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Efficacy of removing calcium hydroxide deposits from endodontic instruments prior to sterilization using different cleaning methods

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SUMMARY

Introduction Endodontic instruments during root canal treatment come into contact with dentinal debris, irrigation solutions and medication agents, which reminants should be eliminated before sterilization. The aim of the study was to verify the effectiveness of different cleaning methods for removing calcium hydroxide paste residues from the surfaces of the working parts of hand instruments, as well as to propose an effective protocol for cleaning endodontic instruments before sterilization.

Material and methods Forty-two new hand endodontic instruments were used to remove calcium hydroxide paste from the filled canals of extracted teeth. After contamination with medication, they were divided into the four groups and subjected to individual decontamination methods - mechanical, chemical and ultrasonic, as well as a combined protocol. The instruments were then observed under a light microscope. The effectiveness of the methods was evaluated based on the amount of residual matter on the surface of the working parts of the instruments.

Results The combined protocol showed a statistically significant difference in the achieved level of cleanliness compared to mechanical ($\chi^2 = 12.00$ $p < 0.05$) and chemical methods ($\chi^2 = 12.00$ $p < 0.05$), but there was no statistically significant difference compared to ultrasonic cleaning in disinfectant solution ($\chi^2 = 2.4$ $p > 0.05$). By applying combined protocol, instruments with completely clean surfaces were found, as well as the lowest values of contamination at the level of the entire group of instruments (8.33%).

Conclusion The protocol that consisted of mechanical cleaning with a sponge soaked in chlorhexidine gluconate, chemical soaking in sodium hypochlorite, and ultrasonic cleaning in a disinfectant showed the best efficiency in removing calcium hydroxide residues.

Keywords: endodontic instruments; cleaning; calcium hydroxide

INTRODUCTION

As endodontic files and reamers are generally accepted as reusable instruments, the evaluation of residual debris on their working part after use has been a significant topic of numerous scientific studies for a long time [1]. Data from the literature do not provide consistent information on the procedure for removing residues from contaminated endodontic instruments [2]. The cleaning procedure mainly involves mechanical (different types of brushes, sponges, etc.) and chemical cleaning (soaking in sodium hypochlorite (NaOCl), detergents, enzymatic cleaners), application of ultrasound and final rinsing before placing the instruments in the sterilizer. Numerous authors who analyzed different decontamination methods proved that no single method completely removes residual debris [3]. Therefore, the choice of appropriate methods of preparation of endodontic instruments for sterilization, justifies the development of an efficient cleaning protocol, with the aim of obtaining clean surfaces without inorganic and biological residues.

In addition to dentine debris, endodontic instruments during root canal treatment come into contact with irrigation solutions and medicated agents, their remains should also be eliminated before sterilization. Bearing in mind different chemical composition and adherence of these agents to the surface of the instruments, it is important to check the effectiveness of decontamination methods in their removal [4].

Calcium hydroxide is the medicament of choice in multi-session treatment of endodontic infections. It is stable in the canal, harmless to the body and has a prolonged bactericidal effect. It induces the formation of hard tissues and is effective against exudation in inflammations [5]. However, its incomplete removal from the root canal can negatively affect the adhesion of the sealer for root canal obturation [6]. Although there are different methods of removal that involve the application of various irrigants, ultrasound waves or laser energy, the remains of calcium hydroxide paste in the root canal must also be removed mechanically using endodontic instruments [7–11]. The paste deposits are then retained in the instrument blades

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along with the dentine debris and may remain even after the sterilization process is completed [4].

The aim of the study was to assess the effectiveness of different cleaning methods for removing calcium hydroxide paste residues from the surfaces of the working parts of hand endodontic instruments, as well as to propose an effective protocol for cleaning endodontic instruments before sterilization.

MATERIAL AND METHODS

The research was carried out at the Department of Restorative Dentistry and Endodontics of the Clinic for Dental Medicine in Niš and at the Scientific Research Center for Biomedicine of the Faculty of Medicine in Niš. The materials used in this research were manual endodontic instruments made of stainless steel - reamers and files (NTI-Kahla GmbH, Germany). Forty-two new stainless steel endodontic instruments - reamers and files were taken from their original packaging and subjected to ultrasonic cleaning to remove manufacturing impurities. The study included single-rooted teeth, extracted due to severe marginal periodontitis. A standard endodontic access cavity was prepared with a diamond bur. Each root canal was treated with a set of 15-40 instruments using a standard manual technique. NaOCl in concentration 0.5% was used for canal irrigation. After drying, the prepared root canals were filled with calcium hydroxide paste (i-CAL, i-dental, Lithuania) using a lentulo spiral. Endodontic access cavities were temporarily filled and stored in hermetically sealed boxes at room temperature for 24 hours. After removal of the temporary filling, the calcium hydroxide paste was flushed from the canal using 0.5% NaOCl, and the wall debris was then removed mechanically with endodontic instruments to achieve contamination of the working surfaces with the paste. The instruments were kept in hermetic boxes on the endodontic stand until the cleaning procedure.

The instruments were divided into the four groups and subjected to different cleaning methods (Table 1):

Group I: mechanical cleaning: with a brush and sponge soaked in chlorhexidine gluconate.

Group II: chemical cleaning: soaking in 1% sodium hypochlorite (NaOCl) and enzymatic cleaner for 10 minutes.

Group III: ultrasonic cleaning in two different media, water and disinfectant for 10 minutes.

Group IV: combination of the most effective mechanical, chemical method and ultrasonic cleaning before placing in the sterilizer.

A 0.2% solution of chlorhexidine gluconate (Curaprox Perio plus forte, Curadent international AG, Switzerland) was used in the research. Enzymatic cleaner Instruton E (Antiseptica, GmbH), used as a general instrument cleaner, contains proteases, amylases, tissue solvents and a corrosion inhibitor. Orocid Multisept plus ("OCC" Switzerland) was used as a disinfectant in the ultrasonic bath. The presence of residual contamination was analyzed by light microscopic examination. The assessment of instrument contamination was performed according to

Table 1. Groups of instruments on which residual deposits of calcium hydroxide were observed, according to the applied decontamination methods
Tabela 1. Podela instrumenata na kojima su posmatrani rezidualni ostaci kalcijum-hidroksida, prema primenjenim metodama dekontaminacije

Decontamination methods Metode dekontaminacije		n(B)	Σ(B)
I group Mechanical cleaning I grupa Mehaničko čišćenje	Manual brushing Čišćenje četkom	6	42
	Sponge soaked in chlorhexidine gluconate Sunđer natopljen hlorheksidin-glukonatom	6	
II group Chemical methods II grupa Hemijske metode	Soaking in 1% NaOCl Natapanje u 1% NaOCl	6	
	Soaking in enzymatic cleaner Natapanje u enzimski čistač	6	
III group Ultrasonic cleaning III grupa Ultrazvučno čišćenje	Ultrasonic cleaning in distilled water Ultrazvučno čišćenje u vodi	6	
	Ultrasonic cleaning in disinfectant solution Ultrazvučno čišćenje u dezinficijensu	6	
IV group Combination of efective methods IV grupa Kombinacija najefikasnijih metoda	Sponge, soaking in 1% NaOCl, ultrasonic cleaning in disinfectant solution Sunđer, natapanje u 1% NaOCl, ultrazvučno čišćenje u dezinficijensu	6	

n – number of samples decontaminated by a certain method
n – broj uzoraka dekontaminisanih određenom metodom

the methodology of Linsuwanont et al. [14]. The assessment of the effectiveness of decontamination methods was evaluated only numerically, with grades from 0 to 4. It was not possible to use a descriptive scale because it was residual material that is not of organic origin and does not stain histologically.

