikazan konzilijumu za karcinome kože i mekih tkiva i predloženo je da se lečenje nastavi zračnom terapijom. Pre otpočinjanja zračne terapije pacijent je upućen nadležnom stomatologu radi sanacije zuba u cilju prevencije oralne toksičnosti i detaljno je upoznat sa merama prevencije akutne i hronične toksičnosti zračne terapije.

Radioterapija lokalnog recidiva je planirana 3D konformalnom tehnikom (Slika 2) iz tri polja sa TD 66 Gy u 33 frakcije standardnim režimom frakcionisanja 2 Gy/dnevno (slike 3 i 4). Zračna terapija je sprovedena jula 2019, uz razvoj lokalnog mukozitisa bukalne sluznice desno gr 2 i radiodermatitisa predela desne bukalne i operisane regije gr 1.

Sada pacijent ima 80 godina i redovno se klinički i radiološki kontroliše. Kontrolni pregledi magnetnom rezonancom ukazuju na stabilnu bolest i postiradijacionu fibrozu zračene regije. Na poslednjoj kontroli, marta 2020. god., nije bilo znakova tumora niti je bilo ispoljene toksičnosti sprovedenog lečenja, a i nije bilo narušavanja kvaliteta života posle sprovedene zračne terapije.

DISKUSIJA

BCK su najčešći karcinomi kože. Nastaju iz bazalnog sloja epidermisa ili pluripotentnih bazalnih ćelija adneksa i obično se nalaze na kosmatim površinama i delovima koji su najviše izloženi suncu.

Postoji nekoliko histoloških podtipova BCK: nodularni, superficijalni, pigmentni, morfea, cistični, keratotični i mikronodularni [6].

Klinički BCK imaju spor rast i obično se prvi put primete kao mala rana koja ne zarasta spontano. Krvarenje ili bol se javljaju tek kada dođe do značajnog rasta tumorske promene ili zahvatanja susednih struktura. BCK izuzetno retko metastaziraju, ali ih karakteriše infiltrativni rast u okolinu (dermis, fascije, periost, perihondrijum ili nervne omotače) [7].

Dijagnoza ovih tumora, pogotovo promena u maksilofacijalnoj regiji, obično ne predstavlja problem zbog lake uočljivosti i dostupnosti promena na koži za biopsiju ili ekscisiju. Međutim, postoje neka benigna i maligna stanja i tumori koji izgledom mogu imitirati BCK, na primer, trihoepitelioma, seboroična hiperplazija, atipični fibroksantomi, melanocitni nevusi, karcinom Merkelovih ćelija i skvamocelularni karcinom [7, 8]. Navedena oboljenja imaju različito biološko ponašanje, i to u nekim slučajevima izuzetno agresivno (karcinom Merkelovih ćelija). Zbog toga se definitivna dijagnoza postavlja tek po obavljenom histopatološkom pregledu.

Imajući u vidu da BCK pokazuju infiltrativni rast, može doći do recidiva i značajne lokalne destrukcije ukoliko se ne sprovede pravovremeno lečenje [6].

Hirurgija je terapija izbora nekomplikovanih slučajeva, bilo kao Mohs hirurgija ili široka ekscizija, gde postizanje čistih ivica resekcije predstavlja izlečenje.

Mohs mikrografska hirurgija je hirurška tehnika kojom se tumor ekscidira horizontalno, sloj po sloj, preseci precizno mapiraju i odmah mikroskopski pregledaju. Proces se ponavlja tako što se ivice proširuju samo na pozitivnoj margini, sve dok se ne dobiju u potpunosti čiste ivice, dok se istovremeno pošteđuje zdravo tkivo. Zbog toga je neophodno da Mohs hirurg istovremeno bude edukovan dermatopatolog [9]. Ovom metodom se postižu najbolji rezultati u lečenju nemelanomskih karcinoma kože, a naročito u regijama gde je važno očuvati funkciju i/ili kozmetski rezultat, kao što je maksilofacijalna regija [10].

Kriohirurgija u terapiji karcinoma kože ograničena je na dobro ograničene, površne lezije niskog rizika koje su manjeg prečnika od 20 mm [11]. Kiretaža i elektrodisekcija su takođe rezervisane za pravilno odabrane tumore niskog rizika [12].

Primena topikalnih preparata 5-fluorouracila ili imikvimoda je takođe uspešna samo kod površnih tumora [4, 12].

Kod uznapredovalih slučajeva treba razmotriti multimodalni pristup.

Poseban estetski i funkcionalni problem može predstavljati lokalizacija BCK na licu. Kod starijih pacijenata sa lokalizacijom ovih tumora u maksilofacijalnoj regiji se u prvoj liniji lečenja preporučuje radioterapija, kojom se postižu i dobri kozmetski rezultati. Takođe, radioterapija je dobra alternativa hirurškom lečenju, posebno kod uznapredovalih tumora. Zračna terapija može biti efikasna za primarni ili rekurentni BCK u zavisnosti od lokalnog stadijuma, ili kao adjuvantna terapija za nepotpuno operisani BCK kod pacijenata kod kojih dalja operacija nije moguća niti je odgovarajuća [8, 13].

