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**Original Article**

# A Comparison of Canal Width Changes in Simulated Curved Canals prepared with Profile and Protaper Rotary Systems

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## ABSTRACT

With advancement in the endodontic technology there is a quest to introduce root canal instruments showing superior performance by removing minimum amount of sound root dentine and retaining the original shape of the root canal. **Objective:** To compare the changes in the width of simulated curved canals prepared with ProFile and ProTaper rotary system. **Methods:** This in-vitro, Quasi Experimental study was carried out in the Dental section of The Aga Khan University Hospital. Pre and post instrumentation photographs (images) of sixty resin blocks prepared with ProFile and ProTaper rotary instruments respectively (with 1:10 magnification) were superimposed using software Adobe Photoshop 6.0. Measurements were done on print out of composite images. Measurements of change in width (resin removed) were recorded along the length of canal at 12 points. **Results:** Two rotary system showed statistically significant difference in simulated curved canals width after preparation. ProTaper rotary instruments showed more resin removal at the inner walls of the canal at 1, 8-12mm from the apex and more resin removal at outer wall of canal at 9-12 mm from apex. **Conclusions**: ProFile and ProTaper rotary files showed statistically significant difference in canal width after instrumentation. ProTaper rotary files showed more resin removal in canals towards the inner wall and coronal part of the outer wall.

## INTRODUCTION

In endodontic therapy mechanical instrumentation of the root canal is a preliminary and vital step, involving debridement of necrotic and vital pulp tissue and creation of space for root canal irrigants and medicaments [1-3]. This step is responsible for creation of final shape of the root canal which ideally should has smallest diameter at the canal apex and widest diameter at the canal orifice [4, 5]. An important consideration in this context is maintenance of three dimensional relationship of original canal to the final preparation [5, 6]. Deviation of the canal from its original path predispose to iatrogenic changes like zipping, instrument separation, apical transportation or artificial canal, outer widening and ledging [7-9]. Endodontic literature has witnessed several types of preparation techniques and endodontic instruments in order to achieve root canal preparation without iatrogenic errors [10, 11]. Different endodontic instruments differ in their cross section, width and taper. But all instruments are designed to achieve the final canal shape that allow close adaptation of the obturating material with the canal in all dimensions [3, 10, 12]. Maintaining the canal curvature while ensuring adequate and symmetric dentine removal during root canal preparation is very important as vigorous removal of root dentine predisposes to deviation of original canal path [2, 4]. Metallurgical properties of instruments, technique employed of canal preparation, position of apical foramina

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and the hardness of dentine effects final shape of curved canals after canal instrumentation [13]. Several Nickel Titanium (NiTi) rotary root canal preparation systems are available in market [14]. Protaper and Profile are two of the commonly used and available NiTi file systems for root canal preparation. We aimed to evaluate canal width changes after canal preparation with Protaper and Profile systems, so that better system can be promoted for improved outcome. The objective of this study was to compare the changes in the width of simulated curved canals prepared with ProFile and ProTaper rotary system. The null hypothesis was that there is no difference in the width of simulated curved canals prepared with ProFile and ProTaper rotary system. The alternate hypothesis was that there is a difference in the width of simulated curved canals prepared with ProFile and ProTaper rotary system.

## METHODS

Clear polyester resin block with simulated curved canals (Endo Training-Bloc, Dentsply Maillefer, Ballaigues, Switzerland) were used for this research. The study was exempted from Ethical review committee of Aga Khan University Hospital as no human or animal subject was involved in this study. Total simulated canal length was 17 mm with 10mm long straight part and 7mm long curved part (Figure 1).

