Evaluation of Portland cement insertion techniques for apical plug confection in teeth with open apex

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ABSTRACT

Introduction: Teeth with open apex hinder biomechanical preparation and formation of an adequate apical stop. An alternative to induce apexification is to seal the open apical foramen with an apical plug. Different techniques can be adopted for insertion and condensation of this material. **Objective:** To evaluate radiographically the formation of an apical plug by means of different techniques used to insert Portland cement (PC). **Material and methods:** Forty single-rooted premolars were extracted, instrumented and enlarged coronally and apically to #140 K file. Teeth were divided into four groups of ten specimens each, according to the technique of cement insertion used to make the apical plug: Group I, gutta-percha cone; Group II, MTA applicator; Group III, Lentulo drill; and Group IV, system of large bore needle. The quality of radiographic apical plug filling made of PC and inserted by means of different techniques was assessed. Data were tabulated and subjected to Kruskal-Wallis non-parametric test with individual comparison between groups (Student-Newman-Keuls) ($p < 0.05$). **Results:** Group I achieved the highest success rate (80%) when compared to the other groups, with significant difference only when compared to Group IV. No significant difference was found between the other groups. **Conclusion:** The technique of cement insertion using gutta-percha cone was superior to the technique with the needle system. It also had a tendency to be better than the other techniques.

Keywords: Endodontics. Root canal treatment. *In vitro*.

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Introduction

Endodontic treatment of immature teeth with necrotic pulp and open apex induce apical closure by apexification procedures in an attempt to provide better conditions for root canal filling.[1]

Whenever a tooth with incompletely formed root undergoes pulp necrosis due to trauma or decay, the formation of dentin and development of that root cease. Consequently, the canal remains wide, with thin and fragile walls as well as open apex, hindering instrumentation and preventing the formation of a suitable apical stop. Thus, in order to prevent the passage of bacteria and their toxins into periapical tissues, allow condensation of filling material and promote optimum sealing, it is necessary to perform apexification by creating an artificial barrier or induce closure of the apical foramen with calcified tissues.[2]

Calcium hydroxide has been used for apexification. Its alkaline pH and physical presence within the canal have a potent antibacterial effect and favor the formation of an apical barrier of mineralized tissue.[1,3] Treatment consists of repeated exchange of material for an indefinite period of time (5 to 20 months), until apex closure is reached.[1] However, despite its effectiveness, this material has some disadvantages, such as the time necessary for the apexification procedure, which negatively affects patient's compliance; weakening of teeth, which might lead to fractures;[4] and potential impairment of prognosis due to temporary filling performed during the procedure, making it more susceptible to coronal infiltration.[5]

An alternative to induce apexification with calcium hydroxide is to seal the open apical foramen with an apical plug made of mineral trioxide aggregate (MTA)[2] or Portland cement (PC). PC contains the same chemical elements of MTA, with the exception of bismuth oxide, and has similar physical properties, thereby triggering similar tissue reactions.[6,7] In addition, PC has the advantage of having a lower cost in comparison to MTA.[6]

Based on the finding that MTA and PC have similar compositions, studies in the endodontic literature have compared the physical, chemical and biological properties of these types of material.[6,7] Estrela et al[6] showed that MTA and PC have similar antimicrobial activity. Recent studies have observed that PC is a biocompatible material, i.e., it is not genotoxic and does not induce cell death.[8] In addition, PC has low cytotoxicity[9] and allow cell proliferation and adhesion.[10] This material is also able to stimulate formation of mineralized tissue.[11]

Studies have demonstrated that in the apexification procedure, by creating an artificial barrier, an apical plug approximately 4 mm thick is more efficient regarding the ability of root sealing and resistance to displacement.[12] Insertion and condensation of material is difficult due to the small diameter of the root canal in relation to the diameter of the instruments. The most common tools used for insertion include mini amalgam carrier or MTA applicator, both of which are similar in shape and diameter,[13] lentulo drill,[14] condenser,[15] system of large bore needle[16] and gutta-percha cone. The material can be condensed in the root apex by means of a file involved in cotton,[14] sterile paper cone,[16] gutta-percha cone,[17] condensers[15] and indirect use of ultrasound.[12]

The objective of this study was to assess radiographically the quality of level and filling of an apical plug by means of different techniques for inserting PC.

Material and methods

This study was approved by the Ethics Committee in Research on Humans of Universidade Estadual de Maringá (#401/2011).

