

APICAL SEALING EFFICIENCY OF DIFFERENT OBTURATION TECHNIQUES OVER APICALLY BROKEN ROTARY NICKEL-TITANIUM FILES (AN IN VITRO STUDY)

Abd El-Wahed MI¹ BDS, Zaazou AM² PhD, El Mallakh BF³ PhD

Abstract:

Introduction: A broken instrument within the root canal is a panic problem which one should never wish to occur during routine endodontic therapy. However, the decision regarding how to manage this problem is complex. Therefore, the clinician must evaluate carefully the options of treatment; retrieving the instrument; bypassing the instrument; or leaving the fractured instrument in the canal as part of the final root canal filling.

Objective: The objective of this study is to compare the sealing ability of three obturation techniques over apically broken nickel-titanium (Ni-Ti) ProTaper file.

Materials and methods: Forty eight extracted human single-rooted mandibular premolars were prepared using ProTaper files (PT) and subjected to breakage of 3mm from F5 tip at the apical one third of the canal. The canals were randomly divided into three groups of 12 teeth each according to type of obturation technique; E&Q plus obturation, using a Thermafil obturator, or lateral compaction technique. The remaining 12 teeth served as positive controls which contained canals with apically broken files only without any type of obturation. Apical leakage was assessed by the dye penetration method in which all teeth were immersed in 2% methylene blue dye for 48 hours. Then the specimens were longitudinally split into two halves. Linear dye penetration was measured in millimeters under a stereomicroscope for each specimen. Statistical analysis of the results was performed using Kruskal-Wallis and post hoc tests.

Results: The results showed no statistically significant difference in apical leakage between the three obturation techniques used over apically broken F5 files.

Conclusions: All obturation techniques used over apically broken PT files played a significant role in the sealing ability.

Key words: apically broken file, ProTaper, obturation technique, apical leakage

1- Masters student of Endodontics, Department of Conservative Dentistry, Faculty of Dentistry- Alexandria University. Dentist at the Ministry of Health, Egypt.

2- Assistant Professor of Endodontics, Department of Conservative Dentistry, Faculty of Dentistry, Alexandria University, Egypt.

3- Professor of Dental Biomaterials, Department of Dental Biomaterials, Faculty of Dentistry, Alexandria University, Egypt.

INTRODUCTION

In practice, there are many procedural accidents that affect the prognosis of root canal therapy. One of the most common procedural accidents is instrument separation that usually occurs due to incorrect use or overuse of an endodontic instrument (1). Although rotary nickel-titanium (Ni-Ti) instruments have high flexibility, they are more frequently fractured than stainless steel hand instruments without warning (2-5). The fracture of rotary NiTi files results from torsional failure or cyclic fatigue (6). The majority of separated Ni-Ti instruments occur in the apical third of the canal where they are difficult to retrieve (7).

Despite technological advancements of instruments and techniques for removing a separated instrument from the root canal, the retrieval of the separated instrument still has been a complicated procedure in endodontic clinical work. Therefore, when the fractured instruments are impossible to retrieve, endodontists prefer to incorporate them as part of the final root canal filling (8). In such cases, a good quality obturation is required so that the sealer or the obturation materials may seal the spaces between the flutes of the broken file resulting in an adequate apical seal (9). Recently, a variety of thermo-plasticized gutta-percha techniques have been

introduced to the market which provide better sealing ability for the root canal.

Consequently, the goal of this study is to evaluate the quality of apical sealing ability of three different obturation techniques namely E&Q plus obturation, Thermafil, and cold lateral compaction over apically broken Ni-Ti ProTaper. The null hypothesis tested was that there would be no significant difference in the apical sealing ability of the three aforementioned obturation techniques when used over apically broken Ni-Ti ProTaper file

MATERIALS AND METHODS

Forty eight freshly extracted human single rooted permanent mandibular premolar teeth were selected to be mature with fully formed apices, no root caries, resorption or fracture; radiographed to confirm the presence of a single canal then were stored in 10% formalin solution. A standard endodontic access cavity was prepared using a #2 high speed round carbide bur then followed by an endo-Z bur for lateral extensions and flaring of the cavity walls, then explored by an endodontic explorer to confirm straight line access.

