

CLINICAL ARTICLE

Effectiveness of ProFile .04 Taper Rotary Instruments in Endodontic Retreatment

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This study investigated the retreatment effectiveness of .04 Taper nickel-titanium rotary ProFiles. Thirty extracted single-rooted anterior teeth were instrumented and obturated with gutta-percha/Roth's Sealer using lateral condensation. They were distributed into three groups of 10 each. Retreatment for group A was done using Profile alone, group B using Profile and chloroform, and group C using hand files with chloroform. The teeth were then split longitudinally into halves. The remaining gutta-percha/sealer on the root canal wall in the cervical, middle, apical thirds, and the whole canals were visually scored with the aid of light microscopes. The results showed that the mean scores in groups A and B were generally lower (better) than group C. Mean scores of the apical thirds tended to be higher (worse) than the middle and the cervical thirds, except in group A. ProFile with or without chloroform seemed to be a viable alternative retreatment method.

Nonsurgical endodontic retreatment, when indicated (1), requires regaining of access to the entire root canal system through complete removal of the pre-existent endodontic obturating material. This enables thorough chemomechanical reinstrumentation and disinfection of the root canal system, which are prerequisites for successful retreatment (2).

Although various materials have been proposed for root canal obturation, gutta-percha, in combination with a variety of sealers, is the most commonly used material. Gutta-percha removal can be effected by endodontic hand files, heat-carrying instruments, ultrasonic devices, or rotary instruments with or without the aid of solvents (3–7). In clinical practice, chloroform is the most effective and the most widely used solvent for gutta-percha (8). However, its safety has been a topic of long debate. Chloroform is classified as a carcinogen (9). Its possible damage to local periapical tissues and

the systemic toxicity and health hazard risk to dental personnel through repeated chloroform vapor inhalation cannot be overlooked (6, 10).

In recent years, nickel-titanium (NiTi) files have been used increasingly in root canal preparation due to their unique physical properties. Increased flexibility is considered advantageous in instrumenting root canals of challenging shapes (11, 12). ProFile .04 Taper Series 29 Rotary instruments (Tulsa Dental Products, Tulsa, OK) are one of the additions to endodontic armamentaria. According to the usage guidelines by the manufacturers this automated instrument is also designed to remove gutta-percha at an rpm of ~500 to 2,500 (12). To date, only two reports on the retreatment effectiveness of ProFile rotary instruments have been documented (13, 14). The retreatment in both studies was conducted in combination with chloroform. To our knowledge, no study has yet evaluated the effectiveness of ProFile rotary instruments used without chloroform in the retreatment of gutta-percha-obturated root canals. It is not known if the use of chloroform would make any difference in the cleanliness of the root canals after retreatment using the ProFile rotary system.

The purpose of our study was therefore to compare the effectiveness in retreating gutta-percha-obturated root canals using ProFile, with and without the aid of chloroform, to hand files with chloroform.

MATERIALS AND METHODS

Sample Preparation

Thirty extracted human single-canal anterior teeth verified radiographically as having patent canals of curvature <30 degrees were selected. Soft tissue and calculus were mechanically removed from the root surfaces. To achieve a certain degree of uniformity, the teeth were carefully distributed into 10 sets of 3 teeth each, according to the canal length and width. In addition, to reduce interoperator variables, each experimental procedure was conducted by the same operator. The 10 sets of teeth were wrapped with saline-saturated cotton wool and stored in 10 separate sealed containers maintained at 100% humidity at 37°C between each experimental stage of the study to simulate oral conditions.

Root Canal Instrumentation and Obturation

Access preparation was made on each tooth using high-speed tungsten carbide round burs and slow-speed round burs. Working lengths were visually determined with the use of #15 K-Flex files (Kerr/Sybron, Romulus, MI) to 1 mm short of the anatomical apices. Root canal preparation was done by a step-back technique using K-Flex files apically to master apical file size 55, and the canal was cervically flared sufficiently to accommodate a fine-medium finger spreader (Kerr/Sybron) to within 2 mm of the working length. Sodium hypochlorite (Riochlor) 1% irrigation was used during cleaning and shaping.

