Deformations of the Manual Endodontic Instruments During Root Canal Instrumentation

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SUMMARY
Introduction Mechanical instrumentation of the complex root canal system is very demanding procedure which requires use of the various manual and rotary instruments. The aim of this study was to assess the frequency and to verify possible deformation of the working part of endodontic instruments after their multiple clinical use.

Material and Methods New sets of the manual endodontic instruments (reamers, K-files and Hedstroem) used in routine clinical use (44 instruments) and for root canal instrumentation of extracted teeth (44 instruments) were included in the study. Instrumentation was performed by Step-Back technique and constant irrigation with 0.5% NaOCl solution, 10 ml for each root canal. All the instruments were used 10 times and after use sterilized in a dry sterilizer or autoclave. The working parts of deformed instruments were analyzed using optimagnetic print.

Results The results obtained after clinical use showed deformations of the working part of the reamers in 50%, K-files in 43% and Hedstroem in 66.7% of used instruments. After instrumentation the canal of the extracted teeth, deformations were observed in 87.5% of the reamers, in 50% of the K-files and in 62.5% of Hedstroem files. The difference in frequency of the deformations was not statistically significant. On the instruments used for the preparation the canals of the extracted teeth and sterilized in autoclave, malformations were observed in 86.4%, comparing to the instruments sterilized in a dry sterilizer where malformations of the working part were registered in 59.1% of the cases. That difference was statistically significant ($\chi^2=5.250; p=0.072$).

Conclusion Multiple use of the manual endodontic instruments in clinical conditions leads to increased frequency of malformations of the working part in all types of manual endodontic instruments.

Keywords: manual endodontic instruments; deformation; sterilization

INTRODUCTION

Instrumentation of the root canal system is the most important phase of endodontic procedure and success of the endodontic treatment largely depends on how it is performed. Adequate mechanical instrumentation of the complex root canal space is very often demanding procedure which requires use of various manual and rotary instruments or its combination [1]. Chemomechanical preparation, cleaning and shaping of the root canal system, provides conical form of the canal and ensures safe conditions for high-quality, three-dimensional hermetic obturation [2].

Manual endodontic instruments (reamers, different types of files) are made of high quality steel or nickel-titanium alloy (NiTi) and usually are for multiple uses. All of these canal instruments during the instrumentation or during their clinical use are subject to various forms of stress and thus different deformations. The concentration of stress and potential possibility of deformation or fracture during endodontic instrumentation depends on many factors, primarily on materials they are made of, the canal anatomy, dynamics and frequency of their use, method of preparation and sterilization, the design of the working part of the instrument or application of various chemicals during the instrumentation [2, 3, 4]. All these factors are closely related to the professional qualities of the therapist and mostly depend on his training to use instruments properly with different preparation techniques. However, the main goal is to provide the best possible results after cleaning and shaping the canals and above all safe instrument manipulation in the complex canal system [2].

Although numerous clinical studies confirmed that the manual endodontic instruments of smaller diameter (0.6; 0.8; 0.10; 0.15; 0.20) should be used only once, it is not often respected in clinical practice. Deformations and fractures of instruments in the canal are much more frequent when they are used many times and lead to greater number of complications during endodontic procedure.

The aim of this study was to assess the frequency and to verify possible deformations of the working part of endodontic instruments after their multiple clinical use.

MATERIAL AND METHODS
The research was conducted at the Clinic for Restorative Dentistry and Endodontics, The School of Dentistry in...
Belgrade. As a research material, new sets of manual endodontic instruments were used: two sets of reamers (K-reamers KENDO 25 mm; size 0.08, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40); two sets of K-files (K-file KENDO 25 mm; size 0.08, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40); and two sets of Hedstroem (H-file KENDO 25 mm; size of 0.15, 0.20, 0.25, 0.30, 0.35, 0.40). 88 manual endodontic instruments were divided into two groups. 44 instruments from the first group were used in routine clinical practice on the teeth of different morphological groups and different diagnosis, while other 44 instruments were used for canal instrumentation in the extracted human teeth (Table 1).