Canal patency was established by passing a #10 K-file into the canal until it was just visible at the apical

foramen. The working length was determined with a #10 K-file, by subtracting 1 mm from the canal length. An initial file was selected according to canal anatomy that bound within the canal walls then this file was used to perform a smooth glide path. The canals were subsequently prepared using ProTaper Universal nickel titanium rotary files (Dentsply Maillefer, Ballaigues, Switzerland) in the following sequence; (S1, S2, F1, F2, F3, F4, F5) using an endodontic electric motor with reduction 20:1 contra angle hand piece (Endo Mate DT, NSK Japan) at a speed of 250 rpm and torque setting 3.5. Irrigation between each successive file was done by using 2.5% sodium hypochlorite (NaOCl) together with Glyde (Dentsply Maillefer Ballaigues, Switzerland) applied to the tip of each file prior to use.

Root canal preparation was carried out until F5 file was used 2mm short of the working length. Another F5 file was previously nicked with a diamond stone 3mm from the tip then was introduced under steady pressure till separation occurred. All canals were subsequently radiographed to ensure that separation occurred in the apical one third of the canal. Then they received irrigation of 5 ml of 17% ethylene-diamine-tetra acetic acid (EDTA) for one minute then washed with 5 ml of 2.5% NaOCl solution, followed by 5 ml of saline solution as a final rinse to eliminate the residual effect of the irrigant. Then they were dried by paper points to be ready for obturation. The canals were randomly divided into four groups of 12 teeth each according to the technique used for obturation.

Group I (E&Q plus obturation): The diameter of the tip of the broken file was measured using a gutta percha gauge, and a single ProTaper gutta percha point (Dentsply Maillefer Ballaigues, Switzerland) corresponding to a size F5 file was trimmed to the same tip diameter with a scalpel. The suitable size of E&Q pen tip and hand plugger that goes 3 mm short of the broken file were selected as a binding point. Topseal sealer was applied in the canal on the trimmed gutta-percha tip of the master cone. The E&Q pen (Meta biome Korea) was set at a temperature of 200 °C and the selected pen tip was activated to sear off the master cone at canal orifice and inserted into the canal to condense the gutta percha till a binding point. The backfill of the remaining part of the canal was done by using E&Q gun of obturation unit that was set on a temperature of 180 °C. Then the gutta percha was injected into the canal using a gun needle gauge 25 and condensed by using a hand plugger to avoid voids in the obturation.

Group II (Thermafil obturator): A Thermafil obturator F5 was cut at 3 mm by a scalpel corresponding to ProTaper points, then Topseal was applied into the canal as with group I. It was heated in a Thermaprep oven for (30-45) seconds then slowly inserted into the canal to the working length with continuous firm apical pressure over the apical broken file to limit shrinkage of the gutta percha while cooling. The shaft of the obturator was cut off at the canal orifice using a Thermacut bur. The coronal gutta percha around the plastic carrier was

compacted using hand pluggers.

Group III (lateral compaction technique): The size of the ProTaper F5 gutta-percha was cut at 3mm by scalpel then Topseal sealer coated the trimmed gutta-percha tip and was applied to the canals. Each canal was obturated by the trimmed ProTaper cone and accessory gutta-percha cones over the apical broken file using lateral condensation technique by using finger spreaders.

Group IV (Positive control): Canals contained apically broken files only and the remainder of the canal was left unobturated. This group acted as a positive control.

After obturation, the coronal access was sealed with Cavit (Espe, Germany) and all specimens were radiographed bucco-lingually and mesio-distally as presented in (Fig.1 A,B, C) then were stored for two weeks at 37°C and 100% humidity to allow for complete setting of the sealer.

