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The influence of two different rotary file systems on the incidence of GuttaCore overextension in curved root canals

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SUMMARY

Objective. The study aimed to evaluate the influence of two different rotary systems on GuttaCore obturation material overextension in curved root canals.

Methods. Sixty-two canals of the extracted human molars with root canals of moderate and severe curvature were included. The teeth were randomly divided into 2 groups according to the rotary instruments used for the root canal shaping: PU group (n=31) – ProTaper Ultimate, and XP group (n=31) – XP-endo Shaper. After shaping root canals were obturated with GuttaCore and AH Plus sealer according to the manufacturer's instructions that differed between the groups. The length of the obturation material was evaluated radiographically and microscopically. The categorical variables homogeneous distribution was evaluated by the Chi-square ($\chi 2$) test. The odds ratio was evaluated to assess the tendency of obturation material overextension in one group compared to another.

Results. After applying inclusion criteria for the root canal obturation quality assessment, 16 specimens were excluded from the further study due to the low-quality obturation. Significantly more specimens with no obturation material overextension in the PU group than in the XP group (p=0.014) were observed. In the XP group, a significantly higher incidence of sealer, sealer and gutta-percha overextension was detected compared to the PU group. The chance of obturation material overextension in the XP group was higher than in the PU group.

Conclusion. The root canals prepared with XP-endo Shaper and obturated with GuttaCore according to the manufacturer's instructions had a higher obturation material overextension incidence in curved root canals compared to ProTaper Ultimate.

Keywords: GuttaCore, overextension, ProTaper Ultimate, XP-endo Shaper, core-carrier obturation.

INTRODUCTION

The root canal obturation material must provide a fluid-tight seal and interfere proliferation of existing microbes and the penetration of oral microorganisms (1). Moreover, an adequate length of obturation material is important. Previous studies showed the healing rate to be significantly higher when the obturation material was 0 to 1 mm or within 2 mm of the apex than filled past the apex or more than 2 mm short of the apex (2, 3).

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Carrier-based obturation method is easy to perform and results in root canal filling with minimal gaps and voids (4). In several studies, carrier-based techniques showed significantly better root canal filling quality than other obturation methods (5-7). Additionally, this technique has a higher potential for gutta-percha movement into the lateral canals (8). The latest generation of core carriers as the carrier for thermoplasticized gutta-percha uses cross-linked gutta-percha. One of these systems is GuttaCore (GC) (Dentsply Maillefer, Ballaigues, Switzerland), which, contrarily to its predecessor Thermafil (Dentsply Tulsa Dental, Tulsa, OK) with a plastic carrier, is easier to remove in case of retreatment or post-space preparation (9). Despite all the advantages, the core-carrier obturation technique

has the disadvantage of unpredictable filling material extrusion over the apex. It was revealed that the success rate of teeth obturated using the core-carrier technique was 83%, 85% of the teeth had an adequate adaptation of filling material, however, a considerable number of teeth (31%) were with obturation material overextension (10).

The core-carriers could be used for the canals prepared with various rotary file systems. GC directions for use point out to choose an obturator according to the taper and the tip size of the final instrument used for root canal shaping. Nevertheless, rotary file systems vary from one another in more aspects than the tip size and the taper. For example, XP-endo Shaper (XP) (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) and ProTaper Ultimate (PU) (Dentsply Sirona Endodontics) rotary instrument systems. XP rotary files perform an eccentric rotary motion by taking on a semicircular shape and adapt to the root canal morphology by expanding or contracting accordingly (11). PU rotary instruments (shapers and finishers) have an off-centered parallelogram cross-section and remain the same variable taper despite the morphology of the root canal (12). It might be speculated that these differences in rotary files could affect the flow of gutta-percha.

Till date, no study has compared the incidence of GC overfilling in curved root canals shaped with XP and PU rotary instrument systems. This study aimed to evaluate the influence of different rotary systems on filling material overextension in curved root canals. The null hypothesis – root canal shaping with two different rotary instrument systems will not affect the incidence of obturation material overextension.

