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Original Article

Apical and lateral accuracy of intraradicular impressions made using the indirect and direct technique at three different locations: A comparative *in vitro* analysis

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ABSTRACT

Background: There is limited literature available comparing the accuracy of intraradicular impressions made with a novel hybrid impression material using the indirect and direct technique at three different locations.

Materials and Methods: For this comparative *in vitro* analysis, postspace was prepared in 15 recently extracted teeth and impressions made with vinyl polysiloxane, polyether (PE), vinyl polyether silicone (VPES), and pattern resin. Postpatterns obtained were re-seated on the teeth and longitudinally sectioned. A binocular microscope was used to measure apical and lateral discrepancies at three locations (L1, L2, and L3). L1 at the postcore junction, L2 at the middle of the post space, and L3, 2 mm short of the apical end. The data obtained were statistically analyzed using the Statistical Package for the Social Sciences (SPSS) software. One-way analysis of variance (ANOVA) (intergroup) followed by Tukey's *post hoc* test with $P \leq 0.05$ was used.

Results: The one-way ANOVA noted a highly significant difference at the apical location. Pattern resin had the highest apical discrepancy (151.93 ± 8.59 μm), whereas the lowest was with vinyl PE silicone (140.31 ± 11.46 μm). At L1, the highest discrepancy was seen with pattern resin (32.09 ± 2.31 μm), whereas the lowest was with the addition silicone (31.94 ± 2.54 μm). At L2, addition silicone (32.88 ± 2.81 μm) showed the highest discrepancy, whereas the lowest was with vinyl PE silicone (30.5 ± 8.79 μm). The PE group had the highest mean at the L3 location (31.38 ± 3.46 μm) and the lowest was with vinyl PE silicone (30.93 ± 2.25 μm). At all lateral locations, no significant difference was noted. Tukey's *post hoc* comparison showed a significant difference between pattern resin and VPES (11.62 μm) followed by pattern resin and addition silicone (11.47 μm) apically.

Conclusion: The indirect technique using VPES or addition silicone is more accurate than the direct technique at the apical location.

Key Words: Polyvinyl, silicones, siloxanes, vinyl polysiloxane

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INTRODUCTION

A post and core re-establishes the form, and function, and acts like an anchorage for the restorative material in an endodontically treated tooth. Intraradicular posts can be either prefabricated

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or custom-made.[1] Custom cast posts are preferred over prefabricated fiber posts, for their higher bond strength and retention.[2] For a successful custom cast intraradicular post, the post pattern must accurately record the prepared canal space. Postpatterns that are incomplete or have voids could result in the failure of the prosthesis.[3] Self-cure acrylic resin, elastomeric impression materials, and inlay casting wax are widely used with the direct or indirect techniques to make postspace impressions.[4] In the direct technique, a prefabricated plastic post is placed directly into the prepared postspace intraorally, and the remaining space between the prepared tooth and post is impressed using a suitable material.[4] On the other hand, in the indirect technique, an impression of the prepared postspace is made to form a working cast that is used to fabricate the postcore pattern, which is then cast.[5] The direct impression technique using autopolymerizing pattern resin is generally preferred by clinicians even though it results in increased chairside time. For the indirect technique, polyvinyl silicone (PVS) and polyether (PE) are the most frequently used.[6] PVS impression materials are inherently hydrophobic and though modifications have been made with the addition of certain nonionic surfactants, these modified PVS impression materials are only slightly less hydrophobic than their predecessors.[7] PE impression materials are inherently hydrophilic and often preferred by some clinicians, but the stiffness of the polymerized PE impression material is one of its major shortcomings.[8] To incorporate the advantageous properties of both PVS and PE impression materials, a new generation of impression material, called vinyl PE silicone (vinyl polyether silicone (VPES), GC) was developed. The composition is intended to incorporate the natural hydrophilicity and flowability of conventional PE materials along with the desirable properties of PVS materials, such as elastic recovery, tear strength, and dimensional accuracy and stability.[9]

There is limited literature available comparing the accuracy of intraradicular impressions concerning canal adaptation apically and laterally at three different locations, using the hybrid VPES impression material. The purpose of this *in vitro* study was to determine the most accurate impression material and technique. The null hypothesis was that no differences would be found between impression materials or techniques used.