**Figure 1:** Pre instrumentation photograph of resin block

The clear resin blocks (Dentsply) were divided into two groups with thirty blocks in each group A and group B (after number allocation to each block). Working length of canal was measured by direct vision of canals using ISO # 10 size manual file which was determined to be 17 mm. Preoperative photographs of each block were taken with camera (Nikon F 90 X) after filling them with black ink to improve their outline and for comparison of images in standardize manner with the help of a stand at standardize distance. Before preparation, the blocks were covered with adhesive tape to prevent operator bias Blocks in group A and group B were prepared with ProFile0.04 rotary instruments and ProTaper rotary instruments respectively. Each instrument was discarded after preparing six resin blocks. EDTA cream (RC prep) was used as as a lubricant with each instrument. The simulated curved canal in resin block were flushed with water after every rotary file use. A plastic syringe carrying 5ml of water and a 27-gauge tip was used for irrigation. An electric motor (Dentsply Maillefer) was used for simulated canals preparations with permanent rotation (250 rpm.), torque and 16:1 reduction headpiece. Gentle in and out motions were used for canals preparation in a crown-down manner. The apical preparation with both rotary systems was limited to a size 30. The instruments sequence for ProFile 0.04 rotary files used was as followed: The straight portion (10mm) of simulated curved canal was prepared with size 40 ProFile. Once the straight portion of the canal was prepared till this length with file rotating freely, the size 35 ProFile was used to the same length. This step was followed by size 30 ProFile which was usd to prepare the canal till 12 mm. Finally sizes 25, 20 and 15 of ProFiles were instrumented to 17 mm (the full working length). The sequence in which ProTaper rotary files were used was as followed: There are six files in ProTaper system: First three were shaping files (Sx, S1, S2) followed by finishing files (F1, F2, F3). ProTaper Sx was employed to three-quarter of the length of simulated canal (17mm) in order to make the space for the next instrument in the sequence. Both S1 and S2 were instrumented to the working length (17mm) until instruments rotated freely in the canal. Then canals were enlarged to finishing instruments F1, F2 and F3 sequentially i up to the working length. After preparation simulated canals in resin blocks were filled with green (ProFile) and red ink (ProTaper). This step improved their outlines and facilitated comparison of pre and post instrumentation images. The obtained were superimposed using software Adobe Photoshop 6.0 was used to superimposed pre and post instrumentation images followed by taking print out of composite images and measurements were done on print outs. One dimensional measurements perpendicular to the surface of canal at twelve different points (starting at 1 mm from the apex and moving coronally till 12 mmm) was done to determine the changes after instrumentation at both outer and inner walls of simulated curved canals. Data of measurements of width changes was collected for 12 points at outer and inner walls (Figure 2).

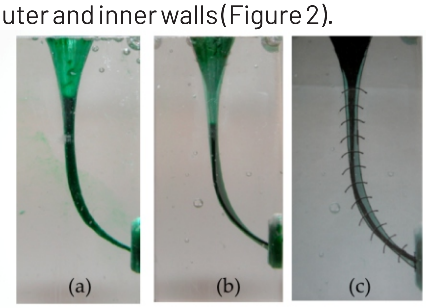


**Figure 2:** a) Post instrumentation photograph of the simulated

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canal prepared with PROFILE 0.04 b) Superimposed image of pre and post instrumentation c) Printout of composite image showing measuring points

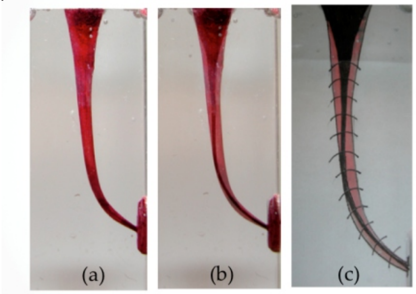


**Figure 3:** a) Post instrumentation photograph of the simulated canal prepared with PROTAPER b) Superimposed image of pre and post instrumentation c) Printout of composite image showing measuring points

Data analysis was done using SPSS version 16.0. Measurements recorded at 1:10 magnification were converted to original values by dividing it by 10. The original values were then subjected to analysis. Descriptive analysis like mean, standard deviation of the numerical variables was determined for canal width changes (both inner and outer) at 12 points starting 1mm from apex at 1mm distance. Independent sample t-test test was applied for the comparison of width changes at every level outer and inner wall of the canal between the group A and B. P-value of less than 0.05 was taken as significant.