The amount of residual matter was determined using the following scale:

0 – clean surface without any residues

1 – only the presence of a residual film

2 – slight contamination (individual, rare particles of calcium hydroxide, scattered on the surface of the working part of the instrument)

3 – medium contamination (numerous particles with fields in the form of a continuous covering on the surface)

4 – heavy contamination (fields on the instruments where the grooves of the working surfaces are completely filled with debris).

Each instrument was evaluated in 12 positions (four sides of the instrument in the coronary, middle and apical thirds) covering the entire blade region of the instrument. The results of all positions were added up. The minimum value was 0 (no presence of intracanal medication residues), and the maximum was 48 (all surfaces were heavily contaminated). The mean value for each instrument (MC) was calculated and then converted to a percentage mean maximum contamination (%MC).

Descriptive and analytical statistical methods were used for statistical data processing. The results were tabulated. Depending on the type of data, statistical parameters were

Table 2. Efficacy of removing calcium hydroxide from instrument surfaces by different methods
Tabela 2. Rezultati efikasnosti metoda uklanjanja kalcijum-hidroksida sa površine instrumenata različitim metodama

Cleaning method Metoda čišćenja	Cleaning results Rezultat čišćenja				
	0	1	2	3	Total Ukupno
Manual brushing Ručno četkanje	0 (0,0%)	0 (0,0%)	3 (7.1%)	3 (7.1%)	6 (14.3%)
Cleaning in sponge Čišćenje u sunđeru	0 (0,0%)	0 (0,00%)	5 (11.9%)	1 (2.4%)	6 (14.3%)
Soaking in NaOCl Natapanje u NaOCl	0 (0,0%)	0 (0,00%)	6 (14.3%)	0 (0,00%)	6 (14.3%)
Soaking in enzymatic cleaner Natapanje u enzimski čistač	0 (0,0%)	0 (0,0%)	2 (4.8%)	4 (9.5%)	6 (14.3%)
Ultrasonic cleaning – water Ultrazvučno čišćenje – voda	0 (0,0%)	4 (9.5%)	2 (4.8%)	0 (0,0%)	6 (14.29%)
Ultrasonic cleaning – disinfectant Ultrazvučno čišćenje – dezinficijens	0 (0,0%)	6 (14.3%)	0 (0.0%)	0 (0,0%)	6 (14.3%)
Combined method Kombinovana metoda	2 (4,8%)	4 (9.5%)	0 (0,0%)	0 (0,0%)	6 (14.3%)
Total Ukupno	2 (4,8%)	14 (33.3%)	18 (42.9%)	8 (19.0%)	42 (100,0%)

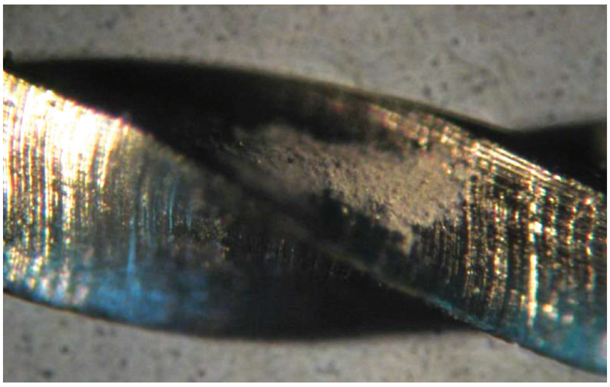

Figure 1. Residual deposit of calcium hydroxide on the working part of a size 30 stainless steel reamer, after the applied hand brushing method (score 3)
Slika 1. Ostaci naslaga kalcijum-hidroksida na radnom delu proširivača od nerđajućeg čelika veličine 30, posle primenjene metode ručnog četkanja (ocena 3)

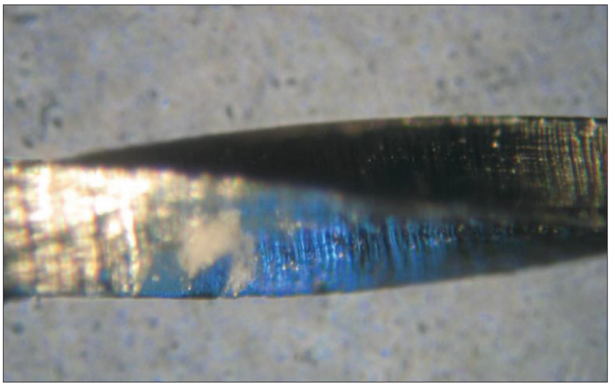

Figure 2. Surface of a size 30 reamer with residual calcium hydroxide particles after treatment with a sponge soaked in chlorhexidine gluconate (score 2)
Slika 2. Površina proširivača veličine 30 sa rezidualnim partikulama kalcijum-hidroksida posle tretmana sunđerom natopljenim hlorheksidin-glukonatom (ocena 2)

tested with appropriate tests. Analysis of variance (ANOVA) with post-hoc test was used for data related to a continuous feature, and the sample was homogeneous. Non-parametric chi squared and Fisher exact tests were used for data related to discontinuous feature.

Statistical processing was done using computer software packages Microsoft Excel and SPSS 20.0.

RESULTS

From the total number of instruments on which the presence of residual calcium hydroxide contamination was examined (42 instruments), 8 instruments were scored 3, 18 were scored 2, and 14 were scored 1 and 2 were scored 0. Subgroup 1, manually cleaned with a brush, showed a high degree of residual contamination. Of the six instruments, 3 were scored 2 and 3 separately (Table 2; Figure 1).

A subgroup of instruments subjected to mechanical cleaning with a sponge soaked in chlorhexidine gluconate showed lower cleanliness scores compared to manual brushing. Only 1 instrument was scored 3, and the other 5 were scored 2 (Table 2; Figure 2).

The effectiveness of the chemical soaking of instruments in sodium hypochlorite showed effectiveness with a score of 2 at the level of the entire subgroup. All 6 instruments had residual contamination in the form of scattered white particles (Table 2; Figure 3).

The chemical method of soaking instruments in an enzymatic cleaner showed the highest degree of residual contamination. Four instruments were scored 3, and 2 were scored 2 (Table 2; Figure 4).

In the subgroup of instruments cleaned in an ultrasonic bath, where distilled water was used as the liquid medium, 2 instruments were scored 2, and 4 were scored 1 (Table 2; Figure 5).

Ultrasonic cleaning in disinfectant solution showed that all 6 instruments were scored as 1 (Table 2; Figure 6).