MATERIALS AND METHODS

For this comparative *in vitro* analysis, 15 recently extracted (<2 months) maxillary central incisors that met the inclusion criteria (single rooted with a straight patent root canal and absence of caries, fractures, attrition, and abfraction lesions) were decoronated, 2 mm above the cementoenamel junction [Figure 1]. The working lengths of the teeth were determined using an apex locator (Canal Pro, Coltene). Biomechanical preparation of the root canal was carried out with a ProTaper system (Dentsply Maillefer, Switzerland) and subsequently obturated using the lateral condensation technique with gutta-percha (Dentsply Mallefer) and sealer (AH Plus Dentsply). After 24 h, the postspace was sequentially enlarged with peso reamers (Nos 1, 2 Nordin Swiss dental products) in the conventional manner following ideal postspace guidelines,[10,11] and radiographs were taken to evaluate the prepared postspace [Figure 2]. Core buildups were made using inlay wax (Medium GC, Tokyo Japan) after the prepared postspaces were blocked with cotton. A triangular antirotation core design was incorporated to facilitate the insertion and positioning of the post [Figure 3]. The roots were mounted in an acrylic resin block measuring 3 cm × 1 cm × 1 cm. After it set, the inlay wax core was eliminated by dewaxing [Figure 4]. A total of 15 specimens were prepared and labeled. The specimens were stabilized with autopolymerizing resin to enable better handling during sectioning.

Four impressions were made for each specimen, three with the indirect technique using addition silicone impression material light body (Aquasil LV-Dentsply, France), PE (Impregum soft light bodied 3M Germany), and vinyl PE silicone (Exalence

Figure 1: Recently extracted maxillary central incisors teeth decorated 2 mm above the cementoenamel junction.

Light Body regular set GC Europe) and 1 with the direct technique, using autopolymerizing pattern resin (Pattern Resin Ls, GC). Petroleum jelly was applied to the postspace with an endodontic K file. For the indirect technique, the impression materials were injected into the prepared canal using a 2 ml syringe and a needle of 1 mm diameter. Fifteen impressions were made using each of the three impression materials [Figure 5]. For the direct technique, fluid pattern resin was injected into the canal in the same manner. Care was taken to repeatedly remove and reseat the pattern post during the setting to prevent engaging any undercuts if present. Excess pattern resin was trimmed with acrylic carbide burs (DFS, Germany). A total of 15 postpatterns were made and numbered as P-1, P-2…… P-15.

The indirect technique involved the additional step of die fabrication. Mold spaces of 3 cm × 1 cm × 1 cm were created using prefabricated stone indices in irreversible hydrocolloid impression material. Postspace impressions were stabilized using cyanoacrylate adhesive in the alginate mold, and the die was poured in type IV die stone. A total of 45 dies were poured, retrieved, and numbered as follows:

1. The addition silicone pattern dies were numbered A-1, A-2 …… A-15
2. The PE pattern dies were numbered E-1, E-2…… ……E-15
3. The vinyl PE silicone pattern dies were numbered H-1, H-2……H-15.

Postpatterns were fabricated in the retrieved stone dies using autopolymerizing pattern resin [Figure 6].