## RESULTS

A total of sixty resin blocks were included in the study based on the selection criteria with thirty resin blocks in each study group. In case of procedural problem like instrument separation another block was selected as replacement thus no sample loss occurred. There were no confounding variables in the study as canal in simulated resin blocks were used and prepared by single operator. Details of resin removal from canal walls is as follows: The greatest resin removal or width changes in the ProFile rotary system (group A) at inner wall of the canal was observed at 6 and 5mm from the apex {0.33 mm (SD ±0.12) and 0.30 mm (SD ± 0.10) mm} and at outer wall of the canal was observed at 12 mm {0.25 mm(SD 0.13). The greatest resin removal or width changes in the ProTaper rotary system (group B) at outer wall of the canal was observed at 12 mm from the apex {0.39mm (SD ± 0.17)} and at inner wall of canal at 6mm and 7 mm from the apex {0.38 mm (SD 0.21) and 0.36 (SD 0.20) respectively}. To compare the canal width changes in inner and outer canal wall at 1 to 12mm from apex between group A and B independent sample t test was used. The ProTaper files showed more resin removal at the inner walls of the canal at 1, 8, 9, 10, 11 and 12mm from the apex with statistically significant association (p-values ≤0.05). Protaper files also removed more resin at the outer wall of canal at 9, 10, 11, and 12 mm from the apex with statistically significant association (p-values ≤0.05)(Table 1 and 2).

| Distance from apex | ProTaper Mean mm(SD) | ProFile Mean mm(SD) | p-value* |
|---|---|---|---|
| Inner wall at 1mm | 0.08 (0.08) | 0.03 (0.04) | 0.019 |
| Inner wall at 2mm | 0.09 (0.09) | 0.09 (0.07) | 0.766 |
| Inner wall at 3mm | 0.14 (0.12) | 0.15 (0.07) | 0.782 |
| Inner wall at 4mm | 0.23 (0.14) | 0.24 (0.11) | 0.751 |
| Inner wall at 5mm | 0.34 (0.19) | 0.30 (0.10) | 0.266 |
| Inner wall at 6mm | 0.38 (0.21) | 0.33 (0.12) | 0.220 |
| Inner wall at 7mm | 0.36 (0.20) | 0.28 (0.11) | 0.078 |
| Inner wall at 8mm | 0.31 (0.16) | 0.22 (0.11) | 0.015 |
| Inner wall at 9mm | 0.28 (0.13) | 0.19 (0.11) | 0.008 |
| Inner wall at 10mm | 0.29 (0.12) | 0.19 (0.10) | 0.002 |
| Inner wall at 11mm | 0.31(0.12) | 0.22 (0.13) | 0.008 |
| Inner wall at 12mm | 0.32(0.14) | 0.24 (0.13) | 0.004 |

**Table 1:** Comparison of Canal width changes on inner canal wall between protaper and profile rotary file.
SD(standard deviation)
Test of significance: independent sample t-test
*Level of significance ≤ 0.05

| Distance from apex | ProTaper Mean mm(SD) | ProFile Mean mm(SD) | p-value* |
|---|---|---|---|
| Outer wall at 1mm | 0.13 (0.10) | 0.11 (0.05) | 0.441 |
| Outer wall at 2mm | 0.17 (0.10) | 0.13 (0.06) | 0.090 |
| Outer wall at 3mm | 0.18 (0.10) | 0.14 (0.07) | 0.103 |
| Outer wall at 4mm | 0.12 (0.08) | 0.11 (0.07) | 0.538 |
| Outer wall at 5mm | 0.06 (0.09) | 0.07 (0.06) | 0.822 |
| Outer wall at 6mm | 0.07 (0.10) | 0.06 (0.06) | 0.467 |
| Outer wall at 7mm | 0.14 (0.12) | 0.11 (0.06) | 0.333 |
| Outer wall at 8mm | 0.20 (0.11) | 0.16 (0.09) | 0.131 |
| Outer wall at 9mm | 0.27(0.12) | 0.20 (0.10) | 0.022 |
| Outer wall at 10mm | 0.34 (0.14) | 0.23 (0.12) | 0.003 |
| Outer wall at 11mm | 0.38 (0.15) | 0.24 (0.12) | 0.001 |
| Outer wall at 12mm | 0.39 (0.17) | 0.25 (0.13) | 0.001 |

**Table 2:** Comparison of Canal width changes on inner canal wall between protaper and profile rotary files
SD(standard deviation)
Test of significance: independent sample t-test
*Level of significance ≤ 0.00

