UDC: 616.314-78 DOI: 10.2298/SGS1404175P

Ultrastructural Analysis of the Surface of Stainless Steel Endodontic Instruments Before and After Use

Jelena Popović[1], Jovanka Gašić[1], Slavoljub Živković[2], Aleksandar Mitić[1], Marija Nikolić[1], Radomir Barac[1]

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

[2]Department of Restorative Dentistry and Endodontics, School of Dentistry, University of Belgrade, Belgrade, Serbia

SUMMARY

Introduction Although many studies have reported various advantages of nickel-titanium endodontic instruments, the use of stainless steel endodontic files still presents a standard in everyday practice. The aim of this study was to evaluate ultrastructure of the surface of stainless steel endodontic instruments before and after their use.

Material and Methods Fourteen sets of non-used stainless steel endodontic reamers and files were included in the study. Each set of instruments was used one, three or six times in simulated clinical conditions on extracted maxillary premolars. After their use the instruments were subjected to cleaning and sterilization procedures. Ultrastructure of the surface of instruments was observed under scanning electron microscope (SEM). Surface analysis was performed based on the number of uses and size of instruments. The following characteristics were analyzed: defects of instrument flutes, defects of cutting edges and instrument deformations.

Results SEM analysis showed defects on the surface of non-used instruments as a result of the manufacturing process. Surface defects, defects of cutting edges as well as flutes deformations were observed after a single use and were more often noticed in small sized instruments. After three uses, flutes deformations were observed in all small sized instruments and some of the medium size. After six uses all groups of instruments showed defects of cutting edges.

Conclusion Non-used stainless steel endodontic instruments showed surface defects created by the manufacturing process. Defects of cutting edges and flutes can be observed after a single use. To minimize complications and mistakes during clinical preparation it is recommended to limit the number of instrument uses.

Keywords: defects; endodontic instruments; SEM; stainless steel

INTRODUCTION

Endodontic treatment of uninfected and infected root canal system includes cleaning, shaping, disinfection and obturation [1]. Although successful endodontic therapy depends on several factors, one of the most important steps in the root canal treatment is canal instrumentation. It is essential because it provides mechanical debridement, creates the space for medicament placement and final obturation [2]. Although numerous studies have emphasized benefits of using nickel-titanium endodontic instruments due to their abilities such as high flexibility and safe penetration into the curved root canals, the use of stainless steel endodontic instruments remains standard in everyday practice [3, 4]. There are number of scientific studies that have analyzed surface structure and wearing of nickel-titanium instruments [5, 6], however, there is little data in the literature that analyzed ultrastructure of stainless steel endodontic instruments after repeated use [7].

The aim of the present study was to perform ultrastructural analysis of the surface of stainless steel endodontic instruments before and after their use.

MATERIAL AND METHODS

The study was completed at the Department of Restorative Dentistry and Endodontics, Clinic of Dentistry and the Institute for Biomedical Research of the Faculty of Medicine in Nis. The analysis included 14 sets of non-used hand stainless steel reamers and files (Kendo, Münich, Germany) size 15-40. After taking out of the packaging, instruments were cleaned of manufacturing impurities in the ultrasonic cleaner (JUS-S01, JEOL) with distilled water for 15 minutes at a frequency of 28 kHz.

Each set of instruments was exposed to one, three and six root canal instrumentation procedures in simulated clinical conditions on extracted maxillary premolars. After preparation of the access cavity, instrumentation of the root canal was performed using one set of instruments (15-40) and applying step-back technique and 0.5% NaOCl irrigation. Four sets were subjected to a single use, four were used three times and four sets were used six times for root canal instrumentation whereas the two sets of non-used instruments served as controls. To avoid the influence of the operator the same person performed all instrumentation procedures.

Address for correspondence: Jelena POPOVIĆ, Department of Restorative Dentistry and Endodontics, Clinic of Dentistry, Bul. Dr Zorana Djindjića 52, 18000 Niš, Serbia; *jelenadp@gmail.com*

After each use, the instruments were subjected to cleaning and sterilization procedures by immersing into 3% hydrogen peroxide, hand brushing, cleaning in ultrasonic bath and autoclave sterilization. Then after the samples were prepared for scanning electron microscopic examination (SEM; JEOL-JSM 5300). In order to obtain adequate visualization of the working parts of instruments, the handles of the instruments were cut off, and their working parts were fixed to the aluminium stubs with a fixing agent (Dotite paint xc 12 Carbon JEOL, Tokyo, Japan) and sputter coated with gold/palladium (in the unit JFC 110 Ion Sputter JEOL).

Ultrastructural surface analysis was performed in relation to the number of uses and the size of instruments (Table 1). Due to the assumption that instruments of various sizes have different susceptibility to surface deformation, all samples were divided into the three groups: I group – small size (size 15 and 20); II group – medium size (size 25 and 30); III group – large size (size 35 and 40).