Selection of teeth and preparation of specimens

Forty (n = 40) human single-rooted permanent premolars, with intact roots and fully formed apices, were selected, cleaned and stored in 10% formalin. Root canal access was performed with spherical diamond drill (#1012) (KG Sorensen Indústria e Comércio Ltda, São Paulo, Brazil) and compensatory wear with trunk-conical diamond drill with inactive tip (#3082), both at high speed. Root canals were instrumented and enlarged up to #80 K file (Dentsply-Maillefer, Ballaigues, Switzerland), followed by Largo drill #6 (1.70 mm); and to complete the preparation, a #140 K file (D16 = 1.72 mm) was used. With the same sequence of files and drill, instrumentation was accomplished via root apex, so that the walls of the canal became divergent apically, with width corresponding to the D16 diameter of the #140 K file, simulating an open apex. Throughout preparation, the teeth remained hydrated in aqueous solution.

In transparent acrylic tubes, holes in the bottom allowed attachment of teeth, so that only the roots remained inside the tube. To secure them in position, acrylic self-curing resin was used around the holes. To prevent penetration of gelatin into the root canal, a polytetrafluoroethylene resin-based sealing tape, compacted in the form of an apical plug, was inserted, taking care to leave a small piece of tape outside the root canal access so as to facilitate its removal after the gelatin had hardened. Then, gelatin was poured into the tubes to simulate periapical tissues,[18] compatible with an apical lesion, and then placed in refrigeration. Once the gelatin solidified, the sealing tape was removed from the root canal.

Experimental groups and manufacture of the apical plug

Forty premolars were randomly divided into four groups according to the technique used to insert PC into the root canal to make the apical plug.

Group I (n = 10): an inverted gutta-percha cone #80 (Dentsply Maillefer, Ballaigues, Switzerland) was used, that is, its largest diameter was used to take PC into the root canal. By means of this technique, the material was inserted incrementally by immersing the tip of the gutta-percha cone in distilled water and then in powder. The material was condensed after each increment with the tip of the gutta-percha cone itself, initially held at the working length, i.e., 1 mm from the apex to reach the desired height of the plug (4 mm).

Group II (n = 10): a MTA applicator (Ângelus, Londrina, Brazil) was used and the paste was inserted in stages into the conduit to the location at which the applicator could reach (tool diameter = 1.87 mm). Subsequently, condensation was performed with gutta-percha cone, so as to adapt the paste in the apical region.

Group III (n = 10): a lentulo drill #80 (Dentsply Maillefer, Ballaigues, Switzerland) was used clockwise and at low speed. The material was inserted by means of the drill 3 mm from the working length, and condensed with gutta-percha cone so as to achieve complete adaptation of the material.

Group IV (n = 10): a needle system (trocarter) consisting of a large bore needle and a plunger, made of orthodontic wire with thickness compatible with the needle diameter, was used. The material was introduced into the needle and then pushed into the conduit to the location at which the instrument could reach (tool diameter = 1.81 mm). Condensation was performed with gutta-percha cone.

Finally, radiographs of the specimens were taken as an evaluation method of the techniques used.

Apical plug

A mini lathe was used to place and stabilize the tubes for subsequent manufacture of the apical plug. For calibration, the apical plug was manufactured by one operator only.

PC was used to manufacture the apical plug. Given its low radiopacity compared to MTA, iodoform was added at a ratio of 4:1. PC powder and distilled water were mixed until a stiff paste was obtained.

Odontometry and the length of each tooth were taken radiographically. After determining the length of each tooth, the working length was established by subtracting 1 mm from this value.

The apical plug was classified as follows: (0) at the tip of the root apex, considered ideal; (1) beyond the root apex, with material overflow into the gelatin; and (2) before the apex when the material did not reach the apical limit. Radiographs representing this classification are shown in Figure 1.

Statistical analysis

Data were tabulated and analyzed by Kruskal-Wallis non-parametric statistical tests, with individual comparison between groups (Student-Newman-Keuls) at a significance level of $p < 0.05$.

Results

Table 1 shows the results of radiographic evaluation performed after apical plug manufacture and in terms of filling level by means of four different techniques for inserting PC.

Radiographic examination revealed significant difference between groups (Kruskal-Wallis, $p < 0.05$). Individual comparison between groups (Student-Newman-Keuls test, $p < 0.05$) (Table 2) revealed significant difference between groups I and IV ($p = 0.009$).

The technique using gutta-percha cone (Group I) presented the highest success rate, with 80% of apical plugs at the tip of the root apex; followed by the technique using the lentulo drill (Group III), in which 60% of the plugs reached the ideal limit. The technique using MTA applicator (Group II) achieved 30% success; and the technique using the needle system (Group IV) had the worst performance, with 90% of plugs with material beyond the root apex and only 10% at the ideal limit.