The embedded teeth were sectioned longitudinally using a diamond disc (Shofu, Japan). The pattern resin posts were reseated on the sectioned specimens, and the distance between the tooth and resin surface was measured apically and laterally at three different locations (L1, L2, and L3). L1 was measured at the postcore junction, L2 was measured at the middle of the post space, and L3

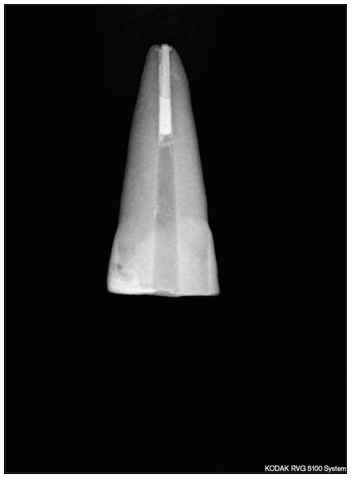


Figure 2: Radio Visio Graphy (RVG) following post preparation.

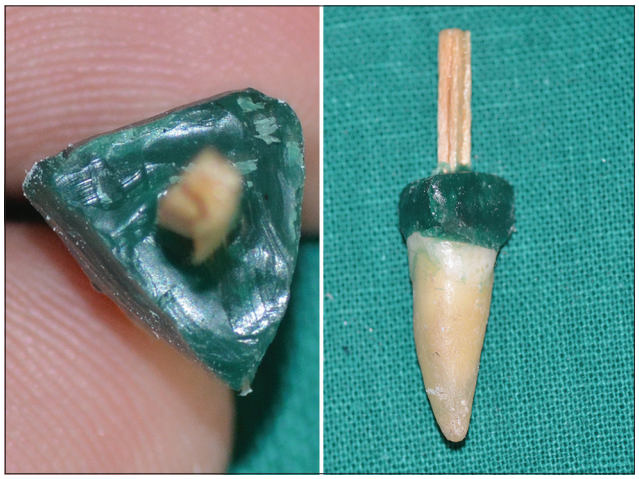


Figure 3: Core build-ups of inlay wax with a triangular anti-rotation design.

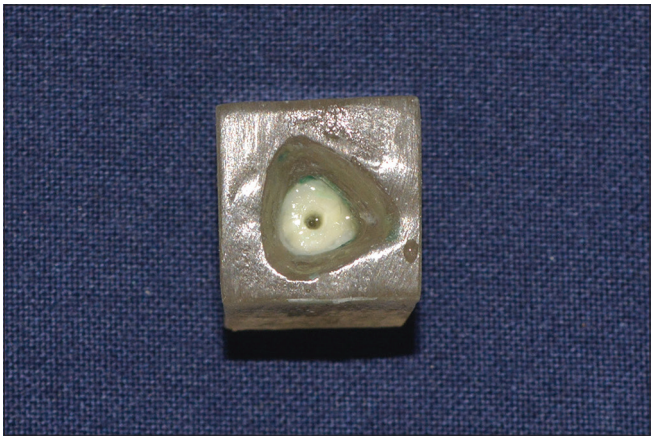


Figure 4: Tooth specimen embedded in autopolymerizing resin after removal of inlay wax core.

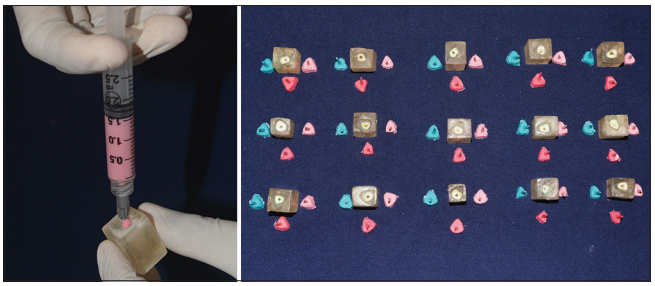


Figure 5: Impressions of the dowel space using the three elastomeric impression materials.

was measured 2 mm shorter than the apical end of the post [Figure 7]. A binocular microscope (SZ16 Stereozoom with DP2 camera and DP2-BSW software, Olympus, Japan) under ×1.6 magnification was used to make the measurements within 24 h. The software repeated each measurement thrice, and the average was calculated [Figure 8]. The Statistical Package for the Social Sciences (SPSS) version 22was used to analyze the data. One-way analysis of variance (ANOVA) (intergroup) followed by Tukey's *post hoc* test with $P \leq 0.05$ was used.

