**In vitro** comparative evaluation of efficiency of XP-endo shaper, XP-endo finisher, and XP-endo finisher-R files in terms of residual root filling material, preservation of root dentin, and time during retreatment procedures in oval canals – A cone-beam computed tomography analysis

Khyati Kapasi, Pooja Kesharani, Payalben Kansara¹, Deepu Patil², Tikal Kansara³, Shirali Sheth⁴

Department of Conservative Dentistry and Endodontics, College of Dental Sciences and Research Center, Manipur, Ahmedabad, Gujarat, India ¹Department of Cariology and Comprehensive Dentistry, New York University College of Dentistry, New York, New York, USA, ²Department of Conservative Dentistry and Endodontics, AME’s Dental College, Raichur, Karnataka, India, ³Department of Medicine, New York Medical College - Metropolitan Hospital Center, New York, New York, USA, ⁴Department of Oral and Maxillofacial Radiology, Dharmasingh Desai University, Nadiad, Gujarat, India

**Abstract**

**Background:** In an oval-shaped canal, no single instrumentation systems were effective in absolute removing obturation.

**Aim:** The aim of the study was to evaluate the performance of ProTaper Universal Retreatment (PTUR) system, XP-endo Shaper (XPS), XP-endo Finisher (XPF), and XP-endo Finisher-R (XPF-R) in removing root-canal filling material and preservation of sound dentin during retreatment procedure.

**Methodology:** Root-canal preparation was performed on 60 mandibular premolars with oval-shaped canals using the ProTaper Gold file system. Preobturation scans were performed to measure canal volume of the canal and recorded. Obturation was performed and the samples were randomly assigned into four groups according to the retreatment protocol used (n = 15): H-file, PTUR files, PTUR followed by XPF file, and XPS supplemented with XPF-R file. After retreatment, the specimens were re-scanned and volumetric analysis of remaining root filling material, volume of the canal space were measured using EZ-3Di Software Version 5.0.0.2. All the data were subjected to one-way ANOVA and post hoc Tukey’s test with a significance of 5%.

**Results:** XPS + XPF-R showed promising results in the removal of obturating material and preservation of root dentin than any other group. The difference is statistically significant.

**Conclusion:** XPS + XPF-R removed gutta-percha more significantly without sacrificing the sound dentin along with instrumentation.

**Keywords:** Loss of dentin; root-canal retreatment; root filling material; XP-endo Finisher-R; XP-endo Shaper

**INTRODUCTION**

The pivotal goal of root-canal retreatment is to restore healthy periapical tissue.¹ It aims to reclaim access to apical foramen by complete removal of obturating materials, thus acknowledging for a new efficacious cleaning–shaping of...
the intricated root-canal system. Residual fillings conceal the residual infection, thus compromising the outcome of retreatment. Hence, the comprehensive endeavors should be directed toward ameliorating cleanliness to establish long-term success.

Hand files, rotary and reciprocating systems, ultrasonics, lasers, and chemical solvents were ineffective in absolute removal of obturating materials.

Recently introduced XP-endo file system includes XP-endo Shaper (XPS), XP-endo Finisher (XPF), and XP-endo Finisher R (XPF-R) (FKG Dentaire, Switzerland) which are non-tapered instruments made with NiTi MaxWire alloy (Martensite-Austenite Electropolish Flex) and are truly resourceful comprehensive retreatment instruments which can be used to radically simplify the procedure. This instrument is straight in its martensitic phase below 30°C; nevertheless, when placed inside the canal at body temperature, it deviates to austenitic phase in which the file preserves a spoon shape in the last 10 mm with a depth of roughly 1.5 mm. When the instrument is introduced into a canal, its shape memory and austenite phase conversion increase its effectiveness in touching and displacing root-filling materials.