The canals were laterally condensed using master gutta-percha cones (Dentsply Asia) size 55. Roth's 801 Sealer (Roth's Root Canal, Chicago, IL) was mixed according to the manufacturer's instructions to ensure consistency, and the same mix was used for the same set of teeth. The same number of fine-medium accessory gutta-percha cones was used for the teeth within the same set of samples. A heated plugger was used to remove the gutta-percha to the level of the cementoenamel junction. The access cavities were temporized with a minimum of 3 mm Cavit (ESPE) to serve as barrier to the ingress of fluids. Teeth were radiographed in buccolingual and mesiodistal directions to confirm the adequacy of the root canal obturation. All teeth were then restored at 100% humidity and 37°C for a period of ~3 months.

Retreatment Technique

The 3 teeth in each of the 10 sets of samples were then randomly assigned to one of the three different modes of retreatment. The temporary restorations were removed. For all teeth, the cervical third of the gutta-percha was removed using a heated 5/7 plugger (Kerr/Sybron). The apical two-thirds of the gutta-percha/sealer were retreated according to one of the three methods described herein.

GROUP A—PROFILE .04 TAPER ROTARY INSTRUMENT ALONE

A NiTi ProFile rotary file size ISO #45 was worked down to the working length. Instrumentation was completed with the NiTi rotary file size 60.

GROUP B—PROFILE NITI ROTARY INSTRUMENT AND CHLOROFORM

Increments of 0.05 ml of chloroform (Mallinkrodt Specialty Chemicals, Paris, KY) were injected into the canals to soften the gutta-percha. A NiTi ProFile rotary file ISO #45 was worked down to the working length. The instrumentation was completed with the NiTi rotary file size 60.

GROUP C—CONVENTIONAL HAND FILES WITH CHLOROFORM

Increments of 0.05 ml of chloroform were injected into the canals to soften the gutta-percha. Hedstrom files starting from size 25 up to size 45 were used for retreatment to the working length in

sequential order. The instrumentation was completed with K-Flex files size 60.

During the retreatment, root canals were constantly irrigated with 1% NaOCl. In all cases, the canals were instrumented to one size larger than the previous master apical file used. The criteria for completion of retreatment were the presence of clean filings, no evident gutta-percha or sealer present on the files or paper points and smooth canal walls. If these requirements were not met, the canals were further instrumented with the same file size, ISO #60, until the criteria were fulfilled. After final instrumentation, all canals were copiously irrigated with NaOCl and dried with paper points. The duration of retreatment, recording to the nearest seconds with a stopwatch, was based solely on the net time used in the retreatment procedure itself, excluding the time for handling of instruments, changing of files, irrigation, etc. In addition, the quantity of chloroform used was also documented.

Evaluation

The teeth were grooved vertically with carborandum discs and water spray on the buccal and lingual surfaces. They were then split longitudinally with a chisel and a mallet into halves. Both halves of each split tooth were divided into cervical, middle, and apical thirds, measuring from the cementoenamel junction to the terminus of the apical preparation, using an indelible pencil. They were then coded and attached to a glass slide using epoxy resin. The specimens were randomly arranged to avoid examiners' bias. The scoring was done visually by three independent examiners under a light microscope at a $\times 4$ magnification.

The amount of residual root canal filling in the three regions and in the whole root canals was scored for both halves of the split teeth. No attempts were made to distinguish between residual gutta-percha and sealer. Evaluation scales used were: score 0, no or negligible trace; and scores 1–3, mild, moderate, and severe retreatment debris, respectively.

Analysis

The degree of agreement of the scores obtained by the three examiners was assessed by Kappa's test. The mean scores in each retreatment group were calculated for each canal level, and compared by Friedman two-way ANOVA. The whole scores of the three groups and the three levels of the same group were compared by the Kruskal-Wallis test and the Mann-Whitney test. The mean time utilized in the three retreatment groups were compared by one-way ANOVA and Tukey HSD, whereas the mean amount of solvent used in groups B and C were compared with the Mann-Whitney *U* test. The significance level was set at 5%. The correlation between the scores from the whole canals, the retreatment time, and the amount of chloroform used in retreatment were also analyzed by Pearson's correlation.