Both, in clinical and in experimental conditions, each manual endodontic instrument was used for the preparation of ten canals. After preparation the access cavity and content removal from each canal, a set of instruments was used for mechanical instrumentation. Reamers were used with rotational and filing movements, while for the K-files filing movements were used only. Canal instrumentation in both groups was performed by Step-back technique with constant irrigation with 0.5% NaOCl solution in quantities of 10 ml for each root canal. In the group of extracted teeth instrumentation included both simple canal systems (central incisors) and complex canal systems (mesiobuccal and distobuccal canals of the upper first molars).

One set of instruments from each group, after their use, was sterilized in a dry sterilizer (Electronic Sutjeska, Belgrade) at the temperature of 121°C for 6 hours. Also, one set of used instruments was sterilized in autoclave (Vacuclave 24B/30B Melag) at the temperature of 134°C.

Working part of all used instruments was analyzed under the magnifying glass and six times magnification.

For manual endodontic instruments (size 0.08, 0.15 and 0.20) with visible deformations of the working part, cross-sections were made at the distances of 3.9, 4.0 and 4.2 mm from the tip of the instrument, for further analysis. The instruments were initially placed in a mold with 4.2 mm from the tip of the instrument, for further analysis.

RESULTS

Deformations of the working part of the reamers after clinical use are found in 50%, of K-files in 43% and Hedstroem in 66.7% of used instruments. However, there was statistically significant difference in frequency of the deformations between used endodontic instruments (Table 2). On endodontic instruments sterilized in a dry sterilizer deformations were registered in 63.6% while on instruments sterilized in the autoclave in 40%. Statistically significant difference in the frequency of deformations regarding the method of sterilization was not observed (Table 3).

Deformations of the working part of the instruments after the canal preparation in extracted teeth were observed in 87.5% of reamers, in 50% of K-files and 62.5% of Hedstroem files. Statistically significant differences in the frequency of deformations on the instruments were not found ($\chi^2=5.250; p=0.072$; Table 4). On instruments sterilized in a dry sterilizer, deformation was not statistically significant different from the autoclave sterilization.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Number of the instruments used in clinical conditions</th>
<th>Number of the instruments used on extracted teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reamers</td>
<td>Dry sterilizer</td>
<td>8</td>
</tr>
<tr>
<td>K-files</td>
<td>Dry sterilizer</td>
<td>8</td>
</tr>
<tr>
<td>Hedstroem</td>
<td>Dry sterilizer</td>
<td>6</td>
</tr>
<tr>
<td>Total/UK</td>
<td>Dry sterilizer</td>
<td>44</td>
</tr>
</tbody>
</table>

**Table 1.** Manual endodontic instruments used in the study.
Tabela 2. Deformacije radnog dela endodontskih instrumenata kod ekstrahovanih zuba.

<table>
<thead>
<tr>
<th>Instrument / Deformation type</th>
<th>Number / Broj</th>
<th>Deformation / Deformacija</th>
<th>Total / Ukupno</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reamers</td>
<td>16</td>
<td>1 (0.15)</td>
<td>2 (0.23)</td>
</tr>
<tr>
<td>K-files</td>
<td>16</td>
<td>2 (0.15)</td>
<td>3 (0.48)</td>
</tr>
<tr>
<td>Hedstroem</td>
<td>12</td>
<td>3 (0.25; 0.35)</td>
<td>8 (0.67)</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>23 (52.3%)</td>
<td>44 (100.0%)</td>
</tr>
</tbody>
</table>

Table 3. Deformacije radnog dela endodontskih instrumenata kod ekstrahovanih zuba u zavisnosti od načina sterilizacije.

<table>
<thead>
<tr>
<th>Sterilization type / Način sterilizacije</th>
<th>Deformation / Deformacija</th>
<th>Total / Ukupno</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suva sterilizacija</td>
<td>21 (47.7%)</td>
<td>44 (100.0%)</td>
</tr>
<tr>
<td>Autoklav</td>
<td>23 (52.3%)</td>
<td>44 (100.0%)</td>
</tr>
</tbody>
</table>

Table 4. Deformacije radnog dela endodontskih instrumenata kod ekstrahovanih zuba.

