Graduating Dental Students’ Ability to Produce Quality Root Canal Fillings Using Single- or Multiple-Cone Obturation Techniques


Abstract: The primary purposes of this study were to compare the quality (length and density) and efficiency (time to completion) of obturation when single- or multiple-cone obturation techniques were used by graduating dental school students on previously instrumented single-canalled teeth using simulated clinical conditions in vitro. Five students took part in the study, each of whom obturated thirty-six teeth using six obturation techniques. The multiple-cone techniques included lateral condensation of gutta-percha, the technique the students had used in their laboratory and clinical courses, and two similar variations: lateral condensation of Epiphany and mechanical lateral condensation of gutta-percha. These three methods were compared to three single-cone techniques: Thermafil, Activa GP, and GuttaFlow. The students had no experience with single-cone techniques except for a brief introduction and demonstration. All obturations were timed, and post-obturation radiographs were taken in the clinical and proximal views (CV and PV). The radiographs were read by two endodontic faculty members who were blinded to technique, student, and fellow faculty member’s results. Data were also separated by operator experience with individual techniques: the first three obturations/techniques were compared to the final three obturations/techniques. Data were analyzed using chi-square tests. The quality produced or time required rarely differed within multiple-cone or single-cone groups, but statistical differences did occur between the two groups. Multiple-cone obturation was more likely to produce adequate length (p=0.0042), density in the CV (p=0.0056), and density in the PV (p=0.0003). Conversely, the single-cone techniques were significantly faster (mean 350 seconds) than the multiple-cone techniques (mean 464 seconds) (p=0.0020). Quality did not improve significantly with the experienced groups versus the inexperienced with any of the six techniques, but the mean time for obturation decreased from 449 seconds to 362 seconds. These preliminary findings suggest that further training and experience are needed to improve the quality of obturation produced when single-cone techniques are used. Further research is needed to determine how much training and/or experience will be needed.

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Endodontic educators attempt to instill in their dental students the ability to produce quality root canal fillings when providing nonsurgical root canal therapy (NSRCT). Quality root canal filling has been described as having “the radiographic appearance of a well-obturated root canal system, where the root canal filling extends as close as possible to the apical constriction of each canal.” Several authors in different countries have used radiographs of clinical endodontic cases to evaluate the ability of private practitioners and dental students to produce root canal fillings of adequate density and length. The results have been universally disappointing: 50–70 percent of the obturations were rated as inadequate or unacceptable. The same studies also showed the importance of producing quality root canal fillings: all the authors reported significantly higher success rates for teeth with quality obturations.
Hommez et al. stated that “the results underscore the need for more and better clinical and didactic endodontic training in dental schools.”

The quality of endodontic treatment is affected by several procedural steps, the primary two being instrumentation and obturation. Recently, Molander et al. published a study showing the influence that instrumentation had on endodontic quality and how utilizing newer technology could improve that quality. The percentage of excellent ratings for obturation of molars completed by dental students who were trained to use automated nickel-titanium instrumentation was 51 percent, compared to 31 percent for an otherwise similar group trained in hand instrumentation (p=0.006). Although many new obturation techniques have also been developed, the educational community has not adopted them as readily as they have new instrumentation techniques. Cold lateral condensation of gutta-percha was the original obturation technique used when gutta-percha cones were developed, and it continues to be the primary technique taught to undergraduate students in forty-eight of fifty-three dental schools (90 percent) in the United States and fifty of seventy dental schools (71 percent) in Europe.

A disadvantage of lateral condensation (LC) is that it involves placement of a master cone and multiple accessory cones into a canal, which can be time-consuming and does not produce a homogeneous mass. Researchers have found that LC fillings can have voids, spreader tracts, excessive amounts of sealer, and a lack of surface adaptation. These results might have led educators and practitioners to explore other methods of obturating (i.e., single-cone methods); however, researchers also have found that LC offers the advantage of excellent length control. Partially because overfilling results in a poorer prognosis compared to cases filled to the apical constriction, the use of LC has persisted.