Discussion

With a view to obtaining an *in vitro* model similar to a clinical situation, gelatin was applied around the root so as to simulate the texture and moisture of periapical tissues, which is in agreement with Steinig et al.[18] In order to avoid gelatin leakage into the root canal, the authors applied wax around the apex. Once the gelatin

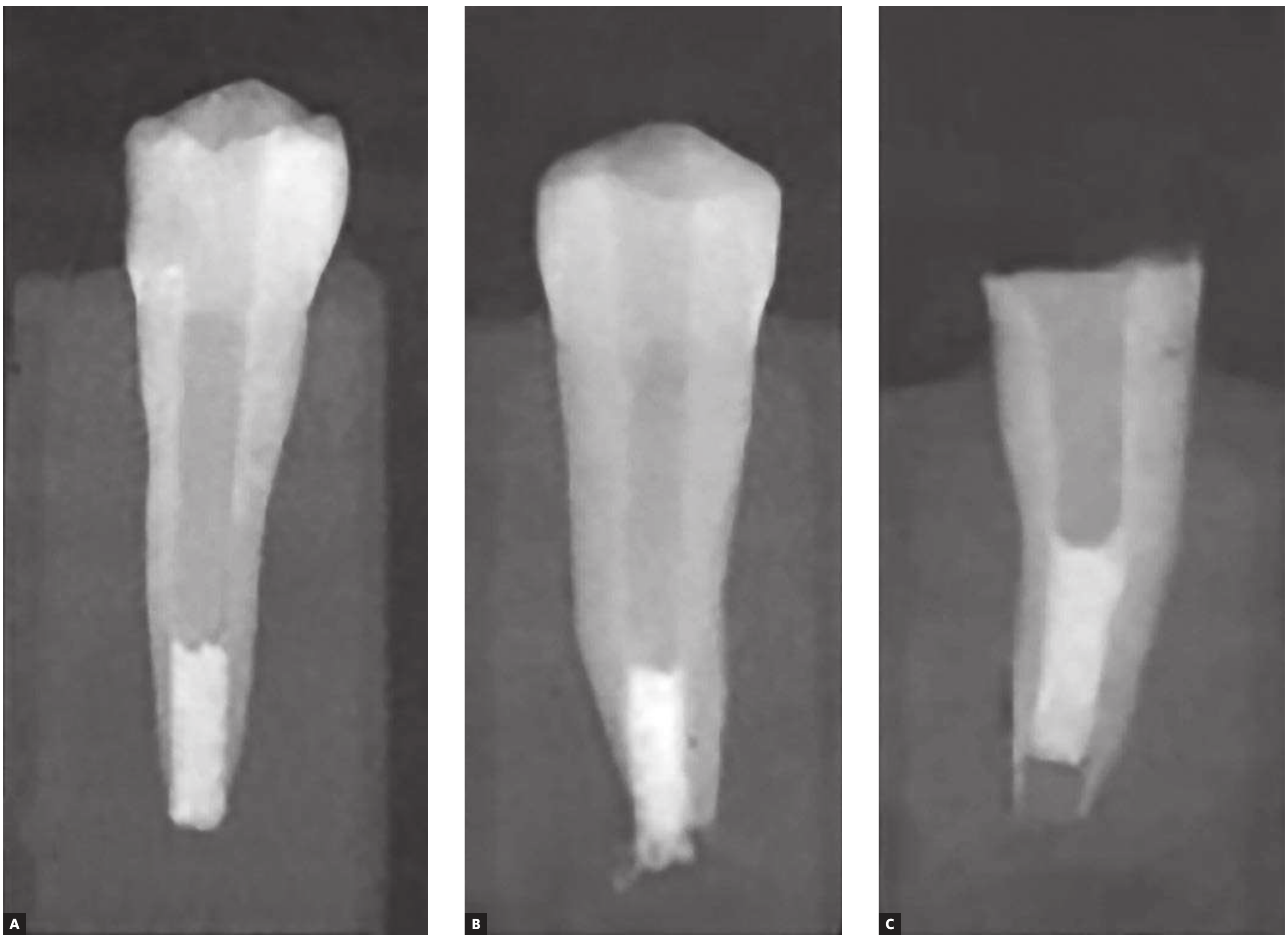

Figure 1. A) Score 0: Apical plug at the tip of the root apex; **B**) Score 1: Apical plug beyond the root apex; **C**) Score 2: Apical plug before the root apex.

Table 1. Results obtained after radiographic evaluation of the apical plug.