Figure 3. Residual white deposit of calcium hydroxide on a size 35 file, after soaking in sodium hypochlorite (score 2)
Slika 3. Zaostala bela masa kalcijum-hidroksida na turpiji veličine 35, posle natapanja u natrijum-hipohlorit (ocena 2)

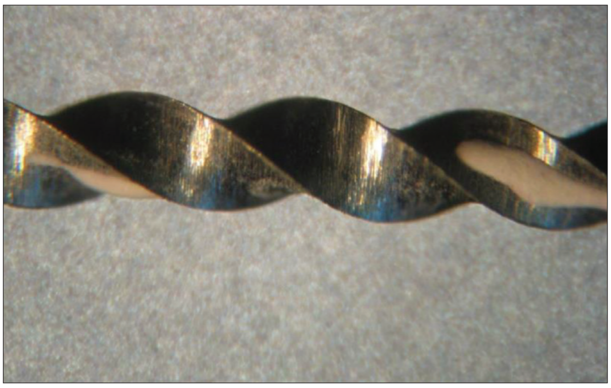

Figure 4. Residual deposits of calcium hydroxide on a size 35 file, after treatment with an enzymatic cleaner (grade 3)
Slika 4. Zaostale naslage kalcijum-hidroksida na površini turpije veličine 35, nakon tretmana u enzimskom čistaču (ocena 3)

Figure 6. Residual film of calcium hydroxide on a size 35 file treated in an ultrasonic bath with disinfectant solution
Slika 6. Preostali film od kalcijum-hidroksida na turpiji veličine 35 tretirane u ultrazvučnom kupatilu sa dezinficijensom

Figure 5. A size 25 file with residual deposit of calcium hydroxide over the entire surface (score 2)
Slika 5. Turpija veličine 25 sa zaostalim naslagama kalcijum-hidroksida na čitavoj površini (ocena 2)

Figure 7. Clean instrument surface without calcium hydroxide deposits subjected to the combined decontamination method
Slika 7. Čista površina instrumenta bez naslaga kalcijum-hidroksida podvrgnuta kombinovanoj metodi dekontaminacije

By decontamination of instruments using the combined method, 4 instruments were scored 1 and 2 were scored 0 (Table 2; Figure 7).

Table 2 shows the cleaning results in relation to the agent used. In an attempt to select the most adequate method, first pairs of means with a similar effect were tested in order to select the more effective one, and then the combined method was tested in relation to the more effective method of the previous pairs. It was calculated that there is no statistically significant difference in the effect of cleaning with a brush or sponge (Fisher exact test $p > 0.05$), ultrasonic cleaning with water versus ultrasonic cleaning with disinfectant ($\chi^2 = 0.60$ Fisher exact $p < 0.05$), but there was a statistically significant difference between chemical cleaning in NaOCl and enzymatic cleaner ($\chi^2 = 3.38$ Fisher exact $p > 0.05$).

Combined method showed a statistically significant difference in the achieved level of cleanliness compared to mechanical and chemical methods (combined method : sponge - $\chi^2 = 12.00$ $p < 0.05$, combined method : NaOCl - $\chi^2 = 12.00$ $p < 0.05$), but there was no statistically significant difference compared to ultrasonic cleaning in disinfection (combined method : ultrasound in disinfectant - $\chi^2 = 2.4$ $p > 0.05$).

The effectiveness of the decontamination methods was also analyzed through the average values of the mean percentage of maximum contamination (MC). Instruments of group 1, decontaminated by manual brushing, showed a MC value of 24.00 for instruments with score 3, and 20.67 for instruments with score 2. The mean percentage of MC value for score 3 was 50.00%, and for score 2 – 43.06%. The mean value of the MC for the entire subgroup is 22.33, i.e. 46.53%.

Group 2, decontaminated with a sponge soaked in chlorhexidine gluconate, had a MC value of 22.00 for score 3 instruments and 20.00 for score 2 instruments. Within the subgroup, the mean MC value was 20.33 and 42.36%, respectively. All instruments of group 3, soaked in NaOCl, had a score of 2, so the mean MC for this group was 21.33, i.e. 44.44%.

Group 4 of instruments soaked in enzymatic cleaner showed MC values of 22.25 for instruments with grade 3, and 23.50 for those with grade 2. The mean percentage of MC for grade 3 was 46.35%, and for grade 2 – 48.96%. At the level of the entire subgroup, the average rating of MC was 22.67, i.e. 47.22%.

Subgroup 5 of instruments, cleaned in an ultrasonic cleaner with distilled water, had a MC value of 12.50 for score 2 and 11.75 for score 1. The mean percentage of MC for score 2 was 26.04%, and for score 1 24.48%. Within the entire subgroup, the average value of the MC was 12.00, or 25.00%. Decontamination of the instruments

Table 3. Average values of %MC after cleaning with different methods
Tabela 3. Prosečne vrednosti %MC posle čišćenja različitim metodama

Cleaning method Metoda čišćenja	Cleaning result Rezultat čišćenja				
	0	1	2	3	Total Ukupno
Manual brushing Ručno četkanje			43.06 ± 2.41	50.00 ± 2.08	46.53 ± 4.30
Cleaning in sponge Čišćenje u sunđeru			41.67 ± 4.42	45.83 ± 0.00	42.36 ± 4.30
Soaking in NaOCl Natapanje u NaOCl			44.44 ± 3.14		44.44 ± 3.14
Soaking in enzymatic cleaner Natapanje u enzimski čistač			48.96 ± 1.47	46.35 ± 3.56	47.22 ± 3.14
Ultrasonic cleaning – water Ultrazvučno čišćenje – voda		24.48 ± 1.04	26.04 ± 1.47		25.00 ± 1.32
Ultrasonic cleaning – disinfectant Ultrazvučno čišćenje – dezinficijens		25.00 ± 0.00			25.00 ± 0.00
Combined method Kombinovana metoda	0.00	8.33 ± 1.32			22.92 ± 1.32
Total Ukupno	0.00	19.26 ± 1.31	41.90 ± 6.81	47.66 ± 3.23	36.21 ± 10.90

of subgroup 6 in the ultrasonic bath with disinfectant resulted in a score of 1 at the level of the entire subgroup, and thus the mean value of the MC was calculated, which was 12.00, i.e. 25.00% for the entire subgroup. Using the combined method, the lowest values of MC were obtained, which for this group of instruments was 4, i.e. 8.33% (Table 3).

The average values of % MC after cleaning with different methods were tested by analysis of variance, and the value F = 87,431 was calculated, which was statistically significant ($p < 0.05$). The post hoc test found that all average values for cleaning scores differ from each other.

DISCUSSION

The presence of debris on the surface of endodontic files and reamers can be detected by various methods. The application of scanning electron microscopy enables a detailed, three-dimensional observation of the surface of the instrument with all irregularities and defects that arise during the production process, including the possible presence of impurities, however, it is difficult to determine the nature and origin of residual matter [12]. In order to observe the colored or uncolored residual material or the highlighting of a thin film on the surface of the grooves of endodontic instruments, the blades of the instruments were observed under a light microscope [3]. Since there is currently no recognized method for testing cleanliness, recommendations regarding cleaning and sterilization are based on currently available scientifically derived and clinically relevant data.

