ORIGINAL ARTICLE

Permeability of Remaining Endodontic Obturation: Comparison of Immediate versus Delayed Post Space Preparation, An In Vitro Study

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ABSTRACT

Purpose: Post and core requires removal of a portion of the gutta-percha from the root canal space. When gutta-percha is removed some factors may have a negative effect on obturating material seal. This study evaluated the microleakage from coronal to apical and from apical to coronal for two different post preparation techniques.

Method: Eighty roots were obturated using lateral condensation method with gutta-percha and Gutta-flow sealer and divided into two groups of 40 roots each. Immediate post space preparation was done for one group and delayed preparation was for the other. Two subgroups of 20 roots each were formed to investigate leakage from coronal to apical and from apical to coronal. The extent of leakage was determined using a dye, Indian ink and clearing technique that rendered the teeth transparent. Eight roots were used as positive and negative controls. Dye penetration analysis was carried out using stereomicroscope by a single examiner.

Results: The dye infiltration values were tabulated and statistical analysis was carried out using unpaired t test. The results showed a significant difference between immediate coronal to apical and delayed coronal to apical groups with lower values for immediate coronal to apical group. ($p<0.05$) There was no significant difference between immediate apical to coronal and Delayed apical to coronal groups.

Conclusion: Coronal to apical permeability was significantly lower for the immediate post preparation technique than for the delayed technique. Apical to coronal permeability was not statistically different for the different post preparation techniques.

Keywords: Delayed technique, immediate technique, microleakage, post space, obturation

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Date of Submission: 31-03-2013
Reviews Completed: 05-04-2013
Date of Acceptance: 05-04-2013

INTRODUCTION

Endodontically treated teeth are commonly restored by a post and core followed by a crown. The first step in making post and core is the removal of a portion of the gutta-percha from the root canal space.[1] When gutta-percha is removed some factors may have a negative effect on obturating material seal. Factors that deserve special attention include the length of the post, amount of remaining gutta-percha and the post preparation technique.[2] The gutta-percha removal technique should be safe, efficient and should not disturb the seal (apical and/or coronal).[1] Two commonly adopted post space preparation techniques are the immediate and the delayed techniques. In immediate technique the gutta-percha was removed immediately after obturation with heated pluggers of decreasing diameters. In delayed technique the gutta-percha was removed at a later stage after a full setting of the sealer using rotary instruments. [2]

The required post space may be prepared either immediately after the completion of the endodontic procedure using hot pluggers or alternatively at a later stage after a full setting of the sealer using rotary instruments.[3]

Immediate removal of the coronal part of a root canal filling by hot plugger is often performed by the same operator who has just finished the root canal obturation, while late removal of coronal guttapercha is performed at a subsequent visit

and frequently by a different operator -a restorative dentist or prosthodontist rather than an endodontist.[4]

Schnell using heated endodontic pluggers for guttapercha removal, reported no significant difference in leakage of the apical seal after immediate or delayed post space preparation.[5]

Kwan and Harrington[6] and Madison and Zakariasen[7] found that post space preparation with Gates Glidden drills immediately after obturation actually decreased the amount of apical leakage.

It is commonly recommended that post space preparation should allow a remaining root canal filling of 5mm to avoid compromising the apical seal.[8] Matisson et al reported that the mechanical removal of GP with a Gates Glidden drill was the most desirable method of post space preparation compared with chemical solvent or heated instrument. Flame heated endo pluggers are a fast and inexpensive means of GP removal and they don't cause canal shape alterations. A disadvantage of this technique is the burn potential for the dentist, dental assistant or the patient. Damage to the PDL by flame heated pluggers does not appear to be a problem. There are various methods for preparing post space such as mechanical (bur/drills), physical (heated instruments) or chemical (solvents)techniques.[6,7] During preparation the remaining filling material might be dislocated, which can create a pathway for re-infection of the root canal system.[9] Therefore, selecting an appropriate root canal filling material and procedure for post space preparation is an essential factor that can affect the treatment outcome.

