GEOMETRIC ROOT CHANGES FOLLOWING TWO DIFFERENT TECHNIQUES FOR IMMATURE PERMANENT INCISORS

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ABSTRACT

Aim: for evaluation and comparison of pulp revascularization and apexification in immature non-vital permanent incisors by CBCT.

Material and methods: 15 immature permanent incisors of children (7-9 years old) had irreversible pulpitits or necrotic pulp were selected and randomly divided into 2 groups; Group I: 7 teeth were treated with Pulp revascularization and group II: 7 teeth were treated with MTA apexification. Each tooth was completely isolated with a rubber dam then access opening was done. Irrigation of the pulp chamber with 2.5% NaOCl then sterile saline and water. The root canal was then dried with paper points, triple antibiotic paste (TAP) was administered, and it was removed two weeks later with saline irrigation. In group I (revascularization) bleeding enhancement was done and MTA material was performed over the formed blood clot while in group II (apexification) the whole root canal space was filled with MTA. Finally, pulp chamber was filled with GIC filling in both groups.

Conclusions: Both groups are resemble in all CBCT criteria except in dentin volume and root length in mesiodistal direction which significant in Revascularization group.

KEYWORDS: Apexification, Cone beam computed tomography, immature non-vital teeth, Mineral trioxide aggregate, Revascularization.

INTRODUCTION

Traumatic injury to young permanent anterior teeth outnumbers dental caries and periodontal disease. Pulp tissue is irritated by a variety of germs, trauma, dental procedures that generate thermal stimulation, and chemical agents. Irritation of pulp tissue alters the microcirculation of the pulp, which may result in pulp necrosis and root development.
arrest. The therapy of these teeth presents a significant challenge to the physician, since inappropriate treatment during trauma might exacerbate the problem, result in the development of periapical lesions, and result in the cessation of tooth growth.

There are several challenges associated with root canal treatment of non-vital immature teeth for example, the apical width of the canal is often greater than the coronal diameter, making debridement challenging. Additionally, the absence of an apical stop results in root canal filling material extrusion, rendering the seal of obturation extremely unachievable in all dimensions. Finally, due to the root canal’s thin, weak walls’ proclivity for fracture, surgical treatment is often not a viable option.

Apexification is described as a technique used by the American Association of Endodontists (AAE) in 2003 to generate a calcified barrier in a root with an open apex and can be done by Calcium hydroxide or mineral trioxide aggregate (MTA) may be used to stimulate the creation of an apical calcified barrier and to create an artificial apical barrier respectively.

Revascularization is the process through which stem cells from the apical area of immature teeth. After passive decontamination, which eliminates some or all of the pulp tissue and or necrotic tissue, tissue ingrowth is guided into the root canal space. This is accomplished by filling the root canal space with blood clots derived from periapical tissues, which aid in the movement of stem cells inside the root canal area.

Cone beam computed tomography (CBCT) is a widely utilized modality for radiographic examination of bone at the head and neck region, showing high accuracy and the provided programs with CBCT allow easy, rapid radiographic interpretation. Recently CBCT was widely replace conventional computed tomography (CT) due to the newly high advances in image quality that become very close to CT images, lower exposure doses, rapid and easy exposure for the patient and easy images interpretation and planning thanks to many available interpretation software.

Increasingly, three dimensions (3D) radiographic modalities can be used for extraction of accurate quantitative measures such as 3D volume measurement and reconstruction. Several programs can be used for 3D volume measurement using Digital Imaging and Communications in Medicine (DICOM) files from CBCT, CT, and MRI, which has become widely used in different dental research as a reliable, reproducible, and valid method for radiographic assessment.

ITK-SNAP software is an easy-to-use, cost-effective, and dependable package for measuring radiographic volumes by importing DICOM files from various imaging modalities such as MRI, CT, CBCT, and ultrasonography. It has been validated for measuring nasopharyngeal volumes and the dimension of the bony defect in patients with cleft palate prior to alveolar bone grafting to avoid unnecessary donor site morbidity due to unnecessary excessive harvesting.

