Original Research Paper

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Comparative Evaluation of the Efficacy of Different Retreatment File Systems With or Without Solvent in Removing Obturation Materials From Root Canals: An in-Vitro CBCT Study

Abstract:

Background: Complete elimination of the existing root filling is fundamental to successful endodontic retreatment.

Aims: To compare three rotary retreatment systems for removal of gutta-percha and bioceramic sealer, with and without xylene.

Materials and Methods: Forty-two extracted human mandibular premolars with single straight canals were shaped with ProTaper Universal rotary files up to F3 and obturated by the single-cone technique using matched ProTaper gutta-percha and CeraSeal RC bioceramic sealer. After storage, specimens were randomly allotted to six groups (n=7): ProTaper Universal Retreatment, HyFlex Remover and MicroMega Remover, each employed with or without xylene. Residual filling material was quantified from pre- and post-retreatment CBCT scans in axial, coronal and sagittal sections.

Statistical analysis used: Two-way ANOVA with post hoc multiple comparisons (GraphPad Prism 10.1.2); $P<0.05$.

Results: Xylene significantly lowered the residual material ($P=0.0025$), and a significant interaction between file system and solvent use was recorded ($P<0.0001$). HyFlex Remover and ProTaper Universal Retreatment left less residue than MicroMega Remover, the difference being widest when no solvent was used.

Conclusions: None of the systems removed the filling completely. Xylene improved removal with all three systems, HyFlex Remover being most efficient, followed by ProTaper Universal Retreatment and MicroMega Remover.

Key-words: Bioceramic sealer, CBCT, gutta-percha, retreatment, rotary files, xylene.

Introduction:

Complete removal of root-filling material during retreatment is essential, since residual debris shelters microorganisms and limits irrigant penetration.[1] Bioceramic sealers bond strongly to dentin, which paradoxically also makes them hard to remove completely.[2] Nickel-titanium rotary systems are commonly used, yet none fully clears filling material, as instrument design influences residual debris.[3,4] Xylene has also been reported to aid removal of bioceramic sealer.[5] CBCT offers a dependable, non-destructive method to quantify residual filling material.[6] This study compared three rotary retreatment systems, with and without xylene, for efficacy in clearing gutta-percha and bioceramic sealer.

Materials and Methods:

Ethical clearance for this study was obtained beforehand from the Institutional Ethics Committee (Reg. no. EC/NEW/INST/2023/3191). Forty-two human mandibular premolars, extracted as part of orthodontic treatment, were selected on the basis of having a single, straight root canal. Teeth were not included if they showed multiple canals, curved canals, internal or external resorption, cracks, fractures, calcification, or any history of earlier endodontic treatment. An ultrasonic scaler was used to remove any

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remaining soft tissue and calculus from the extracted teeth, after which they were stored in saline until required.

Specimen preparation:

Crowns were sectioned off under water cooling using a diamond disc (SS White, New Jersey, USA), bringing every root to a standardized length of 16 mm. Working length was determined by passing a size 10 K-file (MANI, Japan) down the canal until its tip could just be seen at the apical foramen and then subtracting 1 mm from that reading. Canal shaping followed a crown-down protocol using ProTaper rotary files (DentsplyMaillefer, Switzerland) up to an F3 size, with 5.25% sodium hypochlorite (Prime Dental, Maharashtra, India) irrigation between each file change. The canals were finally rinsed with 17% EDTA and then saline to complete the irrigation sequence.

Once dried using paper points, each canal was filled by the single-cone method with a matching ProTaper F3 gutta-percha cone (DentsplyMaillefer, Switzerland) and Meta CeraSeal RC bioceramic sealer. Access cavities were closed with a temporary restorative material, and the specimens were then kept for two weeks at 37°C in an environment of 100% humidity.

Pre-retreatment CBCT evaluation:

After the storage period, specimens were embedded in modelling wax and imaged with a SkyView cone-beam CT scanner (MyRay, Italy). Using the associated CBCT software, the overall area occupied by the root filling material was recorded in axial, coronal, and sagittal views, giving a baseline figure against which later measurements could be compared.