MATERIALS AND METHODS

Tooth selection

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Lithuanian University of Health Sciences Ethics Committee (protocol no. BEC-OF-52). A total of 62 extracted mature human mandibular and maxillary molar teeth were used in the study. Teeth with apical resorptions, open apices, and calcified canals were excluded from the study. For the experimental procedures either one of the mesial root canals of mandibular molars or one of the buccal root canals of the maxillary molars were selected. The specimens were placed in an isotonic solution until further experimental procedures.

Fig. 1. An image showing the tooth placed in ProTrain to standardize the distance between an x-ray film and a tube head

Working length and curvature measurement

All clinical procedures were performed by one operator (M.M). After the preparation of an endodontic access cavity, the teeth were placed in ProTrain (Simit Dental SRL, Italy), and radiographs in a buccolingual direction were performed (Figure 1, 2). For the determination of the working length, the conductive ProTrain gel (Farmacare Srl, Casale, Italy) and electronic apex locator (Root ZX; J Morita Co, Kyoto, Japan) were used. A size 10 k–file was placed into the canal until an apex locator displayed 0.5. The radiographs for working length (WL) determination were performed in the same direction repeatedly (Figure 3). Curvatures of the canals were measured on x-rays using EndoPrep App (Dental Sciences Australia Pty Ltd) (Figure 4). Root canals of moderate (10 to 20 degrees) and severe (25 to 70 degrees) curvatures (13 were included in this study). The curvatures of samples varied between 13º and 57º. The mean value of the root canals' curvatures was 31.7º and 31.4º in the XP and PU groups respectively.

Canal Instrumentation

The teeth were randomly divided into 2 groups. In both groups, the glide path was established with

Table. Incidence of obturation material overextension

Overextended obtura-tion material	Group PU (n=23)	Group XP (n=23)
No extrusion, n (%)	11* (47.8)	4* (17.4)
Sealer extrusion, n (%)	7 (30.4)	12 (52.2)
Sealer and gutta-percha extrusion, n (%)	5 (21.7)	7 (30.4)
In total	12** (52.2)	19** (82.6)

*Statistically significant difference, p=0.014; **Statistically significant difference, p=0.028.

Fig. 2. An image showing a primary x-ray of a specimen in a buccolingual direction

Fig. 3. An image showing an x-ray for WL determination in a buccolingual direction

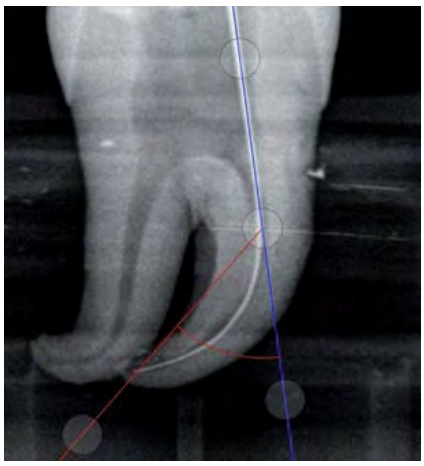

Fig. 4. An image showing the root canal curvature measurement on an x-ray using EndoPrep App. The curvature of showed canal is 49º.

a size 10 and 15 k-files. The teeth in the PU group (n=31) were instrumented with PU endodontic instruments. This rotary system is manufactured of three different heat-treated alloys: M-wire (Slider), Gold-wire (SX, Shaper, F1, F2, F3), and Blue heat-treated wire (FX and FXL). PU F3, which has a variable taper of .09 and a tip size of ISO #30, was the finishing instrument (12). The teeth in the XP group (n=31) were shaped with XP rotary instruments made from NiTi MaxWire alloy. These instruments have a tip size of ISO #30. Initially, the taper of XP is .01 in a martensitic phase, but in the body temperature transforms to an austenitic phase where the taper changes to .04 (14). To simulate clinical conditions and achieve an austenitic phase of XP instruments the temperature of sodium hypochlorite was increased. The syringe of the solution was kept in a water bath at 37ºC and the temperature of the water was verified with a water thermometer (15).

