Most endodontically treated teeth undergo a significant loss of coronal structure because of caries, fractures, and access preparation. To restore the integrity of these teeth, endodontic posts have been successfully used over many years to retain coronal restorations. Posts can be custom made or prefabricated. Custom-made post and cores have long been considered the gold standard for the rehabilitation of severely damaged endodontically treated teeth. They conform better to the shape of the canal and provide maximum retention and support for the coronal restoration.

Other advantages of cast post and cores include their high strength, durability, and the strong union between the core and the post. However, cast posts and cores have been associated with more unfavorable deep root fractures, perhaps because of their relatively high modulus of elasticity. Moreover, the evolution of nonmetal post systems, including fiber-reinforced resin posts, has led to improved esthetics and more favorable stress distribution patterns. Nevertheless, cast posts and cores are still favored in many clinical situations, especially where multiple teeth or misaligned teeth require post placement. Cast post and cores can also offer an advantage over other post systems for teeth with extensive tooth damage, partial fixed dental prosthesis abutments, and bruxism and other heavy occlusion situations. A number of surveys have shown that a good percentage of dentists still prefer the cast post and core system.

---

**ABSTRACT**

**Statement of problem.** Patterns for custom cast posts and cores can be fabricated either by the direct or the indirect technique. Which technique is more accurate is unknown.

**Purpose.** The purpose of this in vitro study was to investigate the effect of pattern fabrication technique on the accuracy of post fit.

**Material and methods.** Ten intact extracted premolar teeth with a single canal and similar dimensions received root canal treatment. The teeth were sectioned 2 mm above the cementoenamel junction. A total of 20 cast post and core patterns, 2 for each tooth, were fabricated, 10 with the direct technique and 10 with the indirect technique. Patterns were cast to produce 20 cast post and cores. Each tooth was scanned using a microcomputed tomography (μCT) system with a resolution of 14.5 μm, once with the post of the direct technique and once with the post of the indirect technique. Ct analyzer software was used to calculate the overall space between the post and canal walls and the space areas in 3 different standardized sections. The Student paired t test was used to determine any significant difference in the scores of the groups.

**Results.** The overall space between the canal walls and posts made with the direct technique ranged between 7.86 and 17.39 mm³, with a mean value of 12.25 mm³, whereas with the indirect technique, the space ranged between 6.68 and 18.02 mm³, with a mean of 11.92 mm³. No significant differences were found between the results of either technique (P>.05).

**Conclusions.** Within the limitations of this study, neither the indirect nor direct pattern fabrication technique influenced the accuracy of post fitting. (J Prosthet Dent 2016;116:411-415)
Clinical Implications

The fitting accuracy of cast posts produced by the direct technique was similar to that produced by the indirect technique.

Many factors may affect the prognosis of teeth restored with cast posts, including the length of the post, taper angle, type of cement used, and post fitting within the canal.1,10,11

The adaptation of tapered posts to root canals has been identified as the main factor associated with the failure threshold of restored teeth.12 The passive fit of the endodontic post and the presence of a homogenous cement layer surrounding it can prevent harmful torque and levers on the tooth structure that might predispose it to fracture.10

Two main techniques have been described and used for cast post and core fabrication: the direct and the indirect technique. For the indirect technique, an elastomeric impression of the post space is made and poured in stone to allow the fabrication of a post and core pattern in the dental laboratory.13,14 For the direct technique, the pattern is fabricated in the prepared canal with an acrylic resin.15

Few studies have compared the accuracy of these 2 techniques in terms of post retention and root fracture resistance. Al-Omari and Zagibe16 investigated the effect of technique and cement type on the retention of custom cast posts and reported no significant influence of the post fabrication technique on the post retention. However, they reported a significant effect of cement type and cementation process on the post retention. In another study, Pitigoi-Aron et al17 examined 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, the accuracy of post fit was obtained and compared. They found that the indirect technique significantly provided better post fit and therefore recommended this technique, especially for multiple posterior teeth or cases with limited interarch space.

Different methods have been used to evaluate the accuracy of fit of dental restorations, including endodontic posts. One of the methods recently adopted in dental research is microcomputed tomography (µCT). The µCT system uses microfocal spot x-ray sources and detectors with high resolution to produce 3-dimensional (3D) reconstructed images with voxels approximately 1 000 000 times smaller in volume and thus with higher spatial resolution than computed tomography imaging. µCT analysis now has many applications in medical and dental research and has been successfully used to study root canal morphology, root canal therapy, root canal volume and surface area, enamel and dentin thickness, and 3D modeling.18,19 Kim et al20 compared the accuracy of µCT measurements with 3D scanners, direct measurements, and photography and concluded that µCT scanning is a reliable method of measuring distances and volumes and of observing internal and external tooth structures.

The purpose of this study was to investigate the fitting accuracy of cast posts made with 2 different techniques, the direct technique and the indirect technique using µCT imaging.

MATERIAL AND METHODS

Before conducting the study, ethical committee approval was obtained from the research center in the Riyadh Colleges of Dentistry and Pharmacy (IRP/2012/009). Two sets of cast post and cores were obtained for the same teeth, using 2 different techniques: the direct and indirect technique. The accuracy of post fit was evaluated using µCT to determine which technique provided more accurate results.