## DISCUSSION

Current study results revealed significant difference in pattern of width changes in simulated canals instrumented with ProFile and ProTaper rotary system. Thus the Null hypothesis was rejected and the alternate hypothesis was accepted. According to results of our study, ProTaper rotary files have a tendency to remove more resin material from the apical, mid and coronal segment of the canal towards inner wall as compare to ProFile rotary system. This rotary system also removes more resin material from coronal segment towards outer wall as compare to ProFile rotary system. The difference in results between two rotary systems can be attributed to the difference in the designs

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of these two instruments. There is neutral or slightly negative rake angle in ProFile rotary system which cuts with a planning action and remain centered in canal [6, 8, 13]. ProTaper rotary system, on the other hand has slight positive rake angle which works like a shaver, requires less energy and remove more material by efficient cutting [14]. The greater amount of resin removal in proTaper group could be attributed to the greater taper and less flexibility of ProTaper finishing files [15, 16]. At the same time convex triangular cross section of proTaper instrument which was claimed to reduce contact area between file and root dentine, also predisposes the root canal to greater transportation when kept in the canal for more than 1 second [11]. In current study we have chosen resin blocks as an alternative to extracted human teeth in order to minimize variations in teeth anatomy and size that can affect the study results. Researches have been conducted on these resin blocks to evaluate different parameters of canal preparation [12, 17]. They offer several advantages over natural teeth like standardization of canals length, curvature and hardness of the material. Assessment of changes in canal width is also possible by superimposition of pre and post-instrumentation images. This assurances a high degree of reliability and the results of these researches can be applied to human teeth [18]. However the difference in micro hardness of resin blocks and dentine is a concern. The limitations of these resin blocks include different micro hardness values of dentine and resin ranging from 35–40 kg/mm2 for dentine and, 20 to 22 kg/mm2 for resin [6, 10]. Giovannone has compared canal width changes of M-two and ProTaper rotary instrument of 40 canals in resin blocks using pre and post instrumentation photographs and with image analysis to evaluate changes in canal shape at different points along length of canal. Results showed that both systems maintained original curvature with minimum transportation of apex which is the area at risk of modification. M-two caused less transportation of apex than ProTaper but it was not statically significant ($P > 0.05$) [19]. However in our study ProTaper files showed more resin removal from inner wall in apical and middle region and symmetrical resin removal in coronal portions of canals. Another study had compared canal width changes of ProFile and K3 rotary instruments in curved canals with 20 and 30 degree curvature. They have used digital images (pre and post instrumentation) on which assessment was done starting from 0.5mm till the end point (total of 28 points comparison). There was more resin removal for both rotary instruments from outer canal walls in comparison to inner canal walls in apical segment with statistical significance [20]. In our study ProFile rotary instruments showed symmetrical removal of resin from both walls along the whole length of simulated canals in resin block. A comparison between ProTaper rotary system versus Hero 642 shaft in 20 resin blocks (L- and S-shaped resin canal) assessed the effect of instrument taper on shaping of canals. The result of width of resin removal showed that Hero 642 rotary instruments having constant taper maintained the original canal curvature with superior canal centering ability as compared to ProTaper rotary instruments. ProTaper instrument showed two patterns of transportation. In L-shaped curved canals there were more width changes at the outer aspect in the apical part and in S-Shaped canals there was more width changes on the inner aspects at the curve [21]. Similarly in our study ProFile having constant taper showed superior centring ability in curved canals (L-shape) as compare to ProTaper rotary instrument which has varying taper along the length of its cutting blades. Every research has some limitations. Although canals in the resin blocks offer many advantages in term of standardization and reproducibility still difference in the hardness and abrasion of acrylic resin and root dentine is a limitation of this research. Also the heat generation by rotary instruments results in more softening of blocks as compare to natural dentine. This can result in more width changes as compare to natural dentine [10].

## CONCLUSIONS

There is a difference in the simulated canal width after preparation with ProFile and ProTaper rotary systems. ProTaper files showed more resin removal from canals towards inner walls at all level (apical, middle and coronal). ProTaper files also showed more resin removal at coronal level towards outer walls. It is recommended that ProTaper rotary system should be used in canals with sufficient amount of root dentine is present. ProTaper F2 and F3 rotary systems should be used with caution in curved canals to prevent excessive removal of inner wall root dentine that can lead to straightening of the canal.

## Conflicts of Interest

The authors declare no conflict of interest.

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