Retreatment demands more mechanical manipulations in the root canal. The thickness of the remaining root dentin may be the critical iatrogenic factor that corresponds to the incoming fracture resistance of the root. Reduction in residual dentin thickness results in an increasing the risk for stress accumulation, craze line, and vertical root fracture, significantly important in oval-shaped root canals.

As cleaning and shaping are crucial in retreatment, preservation of sound root dentin is equally substantial. Therefore, the aim of this study to compare the effectiveness of hand files, ProTaper Universal Retreatment (PTUR) file and XP-endo files in the ability to remove obturating materials along with measurement of loss of root dentin during retreatment using cone-beam computed tomography (CBCT) analysis.

The hypothesis tested was that (1) there is no difference in root-canal filling removal between groups and (2) there is no difference in the loss of sound dentin after re-instrumentation between the groups.

**METHODOLOGY**

After ethical approval, 60 mandibular premolars were collected from the Department of Oral Surgery, College of Dental Sciences and Research Center, Ahmedabad, India. The samples were cleaned, disinfected, and examined under an operative microscope (Labomed Inc., USA) with ×1.6 magnification to determine their eligibility and then stored in saline until used. Radiographs of each sample were taken to confirm the presence of a single oval-shaped canal, which had a buccolingual diameter twice than the mesiodistal diameter. To minimize procedural and environmental bias, a single operator decoronated all teeth with a diamond disk and straight handpiece at a standardized length of 15 mm working inside a cabinet of a 37°C.

**Root-canal preparation**

Following access cavity preparation, the glide path was established using the No. 10 K-file (MANI Inc., Japan), and working length was recorded 1-mm short of the apical foramen. Biomechanical preparation was finished using ProTaper Gold files (Dentsply Maillefer, Switzerland) up to F2 sequence installed in an Endomotor (Endo-mate TC2, NSK, Japan) with a speed of 300 rpm and 3 N/m torque. The instrument was used in pecking motion with a 3 mm amplitude limit along with gentle apical and lateral pressure. Recapitulation was performed throughout the procedure. Chemical irritation was performed with 25 mL of 2.5% NaOCl using a 30-gauge needle inserted up to 1 mm short of working length. 3 mL of 17% EDTA (Prime Dental Products Pvt. Ltd., India) was used for smear-layer removal followed by a final rinse with saline and dry with paper points.

**Preobturation cone-beam computed tomography scan**

All the samples were scanned using CBCT with a microscopic resolution of voxel size of 90 µm, the field of view = 5 cm x 5 cm, kilovoltage = 80–90 kV, milliamperes = 5–10 mA, and exposure time = 18 s. Each scan was subjected to volumetric analysis of canal space [Figure 1a] using EZ-3Di Software Version 5.0.0.2 (Vatech, South Korea), and preobturation canal space volume was recorded in mm³.

**Root-canal obturation**

The root canal was obturated with gutta-percha cones (Dentsply Sirona, USA) and AH-Plus sealer (Dentsply, DeTrey, Konstanz, Germany) using the cold lateral compaction technique. The quality of the obturation was evaluated by buccolingual and mesiodistal radiographs. Cavit (3M ESPE, Germany) was placed in the access, and the samples were stored at 37°C and 100% relative humidity for 30 days.

**Retreatment procedure**

The samples were randomly assigned into four experimental groups according to the retreatment protocol used (n = 15). In each group, the samples were mounted in 4.5-cm diameter wax block and buccal side facing outward. Cavit was removed and one drop of Endosolv R (Septodont, USA) was placed at the root-canal orifice.
Group 1 (H-file)
The coronal third of the obturating material was removed with sizes 3 and 2 of Gates Glidden drills (Mani, Japan) at 2000 rpm. Then, the remaining obturating material was removed with #40, 35, and 30 of H-files (Dentsply Maillefer, Switzerland) in descending order using circumferential filing and quarter-turn push–pull movements until they reached the working length.