Available alternatives include variations of LC using different materials or packing methods. These include warm lateral condensation and mechanical lateral condensation. Both were shown to produce more dense fillings than standard LC in vitro. Chugal et al. showed the importance of density by comparing the prognosis for teeth obturated with dense fills to those with poor density and finding that cases with poor density had more than double the clinical failure rate.

A promising new obturation material called Resilon was introduced in 2004. It was described as a thermoplastic, synthetic polymer-based root canal filling material that performs like gutta-percha. Resilon is used with a resin composite sealer called Epiphany. Resilon/Epiphany can be used with both warm and cold gutta-percha obturation techniques, and is supposed to result in a bond between dentin and the obturating material to create a superior seal compared to gutta-percha/sealer. Research using dogs confirmed that an improved seal can occur with clinical use of Resilon/Epiphany.

Thermafil is one of the most prevalent single-cone techniques used today. It has been a popular alternative since being introduced in 1978. Most laboratory studies comparing the seal of Thermafil to LC have also favored Thermafil. Chu et al. were the first to compare clinical success between the two. They reported no statistical difference in success (both were about 80 percent), but the time needed to complete a case using Thermafil averaged twenty minutes less than for LC.

Two additional innovations in single-cone obturation were recently introduced. In one (Activ GP), glass ionomer particles are incorporated into the gutta-percha point, which, when used with Activ’s glass ionomer sealer, results in a chemical bond between the two. The other technique (GuttaFlow) involves injection of a cold flowable filling material into the canal, then inserting a pre-fit master cone. GuttaFlow consists of a polydimethylsiloxane matrix highly filled with very finely ground gutta-percha and silver particles for radiopacity.

A review of the literature found no studies that simultaneously compare all of these obturation techniques. Also, there is no research on the ability of dental school graduates to perform obturation using different techniques and no surveys to show practitioners’ preferences of obturating techniques. Studies of this kind could potentially be of interest to endodontic faculty members who are designing their laboratory and clinical courses, to dentists who are evaluating their treatment techniques, and to manufacturers of endodontic materials.

The primary purpose of our study was to compare the quality (based on radiographic interpretation) of root canal fillings produced in simulated clinical conditions when various obturation techniques were performed by graduating dental school students. Additional purposes were to compare times of obturation when different techniques were used and to determine whether students’ obturation preferences changed after participating in the research.
Methods and Materials

Approval for this study was obtained from the University of Nebraska’s Institutional Review Board. Senior dental students from the classes of 2007 and 2008 at the University of Nebraska College of Dentistry were given the opportunity to volunteer to participate in this study. Three students from the class of 2007 and two from the class of 2008 accepted the invitation. All the students had completed endodontic treatment on five to eight teeth in the undergraduate clinic. The only obturation technique they had used was LC. Two postgraduate students (JS and TK) selected 180 single-rooted teeth with relatively straight canals and lengths of 20–25 mm for the research and then completed the canal preparation on those teeth. Access cavity preparation was completed, a working length 1 mm short of the apex was determined, and the coronal third of the canal was flared using Gates Glidden drills 4, 3, and 2 in a crown-down sequence. Most of the teeth were instrumented to a size 40 Master Apical File (MAF) using a crown-down technique with .04 taper Profiles (Tulsa Dental, Tulsa, OK). Thirty of the teeth were to be used for the Activ GP technique, and they were instrumented with Endo Sequence files (Brasseler USA, Savannah, GA), also using crown-down technique and also to the equivalent of a 40 MAF. After instrumentation was completed, the apical stop was confirmed by placing a size 40 .04 tapered GT hand file (Tulsa Dental) to the working length. Teeth not having a solid apical stop were discarded. Next, a radiograph was taken with the MAF inserted into the canal to the full working length.