According to Timpawat *et al*. endodontic sealers are used to eliminate the interface between the gutta-percha and dentinal walls. Leakage may, however, occur at the interfaces between the sealer and dentin, sealer and gutta-percha and in spaces within the sealer itself. Thus, the quality of the filling depends on the sealing capacity offered by sealers.[10]

The success of endodontic treatment requires canal obturation materials to have good sealing ability. In addition, the techniques used during and after obturation must not impair these materials ability to preserve the apical and coronal seal.[11] Although several obturating materials are available, studies have shown that none of them are able to avoid apical infiltration completely.[12] All of the materials allow plasma to leak from the apex toward crown or allow saliva to leak in the opposite direction. In both these situations, microbial colonies may develop, leading to treatment failure.[2] In the available literature, studies have assessed either apical to coronal leakage or coronal to apical leakage; however, very few studies have assessed both.

This study therefore incorporates the correlation of dye infiltration using immediate and delayed post preparation techniques (1) From coronal to apical and (2) From apical to the coronal. During preparation of the post space the residual filling material may be dis-lodged, twisted or vibrated which creates a pathway for bacterial invasion and re-infection of the root canal system. Several factors can affect the integrity of the apical seal while post space is prepared such as length of remaining gutta-percha, time of removal of the filling material and method of gutta-percha removal.[13,14,15]

MATERIALS AND METHOD

Eighty eight extracted Human maxillary central incisors were collected and were stored in 4%. Formalin. Teeth with fully formed apex and with straight roots were selected. All the teeth were de-coronated with a diamond disk (Dental future systems, Germany) under water-cooling to obtain a root length of 15 mm. A No. 15 file (MANI INC, Prime Dental Products Pvt. Ltd) was inserted in the canal until it reaches the apical foramen. The file was pulled back 1 mm from the foramen to determine working length. During instrumentation, a 0.5% sodium hypochlorite solution was kept inside the root and replaced every time when the file was changed. Files up to No. 60 will be used to define apical stop at 1 mm from the radiographic apex. After canal instrumentation and preparation, a No.15 file was introduced 1.0 mm beyond the apex to remove debris and ensure apical patency.

The smear layer was removed with 10 ml of 17% EDTA(Canal +, Septodont, France) for 60 seconds, followed by 10 ml of 5.25% NaOCl. Finally, the root canals were flashed with 3 ml saline solution and then dried with paper points.

The canals were obturated with Gutta-flow sealer by lateral condensation with cold gutta-percha. Excess obturating material was removed at the coronal end of the root with a heated knife. A radiograph of each specimen was exposed to confirm satisfactory obturation of the root canal. Samples were randomly divided into four groups. Forty roots in groups 1 and 2 and 4 roots in groups 3 and 4 each.

Group 1 Sample preparation for the immediate group: Immediately after obturation, gutta-percha was removed with heated pluggers (MANI INC, Prime Dental Products Pvt. Ltd) of decreasing diameters to make space for the post, leaving 5.0 mm of obturating material in the root apex. Vertical condensation was performed using the same pluggers. The teeth were put in jars at 100% relative humidity and placed in an incubator at 37°C for two days.

The samples were divided into two subgroups of 20 teeth each: Subgroup (a1); To evaluate dye infiltration from coronal to apical (ICA), and subgroup (b1); To evaluate dye infiltration from apical to coronal (IAC)

Group 2 sample preparation for the delayed group: After

obturation, these teeth also were stored for two days in jars at 100% relative humidity and placed in a bacteriological incubator at 37°C to allow the sealer to set. The preparation of post space was performed with Gates Glidden drills and peso reamers (MANI INC, Prime Dental Products Pvt. Ltd) leaving 5.0 mm of obturating material in the root apex.

The samples were divided into two subgroups of 20 teeth each: Subgroup (a2); To evaluate dye infiltration from coronal to apical (DCA), and subgroup (b2); To evaluate dye infiltration from apical to coronal (DAC).

Group 3, positive control group: This group comprised of four teeth (two in each subgroup) that were instrumented but not obturated.

Group 4, negative control group: This group comprised of four teeth (two in each subgroup). These teeth were obturated like the other teeth except that their surfaces, including the apex and coronal access, were covered with nail varnish.

