A Comparison of Three Gutta-Percha Obturation Techniques to Replicate Canal Irregularities

Jake Collins, BS, MS, Mary P. Walker, DDS, PhD,[†] James Kulild, DDS, MS, and Charles Lee, DDS**

Abstract

A split-tooth model with artificially created intracanal wall defects was used to compare three gutta-percha (GP) obturation techniques, cold lateral, warm lateral, and warm vertical. The techniques were evaluated and compared based on defect replication quality as a function of defect location and size. The obturations were evaluated on an ordinal scale, 0 to 4, based on how much each defect was replicated. There was a statistically significantly better result with both warm techniques compared to cold lateral obturation, while there was no significant difference between the warm obturation techniques. *(J Endod 2006;32:762–765)*

Key Words

Cold lateral, isthmus, lateral canal, warm lateral, warm vertical

From the *Department of Endodontics, [†]Department of Restorative Dentistry, University of Missouri-Kansas City, School of Dentistry, Kansas City, Missouri.

Address requests for reprints to Dr. Mary P. Walker, UMKC School of Dentistry, 650 E 25th St., Kansas City, MO 64108. E-mail address: walkermp@umkc.edu.

0099-2399/$0 - see front matter

doi:10.1016/j.joen.2005.10.001

To increase endodontic treatment success, the root canal system (RCS) must be effectively sealed coronally and apically. The apical seal is the principal barrier to leakage (1, 2); however, loss of the coronal seal also allows bacterial recontamination of endodontically treated teeth leading to failure (3–5). There are many different RCS obturation techniques but no one technique has been identified which is clearly superior.

Lateral compaction produces a cold-welded, nonuniform mass of gutta-percha (GP) cones in the coronal, middle, and apical portion of the canal without perfect replication of the canal, leaving space filled with sealer (6). Teeth obturated with cold lateral compaction (CLC) and different sealers exhibited leakage following minimal storage in saliva (5). Warm vertical compaction (WVC) can increase the GP mass density and homogeneity on previous CLC obturations (7, 8). The WVC technique has shown greater ability to flow into canal irregularities (9–11). A 10% higher healing rate was also reported with WVC versus CLC for teeth with previous apical periodontitis (12). However, negotiating curved RSCs with pluggers and/or GP injection needles can be difficult. Thus, warm lateral compaction (WLC) was developed to enhance GP flow while maintaining the predictability and ease of use of traditional lateral compaction. WLC using an electrically heated spreader increased the homogeneity and density of the GP mass and maximized the advantages of both traditional lateral compaction and WVC (13, 14). Increased GP density leads to fewer voids and theoretically a better apical and coronal seal. The more GP in the canal will limit the space filled by sealer. Gutta-percha, a polyisoprene-based polymer, will be more resistant to hydrolytic degradation than sealers, which are typically zinc-oxide eugenol or calcium hydroxide (15–17). A resultant obturation with more GP and less sealer should provide better long-term results.

The purpose of this study was to test the ability of GP to flow into canal irregularities based on three different obturation techniques using a split-tooth model. The investigation compared CLC, WVC, and WLC as a function of the replication of artificially created intracanal defects based on both defect location and defect size.

Materials and Methods

Specimen Preparation

After embedding an extracted human maxillary central incisor in clear acrylic resin just below the CEJ, four alignment holes (two each on the mesial and distal side of the root) were drilled perpendicular to the tooth long axis (Fig. 1*A*, *B*). Following crown removal at the CEJ (Fig. 1*A*) with a low-speed water-cooled diamond saw blade (Buehler Ltd., Evanston, IL), the embedded root was longitudinally sectioned buccolingually (Fig. 1*B*) through the root canal center.

The working length (WL) was established by placing the tip of a #10 SSK file (Tulsa Dental, Tulsa, OK) on one of the root halves 0.5 mm from the apex. The two halves were reapproximated and bolted back together.

The canal was instrumented using a standard crown-down technique to a #55 ISO 0.04 Profile (Tulsa Dental) at the established WL. The block halves were separated and examined to ensure that equal preparation of the canal was complete on both sides.

Intracanal Defect Preparations

Defects were placed in the coronal, middle, and apical aspects of the canal wall in either the buccal or palatal half of the root canal (Fig. 1*C*) as described below.

