Cast posts and cores have been used to restore endodontically treated teeth\(^1\) which will serve as support for subsequent prosthetic restorative treatment.\(^2\) Custom-fabricated cast metal posts are still regarded as the gold standard for restoring extensively damaged teeth\(^3-6\) and for large fixed dental prostheses with high survival rates.\(^7-11\) Although glass fiber posts may be similar to cast metal posts in terms of survival,\(^11-15\) cast metal posts are commonly chosen when there is insufficient ferrule (<2 mm) or a large fixed partial prosthesis.\(^16\)

The choice of cast metal posts is common as they will fit the irregularly shaped canal walls more intimately, and their shape and structure can resist torsion forces.\(^17\) This is especially true because teeth with no ferrule have not been tested with glass fiber posts supporting extensive partial fixed dental prostheses.

The major advantages of cast posts are low cost, no technique or special cement for fixation, a long history of clinical use, and excellent radiopacity. However, the result of dental lost-wax casting techniques is greatly influenced by the inherent properties of the dental materials, such as the expansion and contraction of all materials used, including impression materials, waxes, gypsum products, plastics, and metals.\(^18\) Distortions in the casting process result\(^19\) in a nonuniform pre-cementation space and absence of passivity and fitting between tooth and metal and inadequate endodontic healing.\(^17,20-24\) Therefore, an adequate impression technique could influence the clinical survival of the definitive restorative treatment because it directly influences the
Clinical Implications
Because all cast posts were considered clinically acceptable, the choice of technique should be based on clinical preference. However, the direct technique yielded posts that filled the post space more completely.

cast metal post retention. However, few studies have compared the accuracy of the cast metal posts considering impression techniques and tooth position. The indirect technique with polyvinyl siloxane impression material has been found to reproduce the details of the root canal space \(^\text{25}\) is faster and easier than the direct technique, especially when multiple posterior teeth are involved or when shorter clinical chair time is necessary \(^\text{26–33}\); yet the direct technique is reliable \(^\text{30}\) and has several advantages, including easy manipulation of acrylic resin, dimensional stability, easy adjustment in the mouth when needed, and less working time at the laboratory, albeit with longer clinical time.

Thus, the purpose of this randomized controlled clinical trial was to evaluate the accuracy of cast metal posts with regard to adaptation and length and considering the impression technique and tooth position on the arch. The null hypothesis was that no differences would be found between impression techniques or tooth position in terms of the time taken to perform the technique or the accuracy of the cast metal posts.

MATERIAL AND METHODS
This double-blinded (patient and evaluator) parallel-group, randomized controlled trial was part of the clinical trial registered at ClinicalTrials.gov (NCT01461239). The study was approved by the local research and ethics committee (protocol 122/2009). Additionally, the terms of the Consolidated Standards of Reporting Trials (CONSORT) items were fulfilled. \(^\text{34}\) Participants’ oral health was assessed, and they provided written informed consent before enrolment in the study. The inclusion criterion was any endodontically treated anterior or posterior tooth with 0- to 0.5-mm ferrule height requiring a cast metal post and a single metal ceramic crown. Exclusion criteria considered teeth that did not require intraradicular retention or that for any reason could not be impressed. The main outcomes evaluated were the time taken to perform the impression and the quality of the posts, and concerned the adaptation and length observed clinically, radiographically, and through standardized photographs.

Assuming equivalence of the impression techniques, the sample size calculation determined that 50 impressions were required to be 90% sure that the limits of a 2-sided 90% confidence interval would exclude a difference of more than 18% between the direct and indirect techniques. Sample size calculation was also performed for the effect of teeth, which resulted in 26 impressions per tooth group. We also considered possible losses and, therefore, included 39 participants with 58 impressions.

A randomization sequence was generated with a computerized random number generator (Excel; Microsoft Corp). For treatment randomization, a person not involved in the study wrote impression techniques (direct or indirect) on slips of paper and inserted them into plain brown envelopes. For every patient entering the clinical practice, an envelope was chosen, and the technique was used. Teeth were not impressed twice; every tooth was impressed with either the direct or indirect technique.

Two operators (A.P.M. and V.P.N.) carried out the impression procedures, and the time elapsed to perform the impression techniques was registered for each impression. All procedures were performed using rubber dam isolation, and all materials were used according to the manufacturers’ instructions. Initially, all teeth included in the study received endodontic treatment using the crown-down technique and irrigation with 2.5% NaOCl solution. Teeth were filled using the lateral condensation technique, Grossman cement (Endo-Fill; Dentsply Maillefer), and gutta percha cones (Dentsply Maillefer). Then, two-thirds of the obturation were removed from the root canal with #5 Gates Glidden burs (Dentsply Maillefer). \(^\text{31}\) Randomization was performed to determine whether direct or indirect impression technique would be used.