Target terapija oralnim preparatima hedgehog inhibitora je odobrena u uznapredovalim slučajevima, u neoadjuvantnom i sistemskom pristupu. Sonidegib se primenjuje samo u lokalno uznapredovalom BCK, dok se Vismodegib može primenjivati i u metastatskoj bolesti [12].

Lokalno uznapredovali bazocelularni karcinomi se retko javljaju, ali mogu biti izazov za lečenje zbog svoje agresivnosti, pogotovo sa lokalizacijom na glavi i vratu, odnosno u maksilofacijalnoj regiji. U ovakvim situacijama je odluku o lečenju neophodno doneti u multidisciplinarnom timu koji bi trebalo da čine ORL specijalista, maksilofacijalni hirurg, radijacioni onkolog, medikalni onkolog, patolog, a po potrebi i druge medicinske specijalnosti.

Prikazani slučaj pokazuje važnost i ulogu radioterapije u multimodalnom pristupu u lečenju i kontroli uznapredovalog BCK ove regije.

Da li ste pažljivo čitali radove?

1. Bazocelularni karcinomi su u predelu glave i vrata zastupljeni sa:
   a) oko 60%
   b) oko 80%
   c) oko 84%

2. Instrumenti manjeg kalibra su:
   a) manje otporni na ciklični zamor
   b) otporniji na ciklični zamor
   c) otporniji na torziona naprezanja

3. Prosečan broj obolelih stalnih zuba po ispitaniku kod dece uzrasta 12 i 15 godina je iznosio:
   a) 4,33
   b) 3,71
   c) 2,43

4. Primena $Bi_2 O_3$ kao rendgenkontrastnog sredstva utiče na:
   a) diskoloraciju zuba
   b) povećanu mehaničku otpornost
   c) smanjuje rastvorljivost cementa

5. Fotogrametrija je:
   a) pouzdana metoda za svakodnevnu praksu
   b) nepouzdana metoda za svakodnevnu praksu
   c) pouzdana samo za određene slučajeve

6. Za zatvaranje prostora posle ekstrakcije zuba najčešće se koristi:
   a) metoda sa elastičnim koncima
   b) primena mobilnih aparata
   c) primena prstenova

7. Karcinomi kože se uglavnom javljaju:
   a) u regiji grudnog koša
   b) u predelu ekstremiteta
   c) u regiji glave i vrata

8. Ukupan karijes zuba kod dece uzrasta 12 i 15 godina iznosio je:
   a) 7,34%
   b) 8,99%
   c) 11,33%

9. Dodatak Bi2 O3 kao rendgenkontrastnog sredstva utiče na:
   a) smanjenu rastvorljivost cementa
   b) povećanu rastvorljivost cementa
   c) veću mehaničku otpornost cementa

10. Fotogrametrija je:
    a) jednostavna i precizna metoda
    b) jednostavna i manje precizna metoda
    c) komplikovana i precizna metoda

11. Merenje postekstrakcionog prostora je neophodno i najčešće se realizuje:
    a) lenjirom
    b) nanijusom
    c) fotogrametrijom

12. Najznačajniji faktor rizika za nastanak karcinoma kože je:
    a) izlaganje UV zracima
    b) izlaganje IC zracima
    c) izlaganje halogenom svetlu

13. K i O kod dece uzrasta 12 godina je iznosio:
    a) 81%
    b) 64%
    c) 57%

14. Novosintetisani cement ACBO DENT je pokazao:
    a) odgovarajuću biokompatibilnost
    b) neodgovarajuću biokompatibilnost
    c) nedovoljnu biokompatibilnost

15. Elastični lanac je:
    a) veoma efikasan mehanizam za zatvaranje postekstrakcionog prostora
    b) neefikasan mehanizam za zatvaranje postekstrakcionog prostora
    c) pouzdan samo u posebnim slučajevima

16. Zatvaranje postekstrakcionog prostora se najčešće radi u okviru terapije:
    a) fiksnim ortodonskim aparatima
    b) mobilnim ortodonskim aparatima
    c) samo kod kombinovanih radova

17. Glavni razlog za nastanak frakture NiTi je:
    a) torzioni stres
    b) ciklični zamor
    c) torzioni stres i ciklični zamor

18. Novosintetisani cement ACBO DENT je pokazao:
    a) zadovoljavajuću rendgenkontrastnost
    b) nezadovoljavajuću rendgenkontrastnost
    c) nedovoljnu rendgenkontrastnost

19. Prosečna vrednost smanjenja širine postekstrakcionog prostora digitalnim kaliperom je iznosila:
    a) 1,00 mm
    b) 1,02 mm
    c) 1,04 mm

20. K i O kod dece uzrasta 15 godina je iznosio:
    a) 81,02%
    b) 64%
    c) 57%

21. Rendgenkontrastnost je ispitivana kod KS cementa:
    a) ACBO MPCA
    b) ACBO OS
    c) ACBO DENT

22. Najčešći razlog za nastanak fraktura NiTi instrumenta je:
    a) stomatolog
    b) izbor NiTi instrumenata
    c) anatomija kanala