Analysed ultrastructural changes on the instruments were: 1) changes on the flat surfaces between two blades (appearance of metal anomalies and irregularities due to poor finshing, accumulation of debris); 2) defects of cutting edges (blunting or disruption of the edges); and 3) deformation of instruments (bending of the instruments, the loss or disruption of threads).

Statistical analysis was performed using χ^2 and Fisher Exact test, a p value of $p<0.05$ was considered statistically significant.

RESULTS

Fifty percent of non-used (control group) instruments showed some manufacturing irregularities on flat surfaces (Figure 1) while 16.6% of the instruments had blunt cutting edges (Figure 2) (Table 2).

After a single use surface irregularities were detected in 50% of instruments of all sizes, blunt cutting edges were observed in 16.6% of the instruments, while loss of threads of the working part was observed in 16.6% of the instruments (Figure 3) (Table 2).

Defects on the surface of instruments used three times were more obvious. Roughness of the metal surface was detected in 50% of the instruments of all sizes. Blunt edges were found in 25% of instruments, while loss of threads occurred in 33.3% of instruments (Table 2).

Table 1. Analyzed endodontic instruments in relation to the size and the number of uses
Tabela 1. Podela ispitivanih endodontskih instrumenata u odnosu na broj korišćenja i veličinu

Group Grupa	Single use 1 upotreba	3 uses 3 upotrebe	6 uses 6 upotreba	Control group Kontrolna grupa	Total Ukupno
I	8	8	8	4	28
II	8	8	8	4	28
III	8	8	8	4	28
Total Ukupno	24	24	24	12	84

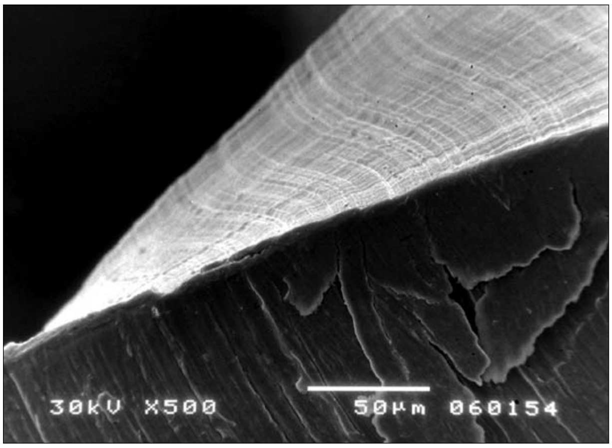

Figure 1. SEM of the manufactruring irregularities on the surface of a non-used stainless steel instrument
Slika 1. SEM prikaz proizvodnih neravnina na površini novog instrumenta od nerđajućeg čelika

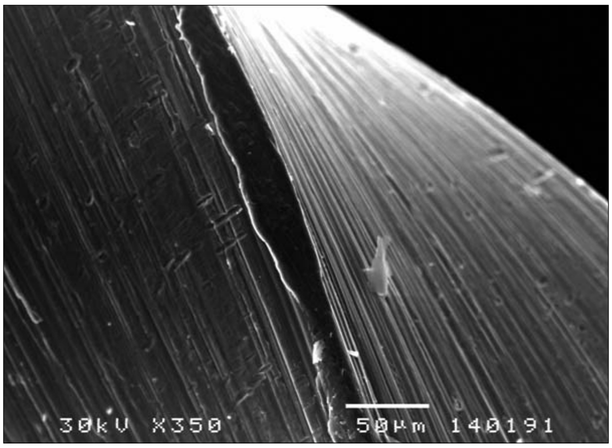

Figure 2. SEM of the blunt cutting edge as a manufacturing defect on a non-used endodontic instrument.
Slika 2. SEM prikaz tupe sečivne ivice kao proizvodnog oštećenja na novom endodontskom instrumentu

Table 2. Working part deformities after multiple uses of instruments
Tabela 2. Oštećenja na radnim delovima endodontskih instrumenata posle upotrebe

Damages Oštećenja	Control group Kontrolna grupa	Single use 1 upotreba	3 uses 3 upotrebe	6 uses 6 upotreba	χ^2-test
Surface irregularities Površinske neravnine	6 (50%)	12 (50%)	12 (50%)	12 (50%)	NS
Defects of cutting edges Oštećenja sečivnih ivica	2 (16.6%)	4 (16.6%)	6 (25%)	24 (100%)	χ^2=40.57 p<0.0001
Deformations of threads Deformacije navoja	0 (0%)	4 (16.6%)	8 (33.3%)	12 (50%)	χ^2=6.00 p<0.05

NS – not statistically significant
NS – nije statistički značajno

Table 3. Working part deformities after multiple use of the group I instruments
Tabela 3. Analiza oštećenja na radnim delovima endodontskih instrumenata I grupe posle upotrebe