<table>
<thead>
<tr>
<th>Instrument / Deformation type</th>
<th>Number / Broj</th>
<th>Deformation / Deformacija</th>
<th>Total / Ukupno</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reamers</td>
<td>16</td>
<td>2 (0.15; 0.22)</td>
<td>3 (0.40)</td>
</tr>
<tr>
<td>K-file</td>
<td>16</td>
<td>2 (0.15)</td>
<td>2 (0.30)</td>
</tr>
<tr>
<td>Hedstroem</td>
<td>12</td>
<td>3 (0.25; 0.35)</td>
<td>4 (0.30)</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>5 (0.25)</td>
<td>8 (0.40)</td>
</tr>
</tbody>
</table>

Table 5. Deformacije radnog dela endodontskih instrumenata kod ekstrahovanih zuba u zavisnosti od načina sterilizacije.

<table>
<thead>
<tr>
<th>Sterilization type / Način sterilizacije</th>
<th>Deformation / Deformacija</th>
<th>Total / Ukupno</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suva sterilizacija</td>
<td>16 (36.4%)</td>
<td>23 (52.3%)</td>
</tr>
<tr>
<td>Autoklav</td>
<td>16 (40.9%)</td>
<td>32 (72.7%)</td>
</tr>
</tbody>
</table>

Table 6. Deformacije radnog dela endodontskih instrumenata kod ekstrahovanih zuba u zavisnosti od načina sterilizacije.

<table>
<thead>
<tr>
<th>Instrument / Deformation type</th>
<th>Number / Broj</th>
<th>Deformation / Deformacija</th>
<th>Total / Ukupno</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reamers</td>
<td>16</td>
<td>3 (0.25; 0.35)</td>
<td>6 (0.40)</td>
</tr>
<tr>
<td>K-file</td>
<td>16</td>
<td>3 (0.25; 0.35)</td>
<td>5 (0.30)</td>
</tr>
<tr>
<td>Hedstroem</td>
<td>12</td>
<td>3 (0.25; 0.35)</td>
<td>2 (0.15)</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>5 (0.25)</td>
<td>8 (0.40)</td>
</tr>
</tbody>
</table>
observed in 59.1% while after sterilization in autoclave deformation of the working part was observed in 86.4%. This difference was statistically significant ($\chi^2=4.125$; $p=0.042$; Table 5).

On reamers which were sterilized in a dry sterilizer after a routine clinical application, deformations in the form of curvature and loss of thread were registered in one instrument, while the loss of thread was observed in three reamers in the apical third of the working part of the instrument (Table 6, Figure 1). Reamers sterilized in autoclave after clinical application showed curvature in one instrument, the curvature and loss of thread also in one, while the loss of thread was registered in two instruments (Table 6).

After instrumentation of the canals in extracted teeth and sterilization in a dry sterilizer, curvature was recorded in three reamers, loss of thread in two instruments, and the curvature and loss of thread on one. Fracture was observed in apical third of one reamer (Table 7). In reamers sterilized in autoclave curvature was observed in the three instruments, the loss of thread in two (Figure 2), while the curvature and loss of thread were registered in two instruments (Table 7).

In K-files sterilized in a dry sterilizer after routine clinical use, deformations in the form of a curvature were found in one instrument. Loss of thread is registered in two instruments and the curvature and loss of thread also in two (Table 6, Figure 3) In K-files sterilized in the autoclave after the clinical use, the curvature was recorded in one and the curvature and loss of thread also in one (Table 6). K-files used on extracted teeth and sterilized in a dry sterilizer had deformations in the form of curvature and loss of thread in one instrument while in group of instruments sterilized in autoclave curvature was registered in two instruments. Curvature and loss of thread were observed also in two instruments. Loss of threads is observed in three files (Figure 4, Table 7).

Deformations in the form of the curvature of the Hedstroem files sterilized in a dry sterilizer after routine clinical use were observed in two instruments (Figure 5). Loss of thread was registered in one and the curvature and loss of thread also in one. Fracture was also observed in only one instrument (Table 6). In files sterilized in autoclave, curvature was recorded in one and the loss of thread also in one. The same was for curvature and loss of thread (Table 6).

Hedstroem files, used for canal instrumentation in extracted teeth and sterilized in a dry sterilizer had deformations in the form of curvature in two and loss of thread in three instruments (Table 7). In Hedstroem files sterilized in the autoclave curvature and loss of thread were observed in four and the loss of thread in one file only (Table 7).