Dye leakage from coronal to apical: To evaluate coronal to apical leakage, the marker (black India ink)(LOBA CHEMIE) was placed inside the roots until it fills the canal. The access to the root canal was sealed with utility wax. The samples were kept for seven days with the apex down in jars at 100% humidity in an incubator at 37°C.

Dye leakage from apical to coronal: To access dye infiltration from apical to coronal, red nail varnish was applied over the entire external root surface to within 1.0 mm of the apical end. As soon as varnish was dried, the teeth were suspended in marker. The samples were also kept for seven days in jars at 100% humidity in an incubator at 37°C.

Then all the roots were rinsed off to remove excess dye and varnish was removed with a sharp scalpel. The teeth were decalcified in 11% nitric acid for 48 hours. At end of this time, a pin was passed through an unimportant part of the root, indicating decalcification was complete. Following thorough rinsing with water, dehydration was carried out sequentially in 75%, 85% and 100% alcohol and the teeth were rendered transparent by storage in methyl salicylate.

The roots were then examined under stereomicroscope ((Magnification 4-40x)(Lawrance& Mayo) for the evaluation of dye infiltration at the apical and coronal direction in different groups using dye penetration analysis. Single examiner measured the extent of microleakage. The dye penetration scores were recorded & tabulated and statistical analysis was carried out.

RESULTS

The original values of coronal to apical and apical to coronal microleakage according to two post preparation techniques were recorded (Graph 1). The group DCA showed more leakage values than other groups. The mean and standard deviation of the scores for coronal to apical leakage for immediate (ICA) and delayed (DCA) techniques were calculated. (Table 1 & Graph 2). Comparison of ICA and DCA was carried out with respect to micro leakage values by unpaired t-test. The results showed a significant difference between ICA and DCA groups with lower values for ICA group (Table 2).

Mean leakage values and standard deviation values for apical to coronal leakage for immediate (ICA) and delayed (DCA) techniques are presented in Table 4. The results showed that

Table 1: Summary statistics according to techniques

Summary	ICA	DCA	Total
Means	0.5700	1.5500	1.0600
Standard Deviation	0.4846	0.6022	0.7330
SE	0.1084	0.1347	0.1159
CV	85.0184	38.8509	69.1538

Table 2: Comparison of ICA and DCA with respect to microleakage values by unpaired t-test

Group	N	Mean	SD	t-value	p-value	Significance
ICA	20	0.5700	0.4846	-5.6700	0.0000	S
DCA	20	1.5500	0.6022			

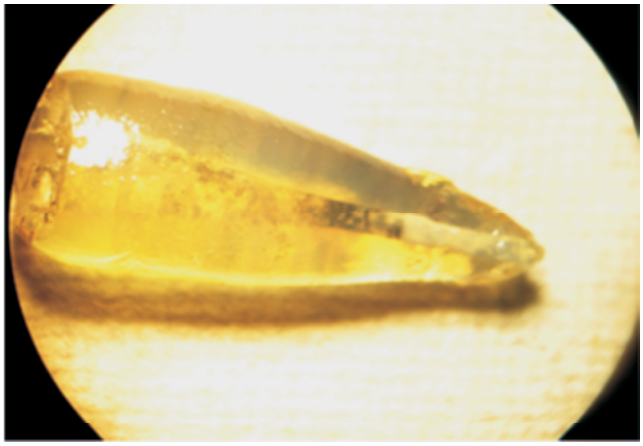

Figure 1: Immediate coronal to apical group as seen under stereomicroscope

IAC group had a mean leakage of 0.1850 mm whereas DAC had a mean of 0.1950 mm. The standard deviation (SD) of group IAC and DAC were 0.0745 and 0.0826 respectively (Table 3& Graph 3). Statistical analysis using unpaired t test disclosed no significant difference ($P < 0.05$) between the groups (Table 4).