Small instruments **Mali instrumenti**	**Number of uses** **Broj upotreba**			
Damages **Oštećenja**	**1**	**3**	**6**	**χ²-test**
Surface irregularities Površinske neravnine	4 (50%)	4 (50%)	4 (50%)	NS
Defects of cutting edges Oštećenja sečivnih ivica	2 (25%)	3 (37.5%)	8 (100%)	χ^2=10.41 p<0.05
Deformations of threads Deformacije navoja	4 (50%)	8 (100%)	8 (100%)	χ^2=9.60 p<0.05

Table 4. Working part deformities after multiple use of the group II instruments
Tabela 4. Analiza oštećenja na radnim delovima endodontskih instrumenata II grupe posle upotrebe

Medium instruments **Instrumenti srednje veličine**	**Number of uses** **Broj upotreba**			
Damages **Oštećenja**	**1**	**3**	**6**	**χ²-test**
Surface irregularities Površinske neravnine	4 (50%)	4 (50%)	4 (50%)	NS
Defects of cutting edges Oštećenja sečivnih ivica	2 (25%)	3 (37.5%)	8 (100%)	χ^2=10.41 p<0.05
Deformations of threads Deformacije navoja	0 (0%)	0 (0%)	4 (50%)	χ^2=9.60 p<0.05

Table 5. Working part deformities after multiple use of the group III instruments
Tabela 5. Analiza oštećenja na radnim delovima endodontskih instrumenata III grupe posle upotrebe

Large instruments **Veliki instrumenti**	**Number of uses** **Broj upotreba**			
Damages **Oštećenja**	**1**	**3**	**6**	**χ²-test**
Surface irregularities Površinske neravnine	4 (50%)	4 (50%)	4 (50%)	NS
Defects of cutting edges Oštećenja sečivnih ivica	0 (0%)	0 (0%)	8 (100%)	χ^2=24.00 p<0.0001
Deformations of threads Deformacije navoja	0 (0%)	0 (0%)	0 (0%)	NS

After six uses endodontic instruments showed numerous ultrastructural changes. Metal surface irregularities were observed in 50% of instruments equally within all groups and small amount of adhered dentin debris was also detected on their surface (Figure 4). Damaged cutting edges were observed in all instruments (100%) (Figures 4 and 5) and loss of threads was detected in 50% of instruments (Table 2).

Statistical analysis showed that number of instrument uses did not affect the number of instruments with surface defects. Defects of cutting edges were observed after multiple uses (p<0.0001), and number of instruments with deformations increased with increased number of uses (p<0.05) (Table 2).

In the group of small instruments (sizes 15 and 20) there was no significant difference in the presence of surface irregularities depending on the number of use. Defects of the cutting edges after single use were observed in 25% of instruments, after three uses in 37.5%, and after six uses in 100% of instruments that was statistically significant (p<0.05). A statistically significant difference

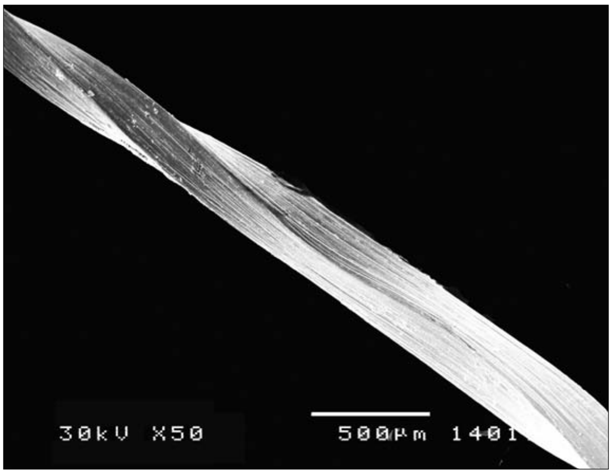

Figure 3. The loss of threads on a stainless steel instrument
Slika 3. Ispravljanje navoja sečiva na instrumentu od nerđajućeg čelika

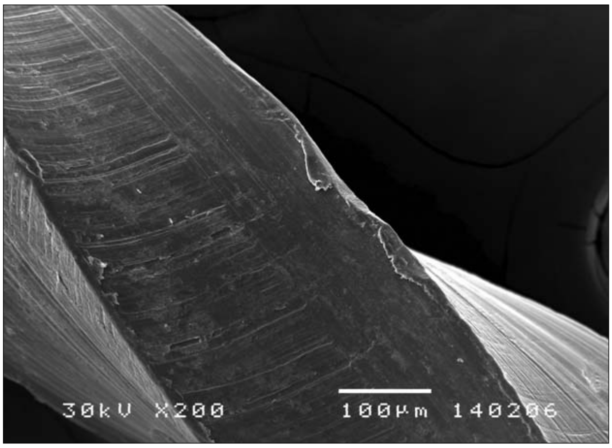

Figure 4. SEM of the metal surface roughness and disrupted cutting edge with adhered dentin debris
Slika 4. SEM prikaz površinske neravnine i zalomljene sečivne ivice sa adheriranim dentinskim debrisom

