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Assessment of filling techniques for primary teeth

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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.[1] Endodontic and amalgam pluggers (King et al. 1984), Jiffy™ Tubes[a] (Rifkin 1980), mechanical syringes[b], 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[c]; (2) a mechanical syringe; (3) a lentulo spiral[d]; (4) a Jiffy Tube; and (5) a tuberculin syringe.[e]

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

TABLE 1. Ratio of Zinc Oxide Powder to Eugenol Liquid

Technique	*Ratio in ml/1 g*
Endodontic pressure syringe	0.275
Mechanical syringe	0.450
Lentulo spiral	0.400
Jiffy tube	0.400
Tuberculin syringe	0.400

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[g] 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[h] (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 con-

[a] Jiffy™ Tube—Getz-Teledyne; Elk Grove Village, IL.
[b] Centrix Omnisyringe-Root Canal Barrel System—Centrix Inc; Stratford, CT.
[1] Greenberg 1961, 1963; Berk and Krakow 1972; Dannenberg 1974; Frigoletto 1973; Hobson 1970; Krakow and Berk 1965; Rifkin 1980, 1982; Spedding 1973.

[c] Pulpdent Root Canal Pressure Syringe—Pulpdent Corp of America; Brookline, MA.
[d] Lentulo spiral ISO 25—Premier Dental Products; Philadelphia, PA.
[e] Tuberculin syringe 26g 3/8"—Becton-Dickinson Co; Rochelle Park, NJ.
[f] Zinc Oxide and Eugenol U.S.P.—Sultan Chemists Inc; Englewood, NJ.
[g] Ohaus Triple Beam Balance, cap. 2610 g—Ohaus Scale Corp; Florham Park, NJ.
[h] Canal molds, Ransom and Randolph Dynatrak Self-Study course—The LD Caulk Co-Division of Dentsply International Inc; Milford, DE.

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

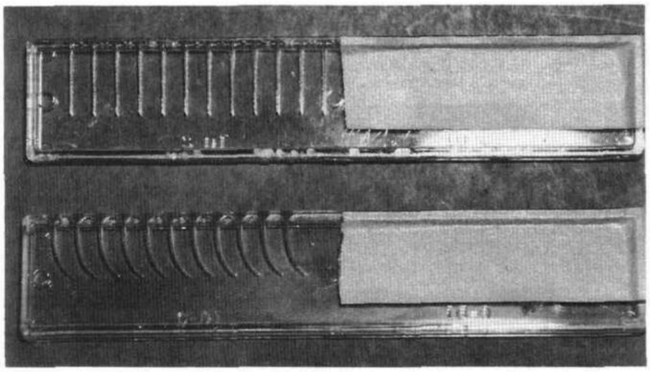

FIG 1. Straight and curved canal simulation molds.

was prevented by covering them with masking tape. This discouraged operator bias and allowed a true comparison to in vivo conditions. Each technique was repeated under identical conditions seven times to develop operator proficiency, then preformed 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 mixture was injected into the simulated canals. The mechanical 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 withdrawn 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 manufacturer'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

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

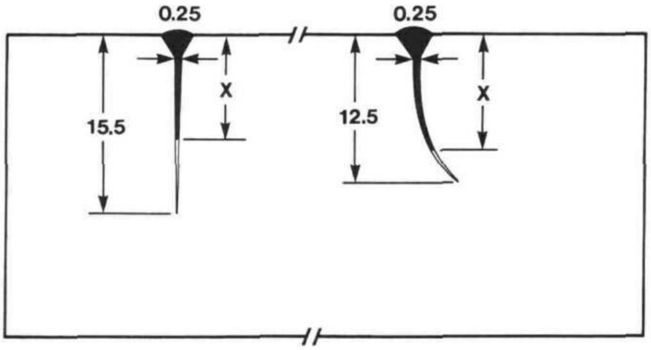

FIG 2. Measurement and dimensions of simulated canals.

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 appeared 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 expressed into the canal with a downward squeezing motion 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 determined. 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 intergroup comparisons.

Results

The mean (μ) and standard deviation (SD) for each technique during the initial trial period, the experimental 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 spiral (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 pressure 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.

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

		Pressure Syringe	*Mechanical Syringe*	*Lentulo Spiral*	*Jiffy Tube*	*Tuberculin Syringe*
Trial	μ	14.20	15.34	15.50	7.74	15.50
	SD	0.714	0.416	0	0.70	0
Expt.	μ	14.88	14.42	13.29	11.43	12.90
	SD	0.911	2.060	2.700	1.700	0.970
Total	μ	14.68 (1)*	13.28 (4)*	13.94 (2)*	10.35 (5)*	13.66 (3)*
	SD	0.900	2.200	2.470	2.230	1.450

* Rank of the mean.

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

		Pressure Syringe	*Mechanical Syringe*	*Lentulo Spiral*	*Jiffy Tube*	*Tuberculin Syringe*
Trial	μ	8.89	10.03	11.66	10.60	10.73
	SD	0.60	1.43	0.83	1.32	1.56
Expt.	μ	10.15	7.80	11.02	8.05	8.91
	SD	0.84	0.27	0.84	1.50	1.79
Total	μ	9.75 (2)*	8.51 (5)*	11.22 (1)*	8.86 (4)*	9.49 (3)*
	SD	0.97	1.33	0.86	1.86	1.89

* Rank of the mean.

TABLE 4. Student's "t" Regression for Straight Canals

df = 44 *P @ 0.05 = 2.017*	*Pressure Syringe*	*Mechanical Syringe*	*Lentulo Spiral*	*Jiffy Tube*	*Tuberculin Syringe*
Pressure syringe	—	2.902*	1.673	12.175*	2.937*
Mechanical syringe	2.902*	—	0.985	4.574*	0.716
Lentulo spiral	1.673	0.985	—	5.285*	0.479
Jiffy tube	12.175*	4.574*	5.285*	—	6.096*
Tuberculin syringe	2.937*	0.716	0.479	6.096*	—

* = significant difference, df = degrees of freedom.

TABLE 5. Student's "t" Regression for Curved Canals

df = 44 *P @ 0.05 = 2.017*	*Pressure Syringe*	*Mechanical Syringe*	*Lentulo Spiral*	*Jiffy Tube*	*Tuberculin Syringe*
Pressure syringe	—	3.533*	5.319*	1.990	0.574
Mechanical syringe	3.533*	—	8.026*	0.718	1.989
Lentulo spiral	5.319*	8.026*	—	5.402*	3.908*
Jiffy tube	1.990	0.718	5.402*	—	1.114*
Tuberculin syringe	0.574	1.989	3.908*	1.114*	—

* = significant difference, df = degrees of freedom.

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 6. Two-Way Analysis of Variance with Unequal Class Sizes (ANOVA)

Source of Variation	*df*	*SS*	*MS*	*F*	*P*
Subgroups					
Straight vs. curved	1	751.261	751.261	240.70	<0.001
Techniques	4	263.737	65.934	21.74	<0.001
A × B (interaction)	4	98.880	24.720	8.15	<0.001
Within subgroups (error)	220	667.217	3.033		
Total	229	1781.095			

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.

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