Group allocation:

Specimens were then divided at random into six groups of seven teeth each (n=7):

Group Ia: ProTaper Universal Retreatment + xylene
Group Ib: ProTaper Universal Retreatment without xylene
Group IIa: HyFlex Remover + xylene
Group IIb: HyFlex Remover without xylene
Group IIIa: MicroMega retreatment files + xylene
Group IIIb: MicroMega retreatment files without xylene

Retreatment procedure:

For groups receiving xylene, a small amount of the solvent was introduced at the canal orifice before instrumentation began, allowing it to soften the gutta-percha. Passive ultrasonic irrigation with sodium hypochlorite, followed by saline, was performed between successive instruments. Retreatment was considered finished once the original working length had been re-established and no trace of filling material could be seen on the flutes of the instruments or on the paper points used to check the canal.

Post-retreatment CBCT evaluation:

Following retreatment, every specimen was scanned a second time on the same CBCT unit, using identical exposure parameters. The imaging software was used to measure the cross-sectional area of any remaining obturation material in the axial, coronal, and sagittal planes, and these three readings were averaged to give the mean residual area. The proportion of filling material left behind was then calculated with the following formula:

Percentage of remaining filling material = (mean residual area across the 3 sections / total pre-retreatment filling area) x 100
Two-way ANOVA was used to assess how retreatment system and xylene use, individually and in combination, affected the percentage of residual obturation material, with post hoc multiple-comparison tests carried out where indicated; significance was set at $P < 0.05$.

Results:

No significant difference was found in the mean pre-retreatment obturated canal area across groups ($P = 0.17$), confirming that the groups were comparable at baseline.

The mean area of residual obturation material for each group following retreatment is shown in Table 1. Two-way ANOVA revealed a significant interaction between file system and xylene use ($F = 22.53$, $P < 0.0001$), together with independent significant effects of xylene ($F = 10.53$, $P = 0.0025$) and file system ($F = 32.69$, $P < 0.0001$). In the absence of xylene, pairwise comparisons showed that MicroMega left significantly more residual material behind than either ProTaper Universal Retreatment or HyFlex Remover (Figure 1). Across the board, xylene use was associated with significantly less residual filling material, and a similar trend emerged when residual material was expressed as a percentage of the original obturation volume rather than as an absolute area (Figure 2).

Discussion:

The bond that bioceramic sealers form with root dentin arises from both chemical and micromechanical processes: hydroxyapatite precipitates within a mineral infiltration zone at the interface between sealer and dentin, while sealer particles diffuse into the dentinal tubules and lock in place micromechanically.[7] Singh et al. reported a comparable pattern, noting that canals filled with bioceramic sealer still contained residual material even after retreatment using ProTaper Universal Retreatment combined with xylene.[5] In a similar vein, Peña-Bengoaet al. found that although supplementary cleaning steps improved bioceramic sealer removal, none of the techniques they tested achieved a completely clean canal wall.[8]

Among the three systems tested, HyFlex Remover consistently left behind the smallest amount of residual obturation material, regardless of whether xylene was used (Table 1). A likely explanation lies in the instrument's design: it has a triple-helix cross-section with an irregular, asymmetric blade shape and a non-cutting tip, and is produced through a patented heat-treatment process (C-wire) that gives it greater flexibility and resistance to cyclic fatigue than conventional nickel-titanium alloys offer.[9,10] Together with its inactive tip, these features are thought to allow the file to track canal anatomy more closely while cutting down on procedural mishaps during retreatment.[10] In a comparable finding, Kim et al. showed that HyFlex Remover had the highest resistance to buckling among the single- and multi-file retreatment systems they compared, a mechanical trait that could allow more controlled penetration through resistant filling material.[11] This aligns with work by Alelyani, who found that HyFlex Remover and XP-Endo Retreatment cleaned calcium silicate-based sealer more effectively than other systems, especially in the coronal and middle thirds of the canal.[12]