The volunteers were given thirty-six teeth to obturate, thirty of which were randomly selected from those instrumented using Profiles and six randomly selected from those instrumented with Endo Sequence files. Putty was placed in sockets of an Acadental Articulator (Endo Dent, Mission, KS), and the teeth were placed into the putty. The articulator attached to an Acadental mounting pole, the other end of which was attached to the headrest on a dental chair, simulating the position of a clinical patient’s head. Rubber dam isolation was used for all cases.

Obturation Techniques

The postgraduate students described all of the obturation techniques to the volunteers. All questions were answered, and demonstrations were given as needed.

The volunteers were asked to time the obturation procedure using a stopwatch, starting when master cone fit had been verified (tug-back confirmed) and ending when the coronal obturation material was removed to the level of the cemento-enamel junction (CEJ). They also numbered each case as being the first, second, third, fourth, fifth, or sixth they had obturated with each technique. The following obturation techniques were used.

**Lateral condensation (LC) of gutta-percha.** An 0.2 mm tapered master cone (Spectra-Point Hygienic, Akron, OH) was placed into the canal and adapted to fit tightly at the length of the MAF. Sealer (AH26, Dentsply, York, PA) was mixed and placed into the canal using the master cone. Next, a size fine nickel-titanium spreader (Hyflex Hygienic, Akron, OH) was placed alongside the master cone and advanced as far as possible (up to within 1 mm of the MAF length) using apical and lateral pressure. After allowing several seconds to deform the master cone, the spreader was removed. Then, an accessory cone (Hyflex Hygienic), one size smaller than the finger spreader, was coated with sealer, placed into the canal, and advanced as far as possible. Additional points were added using the same procedure until the spreader would not advance beyond the CEJ. Next, the gutta-percha mass was severed at the CEJ using a heated instrument.

**Lateral condensation of Resilon.** The LC gutta-percha technique described previously was also used for this group, but Resilon (Resilon Research LLC, Madison, CT) was used instead of gutta-percha, and Epiphany root canal sealant (Pentron Clinical Technologies, Wallingford, CT) was used instead of Kerrs’ EWT sealer. Also, prior to obturating, Epiphany primer (Pentron Clinical Technologies) was applied to the root canal walls using sterile paper points soaked with the primer, according to the manufacturer’s instructions. The mass was severed at the CEJ using a heated instrument, as with LC.

**Mechanical lateral condensation (MLC) of gutta-percha.** The MLC technique is similar to LC, except the finger-spreaders were placed in a reciprocating-action handpiece (Endo-Gripper, EndoSolutions, York, PA), and advanced into the canal until resistance was felt. The handpiece (set at the maximum speed setting) was activated, and a light force was used to slowly advance the spreader apically to the desired length or maximum level of penetration. Activation was continued at that level for one to five seconds and during the removal of the spreader. Ac-
cessory cones were placed and obturation completed as described with LC.

**Thermafil technique.** Canals were coated with sealer as with LC. Then, the appropriate size Thermafil obturator with plastic carrier (Tulsa Dental, Tulsa, OK) was introduced according to the manufacturer’s recommendations (Thermafil Plus Instruction Manual, 2002). After heating the obturators for ten seconds in a Thermaprep oven (Tulsa Dental), they were slowly inserted into the canals to 0.5 mm from the working length. Next, an inverted cone bur was used to separate the handle from the rest of the carrier at the level of the cemento-enamel junction, and the coronal gutta-percha was vertically condensed with Schilder pluggers until cooling occurred.

**Activ GP.** Instrumentation was completed using Endo Sequence files and the technique recommended by the manufacturer (Brasseler USA, Savannah, GA). An Activ GP gutta-percha point that matched the last rotary file taken to length was prefitted in the canal. Then, it was coated with Activ GP glass ionomer sealer and slowly seated to length. Additional points were added in oval canals as needed, but condensation was not used. The master cone and any accessories were sectioned off, and the canal was backfilled with sealer if necessary.

