

Original Article

Digital Radiographic Evaluation of the Quality of Different Root Canal Obturation Techniques in Deciduous Mandibular Molars after Preparation with Rotary Technique

Mehdi Jafarzadeh, DMD, MScD¹- Masood Saatchi, DMD, MScD²- Parisa Jafarnejadi, DMD, MScD³- Morteza Gooran, DMD, MScD⁴

¹ Dept. of Pedodontics, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.

² Dept. of Endodontics, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.

³ Dept. of Pedodontics, Faculty of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

⁴ Dept. of Orthodontics, Faculty of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

KEY WORDS

Pulpectomy;
Root canal obturation;
Deciduous teeth;
Zinc oxide-eugenol cement;

ABSTRACT

Statement of the Problem: Several factors affect the success of pulp therapy of primary teeth, including cleaning and shaping of the root canals and the quality of obturation as the most important steps.

Purpose: The aim of the present study was to compare the quality of different root canal obturation techniques in deciduous mandibular molars subsequent to preparation of the root canals with the rotary technique, using the photo stimulated phosphor (PSP) digital radiographic technique.

Materials and Method: In this *in vitro* study, 221 root canals were selected in 80 extracted deciduous mandibular second molars. The root canals were prepared with a modified protocol for ProTaper NiTi rotary files and with only two instruments (SX and S2) and obturated using a lentulo spiral, condensation technique, an anesthetic syringe, and tuberculin syringe techniques with ZOE paste. The quality of the root canal obturation (obturation length and the number and sizes of the voids) was evaluated using PSP radiographic technique. Data were analyzed with SPSS 21, using chi-squared, Kruskal-Wallis and Mann-Whitney tests.

Results: There were no significant differences in the obturation length ($p=0.285$) and the number of voids ($p=0.061$) between the study groups; however, there were significant differences in void sizes between the study groups ($p=0.001$). The condensation and tuberculin syringe groups exhibited the best and worst results considering the obturation length, respectively. Lentulo and anesthetic syringe techniques have also exhibited acceptable results. The condensation and anesthetic syringe groups exhibited the minimum and maximum number of voids, respectively. The condensation and lentulo groups exhibited the maximum and minimum void sizes, respectively.

Conclusion: If implemented correctly, there will be no significant difference among the experienced root canal obturation techniques considering obturation length and the number of voids.

Corresponding Author: Jafarnejadi P, Dept. of Pedodontics, Faculty of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Email: jafarnejad.parisa@yahoo.com

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Introduction

Loss of an infected deciduous molar tooth, which results in loss of space, is a great concern in pediatric dentistry. In such cases, proper therapeutic measures should be ad-

opted to preserve space, function, and esthetics [1]. When widespread caries affects the dental pulp, pulp therapy becomes necessary and if pulpal inflammation spreads into the root canals, pulpectomy is the treatment

of choice [2-3]. The principal aim of endodontic treatment is to eliminate microorganisms from the root canals, which is achieved by elimination of vital tissues, residual necrotic debris and infected dentin [1]. Therefore, the success of endodontic treatment directly depends on decreasing the number of microorganisms in the root canal, and cleaning, shaping and sealing of the root canal system. When the manual technique is used for pulpectomy in deciduous teeth, there are concerns and limitations in relation to cleaning of the root canal, the anatomic conditions, and the duration of the procedure [4].

In addition, manual preparation technique might give rise to iatrogenic problems such as ledge formation, zipping, canal transportation, and apex closure compared to rotary files that preserve the original root canal configuration effectively [1, 4].

Preparation of deciduous teeth with the use of NiTi rotary files was reported for the first time by Barr *et al.* who used Profile 0.04-taper files. They concluded that use of rotary files is cost-effective for the preparation of the root canals of deciduous teeth and results in the preservation of the integrity and shape of the root canal, with predictable obturation quality [5].

One of the factors affecting the success of pulpectomy is the quality of root canal obturation, and how obturation materials are placed in the root canal is an important aspect of root canal obturation procedure [6]. In other words, in order to prevent recurrence of the disease conditions after treatment, microorganisms should be eliminated from the root canal system as effectively as possible, with no residual spaces for the accumulation and proliferation of bacteria. The presence of voids in the apical and central thirds of the root might provide a path for leakage, allowing the bacteria to accumulate and cause disease. Voids that can form in the whole root canal length result in a higher odds of recurrence; however, it is very difficult to eliminate voids [7].

