

Comparative evaluation of Apical Microleakage in root canals containing separated endodontic files: An in vitro study

ABSTRACT

Aims: The aim of the present in vitro study was to evaluate apical seal in the root canals containing separated instrument (Hand k files, Hyflex CM and Reciprocation Neoendo file) using dye penetration method.

Study design: An in vitro study

Place and Duration of Study: Department of Conservative Dentistry & Endodontics, SGRD Institute of Dental Sciences, Amritsar, Punjab, India between Feb 2022 and Nov 2023.

Methodology: In this study 3 different file systems were used for root canal preparation of 90 teeth. The files were intentionally separated (n=20 each) at the apical third and tooth was obturated using lateral condensation method along with 2 control groups (n=5 each) and the analysis of microleakage was done using dye penetration method under stereomicroscope.

Results: The highest mean microleakage was observed in Hyflex CM (5.49mm) group followed by Hand K file (3.338mm) whereas least microleakage was observed in samples containing separated Reciprocation file Neoendo (3.220mm).

Conclusion: Maximum microleakage was observed in Hyflex CM files and least in Reciprocation File Neoendo group.

Keywords: Continuous rotary motion; Dye penetration; Reciprocation; Microleakage; Apical seal

1. INTRODUCTION

In endodontic therapy, the root canal space is biomechanically prepared using endodontic instruments to remove microbial pathogens and create a surface free of debris. It also ensures adequate space for the irrigants to reach till the apical third and disinfect the canal space. But instrument fracture is an adverse sequelae of root canal shaping.

Although the existence of an instrument fragment within the tooth does not inherently impact the result of endodontic treatment, improper management of this condition can compromise the eradication of infected and/or vital tissues by endangering chemo-mechanical disinfection and obturation procedures [1].

.According to Madarati et al. (2008)[2] various factors influencing instrument separation include operator proficiency, complicated root canal anatomy, overuse of the instrument, instrument metallurgy and inherent micro cracks, size and cross-section of file, sterilisation, calcified canals etc. and these factors should considered to determine overall prognosis of treatment.

Kosti et al. (2011)[3] stated that maximum separations were discovered in canals with extreme curvature ($60\pm 10^\circ$). Also, the chances of breaking a file in the apical regions was thirty-three times higher than in the cervical region [4].

Once separated the instrument may be bypassed, or retrieval attempts may be made with retrieval kits, ultrasonics and the more recent minimally invasive gentle wave method but sometimes, it is impossible to retrieve the split piece. Therefore, endodontists want to include them in the final root canal filling.[5] Empirical data indicates that, adequately cleansed and sealed canals are not negatively affected by presence of fractured tools inside the tooth canal.[6]

So the present study seek to evaluate the effect of separated instruments with varying file designs and cross-section on the apical seal of the tooth and the microleakage was measured using dye penetration method. The null hypothesis under consideration was:

There will be no difference in microleakage values in root canals containing separated files as compared to canals without instrument separation.

2. MATERIAL AND METHODS

To assess the aftermath of a separated tool on the apical seal of obturated canals containing separated files, freshly removed teeth were collected from the Department of Oral and Maxillofacial Surgery and then evaluated for inclusion and exclusion criteria.

INCLUSION CRITERIA:

1. Permanent teeth with full root formation.
2. Restoration- and crack-free teeth.

EXCLUSION CRITERIA:

1. Teeth with fracture lines
2. Teeth with periodontal defects.

Procedure: Using an ultrasonic scaler, hard deposits were removed and organic debris was cleaned from the extracted teeth. The teeth were preserved in 10% formalin until needed, after being cleaned with distilled water to get rid of any soft tissue fragments.

The selected teeth were prepared using either of the three endodontic files as allocated by Random allocation software 2.0.

Biomechanical preparation: After determining the working length using Ingle's method, three separate file systems were used to prepare these canals:

2.1 Reciprocation file Neo-Endo: The glide path was established by 17/4% file(NeoEndo flex) and root canal preparation was done by 20 no. file (Reciprocation File NeoEndo). A 30-gauge side-vented needle was used to irrigate the root canals during preparation. First, 5.25% sodium hypochlorite solution was used, followed by 17% ethylenediamine tetra acetic acid (EDTA). Normal saline was used as the last irrigant.

2.2 Hand Files:The 15/.02 hand K file (DentsplyMaillefer) set the glide route. Root canal preparation was carried out by DentsplyMaillefer's 20/.02 K-file. A 30-gauge side-vented needle was used to irrigate the root canals during preparation. First, 5.25% sodium hypochlorite solution was used, followed by 17% EDTA. The final irrigant was regular saline.

