# A comparison of two gutta-percha obturation techniques to replicate canal irregularities in a split-tooth model

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***Objective.*** The purpose of this study was to compare a modified injectable gutta-percha (MIGP) obturation technique with continuous wave technique (CWT) for the ability to fill the root canal system (RCS) and replicate artificially created intracanal defects at the apical third, using a split-tooth model.
***Study design.*** A maxillary canine was use to build a split-tooth model. The root canal was cleaned and shaped using crown-down technique with rotary files to size #40 at the apex. Intracanal defects were created in the dentin of the root canal walls with a half-round bur at the apical third. The canal was obturated 48 times with gutta-percha and sealer. Twenty-four obturations were performed for each technique, MIGP and CWT. After each obturation, the model was separated in 2 halves; buccal and lingual. Each obturation was examined and photographed under operating microscope at ×5 magnification. The images were blindly evaluated by 2 endodontists for the length of gutta-percha fill, ability to fill the RCS, presence of voids, and replication of the canal defects.
***Results.*** Results were analyzed with the Mann-Whitney *U* test and showed statistical difference between the 2 groups in the quality of the obturation ($P < .05$).
***Conclusions.*** The MIGP technique appeared to replicate the canal defects at the apical third better than CWT, with fewer voids in between the canal walls and the gutta-percha mass. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e29-e34)**

It has been demonstrated that the quality of root canal obturation is important to the successful outcome of the endodontic therapy.[1,2] The anatomy of the root canal system (RCS) is composed of various irregularities, creating challenges for a proper seal during obturation.[3] Root canal obturation should aim at providing a 3-dimensional seal apically, laterally, and coronally.[4] It is well established that the success of root canal therapy is directly correlated to a proper apical and coronal seal.[4-9]

Several obturation techniques and materials have been used in the past. Historically, gutta-percha (GP) has been the material of choice since the middle 1800s, and it remains the most popular material for obturation owing to its biologic, chemical, and physical properties.[8-10] It is suitable to be used with many obturation techniques, including lateral condensation, warm lateral condensation, warm vertical condensation, continuous wave, and injectable GP (IGP) techniques, among others.

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Thermoplasticized gutta-percha techniques have been developed in an effort to improve the obturation of root canal irregularities, to improve density of the fill, and to reduce voids. It has been shown that warm vertical compaction of gutta-percha has the capacity to fill twice as many lateral canals than cold lateral condensation.[11] A version of this approach is the continuous wave technique (CWT) in which a single master cone corresponding to the master apical file is used in conjunction with a heat source and pressure from the heated plugger.[12] This technique provides an effective apical seal in addition to obturating lateral canals.[13] Others studies, however, showed that CWT was not able to predictably replicate apical third defects with a homogeneous and void-free obturation.[10,14]

Injectable GP obturation technique delivers either high- or low-temperature thermoplasticized GP inside the RCS with the use of a cannula. This technique, which does not use a master cone as part of the obturation protocol, has been shown to reproduce the internal root canal anatomy better than traditional lateral condensation,[10,14-16] with closer adaptation of the gutta-percha to canal walls when analyzed under the scanning electron microscope.[17] Although lateral canal replication is significant, extrusion of the material out of the apex is also an important factor to be avoided,[14,16,18,19] even when a proper apical stop has been created.[20,21] Yelton showed that a 0.40-mm apical

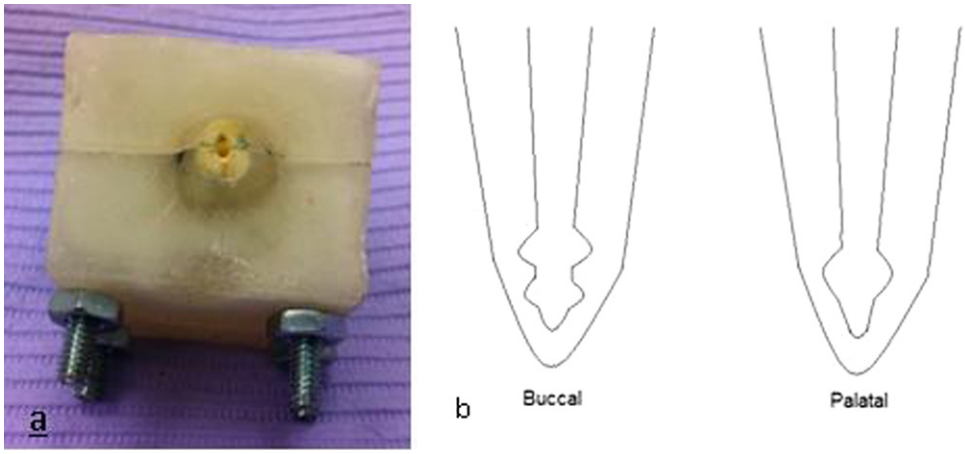


Fig. 1. **a,** Split tooth model. **b,** Diagrammatic representation of the intracanal defects.

preparation might yield better intracanal defect and WL replication when using IGP technique in the clinical situation.[22]

The purpose of the present study was to compare a modified IGP technique (MIGP) with CWT for the ability to replicate working length and artificially created intracanal defects at the apical third and for the presence of voids in between the canal walls and the GP, using a split-tooth model.