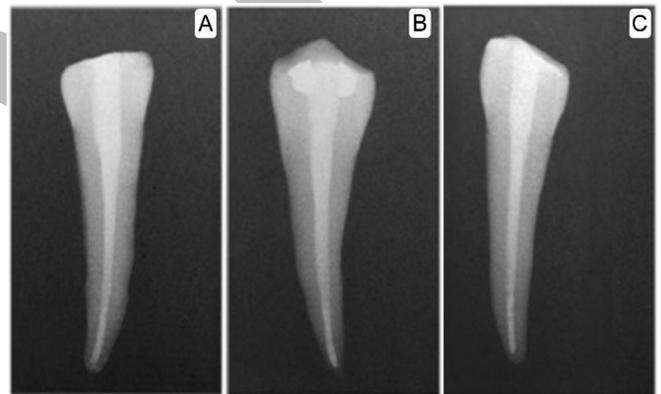


Fig 1: Periapical X-ray films showing a bucco-lingual view of teeth obturated with: A) E&Q plus obturation. B) Thermafil obturation. C) Lateral condensation technique.

Evaluation of the sealing ability: In all groups, the teeth were dried with compressed air then coated with a double coating of nail polish and a layer of sticky wax except 1 mm of the apical foramina of roots. All specimens were immersed in 2% methylene blue solution for 48 hours. Then they were washed under tap water and dried with compressed air. Sticky wax and coating layers were removed from external teeth surfaces. Then all specimens were grooved longitudinally from buccal and lingual surfaces using a diamond disc in a low speed hand piece, in a direction parallel to the long axis of the tooth through the apex then they were split by a chisel into two halves (10). All specimens were finished and polished using wetted smooth sand paper. Linear dye penetration was measured by two observers in millimeters under 30X magnification power using an optical stereomicroscope. Statistical analysis of the results was performed using non parametric Kruskal-Wallis test which was used to compare median leakage and followed by post hoc test to identify the different groups responsible for statistical significance. The P value was set to ≤ 0.05 .

RESULTS

Collected data were described using range (minimum and maximum) mean, standard deviation and average (median), as presented in (Table 1) and (Fig. 2). The results of this study showed no statistically significant differences in apical leakage when comparing E & Q plus, Thermafil, and Lateral condensation as obturation techniques over an apically broken F5 ProTaper file. Group IV (positive control) showed the highest apical leakage, and was significantly different when compared with the other three groups at P <0.001.

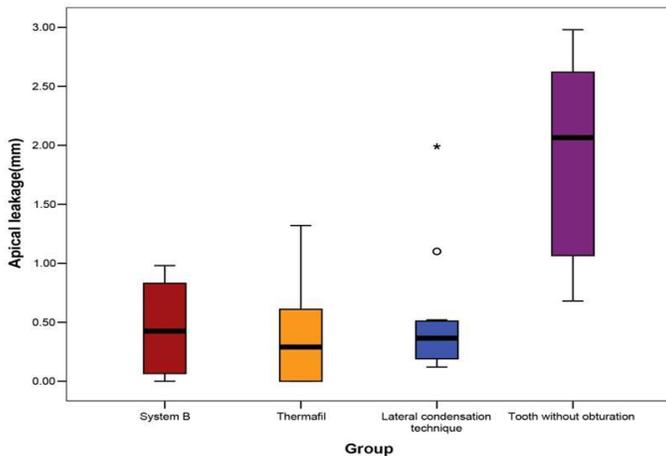


Fig 2: Box Plot showing the range and average of apical dye penetration (mm) of the four experimental groups.

Table 1: The average of apical leakage, mean, standard deviation, minimum and maximum values for each group.

Group	N	Apical leakage(mm)					H (P)
		Minimum	Maximum	Mean	SD	Median	
E&Q plus obturation	12	0.00	0.98	0.44	0.38	0.43	22.0 (0.001)
Thermafil	12	0.00	1.32	0.39	0.45	0.29	
Lateral condensation technique	12	0.12	1.99	0.52	0.53	0.37	
Teeth without obturation	12	0.68	2.98	1.90	0.83	2.07 d	

N= number of specimens. SD= standard deviation
 H: Kruskal-Wallis test. * P < 0.05 (significant).
 d: significantly different group identified by Post Hoc test.

DISCUSSION

Fracture of endodontic instruments within the root canal is a frustrating problem that creates a major obstacle during routine endodontic therapy (1, 11). Nickel-titanium rotary instruments have been developed to simplify and improve the efficacy of endodontic shaping procedures. However, instrument separation occurs without warning during clinical use (11-14). Numerous factors have been contributed to the fracture of NiTi instruments including cyclic fatigue (1, 4, 15-17), operator skill / experience, instrumentation technique, dynamics of instrument use, number of uses, instrument

design, anatomical configuration of the canals, and effect of sterilization (18).