DISCUSSION

Deficient crown restorations, as well as inadequate endodontic obturations, may allow bacteria and endotoxins

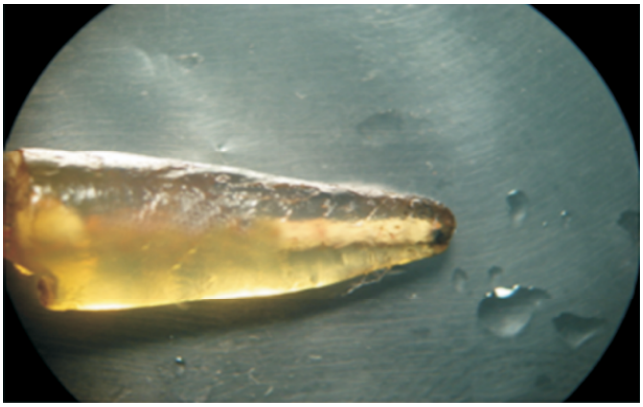

Figure 2: Immediate apical to coronal group as seen under stereomicroscope

Table 3: Summary statistics according to techniques

Summary	IAC	DAC	Total
Means	0.1850	0.1950	0.1900
Standard Deviation	0.0745	0.0826	0.0778
SE	0.0167	0.0185	0.0123
CV	40.2789	42.3373	40.9421

Table 4: Comparison of IAC and DAC with respect to micro leakage values by unpaired t-test

Group	n	Mean	SD	t-value	p-value	Significance.
IAC	20	0.1850	0.0745	-0.4021	0.6898	NS
DAC	20	0.1950	0.0826			

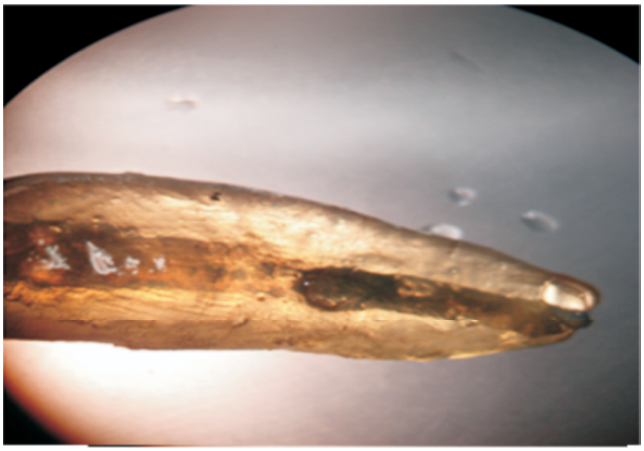

Figure 3: Delayed coronal to apical group as seen under stereomicroscope

to migrate into the root canal and trigger periapical inflammation.[16] The bacteria that cause periapical inflammation enter the root canal space from the coronal end before, during and after endodontic treatment.[2]

Cold lateral condensation of gutta-percha with AH plus sealer was used in this study since this has been the most popular root canal filling technique. In addition several

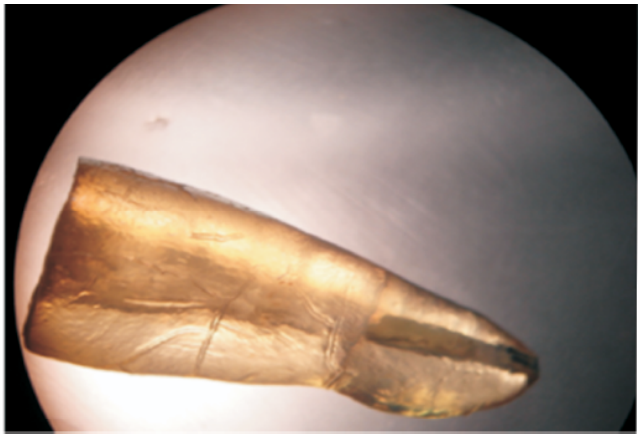

Figure 4: Delayed apical to coronal group as seen under stereomicroscope

studies have showed alternate obturation techniques yielded no statistical difference in the apical provided 4 to 5 mm of gutta-percha remained at the apex. In this study and during post space preparation 5 mm of gutta-percha left at the apical third of the canal in accordance with the recommendations of several investigators.[17,18] Apical to coronal leakage occurs when 3.0 mm or less of obturating material is in the apex.[19] Several studies involving apex to cervix leakage that left 4-5 mm of obturating material in the apex did not find any statistically significant differences between these two preparation techniques.[11,20]