Root canal instrumentation was performed using X-Smart Plus (Dentsply Sirona, Ballaigues, Switzerland) endodontic motor. The motor was set at 400 rpm and 4 Ncm torque in the PU group and 800 rpm and 1 Ncm torque in the XP group. According to the manufacturer's instructions, the coronal parts of the canals were flared with Protaper SX 020/.03v to ensure the GC Obturator has sufficient space to enter the root canal. During instrumentation, the canals were irrigated with 2.5% sodium hypochlorite (Cerkamed Medical Company, Stalowa, Poland). A size 10 k-file was used after the use of each instrument to maintain apical patency. The final irrigation was completed with 2.5% sodium hypochlorite followed by sterile saline and 17% EDTA (Cerkamed Medical Company, Stalowa, Poland) and canals were dried with size 30 absorbent paper points.

Canal obturation and evaluation

In both groups, the apical size was verified. The size of the GC obturator has been chosen according to the manufacturer's instructions – size 25 in the XP group and size 30 in the PU group. Before an obturation process, the specimens were placed in ProTrain to keep an apical part hidden from the operator. In both groups, controlling the WL, the canal walls were coated with AH Plus (Dentsply-Maillefer, Ballaigues, Switzerland) sealer using size 30 paper points. Additional absorbent paper points were used to remove the sealer excess. The obturators were heated in GC Obturator Oven (Dentsply Tulsa Dental Specialties, Tulsa, OK) and immediately inserted into the canal with a slow and continuous motion to the WL. The shafts and handles of the obturators were removed by bending them to either side of the canal wall.

After obturation, the radiographs of all specimens in a buccolingual direction were performed, and images of apical parts of the specimens were taken with a surgical operating microscope (Leica M320 for dental, Wetzlar, Germany) at 10x. To reduce the number of factors influencing the study outcome, the density and extension of the filling material were evaluated in the radiographs. The quality of the obturation and the inclusion criteria for further evaluation were as follows: 1) no voids in the obturation material, 2) obturation material 0 to 2 mm from the radiological apex (16). The specimens were excluded from the study if the obturation material contained voids or were more than 1.00 mm short of WL. Microscopic pictures were used for the assessment of obturation materials overextension: (0) no obturation material, (1) sealer, (2) sealer, and gutta-percha (Figure 5).

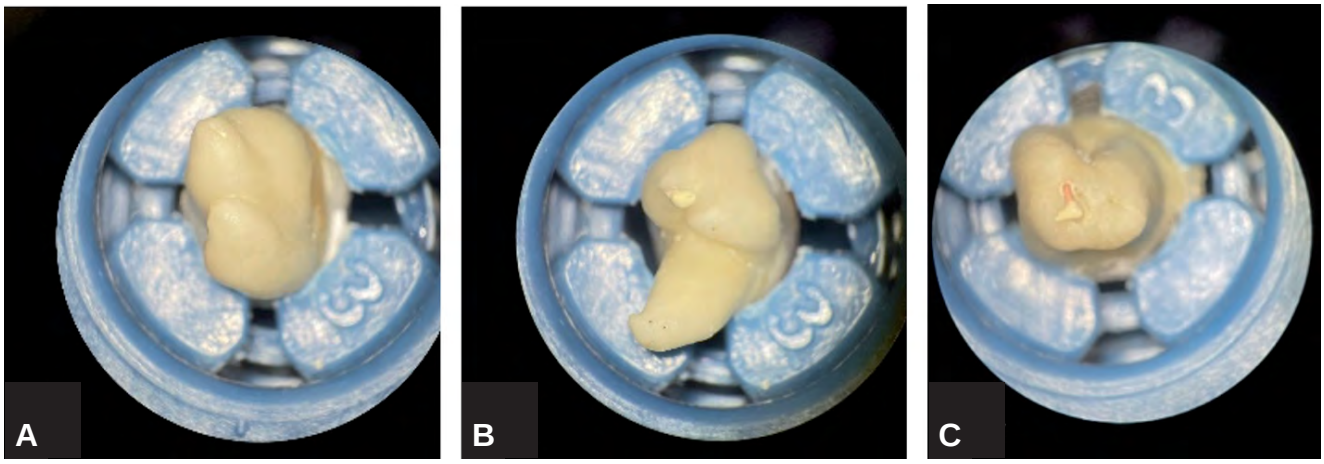

Fig. 5. An image showing microscopic pictures used for the assessment of obturation materials overextension. No obturation material overextended (A), overextended sealer (B), overextended sealer, and gutta-percha (C).