For direct impression, post and core patterns were made from prefabricated acrylic resin posts (Pinjet; Angelus Indústria de Produtos Odontológicos SA) relined with autopolymerizing acrylic resin (DuraLay; Reliance Dental Mfg Co). \(^\text{30}\) For this purpose, the still fluid resin was inserted into the canal, and prefabricated posts moistened with monomer were inserted and bonded to the resin previously placed. Excess resin was accommodated around the prefabricated posts for the core. Insertion and removal of the posts into the root canal was continued until early exothermy and placed in water at 37°C until the end of polymerization. When necessary, the post was relined. \(^\text{35}\) Subsequently, the post and core patterns were sent to a dental laboratory for casting (Ni-Cr; Fit Cast-SB Plus; Talmac).

Indirect impressions were made with acrylic resin prefabricated posts and polyvinyl siloxane impression material (AD Futura; DFL Indústria e Comércio SA). In this technique, the light-bodied material was inserted into the root canal, followed by insertion of a prefabricated post. A tray filled with the putty and light-bodied material was placed and removed with the post after the impression material had polymerized. The indirect impression was poured in Type IV gypsum.
(Durone; Dentsply Maillefer) and sent to a dental laboratory technician to make the wax patterns for casting the posts (Ni-Cr; Fit Cast-SB Plus; Talmax).

The time taken to perform the impression was measured from the beginning of the isolation of the root canal (for the direct technique) until the core was finished. For the indirect technique, the time was considered from the beginning of the impression insertion into the root canal until the setting of the putty material.

Characteristics of the impressions and resulting cast metal posts were evaluated by clinical inspection, and standardized images were made with a digital single lens reflex camera (Canon EOS Rebel XTi; Canon), with a standardized focus (20 mm, f/2.8VR), and at a fixed distance (15 cm) from the records. To standardize and to provide reliability of the image measurements for the direct technique, the acrylic resin patterns were photographed on graph paper, whereas for the indirect technique, impressions were photographed on a black background with a ruler positioned in the limit between the cervical to apical portion of the intraradicular coronal post impression. Cast metal posts obtained from both direct and indirect techniques were measured with a millimeter ruler and photographed on graph paper to ensure the consistency and accuracy of the measurements. Only 1 measurement (with the ruler) was considered, but the graph paper helped in the standardization of the measurement.

Before the cementation procedure, the cast metal posts were evaluated for adaptation and length with periapical radiographs, which were made with a parallel technique and Ultra-Speed films (Eastman Kodak Co) to evaluate post adaptation and to determine whether they could be cemented. All cast metal posts were luted with self-adhesive resin cement (RelyX U200; 3M ESPE), using a Centrix syringe (Centrix syringe; DFL Indústria e Comércio SA). Digital pressure was applied for 5 minutes, and excess cement was removed, followed by light-polymerization for 40 seconds/surface. All teeth received single metal ceramic crowns. Statistical analysis was performed with software (SigmaStat v3.5 α=.05; Informer Technologies, Inc). Considering the impressed posts and length of the metal post, data were analyzed with paired t tests for intragroup comparisons. With regard to time, data were ranked and a 2-way ANOVA was followed by the Student-Newman-Keuls post hoc test (α=.05).

**RESULTS**

Of the 58 impressions made, 5 were excluded (Fig. 1). Results are summarized in Tables 1 and 2. Considering the impressed post space, and the length of the metal post, statistically significant differences were found for all tested variables, with direct (P=.04) and indirect (P=.02) techniques for anterior teeth, and direct (P=.04) and indirect (P=.01) techniques for posterior teeth, all resulting in shorter posts after casting. The mean reduction for the metal posts was 2.3% for direct anterior, 5.7% for direct posterior, 6.3% for indirect anterior, and 7.2% for indirect posterior technique.

Considering the time, a statistically significant difference was found between the techniques and tooth position (P=.031), with the direct technique being more time consuming than the indirect technique (P<.001) for both tooth groups. For the indirect technique, both tooth groups were similar with respect to time (P=.459) (Table 2).