## MATERIALS AND METHODS

### Split-tooth model and root canal preparations

The split-tooth model was constructed as described in detail by Budd et al.[16] with some modifications. A maxillary canine with a single straight root and canal was used to produce a split-tooth model for all obturations. The tooth was accessed with a #4 surgical length bur (Brasseler USA, Savannah, GA), and the orifice was preflared with 2, 3, and 4 Gates-Glidden drills (Brasseler USA). The crown was removed at the cementoenamel junction with a cross-cut fissured bur (Brasseler USA), leaving the root with a length of 20 mm. The root was mounted in clear orthodontic acrylic resin (Caulk/Dentsply, Milford, DE) and left to cure at room temperature for 48 hours. A model trimmer was used to square the sides of the cured resin block, which was subsequently polished with a rag wheel using water and polishing compound. Four alignment holes were drilled through the acrylic block perpendicular to the long axis of the root, 1 in each corner of the block. The tooth was then separated into buccal and lingual halves by making a cut through the center of the opened canal orifice with a 150-μm diamond blade in an Isomet saw (Buehler, Lake Bluff, IL). The 2 halves were subsequently repositioned using bolts that fit snuggly into the 4 predrilled holes (Fig. 1). The working length (WL) was determined to be 1 mm short of the anatomic apex of the tooth. Cleaning and shaping was performed using rotary instrumentation in a crown-down method with Profile GT series to a final size of 40/0.06 taper. RC Prep was used as lubricant (Premier Pharmaceuticals, Philadelphia, PA) and 6% sodium hypochlorite (NaOCl) as an irrigant. The model was then separated into the 2 halves and examined to ensure that equal preparation of each canal occurred on both halves.

### Preparation of Intracanal Defects

Defects were placed in the apical one-third of the canal in both sections of the root (Fig. 2). Two depressions were placed on the mesial and distal sides of the canal 2 mm short of the WL, using a quarter round bur on the palatal half and a half round bur on the buccal half. The depth of the defects was maintained at one-half the diameter of the burs. On the buccal half, 2 additional defects were prepared on the mesial and distal side of the canal at 2 and 3 mm short of the WL.

An additional depression was made at the WL level on the acrylic block to allow for gutta-percha flow and patency. To maintain canal patency, a #20 K-file was introduced past the WL and into the depression after the 2 sides of the model were repositioned. This step was repeated before each obturation.

### Obturation

Two groups of 24 obturations were performed in the model for each technique evaluated. The same operator completed all obturations. Sealer was used in each case to resemble clinical conditions. Before each obturation, the root canal was inspected and cleaned of any GP and sealer remaining in the root canal, under an operating microscope (Carl Zeiss, Jena, Germany).

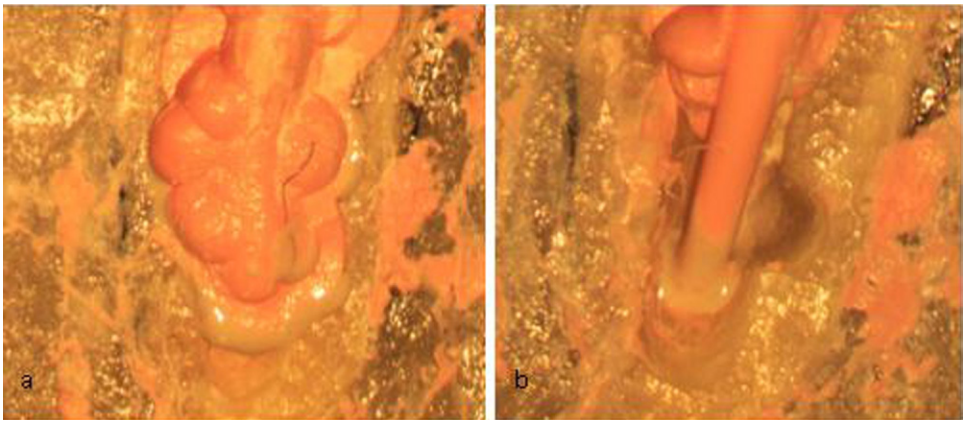


Fig. 2. **a,** Representative sample of modified injectable gutta-percha technique. **b,** Representative sample of continuous wave technique.