RESULTS

The scores and the mean scores for the amounts of residual gutta-percha or sealer in the whole canals and at the three canal levels in the three retreatment groups are presented in Tables 1 and 2. The whole canal mean score for group A (1.10) was lower (better) than that of group B (1.40) and group C (1.63). There was a statistically significant difference between group A and group C

TABLE 1. Frequency of scores for residual root canal filling material by the three examiners

Retreatment Group (n = 10)	Canal Level	Scores			
		0	1	2	3
Group A ProFile	Cervical	0	13	16	1
	Middle	3	24	3	0
	Apical	0	24	6	0
	Whole	0	27	3	0
Group B ProFile & chloroform	Cervical	0	15	13	2
	Middle	0	21	8	1
	Apical	0	16	9	5
	Whole	0	19	10	1
Group C Hand file & chloroform	Cervical	0	13	13	4
	Middle	0	22	8	0
	Apical	0	9	17	4
	Whole	0	12	17	1

TABLE 2. Mean scores of residual root canal filling material after retreatment

Retreatment Group (n = 10)	Mean Score (SE)			
	Cervical	Middle	Apical*	Whole**
Group A*** ProFile	1.60**** (0.17)	1.00**** (0.15)	1.20***** (0.13)	1.10***** (0.10)
Group B ProFile & chloroform	1.57 (0.20)	1.33 (0.17)	1.63 (0.22)	1.40 (0.16)
Group C Hand file & chloroform	1.70 (0.21)	1.27 (0.13)	1.83***** (0.18)	1.63***** (0.16)

p-Values are as follows: significant difference between groups (Kruskal-Wallis test, * p = 0.025, ** p = 0.035); significant difference between levels (Kruskal-Wallis test, *** p = 0.034); significant difference (Mann-Whitney U test, **** p = 0.043, ***** p = 0.011, ***** p = 0.023).

TABLE 3. Mean whole score, mean time, and mean volume of solvent used in retreatment

Retreatment Group (n = 10)	Mean Whole Score* (SE)	Mean Time** [(SE) s]	Mean Solvent [(SE) ml]
Group A ProFile	1.10*** (0.10)	178.30 (7.21)	—
Group B ProFile & chloroform	1.40 (0.16)	160.30**** (5.11)	0.060***** (0.007)
Group C Hand file & chloroform	1.63*** (0.16)	183.40**** (5.95)	0.175***** (0.025)

p-Values are as follows: significant difference between groups (Kruskal-Wallis test, * p = 0.035, Mann-Whitney U test, *** p = 0.023); significant difference between groups (one-way ANOVA, ** p = 0.033, Tukey HSD, **** p = 0.034); significant difference between groups (Mann-Whitney U test, ***** p < 0.001); Pearson correlation for whole score and solvent used in group B is significant (r = 0.783, p = 0.007).

(p = 0.023). A similar trend was seen for the mean scores of the apical canal levels (p = 0.011). For group A, the mean score of the residual root canal filling material was higher in the cervical level (1.60) than the middle (1.00) and the apical levels of the canal (1.20). For groups B and C, however, the apical canal levels had higher mean scores than the cervical and the middle canal levels (Table 2).

The mean time and the average amount of chloroform used as solvent in retreatment are presented in Table 3. The retreatment time of group A (178.3 s) and group B (160.3 s) were shorter than that of group C (183.4 s), with the time difference between groups B and C being significant (p = 0.034). The amount of chloroform

used in group B (0.06 ml) was significantly less (p < 0.001) than group C (0.175 ml).