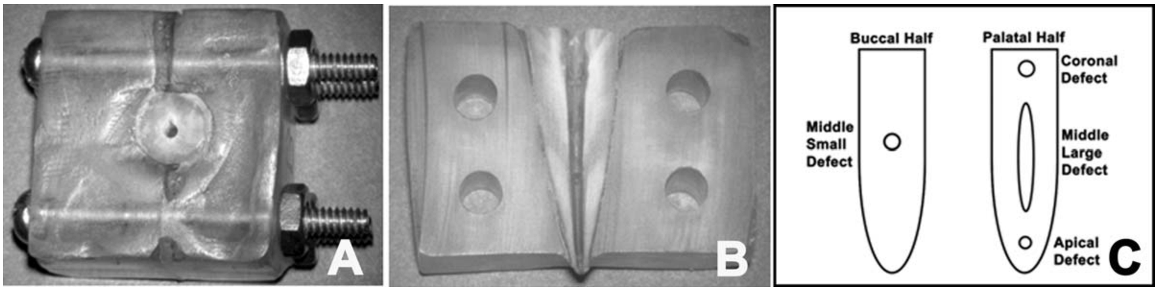

Figure 1. Coronal aspect of maxillary central incisor root embedded in acrylic resin block (*A*). Buccal half of root/block (*B*). Diagrammatic representation of buccal and palatal root halves with respective artificially created intracanal defects (*C*).

Apical Defect (AD) created with one-quarter round bur to half depth of bur diameter in the palatal wall, ~1 mm short of the canal WL.

Middle Small Defect (MSD) created with one-half round bur to half depth of bur diameter in the buccal wall, 6 mm from the anatomical apex.

Middle Large Defect (MLD) created with an EIE two ultrasonic tip (GBC Innovations, San Diego, CA), 0.5 mm deep and 3 mm long in the palatal wall, ~2 mm from the coronal-margin of the prepared AD.

Coronal Defect (CD) created using the same protocol for MSD (one-half round bur), was placed in the palatal wall 2 mm coronal to the MLD coronal margin.

Obturation Techniques

The model was obturated 10 times using each technique. After each obturation, the model was separated and the GP mass removed. Silicone spray was applied to allow GP removal without distortion. The three techniques were performed by three different endodontists very experienced in that technique.

CLC

A #55 0.02 taper GP cone (DiaDent Vancover, BC, Canada) was placed to WL. A fine size finger spreader was advanced to within 1 mm of the WL or to resistance, rotated, and removed. A size #25 0.02 taper accessory GP cone (Tulsa Dental) was placed into the prepared space. To better replicate the apical defect, a smaller size gutta-percha cone was used to allow room for the spreader. This was repeated until no more than 2 mm of the spreader could be advanced into the canal. Excess GP was removed with a #15 scalpel blade at the coronal root surface.

WLC

A #55 0.04 taper GP cone was placed to WL. The spreader of the Endotec II (Medidenta, Woodside, NY) was activated, placed between the master cone and the dentin, and advanced to within 2 mm of the WL. It was removed and a D11T spreader placed to within 1 mm of the WL. A fine medium (FM) size accessory GP point was placed into the prepared space. This was repeated until no more than 2 mm of the spreader could be advanced into the canal. Excess GP was removed with a #15 scalpel blade.

WVC

The continuous wave technique was used (18). A #55 0.04 taper GP cone was placed to WL. A System-B heat source (SybronEndo, Orange, CA), at power setting 10 and 200°C, was used and the RCS backfilled with the Obtura II (Obtura Spartan, Fenton, MO).

After each obturation, the GP was allowed to cool 3 min before model separation.

Root Defect Replication Evaluation

The GP replication quality of the artificial defects was evaluated with the following assessment criteria.

0 = No reproduction of the defect
1 = ≤25% reproduction
2 = >25 to 50% reproduction
3 = >50 to 75% reproduction
4 = >75% to complete reproduction of the defect

The assessments were performed by one blinded evaluator. However, because of the appearance of cold versus warm specimens, the evaluator could distinguish CLC specimens. One week later, specimens were reevaluated to grade evaluator consistency.

Statistical Analyses

Kruskal-Wallis and Friedman Chi tests ($\alpha = 0.01$) were used to determine if there were statistically significant differences between and within the obturation techniques as a function of defect location (apical, middle, or coronal) and defect size (middle small, middle large) Where analyses indicated, Mann Whitney or Wilcoxon test was used for pairwise comparisons. With replication comparisons based on defect location, the scores for the two middle defects were added for each specimen and then divided by two to yield a mean middle defect replication score.

The overall family wise error rate was 0.05; however, using the Bonferroni adjustment technique, each analysis and pairwise comparison was at $\alpha = 0.01$ to account for necessary repeated analyses to evaluate between and within obturation techniques.