*Continuous wave technique.* A #40 0.06 taper GP cone (SybronEndo, Orange, CA) was placed at the WL and presence of tug-back was ensured. A small amount of sealer (Kerr) was placed on the canal walls with a #20 file. A System-B heat source (SybronEndo), at power setting 10 and 200°C and fitted with a 0.06 plugger, was used to heat and cut of the GP cone 3 mm short of the WL. The Calamus system (Dentsply/Tulsa Dental, Johnson City, TN) was used at 180°C and 60% flow rate to backfill the rest of the canal with a 23-gauge needle.

*Modified injectable gutta-percha technique.* A small amount of sealer (Kerr) was placed on the canal wall after each obturation with a #20 file. The split-tooth model was obturated with the use of 23-gauge injection needles with thermoplasticized GP in 2-step obturation, using the Calamus system at 180°C and 60% flow rate. The injection needle was placed 3 mm short of the WL, and the GP was extruded into the canal until one-half of the canal was filled. A prefit Dovgan plugger (0.04 ISO 60-80, 27 mm; Milltex, York, PA) was directed apically to compact the GP. Then, the System B heat source with a 0.06 tapered plugger was placed 3 mm short of the WL, to heat the GP in the apical third for 3-5 seconds A Dovgan plugger was used to compact the GP and prevent shrinkage during cooling. Subsequently, obturation of the middle and coronal portions of the canal was done in a single extrusion of GP, using the Calamus system, until the canal was completely filled. The Dovgan plugger was used again to condense the coronal mass of gutta-percha. After each obturation, the GP was allowed to cool for 3 minutes before model separation.

After each obturation, the tooth-model was separated and a magnified digital image created using the operating microscope at a magnification of ×5. A total of 48 images were created, corresponding to 24 obturations in each of the 2 groups. These images were later analyzed by 2 blinded independent observers, who were calibrated before the reading sessions.

The images were analyzed and scored based on the following criteria:

1. Length of fill: The distance of the obturation material from WL was recorded in mm as a positive (overextension) or negative (under fill) value.
2. Replication to WL was recorded: 0, no gutta-percha extended to WL; 1, GP was extended to WL, but some space remained laterally; 2, GP was extended completely to WL.
3. Replication of intracanal defects (ICDs) at the apical third: 0, the ICDs were not replicated at all; 1, the ICDs were only partially replicated; 2, the ICDs were completely replicated.
5. Voids: 0, evidence of ≥2 areas lacking surface adaptation at the apical third; 1, 1 such area was present; 2, no voids were present.

The results were analyzed with the use of a Mann-Whitney *U* test to determine if there were statistically significant differences between the 2 obturation techniques.

## RESULTS

A statistically significant difference ($P < 0.05$) was found between the techniques in all categories. MIGP was able to replicate the working length the ICDs at the apical third and had fewer voids than CWT. Overall, both techniques did not show overextension. Figure 3 presents the mean scores for each category between groups.

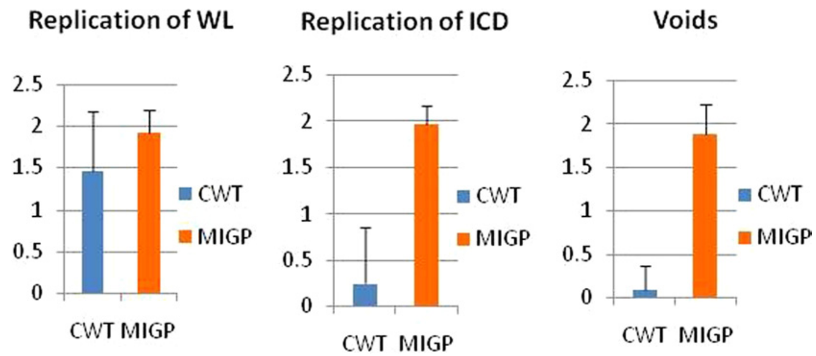


Fig. 3. Mean and standard deviation for the replication of working length (WL), replication of intracanal defects (ICD), and absence of voids. *CWT*, continuous wave technique; *MIGP*, modified injectable gutta-percha technique.