**GuttaFlow.** A master cone was selected and fit as described for LC. A capsule of GuttaFlow (Coltene/Whaledent Inc., Cuyahoga Falls, OH) was mixed for thirty seconds at a frequency of 2000–4500/min, and subsequently flowed into the dispenser end of a syringe. The accompanying plastic tip was prefitted 3 mm short of the working length, and the GuttaFlow was injected until it completely filled the canal. The master cone was streaked and coated with GuttaFlow and inserted into the canal to working length, and the coronal excess was removed with a warm instrument. No condensation was used, but accessory cones were placed into oval canals. If the coronal area was not completely filled, it was backfilled with GuttaFlow.

After obturation was complete, a final radiograph was taken with the tooth lying on the film and oriented in the clinical view (CV). Next, the tooth was placed on a different film and rotated 90° for the proximal view (PV). The processed radiographs were read at a dedicated station containing a light box mounted in a table, subdued lighting, black cardboard background, blackout shields, and hand-held magnifying glasses. The filling quality was rated based on radiographic density and length, in a manner similar to that used by Chugal et al.\textsuperscript{19} Obturation lengths of 0–2 mm from the radiographic apex were considered acceptable; those >2 mm short or extended beyond the apex were unacceptable. The following criteria for density were used:

- **Good Density** = cases with homogeneous filling having no visible space between the material and the walls of the canal or within the body of the obturating material
- **Fair Density** = cases with no more than two small voids (<1 mm in diameter) in the obturated part of the canal
- **Poor Density** = cases with more than two voids or voids >1 mm in diameter in the obturated part of the canal

In addition, the fillings were rated as having or not having the following two findings:

- **Apical Void** = obturation level of >0.5 mm short of the working length
- **Puff** = the presence of sealer extrusion outside the root canal

Before and after participation in the study, the volunteers completed a survey asking which obturation technique they intended to use in private practice. Members of the Class of 2007 not otherwise involved in the research were also asked to complete the survey prior to graduation and again after one year of private practice.

**Data Analysis**

The data on quality and time of obturation were totaled and averaged. The averages for each obturation technique and each operator were compared using a nonparametric analysis of variance with ranks (Kruskal Wallis). Data on the six obturation techniques and on the five operators were also combined into two larger groups for the purpose of additional analysis. A single-cone group (Thermafil, Activ GP, and GuttaFlow) was created, and its data were compared to a multiple-cone group (LC, MLC, and LC with Resilon), using a chi-square test. Also, the combined operators’ results for the first three teeth obturated with each individual technique (inexperienced group) were compared to the combined results for the final three obturations with that same technique (experienced group), using the chi-square test.
Results

The five students who completed the study obturated a total of 180 teeth. For evaluation of quality, the two raters were in agreement on all their length ratings. Since all the CV and PV ratings were also in agreement, the CV and PV length data were combined. However, there was disagreement between the two raters in sixteen of their 360 density ratings (95.6 percent agreement). The Pearson correlation coefficient for agreement between evaluators was calculated to be .91, indicating good agreement. All rating disagreements were resolved by discussion between the evaluators. The density ratings did vary between the CV and PV, so both views were rated. The evaluators also agreed that there were twenty-four apical voids and six sealer puffs.

The results for quality measurements for individual techniques are listed in Table 1. The p value for the effect of technique on length was .0042, indicating that significant differences existed between techniques. There were significantly fewer fills of adequate length for Thermafil vs. EP (p=0.0087), vs. LC (p=0.0099), vs. MLC (p=0.0099), and for Activ GP vs. EP (p=0.0098). The appropriate length was attained in 89 percent of the multiple-cone technique obturations versus 65 percent for the single-cone techniques. The difference was significant (p=0.004).

The p value for effect of technique on CV density was 0.079, indicating differences with operator experience were not significant, nor was the interaction between experience and technique (p=1.000 and 0.956, respectively). The intra-student variance component (0.3) was greater than for the inter-student variance (0.001).