Subsequent to cleaning, the root canals should be obturated with absorbable materials. Some of the most commonly used materials in deciduous teeth are zinc oxide-eugenol (ZOE) cement, iodoform-based pastes, and calcium hydroxide paste. Different techniques are available for placing materials in the tooth canals, including injection methods (endodontic syringes, tuberculin syringe, local anesthetic syringes and Navi tip), co-

ndensation techniques and use of lentulo spirals [8-9].

Thorough evaluation of the root canal system with high-quality radiographs is a prerequisite in all the root canal treatment stages, from the initial diagnosis to follow-up of treatment [10]. Various imaging systems include cone beam computed tomography (CBCT), digital radiography, and analog radiography. Digital radiography is preferable to analog techniques due to lower patient exposure dose, more rapid access to images, no need for chemical materials and image improvement techniques such as magnification [11]. Cederberg *et al.* [12] reported that PSP images are more effective than conventional images in determining the endodontic working length. Huybrechts *et al.* [7] reported that during evaluation of root canal obturation, voids larger than 300 μm could be identified with the use of all the imaging techniques (analog, digital, and CBCT); however, digital techniques are more effective than the analog and CBCT techniques for detection of smaller voids.

Therefore, various factors affect the success of pulpectomy procedures, of which the cleaning and shaping steps of the root canal and the quality of obturation are more important [1, 4, 13-14].

The aim of the present study was to compare the quality of different obturation techniques as a determinative factor in the outcome of the treatment in deciduous mandibular molars, using photo stimulated phosphor (PSP) digital radiographic technique.

Materials and Method

This *in vitro* study was carried out on 80 extracted deciduous mandibular second molars. Teeth with perforations in the furcal area, root fractures, pulp stones, or calcifications [3-4] and internal and external resorption [15] were excluded from the study. Only the teeth with minimal apical resorption of the root and with at least two-thirds of the root remaining were selected [3, 15]. The teeth were rinsed in water after extraction, immersed in 0.5% NaOCl solution for disinfection for one week, and then stored in distilled water [1]. The teeth were randomly divided into 4 groups (n=20). All the teeth were prepared and obturated by one operator [8].

After removal of caries, an access cavity was prepared to gain a straight access to the root canal; then a #10 file was placed in each root canal so that it was visible in the apical foramen and the canal length was de-

terminated. The final working length was set at 1 mm shorter than the initial root canal length. Then each root was covered with red utility wax, followed by mounting of the teeth in acrylic resin. The root canals were prepared with ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) SX (19 mm) and S2 (21 mm) files in a rotary handpiece (ENDO-MATE TC2, NSK, Kanuma Tochigi, Japan) at 300 rpm with the minimum torque. First, the SX file was placed in the root canal 3 mm beyond the orifice in a buccolingual direction to improve the straight-line access by eliminating any dentinal bulge. Then the S2 file was placed in the root canal while it was rotating up to the working length [9]. The root canals were irrigated with normal saline and 1% NaOCl solutions, respectively, after each filing step. The files were discarded after 6 times of use. In each session, to overcome biases resulting from operator fatigue, only five root canals were prepared [1].

Then the root canals were randomly assigned to 4 groups (n=20) and the root canals were obturated with pure ZOE (Zinc Oxide BP, Eugenol BP, Associated Dental Products Ltd, Kemdent, Wiltshire, UK) with the use of different techniques. In order to achieve a uniform consistency for the ZOE obturation material, one unit of powder was mixed with two units of liquid. A total of 23 root canals were excluded from the study due to problems during root canal preparations, including file separation and canal perforation and stripping.

In the group 1, 20 prepared teeth (53 root canals) were randomly selected and ZOE was injected into the root canals with a tuberculin (insulin) syringe. In the group 2, 20 prepared teeth (58 root canals) were randomly selected and ZOE was placed in the root canals with the use of a lentulo spiral (#30). Half the length of the instrument was cut away to facilitate its use. A rubber stop was placed around the thicker end of the instrument to minimize its displacement during the obturation procedure. The lentulo spiral was coated with the paste and placed in the root canal up to the working length. Each root canal was obturated 3–4 times. In the group 3, 20 prepared teeth (54 root canals) were randomly selected and ZOE was placed within an empty cartridge of anesthetic solution and then was injected into the root canal with a 30-gauge needle in a manner similar to that in the group 1. In the group 4, 20 prepared teeth (56 root canals) were randomly selected.