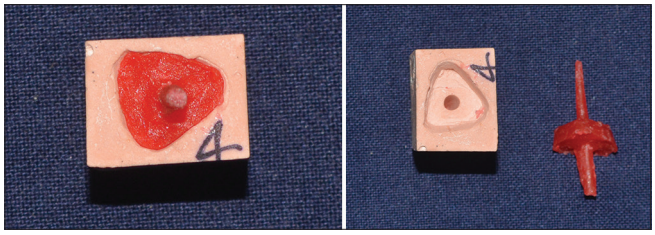


Figure 6: Fabrication of postpattern in the stone die.

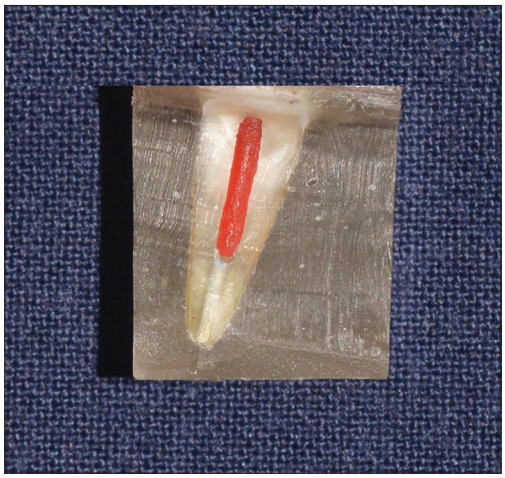


Figure 7: Reseating of the post patterns after sectioning the tooth specimen.

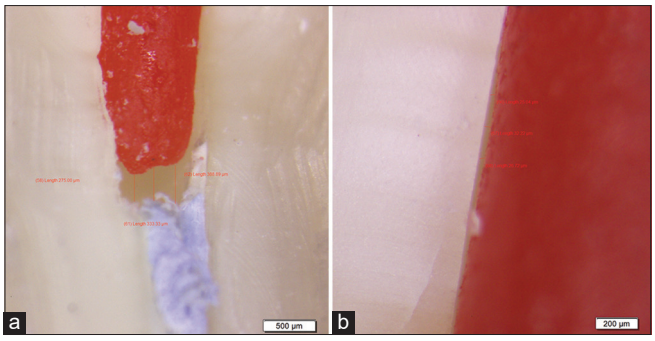


Figure 8: (a) Measurement of apical discrepancy under stereomicroscope, (b) Measurement of lateral discrepancy under stereomicroscope.

RESULTS

A total of 60 postpatterns were fabricated to determine the accuracy of canal adaptation of four different intraradicular impression materials at the apical, L1, L2, and L3 locations.

Intergroup comparisons were done using the one-way ANOVA. Table 1 and Graph 1 depict the mean and standard deviation of the different groups. A highly significant difference ($P \leq 0.05$) was noted among the groups when compared at the apical location. Pattern resin had the highest apical discrepancy (151.93 ± 8.59 µm), whereas the lowest was seen with the vinyl PE silicone group (140.31 ± 11.46 µm). At L1, the highest discrepancy was seen with pattern resin (32.09 ± 2.31 µm), whereas the lowest was seen with addition silicone (31.94 ± 2.54 µm). At L2, addition silicone (32.88 ± 2.81 µm) showed the highest discrepancy, whereas the lowest was seen with vinyl PE silicone (30.5 ± 8.79 µm). The PE group had the highest mean at the L3 location (31.38 ± 3.46 µm) and the lowest was seen with the vinyl PE silicone (30.93 ± 2.25 µm) At L1, L2, and L3 locations, no significant difference was noted among the various groups.