Although there are views supporting the concept of single-use endodontic instruments, the recommendations remain controversial in the published literature. Arguments supporting multiple use mostly concern economic reasons but are supported by studies that guarantee the safety of their reuse [13]. Due to the necessity of eliminating all links in the chain of contamination, cleaning, disinfection and sterilization of endodontic instruments are imperative in the prevention of cross-infections in dental practice. It has been observed that different types of particles (production debris, biological residues or medicament residues) on the surface of new or used endodontic instruments can cause problems during canal preparation, so their elimination is necessary.

Calcium hydroxide is the intracanal medication of choice in endodontics due to its superior antimicrobial properties, ability to inhibit osteoclast activity and induce tissue reparative response. However, its residues in the canal system have a negative effect on the sealer's hermetic obturation, increase the apex permeability and have a negative effect on zinc oxide-eugenol-based filling agents. All methods for its removal from the canal can be divided into 3 categories: instrumentation with irrigation; manual irrigation using a syringe; irrigation performed using different equipment – passive ultrasonic irrigation, Endo-Vac, RinseEndo [15]. The removal of this medication from the root canal is influenced by the type of irrigant and the method of its activation in the canal. Chelating solutions such as ethylenediaminetetraacetic acid (EDTA), citric and maleic acids have shown a better effect of dissolving calcium hydroxide in the canal [16]. However, irrigants such as NaOCl, distilled water and saline, which do not chelate calcium hydroxide, can effectively remove it only when used with different activation systems [17]. Due to the fact that in clinical conditions, during the mechanical removal of calcium hydroxide paste on the surface of the instruments, both medication and dentin particles are simultaneously deposited, the effectiveness of NaOCl was examined in the study because it effectively dissolves dentin and has a disinfectant effect.

The aim of this study was to examine alternative combinations of mechanical, chemical and ultrasonic cleaning methods to perform a simple protocol effective in removing calcium hydroxide paste deposits from endodontic instrument surfaces. The study evaluated the effectiveness of different, in practice most often applied individual methods, for obtaining instruments that did not contain residual remains of calcium hydroxide paste at the microscopic level. In order to perform the final protocol, the results of pairs of methods with a similar effect were first tested. The final protocol was equally effective and applicable for different types of endodontic instruments.

After comparing the cleaning results of two mechanical methods - manual cleaning with a brush and cleaning with a sponge soaked in chlorhexidine gluconate, it was proven that cleaning with a sponge was significantly more effective. The high values of the maximum contamination for the instruments cleaned with a brush can be explained by the inability of the wide fibers to pass through all the grooves. The disadvantage is also that the effectiveness depends to a large extent on the commitment of the staff. Adequate execution of this technique takes a lot of time, which is impractical for application in everyday practice

[18]. Linsuwanont et al. [14] showed that mechanical cleaning removes a significant amount of debris, but is unable to completely clean the instruments. When viewed from the aspect of the risk of injury during work, there is a possibility of puncture, so it is recommended that brushing be performed on an endodontic stand. The use of a sponge soaked in chlorhexidine gluconate provided a satisfactory level of initial cleaning. Lower values of the maximum contamination were achieved due to the fact that all sides of the instrument during operation were affected by the spongy mass. Using a sponge is safer, because the operator does not come into direct contact with sharp parts of the instruments [19]. This method is also important in moist storage of instruments after clinical use, which is the basis for effective cleaning [14, 18].

Analyzing the results of chemical soaking of instruments in sodium hypochlorite and enzymatic cleaner, a significant difference in the efficiency of residual debris removal was observed. Sodium hypochlorite has been used as an endodontic irrigant for over eighty years. It is a widely used disinfectant and oxidizing agent and has the ability to dissolve organic tissue, which largely depends on the ratio of hypochlorite to organic matter [20]. If used as a disinfectant when cleaning nickel titanium endodontic instruments, it can lead to micro-point corrosion. Enzymes and tissue solvents are effective in removing proteins, lipids and carbohydrates from their surfaces [21]. Although both agents exhibit a strong dissolving effect of proteins and organic matter, sodium hypochlorite showed significantly higher efficiency in removing calcium hydroxide. In performing the final decontamination protocol, preference was given to sodium hypochlorite.

By comparing the results of cleaning with two ultrasonic methods - in water and disinfectant, no statistically significant difference in efficiency was observed. The results showed that both ultrasonic methods removed a significant amount of residual debris, but no instrument with a completely clean surface was obtained. These results are in accordance with the results of Aasim et al. [4] who stated in their study that calcium hydroxide deposits were resistant to ultrasonic cleaning. Cleaning in disinfection showed better results, so it was included in the final protocol as a more efficient method. This research showed that the use of ultrasound is an important step in instrument cleaning, which is consistent with the studies of other authors [22, 23]. It improves worker safety compared to manual brushing. If combined with disinfectant solutions, ultrasonic cleaners can also have an antimicrobial effect, thereby reducing residual contamination and ensuring safer handling of instruments and more efficient sterilization [24]. In this study, satisfactory cleaning results were achieved with ultrasonic cleaning for 15 minutes. The same time is recommended by other authors [4]. It is extremely important to rinse the instruments after treatment in order to remove the residual contaminated solution [4, 25]. The results showed that the use of ultrasound, without prior preparation of the instruments, did not give completely clean surfaces of the instruments. Similar results were obtained by Linsuwanont et al. [14]. Their study showed that the combined use of 1% NaOCl and an ultrasonic bath for 5 minutes could not completely remove organic material from instruments without first removing a large amount of debris by brushing. The results of this study showed that all procedures in the protocol are necessary and emphasize the importance of mechanical removal of impurities before chemical and ultrasonic cleaning.

For this reason, a protocol was developed that represented a combination of the most effective methods from the previous three groups - mechanical, chemical and ultrasonic cleaning. It consisted of mechanical cleaning with a sponge soaked in chlorhexidine, soaking in sodium hypochlorite and ultrasonic cleaning in a disinfectant solution. By comparing the results of the protocol in relation to the more efficient method of the previous pairs, it was shown that there is a significant difference in cleaning efficiency. Only the application of the protocol resulted in instruments with completely clean surfaces. The protocol presented in this research relies more on chemical means and equipment than on the human factor in order to obtain satisfactory results of cleaning endodontic instruments. Initial cleaning with a sponge soaked in chlorhexidine gluconate is simple and can be done quickly. Chemical soaking and ultrasonic cleaning are two very important stages and must be carried out consecutively. This protocol is very simple and can be easily adopted and applied routine dental practice.

CONCLUSIONS

Individual mechanical, chemical or ultrasonic methods of decontamination of endodontic instruments are not effective enough to remove calcium hydroxide residues from the working parts of endodontic instruments. Methods that rely on manual cleaning of instruments are insufficiently efficient and do not always produce the same results, as they mostly depend on the motivation of the person performing them. The method of mechanical cleaning of endodontic instruments using a sponge soaked in chlorhexidine showed significantly higher efficiency than mechanical cleaning with a brush in a moist environment. The method of chemical soaking of endodontic instruments in sodium hypochlorite was more effective than soaking in an enzymatic cleaner. The method of ultrasonic cleaning of endodontic instruments in disinfection was significantly more effective compared to ultrasonic cleaning in water. The protocol that consisted of mechanical cleaning with a sponge soaked in chlorhexidine, chemical soaking in sodium hypochlorite, and ultrasonic cleaning in a disinfectant showed the best efficiency in removing calcium hydroxide residues.

