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Comparison of accuracy of direct, indirect and digital impression techniques in determining post space length and mesiodistal dimension in anterior teeth- An in vivo study

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Abstract

Statement of Problem: Direct and indirect impression techniques as well as digital impressions are used for intracanal impression and fabrication of posts. However, whether these three techniques affect the accuracy of the posts is not known.

Purpose: The purpose of this in vitro study was to compare and evaluate the accuracy of direct and indirect intracanal impression techniques and digital impression in determining post space length and mesiodistal dimension in anterior teeth.

Material and Methods: 10 freshly extracted maxillary central incisor were endodontically treated and embedded in self-curing PMMA resin. Post space preparation was done with Peso reamers with a 5 mm of apical gutta-percha to maintain the apical seal. 60 such specimens were made and divided into 6 Groups- Control Group, Indirect impression technique, Direct impression technique, Intraoral scanner, Zirconia post and Cast post. Post space length and mesiodistal dimensions of all the specimens in the study were obtained by using a coordinate measuring machine. All the values obtained from the study were tabulated and subjected to the statistical analysis using ANOVA test, Post- hoc Tukey's test and t-test using IBM SPSS-20 software, at the significance level of 0.05

Results: A significance difference of 4.776 mm was observed between the mean values of post space length and the length of post space obtained by digital technique whereas the least 0.3 mm difference was observed between the mean values of post space length and post space length obtained by using direct technique.

Mesiodistal dimensions obtained from prepared post space and those obtained from direct, indirect, and digital impression techniques had no significant difference.

Conclusions: Impression of post space obtained from the intraoral scanner maybe less accurate as compared to direct impression technique and indirect impression technique and need to be used with caution. Mesiodistal dimensions obtained from prepared post space and those obtained from direct, indirect, and digital impression techniques had no significant difference whereas a significant difference was noticed between the mesiodistal dimension of the prepared post space and those obtained from cast metal post and zirconia post,

Keywords: Cast Post, Intra oral scanner, Post space, Zirconia post.

Introduction

The use of post-and-core restorations to restore endodontically treated teeth has been intensively investigated in the last two decades. Traditionally, a pulp less tooth with a loss of more than half tooth structure receives a dowel-core system to reinforce it and a crown to protect it.[1] Both prefabricated or custom cast dowel-core systems can be used for this purpose. Custom-fabricated, cast posts and cores are regarded as the established technique or gold standard for restoring severely debilitated teeth.[2] They conform better to the shape of the canal and provide maximum retention and support for the coronal restoration. High strength, durability, and the strong union between the core and the post are the other advantages of cast post and cores. [3]

Though metal posts are known for their superior physical properties and excellent biocompatibility, their metallic colour and complete opacity lead to a greyish-blue discoloration of gingiva. This results in a severe aesthetic compromise for anterior teeth particularly if there is a high lip line. Furthermore, corrosion products are bound to deposit in the gingival tissues or cause root discoloration, hence all-ceramic posts and cores were suggested as an alternative to solve the aesthetic problems that metal posts and cores exhibited. All-ceramic posts and cores provide excellent biocompatibility, and do not exhibit galvanic corrosion.[4]

The new generation of the intraoral scanners has been validated as an efficient alternative to the traditional impression in the field of prosthodontics.[5] For fabricating indirect restorations, the use of computer-aided design and computer-aided manufacturing (CAD-CAM) is on the rise. CAD-CAM milling technologies make laboratory processes easier and eliminate the drawbacks of casting. CAD-CAM technology may be able to outperform this "hand-made" technique.

The significance of adequate dowel length to maximize dowel retention is well recognized. Retentiveness of dowel is thus, directly related to the length.[6] Increasing the length of the posts tends to improve retention.[7] Also, there has been a trend towards maximizing dowel length in all teeth as it is believed to influence stress distribution in the root and thereby affecting its resistance to fracture. Ideally, the post should be as long as possible without jeopardizing the apical seal or the strength or integrity of the remaining root structure.[8] Therefore, an appropriate impression technique could influence the clinical survival of definitive restorative treatment as it directly influences the cast metal post retention.[9]

However, not much research has been conducted in the past to evaluate the effect of different impression techniques on the length and mesiodistal width of cast posts and zirconia posts. Therefore, the present study was conducted to evaluate and compare the accuracy of post

space obtained from intraoral scanner, silicon impression and direct pattern resin.