Group 2 (ProTaper Universal Retreatment)
PTURs were used at a speed of 500 rpm with a 3 N/cm torque in brushing motion. The coronal, middle and apical third of the canal was cleaned with ProTaper D1, D2, and D3 files, respectively.

Group 3 (ProTaper Universal Retreatment + XP endo-Finisher)
All samples were first prepared the same as Group 2.

Supplementary step with XPF - The XPF file was placed 2 mm from working length and operated at 800 rpm and 1 N/cm with an up-down brushing motion for 20 s. Slow, gentle longitudinal movements of 7–8 mm were applied to cover the entire length of the canal.

Group 4 (XP-endo Shaper + XP-endo Finisher-R)
XPS was operated at 800 rpm and 1 N/cm torque, using a single instrument. The file was pressed against canal walls during the procedure to change its form to aid in better filling removal. The instrument was also used in 3 cycles, each one consisting of in-and-out motions with an amplitude of 3–4 mm, up-to-the working length.

Supplementary step with XPF-R - the recommendation for using this file is the same as XPF.

The root canal was irrigated using 2.5% NaOCl between each file and the final irrigation was performed using 5 mL of 2.5% NaOCl and 17% EDTA, followed by 5 mL of distilled water. Time was measured using a chronometer from initiation to complete removal of the material.

Postretreatment cone-beam computed tomography scanning
After retreatment procedures, all the samples were scanned using the same parameters as described during the previous CBCT scan in axial, sagittal, and coronal planes.

Volumetric analysis from CBCT images for loss of dentin [Figure 1b] and residual gutta-percha material [Figure 2].
The volume of residual obturating material and canal space volume were measured in mm$^3$ using the volumetric tool of the software Ez-3Di software version 5.0.0.2. The slice thickness and slice interval during these measurements were 0.1mm each. The loss of dentin was calculated by subtracting the preobturation canal space volume [Figure 1a] from postretreatment canal space volume [Figure 1b].

Statistical analysis
ANOV A and post hoc Tukey’s tests were performed using Statistical Package for Social Science (SPSS, version 23.0, USA).

RESULTS

Comparison of mean percent gutta-percha remaining in the coronal one-third (Graph 1 and Table 1)
PTUR file showed the least amount of gutta-percha, followed by XPS + XPF-R. An intra-group comparison stated a statistically significant difference between group 1 and group 2, group 1 and group 3.

Comparison of mean percent gutta-percha remaining in the middle one-third (Graph 1 and Table 1)
H-file displayed the highest amount of gutta-percha followed by PTUR, PTUR + XPF, and XPS + XPF-R file. An intragroup comparison showed a statistically significant
Comparison of mean percent gutta-percha remaining in the apical one-third (Graph 1 and Table 1)
PTUR + XPF unveiled the least amount of gutta-percha followed by XPS + XPF-R and PTUR. There is no statistically significant difference between Group 3 and Group 4.

Comparison of the mean percent of total gutta-percha remaining in the entire tooth (Graph 1 and Table 1)
H-file proclaimed the highest amount of gutta-percha, whereas XPS + XPF-R showed the least amount of gutta-percha ($P < 0.05$). Post hoc Tukey’s test indicates that the difference was statistically significant between all groups except between Group 3 and Group 4.

Comparison of loss of dentin in the coronal one-third (Graph 2 and Table 2)
Group 3 appeared to have less preservation of root dentin followed by Group 2, Group 4, and Group 1; however, the difference is not significant.

Comparison of loss of dentin in the middle one-third (Graph 2 and Table 2)
PTUR + XPF showed the highest dentin loss followed by the Groups 2, 1, and 4; nevertheless, the difference is not significant.

Comparison of loss of dentin in the apical one-third (Graph 2 and Table 2)
XPS + XPF-R manifested more preservation of sound difference ($P < 0.05$) between Group 1 to Group 2, Group 3, and Group 4.
Comparison of loss of dentin in the entire tooth (Graph 2 and Table 2)

PTUR showed the highest amount of loss of dentin, whereas XPS + XPF-R showed the least, and the difference is statistically significant ($P < 0.05$).