Sample	Group I	Group II	Group III	Group IV
1	0	1	2	1
2	0	1	1	0
3	0	0	0	1
4	0	1	1	1
5	0	0	0	1
6	1	1	1	1
7	0	1	0	1
8	0	1	0	1
9	0	1	0	1
10	1	0	0	1

Groups: I = gutta-percha cone, II = MTA applicator, III = lentulo drill, IV = needle system. Score 0: at the tip of the root apex, score 1: beyond the root apex, score 2: before the root apex.

Table 2. Student-Newman-Keuls test for individual comparison between groups.

Comparison	Mean rank difference	P value
Groups I and II	9.75	0.0622
Groups I and III	5	0.3389
Groups I and IV	13.65	0.009*
Groups II and III	4.75	0.3636
Groups II and IV	3.9	0.4557
Groups III and IV	8.65	0.098

* Significant at $P < 0.05$.

had hardened, the tooth was detached from the material so as to remove the wax from the apex and reposition it in its mark on gelatin. Nevertheless, in the present study, in order to make the apparatus more reliable, a sealing tape was placed inside the canal, compacted in the form of an apical plug with its end accessed via coronal access. Once the gelatin had solidified, the tape was removed from the root canal by the coronal portion. In addition, a dark-colored gelatin was used to avoid direct visualization of the apex. Sarris et al[19] used wax to cover the apex in an *in vitro* study; however, they noted that the manufactured model was not similar to actual clinical conditions, as the wax represented a hard physical barrier to which MTA could certainly be condensed. Importantly, this barrier does not clinically exist and the material needs to be lightly pressed in place so as to prevent the overflow to periapical tissues.

PC was chosen not only due to its low cost compared to MTA, but also based on studies that confirm the similarity between these two types of material.[6,7] In the present research, iodoform was added to PC, at a ratio of 4:1, for the purpose of providing radiopacity. There are reports showing that the only difference between MTA and PC is bismuth oxide, as the composition of MTA is essentially PC (80%) and 20% bismuth oxide.[20] MTA has advantages compared to other types of material used to fill the apical plug, but some studies reveal that bismuth oxide negatively affects some properties of PC, such as compressive strength[21] and biocompatibility.[9] Bismuth oxide is not part of MTA setting reaction,[22] and its presence increases the porosity of PC, which may cause an increase in its solubility and disintegration, thus reducing the cement strength.[21]

Different techniques can be employed to manufacture an apical plug, with manual tools being properly used to insert and condense the material. MTA applicator is commonly used to this end;[13,19] but its thickness makes it difficult to insert the material into the apical portion, requiring the use of other thinner tools[19] to complement condensation. Despite its widespread use, the technique using this tool (Group II) achieved a 30% success rate. The lentulo drill (Group III), at low speed, can also be used. It is usually introduced 3 mm from the root apex,[14] and, in this study, it reached satisfactory results in 60% of apical plugs. The technique using the well-known and accessible gutta-percha cone (Group I), in which PC was inserted into the root apex by increments formed from the immersion of the tip of the gutta-percha cone in distilled water and then in powder, proved to be efficient in filling (80%). In turn, the needle system (Group IV) had the worst performance, with only 10% of success, thereby revealing significant difference when compared to Group I ($p < 0.05$).

The condensation of each increment of material may be performed by condensers,[15,23] gutta-percha cone,[17] paper cone[16,19,23] and file involved in cotton.[14] Ultrasound can be used as a complementary measure to condensation carried out with condensers. The ultrasound device is supported by the condenser rod, which is in passive contact with the plug, and activated on its lowest potency.[12] In the present study, an inverted gutta-percha cone #80 was used for condensation of the material in the root apex, since it was promptly available and showed direct access to the apical plug.

Conventional root canal filling procedures are challenging in cases of teeth with pulp necrosis, immature apex, and periapical lesions due to absence of natural apical constriction.[24] Under clinical conditions, there is no barrier; therefore, when making an apical plug, PC should be lightly pressed in place so as to prevent extrusion to periapical tissues. In order to overcome this limitation, in addition to the different techniques for apical plug insertion presented herein, it has been suggested that a physical apical barrier be created before placing PC. This can be achieved with collagen-like material, such as Collatape (Centerpulse Dental, Carlsbad, CA, USA) and calcium sulfate (Classe Implant, Rome, Italy).[25]

Conclusion

The results of this study reveal that the gutta-percha cone technique is radiographically superior in comparison to the technique using a large bore needle system to make an apical plug. In addition, the former has a tendency to be better than other techniques.

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