**MATERIALS AND METHODS:**

**Study design:** This study employed a randomized controlled clinical trial design.

**Study setting:** The study was done in Pediatric Dentistry Department outpatient clinic, Faculty of Dentistry, Tanta University, Egypt.

**Study sample:**

The sample size was calculated using power analysis by Epi-Info software package created by world organization (WHO) and central for disease prevention and control (CDC) version 2007. The confidence limit was 95%, power of the study was 80%, case to control ratio was 1:1 and the sample size was found to be N=14 (7 in group 1 and 7 in group 2) with extra 4 teeth to avoid sample attrition. The children (7-9 years old) incisors teeth having irreversible pulpitis or necrotic immature permanent incisors. The youngsters were chosen from the Pediatric Dentistry Department’s outpatient clinic, Faculty of Dentistry, Tanta University, Egypt. Teeth were examined clinically and radiographically using
standardized parallel cone technique” of periapical x-ray (XCP: extension cone paralleling)** at the start of the study then randomly divided into two groups.

Patient’s rights:

The Faculty of Dentistry’s Research Ethics Committee granted approval for this investigation (REC). The goal of this study was described to patients, and informed consent was obtained from parents as well as their children over the age of eight, in compliance with the research ethics rules issued by Tanta University’s Faculty of Dentistry’s Research Ethics Committee.

Group assignment:

- **Group I**: “Study group” 7 teeth were treated with Pulp revascularization.
- **Group II**: ” Positive control group” 7 teeth were treated with MTA apexification.

Inclusion criteria:

- Carious or fractured non vital or necrotic immature permanent incisors.
- Irreversible pulpitis (with or without apical periodontitis/abscess) even with previous intervention.
- Restorable tooth.
- Cooperative child.

Exclusion criteria:

- Simple carious lesions.
- Splited crown fracture.
- Children having any systemic diseases as cardiac and blood disorders or history of allergy to any of the antibiotics used in tri-mix.
- Disabled and special needs children.
- Severe luxation injury.

After history taken from the child and parents, clinical examination was done to evaluate traumatized or fractured incisors for presence or absence of the following parameters:

1. Pain or discomfort.
2. Tenderness to percussion
3. Mobility Score\(^0\) = normal mobility, 1 = slight mobility, 2=sever mobility.
4. Swelling and fistula.

Cone beam computed tomography limited field of view CBCT taken to measure the following criteria once at the start and the end of follow up period after 18 months:

1. Dentin volume.
2. Pulp space volume.
3. Root length (at mesiodistal direction).
4. Root length (at buccolingual direction).

Dentin and pulp space volume measurement:

Using ITK-SNAP*** software, both volumes were measured from fixed reference point to the most apical point of the root using the axial view depending on semi-automated option of self and isotropic voxel recognition of ITK-SNAP. Dentin and pulp space were identified separately using two different colored labels. Rechecking from coronal and sagittal view was done for dentin and pulp respectively.

Automatic calculation of the dentin and pulp space volume was done by the software.

Root length measurement.

The mean of root length was measured twice, one at mesiodistal view and the other one at buccolingual view from the cemento-enamel junction (CEJ) to the most apical point of the root at mesial and distal line angles, also at buccal and lingual line angle respectively as the root lengths were not always with a uniform length.

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* De Gotzen Varese Italy, 70 kVp.
** Dentsply Rinn, made in USA.
*** ITK-SNAP version 3.8.0, Supported by the U.S. National Institute of Biomedical Imaging and Bioengineering.
Treatment Procedures:

First appointment

- Local anesthesia was given using 2% Mepivacaine *with 1:20,000 Levonordefrin local vasoconstrictor agent.

The tooth was isolated with a rubber dam.

A cavity for access was made using an Endo-Z bur held in a high-speed hand piece sprayed with sufficient amounts of water.

- Initial debridement of coronal 1/3 of the root canal was done using hand stainless steel H-files.