In the present study, ProTaper Universal Retreatment performed at a level similar to HyFlex Remover, whether or not xylene was used (Table 1). This system relies on three instruments used in sequence (D1, D2, D3), each with a convex triangular cross-section, applied respectively to the coronal, middle, and apical thirds of the canal.[13] In one of the earlier assessments of this system, Gu et al. found that ProTaper Universal Retreatment removes gutta-percha efficiently without achieving a fully clean canal, a conclusion that later evaluations of rotary retreatment systems have generally supported.[1,13,14] More recently, Srirama et al. used micro-computed tomography to test ProTaper Universal Retreatment against a bioceramic sealer (BioRoot RCS) and likewise reported effective but incomplete removal of the filling material.[15]

Canals treated with MicroMega retreatment files retained significantly more obturation material than those treated with either HyFlex Remover or ProTaper Universal Retreatment, and this gap was widest when xylene was withheld ($P < 0.0001$). This matches Alelyani's finding of reduced removal efficiency for MicroMega Remover compared with HyFlex Remover, again in canals containing calcium silicate-based sealer.[12] It does, however, diverge from the results of Dursun et al., who reported no statistically significant difference in residual filling material among MicroMega Remover, ProTaper Universal Retreatment, Reciproc, and Hedströmfiles when working in curved canals filled with a conventional resin-based sealer.[3]

A further finding of this study was a significant interaction between file system and xylene use: xylene reduced residual material by a disproportionately larger margin for MicroMega retreatment files than for HyFlex Remover or ProTaper Universal Retreatment (Table 1). This implies that systems with weaker intrinsic mechanical cutting ability gain more from the chemical softening xylene provides. Solvents of this kind work chiefly by softening and dissolving the gutta-percha, which in turn makes it easier for instruments to penetrate the canal and retrieve debris coronally. Xylene has also been shown to dissolve bioceramic sealers to a measurable extent, although exactly how it does so is still not well understood.[16,17]

Table 1:-Comparisons of the Area of Remaining Obturating material (in mm^2) across xylene status within and between study groups

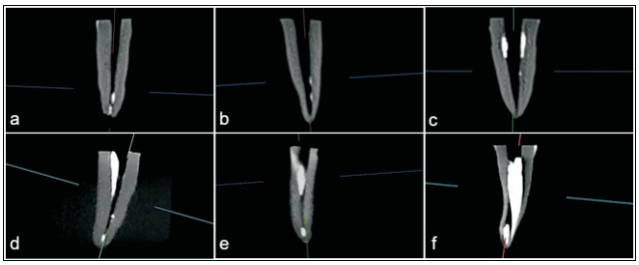
File Systems/Xylene Status	Protaper Retreatment	Hyflex Remover	Micromega Retreatment
With Xylene	2.684±0.1761	2.66±0.3068	3.25±0.3533
Without Xylene	3.019±0.2061	2.986±0.3052	4.096±0.3166

Values expressed in terms of Mean±Standard deviation

Figure Legends

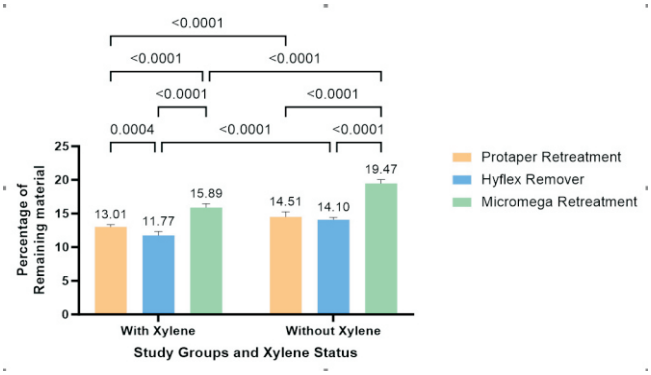
Legends for the figure 1:

Representative CBCT images(Coronal section):- (a) Group Ia; (b) Group IIa; (c) Group IIIa; (d) Group Ib; (e) Group IIb; and (f) Group IIIb



Legends for the figure 2:

Bar Graph: Mean (± standard deviation) of the Percentage of Remaining Obturating material among the study groups for with/without Xylene. Statistically significant pairwise comparisons are indicated overhead by the corresponding P values (adjusted).



Conclusion:

No retreatment system tested was able to remove the obturation material entirely. Xylene use significantly improved removal outcomes overall, with HyFlex Remover proving the most effective system, followed in turn by ProTaper Universal Retreatment and then MicroMega.

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