Statistical analysis

Categorical variables were expressed with their frequency and relative frequency rate (%). The categorical variables homogeneous distribution was evaluated by the Chi-square (χ^2) test. To assess the tendency of overextension occurrence in one group compared to another, the odds ratio (OR) was evaluated. The statistical analysis was conducted using the Chi-Square Test of Independence with IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, New York, USA).

RESULTS

After inclusion criteria were applied 46 samples (23 for the PU group and 23 for the XP group) were analysed and compared, while 16 specimens were removed from the further study. The results revealed significantly more specimens with no obturation material overextended in the PU group than in the XP group: 11 (47.8%) for the PU group vs. 4 (17.4%) in the XP group; p=0.014 (Table). There was no statistically significant difference between the groups in sealer solely (30.4% and 52.2%, in the PU and XP groups respectively, p>0.05) and obturation material (sealer and gutta-percha) overextension (21.7% and 30.4%, in the PU and XP groups respectively, p>0.05) (Table). Incidence of sealer, sealer and gutta-percha overextension was significantly more frequent in the XP group than in the PU group, 19 (82.6%) and 12 (52.2%) respectively, p=0.028 (Table). The chance of the obturation material overextension in the XP group is higher compared with the PU group (OR (4.354; 95 % CI 1.106-16.854). The null hypothesis, that root canal shaping with two different rotary systems will not affect the incidence of obturation material overextension, was rejected.

DISCUSSION

Complicated root canal anatomy makes challenges in endodontic treatment during cleaning, shaping and obturation procedures. This in vitro study aimed to assess the influence of XP and PU rotary systems on GC and sealer overextension in curved root canals. Moderately and severely curved root canals were included in this study, hence these conditions make an obturation procedure more complex. Also, other authors revealed a significant relationship between the extent of the root canal curvature and filling material homogenity and adaptation (17, 18). The study was performed on extracted human teeth as physiological apical constriction can affect the obturation material movement through the apex. An ex vivo study design simulating apical resistance created by periodontal ligament was declined since it could have inhibited the flow of obturation material and biased the results. Previous studies also used the open model system, with no periodontal ligament imitation, to assess the appearance of the root canal filling material overextension (19, 20). On the contrary, Mancino *et al.* in their in vitro study of different obturation techniques quality evaluation used a closed model system by sealing an apex with cyanoacrylate glue (5).

The ProTrain endodontic procedures laboratory training kit was used in this research. The kit includes the training platform and electroconductive gel, recommended as embedding media. The Protrain allows the WL establishment by electronic and radiographic means while keeping the tooth fixed (21, 22). Also, it helps to standardize the distance between an x-ray

film and a tube head. The goal of using ProTrain was to mimic clinical scenarios and to achieve precise WL establishment. Other in vitro studies, which included core-carriers and were conducted on extracted human teeth, used various methods for the WL measurement. In three studies the WL was assessed microscopically. When a k-file had reached an apical foramen, the WL was defined as 1.0 mm or 0.5 mm shorter than the root canal length (19, 20, 23). The other two studies detected the WL in the same manner, however, no magnification was mentioned (17, 24). Only in one research, the specimens were mounted on ProTrain, and the WL was obtained with a k-file using conductive gel and an electronic apex locator (5). However, Iparraguirre Nuñovero and co-authors compared two different embedding media (alginate and electroconductive gel) used in a laboratory setting for electronic root canal length measurement. The results revealed that the ProTrain conductive gel resulted in more overextension cases than alginate while measuring the length of the root canal (25). Thus, it could be a possible explanation for the current study results why there were cases of GC and sealer overextension.