For PV density, the differences with experience were also not significant for any technique, nor was the interaction between experience and technique (p=0.1233 and 0.8995, respectively). The intra-student variance component (0.4) was also greater than for the inter-student variance (0.028). The quality ratings for IOs did not differ from those for EOs.

The times for all students combined for each technique are listed in Table 3, along with the times for the IOs and EOs for each technique. The total time for obturating the 180 teeth was 72,948 seconds; the average was 6:50 minutes per tooth. The p value for

<table>
<thead>
<tr>
<th>Table 1. Comparison of the quality of obturation for individual obturation technique groups</th>
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<tbody>
<tr>
<td>Technique</td>
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<tr>
<td>LC</td>
</tr>
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<td>EP</td>
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<td>MLC</td>
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<tr>
<td>TF</td>
</tr>
<tr>
<td>Activ GP</td>
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<tr>
<td>GuttaFlow</td>
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<tr>
<td>Average/180 teeth</td>
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</table>

Notes: Length equals the percentage of the 30 fillings in each group that were of correct length (neither short nor long). Density scores (2 for Good, 1 for Fair, and 0 for Poor) were totaled and expressed as the percentage of the maximum score possible. The percentage of Apical Voids and Puffs/30 teeth obturated with each technique are listed. The bottom row lists the average value/180 teeth for each of the measured variables.
The effect of technique on time was 0.0055, indicating that significant differences occurred between some of the obturation groups. The differences were that Activ GP was significantly faster than MLC (p=0.0005), LC (p=0.008), GuttaFlow (p=0.013), and EP (p=0.018). Thermafil was also significantly faster than MLC (p=0.003) and LC (p=0.046). No other differences were statistically significant.

Regarding decreases in time with experience, the differences for the LC, GuttaFlow, and Thermafil techniques were significant, as shown in the p value row.

The average time for the three single-cone techniques combined (350 seconds) was significantly faster than the three multiple-cone techniques combined (464 seconds) (p=0.0020). Based on the estimate of variance components, the variance component for time of obturation between students (16.83) was about 1.5 times the variance within students (10.18).

The participating students were surveyed after using all the techniques and were asked to rate the obturation techniques in order of their preference. The numbers were totaled and averaged, and the results are presented in Table 4.

The forty-three graduates in the Class of 2007 also received the survey prior to graduation and were asked what they thought their preferred obturation technique in private practice would be. These individuals also received a similar survey one year after graduating. Sixteen answered the obturation question on both surveys. Their preferences are listed in Table 5. Only cold lateral condensation of gutta-percha, Thermafil, Activ GP, GuttaFlow, and warm vertical condensation (WVC) were listed by the graduates as preferred techniques, and only a few changed...
Discussion

One of the purposes of this study was to obtain data on the quality of obturation that our graduating dental students were able to produce, which would give a preliminary measurement of the effectiveness of our endodontic teaching methods. We were unable to find published research that offered any similar data. The dental students in our study all had similar experience levels—all having completed NSRCT on eight to twelve extracted teeth in the preclinical laboratory and five to eight clinical cases in the undergraduate clinic. About 80 percent of the 180 obturations produced by these students were graded as being of good quality (having adequate length and density, in the clinical view, and lacking apical voids). These results compare favorably with those from previously cited research that compared the quality of clinical cases.

However, ours was an in vitro study with simulated clinical conditions, and the teeth had single, straight canals that were ideally instrumented; thus, comparisons may not be valid.

One researcher related operators’ experience levels to quality (length only) of obturation. Clinical results of undergraduate dental students were compared to those of practicing general dentists (GPs) and endodontists in Norway. In this study, GPs were much more likely to fill short (>60 percent), compared to about 45 percent for undergraduates and endodontists. Conversely, 10 percent of endodontists’ and 20 percent of students’ fills were long compared to 7 percent for GPs’. In our study, undergraduates were even more likely to fill short than long (22 percent versus 1 percent).