DISCUSSION

Our study aimed at investigating the possibility of retreatment gutta-percha-obtured root canals using ProFile with or without chloroform. As has been shown in the literature, it was impossible to remove all traces of gutta-percha and sealer from the root canal walls with any retreatment techniques, whether used singly or in combination (5). This was also evident in our study. None of the

study samples, when considered as whole canals, had a score of 0, regardless of the retreatment techniques (see Table 1). On the other hand, scores of 3 were infrequent (19/360), possibly due to the criteria for canal cleanliness required before retreatment and instrumentation could be considered complete. From Table 2, the mean scores for the whole canals in group A were lower than in groups B and C, with significant difference between group A and group C ($p = 0.023$). Likewise, retreatment by ProFile NiTi rotary files without chloroform (group A) produced cleaner canals at the middle and apical third levels, compared with the other two retreatment techniques with chloroform (groups B and C). However, the only significant difference between group A and group C was in the apical third level of the canals ($p = 0.011$). For the cervical thirds, such trend in the mean scores was not observed. Generally, the root canal cleanliness was less satisfactory in the cervical thirds in which the gutta-percha were removed by heated pluggers and in groups B and C in which chloroform was used as solvent for retreatment. The softening effect on gutta-percha produced by heat may have resulted in the "smearing" of the root canal walls, whereas chloroform-softened gutta-percha seemed to be inadvertently distributed throughout the canal and resulted in a "filmy appearance" on the canal walls. Consistent with other studies (3, 15, 16), there was a tendency to leave more residual root canal filling material in the apical third of the canals. Nevertheless, ProFile NiTi rotary files without chloroform proved to be efficient in rendering the apical thirds cleaner than the conventional hand file retreatment ($p = 0.011$).

Conventionally, removal of gutta-percha using hand files with or without chloroform (7) can be a tedious and time-consuming process, especially when the root canal filling material is well condensed. In many cases, the combined use of different techniques may be the most efficient and time-saving method (3, 5, 7). These were also reflected in our results (Table 3). Retreatment using ProFile rotary files with or without chloroform (groups A and B) were overall faster than the hand files with chloroform (group C). In particular, the retreatment time in group B using rotary instruments with chloroform was significantly shorter than group C using conventional hand files with chloroform ($p = 0.034$). The amount of chloroform used in group B was, on the other hand, significantly less than that used in group C ($p < 0.001$). It was possible that the rotary movement of ProFile might have produced a certain degree of frictional heat to further soften the gutta-percha, making it easier for removal, thus requiring less chloroform.

Prudence should be exercised in result interpretation with reference to two other similar retreatment studies using ProFile rotary instruments (13, 14). In terms of the amount of residual gutta-percha and sealer, our results from groups B and C (Table 2) were comparable with these two studies. There were also no statistically significant differences at any canal level or from the whole canal between ProFile with chloroform and stainless steel K-Flex files with chloroform. In the present study, direct visual scoring with the aid of microscope was adopted as the mode of evaluating residual gutta-percha/sealer on canal walls. This was considered a simple and cost-effective approach, but the three-dimensional nature of the residual root canal filling could not be accounted for. Nevertheless, the evaluation method in this study, compared with the quantification by projected photographic images (13) or a computerized image analysis system (14), did not seem to have any major impact on the assessment of canal cleanliness after retreatment. There might be some concern regarding the subjectivity of our evaluation method. However, interexaminers variability

TABLE 4. Measurement of agreement between examiners

Examiners	κ Value
1 & 2	0.801
1 & 3	0.655
2 & 3	0.722

seemed to be within an acceptable range (Table 4). The degree of agreement was particularly high between examiners 1 and 2.

In contrast to the study by Barrieshi et al. (13), which found that ProFile rotary files took significantly longer in retreatment, our results demonstrated a significantly shorter time in group B compared with group C (Table 3). It was also noted that the mean time taken in our group B (160.3 s) and group C (183.4 s) was shorter than that taken in the earlier study, which took 474 s and 378 s, respectively (13). These discrepancies were possibly due in part to our unique measurement of retreatment time, which was based solely on the net time used in the retreatment procedure itself. Differences in the methodologies might also account for the differences. No information was available on the amount of chloroform used or the criteria for completing the retreatment procedure in the previous study. In our study, efforts were made to distribute teeth of similar canal width and length into the same set of samples. Root canal instrumentation and flare, as well as root canal filling, were consistently controlled as described. These measures were made in an attempt to indirectly quantify and standardize the amount of root canal filling material used for teeth within the same set of samples, so that retreatment within the same set of samples would be better comparable. In addition, the application of heat with pluggers to the gutta-percha in the cervical third of the root canals yielded an initial softening effect. This facilitated the initial penetration of files and the subsequent removal of gutta-percha in the apical two-thirds, resulting in a shorter time taken in retreatment despite minimal use of chloroform in group B (0.06 ml) and group C (0.175 ml). This phenomenon was considered encouraging because of the concern for possible toxicity to the periradicular tissues in contact with chloroform.