In this study, two different rotary file systems were used. XP is a single file system and has been shown, to have the same preparation quality as multiple instrument systems (15). It is advantageous concerning the working time and patient's and operator's fatigue. According to the manufacturer, the instrument can reach a final diameter of ISO .30 and a taper of .04. PU is the latest generation of the ProTaper rotary instruments family. This system is manufactured by using a specific heat treatment technology to induce distinct crystallographic arrangements and, consequently, to create flexible and strong rotary instruments (12). The finishing PU instrument used in this study shapes the apical part to ISO .30 and has a .09 varied taper. The GC obturators were chosen by the manufacturer's instructions. In the XP group one size smaller than the final instrument. In the PU group, with the final shape greater than .06 taper, the same size as the final instrument. However, the results of the current study revealed a higher overextension of obturation materials (sealer and gutta-percha) in the XP group than in the PU group. Probably the smaller size GC obturator that has been chosen according to the manufacturer's instructions could cause the overfilling of the material in the XP group. The instructions could be revised according to the GC obturator selection and final shape taper. Azim *et al.* revealed that the final preparation taper of XP varies depending on the anatomy of the treated tooth as the instrument follows the original anatomy. Such data suggest that it is not possible to predict the final taper of the preparation achieved by the XP (26). The possibility of greater taper might be the cause of a higher incidence of obturation material overextension in the XP group than in the PU group. Also, Whitten and Levitan observed a higher incidence of overfilling while using size smaller GC obturator in canals with a .04 taper, than filling canals with the same as the final instrument size obturator (19). Based on these results, it could be speculated that the smaller size obturator used in the XP group impacted the higher incidence of obturation material. These findings highlight the importance of GC obturator size verification.

Heeren and Levitan compared the extension of two thermoplastic obturation systems - Thermafil Plus (Dentsply Tulsa Dental, Tulsa, OK) and RealSeal 1 (SybronEndo, Glendora, CA). They evaluated two different straight root canal preparation methods – a .04 standardized taper preparation and a varied taper preparation as well. The results showed that with RealSeal 1 obturation system the canals can be obturated with a low chance of overextension in both root canal preparation groups. However, in the Thermafil Plus group, a significantly higher incidence of obturation material extension over the apex appeared in the standardized taper preparation group than in the varied taper preparation group (20). In another in vitro study, the overextension of GC obturation material in straight root canals, prepared with standard or varied taper, was evaluated. The outcome of the study revealed a higher number of cases with obturation material overextension in the standardized taper group than in the varied taper group (19). According to the results of these two in vitro studies and the current study outcome, it might be speculated that the canals shaped in varied taper can be obturated with core-carriers with a low likelihood of obturation material overextension.

CONCLUSION

The root canals prepared with XP and obturated with GC according to the manufacturer's instructions had a higher obturation material overextension incidence in curved root canals compared to the PU.

STATEMENT OF CONFLICTS OF INTEREST

The authors state no conflict of interest.