Removal of fractured files has been technically difficult, time consuming and high risk of procedure errors (18). On the other hand, some studies concluded that the presence of a fragment of the fractured instrument in the root canal had little influence on the rate of endodontic failure when the root canal treatment was performed under ideal conditions (19, 20).

A ProTaper universal Ni Ti rotary file was selected as it is one of the most commonly used NiTi rotary systems. According to debates concerning the extent of apical enlargement, it has been recommended to enlarge apical preparation to more than #25 to allow more efficient irrigation (21). In addition, the apical preparation larger than #40 has been advocated for removing a higher amount of infected dentin and for promoting proper cleaning of the apical region of root canals (22).

Therefore; in the present study, F5 ProTaper file with 5% taper and 0.50 tip diameter was used as an apically broken file when comparing the apical sealing ability of three obturation techniques as found by Madarati et al in 2010 (23). While most of the previous studies (10, 24, 25) evaluated the apical sealing ability of different obturation techniques over apically broken F3 ProTaper files. Regardless of the instrument size, the master file was used 2 mm shorter than the working length to create a tighter apical diameter to facilitate file separation at the apical one third of the tooth. Another file which was previously nicked with a diamond stone 3 mm from the tip to ease the separation process was then introduced under steady pressure till separation occurred. This method of file separation allowed the broken file firmly bind to the canal wall as well as simulating the clinical condition.

Three dimensional obturation of radicular space is essential for long-term success of endodontic treatment. There are various techniques used to obturate the root canal system, as cold lateral compaction which is widely used by practitioners and is proven as a clinically effective filling technique. Nevertheless, some studies reported the creation of voids, spreader tracts, excessive volume of sealer, and lack of surface adaptation to canal walls (9). The thermo-plasticized obturation techniques were recently introduced to improve the homogeneity and surface adaptation of gutta percha (26). The Thermafil system is one of the most common carrier based obturation systems at which thermo-plasticized gutta-percha could be more easily introduced into the root canal using a carrier to provide a void free obturation along with minimal sealer thickness and a higher degree of homogeneity (27, 28). Also E&Q plus obturation is one of the combined obturation systems, based on continuous warm vertical compaction as System B and thermo-plasticized injectable obturation technique as Obtura II. This combination provides significantly superior sealing ability over a separated F3 ProTaper tip when compared to both lateral condensation

and ultrasonic thermo-plasticized gutta percha obturation techniques, as found by Hussein, and Zaazou in 2008 (10).

Therefore, in this study, the apical sealing ability of the three aforementioned obturation techniques in conjunction with Topseal sealer were compared over an apical broken F5 file. Topseal was used as epoxy amine-resin based sealer which is characterized with its excellent biocompatibility, low viscosity, self-adhesive properties, and dimensional stability (29).

Dye penetration has been long used as an apical microfiltration assessment method. Although new methods have been introduced to evaluate microfiltration, but the dye penetration still showed no significant difference when compared to these methods (30, 31). According to Ahlberg et al in 1995, methylene blue has been proved to be a useful aid in endodontics (32). Methylene blue dye was used in the present study as it has been inexpensive, easy to manipulate, has a high degree of staining and a molecular weight even lower than that of bacterial toxins (33). All specimens were grooved longitudinally from buccal and lingual surfaces using a diamond disc then were split by a chisel into two halves (10). This enabled examination of the exposed filling material and any dye penetration into the material or at the dentin-material interface on one side as supported by Ahlberg et al (32).

The results of this study showed no statistically significant difference in apical leakage when compared E & Q plus, Thermafil, and Lateral condensation as obturation techniques over an apical broken F5 ProTaper file. The results were in agreement with the results of Saunders et al (2004) and Mohammadi, and Khademi (2006) who reported that the presence of 3 mm of fractured instrument within the apical third of a root canal had no influence on the time required for bacterial penetration, and it did not compromise the obturation of the root canal space (8, 34). As well, they found that the fractured instrument has flutes, so it is questionable to completely obturate the root canal space by itself. So when the sealer extruded between the flutes of the fractured file, it will become equivalent to any other obturation material (8). On the contrary, the results of the present study were in disagreement with previous studies (9, 10, 24, 25, 35). This disagreement might be due to the difference in leakage test used, obturation techniques, filling materials and sealers, as well as the use of different sizes of ProTaper or different types of rotary. Also other factors might have been contributed to that conflict such as variations in root canal anatomy of the selected teeth and the difference of operator's experience.