- The pulp chamber and root canal were freely irrigated with a 10ml solution of 2.5 percent sodium hypochlorite (NaOCl) for 2-5 minutes followed by sterile saline. Throughout irrigation, the needle should be injected into the root canal to a point 2 mm shorter than the apical foramen. The root canal was then dried with the use of paper points.

- Modified triple antibiotic paste “TAP” was used as canal disinfectant (Mixture of equal proportion of three antibiotics: (250mg Metronidazole, 250mg ciprofloxacin and 250mg Amoxicillin) bonded with propylene glycol and Macrogol to form a creamy paste then inserted into the pulp chamber and coronal (third or half) of root canal with a hand K-file and cotton pellet. The ac-
cess cavity’s walls were cleansed with a sterile cotton pellet and then filled with Cavit temporary filling paste lifting for 2 weeks.

Second appointment

The patient was scheduled for a follow-up appointment two weeks later. Prior to advancing to the next step of treatment, the tooth remained asymptomatic throughout the postoperative period and the temporary filling remained intact. If clinical indications or symptoms continue, the first appointment’s procedures should be repeated.

When proceeding with the second appointment, the tooth was anaesthetized using anesthetic solution without vasoconstrictor.

- After that if the tooth is asymptomatic, a rubber dam isolation of the tooth was done and gentle removing of the cavit temporary restoration. The TAP paste was washed out by copious irrigation of root canal with 2.5% sodium hypochlorite, rinsing the canal with sterile saline and water. Then root canal was dried using sterile paper point size 80.

- In this group apical bleeding was induced by inserting a disinfected #15 K-file into the apical tissues 2 mm beyond the apical foramen to begin root canal bleeding. Blood level must be at least 2-3 mm below the cement-enamel junction.

- Bleeding should be limited to a location roughly 2-3 mm apical to the CEJ. This is performed by exerting pressure to the intra-canal with a sterile saline-soaked cotton pellet until a clot forms. The estimated mean time required to form a stable blood clot is 5-10 minutes. To ensure the clot’s stability, gently contact it with the reverse end of a big sterile paper point.

- White MTA was mixed in powder-distilled water ratio of 3:1 according to the manufacturer’s instructions. MTA paste was placed using Amalgam carrier on the formed blood clot below the CEJ to form hermetic seal then wet cotton pellet was placed on MTA paste until the initial setting occurred.

Group II: MTA Apexification: Fig.3

- In this group MTA paste was carried inside the canal to reach 2mm. shorter than the root end using the applicator or hand K-file instrument covered with cotton for condensation.


* Pro-Root MTA; Dentsply Tulsa Dental Specialties, Tulsa, OK, USA
MTA was carried in small increments inside the canal as filling material to reach a level below the CEJ\textsuperscript{25}, each increment was vertically compacted using hand plugger\textsuperscript{*}. Then wet cotton pellet was placed on MTA paste until initial setting occurs after filling.

Finally, the teeth of both groups were restored using reinforced Fuji GIC filling after the initial setting of MTA then peri-apical radiographic x-ray film was taken at the end of second appointment while CBCT was taken before and after 18 months follow up period.

RESULTS

The present study evaluated and compared pulp revascularization and apexification in immature non-vital permanent incisors radiographically by CBCT.

The computer was fed the data and the IBM SPSS software programmer version 20.0 was used to analyses it. (Armonk, New York: IBM Corporation). The Shapiro-Wilk test was used to determine the normality of continuous data. The range (minimum and maximum values), mean, standard deviation, and median were used to express the distributed data. The student t-test was used to compare two groups with normally distributed quantitative data, whereas the Paired t-test was used to compare pre- and post-treatment groups with normally distributed quantitative variables. On the other hand, the Mann Whitney test was used to compare two groups for quantitative variables that were not normally distributed, whilst the Wilcoxon signed ranks test was used to compare two periods. The significance of the obtained data was determined at the 5\% level.