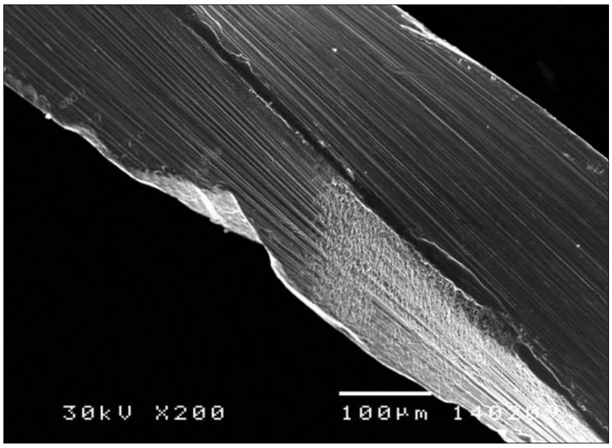

Figure 5. SEM of damaged cutting edge on a stainless steel instrument
Slika 5. SEM prikaz oštećene sečivne ivice na instrumentu od nerđajućeg čelika

was found in the occurrence of deformation of threads (p<0.05); after one use it was observed in 50% while after three uses in 100% of instruments (Table 3).

Medium sized instruments (sizes 25 and 30) did not show significant difference in the occurrence of surface roughness depending on the number of uses. There was statistically significant difference in the number of instruments with defects of cutting edges depending on the number of uses ($p<0.05$); after one use 25% of instruments showed damages of cutting edges, after three uses 37.5% while after six uses 100% instruments showed damages. After one and three uses none of instruments showed thread deformations but after six uses 50% of instruments showed loss of threads and this was statistically significant ($p<0.05$) (Table 4).

In the group of large instruments (size 35 and 40) statistically significant difference in the number of instruments with defects of cutting edges in relation to the number of uses was found ($p<0.0001$). Defects were not observed after one and three uses, while after six uses 100% of the instruments had blunt or disrupted cutting edges. There was no significant difference in the occurrence of surface roughness and deformation of threads (Table 5).

DISCUSSION

One of the primary objectives of endodontic treatment is to remove existing and potential irritants from the root canal system. This goal can be achieved by chemomechanical instrumentation of the root canal [8]. Efficient instrumentation depends on many factors such as material and design of endodontic instruments, root canal morphology, as well as experience of the therapist [9]. Stainless steel instruments have good cutting efficacy, however, their modulus of elasticity is high, which makes them less flexible [10]. On the contrary, nickel-titanium instruments have high flexibility that makes them suitable for instrumentation of narrow and curved canals [11].

Regardless of the material of endodontic instruments their fractures most often occur due to torsional and flexural fatigue. Torsional fractures occur when the working part of the instrument, usually the tip, gets stuck in the canal while the operator continues with movements or rotations. Flexion fractures occur due to the material fatigue after multiple uses of instruments [10]. Therefore, the number of use of endodontic instruments must be limited. Although numerous clinical studies have confirmed that endodontic hand instruments, especially smaller size, should be used once only, often it is disrespected in clinical practice [12]. It is well known fact that endodontic instruments in everyday practice are discarded only when they are visibly deformed or broken [13]. This study aimed to analyze defects of instruments at the microscopic level after a certain number of uses.

Results of the current study revealed that even non-used instruments had some defects, most commonly metal surface irregularities and blunt cutting edges. A large number of these defects originating from the manufacturing process can compromise cutting efficiency of endodontic instruments and potentially cause problems with corrosion [14].

Irregularities of metal surfaces and retained dentin debris after six uses were equally present in all sizes of instruments. Elmsallati et al. [8] demonstrated debris retention on the surface of instruments even after ultrasonic cleaning. After multiple uses there was increasing number of instruments with defects of cutting edges. Blunt cutting edges were present in non-used instruments and their number increased with the number of uses. Disruption of edges was observed after six uses even in the groups of medium and large size instruments.

Deformation in the form of thread loss was observed after one use of small sized instruments. Number of deformed instruments increased with the number of uses and after sixth use loss of threads was observed even in the group of medium size instruments. Similar results were reported by Bonetti-Filho et al. [15] who recommended a single use of small sized instruments.

Sterilization has also been shown to have a significant impact on instruments. Nešković et al. [12] demonstrated significantly more frequent occurrence of instrument deformations after autoclave sterilization compared to dry heating sterilization. Casella and Rosalbino [16] showed that instruments subjected to presterilization cleaning in sodium hypochlorite solution followed by sterilization presented significant corrosion rate compared to the control group of instruments. These results are important because corrosion is one of the most important factors that promote material fatigue making instruments more susceptible to deformation during further use.

CONCLUSION

Non-used stainless steel endodontic instruments have numerous surface defects originating from the manufacturing process. First signs of instruments deformation occur after the first clinical use. Small instruments should be used once only in narrow and curved canals, up to three times in straight canals whereas the number of uses should be limited to six for medium and large instruments due to the visible ultrastructural changes.