We were also interested in comparing the obturating ability of individual students and then measuring the learning curve for students’ obturating ability. These data would help to determine if quality improved with experience and, if so, how much experience was needed to create a significant improvement. The variation in individual operators’ ability levels is shown in Table 2. The results show a maximum of 20 percent variation in quality measurements between our five students. Since these students were approximately equal in experience, the results suggest that individual ability has some influence on quality, no matter what obturation technique is used. We were surprised by the other results that appear in Table 2, which showed that there was only a slight improvement in all quality measurements (2–3 percent) for the experienced groups. Since the students had no previous experience with most of the techniques, we expected a greater amount of improvement with experience. These data suggest that these students started with the ability to obturate single-canalled teeth at a relatively high level of quality, and a small amount of practice may or may not result in improvement in that ability.

We looked at the results for individual techniques to shed more light on these findings. Table 1 shows a better than average percentage in all quality measurements for the technique our students had significantly more experience using (LC of gutta-percha). The quality was better than all others except for LC of Resilon, which had significantly more dense fills in the PV. Since LC of Resilon and LC of gutta-percha are essentially the same technique with different materials, this finding is difficult to explain. Epley et al. also obturated teeth in vitro and reported LC of Resilon had significantly fewer voids than LC with gutta-percha, which they attributed to the bonding of Epiphany

Table 4. Preferences in obturation techniques after participating in the obturation research: 1 is the most preferred and 6 the least preferred

<table>
<thead>
<tr>
<th>Operator</th>
<th>LC</th>
<th>EP</th>
<th>MLC</th>
<th>TF</th>
<th>Activ</th>
<th>GF</th>
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<tr>
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<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>6</td>
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<td>Op B</td>
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<tr>
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<td>3</td>
<td>5</td>
<td>2</td>
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<td>6</td>
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Table 5. Preferred obturation technique of participants from the Class of 2007 prior to and one year after graduation

<table>
<thead>
<tr>
<th></th>
<th>CLC</th>
<th>Thermafill</th>
<th>Activ GP</th>
<th>GuttaFlow</th>
<th>WVC</th>
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<tr>
<td>Prior to graduation</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>After graduation</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>2</td>
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</table>

*Note: There were insufficient numbers for statistical analysis of any of these survey data.*
to Resilon and to the canal wall. The data for both LC techniques suggest that either the greater amount of experience with LC did result in an improvement in quality or that students are better able to produce quality obturations with LC.

Although MLC is also a multiple-cone technique, it was not taught in our curriculum. The quality readings were all also above average for MLC. In a similar study, postgraduate students who were also not experienced with MLC had more dense fillings with MLC than LC of gutta-percha.

Conversely, the quality ratings were almost all below the averages for the three single-cone techniques. The results conflict with the findings in similar research studies. Jarrett et al. found Thermafil obturations were as dense as MLC and more dense than LC of gutta-percha. De-Deus et al. found significantly fewer voids with Thermafil than with LC of gutta-percha. We could only find bacterial leakage research for the other single-cone techniques. De-Deus et al. found less leakage in extracted teeth obturated with GuttaFlow than with LC of gutta-percha, and Fransen et al. reported no statistical difference in leakage between Activ GP and LC with Resilon or gutta-percha.

Some explanations for the high percentage of short fillings the students had with the single-cone techniques were found in the comment sections of their post-obturation surveys. Three of the students were not sure if the Thermafil oven was heating properly, because they had difficulty getting the cones to length. Conversely, others felt Thermafil was easy to use and created dense fillings, even in irregularly shaped canals. Two of the students using Activ GP complained about the consistency, stating it was sticky and dense and had a short working time. However, they did consider it to be fast and easy. Three students stated that the Guttapercha sealer was also very sticky, but they did like the system and the convenience of the capsules.