## DISCUSSION

In this study, MIGP showed better replication of ICDs at the apical third and more homogeneous obturations than CWT, which is in concordance with earlier studies.[10,14,22] MIGP was able to reproduce the WL without overextension of GP beyond the apex in the present study. There are several reasons for these observations. First, in this study the RCS was cleaned and shaped to an apical size of 40/0.06, allowing the 23-gauge needle to be placed within 3 mm of WL to deposit moldable GP close to the apex.[22] Tapering the canal also allowed the prefitted plugger to compact the GP in its moldable state and to reheat the GP mass 3 mm from the WL and compact it again. Application of additional heat, using the System B, to the apical GP and the additional compaction using the pluggers aid in the obturation of canal irregularities,[9,23-25] especially in the apical third, where the presence of isthmus, deltas, and accessory canals are known to be present.[26-28] Second a meticulous instrumentation technique was performed to create an apical stop at the WL. Earlier studies have shown that this is extremely important to prevent apical extrusion of GP.[20,29,30] Third, in this study all obturations were performed after coating the canal walls with a very thin layer of Kerr sealer. The presence of sealer enhances the flowable properties of GP within the RCS.[31,32]

The CWT group showed significantly poorer apical defect replication. Twenty-one out of 24 obturations showed a lack of adaptation of the single cone in the apical third, in agreement with previous studies.[14,25,33] Other authors[8,10] found that heat is conducted 2-3 mm into the GP from the point of application of the heat source. However, in the present study, the application of heat at 3 mm in the CWT did not show enough transportation of heat through the GP to make it compactable and moldable to replicate the apical defects. Although this study did not evaluate sealer, all of the images showed that a thin layer of sealer had flowed into the apical defects. These findings are in agreement with earlier studies,[32-34] where the percentage of sealer that coated the canal perimeter was shown to be higher in single cone obturation. This occurs due to sealer not been pushed up when the warm GP is condensed. Moreover, these findings can explain why when using CWT in a clinical setting, a complete replication of the RCS appeared radiographically.

Another category evaluated was the replication of the WL, which was achieved in 91% of the cases, in agreement with Smith et al.[10] No extrusion of GP beyond the apex was seen in any of the 24 obturations. This could be explained by the presence of an apical stop, showing good adaptation of GP to the WL. Furthermore, high incidences of voids were found with CWT, especially in between the canal walls and the GP,[34] where intracanal defects were present, as well as in the interface between the "single cone" and the backfilled GP.

Because the deep application of heat with different thermoplasticized GP techniques is favorable to improve the replication of the apical portion of the RCS,[8,10,24] the transference of heat toward the cementum, periodontal ligament, and alveolar bone is a clinical concern. Eriksson and Albrektsson[35] reported that bone in rabbits could resist up to 47°C for a minute before the bone tissue showed signs of irreversible damages. Earlier in vitro studies[8,36,37] in which GP heated to 160°C-200°C was used to fill RCS showed that the temperature rises below the theoretic critical level. Lipski[38] determined that the heat transfer is dependent on the remaining radicular dentin, so special considerations have to be taken with teeth that have thinner root structure when using thermoplasticized GP obturation technique. Another important point to consider is that a second application of heat always causes a higher rise in temperature, owing to the lack of cooling after the first application of heat.[38] Another study showed that the presence of sealer reduces the amount of heat transfered to the root surface.[31]

Ideally, obturations techniques should have predictable length control. In the present study, none of the obturations in both groups exhibited overfill. The fact that the split-tooth model does not recreate a perfectly restricted canal, the presence of lateral extrusion of GP was seen in all obturations between the 2 halves of the model,[10,14,16,39] especially in the middle and coronal third, where a greater volume of heated GP was able to flow in between the 2 halves. These lateral extrusions of GP in the split-tooth model may explain the absence of overfill in any of the obturations.

Moreover, when extrusions occur, it has been demonstrated that periradicular tissues can tolerate extrusions of GP, especially if the canal system has been properly cleaned and shaped.[40] On the other hand, in cases of apical lesions, the healing process can be delayed by the presence of GP overfills, and chronic foreign body reactions can be caused by the extrusion of the filling materials into the apical tissues.[30,40]

As an in vitro study, this model does not replicate clinical conditions. However, the split-tooth model[16] provided standardized root canal which allowed direct comparison of obturations, eliminating variability caused by the use of different teeth.[14]

In conclusion, MIGP superiorly replicated the apical defects compared with CWT, but further research and a new in vitro model are needed to properly evaluate the length control with MIGP. Future studies to evaluate the effect of consecutive heat application on the periodontal ligament and surrounding bone also need to be evaluated. Limitations with this technique include RCSs where the apical stop cannot be achieved and narrow and sharply curved root canals. Appropriate case selection, knowledge, clinical skills, and common sense are needed to accomplish successful root canal therapy.

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