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Procena efikasnosti različitih metoda uklanjanja naslaga kalcijum-hidroksida sa endodontskih instrumenata pre sterilizacije

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KRATAK SADRŽAJ

Uvod Endodontski instrumenti tokom mehaničko-medikamentozne obrade kanala dolaze u kontakt sa dentinskim debrisom, rastvorima za irigaciju i sredstvima za medikaciju, čiji ostaci treba da budu eliminisani pre sterilizacije.

Cilj istraživanja je bio da se proveri efikasnost različitih metoda čišćenja za uklanjanje ostataka paste kalcijum-hidroksida sa površina radnih delova ručnih instrumenata, kao i da se predloži efikasan protokol čišćenja endodontskih instrumenata pre sterilizacije.

Materijal i metode Četrdeset dva nova ručna endodontska instrumenta korišćena su za uklanjanje paste kalcijum-hidroksida iz napunjenih kanala ekstrahovanih zuba. Posle kontaminacije medikamentom podeljeni su u četiri grupe i podvrgnuti pojedinačnim metodama dekontaminacije – mehaničkim, hemijskim i ultrazvučnim, kao i kombinovanom protokolu. Instrumenti su zatim posmatrani na svetlosnom mikroskopu. Procena efikasnosti metoda je procenjivana na osnovu količine rezidualne materije na površini radnih delova instrumenata.

Rezultati Kombinovani protokol je pokazao statistički značajnu razliku u postignutom stepenu čistoće u odnosu na mehaničke ($\chi^2 = 12{,}00$, $p < 0{,}05$) i hemijske metode ($\chi^2 = 12{,}00$, $p < 0{,}05$), ali nije postojala statistički značajna razlika u odnosu na ultrazvučno čišćenje u dezinficijensu ($\chi^2 = 2{,}4$, $p > 0{,}05$). Primenom kombinovanog protokola dobijeni su instrumenti sa potpuno čistim površinama, kao i najniže vrednosti maksimuma kontaminacije na nivou cele grupe instrumenata (8,33%).

Zaključak Protokol koji se sastojao od mehaničkog čišćenja sunđerom natopljenim hlorheksidin-glukonatom, hemijskog natapanja natrijum-hipohloritom i ultrazvučnog čišćenja u dezinfekcionom sredstvu bio je najefikasniji u uklanjanju ostataka kalcijum-hidroksida.

Ključne reči: endodontski instrumenti; čišćenje; kalcijum-hidroksid

UVOD

Kako su endodontske turpije i proširivači generalno prihvaćeni kao instrumenti za višekratnu upotrebu, procena rezidualnih ostataka na njihovom radnom delu nakon upotrebe je već duže vreme značajna tema brojnih naučnih studija [1]. Podaci iz literature ne daju usaglašene informacije o postupku uklanjanja ostataka sa kontaminiranih endodontskih instrumenata [2]. Postupak čišćenja uglavnom podrazumeva mehaničko (različite vrste četkica, sunđera i sl.) i hemijsko čišćenje (natapanje u NaOCl, deterdžente, enzimske čistače), primenu ultrazvuka i završno ispiranje pre postavljanja instrumenata u sterilizator. Brojni autori koji su se bavili analizom različitih metoda dekontaminacije su dokazali da nijedna pojedinačna metoda potpuno ne uklanja rezidulani debris [3]. Stoga, izbor odgovarajućih metoda pripreme endodontskih instrumenata za sterilizaciju opravdava razvijanje efikasnog protokola čišćenja, sa ciljem dobijanja čistih površina bez neorganskih i bioloških ostataka.

Osim sa dentinskim debrisom, endodontski instrumenti tokom mehaničko-medikamentozne obrade kanala dolaze u kontakt i sa rastvorima za irigaciju i sredstvima za medikaciju, čiji ostaci takođe treba da budu eliminisani pre sterilizacije. Imajući u vidu različiti hemijski sastav i adherentnost ovih sredstava za površinu instrumenata, od značaja je izvršiti proveru efikasnosti dekontaminacionih metoda kod njihovog uklanjanja [4].

Kalcijum-hidroksid predstavlja medikament izbora u višeseansnom lečenju endodontskih infekcija. Stabilan je u kanalu, neškodljiv za organizam i ima vremenski ograničeno baktericidno dejstvo. Indukuje formiranje tvrdih tkiva i efikasno deluje na eksudaciju kod inflamacija [5]. Međutim, njegovo nekompletno uklanjanje iz kanala korena može negativno uticati na adherentnost silera za definitivnu opturaciju [6]. Iako postoje različite metode uklanjanja koje podrazumevaju primenu različitih iriganasa, ultrazvučnih talasa ili energije lasera, ostaci paste kalcijum-hidroksida u kanalu korena moraju se ukloniti i mehanički korišćenjem endodontskih instrumenata [7–11]. Naslage paste se tada zadržavaju u sečivima instrumenata zajedno sa dentinskim opiljcima i mogu zaostati i posle završenog procesa sterilizacije [4].

Cilj istraživanja je bio da se proveri efikasnost različitih metoda čišćenja za uklanjanje ostataka paste kalcijum-hidroksida sa površina radnih delova ručnih instrumenata, kao i da se predloži efikasan protokol čišćenja endodontskih instrumenata pre sterilizacije.

MATERIJAL I METODE

Istraživanje je obavljeno na Odeljenju za bolesti zuba i endodonciju Klinike za dentalnu medicinu u Nišu i u Naučnoistraživačkom centru za biomedicinu Medicinskog fakulteta u Nišu.

Kao materijal u ovom istraživanju korišćeni su ručni endodontski instrumenti od nerđajućeg čelika – proširivači i turpije (NTI-Kahla GmbH, Germany). Četrdeset dva nova endodontska instrumenta – proširivači i turpije od nerđajućeg čelika uzeti su iz originalnih pakovanja i podvrgnuti ultrazvučnom čišćenju da bi se oslobodili proizvodnih nečistoća.

U studiju su bili uključeni jednokoreni zubi, ekstrahovani zbog uznapredovale parodontopatije. Standardni endodontski pristupni kavitet je preparisan dijamantskim borerom u visokoturažnoj mašini. Svaki kanal korena je obrađen setom instrumenata 15-40 standardnom ručnom tehnikom. Za irigaciju kanala korišćen je 0,5% NaOCl. Nakon sušenja, ispreparisani kanali korena su lentulo spiralom napunjeni pastom na bazi kalcijum-hidroksida (i-CAL, i-dental, Lithuania). Endodontski pristupni kaviteti su zatvoreni privremenim ispunom i čuvani u hermetički zatvorenim kutijama na sobnoj temperaturi 24 sata. Posle uklanjanja privremenog ispuna, pasta kalciijum-hidroksida je ispirana iz kanala korišćenjem 0,5% NaOCl, a ostaci sa zidova su nakon toga uklanjani mehanički endodontskim turpijama da bi se postigla kontaminacija površina radnih delova sa pastom. Instrumenti su na endodontskom stalku do postupka čišćenja čuvani u hermetičkim kutijama.