The null hypothesis proposed for the present study was that accuracy of intraoral scanner, traditional silicon impression & direct pattern resin technique is same in evaluation of post space accuracy with respect to post length and mesiodistal dimension.

Materials and Method

Ten freshly extracted, intact, fully formed single rooted human Maxillary Central Incisor with similar mesiodistal and buccolingual dimensions were selected. Teeth were kept hydrated at room temperature in 0.9 % saline at all times during the study except during operative procedures and testing.

All samples were endodontically treated and decoronated by using a sectioning disk at the level of 2 mm coronal to the cementoenamel junction and perpendicular to the long axis of the tooth. Following the sectioning, post space was prepared with the help of Peeso reamers (Mani, Japan) so as to have a 5 mm of apical gutta-percha to maintain the apical seal. The remaining gutta-percha length was confirmed by radiograph. After post space preparation, teeth were then embedded in self-curing polymethyl methacrylate resin to the level of the cementoenamel junction. A total of 60 such specimens were made and divided into 6 Groups.

Group I (Control Group): Post space length was measured from the coronal most portion of the decoronated tooth using K file (Dentsply India Private Limited).

Group II (Indirect impression technique): An indirect impression was made with prefabricated acrylic resin post (Pin jet, Angelus), polyvinyl siloxane impression material (3M ESPE) and customized light-cured resin tray (Individo Lux), coated with tray adhesive. (Figure 2)

Group III (Direct impression technique): Post and core pattern was made from prefabricated acrylic resin post along with pattern resin (GC Patter Resin- GC America). Brush and bead technique was used. (Figure 3)

Group IV (Intraoral scanner): Digital impressions were made with an Intraoral scanner (3 Shape TRIOS, Denmark). They were firstly obtained as the remaining silicone material and pattern resin after indirect and direct impression techniques respectively may affect the precision or depth size of the digital impression data. All digital data obtained with the intraoral scanner were processed using 3Shape software. (Figure 4)

Group V (Zirconia post): Wax patterns were fabricated from the cast (Kala Bhai Ultra rock Die Stone) obtained from indirect impression technique that were scanned through EXO CAD software and then milled to fabricate zirconia posts. (Figure 6)

Group VI (Cast metal post): Indirect impressions obtained from Group II were poured in type IV gypsum product (Maruvest Speed, Mega dental Germany) in order to fabricate cast metal posts (4 All metal Ivoclar-Vivadent) from the wax pattern (Maarc Dental) through lost wax technique.

A. For all the Groups, except Group IV, post space length was measured thrice with a digital Vernier calliper (DD Enterprise, India) using K file and average was taken. Mesiodistal dimensions were obtained by using a coordinate measuring machine.

Result

All the values obtained from the study were tabulated (Table I-II) and subjected to the statistical analysis using ANOVA test, Post- hoc Tukey's test and t-test using IBM SPSS-20 software, at the significance level of 0.05 ($P<0.05$=Significant).

Comparison of post length and mesiodistal dimensions between all Groups: ANOVA test revealed a statistically significant difference between the obtained mean values of length (Table I,).

Inter Group comparison for post length (Tukey's Post Hoc test): Highest difference was observed between the mean values of post space length (Group 1) and the length of post space obtained by digital technique (Group 4) (4.78 mm). Least difference was observed between the mean values of post space length (Group I) and post space length obtained by using direct technique (Group III) (0.30 mm). However, there was no statistically significant difference seen between Group 1 and Group 2 (P = 0.881) also Group 1 and Group 3 (P= 0.992) (Table I and Graph I).

Inter Group comparison for mesiodistal dimension (Tukey's Post Hoc test): Highest difference was observed between the mean values of Group I and Group VI (0.34 mm) and least difference was observed between Group 1 and Group 4 (0.13mm). Based on values obtained from different techniques, there was statistically significant difference between Group 1 and Group 5 (P= 0.005), also Group 1 and Group 6 (P=0.000. (Table I and Graph I).