Cross-section analysis of new unused manual instrument (the reamer; 0.15) and deformed part of the instrument (the reamer; 0.15) by optomagnetic print showed that there is a difference in the structure of the material between these instruments (Graphs 1 and 2). The analysis also showed that changes in used instruments were especially presented in the area of deformation.
The outcome of endodontic treatment mostly depends on the quality and safe mechanical instrumentation of root canals. Although the design of the endodontic instruments (especially rotary) was considerably improved and instrumentation techniques have become safer and more efficient, deformations and fractures of instruments during endodontic procedures are still a significant problem [6, 7].

Endodontic instruments are exposed to numerous stresses during clinical use in the complex root canal system [6, 8]. Specifically, during root canal instrumentation various clinical factors can incorporate during cleaning and shaping of the root canal and they are hard to control. These are the morphology of the root canal system and initial diameter of the canal (curvature, length and width), the selection and design of the endodontic instruments, preparation technique, irrigation and experience of the therapist [2, 4]. Therefore, canal instruments are exposed to various forms of stress during clinical use and the concentration of stress and potential possibility for deformation (curvature, loss of thread, fracture) mainly depend on the complexity of the canal system, the dynamics of use in the canal (rotation, filing) how many times were used, sterilization type and above all, experience of the therapist. After multiple use, instruments become less effective and vulnerable to fractures when used in the complex canal system [9, 10].

In this study manual endodontic instruments were used in routine clinical practice in patients with different teeth diagnosis and different canal systems. Canal instrumentation in extracted teeth included teeth with complex canal system (upper molars with narrow and curved buccal canals) and frontal teeth with a simple canal system, to ensure similar conditions to clinical conditions [2]. To obtain similar instrumentation conditions, all instruments were used 10 times and canal preparations in clinical and experimental conditions were done by one practitioner.

The experience of the therapist as well as his sense of the work is important factors in assessing possible damage of the endodontic instruments during their use [6].

Deformations of the working part of reamers were slightly more presented in the root canal preparation of extracted teeth. This could be explained by the fact that some of extracted teeth had narrowed and curved canals, while in the routine clinical practice, the choice of teeth for endodontic treatment depended only on the current pathology of the patients in the clinic. This could explain also increased resistance of the larger reamers during instrumentation of the narrow canal compared to the instruments of smaller dimensions [8]. The greatest number of deformities in the form of curvature and loss of thread and one fracture of small size reamer confirmed the fact that these instruments should be used only once [8, 11]. The excessive rotation in curved and narrowed canal leads to torsion stress, because while the handle of the instrument rotates, the tip of the instruments in curved and narrowed canal is squeezed and hard to rotate. When this stress overcomes the limits of material fatigue fracture or fractures of the instrument occur(s) [8, 12, 13, 14]. It has been confirmed that manual endodontic instruments show excellent plastic deformation before fracture occurs [8, 12].

Design of the K-files allows only filing movements in the canal and therefore the deformation of these instruments were fairly consistent in routine clinical use and during root canal instrumentation in extracted teeth [11, 13]. Deformations in the form of curvature are the result of the narrow canal, cross-sectional design and inertia that occurs during the canal preparation [7]. When the tip of the instrument is forced through the small lumen of the canal, it causes large torsion stress and deformation of the working part even if rotation is low [7, 8]. Mathematical analysis showed that the concentration of stress occurs at the edges of the instrument, not on the cutting edge, which disrupts the efficiency of dentine cutting during the canal instrumentation [6].

Deformations of the working part of the instrument were significantly present after sterilization in autoclave. This could be explained by increased temperature during sterilization but also the fact that these instruments are used repeatedly in a complex canal system, where the working part was often stressed during the instrument-
Deformations of the manual endodontic instruments during root canal instrumentation [10, 11]. Increase in diameter of manual instrument contributes to the increasing resistance to deformation and reducing the resistance to material fatigue [6, 13]. This is especially important after multiple use of instruments. Right preparation technique would be to use larger diameter files first, then the smaller (crown-down). That way, one provides less friction when shaping narrow canal [2, 7, 12].