One fundamental investigation that has not been investigated fully involves methods of removing obturating

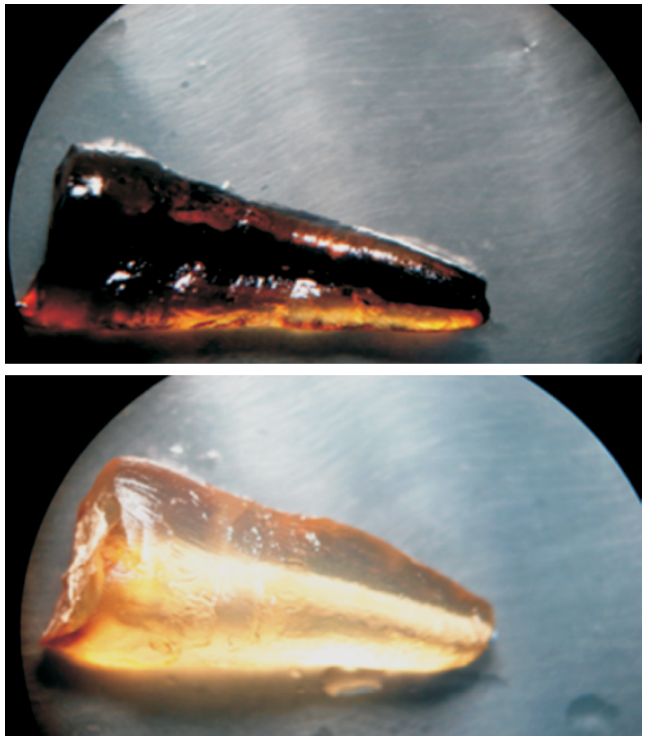

Figure 5 (a): Positive control seen under stereomicroscope (b) Negative control seen under stereomicroscope

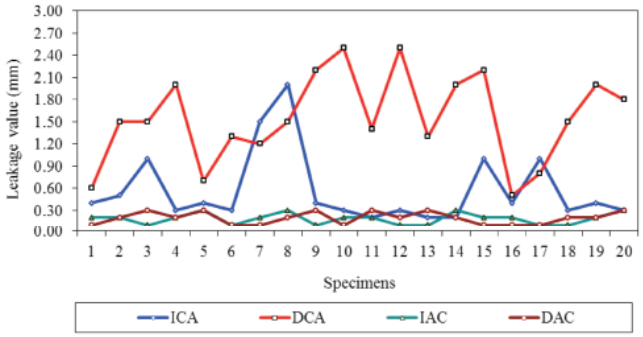

Figure 6: Original values (mm) of marginal cervical to apical leakage and apical to cervical leakage

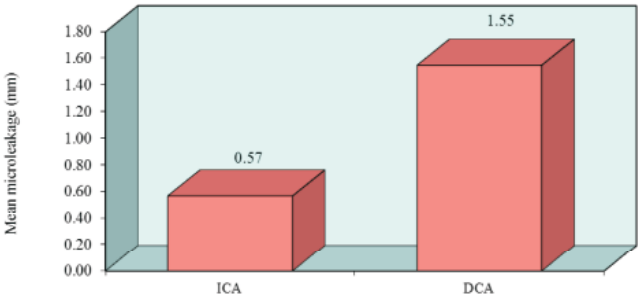

Figure 7: Comparison of ICA and DCA with respect to mean microleakage (mm)

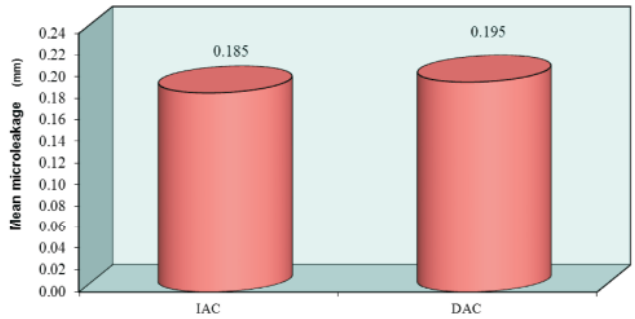

Figure 8: Comparison of IAC and DAC with respect to mean microleakage (mm)