Then a thick mixture of ZOE (4 powder units and 2 liquid units) was prepared and placed into the root canals up to the initial length with #1 and #2 endodontic pluggers. The paste was placed in several additional layers until each root canal was completely obturated.

To control the obturation of the root canals with ZOE up to the entire working length in all the groups a rubber stop was placed on each instrument at a length that had already been determined. In all the groups, when it appeared that the root canal had been obturated, a wet cotton pellet was used to condense the material within the root canal. Then the access cavity was sealed with Zonalin paste (Associated Dental Products Ltd, Kemdent work, Wiltshire, UK) [8] and the canals underwent radiography with the PSP technique.

The radiographs were evaluated by two researchers (an endodontist and a radiologist). The two researchers reached an agreement on how to score the obturation techniques before evaluating the radiographs. To this end, each researcher evaluated 15 teeth in relation to the quality of obturation. If there was disagreement, the final evaluation was carried out by the third researcher. After calibration of the researchers, the radiographs were evaluated in relation to the following factors. The obturation quality of the different techniques in relation to the distance from the apex (in mm) was evaluated and scored. The records were classified as score 1(half or less than half of the root canal obturated), score 2(more than half of the root canal obturated but less than the optimal level), score 3(optimal obturation level at a distance of 0–1.5mm from the apex), and score 4(extrusion of the obturation material from the apex).

The presence, number and the sizes of voids were evaluated in mm with the use of Scanora Version 5 (Sordex, Finland) software program of the PSP system [8, 16]. Data were analyzed with SPSS 21, using chi-squared, Kruskal-Wallis and Mann-Whitney tests.

Results

Figure 1 presents the frequencies of scores of obturation qualities in all the groups. Condensation and tuberculin syringe techniques exhibited the maximum and minimum obturation quality scores with 57.1% and 39.6%, respectively; score 3 represented the optimal quality. Lentulo (55.2%) and anesthetic syringe (51.9%) techniques have also exhibited acceptable results in relation

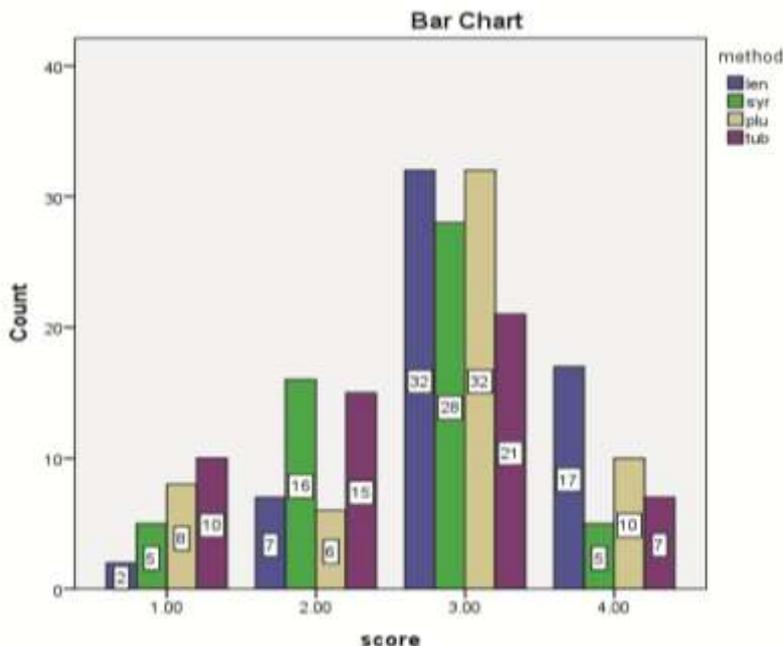


Figure 1: The frequencies of scores of obturation qualities in all the groups

to optimal obturation (score 3). Comparison of the quality of obturation with chi-squared test did not reveal any significant differences between the study groups ($p=0.285$).