Evaluator consistency based on two separate assessments of all specimens, 1 wk apart, was analyzed with a rank order correlation coefficient (Spearman's rho, $\alpha = 0.01$)

Results

The results are presented in Table 1. The CLC technique did not replicate any of the artificially-created lateral root defects. In contrast, both WVC and WLC produced at least partial replication of all defect sites in some specimens. Thus, there was a statistically significant difference ($p \leq 0.01$) as a function of obturation technique based on both defect location and defect size.

The post hoc comparison based on defect location (apical, middle, or coronal) indicated that WVC performed significantly better ($p \leq 0.01$) than CLC at all locations, while WLC replication was significantly better ($p \leq 0.01$) than CLC at coronal and middle defects but not apical defects ($p > 0.01$).

TABLE 1. Results of GP replication of root canal wall defects based on condensation technique and defect site.

	Defect site replication (Percent of replications scored 0–4*)			
Condensation Technique N = 10	Apical	Middle Palatal (large)	Middle Buccal (small)	Coronal
CLC	100%:0	100%:0	100%:0	100%:0
	70%:0	30%:0	0%:0	0%:0
	20%:1	20%:1	20%:1	20%:1
WLC	10%:2	30%:2	30%:2	10%:2
	0%:3	20%:3	30%:3	10%:3
	0%:4	0%:4	20%:4	60%:4
	20%:0	0%:0	0%:0	0%:0
	80%:1	10%:1	30%:1	0%:1
WVC	0%:2	90%:2	40%:2	0%:2
	0%:3	0%:3	30%:3	10%:3
	0%:4	0%:4	0%:4	90%:4

*0 = No reproduction of the defect; 1 = ≤25% reproduction; 2 = >25% to 50% reproduction; 3 = >50% to 75% reproduction; 4 = >75% to complete reproduction of the defect.

The post hoc comparisons across defect locations within both WVC and WLC techniques indicated a significant difference ($p \leq 0.01$) in replication quality between sites. Both WLC and WVC exhibited the best replication of CDs, with 60% of WLC and 90% of WVC specimens exhibiting >75% to complete reproduction (score 4). In contrast, both warm obturation techniques exhibited poorest performance at the AD. The percent of specimens with either no defect reproduction (score 0) or ≤25% reproduction (score 1) of the AD were, respectively, 70% and 20% of the WLC group and 20% and 80% of the WVC group.

The post hoc analysis based on defect size comparing replication of the small and large middle root defects indicated there was no significant difference ($p > 0.01$) either between or within WVC and WLC techniques.

It should also be noted that based on the intra-rater analysis of two separate assessments of specimens there was 95% evaluator consistency across the four measurement sites.

Discussion

Numerous in vitro investigations have evaluated obturation techniques by comparing different variables such as length of fill, defect replication, and GP density (6–9, 11, 14, 19). In the current investigation, the focus was defect replication. To date, this is the first investigation to evaluate and statistically compare defect replication based on both defect intracanal location (coronal, middle, or apical) and defect size.

In this study, CLC did not replicate any of the artificially created defects. Most of the CLC specimens were cold welded together and many fell apart when removed from the model. The space not filled with GP would be filled with sealer. A previous investigation measuring leakage/dye penetration reported that all teeth obturated with CLC and three different sealers exhibited dye penetration along 33 to 80% of the sealer/canal surface interface following 1-wk storage in saliva (5). Sealer alone is not efficient at prohibiting bacterial ingress (20). Therefore, it is important to minimize the amount of sealer and flow the GP into as many anatomical areas of the canal as possible. Venturi and Breschi reported less dye penetration when using vertical compaction with apical backfilling (19). Both WVC and WLC techniques used in this study performed significantly better than CLC. This is in agreement with other studies (6–8, 11, 14).

While the warm obturation techniques were significantly better than CLC, there was no significant difference between the two warm techniques. Additional information provided from defect size and location comparisons indicated no statistically significant difference between small and large middle defect replication with either warm technique; however, there was a significant replication difference based on defect location with both warm techniques. The best replication was exhibited at the CD, with 70% of WLC and 100% of WVC specimens exhibiting >50 to 100% defect replication (scores 3 and 4). The better replication of CDs would be seemingly related to several factors, such as better access and better GP thermoplasticization because of CD being closest to the heat source. In contrast, the AD was most difficult to fill with 80% of WLC group and 100% of WVC group exhibiting ≤25% to no defect reproduction (scores 1 and 0). The less than optimal AD replication is doubtless related to more difficult access. Although there was no statistically significant difference between the warm techniques, it should be noted that 80% of WVC specimens versus only 20% of WLC specimens had minimal AD reproduction (score 1). Although this level of reproduction is not ideal, the WVC minimal AD replication may be related to tip vertical pressure yielding some lateral GP displacement into the defect. This explanation would tend to be supported by previous reports showing improved three-dimensional obturation with a more apically placed System B (WVC) (21, 22). With the WLC technique, in the apical area it may be more difficult to center the tip in the GP mass to allow circumferential GP displacement.