Instrumenati su podeljeni u četiri grupe i podvrgnuti različitim metodama čišćenja (Tabela 1):

I grupa – mehaničko čišćenje: četkom i sunđerom natopljenim u hlorheksidin-glukonat.

II grupa – hemijsko čišćenje: natapanje u 1% natrijum-hipohlorit (NaOCl) i enzimski čistač u trajanju od 10 minuta.

III grupa – čišćenje ultrazvukom u dva različita medijuma, vodi i dezinficijensu, u trajanju od 10 minuta.

IV grupa – kombinacija najefikasnije mehaničke, hemijske metode i ultrazvučnog čišćenja pre postavljanja u sterilizator.

U istraživanju je korišćen 0,2% rastvor hlorheksidin-glukonata (Curaprox Perio plus forte, Curadent international AG, Switzerland). Enzimski čistač Instruton E (Antiseptica, GmbH), koji se koristi kao opšti čistač instrumenata, sadrži proteaze, amilaze, tkivne rastvarače i inhibitor korozije. Kao dezinficijens u ultrazvučnom kupatilu korišćen je Orocid Multisept plus („OCC" Switzerland).

Prisustvo rezidualne kontaminacije je analizirano svetlosnomikroskopskim ispitivanjem. Procena kontaminacije instrumenata je vršena prema metodologiji koju su koristili Linsuwanont i saradnici [14].

Procena efikasnosti dekontaminacionih metoda je ocenjena samo numerički, ocenama od 0 do 4. Deskriptivnu skalu nije bilo moguće koristiti jer je bio u pitanju rezidualni materijal koji nije organskog porekla i histološki se ne boji.

Količina rezidualne materije je utvrđivana pomoću sledeće skale:

0 – čista površina bez ikakvih ostataka

1 – samo prisustvo rezidualnog filma

2 – neznatna kontaminacija (pojedinačne, retke partikule kalcijum-hidroksida, rasute po površini radnog dela instrumenta)

3 – srednja kontaminacija

4 – izrazita kontaminacija (polja na instrumentima gde su žlebovi radnih površina potpuno ispunjeni debrisom)

Svaki instrument je ocenjen u 12 položaja (četiri strane instrumenta i koronarna, srednja i apeksna trećina), što je obuhvatilo čitavu sečivnu regiju instrumenta. Rezultati svih položaja su sabrani. Minimalna vrednost je bila 0 (nema prisustva ostataka intrakanalnog medikamenta), a maksimalna je bila 48 (sve površine su bile jako kontaminirane). Izračunata je srednja vrednost za svaki instrument (MK), a zatim je preračunata u procentualnu srednju vrednost maksimuma kontaminacije (%MK).

Za statističku obradu podataka korišćen je deskriptivni i analitički statistički metod. Rezultati su prikazani tabelarno. U zavisnosti od vrste podataka, statistički parametri su testirani odgovarajućim testovima. Za podatke koji se odnose na kontinuirano obeležje, a uzorak je homogen, korišćena je analiza varijanse (ANOVA) sa post-hok testom. Za podatke koji se odnose na diskontinuirano obeležje korišćeni su neparametrijski testovi χ^2 test i Fišerov test.

Statistička obrada je urađena korišćenjem računarskih programskih paketa Microsoft Excel i SPSS 20.0.

REZULTATI

Od ukupnog broja instrumenata na kojima je ispitivano prisustvo rezidualne kontaminacije kalcijum-hidroksida (42 instrumenta), osam instrumenata je ocenjeno ocenom 3, 18 ocenom 2, a 14 ocenom 1 i dva ocenom 0.

Podgrupa 1, ručno čišćena četkom, pokazala je visok stepen rezidualne kontaminacije. Od šest instrumenata, po tri su ocenjena ocenom 2 i ocenom 3 (Tabela 2; Slika 1).

Podgrupa instrumenata podvrgnuta mehaničkom čišćenju sunđerom natopljenim hlorheksidin-glukonatom pokazala je niže ocene čistoće u poređenju sa ručnim četkanjem. Samo jedan instrument je ocenjen ocenom 3, a ostalih pet je ocenjeno ocenom 2 (Tabela 2; Slika 2).

Efikasnost hemijskog natapanja instrumenata u natrijumhipohlorit pokazala je efikasnost ocenom 2 na nivou cele podgrupe. Svih šest instrumenata je imalo rezidualnu kontaminaciju u vidu razbacanih partikula bele boje (Tabela 2; Slika 3).

Hemijska metoda natapanja instrumenata u enzimski čistač je pokazala najviši stepen rezidualne kontaminacije. Četiri instrumenta su ocenjena ocenom 3, a dva ocenom 2 (Tabela 2; Slika 4).

U podgrupi instrumenata očišćenih u ultrazvučnom kupatilu, gde je kao tečni medijum korišćena voda, dva instrumenta su ocenjena ocenom 2, a četiri ocenom 1 (Tabela 2; Slika 5).

Ultrazvučno čišćenje u dezinficijensu je pokazalo da je svih šest instrumenata ocenjeno ocenom 1 (Tabela 2; Slika 6).

Dekontaminacijom instrumenata kombinovanom metodom četiri instrumenta su ocenjena ocenom 1 i dva ocenom 0 (Tabela 2; Slika 7).

U Tabeli 2 su prikazani rezultati čišćenja u odnosu na upotrebljeno sredstvo. U pokušaju odabira najadekvatnije metode, testirani su prvo parovi sredstava sličnog efekta radi odabiranja efikasnijeg, a potom je testirana kombinovana metoda u odnosu na efikasniji metod od prethodnih parova. Izračunato je da ne postoji statistički značajna razlika efekta čišćenja četkom ili sunđerom (Fišerov test $p > 0,05$), ultrazvučnog čišćenja vodom u odnosu na ultrazvučno čišćenje dezinficijensom ($\chi^2 = 0,60$ Fišerov test $p < 0,05$), ali postoji statistički značajna razlika između hemijskog čišćenja u NaOCl i enzimskom čistaču ($\chi^2 = 3,38$ Fišerov test $p > 0,05$).

Kombinovana metoda pokazala je statistički značajnu razliku u postignutom stepenu čistoće u odnosu na mehaničke i hemijske metode (kombinovana metoda : sunđer – $\chi^2 = 12,00$ $p < 0,05$, kombinovana metoda : NaOCl – $\chi^2 = 12,00$, $p < 0,05$), ali nije postojala statistički značajna razlika u odnosu na ultrazvučno čišćenje u dezinficijensu (kombinovana metoda : ultrazvučno čišćenje u dezinficijensu – $\chi^2 = 2,4$, $p > 0,05$).

Efikasnost metoda dekontaminacije je analizirana i kroz prosečne vrednosti srednjeg procenta maksimuma kontaminacije (MK).