Regarding fractured ProTaper instruments, Altundasar et al in 2008 (24) reported that teeth with fractured ProTaper instruments showed significantly less leakage than those filled without fractured ProTaper instrument, regardless of the obturation technique used as consistent with Taneja et al in 2012 (9). The method of file separation in this study occurred under stress that was created through increased contact and binding of the file

within the canal. So this screwing force that led to the separation of ProTaper files could have forced the instrument firmly into the dentin, allowing a more intimate contact between the file and the root canal walls at the apical one third (9). Moreover, ProTaper files are triangular cross sectional design with sharp cutting edges and no radial land which results in better debris removal and less irregularities in prepared canal. That is why; the broken F5 ProTaper file provided a good apical seal by itself.

CONCLUSIONS

The thermo-plastic obturation techniques demonstrated better sealing ability over apically broken PT file when compared to lateral condensation technique. As well, the fractured file would be incorporated as part of the final obturation to minimize the hazards of apical leakage.

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STATEMENT OF CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

- 1- Gambarini G. Cyclic fatigue of ProFile rotary instruments after prolonged clinical use. *Int Endod J* 2001; 34: 386-9.
- 2- Alapati SB, Brantley WA, Svec TA, Powers JM, Nusstein JM, Daehn GS. SEM observations of nickel-titanium rotary endodontic instruments that fractured during clinical use. *J Endod* 2005; 31: 40-3.
- 3- Ankrum MT, Hartwell GR, Truitt JE. K3 Endo, ProTaper, and ProFile systems: breakage and distortion in severely curved roots of molars. *J Endod* 2004; 30: 234-7.
- 4- Pruett JP, Clement DJ, Carnes DL Jr. Cyclic fatigue testing of nickel-titanium endodontic instruments. *J Endod* 1997; 23: 77-85.
- 5- Arens FC, Hoen MM, Steiman HR, Dietz GC Jr. Evaluation of single-use rotary nickel-titanium instruments. *J Endod* 2003; 29: 664-6.
- 6- Sattapan B, Palamara J E A, Messer H H. Torque during canal instrumentation using rotary nickel-titanium files. *J Endod* 2000; 26: 156-60.
- 7- Spili P, Parashos P, Messer HH. The impact of instrument fracture on outcome of endodontic treatment. *J Endod* 2005; 31: 845-50.
- 8- Saunders JL, Eleazer PD, Zhang P, Michalek S. Effect of a separated instrument on bacterial penetration of obturated root canals. *J Endod* 2004; 30: 177-9.
- 9- Taneja S, Chadha R, Gupta R, Gupta A. Comparative evaluation of sealing properties of different obturation systems placed over apically fractured rotary NiTi files. *J Conserv Dent* 2012; 15: 36-40.