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REFERENCES

1. Liu H, Lai WWM, Hieawy A, Gao Y, von Bergmann H, Haapasalo M, Tay FR, Shen Y. Micro-computed Tomographic Evaluation of the Quality of Root Canal Fillings in Mandibular Molars after Obturation for 54 Months. J Endod. 2021;47:1783-1789.
2. Schaeffer MA, White RR, Walton RE. Determining the optimal obturation length: a meta-analysis of literature. J Endod. 2005;31:271-4.
3. Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodon-tic treatment. J Endod. 1990;16:498-504.
4. Zogheib C, Naaman A, Sigurdsson A, Medioni E, Bourbouze G, Arbab-Chirani R. Comparative mi-cro-computed tomographic evaluation of two carrier-based obturation systems. Clin Oral Investig. 2013;17:1879-83.
5. Mancino D, Kharouf N, Cabiddu M, Bukiet F, Haïkel Y. Microscopic and chemical evaluation of the filling quality of five obturation techniques in oval-shaped root canals. Clin Oral Investig. 2021;25:3757-3765.
6. Yadav S, Nawal RR, Chaudhry S, Talwar S. Assessment of Quality of Root Canal Filling with C Point, Guttacore and Lateral Compaction Technique: A Confocal Laser Scanning Microscopy Study. Eur Endod J. 2020;5:236-241.
7. Soo WK, Thong YL, Gutmann JL. A comparison of four gutta-percha filling techniques in simulat-ed C-shaped canals. Int Endod J. 2015;48:736-46.
8. Suguro H, Takeichi O, Hayashi M, Okamura T, Hira A, Hirano Y, Ogiso B. Microcomputed tomo-graphic evaluation of techniques for warm gutta-percha obturation. J Oral Sci. 2018;60:165-169.
9. Beasley RT, Williamson AE, Justman BC, Qian F. Time required to remove guttacore, thermafil plus, and thermoplasticized gutta-percha from moderately curved root canals with protaper files. J Endod. 2013;39:125-8.
10. Wong AW, Zhang S, Li SK, Zhang C, Chu CH. Clinical studies on core-carrier obturation: a sys-tematic review and meta-analysis. BMC Oral Health. 2017;17:167.
11. Gavini G, Santos MD, Caldeira CL, Machado MEL, Freire LG, Iglecias EF, Peters OA, Candeiro GTM. Nickel-titanium instruments in endodontics: a concise review of the state of the art. Braz Oral Res. 2018;32(suppl 1):e67.
12. Martins JNR, Silva EJNL, Marques D, et al. Characterization of the file-specific heat-treated ProTaper Ultimate rotary system. Int Endod J 2023;56:530–42.
13. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol. 1971;32:271-5.
14. Elnaghy A, Elsaka S. Cyclic fatigue resistance of XP-endo Shaper compared with different nickel-titanium alloy instruments. Clin Oral Investig. 2018;22:1433-1437.
15. Marques JLC, Freire LG, Scardini IL, Vieira BR, de Sousa FB, Dos Santos M. Shaping efficiency of XP-endo shaper and Mtwo instruments in long oval root canals: A micro-CT study. Aust Endod J. 2021 ;47(3):624-630.
16. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature -- Part 2. Influence of clinical factors. Int Endod J. 2008;41:6-31.
17. Neuhaus KW, Schick A, Lussi A. Apical filling characteristics of carrier-based techniques vs. single cone technique in curved root canals. Clin Oral Investig. 2016;20:1631-7.
18. Leung SF, Gulabivala K. An in-vitro evaluation of the influence of canal curvature on the sealing ability of Thermafil. Int Endod J. 1994;27(4):190-6.
19. Whitten RB, Levitan ME. The effect of canal preparation on fill length in straight root canals obtu-rated with GuttaCore. J Endod. 2015;41:155-8.
20. Heeren TJ, Levitan ME. Effect of canal preparation on fill length in straight root canals obturated with RealSeal 1 and Thermafil Plus. J Endod. 2012;38:1380-2.
21. Mancini M, Felici R, Conte G, Costantini M, Cianconi L. Accuracy of three electronic apex locators in anterior and posterior teeth: an ex vivo study. J Endod. 2011;37:684-7.
22. Cianconi L, Angotti V, Felici R, Conte G, Mancini M. Accuracy of three electronic apex locators compared with digital radiography: an ex vivo study. J Endod. 2010;36:2003-7.
23. Angerame D, De Biasi M, Brun F, Turco G, Franco V. Computed microtomography study of un-treated, shaped and filled mesiobuccal canals of maxillary first molars. Aust Endod J. 2019;45:72-78.
24. Schäfer E, Schrenker C, Zupanc J, Bürklein S. Percentage of Gutta-percha Filled Areas in Canals Obturated with Cross-linked Gutta-percha Core-carrier Systems, Single-Cone and Lateral Compac-tion Technique. J Endod. 2016;42:294-8.
25. Iparraguirre Nuñovero MF, Piasecki L, Segato AVK, Westphalen VPD, Silva Neto UX, Carneiro E. A laboratory study of the accuracy of three electronic apex locators: influence of embedding media and radiographic assessment of the electronic apical limit. Int Endod J. 2021;54:1200-1206.
26. Azim AA, Piasecki L, da Silva Neto UX, Cruz ATG, Azim KA. XP Shaper, A Novel Adaptive Core Rotary Instrument: Micro-computed Tomographic Analysis of Its Shaping Abilities. J Endod. 2017;43:1532-1538.

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