REFERENCES

1. Chianello G, Specian VL, Hardt LCF, Raldi DP, Lage-Marques JL, Habitante SM. Surface finishing of unused rotary endodontic instruments: A SEM study. Braz Dent J. 2008; 19:109-13.
2. Peters OA. Current challenges and concepts in the preparation of root canal systems. J Endod. 2004; 30:559-67.
3. Kazemi RB, Stenman E, Spangberg IS. A comparison of stainless steel and NiTi H type instruments of identical design: torsion and bending tesis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000; 90:500-6.
4. Zuolo MI, Walton RE. Instrument deterioration with usage: nickel titaniun versus stainless steel. Quintessence Int. 1997; 28:397-402.
5. Eggert C, Peters O, Barbakow F. Wear of nickel-titanium lightspeed instruments evaluated by scanning electron microscopy. J Endod. 1999; 25:494-8.
6. Inan U, Aydin C, Uzun O, Topuz O, Alacam T. Evaluation of surface characteristics of used and new pro-taper instruments: an atomic force microscopy study. J Endod. 2007; 33:1334-7.
7. Lopes HP, Elias CN, Siquiera Junior JF. Defects from the manufacturing process of K-type files. Rev Peul Odontol. 2002; 24:4-7.
8. Elmsallati EA, Wadachi R, Ebrahim AK, Suda H. Debris retention and wear in three different nickel-titanium rotary instruments. Aust Endod J. 2006; 32:107-11.

9. Cheung GS, Bian Z, Shen Y, Peng B, Darvell BW. Comparison of defects in ProTaper hand-operated and engine-driven instruments after clinical use. Int Endod J. 2007; 40:169-78.
10. Kumar J. A scanning electron microscopic evaluation of surface changes of new and used greater taper nickel titanium hand and rotary instruments – an in vitro study. Endodontology. 2013; 25:37-50.
11. Alapati SA, Brantley WA, Svec TA, Powers JM, Mitchell JC. Scanning electron microscope observations of new and used nickel-titanium rotary files. J Endod. 2003; 29:667-9.
12. Nešković J, Damjanov M, Živković S, Grga Dj, Koruga Dj, Kojić D. Deformations of the manual endodontic instruments during root canal instrumentation. Stomatološki glasnik Srbije. 2010; 57:21-9.
13. Smith A, Dickson M, Aitken J, Bagg J. Contaminated dental instruments. J Hosp Infect. 2002; 51:233-5.
14. Thompson SA. An overview of nickel-titanium alloys used in dentistry. Int Endod J. 2000; 43:69-76.
15. Bonetti-Filho I, Esberard R, Leonardo RT, Del Rio CE. Microscopic evaluation of three endodontic files pre and post instrumentation. J Endod. 1998; 24:461-3.
16. Casella G, Rosalbino F. Corrosion behaviour of NiTi endodontic instruments. Corros Eng Sci Techn. 2011; 46:521-3.

Received: 09/06/2014 • Accepted: 16/10/2014

Ultrastrukturna ispitivanja površine endodontskih instrumenata od nerđajućeg čelika

Jelena Popović[1], Jovanka Gašić[1], Slavoljub Živković[2], Aleksandar Mitić[1], Marija Nikolić[1], Radomir Barac[1]

[1]Odeljenje za bolesti zuba i endodonciju, Klinika za stomatologiju, Medicinski fakultet, Univerzitet u Nišu, Niš, Srbija;
[2]Klinika za bolesti zuba i endodonciju, Stomatološki fakultet, Univerzitet u Beogradu, Beograd, Srbija

KRATAK SADRŽAJ

Uvod Iako brojne studije ističu prednost korišćenja instrumenata od nikl-titanijuma zbog njihovih prednosti, primena endodontskih instrumenata od nerđajućeg čelika i dalje je standard u svakodnevnoj praksi. Cilj ovog rada je bio da se provere ultrastrukturne odlike površine radnog dela endodontskih instrumenata od nerđajućeg čelika pre i posle njihove upotrebe.

Materijal i metode rada U istraživanju je korišćeno 14 setova novih ručnih proširivača i turpija od nerđajućeg čelika. Instrumenti svakog seta su korišćeni jednom, tri i šest puta za preparaciju kanala u simuliranim kliničkim uslovima na ekstrahovanim gornjim premolarima. Nakon svake upotrebe instrumenti su očišćeni i sterilizovani. Površina instrumenata je posmatrana i analizirana na skening-elektronskom mikroskopu (SEM). Analiza ultrastrukture instrumenata vršena je u pogledu broja upotreba i veličine. Kada su u pitanju ultrastrukturne promene na instrumentima, analizirani su oštećenja površine i sečiva i deformacije instrumenata.

