Assessment of filling techniques for primary teeth

Steven R. Aylard, DDS  Ronald Johnson, DDS

Abstract

Five techniques for delivering ZOE into straight and curved simulated root canals were investigated for their depth-of-fill capabilities. The techniques tested were those using the endodontic pressure syringe, the mechanical syringe, the lentulo spiral, the Jiffy™ Tube, and the tuberculin syringe. Statistical analysis revealed that the instruments of choice for filling straight canals were the endodontic pressure syringe and the lentulo spiral (P = 0.05). Also, the lentulo spiral was found to be the instrument of choice when filling curved canals (P = 0.05). When considering the depth-of-fill properties, it was concluded that the lentulo spiral was the best overall ZOE filling tool.

The methods selected by practitioners to fill the pulpectomized canals of primary teeth are numerous and varied. The most popular of these filling techniques appear to be those that use the endodontic pressure syringe. Endodontic and amalgam pluggers (King et al. 1984), Jiffy™ Tubes® (Rifkin 1980), mechanical syringes®, and a plugging action with wet cotton pellets also have been used with reported success.

It was the purpose of this in vitro study to determine which filling technique was capable of satisfying good endodontic principles for depth of fill.

Methods and Materials

The material of choice for filling pulpectomized primary teeth is zinc oxide and eugenol (ZOE) as stated by Nicholis (1964), Erausquin and Muruzabal (1967), and many other investigators.

Five of the most common techniques for the delivery of ZOE to the apex of pulpectomized primary teeth were selected from those currently in use. These methods included those using (1) an endodontic pressure syringe; (2) a mechanical syringe; (3) a lentulo spiral®; (4) a Jiffy Tube; and (5) a tuberculin syringe.*

A standardized mixture of pure ZOE USP without additives or fillers was prepared for each technique as per the manufacturer’s recommendation and or the technique limitation (Table 1).

<table>
<thead>
<tr>
<th>Technique</th>
<th>Ratio in ml/1 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endodontic pressure syringe</td>
<td>0.275</td>
</tr>
<tr>
<td>Mechanical syringe</td>
<td>0.450</td>
</tr>
<tr>
<td>Lentulo spiral</td>
<td>0.400</td>
</tr>
<tr>
<td>Jiffy tube</td>
<td>0.400</td>
</tr>
<tr>
<td>Tuberculin syringe</td>
<td>0.400</td>
</tr>
</tbody>
</table>

The difference in the consistencies of the ZOE mixtures was attributable to the physical limitations of the different techniques. The same mixture ratio could therefore not be used in every technique.

A triple beam balance® was used to measure each gram of zinc oxide powder. A tuberculin syringe was used to dispense the corresponding amount of eugenol liquid. The mixtures were spatulated on a dry glass slab at room temperature (68°F) for 45 sec and then placed into identical canal simulation molds® (Fig 1, next page), using one of the five techniques.

Two canal configurations were tested — straight and curved. Each straight-canal mold contained 24 total canals, each measuring 15.5 mm in length by 0.25 mm in diameter at the orifice. Each curved-canal mold contained...
tained 22 total canals, each measuring 12.5 mm in vertical
length and 0.25 mm at the canal orifice (Fig 2). Both canal
types would snugly accommodate a size 15 endodontic
file.¹

A direct view of the canals in the clear plastic molds
was prevented by covering them with masking tape. This
discouraged operator bias and allowed a true compar-
sion to in vivo conditions. Each technique was repeated
under identical conditions seven times to develop oper-
dor proficiency, then performed again 17 times each in the
straight canals and 15 times each in the curved canals a
minimum of one week later. This entire procedure was
completed a total of 24 or 22 times depending on the canal
configuration being tested. The masking tape then was
removed from the molds and each filled canal measured
to the greatest vertical depth using a standard Boley
gauge and a 3x optical magnifier.

The technique for the placement of the standardized
mixtures into the simulated canal molds was as follows:

1. **Endodontic pressure syringe** — Using the technique
described by Greenberg (1963) and following the
manufacturer's recommendation, the standardized mix-
ture was injected into the simulated canals. The mecha-
nical nature of the pressure syringe (which operates by a
screw mechanism) expressed the mixture through a 30-
gauge needle. The needle was inserted into the simulated
canal until wall resistance was encountered. Using a
slow, withdrawing-type motion the needle was with-
drawn in 3-mm intervals with each quarter turn of the
screw until the canal was visibly filled at the orifice. (A 30-
gauge needle was selected for filling primary teeth if the
canal was able to accommodate a standard size 15-30
endodontic file.)

2. **Mechanical syringe** — The standardized ZOE
mixture was loaded into the syringe as per the manufac-
turer's recommendation and expressed into the
simulated canal with continuous pressure via a 30-gauge
needle while withdrawing the needle. The pressure was
generated by the mechanical lever action of the trigger
grip which then was transferred to a plunger and in turn

³Endodontic file, size 15—Union Broach Co Inc; Long Island
City, NY.

expressed the ZOE out of the needle.