Table 1: One-way ANOVA test for remaining gutta-percha at coronal, middle, apical third, and entire tooth

| Groups          | n  | Mean  | Standard deviation | Standard error | 95% confidence interval for mean | Minimum | Maximum |
|-----------------|----|-------|--------------------|----------------|---------------------------------|---------|---------|
| Coronal 1/3     | 1  | 15    | 3.87               | 1.356          | 0.350                           | 3.12    | 4.62    |
|                 | 2  | 15    | 1.07               | 0.799          | 0.206                           | 0.62    | 1.51    |
|                 | 3  | 15    | 2.07               | 0.799          | 0.206                           | 1.62    | 2.51    |
|                 | 4  | 15    | 1.47               | 1.246          | 0.322                           | 0.78    | 2.16    |
|                 | Total 60 | 2.11  | 1.50               | 0.194          | 3.12                            | 1.72    | 2.50    |
| Middle 1/3      | 1  | 15    | 9.60               | 2.640          | 0.682                           | 8.14    | 11.06   |
|                 | 2  | 15    | 2.67               | 1.047          | 0.270                           | 2.09    | 3.25    |
|                 | 3  | 15    | 2.67               | 1.113          | 0.287                           | 2.05    | 3.28    |
|                 | 4  | 15    | 1.07               | 1.387          | 0.358                           | 0.30    | 1.83    |
|                 | Total 60 | 4.00  | 3.70               | 0.478          | 3.04                            | 4.95    | 0.15    |
| Apical 1/3      | 1  | 15    | 5.53               | 1.125          | 0.291                           | 4.91    | 6.16    |
|                 | 2  | 15    | 4.00               | 1.558          | 0.402                           | 3.14    | 4.86    |
|                 | 3  | 15    | 0.87               | 0.743          | 0.192                           | 0.46    | 1.28    |
|                 | 4  | 15    | 1.80               | 1.146          | 0.296                           | 1.17    | 2.43    |
|                 | Total 60 | 3.05  | 2.17               | 0.280          | 2.48                            | 3.61    | 0.7     |
| Entire teeth    | 1  | 15    | 2.67               | 1.718          | 0.444                           | 1.72    | 3.62    |
|                 | 2  | 15    | 4.60               | 1.882          | 0.486                           | 3.56    | 5.64    |
|                 | 3  | 15    | 5.13               | 1.642          | 0.424                           | 4.22    | 6.04    |
|                 | 4  | 15    | 4.00               | 1.175          | 0.303                           | 2.02    | 3.32    |
|                 | Total 60 | 4.39  | 2.47               | 0.319          | 3.75                            | 5.02    | 1.9     |
| Middle 1/3      | 1  | 15    | 5.73               | 1.625          | 0.424                           | 4.17    | 7.29    |
|                 | 2  | 15    | 2.67               | 1.175          | 0.303                           | 2.02    | 3.32    |
|                 | 3  | 15    | 6.03               | 0.292          | 0.754                           | 5.86    | 6.19    |
|                 | 4  | 15    | 1.13               | 0.834          | 0.215                           | 0.67    | 1.60    |
|                 | Total 60 | 4.50  | 2.58               | 0.333          | 3.84                            | 5.17    | 1.11    |
| Apical 1/3      | 1  | 15    | 4.53               | 1.685          | 0.435                           | 3.60    | 5.47    |
|                 | 2  | 15    | 7.73               | 2.549          | 0.658                           | 6.32    | 9.14    |
|                 | 3  | 15    | 4.45               | 0.429          | 0.11                            | 4.21    | 4.68    |
|                 | 4  | 15    | 2.73               | 1.981          | 0.511                           | 1.64    | 3.83    |
|                 | Total 60 | 4.86  | 2.55               | 0.329          | 4.20                            | 5.52    | 1.15    |
| Entire teeth    | 1  | 15    | 12.13              | 2.446          | 0.631                           | 10.78   | 13.49   |
|                 | 2  | 15    | 17.93              | 5.021          | 1.296                           | 15.15   | 20.71   |
|                 | 3  | 15    | 18.11              | 0.902          | 0.233                           | 17.61   | 18.61   |
|                 | 4  | 15    | 6.33               | 2.820          | 0.728                           | 4.77    | 7.89    |
|                 | Total 60 | 13.62 | 5.77               | 0.746          | 12.13                           | 15.12   | 1.26    |