Discussion

The null hypothesis of the present study was rejected because there were statistically significant differences between direct and indirect impression techniques and intraoral scanners. Although various factors affecting retention of dowels have been studied previously, there is a lack of studies about the influence of impression techniques on the length of post space and mesiodistal dimensions obtained. Thus, the aim of the present in vitro study was to investigate the accuracy of different techniques. The findings of the present study showed that impressions obtained from intraoral scanner were less accurate compared to impressions obtained from indirect technique in terms of length. This result observed is in agreement with the previous study conducted by Pinto et al.[5] They evaluated the depth and quality of the post-space reading using an IOS without scan post compared to traditional silicon technique. They found that the digital technique has achieved less than 10% difference compared to the traditional technique, but there have been also cases in which the variation in depth has reached almost 40%. In their study the IOS for post space reading proved to be still not reliable as the light beam if IOS had difficulty to reach the deepest and narrowest areas of the prepared post space. In present study as the scan posts were not used which could be the possible reason for the reduction in the length of the post space reading obtained by IOS.

Results from the study showed that metal posts fabricated with the indirect technique presented significant differences between measured post space length and length of cast metal posts obtained from indirect impression technique. This result observed is in agreement with the previous study conducted by Aline Pinheiro de Moraes et al.[9] They evaluated the accuracy of cast metal posts depending on tooth position and impression technique. They found that metal posts fabricated with the direct technique presented fewer differences between impressed post space length and cast posts but without any statistically significant difference. However, indirect technique presented a higher percentage of reduction in length. This according to them was probably linked to ability of the technician and the inherent distortions of the materials used with the indirect technique. There was statistical difference between the length of post space and length of zirconia posts fabricated using indirect technique. In present study, as

the registered post space was not digitized after traditional indirect impression technique instead zirconia post was milled from the wax pattern fabricated from the cast obtained by indirect technique, could have contributed to reduction in the length of obtained zirconia posts.

Studies have shown that the length of the post had a significant effect on its retention and in most instances, the more deeply the post is placed in the canal, the more retentive it turns into.[2, 10, 11] According to Shillingburg,[1] the larger the dowel, the greater is its retention. Leary et al.[28] concluded that when compared to posts that were half or quarter the root length, posts with a length of at least 3-quarters of the root length offered the most stiffness and least root deflection (bending). Short posts are thought to be particularly dangerous, with a substantially greater failure rate. Therefore, in our study 5mm of remaining gutta percha was left which depicted the length equal to crown height or two-third of the remaining root length.

Traditionally, patterns for dental castings have been formed from inlay casting wax. These materials associates familiarity and ease of manipulation with good replication of detail and cost effectiveness. However, a high coefficient of thermal expansion and the tendency of inlay wax to warp or distort upon standing are the two major disadvantages.[12] Wax patterns, regardless of the method of manipulation, develop a certain degree of internal strain during its preparation.

This strain tends to be relieved over time and the wax pattern distorts. Distortion of wax is both time and temperature dependent and ideally wax patterns must be invested immediately after removal from the preparation, which is not possible every time a wax pattern is fabricated in clinical scenario. [13] In a study by Rajagopal et al, they found that auto polymerized resin had a slightly higher initial gap than inlay wax (at one hour), but the difference was not statistically significant. [14] On long-term storage, resin pattern materials undergo far less dimensional change than inlay waxes. Hence for present study Autopolymerizing acrylic resin was selected. Patterns made of auto polymerized acrylic resin can be made in bulk or with a brush and bead technique. Earlier studies have shown that the polymerization shrinkage of auto polymerized resin was much greater when the pattern was fabricated with the bulk technique.

Hence, it was decided to fabricate the auto polymerized resin patterns using the brush and bead technique rather than bulk technique. [15, 16] Present study had certain limitations viz.; an in vitro study methodology does not account for all of the mouth environment's characteristics, such as oral fluids and IOS motion limitations.[17, 18]Further studies on larger sample size and with different IOS systems should be undertaken for recording post space via a digital impression. However, since there are very few in vivo studies conducted to determine the influence of different impression techniques on post space length, more studies should be conducted with greater sample size to confirm the conclusion.