Instrumenti grupe 1, dekontaminisani ručnim četkanjem, pokazali su vrednost MK od 24,00 za instrumente sa ocenom 3, i 20,67 za instrumente sa ocenom 2. Srednja vrednost procenta za ocenu 3 je iznosila 50,00%, a za ocenu 2 – 43,06%. Srednja vrednost MK za celu podgrupu iznosila je 22,33, odnosno 46,53%.

Grupa 2, dekontaminisana sunđerom natopljenim hlorheksidin-glukonatom, imala je vrednost MK od 22,00 za instrumente sa ocenom 3 i 20,00 za instrumente sa ocenom 2. U okviru podgrupe srednja vrednost MK je iznosila 20,33, odnosno 42,36%.

Svi instrumenti grupe 3, natapani u NaOCl, imali su ocenu 2, tako da je prosečan MK za ovu grupu iznosio 21,33, odnosno 44,44%.

Natapanje instrumenata grupe 4 u enzimski čistač je pokazalo vrednosti MK od 22,25 za instrumente sa ocenom 3, i 23,50 za one sa ocenom 2. Srednji procenat MK za ocenu 3 je iznosio 46,35%, a za ocenu 2 – 48,96%. Na nivou cele podgrupe srednja ocena MK je iznosila 22,67, odnosno 47,22%.

Instrumenti podgrupe 5, potapani u ultrazvučno kupatilo sa vodom, imali su vrednost MK 12,50 za ocenu 2 i 11,75 za ocenu 1. Srednja vrednost procenata MK za ocenu 2 je iznosila 26,04%, a za ocenu 1 – 24,48%. U okviru cele podgrupe prosečna vrednost MK je iznosila 12,00, odnosno 25,00%.

Dekontaminacija instrumenata podgrupe 6 u ultrazvučnom kupatilu sa dezinficijensom je kao rezultat imala ocenu 1 na nivou cele podgrupe, a samim tim je izračunata srednja vrednost MK, koja je iznosila 12,00, odnosno 25,00% za celu podgrupu.

Primenom kombinovane metode dobijene su najniže vrednosti MK, koji je kod ove grupe instrumenata iznosio 4, odnosno 8,33% (Tabela 3).

Prosečne vrednosti % MK posle čišćenja različitim sredstvima testirane su analizom varijanse, i izračunata je vrednost $F = 87{,}431$, koja je statistički značajna ($p < 0{,}05$). Post hok testom je ustanovljeno da se sve prosečne vrednosti po ocenama čistoće međusobno razlikuju.

DISKUSIJA

Postojanje debrisa na površini endodontskih turpija i proširivača može se detektovati različitim metodama. Primenom skening elektronske mikroskopije omogućeno je detaljno, trodimenzionalno sagledavanje površine instrumenta sa svim iregularnostima i defektima koji nastaju u toku procesa proizvodnje, uključujući i eventualno prisustvo nešistoća, međutim, teško je utvrditi prirodu i poreklo rezidualne materije [12]. Radi uočavanja obojenog ili neobojenog rezidualnog materijala ili isticanja tankog filma na površini žlebova endodontskih instrumenata, sečiva instrumenata se posmatraju pod svetlosnim mikroskopom [3]. S obzirom na to da trenutno ne postoji ni jedan priznati metod za ispitivanje čistoće, preporuke koje se tiču čišćenja i sterilizacije baziraju se na trenutno dostupnim naučno dobijenim i klinički relevantnim podacima.

Iako postoje stavovi koji podržavaju koncept jednokratne upotrebe endodontskih instrumenata, u objavljenoj literaturi preporuke ostaju kontroverzne. Argumenti koji podržavaju višestruku upotrebu najviše se tiču ekonomskih razloga, ali su podržani studijama koje garantuju bezbednost njihove ponovne upotrebe [13]. Zbog neophodnosti eliminacije svih veza u lancu kontaminacije, čišćenje, dezinfekcija i sterilizacija endodontskih instrumenata predstavljaju imperativ u prevenciji unakrsnih infekcija u stomatološkoj praksi. Uočeno je da različiti tipovi čestica (proizvodni debris, biološki ostaci ili ostaci medikamenata) na površini novih ili već korišćenih endodontskih instrumenata mogu da prouzrokuju probleme tokom pripreme kanala, pa je neophodna njihova eliminacija.

Kalcijum-hidroksid je intrakanalni medikament izbora u endodonciji zbog superiornih antimikrobnih osobina, sposobnosti da inhibira osteoklastnu aktivnost i izazivanja reparativnog odgovora tkiva. Međutim, njegovi ostaci u kanalnom sistemu loše utiču na hermetičku opturaciju silera, povećavaju apeksnu propustljivost i loše utiču na sredstva za punjenje na bazi cink-oksid eugenola. Sve metode za njegovo uklanjanje iz kanala mogu da se podele u tri kategorije: instrumentacija sa irigacijom; manuelno izvedena irigacija pomoću šprica; irigacija izvedena pomoću različite opreme – pasivna ultrazvučna irigacija, Endo-Vac, RinsEndo [15]. Na uklanjanje ovog medikamenta iz kanala korena utiče vrsta iriganska i način njegove aktivacije u kanalu. Helatni rastvori kao što su etilendiamintetrasirćetna kiselina (EDTA), limunska i maleinska kiselina pokazale su bolji efekat rastvaranja kalcijum-hidroksida u kanalu [16]. Međutim, irigansi kao što su NaOCl, destilovana voda i fiziološki rastvor, koji nemaju helatno dejstvo na kalcijum-hidroksid, mogu ga efikasno ukloniti samo kada se koriste uz različite aktivacione sisteme [17]. Zbog činjenice da se u kliničkim uslovima prilikom mehaničkog uklanjanja paste kalcijum-hidroksida na površini instrumenata istovremeno talože i medikament i opiljci dentina, u studiji je ispitivana efikasnost NaOCl jer efikasno rastvara dentin i ima dezinficijentno dejstvo.

Cilj ove studije je bio da se ispitaju alternativne kombinacije metoda mehaničkog, hemijskog i ultrazvučnog čišćenja radi izvođenja jednostavnog protokola efikasnog u uklanjanju naslaga paste kalcijum-hidrokida sa površina endodontskih instrumenata. U radu su procenjivane efikasnosti različitih, u praksi najčešće primenjivanih pojedinačnih metoda, za dobijanje instrumenata koji nisu sadržali rezidualne ostatke paste kalcijum-hidroksida na mikroskopskom nivou. U cilju izvođenja konačnog protokola najpre su testirani rezultati parova metoda sličnog efekta. Konačni protokol je bio jednako efikasan i primenjiv za različite tipove endodontskih instrumenata.