*The mean difference is significant at the 0.05 level

Time (Graph 3 and Table 3)

PTUR was fastest in all groups. The difference was not significant between Groups 2 and 3.

DISCUSSION

XPS + XPF-R showed magnificent results in the removal of dentin, and PTUR exhibited the least. The difference is statistically significant ($P < 0.05$).
of remaining gutta-percha material at coronal, middle, and apical levels, the difference is statistically significant. Consequently, the first hypothesis is rejected. This is explained by innovative alloy used to manufacture XP-endo files, which authorizes expansion at body temperature. During instrumentation, its elliptical part is compressed by resistance obtruded by root canal, hence impelling the tip of the file against canal walls. This mechanism may have allowed it to touch and supplant residual filling materials by increasing helical movements inside the root canal.

The study results are following the previous studies which showed that the XP-endo files alone or supplemented with other file systems were more effective than other groups.

The existing study indicated that XP-F is less effective than its newer version of the file XP-F-R due to differences in the core diameter and tip angulation, which makes XP-F-R stiffer and more aggressive in the removing obturating material. This outcome is in line with the investigation done by Silva et al., who claimed that XP-F-R is effective than other systems ($P < 0.05$).

We selected oval-shaped canals as it composes the larger part of the human root canals and instrumentation in these canals fail to abolish microorganisms from the buccal and lingual extensions of an oval shape which may harbor bacteria and causes root-canal failure.

Techniques used for quantification of residual obturating materials include radiographic imaging, longitudinal severance of roots for microscopic analysis using stereomicroscope, and scanning electron microscope, which were failed to dispense computable volumetric information before and after the retreatment. CBCT has been precisely designed to propagate undistorted three-dimensional information of teeth, with a remarkable lower effective radiation exposure.

No studies have been reported the measurement of dentinal loss during the retreatment using XP-endo files. XPS + XP-F-R exhibited favorable outcomes in terms of dentin loss, while PTUR appeared to have ominous results ($P < 0.05$). Therefore, the second null hypothesis is rejected. This is explained by the XP-endo file's high flexibility, zero tapers, and NiTi MaxWire technology. It will capable of moving through every corner and walls of the root canal and scrubbed debris that has been left inside without deviating its natural path of the root canal.

PTUR files are different than XP endo systems in tip design, file sequences, cross-section of the file, taper, manufacturing alloy and flexibility. This file has a negative rake angle, increased core diameter, large taper, and the convex triangular cross-section makes it less flexible, resulting in more root dentin removal along with obturating materials. This Ni-Ti alloy has less flexibility than NiTi MaxWire alloy and provides continuous rotational force and constant torque inside the root canal. Loss of sound dentin linked with increased susceptibility of cracks since functional loads from repeated occlusal forces after restoration can boost if the remaining dentin thickness is reduced. Our finding is correlated with the study done by Rödig et al., who stated that PTUR removed considerably more amount of dentin than H-file and D-Race file systems.

**CONCLUSION**

XPS + XP-F-R showed promising results in gutta-percha removal for retreatment without sacrificing the sound dentin than PTUR and H-file. PTUR was fastest among all groups. Further in vivo research is required to strengthen these findings.

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Conflicts of interest
There are no conflicts of interest.

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