2.3 HyFlex CM (coltene): The glide path was established by 15/.04 file(HyFlexCM) and root canal preparation was done by 20/.04 file(HyFlex CM). A 30-gauge side-vented needle was used to irrigate the root canals during preparation. First, 5.25% sodium hypochlorite solution was used, followed by 17% EDTA. The final irrigant was regular saline.

After which the endodontic file was split by nicking it in the apical third of the canal. Based on the endodontic file fractured, three groups of sixty teeth (experimental samples) were created.

GROUP-A:-Reciprocation File Neo Endo(Orikam Healthcare India Private Limited)

GROUP- B:-Hand K-files (DentsplyMaillefer)

GROUP- C:-HyFlex CM (ColteneWhaledent, Altstetten, Switzerland)

All the canals were then obturated using Cold Lateral Compaction Technique above the divided file: The canal was first dried and the apical length of the guttapercha was trimmed in accordance with the length of the separated file, and the master guttapercha cone was chosen based on the most recent file used at working length. Sealer was coated on canal walls and the modified guttapercha cone. In order to condense the apical portion of the canal, a spreader was placed alongside the main cone. Secondary guttapercha cones were used in this manner until the canal was completely filled.

5 positive and negative samples were prepared for each group that constituted of biomechanically prepared root canals without obturation and root canals obturated with lateral compaction technique after biomechanical preparation respectively. The produced samples were kept in a 100% humidity environment at 37°C.

Using a stereomicroscope and the dye penetration method, microleakage was evaluated: With the exception of the apical 2-3 mm, samples were covered in nail varnish. After the varnish coat had dried, it was submerged in dye for 72 hours in various specimen containers. After rinsing the samples under running water, a surgical blade was used to remove the nail polish. Using a diamond disc and straight handpiece, all specimens were longitudinally sectioned in the buccolingual direction. The depth of dye penetration was measured in millimetres off all the samples using an Image ruler (Version 1.1). Representative images of all the groups are depicted in Fig. 1. After calculation, the data was analysed using One-way ANOVA and Post-hoc Bonferroni Analysis of Variance