Figures and Tables

Figure 1: Specimen preparation.

Figure 2: Impression made by indirect technique using light body impression material on a light cure acrylic impression tray.

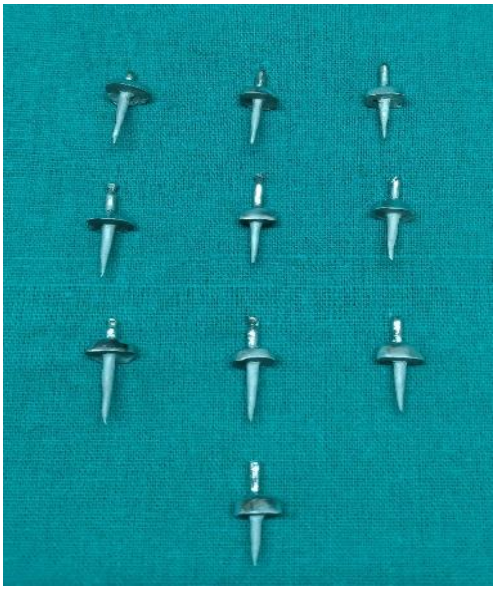

Figure 3: Impression made by direct technique using pattern resin.

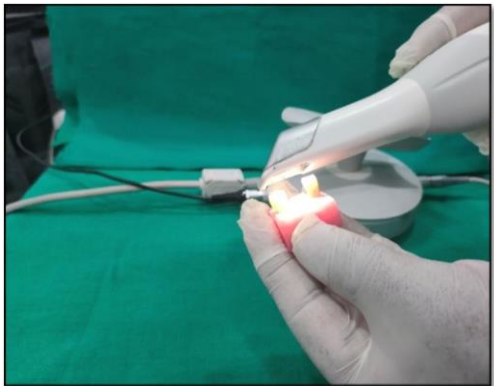

Figure 4: Scanning of post space by intraoral scanner.

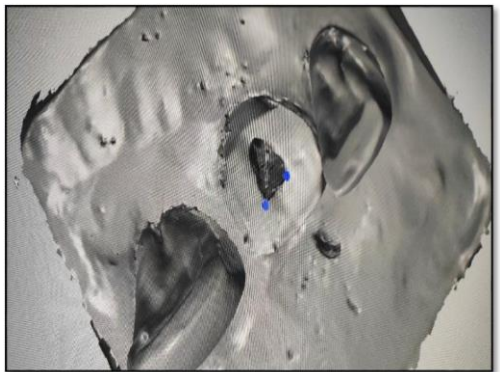

Figure 5: Post space length and mesiodistal dimension obtained by scale in the software.

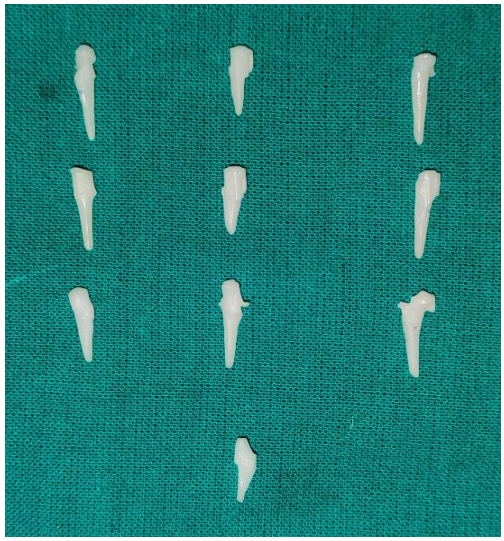

Figure 6: Zirconia post and Cast post fabrication.