The results of Tukey's *post hoc* test are demonstrated in Table 2. A highly significant difference was seen only at the apical location when the groups were compared. Hence, the *post hoc* results showed the

Table 1: Intergroup comparisons using one-way ANOVA

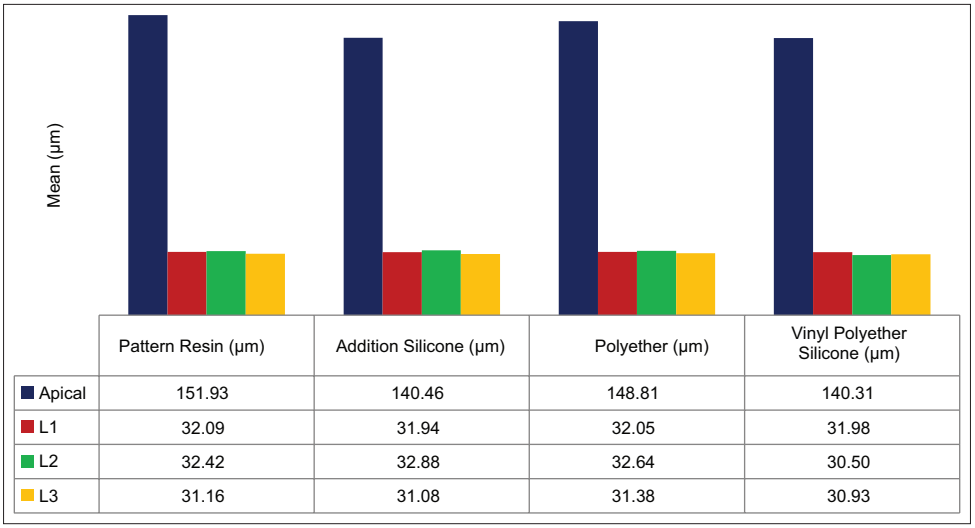
Location	Groups	Mean±SD (µm)	Significant
Apical	Pattern resin	151.93±8.59	0.006*
	Addition silicone	140.46±10.91	
	PE	148.81±11.11	
	VPES	140.31±11.46	
L1	Pattern resin	32.09±2.31	1.00
	Addition silicone	31.94±2.54	
	PE	32.05±3.43	
	VPES	31.98±2.46	
L2	Pattern resin	32.42±2.52	0.57
	Addition silicone	32.88±2.81	
	PE	32.64±3.77	
	VPES	30.50±8.79	
L3	Pattern resin	31.16±2.36	0.98
	Addition silicone	31.08±2.61	
	PE	31.38±3.46	
	VPES	30.93±2.25	

*$P \leq 0.05$. SD: Standard deviation; PE: Polyether; VPES: Vinyl PE silicone

Table 2: Tukey's *post hoc* intergroup comparison

Location	(I) groups	(J) groups	Mean difference (I−J) (µm)	Significant
Apical	Pattern resin	Addition silicone	11.47	0.022*
	Pattern resin	PE	3.11	0.85
	Pattern resin	VPES	11.62	0.02*
	Addition silicone	PE	−8.36	0.15
	Addition silicone	VPES	0.15	1.00
	PE	VPES	8.51	0.14
L1	Pattern resin	Addition silicone	0.15	1.00
	Pattern resin	PE	0.04	1.00
	Pattern resin	VPES	0.11	1.00
	Addition silicone	PE	−0.11	1.00
	Addition silicone	VPES	−0.04	1.00
	PE	VPES	0.07	1.00
L2	Pattern resin	Addition silicone	−0.46	1.00
	Pattern resin	PE	−0.22	1.00
	Pattern resin	VPES	1.92	0.74
	Addition silicone	PE	0.24	1.00
	Addition silicone	VPES	2.38	0.59
	PE	VPES	2.14	0.67
L3	Pattern resin	Addition silicone	0.08	1.00
	Pattern resin	PE	−0.22	1.00
	Pattern resin	VPES	0.23	1.00
	Addition silicone	PE	−0.30	0.99
	Addition silicone		0.15	1.00
	PE	VPES	0.45	0.97

*$P \leq 0.05$. PE: Polyether; VPES: Vinyl PE silicone



Graph 1: Mean values of intergroup comparisons at the various locations.

highest mean difference between pattern resin and vinyl PE silicone (11.62) with a significance of 0.02 followed closely by the mean difference of pattern resin and addition silicone materials (11.47) with a significance of 0.022. The lowest mean difference was seen between the addition silicone and PE (−8.36). No significant difference was found at the remaining locations.