3. **Lentulo spiral** — A 25-mm lentulo spiral was
selected and used to deliver the standardized mixture of
ZOE into the simulated canal. The latch-type lentulo was
placed on a contra-angle, slow-speed handpiece and
operated in reverse to pick up the material. The lentulo
then was slowly inserted into the canal and the material
deposited in the forward position until the canal ap-
ppeared visibly filled at the orifice. It then was removed
with a pumping action while still in the forward position.

4. **Jiffy Tube** — The standardized mixture of ZOE
was back-loaded into the tube. The tube tip was placed
into the simulated canal orifice and the material ex-
pressed into the canal with a downward squeezing mo-
tion until the orifice appeared visibly filled.

5. **Tuberculin syringe** — The standardized mixture of
ZOE was back-loaded into the syringe. The syringe
utilized a standard 26-gauge, 3/8-inch needle. This was
the smallest of the most common needles used for the
tuberculin syringe. The material was expressed into the
canal by slow finger pressure on the plunger until the
canal was visibly filled at the orifice.

Following data collection as previously described,
the statistical analysis was performed. The mean and
standard deviation of each individual group was deter-
mined. A two-way analysis of variance with unequal
subclass sizes was used in conjunction with a Student’s t
regression analysis to provide both intragroup and inter-
group comparisons.

**Results**

The mean (μ) and standard deviation (SD) for each
technique during the initial trial period, the experimen-
tal period, and the overall total appear in Tables 2 and 3.

By ranking the overall mean of each technique, the
following order was established for straight canals: (1)
endodontic pressure syringe (14.68 mm); (2) lentulo spi-
ral (13.94 mm); (3) tuberculin syringe (13.66 mm); (4)
mechanical syringe (13.28 mm); and (5) Jiffy Tube (10.35
mm).

For straight canals, the Student’s t regression (Table
4) was unable to distinguish between the endodontic
The endodontic pressure syringe was significantly better than the mechanical syringe and the lentulo spiral ($P = 0.05$). However, the endodontic pressure syringe was significantly better than the other three techniques tested. The lentulo spiral was not significantly better at filling straight canals than either the mechanical or tuberculin syringes, but was significantly better than the Jiffy Tube. There appeared to be no difference in the straight canal filling capabilities of either the tuberculin or mechanical syringes. The Jiffy Tube filling method did not perform well in straight canals.

For curved canals, a rank of the means produced an entirely different order (Table 3): (1) lentulo spiral (11.22 mm); (2) endodontic pressure syringe (9.75 mm); (3) tuberculin syringe (9.49 mm); (4) Jiffy Tube (8.86 mm); and (5) mechanical syringe (8.51 mm).

According to the Student's $t$ regression analysis (Table 5), the lentulo spiral was better than all other techniques for filling curved canals. The endodontic pressure syringe, ranked second by the mean, was not significantly better than either the tuberculin syringe or Jiffy Tube, but was significantly better than the mechanical syringe. The Jiffy Tube, the tuberculin syringe, and the mechanical syringe were essentially the same in their ability to fill curved canals.

The two-way analysis of variance (Table 6) reveals some significant differences in this study. There was a very significant difference between the straight and curved canals regardless of the filling technique ($P < 0.001$). The straight canals displayed a greater capacity to be filled as exhibited by consistently larger overall depth-of-fill measurements. However, there were also significant differences among filling techniques regardless of the canal geometry. This was evident since each technique was rankable in its respective group. If each tool had been essentially the same in its ability to fill the straight or curved canal configurations, then this significant difference would not have been found.

Finally, the differences among the techniques were found to be significantly dependent upon the differences in canal shape. This was obvious because the intragroup rankings were not the same for the straight and curved canals.

**Discussion**

This study utilized simulated canals of two geometric shapes, straight and curved, to investigate the ability of five techniques to deliver ZOE. No attempt had been made to locate the artificial apex of the synthetic canal.

---

**Table 2.** Mean and Standard Deviation of All Techniques in Straight Canals in mm

<table>
<thead>
<tr>
<th>Pressure Syringe</th>
<th>Mechanical Syringe</th>
<th>Lentulo Spiral</th>
<th>Jiffy Tube</th>
<th>Tuberculin Syringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial $\mu$</td>
<td>14.20</td>
<td>15.34</td>
<td>15.50</td>
<td>7.74</td>
</tr>
<tr>
<td>SD</td>
<td>0.714</td>
<td>0.416</td>
<td>0</td>
<td>0.70</td>
</tr>
<tr>
<td>Expt. $\mu$</td>
<td>14.88</td>
<td>14.42</td>
<td>13.29</td>
<td>11.43</td>
</tr>
<tr>
<td>SD</td>
<td>0.911</td>
<td>2.060</td>
<td>2.700</td>
<td>1.700</td>
</tr>
<tr>
<td>Total $\mu$</td>
<td>14.68 (1)*</td>
<td>13.28 (4)*</td>
<td>13.94 (2)*</td>
<td>10.35 (3)*</td>
</tr>
<tr>
<td>SD</td>
<td>0.900</td>
<td>2.200</td>
<td>2.470</td>
<td>2.230</td>
</tr>
</tbody>
</table>

* = Rank of the mean.