Forty-four extracted premolar teeth were collected and cleaned of deposits and calculus by hand scaling. The teeth were then examined visually and by radiographs. Only teeth with a patent single root canal, complete apex, no cracks, and no root resorption were considered. Finally, 10 teeth with similar root morphology, length, and width were included. Using statistical software (G*power v3.1; Faul, Erdfelder, Lang, & Buchner)21 this sample size was able to achieve 0.8 power analysis assuming α=.05.

The teeth were then sectioned with a diamond disk, leaving 2 mm above the cementoenamel junction. All pulp tissue was removed, and the canals were cleaned and shaped in the conventional manner.16 Obturation was carried out using gutta percha and sealer (AH26; Dentsply DeTrey). Any excess coronal to the canal orifice was removed with a warm plunger.

After 24 hours, 12 mm of the obturation was removed with Gates Gliddens drills size 2 and 3. The post spaces where finalized with RelyX post drills (3M ESPE) sizes 1 and 2. The canals were then irrigated before the roots were mounted in acrylic resins.

For each tooth, 2 patterns were made, 1 with the direct technique and 1 with the indirect technique. The patterns were cast to produce 20 custom cast post and cores, which were divided into 2 groups. group (D) had the 10 posts fabricated with the direct technique, and group (ID) had the 10 posts fabricated with indirect technique.

For the indirect technique, a sectional plastic tray (COE spacer tray; GC Corp) was loaded with polyvinyl siloxane putty impression material (Express STD; 3M ESPE) while injecting the light body polyvinyl siloxane
into the post space. A plastic dowel (Pattern Resin LS; GC Corp) was fitted into the post space, and the impression was made. The material was poured in dental stone (Elite Master; Zhermack) after 60 minutes. Post and core patterns were made using inlay wax (GC Corp). Cores were standardized to 2 mm in height with a flat occlusal table.

For the direct technique, pattern acrylic resin (Pattern Resin LS; GC Corp) was used to fabricate post and core patterns. Petroleum jelly was applied to the post space with an endodontic K file. The resin was then mixed and inserted into the post space using a syringe with a small nozzle. A plastic post was then placed to support the resin in the canal, and the core was completed using the same acrylic resin material. The cores were made 2 mm in height and had a flat occlusal table. All patterns were invested in phosphate bonded investing material (Bel-lavest SH; Bego) and cast in a centrifugal casting machine with beryllium-free nickel chromium alloy (MEAlloy; Dentsply Intl).

The fit of the posts was verified visually and radiographically by 2 independent examiners to ensure proper fit. The teeth were then scanned using a Skyscan 1173 at high resolution and energy μCT (Skyscan; Kartuizersweg 3B) at 95 kV and 85 μA with a resolution of 14.5 μm, using a brass 0.25-mm-thick filter and 52% beam-hardening reduction. Each tooth was fixed and scanned twice, once with the post of the direct technique and once with the post of the indirect technique. After image reconstruction, 2D virtual slices were acquired in the axial plane. Each slice series was examined coronoapically to determine the respective analysis area in the root canal. Software (Skyscan CT Analyser; Bruker Corp) was used to calculate the areas and volume of space between each post and the root canal.

Five measurements were made for each post. The first measurement was the overall space volume existing between the post and prepared canal walls; the second was the space between the end of the post and the remaining gutta percha. The remaining 3 were measurements of space areas between the post and canal walls in 3 different sections (A, B, and C). Section A was made at the post-core junction, section B was made in a middle location of the post space, and section C was made 2 mm shorter than the apical end of the post (Fig. 1). Each measurement was repeated twice to ensure the reproducibility of the results. A paired t test of the scores was made with software (IBM SPSS Statistics v20.0; IBM Corp) package to determine the significance of difference in the post fitting between the 2 techniques.

RESULTS

Mean ± standard deviation values of the 5 space measurements are summarized in Table 1. The overall space volume between the post and prepared canal walls for group D ranged between 7.86 and 17.39 mm³ with a mean value of 12.25 mm³. For group ID, the space volume ranged between 6.68 and 18.02 mm³ with a mean value of 11.92 mm³. No significant differences were found in the results of either technique (P > .05).

The space area measured in section A between canal walls and posts in group D ranged between 0.02 and 1.92 mm² with a mean value of 1.18 mm², whereas in group ID, the space area ranged between 1.11 and 3.21 mm² with a mean value of 1.65 mm². The space area measured in section B between canal walls and posts in group D ranged between 0.34 and 1.91 mm² with a mean value of 1.20 mm², whereas in group ID, the space area ranged between 0.64 and 2.59 mm² with a mean value of 1.29 mm². The space area measured in section C between canal walls and posts in group D ranged between 0.28 and 1.53 mm² with a mean value of 0.88 mm², whereas in group ID, the space area ranged between 0.44 and 1.50 mm² with a mean value of 0.98 mm². The Student paired t test revealed significant difference between the results of both techniques only in section A (P = .042).