Rezultati SEM analiza je pokazala da i kod novih instrumenata postoje oštećenja koja su verovatno posledica proizvodnog procesa. Nakon prve upotrebe javljala su se oštećenja površine, sečivnih ivica, kao i deformacije navoja, i to češće kod manjih veličina. Nakon tri upotrebe deformiteti navoja su se javili kod svih instrumenata malih veličina i kod pojedinih instrumenata srednje veličine. Nakon šeste upotrebe dominirala su oštećenja u vidu tupljenja i zalamanja sečivnih ivica, koja su bila jednako zastupljena u svim grupama instrumenata.

Zaključak Novi endodontski instrumenti od nerđajućeg čelika imaju na svojoj površini oštećenja koja potiču od procesa proizvodnje, a deformacije instrumenata i oštećenja sečiva se javljaju već posle prve kliničke upotrebe. Da bi se sprečile komplikacije i greške u kliničkom radu, preporuka je da broj upotreba endodontskih instrumenata bude ograničen.

Ključne reči: defekti; endodontski instrumenti; SEM; nerđajući čelik

UVOD

Endodontsko lečenje neinficiranog i inficiranog kanalnog sistema podrazumeva njegovo čišćenje, oblikovanje, dezinfekciju i opturaciju [1]. Iako uspešna endodontska terapija zavisi od nekoliko faktora, jedan od najvažnijih koraka u tretmanu kanala korena je preparacija kanala. Ona je od suštinskog značaja jer se dobrom preparacijom obezbeđuju mehanički debridman, stvaranje prostora za nanošenje medikamenata i prostora za odgovarajuću opturaciju kanalnog sistema [2]. Iako brojne studije ističu prednost korišćenja instrumenata od nikl-titanijuma zbog njihovih prednosti, od kojih su najvažnije visoka fleksibilnost i mogućnost prodora u najzakrivljenije kanale, korišćenje endodontskih instrumenata od nerđajućeg čelika i dalje je standard u svakodnevnoj praksi [3, 4]. Postoji veliki broj naučnih studija koje su se bavile analizom površinske strukture i trošenjem instrumenata od nikl-titanijuma [5, 6], međutim, malo je podataka u literaturi koji govore o ultrastrukturi površine endodontskih instrumenata od nerđajućeg čelika posle višestrukog korišćenja [7].

Cilj ovog rada je bio da se provere ultrastrukturne odlike površine radnog dela endodontskih instrumenata od nerđajućeg čelika pre i posle njihove upotrebe.

MATERIJAL I METODE RADA

Istraživanje je urađeno na Odeljenju za bolesti zuba i endodonciju Klinike za stomatologiju i Institutu za biomedicinska istraživanja Medicinskog fakulteta u Nišu. Za analizu je korišćeno 14 setova novih ručnih proširivača i turpija od nerđajućeg čelika (*Kendo*, Minhen, Nemačka), veličine 15–40. Po uzimanju iz pakovanja instrumenti su očišćeni od proizvodnih nečistoća u ultrazvučnom čistaču (*JUS-S01, JEOL*) destilovanom vodom u trajanju od 15 minuta, na frekvenciji od 28 kHz.

Instrumenti svakog seta su korišćeni jednom, tri i šest puta za preparaciju kanala u simuliranim kliničkim uslovima na ekstrahovanim gornjim premolarima. Nakon preparacije pristupnog kaviteta urađena je obrada kanala korena tzv. *step-back* tehnikom uz irigaciju rastvorom NaOCl u koncentraciji od 0,5%, pri čemu je za svaki kanal korena korišćen set instrumenata (veličine 15–40). Po četiri seta su korišćena za obradu jednog, četiri, odnosno šest kanala, a dva nova seta su poslužila kao kontrola. Preparacije svih kanala korena izvršio je jedan istraživač, da bi se izbegle interpersonalne greške.

Nakon svake upotrebe instrumenti su očišćeni i sterilisani, a ovi postupci su podrazumevali: potapanje u troprocentni rastvor vodonik-peroksida, ručno četkanje, čišćenje u ultrazvučnom kupatilu i sterilizaciju autoklavom. Nakon toga uzorci su pripremani za skening-elektronsko mikroskopsko ispitivanje (SEM). Da bi se radni delovi instrumenata na odgovarajući način videli, odsecana je ručica instrumenata, a njihovi radni delovi su fiksirani za cilindrične nosače sredstvom za fiksiranje (*Dotite paint xc 12 Carbon JEOL*, Tokio, Japan). Nanošenje tankog sloja zlata izvršeno je u uređaju za jonsko raspršivanje (*JFC 110 Ion Sputter JEOL*). Površina instrumenata je posmatrana i analizirana na skening-elektronskom mikroskopu tipa *JEOL JSM 5300*.

Analiza ultrastrukture instrumenata je urađena u pogledu broja upotreba i prečnika instrumenta (Tabela 1). Zbog pretpostavke da instrumenti različitih dimenzija mogu biti i različito deformisani, uzorci su svrstani u tri grupe: I grupu činili su instrumenti malih veličina (veličine 15 i 20), II grupu instrumenti srednje veličine (veličine 25 i 30), a III grupu instrumenti većih veličina (veličine 35 i 40).