Deformations of the working part of Hedstroem files were also fairly consistent in routine clinical use and during instrumentation of the root canal in extracted teeth but in a slightly larger number than the K-files. The curvature of the manual endodontic instruments was slightly expressed near to the tip of the instrument also in the larger diameter instruments. This could be explained by presented stress during instrumentation in curved and narrowed canals. Excessive stress did not cross the border of material fatigue and fracture of the instrument was not presented (except in one case) because this file was used carefully and without rotation in the canal [13]. During the cutting of the dentine and filing movements (up-down), stress was smaller than the mechanical properties of materials of which the instrument was built, and the anatomy of the canal did not have influenced on deformations [8, 15].

CONCLUSION

Multiple use of the manual endodontic instruments in clinical conditions and during the canal instrumentation in extracted teeth led to malformations of the working part in the form of curvature and loss of thread in all types of used instruments. Higher degree of deformations was shown on instruments sterilized in the autoclave after their use.

REFERENCES

Deformacije ručnih endodontskih instrumenata
tokom instrumentacije kanala korena zuba

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KRATAK SADRŽAJ
Uvod
Instrumentacija kanala korena zuba je najvažnija faza endodontske procedure i od njene pravilne realizacije uglavnom zavisí i uspeh endodontskog lečenja. Adevratna mehanička obrađa složenog kanalskog prostora je često vrlo teška i komplikovana i zahteva primenu različitih ručnih i mašinskih rotirajućih instrumenata, odnosno njihovh kombinaciju [1]. Hemomehaničkom pripremom, čišćenjem i oblikovanjem kanalskog sistema neophodno je obezbediti konični oblik kanala i osigurati bezbedne uslove za kvalitetnu trodimenzionalnu hermetičku opturaciju tako pripremljenog kanala korena zuba [2].

Endodontski instrumenti za ručnu upotrebu (prošrivači, različite vrste turpija) izrađeni su od visokokvalitetnog čelika ili nikl-titanijumske legure (NiTi) i obično se koriste višekratno. Svi oni su tokom instrumentacije kanala, odnosno tokom kliničke upotrebe podložni različitim vidovima pritiska, a time i različitim deformacijama. Koncentracija pritiska i mogućnost njihove deformacije ili lomljenja tokom njihovog rukovanja za- visi od raznih faktora: materijala od kojeg su izrađeni, anatomskih osobina kanala, dinamike i učestalosti njihove primene u kanalu, načina pripreme i sterilizacije, dizajna radnog dela samog instrumenta i primene različitih hemijskih sredstava tokom instrumentacije [2, 3, 4]. Svi ovi faktori su blisko povezani s strašnim kvalitetima terapeuta i najviše zavisite od njegovih obučenosti da pravilno koristi instrumente tokom realizacije različitih tehničkih operacija kanala. Ipak, osnovni cilj je obezbeđivanje najboljeg efekta čišćenja i oblikovanja kanala, a tada sve bezbednosti tokom manipulacije u komplikovanom kanalskom sistemu [2].

Iako mnoge kliničke studije potvrđuju da ručne endodontske instrumente manje prečnika (0,6; 0,8; 0,10; 0,15; 0,20) treba koristiti samo jednokratno, to se u kliničkoj praksi vrlo često ne poštuje. Naime, deformacije i lomljenje instrumenata u kanalu su mnogo češći kod njihove višekratne upotrebe, pa su zbog toga ove komplikacije tokom izvođenja endodontskog postupka česte i značajne.

Cilj rada je bio da se proveri učestalost mogućih deformacija radnog dela ručnih endodontskih instrumenata posle njihove višekratne kliničke primene u preparaciji kanala korena zuba.

MATERIJAL I METODE RADA
Istraživanje je urađeno na Klinici za bolesti zuba Stomatološkog fakulteta Univerziteta u Beogradu. Kao materijal korišćeni su setovi novih ručnih endodontskih instrumenata: dva seta proširivača tipa K (KENDO K-reamers 25 mm, veličine 0,08; 0,10; 0,15; 0,20; 0,25; 0,30; 0,35; 0,40), dva seta turpija tipa K (KENDO K-file 25 mm, veličine 0,08; 0,10; 0,15; 0,20; 0,25; 0,30; 0,35; 0,40) i dva seta turpija tipa H – Hedstrom (KENDO H-file 25 mm, veličine 0,15; 0,20; 0,25; 0,30; 0,35; 0,40). Korišćeno je ukupno 88 ručnih kanalskih instrumenata svrstanih u dve grupe. Prvu grupu su činila 44 instrumenata koja su korišćena u rutinskom kliničkom radu kod endodontskih zahvata na zvorni različitih morfoloških grupa i različitih dijagnoza, a drugu takođe 44 instrumenata korišćena za instrumentaciju kanala ekstrahovanih zuba (Tabela 1).