material from the root canal to avoid changes to the apical seal or keep them to a minimum.[2] In this study Indian ink was used as a microleakage marker, because it permits an adequate visualization after decalcification and clearing of the specimens. The high contrast between Indian ink and pink and red gutta-percha material made the leakage pattern quite visible. Indian ink is a neutral suspension of carbon particles (pH 7.5-8.5), most of which are about 10 µm in size. In theory, due to the particle size, the Indian ink should not enter into the tubules or small deficiencies around restorations and root fillings. Nevertheless, the range of particle sizes within the ink suspension makes their penetration possible into the cracks where microleakage may occur.[21]

Removing gutta-percha by using Peeso reamers, heated endodontic pluggers or endodontic files to carry chloroform did not reveal statistically significant differences on the apical seal of obturated canals with 5.0 mm of remaining obturating material, although better results were achieved by using gates glidden drills or heated pluggers.[22,23]

This study revealed that the apical seal was not affected by either technique – no statistically significant differences were found for apical to coronal leakage groups. This finding may be explained by the fact that at least 5.0 mm of gutta-percha was left in place. These results are in agreement with results of Madison and Zakariasen,[11] Bourgeois and Lemon[24] and Abramovitz *et al.*[25] In contrast, the studies by Portell *et al.*,[27] Fan *et al.*[27] and Kawn & Harrington[28] resulted in conclusions that significantly less leakage occurred when post spaces were prepared immediately after obturation.

This study also assessed coronal to apical leakage after post space preparation. This investigation is justified by the recent attention that has been directed to procedures conducted after completion of root canal treatment and the impact of these procedures on the prognosis of endodontic therapy. These procedures could result in delayed failure because they may allow microorganisms and their products to migrate to the apical end of the root and later to the alveolar bone, where they may trigger periapical periodontitis. The microorganisms and nutrients can enter the pulp cavity through a permeable restoration, a leaking restoration or the dentinal tubules of unsealed canal. In vitro studies have shown that obturating material is susceptible to leakage when exposed coronally to artificial saliva or microorganisms; however in vivo studies have not confirmed these findings.[29]

The longevity of a tooth treated endodontically depends on the quality of the coronal restoration. An unsatisfactory endodontic treatment associated with an inadequate coronal restoration may lead to a greater number of periapical inflammatory reactions.[2] Torabinejad *et al.*[30] observed that only 18.1% of teeth with inadequate canal obturation and coronal sealing did not demonstrate periapical reactions.[30] This study also assessed the degree of dye leakage from coronal to apical to determine if a correlation exists between post preparation techniques and damage to coronal end sealing of the remaining obturating material. The samples in immediate technique group (ICA/a_1) showed less leakage than those in the delayed technique (DCA/a_2); these results were statistically significant. These results may be explained by the fact that use of hot pluggers removes obturating material more regularly, compared with the drills that usually displace some gutta-percha and may consequently lead to superficial cracks in the material and subsequent dye penetration. Moreover, when hot pluggers are used, it is possible to perform vertical condensation, which provides a better seal and reduces leakage.

The great majority of microleakage studies have examined linear dye penetration along a filling material. However, it is important to note that such studies can only give information about the length of a gap in a sealing material/ filled root canal. In this study volume of void could not be substantiated. Studies using quantitative volumetric data would be more reliable to compare various kind of filling materials.[21] From clinical point of view, it seems to be more relevant to measure the volume of dye or fluid leaking through the apical foramen by determining coronal to apical leakage.[2] In this study, all samples in the positive control group presented extensive dye penetration and negative control group showed no leakage at all.

CONCLUSION

- Microleakage studies though controversial should be interpreted with caution. Within the parameters of this *in vitro* study, the following conclusions can be drawn:
- Coronal to apical permeability was significantly lower for the immediate post preparation technique than for the delayed technique.
- Apical to coronal permeability was not statistically different for the different post preparation techniques.
- Exposure to Indian ink followed by decalcification and clearing of the teeth, proved to be an effective method of evaluating leakage.

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