DISCUSSION

Postfit plays a significant role in the prognosis of a post and core restoration. Optimal postfit aids in optimal retention and provides greater fracture resistance. Postfit can be evaluated by determining the space between the cast post, the prepared canal, and the remaining gutta-percha.[12]

To minimize the possible role of expansion and contraction that occurs during casting and subsequently causes a nonuniform precementation space,[13,14] the post was not cast, and the distance between the resin post and the tooth was measured directly. Moshonov[15] evaluated the apical gap between the gutta-percha and the post and found that an increased gap negatively influenced the clinical outcome of endodontically treated teeth restored with a post and core.

The present study evaluated the post fit at the apical and lateral locations in sections L1, L2, and L3 indicating the relative postfit at the postcore interface, the middle of the post space preparation, and 2 mm above the apex of the post, respectively. Greater cement thickness, especially in the cervical area, could result in greater microleakage which in turn could adversely affect the clinical survival rate.[16]

Postimpressions can be made with either the indirect technique which reduces chairside time but is considered to be technically demanding due to a greater number of intermediate steps[17] or the direct technique which many practitioners prefer because they assume it provides a more accurate fit but requires greater operator skill.[18] Besides the technique used, intraradicular impression materials also play a role in the accuracy of canal adaptation. The present study found significant differences at the apical location between pattern resin impressions made using the direct technique with vinyl PE silicone and addition silicone impressions made with the indirect technique. Hence, the null hypothesis was partly accepted and partly rejected.

Balkenhol *et al*.[18] evaluated the post and core survival rate in their 10-year retrospective study and concluded that the direct fabrication technique had a lower survival probability than the indirect technique probably, due to the difficulty in fabricating a post and core intraorally with the same precision as with indirect fabrication on a cast. Pitigoi-Aron *et al*.[19] determined the accuracy of cast posts made with both techniques by measuring the weight of the impression material which occupied the space between the post and the canal. They found that the indirect technique significantly provided better postfit and therefore recommended this technique. Al-Omari and Zagibeh[17] investigated the effect of technique and cement type on the retention of custom cast posts and reported no significant correlation between post fabrication technique and post retention. However, they reported a significant effect of cement type and cementation process on the post retention.

Rayyan *et al*.[20] used microcomputed tomography to evaluate the accuracy of casted posts using the direct and indirect techniques and found no significant difference between the space area in the coronal, middle, and apical sections as well as the volume at the apical end and overall volume. The present study utilized a binocular microscope under ×1.6 magnification and came to the same conclusion for all lateral locations.

For all the impression materials tested, the postspace impressions were made with the injection technique. This technique facilitated the free flow of the material into the narrowest postspace and prevented air trapping within the material.[21] The present study is limited by being an *in vitro* assessment of the intraradicular impressions. Further research is warranted through *in vivo* clinical trials where the posts could be cast and evaluated for fit visually and radiographically. Long-term survival rates could also be assessed.

CONCLUSION

Within the limitations of this *in vitro* study, it can be concluded that in the cervical region where the accuracy of the postfit is of utmost importance, no significant differences were noted. However, in the apical region, the indirect impression technique with vinyl PE silicone and an addition silicone group was significantly more accurate than the direct postpattern fabrication technique.

Clinical significance

As all postspace impressions were considered clinically acceptable, the choice of technique and material should be based on clinical preference. However, the postspace impressions made by the indirect technique, using vinyl PE silicone and addition silicone were more precise comparatively.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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