The heat applied on the gutta-percha also resulted in "smearing" of the cervical root canals. Gates Gliddens have been advocated to remove gutta-percha in the cervical portions (4, 7). They have been shown to produce a cleaner canal after gutta-percha removal (7). More effort should be made to clean the cervical third of the canals, either with the supplementary use of Gates Gliddens or by more meticulous usage of the ProFile rotary files, wherever applicable. For clinical relevance, further investigation of ProFile NiTi rotary files will still be needed on the extent of extrusion of root canal filling materials, if any, and the degree of acceptance of these instruments by patients. It would also be of future interest to evaluate teeth with curved canals, teeth obturated with different obturation techniques, and with gutta-percha in conjunction with different sealers.

Under the present experimental conditions, ProFile .04 Taper seemed to be a viable alternative retreatment technique for gutta-percha-obturated root canals, even without the use of chloroform. Nevertheless, further evaluation will be needed before routine usage could be recommended.

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References

1. Friedman S, Stabholz A. Endodontic retreatment—case selection and technique. Part 1. Criteria for case selection. *J Endodon* 1986;12:28–33.
2. Bergenholtz G, Lekholm U, Milthon R, Heden G, Odesjo B, Ergstrom B. Retreatment of endodontic fillings. *Scand J Dent Res* 1979;87:217–24.
3. Teplitsky PE, Rayner D, Chin I, Markowsky R, Sask S. Gutta percha removal utilising GPX instrumentation. *Sci J* 1992;58:53–8.
4. Friedman S, Stabholz A, Tamse A. Endodontic retreatment—case selection and technique. Part 3. Retreatment techniques. *J Endodon* 1990;16:543–9.
5. Wilcox LR, Krell KV, Madison S, Rittman B. Endodontic retreatment—evaluation of gutta-percha and sealer removal and canal re-instrumentation. *J Endodon* 1987;13:453–7.
6. Zakariasen KL, Brayton SM, Collinson DM. Efficient and effective root canal retreatment without chloroform. *J Can Dent Assoc* 1990;56:509–12.
7. Hulsmann M, Stotz S. Efficiency, cleaning ability and safety of different devices for gutta-percha in root canal retreatment. *Int Endod J* 1997;30:227–33.
8. Tamse A, Unger U, Metzger Z, Rosenberg M. Gutta percha solvents—a comparative study. *J Endodon* 1986;12:337–9.
9. International Agency for Research of Cancer. IARC monographs on the evaluation of carcinogenic risk to humans. 1987;7:152–4.
10. Wennberg A, Orstavik D. Evaluation of alternatives to chloroform in endodontic practice. *Endod Dent Traumatol* 1989;5:234–7.
11. Poulsen WB, Dove SB, del Rio CE. Effect of Nickel-titanium engine-driven instrument rotational speed on root canal morphology. *J Endodon* 1995;21:609–12.
12. Tulsa Dental Products. ProFile manufacturer's instructions for use. ProFile .04 Taper Series 29 Rotary Instruments. Tulsa: Tulsa Dental Products, 1994.
13. Barrieshi K, Wilcox L, Walton R. Endodontic retreatment: effectiveness of nickel-titanium rotary instruments versus stainless steel K-flex files [Abstract]. *J Endodon* 1995;21:235.
14. Zuolo ML, Kherlakian D, Imura N. Effectiveness of nickel-titanium rotary and hand instrumentation in endodontic retreatment [Abstract]. *J Endodon* 1996;22:209.
15. Wilcox LR. Therafil retreatment with and without chloroform solvent. *J Endodon* 1993;19:563–6.
16. Friedman S, Moshnov J, Troupe M. Efficacy of removing glass ionomer cement, zinc oxide eugenol and epoxy resin sealers from retreated root canals. *Oral Surg Oral Med Oral Pathol* 1992;73:609–12.