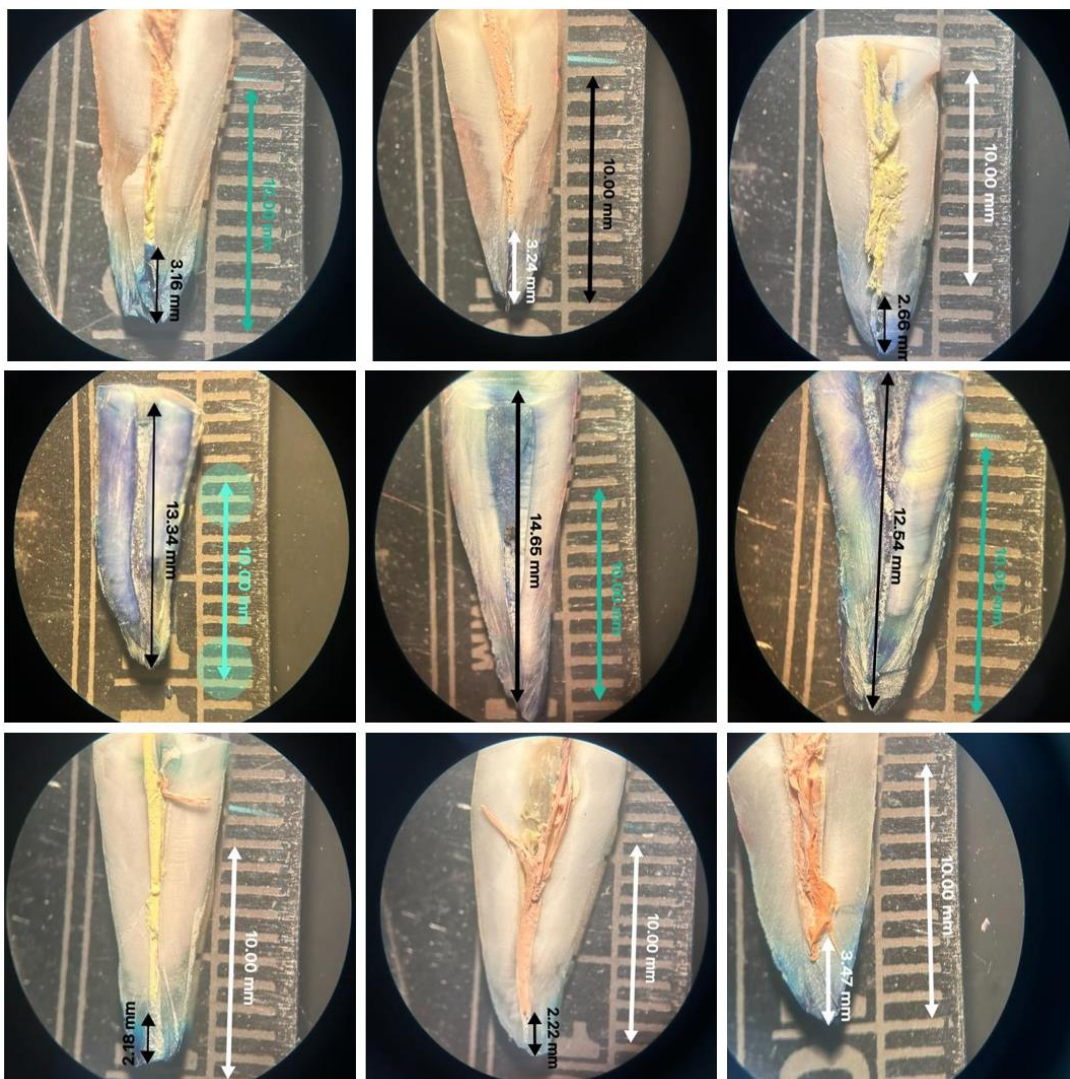


Fig 1: Dye penetration in samples containing separated instrument : Experimental samples (A-C) : Fig.A – Reciprocation Neoendo file, Fig. B- Hand k file, Fig. C- Hyflex CM. Positive control samples(D-F): Fig.D – Reciprocation Neoendo file, Fig. E- Hand k file, Fig. F Hyflex CM and Negative control samples (G-I): Fig.G – Reciprocation Neoendo file, Fig. H- Hand k file, Fig. I- Hyflex CM

Table 1: Mean Microleakage among different experimental groups

| Groups | N | Mean |
|---------------------------------------|-------|-------|
| Group-A: Neo Endo Reciprocation Group | 20 | 3.220 |
| Group-B: Hand K File Group | 20 | 3.338 |
| Group-C: Hyflex CM File Group | 20 | 5.498 |
| <i>P</i> -value | 0.003 | |

Applied test : One-way ANOVA

Significant ($P < 0.05$)

Table-2: Multiple comparisons between different study groups:

| Groups comparisons | Mean Difference (I-J) | Sig. |
|--------------------|-----------------------|-------|
| Group-A & B | -0.118 | 1.000 |
| Group-A & C | -2.27800* | 0.007 |
| Group-B & C | -2.16000* | 0.011 |

*. The mean difference is significant at the 0.05 level.

Test applied: Post-hoc Bonferroni Analysis of Variance

Table 3: Comparison between experimental and control values of microleakage within various groups:

| Particulars | N | Group-A | | Group-B | | Group-C | |
|--------------------|----|---------------------|-------|---------------------|-------|---------|-------|
| | | Mean | ±SD | Mean | ±SD | ±SD | SE |
| Experimental Group | 20 | 3.220 ^a | 0.833 | 3.338 ^a | 1.347 | 3.58 | 0.801 |
| Negative control | 5 | 3.178 ^a | 1.083 | 3.162 ^a | 1.021 | 0.935 | 0.418 |
| Positive control | 5 | 13.600 ^b | 1.181 | 11.468 ^b | 2.325 | 3.135 | 1.402 |
| <i>P</i> -value | | < 0.001 | | < 0.001 | | 0.003 | |

Applied test: One-way ANOVA

The groups with same letters; $P > 0.05$ i.e. have insignificant variation & different letter in the superscripts differ significantly ($P < 0.05$)

3.RESULTS AND DISCUSSION

3.1 Results: The highest mean microleakage values were seen in Group- C (5.498mm) followed by Group- B (3.338mm) and Group-A(3.220mm) in experimental samples containing fractured instruments and the dissimilarity was significant($P=.03$) as depicted in Table-1. The intergroup analysis revealed statistically significant difference between group-A & C ($P=.007$) whereas the dissimilarity between Group-A & Group-B ($P=1.00$) and Group-A & Group-C ($P=1.00$) was insignificant as displayed in Table-1.

Table-3 depicts an intra-group comparison between experimental, positive and negative samples of various groups. The Group-A revealed that the difference between microleakage values in experimental and negative control group was insignificant whereas that of experimental and positive control was significant ($P < 0.05$).