Posle poređenja rezultata čišćenja dve mehaničke metode – ručnog čišćenja četkom i čišćenja sunđerom natopljenim hlorheksidinom, dokazano je značajno efikasnije čišćenje sunđerom. Visoke vrednosti koeficijenta maksimuma kontaminacije kod instrumenata čišćenih četkom mogu se objasniti nemogućnošću širokih vlakana da prođu kroz sve žlebove. Nedostatak je i u tome što efikasnost u velikoj meri zavisi od posvećenosti osoblja. Adekvatno izvođenje ove tehnike oduzima dosta vremena, što je nepraktično za primenu u svakodnevnoj praksi [18]. Linsuwanont i saradnici [14] pokazali su da mehaničko čišćenje uklanja značajnu količinu debrisa, ali nije u mogućnosti da potpuno očisti instrumente. Kada se posmatra sa aspekta rizika od povređivanja u toku rada, postoji mogućnost uboda, pa se preporučuje da se četkanje izvodi na endodontskom stalku. Upotreba sunđera natopljenog u hlorheksidin-glukonat obezbedila je zadovoljavajući stepen inicijalnog čišćenja Niže vrednosti koeficijenta maksimuma kontaminacije postignute su zahvaljujući tome što su sve strane instrumenta u toku rada zahvaćene sunđerastom masom. Korišćenje sunđera je bezbednije, jer operator ne dolazi u direktan kontakt sa oštrim delovima instrumenata [19]. Ova metoda ima značaja i u vlažnom čuvanju instrumenata posle kliničke upotrebe, koja je osnova za efikasno čišćenje [14, 18].

Analizom rezultata hemijskog natapanja instrumenata u natrijum-hipohlorit i enzimski čistač uočena je značajna razlika u efikasnosti uklanjanja rezidualnog debrisa. Natrijum-hipohlorit se koristi kao endodontsko sredstvo za ispiranje više od 80 godina. On je široko primenjivano dezinfekciono sredstvo i oksidacioni agens i poseduje sposobnost rastvaranja organskog tkiva, koja u velikoj meri zavisi od odnosa hipohlorita i organske materije [20]. Ukoliko se koristi kao dezinfekciono sredstvo pri čišćenju endodontskih instrumenata od nikl-titanijuma, može da dovede do mikrotačkaste korozije. Enzimi i tkivni rastvarači su efikasni u uklanjanju proteina, lipida i ugljenih hidrata sa njihovih površina [21]. Iako oba sredstva ispoljavaju jak rastvarački efekat proteina i organske materije, natrijum-hipohlorit je pokazao značajno veću efikasnost u uklanjanju kalcijum-hidroksida. U izvođenju krajnjeg protokola dekontaminacije data je prednost natrijum-hipohloritu.

Poređenjem rezultata čišćenja kod dve ultrazvučne metode – u vodi i dezinficijensu, nije uočena statistički značajna razlika u efikasnosti. Rezultati su pokazali da su obe ultrazvučne metode uklonile znatnu količinu rezidualnih ostataka, ali nije dobijen nijedan instrument sa potpuno čistom površinom. Ovi rezultati su u skladu sa rezultatima Aasima i saradnika [4], koji su u svojoj studiji izneli da su depoziti kalcijum-hidroksida bili rezistentni na ultrazvučno čišćenje. Čišćenje u dezinficijensu je pokazalo bolje rezultate, pa je kao efikasnija metoda uključena u izvođenje konačnog protokola. Ovo istraživanje je pokazalo da je korišćenje ultrazvuka važan korak u čišćenju instrumenata, što se podudara sa studijama drugih autora [22, 23]. Ono unapređuje bezbednost radnika u poređenju sa ručnim četkanjem. Ukoliko se kombinuju sa dezinficijentnim rastvorima, ultrazvučni čistači mogu imati i antimikrobno dejstvo, time se smanjuje rezidualna konatаminacija i obezbeđuje bezbednije rukovanje sa instrumentima i efikasnija sterilizacija [24]. U ovoj studiji zadovoljavajući rezultati čišćenja postignuti su ultrazvučnim čišćenjem u trajanju od 15 minuta. Isto vreme je preporučeno od strane drugih autora [4]. Od izuzetne važnosti je ispiranje instrumenata posle tretmana radi otklanjanja rezidualnog kontaminiranog rastvora [4, 25]. Rezultati su pokazali da upotreba samog ultrazvuka, bez prethodne pripreme instrumenata, nije dala potpuno čiste površine instrumenata. Slične rezultate su dobili Linsuwanont i saradnici [14]. Njihova studija je pokazala da kombinovana upotreba 1% NaOCl i ultrazvučnog kupatila u toku pet minuta ne može potpuno ukloniti organski materijal sa instrumenata bez prethodnog uklanjanja velike količine debrisa četkanjem. Rezultati ove studije pokazuju da su svi postupci u protokolu neophodni i naglašavaju važnost mehaničkog uklanjanja nečistoća pre hemijskog i ultrazvučnog čišćenja.

Iz tog razloga je razvijen protokol koji je predstavljao kombinaciju najefikasnijih metoda iz prethodne tri grupe – mehaničkog, hemijskog i ultrazvučnog čišćenja. Sastojao se iz mehaničkog čišćenja sunđerom natopljenim hlor-heksidinom, natapanja u natrijum-hipohlorit i ultrazvučnog čišćenja u rastvoru deterdženta. Poređenjem rezultata protokola u odnosu na efikasniji metod od prethodnih parova, pokazano je da postoji značajna razlika u efikasnosti čišćenja. Jedino je primena protokola kao rezultat imala instrumente potpuno čistih površina. Protokol predstavljen u ovom istraživanju se više oslanja na hemijska sredstva i opremu nego na ljudski faktor u cilju dobijanja zadovoljavajućih rezultata čišćenja endodontskih instrumenata. Početno čišćenje sunđerom natopljnim u hlorheksidin-glukonatu je jednostavno i može se brzo obaviti. Hemijsko natapanje i ultrazvučno čišćenje su dve vrlo važne faze i moraju se izvršiti uzastopno. Ovakav protokol je vrlo jednostavan i lako se može usvojiti i primenjivati kako u privatnoj praksi tako i u institucionalnom okruženju.

ZAKLJUČAK

Pojedinačne mehaničke, hemijske ili ultrazvučne metode dekontaminacije endodontskih instrumenata nisu dovoljno efikasne za uklanjanje ostataka kalcijum-hidroksida sa radnih delova endodontskih instrumenata. Metode koje se oslanjaju na ručno čišćenje instrumenata su nedovoljno efikasne i ne daju uvek iste rezultate, jer uglavnom zavise od motivacije osobe koja ih izvodi. Metoda mehaničkog čišćenja endodontskih instrumenata pomoću sunđera natopljenim hlorheksidinom je pokazala značajno veću efikasnost od mehaničkog čišćenja četkom u vlažnoj sredini. Metoda hemijskog natapanja endodontskih instrumenata u natrijum-hipohlorit je bila efikasnija od natapanja u enzimski čistač. Metoda ultrazvučnog čišćenja endodontskih instrumenata u dezinficijensu je bila značajno efikasnija u odnosu na ultrazvučno čišćenje u vodi. Najbolju efikasnost uklanjanja ostataka kalcijum-hidroksida je pokazao protokol koji se sastojao iz mehaničkog čišćenja u sunđeru natopljenim hlorheksidinom, hemijskog natapanja u natrijum-hipohlorit i ultrazvučnog čišćenja u dezinficijensu.

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