Kod instrumenata su analizirane: 1) promene na ravnim površinama navoja između dva sečiva (pojava metalnih nepravilnosti usled loše završne obrade, akumulacija debrisa); 2) promene na sečivima (zatupljenje sečiva i zalamanje sečiva); 3) deformacije instrumenata (povijanje instrumenata, ispravljanje – derotacija navoja).

Statistička analiza je vršena pomoću χ^2-testa i Fišerovog (*Fisher*) testa egzaktnosti. Prag značajnosti je bio na vrednosti od p<0,05.

REZULTATI

Ultrastrukturnom analizom kontrolne grupe instrumenata, kod 50% instrumenta su uočene proizvodne nepravilnosti na ravnim površinama (Slika 1), dok su oštećenja u vidu zatupljenog sečiva zabeležena kod 16,6% instrumenata (Slika 2) (Tabela 2).

SEM analiza instrumenata koji su korišćeni samo jednom pokazala je površinske neravnine kod 50% instrumenata (instrumenata svih veličina). Tupe sečivne ivice su uočene kod 16,6% instrumenata, dok je ispravljanje navoja instrumenata usled deformacije zapaženo kod 16,6% instrumenata (Slika 3) (Tabela 2).

Kod instrumenata koji su korišćeni tri puta uočene su jasnije promene. Neravnine na metalnoj površini su uočene kod 50% instrumenata svih veličina. Oštećenja u vidu tupih sečivnih ivica su zabeležena kod 25% instrumenata, dok je ispravljanje sečivnih navoja zapaženo kod 33,3% instrumenata (Tabela 2).

Nakon šest upotreba endodontski instrumenti su ispoljili veliki broj promena na ultrastrukturnom nivou. Neravnine na metalnoj površini su uočene kod 50% instrumenata (jednako u okviru svih grupa), a zapažene su i manje količine dentinskog debrisa koje su prianjale na ovim neravninama (Slika 4). Nepravilnosti u vidu oštećenih sečivnih ivica su zapažene kod svih instrumenata (Slika 4 i 5), dok je ispravljanje sečivnih navoja zabeleženo kod 50% instrumenata (Tabela 2).

Statistička analiza je pokazala da broj korišćenja instrumenata nije uticao na broj instrumenata s površinskim neravninama. Promene na sečivima su se javljale statistički značajno češće s većim brojem korišćenja (p<0,0001), a sa povećanjem broja upotreba statistički značajno se povećavao i broj instrumenata sa deformacijama (p<0,05) (Tabela 2).

U okviru grupe instrumenata manjih dimenzija (veličine 15 i 20) nije uočena razlika u pojavi površinskih neravnina u zavisnosti od broja upotreba. Oštećenja na sečivima instrumenata posle jedne upotrebe uočena su kod 25% instrumenata, nakon tri upotrebe kod 37,5%, a nakon šest upotreba kod svih instrumenata; ova razlika je bila statistički značajna (p<0,05). Pojava deformacija navoja (p<0,05) nakon jedne upotrebe uočena je u 50% slučajeva, a već posle treće upotrebe svih 100% instrumenata je bilo deformisano; ova razlika je bila statistički značajna (p<0,05) (Tabela 3).

U okviru grupe instrumenata srednje veličine (veličine 25 i 30) nije zapažena razlika u pojavi površinskih neravnina u zavisnosti od broja upotreba. Sa brojem upotreba statistički značajno češće su se beležila oštećenja sečivnih ivica (p<0,05). Nakon jedne upotrebe 25% instrumenata je pokazalo oštećenje sečivnih ivica, nakon tri upotrebe 37,5%, dok je nakon šeste upotrebe 100% instrumenata bilo oštećeno. Nakon jedne i tri upotrebe nisu uočene deformacije navoja, a nakon šeste upotrebe kod 50% instrumenata je uočeno ispravljanje sečivnih navoja, tako da je razlika bila statistički značajna (p<0,05) (Tabela 4).

U okviru grupe instrumenata većih dimenzija (veličine 35 i 40) zapažena je visoko statistički značajna razlika u pojavi oštećenja sečiva u odnosu na broj upotreba instrumenata (p<0,0001). Ova oštećenja nisu uočena nakon jedne, odnosno tri upotrebe, dok su posle šeste primene uočena kod svih instrumenata. Razlike u pojavi površinskih neravnina i deformacija navoja nisu zabeležene (Tabela 5).