Voids number

Voids were detected with all obturation techniques. Condensation technique resulted in the least canals with voids (58.9% of all the root canals in this group), as well as in the lentulo (65.5%) and tuberculin syringes (75.5%). Anesthetic syringe technique resulted in maximum canal with voids (81.5%). The minimum and maximum numbers of voids in each canal were detected with the condensation (1.01 ± 1.16) and anesthetic syringe (1.72 ± 1.54) techniques, respectively, followed by the lentulo (1.63 ± 1.67) and tuberculin (1.39 ± 1.33) techniques. Kruskal-Wallis test did not reveal any significant differences in the number of voids among the study groups ($p=0.61$).

Voids size

Since it was possible to detect several voids in one root canal, the mean of the largest dimension of voids was calculated in each root canal. Lentulo technique exhibited the best result (the minimum means size of 0.29mm), followed by anesthetic syringe (0.32mm) and tuberculin syringe (0.33mm) techniques, which exhibited larger voids. Finally, the condensation technique exhibited the largest mean void size (0.38mm). Analysis of data with Kruskal-Wallis test showed significant differences be-

tween the study groups ($p=0.001$). Mann-Whitney test was used for two-by-two comparisons of the groups (Table 1).

Discussion

The success of root canal therapy directly depends on decreasing microorganisms in the root canal and root canal cleaning, shaping, and sealing [14]. There are limitations and concerns about cleaning the root canals, anatomic conditions and the procedure duration when the manual technique is used for pulpectomy of deciduous teeth. Some of the advantages of NiTi files over the normal technique are easy cleaning, a decrease in preparation time, and easy access to the root canal [4].

One of the factors affecting the success of pulpectomy is the quality of root canal obturation. The final aim of root canal obturation is proper adaptation of the paste with root canal walls through obturation of the entire root canal length (apical seal without overfilling) and attempts to avoid voids or gaps within the paste [8].

Table 1: The results of comparisons made among the study groups in relation to the means of the maximum dimensions of voids in the obturated root canals

Group	Lentulo	Anesthetic syringe	Condensation
Anesthetic syringe	0.164		
Condensation	0.001*	0.007*	
Insulin syringe	0.143	0.906	0.008*

*Significant ($p < 0.05$)

The present study showed no significant differences between the different obturation techniques considering the length of root canal obturation ($p= 0.285$). In the present study, the condensation technique exhibited the maximum percentage of favorable root canal obturation (score 3) (57%), consistent with the results of a study by Dandashi *et al.* [16] who reported the best apical seal with the use of the condensation technique. In addition, Dandashi *et al.* [15] reported no significant differences between the lentulo, injection syringe and condensation techniques. There was no significant difference between condensation method and three other methods in the study of Memarpour *et al.* [8] either. The condensation technique is more difficult in slender and curved root canals compared to wide canals. Since plugger exhibit limited flexibility; they cannot completely penetrate into slender and curved root canals [8]. However, in the present study, in which the root canals were prepared with rotary files, it was shown that a higher percentage of root canals had been optimally obturated, one of the possible reason for which might have been better preparation of root canals, resulting in better access to the apex.

Lentulo application exhibited acceptable results in relation to the length of root canal obturation, so that 55% of canals showed score 3 that this superiority was confirmed in previous studies. Statistical tests showed no significant difference between lentulo method with other methods, contrary to the results reported by Aylard and Johnson [17] in which there was a significant difference between the lentulo and the tuberculin syringe technique. Also in the study of Memarpour *et al.* [8], there was a significant difference between lentulo, anesthetizing and tuberculin syringe method. One of the possible reasons for different results of the present study, the preparation of canals with rotary files and, consequently, better access to apical area. The design and flexibility of a lentulo spiral allows it to transfer the paste homogeneously into slender and curved root canals of deciduous teeth [8, 18]. At the same time, it makes it possible for the paste to penetrate into lateral canals and other irregularities of the root canal [18]. The problems associated with lentulo spirals consist of fractures and a tendency to push the materials out of the apex. In addition, a lack of adequate fit of the rubber stop on the lentulo makes it difficult to observe the correct working length, which results in extrusion of more

material out of the apex [6, 8-9]. To decrease the odds of fracture, it is advisable to use lentulo spirals 1–2 sizes smaller than the last file size used, so that adequate space will remain within the root canal space for rotation of lentulo; in addition, the odds of lentulo being locked in the canal will decrease [9].