**DISCUSSION**

The present study compared the accuracy of cast metal posts, considering the impression technique and position of tooth on the arch and considering the time to obtain an impression of the intraradicular posts and length of the impressed post space versus the cast post. To the authors’ knowledge, this is the first randomized controlled trial designed to compare the quality of cast metal posts made for intracanal impression based on the assumed equivalence of the techniques. Both of the

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**Table 1. Variables related to length of posts**

<table>
<thead>
<tr>
<th>Technique/teeth</th>
<th>Impressed Post Space</th>
<th>Cast Post</th>
<th>Mean Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>10.3 ±2.1b</td>
<td>10 ±2.0a</td>
<td>2.3</td>
</tr>
<tr>
<td>Posterior</td>
<td>11.3 ±3.1b</td>
<td>10.6 ±3.4a</td>
<td>5.7</td>
</tr>
<tr>
<td>Indirect</td>
<td>9.8 ±2.8b</td>
<td>9.2 ±2.5a</td>
<td>6.3</td>
</tr>
<tr>
<td>Posterior</td>
<td>7.8 ±2.4b</td>
<td>7.1 ±1.9a</td>
<td>7.2</td>
</tr>
</tbody>
</table>

*Values are mean ±SD. Different letters represent differences between impressed and cast posts for same impression technique and tooth group (paired t tests, P<.05).
intracanal impression techniques resulted in statistically significant shorter posts, but all posts could be cemented. The null hypothesis tested was that no differences would be found between impression techniques on the quality of metal posts. Thus, the hypothesis was rejected statistically but accepted clinically.

Although we found differences between the impressed post space and cast post lengths, they were considered clinically irrelevant, with a mean reduction of 2.3% (0.3 mm) for direct in anterior teeth, 5.7% (0.7 mm) for direct in posterior teeth, 6.3% (0.6 mm) for indirect in anterior teeth, and 7.2% (0.7 mm) for indirect in posterior teeth. These results showed that metal posts fabricated with the direct technique presented fewer differences between impressed post space and cast posts but without any statistically significant difference. The indirect technique presented a higher percentage of shortage, probably because the dental technician creates a relief in the gypsum cast on which the acrylic resin pattern is made; this results in a greater probability of inaccuracy in the cast. Seating interferences from the resin patterns in the dental laboratory often occur with the indirect technique and are probably linked to ability of the technician and the inherent distortions of the materials used with the indirect technique. However, this result did not influence the clinical result, as all posts were considered adequate for cementation and were not remade, as previously shown. A previous clinical study that compared direct with indirect techniques with regard to survival probability found no statistically significant differences.

The use of acrylic resin can overcome the technically demanding nature of the indirect technique with its greater number of intermediate steps, most of which are out of the dentist’s control. However, it is more time consuming, as corroborated by our results, and is quite difficult to apply when the interarch space is minimal. Conversely, the direct fabrication technique for posts and cores has shown lower survival probability than the indirect technique. The reason could be the difficulty of fabricating a post and core intraorally with the same precision as with indirect fabrication on a cast. The direct fabrication of posts requires a greater degree of operator skill. Although the study of Balkenhol et al stated that the indirect fabrication of post and cores is a way to ensure long-term success, all the teeth included were in place after 4 years of follow-up.

The indirect technique is considered technically demanding, with its extra number of intermediate steps. However, if an accurate and stable impression material is used and meticulous laboratory procedures are followed, it can give results comparable with those obtained by direct technique, which is in accordance with the findings of this study. Additionally, in some situations where multiple teeth are involved or interarch space reduced, the indirect technique is usually the technique of choice. This study showed that the indirect technique is faster than the direct technique because it is less time consuming for the practitioner, corroborating previous studies.

For this study, and to be considered adequate for cementation, the quality of the post should be adequate, with the margins of the coronal part of the post sufficiently well adapted to prevent bacteria penetration. As no clinical data support that assessment of restoration quality can be adequately achieved based only on the examination of periapical radiographs, a maximum of 1- to 2-mm shorter length (compared to the initial impressed post) together with the evaluation of the correct binding to the root canal wall was used. If the post is more than 2 mm shorter, it may be dislodged or even induce fracture, while a gap of more than 2 mm has been shown to increase endodontic failures. To ensure adequate retention and favorable mechanical/biological principles, all posts were at least the length of the future clinical crown, and the apical post diameter was similar to that of the root canal.

CONCLUSIONS

Although the indirect technique produced shorter posts than the direct technique, both techniques resulted in shorter metal posts, which could still be cemented. The indirect technique proved faster than the direct technique, which is especially important in situations involving multiple teeth and/or reduced interarch space.

REFERENCES