- 10- Hussein AN, Zaazou A. Sealing ability of different obturation systems applied over apically separated rotary nickel-titanium files. *CDJ* 2008; 24: 205-9.
- 11- Parashos P, Messer HH. Rotary NiTi instrument fracture and its consequences. *J Endod* 2006; 32: 1031-43.
- 12- Peters OA, Barbakow F. Dynamic torque and apical forces of ProFile. 04 rotary instruments during preparation of curved canals. *Int Endod J* 2002; 35: 379-89.
- 13- Young JM, Van Vliet KJ. Predicting in vivo failure of pseudoelastic NiTi devices under low cycle, high amplitude fatigue. *J Biomed Mater Res B Appl Biomater* 2005; 72: 17-26.
- 14- Sattapan B, Nervo GJ, Palamara JE, Messer HH. Defects in rotary nickel-titanium files after clinical use. *J Endod* 2000; 26: 161-5.
- 15- Gambarini G. Cyclic fatigue of nickel-titanium rotary instruments after clinical use with low- and high-torque endodontic motors. *J Endod* 2001; 27: 772-4.
- 16- Yared GM, Bou Dagher FE, Machtou P. Cyclic fatigue of Profile rotary instruments after simulated clinical use. *Int Endod J* 1999; 32: 115-9.
- 17- Yared GM, Bou Dagher FE, Machtou P. Cyclic fatigue of Profile rotary instruments after clinical use. *Int Endod J* 2000; 33: 204-7.
- 18- McGuigan MB, Louca C, Duncan H F. Endodontic instrument fracture: causes and prevention. *BDJ*; 2013; 214: 341-8.
- 19- Alazrag M. The Effect of Fractured Instruments on the Prognosis of Endodontic Treatment. *Health & Medicine*, 2015. Available at: <http://www.slideshare.net/mohammedalazrak9/prognosis-of-fractured-instrument-47537712>
- 20-Simon S, Machtou P, Tomson P, Adams N Lumley P. Influence of Fractured Instruments on the Success Rate of Endodontic Treatment. *Endodontics* 2008; 35: 172-9.
- 21- Boutsoukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW. The effect of apical preparation size on irrigant flow in root canals evaluated using an unsteady Computational Fluid Dynamics model. *Int Endod J* 2010; 43: 874-8.
- 22- Baratto-Filho F, Leonardi DP, Zielak JC, Vanni JR, Sayão-Maia SM, Sousa-Neto MD. Influence of ProTaper finishing files and sodium hypochlorite on cleaning and shaping of mandibular central incisors - a histological analysis. *J Appl Oral Sci* 2009; 17: 229-33.
- 23- Madarati AA, Qualtrough AJ, Watts DC. Effect of retained fractured instruments on tooth resistance to vertical fracture with or without attempt at removal. *Int Endod J* 2010; 43: 1047-53.
- 24- Altundasar E, Sabin C, Ozcelik B, Cehreli ZC. Sealing properties of different obturation systems applied over apically fractured rotary nickel-titanium files. *J Endod* 2008; 34: 194
- 25- Moreno GVA, Argüello RG, Pérez THE. Assessment of apical sealing of three warm obturation techniques in the presence of fractured NiTi rotary instruments. *Rev Odont Mex* 2013; 17: 20-5.
- 26- Weller RN, Kimbrough WF, Anderson RW. A comparison of the thermoplastic obturation techniques: Adaption to the canal walls. *J Endod* 1997; 23: 703-6.
- 27- Weis MV, Parashos P, Messer HH. Effect of obturation technique on sealer cement thickness and dentinal tubule penetration. *Int Endod J* 2004; 37: 653-63.
- 28- Gulsahi K, Cehreli ZC, Kuraner T, Dagli FT. Sealer area associated with cold lateral condensation of gutta-percha and warm coated carrier filling systems in canals prepared with various rotary NiTi systems. *Int Endod J* 2007; 40: 275-81.
- 29- Sevimay S, Kalayci A. Evaluation of apical sealing ability and adaptation to dentine of two resin based sealer. *J Oral Rehabil* 2005; 32: 105-10.
- 30- Camps J, Pashley D. Reliability of the dye penetration studies. *J Endod* 2003; 29: 592-4.
- 31- Pathomvanich S, Edmunds DH. The sealing ability of Thermafil obturators assessed by four different microleakage techniques. *Int Endod J* 1996; 29: 327-34.
- 32- Ahlberg KM, Assavanop P, Tay WM. A comparison of the apical dye penetration patterns shown by methylene blue and india ink in root-filled teeth. *Int Endod J* 1995; 28: 30-4.
- 33- Verissimo DM, do Vale MS. Methodologies for assessment of apical and coronal leakage of endodontic filling materials: a critical review. *J Oral Sci* 2006; 48: 93-8.
- 34- Mohammadi Z, Khademi AA. Effect of a separated rotary instrument on bacterial penetration of obturated root canals. *J Clin Dent* 2006; 17: 131-3.
- 35- Hegde J, Bashetty K, Kumar K, Chikkamallaiah C. Comparative evaluation of the sealing ability of different obturation systems used over apically separated rotary nickel-titanium files: An in vitro study. *J Conserv Dent* 2013; 16: 408-12.