Very few researchers have measured obturation time; however, we suspect it is an important factor for graduates who are selecting obturation technique(s) for use in private practice. Chu et al. did not measure obturation time per se, but did report that Thermafil cases were completed in twenty minutes less than LC cases. Our findings agree with Chu et al.; times for Thermafil were 26 percent less than for LC, and single-cone fillings as a group were 25 percent faster than multiple-cone fillings. Unlike quality, there was significant improvement in efficiency with experience. The learning curve data even improved for the technique the students had been trained in, whereas times for LC of gutta-percha surprisingly decreased significantly (p=0.0001) with experience.

A major concern became evident regarding the variability of the data. Inter-student quality was significantly better than intra-student quality; indicating a great lack of consistency for individual students. This lack of consistency occurred despite the similarity in cases treated and was not related to experience levels. These findings suggest that educators need to focus on teaching the consistent production of quality and researchers should consider consistency when designing similar studies. Interestingly, the opposite was true with efficiency: inter-operator times were 1.5 times more variable than intra-operator times, suggesting that some providers will usually obturate canals faster than others, no matter what the experience level.

Based on conversations with students and former students, we did not expect our graduates to continue to use LC of gutta-percha, but the surveys showed that it remains one of the most popular obturation techniques. Additional training in alternative techniques or additional time for experience might change the survey results, but, for now, it appears that many of our graduates have established a comfort level with LC of gutta-percha.

One of the weaknesses of this study was that the results were based on radiographic interpretation. The approximately 20 percent lower quality ratings for the PV radiographs compared to the CV (CV is used in all in vivo research) demonstrate the potential for inaccuracy occurring when research relies solely on radiographic interpretation. However, Youngson et al. used image analysis to calculate the percentages of voids on radiographs of extracted, obturated teeth, then sectioned the teeth and measured the voids. They reported that radiographs were as accurate at detecting voids as tooth sections. Kositbowornchai et al. compared digital images, including magnified images, to conventional radiographs for ability to detect simulated voids in extracted teeth and also found no significant difference. The lower density ratings for PV radiographs are attributed to the presence of oval canals in anterior and premolar teeth, with the bucco-lingual diameter being the largest. Hence, the x-ray beam passes through the least amount of filling material at the buccal and lingual margins, which would make voids more apparent. This difference suggests clinical radiographs would overestimate the density of obturation in studies using clinical patients.
An additional weakness of our study is the low number of subjects and the use of extracted teeth with varying anatomy. We originally planned to have twice as many students and to only use maxillary incisors, but constraints on students’ time at graduation and difficulty in finding adequate teeth for the research hampered our efforts. We compromised by using sixteen mandibular premolars with single canals, but the possible effect of variations in their anatomy was not calculated. Eleftheriadis and Lambrianidis also compared technical quality to endodontic treatment provided by undergraduate dental students, but the research was on 620 clinical cases. They found that the frequency of acceptable fillings was 72 percent for anterior teeth compared to 55 percent in premolars and 47 percent in molars. Our recommendations for future research include using plastic tooth models and initiating research when students have more time available.

One limitation of this study is that we were only concerned with students’ ability to obturate teeth. Weine and Wenckus state that emphasizing the filling technique fails to recognize that the most important phase of endodontic therapy is the preparatory phase, which rids the canal of irritants, substrates, gross irregularities, pulpal debris, etc., and that when great care is used in preparation, any of the popularly used filling methods will yield successful results in a high percentage of cases. We attempted to standardize the preparatory phase by having graduate students complete the instrumentation. However, the differences in quality of treatment after the instrumentation was semistandardized suggest that obturation techniques are also an important factor in the production of quality endodontic treatment.

In summary, researchers have shown the need for improving the quality of obturation and that the use of recent innovations can help practitioners reach that goal. We concluded that, within the limits of this study, students with experience in multiple-cone techniques can produce better quality root canal fillings than using selected single-cone techniques with which they are unfamiliar. The students’ obturation time significantly decreases with limited practice of most techniques, while the quality remains unchanged. Although our research offers some preliminary data, further research is needed to determine if teaching different methods of obturation can help improve the overall obturation quality.

REFERENCES