DISKUSIJA

Jedan od primarnih ciljeva endodontskog lečenja je uklanjanje postojećih i potencijalnih iritansa iz kanalnog sistema, što se postiže hemomehaničkim čišćenjem i oblikovanjem kanala [8]. Za efikasnu preparaciju od suštinske su važnosti proizvodne osobine i dizajn instrumenata, kao i anatomomorfološke odlike kanalnog sistema i iskustvo terapeuta [9]. Instrumenti od nerđajućeg čelika imaju dobru sečivnu efikasnost, međutim, njihov modul elastičnosti je visok, što ih čini manje fleksibilnim [10]. Nasuprot njima, instrumenti od nikl-titanijuma poseduju visoku fleksibilnost, što ih čini pogodnim za obradu uskih i povijenih kanala [11].

Bez obzira na materijal od kojeg je endodontski instrument izrađen, njihovi prelomi su mogući i najčešće se dešavaju usled torzionog i fleksionog zamora. Torzioni prelomi nastaju kada se radni deo instrumenta (najčešće vrh) zaglavi u kanalu, a operator nastavi s naglim pokretima rotiranja ili turpijanja. Do fleksionih preloma dolazi usled zamora materijala od kojeg je izrađen instrument posle višestrukih upotreba [10]. Stoga broj upotreba endodontskih instrumenata mora biti ograničen. Iako su brojne kliničke studije potvrdile da ručne endodontske instrumente, posebno one manjih veličina, treba koristiti jednokratno, što se u kliničkom radu često ne poštuje [12]. Poznata je činjenica da se endodontski instrumenti u svakodnevnoj praksi odbacuju tek kada budu vidljivo deformisani ili polomljeni [13]. Zbog toga je ova studija izvedena kako bi se oštećenja na instrumentima analizirala na mikroskopskom nivou posle određenog broja upotreba.

Analizom rezultata ovog istraživanja utvrđeno je da se već na novim instrumentima uočavaju neka oštećenja, s pojavom neravnina metalne površine i zatupljenih sečivnih ivica. Veliki deo ovakvih oštećenja koji potiču od procesa proizvodnje može da ugrozi sečivnu efikasnost endodontskih instrumenata i dovede do korozije, koja je jedan od glavnih faktora koji utiču na zamor i prelom instrumenta [14].

Neravnine metalne površine su bile jednako zastupljene kod instrumenata svih veličina i, s obzirom na to da predstavljaju dobru retencionu površinu, posle šeste upotrebe na njihovoj površini došlo je do zadržavanja dentinskog debrisa. Retenciju debrisa i trošenje instrumenata ispitivali su u svojoj studiji i Elmsalati (*Elmsallati*) i saradnici [8], koji su pokazali da kod zastupljenih površinskih nepravilnosti značajne količine debrisa zaostaju na površini instrumenata posle njihove primene čak i nakon ultrazvučnog čišćenja. Sa brojem upotreba se povećavao i broj instrumenata sa oštećenjima sečivnih ivica. Tupe sečivne ivice su se javljale i kod novih instrumenata, ali se njihov broj povećavao s povećanjem broja upotreba, dok je oštećenje sečivnih ivica zapaženo posle šest primena i kod instrumenata srednjih i većih veličina.

Deformacije u vidu ispravljanja navoja su uočene već posle prve upotrebe kod instrumenata manjih veličina. S većim brojem upotreba povećavao se i broj deformisanih instrumenata, pa je posle šeste primene došlo i do ispravljanja sečiva i kod instrumenata srednjih veličina. Slične rezultate u svojoj studiji dobili su i Boneti-Filjo (*Bonetti-Filho*) i saradnici [15], koji su zato preporučili da se instrumenti manjih veličina odbacuju već nakon jednog korišćenja.

Istraživanja su pokazala da značajan uticaj na instrumente može imati i sterilizacija. Nešković i saradnici [12] su dokazali značajno češću pojavu deformacija na instrumentima koji su više puta sterilisani u autoklavu u poređenju s onima sterilisanim u suvom sterilizatoru. Studija Kasele (*Casella*) i Rozalbina (*Rosalbino*) [16] je pokazala da su instrumenti podvrgnuti predsterilizacionom čišćenju u natrijum-hipohloritu, a zatim sterilizaciji, ispoljili značajnu stopu korozije u odnosu na kontrolnu grupu instrumenata. Ovakvi rezultati su značajni jer je korozija jedan od prvih faktora koji ukazuju na „zamor" materijala od kojeg su endodontski instrumenti izrađeni i koji, kao takvi, postaju podložniji deformacijama pri daljoj upotrebi.

ZAKLJUČAK

Novi endodontski instrumenti od nerđajućeg čelika imaju na svojoj površini brojna oštećenja koja potiču od procesa proizvodnje. Prvi znaci deformacija instrumenata se mogu javiti već posle prve kliničke primene. Preporuka je da broj upotreba instrumenata manjih veličina treba ograničiti na jednu kod uskih i povijenih kanala, odnosno do tri puta kod pravih kanala, a upotrebu instrumenata srednjih i većih dimenzija ograničiti na šest, jer se posle toga na ultrastrukturnom nivou uočavaju vidljiva oštećenja njihove površine.