23. Grupa dece uzrasta od 15 godina obuhvatila je:
    a) 175 dece
    b) 195 dece
    c) 235 dece

24. Kalcijum-silikatni cement ACBO DENT se može koristiti:
    a) za punjenje kanala
    b) za direktno prekrivanje pulpe
    c) za reparaciju kompozitnih ispuna

25. Zatvaranje postekstrakcionog prostora je realizovano kod:
    a) 19 pacijenata
    b) 29 pacijenata
    c) 38 pacijenata

26. Najčešći maligni tumori su:
    a) karcinomi kože
    b) melanomi kože
    c) sarkomi kože

27. Kao rendgenkontrastno sredstvo kod ACBO DENTA je korišćen:
    a) SR CO3
    b) Ca CO3
    c) Mg CO3

28. Uzorak u istraživanju postekstrakcionog prostora je činilo:
    a) 19 postekstrakcionih prostora
    b) 38 postekstrakcionih prostora
    c) 42 postekstrakciona prostora

29. Široka primena NiTi instrumenta dovela je do:
    a) učestalijih fraktura
    b) smanjenja loma
    c) manjih briga kod stomatoloških praktičara

30. Razblaženja ekstrakta cementa ACBO DENT:
    a) uticala su na vijabilnost L 929 ćelija
    b) nisu uticala na vijabilnost L 929 ćelija
    c) uticala su na vijabilnost samo kod MTA

31. Najčešće zatvaranje postekstrakcionih prostora je realizovano posle ekstrakcije:
    a) prvih premolara
    b) drugih premolara
    c) očnjaka

32. Uvođenje NiTi instrumenta u endodonsku praksu je:
    a) olakšalo rešavanje endodonskih problema
    b) otežalo rešavanje endodonskih problema
    c) endodonsku terapiju učinilo nedostupnom

33. Kao kontrolni materijal u ispunjavanju biokompatibilnosti ACBO DENTA korišćen je:
    a) fosfatni cement
    b) kalcijum-aluminatni cement
    c) PORTLAND cement

34. Praćenje zatvaranja postekstrakcionih prostora je bilo:
    a) tokom dva meseca
    b) tokom četiri meseca
    c) tokom šest meseci

35. Učestalost karijesa kod školske dece je proveravana kod:
    a) 309 dece
    b) 409 dece
    c) 509 dece

36. Kontrolni pregledi pri praćenju zatvaranja postekstrakcionih prostora su rađeni:
    a) svake sedmice
    b) svake dve sedmice
    c) svake četiri sedmice

37. Grupa dece uzrasta od 12 godina obuhvatila je:
    a) 214 dece
    b) 314 dece
    c) 324 dece

38. Vijabilnost ćelija pri proveri biokompatibilnosti je utvrđivana pomoću sredstva:
    a) kristal violet
    b) alizarin crveno
    c) srebro-nitrata

39. Merenja širine postekstrakcionih prostora su obavljena:
    a) šestarom
    b) lenjirom
    c) fotogrametrijom i digitalnim nanijusom

40. Rendgenkontrasnost ACBO DENTA je proveravana:
    a) digitalnom radiografijom
    b) primenom CT
    c) kombinacijom dve tehnike

41. Osnovu preventivnih programa u stomatologiji čine:
    a) analiza oralnog zdravlja
    b) analiza stanja tvrdih zubnih tkiva
    c) analiza stanja mekih tkiva usne duplje

42. Ćelijska morfologija pri proveri biokompatibilnosti je praćena:
    a) fazno-kontrastnom mikroskopijom
    b) pomoću stereo-lupe
    c) pomoću računarskog programa

43. Prosečno smanjenje širine postekstrakcionog prostora merenjem fotogrametrijskom metodom je iznosilo:
    a) 0,80 mm
    b) 1,00 mm
    c) 1,10 mm

44. U prevenciji stanja oralnog zdravlja najčešće se posmatra stanje:
    a) dece predškolskog uzrasta
    b) dece školskog uzrasta
    c) odraslih osoba

45. Zadovoljavajući kontrast kod ACBO DENTA obezbeđuje:
    a) 10% SR CO3
    b) 20% SR CO3
    c) 30% SR CO3

46. Biokompatibilnost ALBO DENTA je proveravana:
    a) na kulturi ćelija
    b) implantacijom u potkožno tkivo pacova
    c) aplikacijom u zube pacova

47. Učestalost karijesa kod školske dece je proveravana na:
    a) teritoriji opštine Čukarica
    b) teritoriji opštine Novi Beograd
    c) teritoriji opštine Zemun

48. ALBO DENT pokazuje bolju biokompatibilnost:
    a) samo od cementa Portland
    b) samo od MTA
    c) i od cementa Portland i od MTA

49. Biokompatibilnost ACBO DENTA je proveravana na:
    a) fibroblastima miša L929
    b) fibroblastima miša K838
    c) fibroblastima miša M233

50. Učestalost karijesa kod školske dece utvrđivana je kod školske dece uzrasta:
    a) 8 i 10 godina
    b) 10 i 12 godina
    c) 12 i 15 godina

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