Kako u kliničkim, tako i u eksperimentalnim uslovima svi ručni endodontski instrumenti su upotrebljeni za prepiraciju deset kanala. Nakon formiranja pristupnog kvetita i uklanjanja sahranja iz kanala, svaki set instrumenata je korišćen za mehaničku instrumentaciju kanala korena zuba. Proširivači
Deformacije radnog dela instrumenta cylindera korišćene za instrumentaciju kanala ekstrahovanih zuba sterilizisanih u svom autoklavu zakrivljenosti kod jednog instrumenta, kao i za krichljenost i gubitak navoja, dok je gubitak navoja obećan po uvočenim kod dva instrumenta (Tabela 6).
(proširivač tipa K; 0,15) optomagnetnim otiskom otkrila je razliku u strukturi materijala ovih instrumenata (Grafikon 1 i 2). Analiza je takođe pokazala da su promene kod korišćenih instrumenata naročito izražene na mestu deformacije.

**DISKUSIJA**

Ishod endodontskog lečenja zuba u najvećoj meri zavisi od kvalitetne i sigurne mehaničke instrumentacije kanala korena zuba. Iako je poslednjih godina značajno poboljšan dizajn endodontskih instrumenata (pogotovo mašinskih rotirajućih), a tehničke instrumentacije postale sigurnije i efikasnije, deformacije i lomljenje ovih instrumenata tokom izvođenja endodontskog postupka i dalje su značajan problem [6, 7].

Endodontski instrumenti su tokom kliničke upotrebe izloženi brojnim pritiscima u komplikovanom kanalskom sustemu zuba [6, 8]. Naime, tokom instrumentacije kanala korena zuba inkorporiraju se različiti klinički faktori koje je tokom čišćenja i oblikovanja kanala korena teško kontrolisati. To su, pre svega, morfološke osobenosti kanalskog sistema zuba i inicijalni prenicking kanala (zakrivljenost, dužina, širina), izbor i dizajn endodontskih instrumenata, tehnike preparacije i irigacije kanala korena zuba i, naravno, iskustvo terapeuta [2, 4]. Kanalski instrumenti su zato izloženi različitim vidovima pritiska tokom kliničke primene, a koncentracija pritiska i mogućnost deformacije (zakrivljenost, gubitak navoja, lomljenje) uglavnom zavise od komplikovanosti kanalskog sistema, dimačke primene u kanalu (rotacija, turpiranje), učestalosti korišćenja, načina sterilizacije i praktičnog iskustva terapeuta. zbog toga su ovi instrumenti manje efikasni tokom instrumentacije i podložniji lomljenju pri korišćenju u komplikovanom kanalskom sustemu [9, 10].

U ovom istraživanju ručni endodontski instrumenti su korišćeni u rutinskoj kliničkoj praksi kod pacijenata s različitim patologijom zuba i različitim kanalskim sistemima. Instrumentacija kanala kod ekstrahovanih zuba obuhvatila je zube sa složenijim kanalskim sistemom (gornji molarji sa suženim i zakrivljenim bukvalnim kanalima), odnosno prednje zube s jednostavnijim kanalskim sistemom, kako bi se obezbedili uslovi slični kliničkim [2]. Da bi uslovi instrumentacije bili što ujednačeni, svi instrumenti su korišćeni po deset putna, a preparaciju kanala i u kliničkim i u eksperimentalnim uslovima obavio je jedan praktičar. Iskustvo terapeuta je veoma važan faktor u proceni mogućih oštećenja endodontskih instrumenata tokom rada, kao i njegov osećaj pri radu [6].