Because laboratory testing cannot exactly simulate in vivo conditions, the results of any in vitro investigation must be viewed with caution. A potential weakness is crown removal from the split-tooth model, which made the protocol more functional, but it does not simulate clinical treatment. However, the split-tooth model (6), provides a number of advantages to laboratory studies, such as reproducible in vitro evaluations, GP examination, and elimination of tooth morphology variability.

Within the limitations of this in vitro investigation, the evidence suggests both warm techniques were significantly better at replicating defects than CLC with no significant difference between the two thermoplastic obturation techniques.

Acknowledgment

The authors appreciate the funding for this project provided by the Rinehart Foundation, University of Missouri-Kansas City School of Dentistry.

References

1. Simons J, Ibanez B, Friedman S, Trope M. Leakage after lateral condensation with finger spreaders and D-11-T spreaders. J Endod 1991;17:101–4.

2. Seltzer S, Green DB, Weiner N, DeRenzis F. A scanning electron microscope examination of silver cones removed from endodontically treated teeth. J Endod 2004;30:463–74.
3. Tselnik M, Baumgartner JC, Marshall JG. Bacterial leakage with mineral trioxide aggregate or a resin-modified glass ionomer used as a coronal barrier. J Endod 2004;30:782–4.
4. Swanson K, Madison S. An evaluation of coronal microleakage in endodontically treated teeth. Part I. Time periods. J Endod 1987;13:56–9.
5. Madison S, Swanson K, Chiles SA. An evaluation of coronal microleakage in endodontically treated teeth. Part II. Sealer types. J Endod 1987;13:109–12.
6. Budd CS, Weller RN, Kulild JC. A comparison of thermoplasticized injectable gutta-percha obturation techniques. J Endod 1991;17:260–4.
7. Nelson EA, Liewehr FR, West LA. Increased density of gutta-percha using a controlled heat instrument with lateral condensation. J Endod 2000;26:748–50.
8. Lea CS, Apicella MJ, Mines P, Yancich PP, Parker MH. Comparison of the obturation density of cold lateral compaction versus warm vertical compaction using the continuous wave of condensation technique. J Endod 2005;31:37–9.
9. Goldberg F, Artaza LP, De Silvio A. Effectiveness of different obturation techniques in the filling of simulated lateral canals. J Endod 2001;27:362–4.
10. Reader CM, Himel VT, Germain LP, Hoen MM. Effect of three obturation techniques on the filling of lateral canals and the main canal. J Endod 1993;19:404–8.
11. Clinton K, Van Himel T. Comparison of a warm gutta-percha obturation technique and lateral condensation. J Endod 2001;27:692–5.
12. Farzaneh M, Abitbol S, Lawrence HP, Friedman S. Treatment outcome in endodontics-the Toronto Study. Phase II: initial treatment. J Endod 2004;30:302–9.
13. Liewehr FR, Kulild JC, Primack PD. Obturation of a C-shaped canal using an improved method of warm lateral condensation. J Endod 1993;19:474–7.
14. Liewehr FR, Kulild JC, Primack PD. Improved density of gutta-percha after warm lateral condensation. J Endod 1993;19:489–91.
15. O'Brien WJ. Dental materials and their selection, 3rd ed. Chicago, IL: Quintessence Publishing Co, Inc., 2002.
16. Craig RG, Powers JM. Restorative dental materials, 11th ed. St. Louis: Mosby, 2002.
17. Black J. Biological performance of materials, 3rd ed. New York: Marcel Dekker, Inc., 1999.
18. Buchanan LS. The continuous wave of obturation technique: 'centered' condensation of warm gutta-percha in 12 seconds. Dent Today 1996;15:60–2, 4–7.
19. Venturi M, Breschi L. Evaluation of apical filling after warm vertical gutta-percha compaction using different procedures. J Endod 2004;30:436–40.
20. Shipper G, Trope M. In vitro microbial leakage of endodontically treated teeth using new and standard obturation techniques. J Endod 2004;30:154–8.
21. Smith RS, Weller RN, Loushine RJ, Kimbrough WF. Effect of varying the depth of heat application on the adaptability of gutta-percha during warm vertical compaction. J Endod 2000;26:668–72.
22. Bowman CJ, Baumgartner JC. Gutta-percha obturation of lateral grooves and depressions. J Endod 2002;28:220–3.