The space measured between the remaining gutta percha and the end of posts in group D ranged between 0.08 and 2.12 mm³ with a mean value of 0.61 mm³, while

<table>
<thead>
<tr>
<th>Technique/Measurement</th>
<th>Direct group (D)</th>
<th>Indirect group (ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall space (mm³)</td>
<td>12.25 ± 2.97</td>
<td>11.92 ± 3.38</td>
</tr>
<tr>
<td>Space area in section A (mm²)</td>
<td>1.18 ± 0.63</td>
<td>1.65 ± 0.62</td>
</tr>
<tr>
<td>Space area in section B (mm²)</td>
<td>1.20 ± 0.48</td>
<td>1.29 ± 0.57</td>
</tr>
<tr>
<td>Space area in section C (mm²)</td>
<td>0.88 ± 0.53</td>
<td>0.98 ± 0.49</td>
</tr>
<tr>
<td>Space at end of post (mm³)</td>
<td>0.61 ± 0.63</td>
<td>0.55 ± 0.57</td>
</tr>
</tbody>
</table>
in group ID, the space ranged between 0.02 and 1.75 mm\(^2\) with a mean value of 0.55 mm\(^2\). The paired \(t\) test revealed no significant difference in the results of the techniques \((P>.05)\).

**DISCUSSION**

Although most dental prostheses are fabricated indirectly in the dental laboratory, which is more convenient for both the dentist and the patient, many practitioners prefer the direct technique for post pattern fabrication because they assume it provides a more accurate fit.

Results of the current study revealed no significant differences between overall accuracy of fit of posts made with the direct technique and that of posts made with the indirect technique. The first measurement obtained by \(\mu\)CT in the current study was the overall space between each post and the respective root canal walls, which can be considered the main indicator of the overall accuracy of post fit.\(^{17}\) Measurements of the horizontal space surface area in sections A, B, and C indicate the relative post fit at the post-core interface, the middle of the post space preparation, and the apical part of the post respectively. Space between the post and the remaining gutta percha is also an important indicator of post fit and was measured for all posts.

Because post fitting is known to be crucial in post retention, these results support the results of Al-Omari and Zagibeh,\(^{16}\) who found no effect of the fabrication technique on the retention of cast posts. However, the results of the current study are contradicted by the findings of Pitigoi-Aron et al,\(^{17}\) who reported that the indirect technique provided better fit and accuracy than the direct technique. The source of this controversy could be the difference in the method used to measure the accuracy of post fit. The varied skills of the operators, laboratory techniques, and the experimental environment must also be considered as limitations in all in vitro studies, including this one.

The comfort of the patient and reduction in chairside time is an objective of any dental procedure. The indirect technique for fabricating a cast post and core may be easier and consume less time and be less irritating to the patient than the direct technique, especially in treatments with multiple restorations, limited interarch space, or limited accessibility.\(^{13,14}\)

Although the direct technique is preferred by many clinicians as a more predictable method of fabricating custom cast post and cores, the results of the current and previous studies confirm that, when the proper technique is applied, the indirect technique can produce posts that fit as accurately as posts obtained by the direct technique. \(\mu\)CT has been used in this study to measure the volumes and surface areas of the space between the post and the root canal. This method has been used successfully to study root canal configurations and measure the dimensions of different root canal systems. Because of its high resolution and very low voxel volume, it has been considered more accurate than other imaging techniques.\(^{19,20}\)

In vitro experiments using extracted teeth are limited in their ability to replicate the clinical situation. However, with proper standardization and control of the variables, they can provide valuable results which sometimes cannot be obtained by clinical trials.\(^{16,17}\)

One of the study’s limitations is that the accuracy of only 1 direct technique was compared with only 1 indirect technique. Other direct and indirect techniques could render different results.

Although the prior power analysis indicated that the sample size was adequate, the mean values showed relatively high standard deviation, which reduced the effect size and the power of the statistical significance. Although similar studies used a similar sample size,\(^{16,17}\) a larger sample size is necessary to obtain more conclusive results.

**CONCLUSIONS**

Within the limitations of this in vitro study, the use of either a direct or indirect post pattern fabrication technique does not affect the accuracy of cast post and core fit. When proper procedures are conducted in the clinic and the dental laboratory, the indirect technique could save chair side time and be more convenient to both patient and dentist while also producing accurately fitted posts.

**REFERENCES**

Complete edentulism and comorbid diseases: An update

Felton DA

J Prosthodontics 2016;25:5-20

The relationship between complete edentulism, which is the terminal outcome of a multifactorial oral disease process and other comorbid diseases, was first reported in 2009. Although the relationship between edentulism and a multitude of systemic diseases was reported, none of the publications studied could determine causality of tooth loss on the incidence of any comorbid disease. Since that publication, there has been a renewed interest in this relationship, and a plethora of new articles have been published. This article will provide an update on articles published since 2008 on the relationship between edentulism and comorbid diseases, and will include the relationship between complete edentulism and such comorbid conditions as malnutrition, obesity, cardiovascular disease, rheumatoid arthritis, pulmonary diseases (including chronic obstructive pulmonary disease), cancer, and even mortality.

Reprinted with permission of the American College of Prosthodontists.