Deformacije radnog dela proširivača tipa K bile su nešto češće pri preparaciji kanala korena ekstrahovanih zuba. Ovo se moglo objasniti činjenicom da je kod ekstrahovanih zuba bilo više kanalnih sistema sa suženim i zakrivljenim kanalima nego što je to bilo u rutinskoj kliničkoj praksi, gde je izbor zuba za endodontsko lečenje zavisio od trenutne patologije zuba pacijenta koji se javio na Kliniku. Ovde bi se mogla objasniti i povećana otpornost proširivača većih dimenzija tokom instrumentacije suženih kanala u odnosu na instrumente manjeg prečnika [8]. Najveći broj deformacija u vidu zakrivljenja i gubitaka navoja i jedno lomljenje kod proširivača manjih dimenzija samo potvrđuje činjenicu da ove instrumente treba koristiti samo jedanput [8, 11]. Naime, preterana rotacija na zakrivljenom i suženom kanalu dovodi do torzijonog stresa, jer dok se drška ručnog instrumenta rotira, vrh instrumenta u zakrivljenom i suženom kanalu se stisnut i teško se okreće. Kada ovaj pritisak prenosi granice zamora materijala, dolazi do lomljenja instrumenata [8, 12, 13, 14]. Potvrđeno je inače da ručni endodontski instrumenti pokazuju izuzetnu plastičnu deformaciju prenošenje do preloma [8, 12].

Dizajn turpirija tipa K omogućava samo pokrete turpiranja u kanalu i zbog toga su deformacije ovih instrumenata bile prična ujednačene i u rutinskoj kliničkoj primeni i pri instrumentaciji kanala korena ekstrahovanih zuba [11, 13]. Deformacije u vidu zakrivljenja instrumenta posledica su suženog prenickinga kanala, dizajna poprečnog preseka i inercije koja se javlja tokom pripreme kanala [7]. Kada se vrh instrumenta forira kroz mali lumen kanala, dolazi do velikog torzijonog stresa i deformacije radnog dela i pri najmanjoj rotaciji [7, 8]. Matematička analiza je pokazala da do koncentracije pritiska dolazi na delu instrumenta uz ivicu, a ne na samo sećinu ivici, čime se i remeti efikasnost sećenja dentina pri instrumentaciji kanala [6].

Deformacije radnog dela instrumenta su bile značajno veće nakon sterilizacije u automatlu. Ovo bi se moglo objasniti povećanjem temperaturom tokom sterilizacije, ali i činjenicom da su ovi instrumenti korisčeni nekoliko puta u komplikovanom kanalskom sustemu, gde je radni deo bio češće pod pritiskom tokom instrumentacije kanala [10, 11]. Povećanje promera ručnog instrumenta doprinosi povećanju otpornosti na deformaciju, ali i smanjuje otpornost na zavor materijala [6, 13]. Ovo je naročito važno nakon povećanja broja korišćenja instrumenata u kanalu. Izborom prave tehnike preparacije, gde se prvo koriste turpirije većeg prečnika pa onda manjeg (crowndown), omogućava se manje trenje prilikom oblikovanja kanala instrumentima malog prečnika [2, 7, 12].

Deformacije radnog dela turpirja tipa H takođe su bile prična ujednačene i u rutinskoj kliničkoj primeni i pri instrumentaciji kanala korena ekstrahovanih zuba, ali u nešto većem broju nego kod turpirja tipa K. Zakrivljenost ovih ručnih endodontskih instrumenata je bila nešto izraženija pri vrhu instrumenta, kao i kod instrumenta većeg prečnika. Ovo bi se moglo objasniti izraženom pritiskom tokom instrumentacije u suženim i zakrivljenim kanalima. Preterani pritisak nije prešao granice zamora materijala i nije izazvao lomljenje instrumenta (osim u jednom slučaju), jer je ova turpirija korišćena pažljivo i bez rotacije u kanalu [13]. Naime, sećenjem dentina i pokretima turpiranja (gore-dole) pritisak je bio manji od mehaničkih odlika materijala od kojih je instrument izrađen, a anatomski i osobnosti kanala nisu dodatno uticale na deformacije [8, 15].

**ZAKLJUČAK**

Posle višekratne primene endodontskih instrumenata u kliničkim uslovima i pri instrumentaciji kanala ekstrahovanih zuba došlo je do izraženih deformacija radnog dela u vidu zakrivljenosti i gubitka navoja kod svih tipova korišćenih instrumenata. Veći stepen deformacija je utvrđen kod instrumenata koji su nakon korišćenja sterilizani u automatlu.