In the present study, the lentulo group exhibited the highest percentage of cases in which the obturation material had extruded from the root canal (score 4) compared to the other groups, which might be attributed to a decrease in tactile sensation during the use of rotational instruments, displacement of rubber stop and use of rotary files. Some believe that the risk of failure of pulpectomy procedure after extrusion of materials from the apex is higher than that when the obturation length is short (underfilling) [9, 19]. To decrease the odds of such problems, it might be logical to clean and shape the entire root canal length with rotary files but obturate the root canal shorter than the working length so that both the advantages of the rotary system and proper filling lengths with no material extrusion can be achieved. In addition, it might be suggested that in teeth with wide root canals and open apices, this technique should be used with more care; otherwise, alternative techniques should be used.

Use of the anesthetic syringe resulted in proper obturation length (score 3) with a favorable percentage compared to other techniques, contrary to the results of Memarpour *et al.*'s study [8]. In the present study, it is possible that use of rotary files resulted in better preparation and shaping of root canals and better access of the syringe to the apical area of the root canal. However, this technique still exhibited the disadvantages reported by previous studies [8, 20], including the possibility of ZOE being locked in the needle during injection and the need for repeatedly changing the needle, and even some cartridges fractured.

The insulin syringe group exhibited the least optimal obturation level (score 3) percentage compared to the other groups; however, there were no significant differences between this group and the other groups, contrary to the results reported by Memarpour *et al.* [8] and Aylard and Johnson [17] who reported a significant difference between the lentulo and insulin syringe technique. The possible reason for such a difference is the favorable effect of the rotary files on root canal prepara-

tion, resulting in proper root canal preparation and better access of instruments to the apex and finally better root canal obturation. The chief disadvantage of this technique is separation of the needle from the syringe. In the present study, in order to overcome such a problem the needles used were not separable from the syringe body.

The presence of voids in the apical and central thirds of the root might provide a path for leakage, allowing the bacteria to accumulate and cause disease. In the present study, there were differences in the number of voids in the root canals between the study groups, with the maximum voids in the anesthetic technique compared to other techniques; however, the difference was not statistically significant. After the anesthetic syringe, the tuberculin syringe and lentulo techniques ranked the second and third in relation to the number of voids, contrary to the results of a study by Subba Reddy *et al.* [21], in which the number of voids with the tuberculin syringe technique, were less than the lentulo technique. However, in a study by Estrela *et al.* [22], the number of voids in the plugger group was less than that in the lentulo group, and in a study by Peters *et al.* [20], the lentulo technique resulted in fewer voids in the root canal compared with the injection technique, consistent with the results of the present study.

In a study by Memarpour *et al.* [8], the condensation group exhibited the maximum number of voids, contrary to the results of the present study, which might be attributed to differences in the concentration of the obturation material, the technique used for preparation, and differences in the skills of operators. In addition, as the use of rotary files resulted in better access of plugger to the canal and improved quality of root canal obturation in the condensation technique, in the same manner, it might have resulted in better condensation of the material, decreasing the number of voids. However, similar to the present study, in the study carried out by Memarpour *et al.* [8], the voids in the insulin and anesthetic syringe techniques were also more numerous than that in the lentulo technique.

In relation to void sizes, condensation resulted in the largest voids, which is attributed to the higher concentration of the obturation material in this technique and the additional nature of this technique in which the relatively thick increments of the material are consecutively condensed on each other, making it possible for voids to

form between the increments. Tuberculin and anesthetic syringe techniques ranked the second and third in relation to void sizes, with the lentulo technique exhibiting the smallest voids. The void sizes might be affected by factors such as the concentration of the obturation material, the technique used for root canal preparation, the injection tool, and the injection technique. In addition, since two-dimensional radiographic techniques were used in the present study and other similar studies for the evaluation of the results and since the voids are three-dimensional structures, it seems logical that the reported sizes would be different in different studies.

Conclusion

Given the *in vitro* conditions of the present study and preparation of the root canals with rotary files, it might be concluded that if all the four root canal obturation techniques were implemented correctly, there would be no significant differences among them considering the obturation length and the number of voids. However, significant differences were detected among these techniques concerning the void sizes.

Conflict of Interest

The authors declare that they have no conflict of interest.

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