3.2 Discussion: Endodontics is the branch of science which deals with the identification, prevention and treatment of paralogical pulpal, periapical and periradicular conditions [7]. The canals must be cleaned and sculptured, among other sequential steps, for endodontic therapy to be successful. The tooth canal instrumentation is a key factor determining the success of endodontic therapy as it decreases the microbial load and achieve a complete 3-D seal but is associated with complication of file separation. This is influenced by various factors like instrument cross-section, material of the file, kinematics etc.

Although mere existence of fragment may not complicate the prognosis of tooth but might hinder in the disinfection of canal. So in the current investigation the effect of instrument separation of endodontic files with varying cross-section and operated using different operation motions (Reciprocating, manual instrumentation and continuous rotary motion) on the microleakage of samples was evaluated.

The current investigation revealed significantly higher ($P=0.003$) microleakage values in Group-C followed by Group-B & A respectively. The reason for lower microleakage values may be attributed to the S-shaped cross-section of Reciprocation Neo endo files which allowed better removal of the dentinal debris. In contrast to Hand K files possessing rectangular cross-section and Hyflex CM files- a three cornered cross-section which had relatively smaller gaps for debris clearing and encouraged smear layer collection. Also, the S-shaped cross-section allowed sealer to flow along the broken file providing better obturation. These observations corroborate with the findings of various authors [8-11].

The inter-group comparison amongst Group-A & B disclosed insignificant difference ($P=1.00$) between the two groups and corroborates with observations of Subramaniam et al. (2016) [12] who compared smear layer formation between rotary and hand files and concluded that both performed similarly with statistically insignificant difference ($p>0.05$). These findings may be attributed to increased accumulation of smear layer, dentinal chips and lower clearance of produced debris in Hyflex CM files as compared to group-A Neoendo reciprocation files with S-shaped cross-section that ensured efficient elimination of the debris due to the large gaps between the cutting blades and hence eliminating any obstruction to the smear layer removal.

On the contrary, dissimilarity between Group-A&C ($p=0.007$) and Group-B&C ($P=0.011$) was statistically significant. The higher microleakage in Hyflex CM files with a three-cornered cross-section might due to increased accumulation of smear layer, dentinal chips and lower clearance of the produced debris as compared to group-A Neoendo reciprocation files. The superior performance of Hand k files may be attributed to the lower production of smear layer and debris in hand files as compared to the rotary endodontic files. The rotary files undergo more number of cycles leading to higher and thicker smear layer formation. As a physical barrier, the smear layer inhibited the sealer's adhesion and penetration into the tubules, which caused spaces to form between the dentinal walls and the obturation materials and increased micro leakage. These finding are in accordance to the observations of various authors [10, 13-17].

The intra-group comparison as depicted in table-3 revealed that the lowest microleakage values were seen in negative control samples of all the groups followed by the experimental samples and the difference between the two was insignificant ($P>0.05$). These results confer with findings of various authors [18-22] that reported higher microleakage values in obturated teeth obturated containing a separated file as compared to teeth without them. Similarly, in a study conducted Ok E and Ertas H (2014)[18] it was concluded that regardless of variant of file, fracture of instrument will have a negative impact on the apical seal.

On the contrary, significantly higher ($p<0.05$) microleakage value was observed in positive control samples. This may be because positive control samples constituted biomechanically prepared root canals without obturation and the higher microleakage values are due to the absence of obturating material allowing higher amount of dye to penetrate and is in corroboration with findings of various authors [23, 24].

Thus the current investigation helps in analysing the effect on the apical seal in a tooth containing fractured file and its impact on the overall prognosis of the endodontic therapy.

In order to guarantee the separation of endodontic file at the apical portion of tooth for the purpose of evaluating microleakage, the files were nicked at a distance of 3 mm. As a result, the separated fragment may not be as tightly bound to the dentin, with a decreased smear layer and debris formation, than the instrument separated due to torsional or cyclic fatigue in the canal, which could have resulted in higher microleakage values.

4. CONCLUSION

Within the shortcomings of this research The Reciprocation File Neoendo displayed the lowest microleakage values among the various study groups. Hence the present study validates the better performance of S-shaped reciprocation file systems and encourages their application as along with their superior fatigue resistance they also have least negative impact if left within the canal.

CONSENT

Not applicable as it was an in vitro study.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

The necessary ethical approval was obtained by the authors from Institutional ethical committee of Sri Guru Ram Das Institute of dental sciences and research, Amritsar.

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