**Table 3.** Mean and Standard Deviation of All Techniques in Curved Canals in mm

<table>
<thead>
<tr>
<th>Pressure Syringe</th>
<th>Mechanical Syringe</th>
<th>Lentulo Spiral</th>
<th>Jiffy Tube</th>
<th>Tuberculin Syringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial $\mu$</td>
<td>8.89</td>
<td>10.03</td>
<td>11.66</td>
<td>10.60</td>
</tr>
<tr>
<td>SD</td>
<td>0.60</td>
<td>1.43</td>
<td>0.83</td>
<td>1.32</td>
</tr>
<tr>
<td>Expt. $\mu$</td>
<td>10.15</td>
<td>7.80</td>
<td>11.02</td>
<td>8.05</td>
</tr>
<tr>
<td>SD</td>
<td>0.84</td>
<td>0.27</td>
<td>0.84</td>
<td>1.50</td>
</tr>
<tr>
<td>Total $\mu$</td>
<td>9.75 (2)*</td>
<td>8.51 (5)*</td>
<td>11.22 (1)*</td>
<td>8.86 (4)*</td>
</tr>
<tr>
<td>SD</td>
<td>0.97</td>
<td>1.33</td>
<td>0.86</td>
<td>1.86</td>
</tr>
</tbody>
</table>

* = Rank of the mean.

**Table 4.** Student's $t$ Regression for Straight Canals

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>$df$</th>
<th>$SS$</th>
<th>$MS$</th>
<th>$F$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgroups</td>
<td>1</td>
<td>751.261</td>
<td>751.261</td>
<td>240.70</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Techniques</td>
<td>4</td>
<td>263.737</td>
<td>65.934</td>
<td>21.74</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>A x B (interaction)</td>
<td>4</td>
<td>98.880</td>
<td>24.720</td>
<td>8.15</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Within subgroups (error)</td>
<td>220</td>
<td>667.217</td>
<td>3.033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>229</td>
<td>1781.095</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$df$ = degrees of freedom, $SS$ = sum of squares, $MS$ = mean sum of squares, $F$ = $MS$/error, $P$ = probability.
prior to ZOE placement. Before a technique is chosen to place a material to a specific site or depth (e.g., 2 mm from the apex), it should be known if that technique effectively delivers the material at all. It has been generally accepted that all of these techniques can deliver ZOE. However, it has never been scientifically determined which technique is actually superior in its depth-of-fill capabilities.

For straight canals, as are seen in primary or permanent incisors, two techniques proved superior to the rest — the endodontic pressure syringe and the lentulo spiral. There was no significant difference in the depth-of-fill measurements found with either technique. For curved canals the lentulo spiral was by far the best technique according to statistically significant parameters.

Therefore, the canal shape governed the selection of the filling technique, i.e., an endodontic pressure syringe or lentulo spiral should be selected for straight canals and the lentulo spiral for curved canals.

It would appear that the two pressure system techniques (i.e., the endodontic pressure syringe and the mechanical syringe) would have similar results, but under the conditions of this study this was not found to be true.

The mechanical syringe was a poor performer in both canal types. The ZOE powder-to-liquid ratio and/or the amount of pressure actually exerted are the only logical reasons for this discrepancy. The different thicknesses of the filling materials would have to be disregarded, because the mechanical syringe did not deliver its thinner mix (0.45 ml/g) as effectively as did the endodontic pressure syringe (0.275 ml/g). The greater pressures generated by the endodontic pressure syringe must therefore have been the difference in the result. Unfortunately, due to the nature of the systems used, the pressures exerted could not be measured. But, it should be obvious that the screw mechanism of the endodontic pressure syringe would be able to generate far greater pressures than could a plunger system as is seen with the mechanical syringe.

Conclusion

Canal filling techniques utilizing the endodontic pressure syringe and the lentulo spiral were found to be superior when filling straight canals. The lentulo spiral filling method was superior for filling curved canals. Overall, the lentulo spiral performed the best and should therefore be recommended as the technique of choice for ZOE placement when considering depth of fill.

Dr. Aylard is in the private practice of pediatric dentistry in Pasadena and Mission Viejo, California, and Dr. Johnson is professor and chairman, pediatric dentistry, University of Southern California. Reprint requests should be sent to Dr. Ronald Johnson, Dentistry, Room 304-A, University Park, MC-0641, University of Southern California, Los Angeles, CA 90089-0641.

References