At baseline the two treatment groups showed nonsignificant differences regarding the parameters namely, dentin volume, pulp space volume, MD root length, and BL root length. This was evidenced by their baseline values as shown in table (1) as \(p>0.05\).

**Group I (Revascularization):**

Results presented substantial elevation in the mean value of dentin volume and root length in mesiodistal direction from 40 ± 14 mm\textsuperscript{3} and 10.6 ± 1.7 mm to 73.5 ± 40.2 mm\textsuperscript{3} and 12.4 ± 1.4 mm respectively as \(p < 0.05\), while the root length increase in buccolingual direction but not statically significant increase. It was found also a significant decrease in pulp space volume from 16 ± 14.6 mm\textsuperscript{3} to 9.3 ± 7.7 mm\textsuperscript{3} as shown in table (1).

**Group II (Apexification):**

Results showed non-significant increase in the mean value of dentin volume, pulp space volume, root length in mesiodistal direction, and root length in buccolingual direction from 38.2±8.8 mm\textsuperscript{3}, 8.6±4.3 mm\textsuperscript{3}, 11.9±1.3 mm, and 12.8±1.8 mm to 48.5 ± 11.4 mm\textsuperscript{3}, 11.2±3.5 mm\textsuperscript{3}, 12.3 ± 1.7 mm, and 13.2±1.7 mm respectively as shown in table (1).

**Intergroup comparison:**

The differences between the two groups for the mean of dentin volume and pulp space volume were statistically significant at post treatment study interval in favor of group I as \(p<0.05\). However, for the root length in both mesiodistal and buccolingual directions were non-statistically significant difference as \(p>0.05\) as shown in table 1.

\* Dentsply, USA.
### TABLE (1): Comparison between the two studied groups according to dentin and pulp space volumes and root length parameters

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Test of Sig.</th>
<th>p</th>
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<tr>
<td><strong>Dentin volume (mm³)</strong></td>
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<td>Pretreatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>40 ± 14</td>
<td>38.2 ± 8.8</td>
<td>t=</td>
<td>0.785</td>
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<tr>
<td>Median (Min. – Max.)</td>
<td>34.5 (22.9 – 66.5)</td>
<td>36.5 (25.6 – 51.2)</td>
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<tr>
<td>Post treatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>73.5 ± 40.2</td>
<td>48.5 ± 11.4</td>
<td>t=</td>
<td>0.016*</td>
</tr>
<tr>
<td>Median (Min. – Max.)</td>
<td>70.3 (32.2 – 157)</td>
<td>46.5 (36.4 – 68)</td>
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<td>$t_0$ ($p_0$) 2.300° (0.049°)</td>
<td>$t_0$ ($p_0$) 2.399 (0.062)</td>
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<td><strong>Pulp volume (mm³)</strong></td>
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<tr>
<td>Pretreatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>16 ± 14.6</td>
<td>8.6 ± 4.3</td>
<td>U=</td>
<td>0.456</td>
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<tr>
<td>Median (Min. – Max.)</td>
<td>8.71 (4.7 – 44.82)</td>
<td>7.2 (3.9 – 14.1)</td>
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<tr>
<td>Post treatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>9.3 ± 7.7</td>
<td>11.2 ± 3.5</td>
<td>U=</td>
<td>0.048*</td>
</tr>
<tr>
<td>Median (Min. – Max.)</td>
<td>7.6 (2.8 – 27)</td>
<td>9.4 (8.7 – 17.7)</td>
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<td>$Z$ ($p_0$) 2.490° (0.013°)</td>
<td>$Z$ ($p_0$) 1.363 (0.173)</td>
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<tr>
<td><strong>MD Root length</strong></td>
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<td>Pretreatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>10.6 ± 1.7</td>
<td>11.9 ± 1.3</td>
<td>t=</td>
<td>0.132</td>
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<tr>
<td>Median (Min. – Max.)</td>
<td>11.1 (7.8 – 13.7)</td>
<td>12 (10.43 – 13.9)</td>
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<tr>
<td>Post treatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>12.4 ± 1.4</td>
<td>12.3 ± 1.7</td>
<td>t=</td>
<td>0.862</td>
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<tr>
<td>Median (Min. – Max.)</td>
<td>12.7 (9.8 – 14)</td>
<td>11.9 (10.5 – 14.7)</td>
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<td></td>
<td>$t_0$ ($p_0$) 3.362° (0.010°)</td>
<td>$t_0$ ($p_0$) 1.036 (0.348)</td>
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<tr>
<td><strong>BL Root length</strong></td>
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<td>Pretreatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>11.8 ± 2.1</td>
<td>12.8 ± 1.8</td>
<td>t=</td>
<td>0.374</td>
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<tr>
<td>Median (Min. – Max.)</td>
<td>11.4 (9.1 – 15.1)</td>
<td>12.7 (10.5 – 15.4)</td>
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<tr>
<td>Post treatment</td>
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<tr>
<td>Mean ± SD.</td>
<td>12.9 ± 1.8</td>
<td>13.2 ± 1.7</td>
<td>t=</td>
<td>0.770</td>
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<tr>
<td>Median (Min. – Max.)</td>
<td>13.2 (10.1 – 15.5)</td>
<td>13.1 (11 – 15.3)</td>
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<td></td>
<td>$t_0$ ($p_0$) 1.996 (0.081)</td>
<td>$t_0$ ($p_0$) 1.780 (0.135)</td>
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</table>