Groups		Mean difference	Mean% reduction	Standard error	p	95% Confidence Interval for mean Difference	
						Lower	Upper
1	2	.56200	4.98	.51257	.881	-.9524	2.0764
	3	.30000	2.62	.51257	.992	-1.2144	1.8144
	4	4.77600*	41.78	.51257	.000	3.2616*	6.2904
	5	2.70000*	19.19	.51257	.000	1.8216*	4.8504
	6	1.94000*	16.95	.51257	.005	.4256*	3.4544
2	1	-.56200	-4.98	.51257	.881	-2.0764	.9524
	3	-.26200	-2.42	.51257	.996	-1.7764	1.2524
	4	4.21400*	38.73	.51257	.000	2.6996*	5.7284
	5	2.77400*	25.48	.51257	.000	1.2596*	4.2884
	6	1.37800	12.60	.51257	.094	-.1364	2.8924
3	1	-.30000	-2.62	.51257	.992	-1.8144	1.2144
	2	.26200	-2.42	.51257	.996	-1.2524	1.7764
	4	4.47600*	40.21	.51257	.000	2.9616*	5.9904
	5	3.03600*	27.28	.51257	.000	1.5216*	4.5504
	6	1.64000*	14.72	.51257	.027	.1256*	3.1544
4	1	-4.77600*	-41.78	.51257	.000	-6.2904*	-3.2616
	2	-4.21400*	-38.73	.51257	.000	-5.7284*	-2.6996
	3	-4.47600*	-40.21	.51257	.000	-5.9904*	-2.9616
	5	-1.44000	-17.77	.51257	.071	-2.9544	.0744
	6	-2.83600*	-29.89	.51257	.000	-4.3504*	-1.3216
5	1	-2.70000*	-19.19	.51257	.000	-4.8504*	-1.8216
	2	-2.77400*	-25.48	.51257	.000	-4.2884*	-1.2596
	3	-3.03600*	-27.28	.51257	.000	-4.5504*	-1.5216
	4	1.44000	17.77	.51257	.071	-.0744	2.9544
	6	-1.39600	-14.73	.51257	.087	-2.9104	.1184
6	1	-1.94000*	-16.95	.51257	.005	-3.4544*	-.4256
	2	-1.37800	-12.60	.51257	.094	-2.8924	.1364
	3	-1.64000*	-14.72	.51257	.027	-3.1544*	-.1256
	4	2.83600*	29.89	.51257	.000	1.3216*	4.3504
	5	1.39600	14.73	.51257	.087	-.1184	2.9104

*. The mean difference is significant at the 0.05 level

Groups	Mean	Standard deviation	Standard error	95% Confidence Interval for mean		F	p
				Lower	Upper		
1	2.3060	.11616	.03673	2.2229	2.3891	6.230	.000
2	2.1630	.14545	.04600	2.0589	2.2671		
3	2.1720	.16089	.05088	2.0569	2.2871		
4	2.1760	.10710	.03387	2.0994	2.2526		
5	2.0560	.12213	.03862	1.9686	2.1434		
6	1.9640	.21188	.06700	1.8124	2.1156		

Table 1: Multiple comparisons for in post length between all groups using Tukey's post-hoc test.

Graphs

Graph I : Comparison of mean length of post space in millimeter between all groups

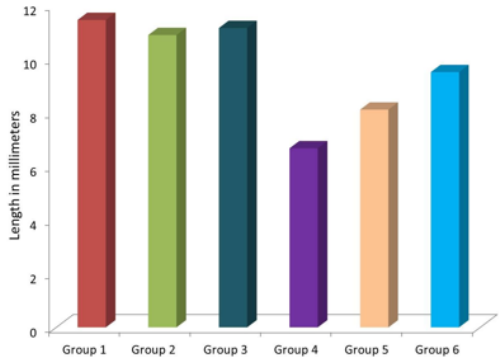

Table 2: Difference in mesio-distal dimension between all the groups

Conclusion

Within the limitations of the study following conclusion can be drawn-

1. Impression of post space obtained from the intraoral scanner was less accurate as compared to direct impression technique and indirect impression technique.

2. Cast metal post and zirconia post fabricated using indirect technique produced significantly shorter posts when compared with prepared post space length.

3. There was no significant difference between cast post and zirconia post in terms of length.

4. Mesiodistal dimensions obtained from prepared post space and those obtained from direct, indirect, and digital impression techniques had no significant difference whereas a significant difference was noticed between cast metal post and zirconia post.

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