### DISCUSSION

Pulp revascularization is a relatively novel and promising treatment option for immature teeth but until now not enough data that recommend it as an alternative to apexification in permanent teeth in their adolescent years with irreversible pulpitis and pulp necrosis. So, radiographic comparisons were necessary in the present study to detect the best technique in the treatment of permanent immaturity teeth.²⁶

Root canal management of the non-vital immature permanent teeth is a difficulty to clinicians.
Their primary concerns when treating teeth with “blunderbuss” canals are with the appropriateness of canal space disinfection and obturation issues, particularly in managing working length. Apexitification with calcium hydroxide is the most often used treatment for controlling such teeth. Traditionally, the usage of MTA to generate calcific apical barrier then location of a bonded core within the canal for strength of the weakened roots which was standard for non-vital teeth with open apices.

MTA offers a higher long-term success rate because it avoids several of the disadvantages of standard calcium hydroxide apexitification methods, such as reduced treatment time and patient visits, and prompt restoration of the tooth, which results in a decreased risk of fracture and a boost in patient compliance as a result, this material was incorporated into this research.

The success rate of endodontic regeneration operations as proposed by the American Association of Endodontists (AAE), is largely measured by the extent to which it is possible to attain several goals. The major objective is to eliminate symptoms and to demonstrate bone repair. The secondary goal is to enhance the thickness of the root wall and/or the length of the roots. The tertiary objective entails a favorable response to vitality testing (which could indicate a more organized and vital pulp tissue).

Controlling infection with chemical agents and mechanical instrumentation is critical for successful endodontic treatment of infected root canals. Both the pulp cavity and dentinal walls must be properly cleaned prior to the ingrowth of important tissue during pulp regeneration. However, mechanical eradication of germs is not suggested in young teeth owing to the fragility of the thin root walls. Additionally, mechanical cleaning may exacerbate the fragility of the root canal walls. Then eliminate any critical tissue remains that may remain in the canal’s apical portions allowing subsequent further root development, and hence should be avoided during this procedure. Therefore, minimal initial instrumentation is used in the present study.

Root canal disinfectant in immature non-vital teeth is mainly restricted to irritant solution and intra-canal medicaments. The AAE recommends the use of as low a concentration of sodium hypochlorite irrigant as possible due to the possibility of its extrusion through the open apex causing cytotoxicity to the apical stem cells. Therefore, NaOCl irrigant solution was used in concentration of 2.5% in the present study to avoid the cytotoxic effect of higher concentration on periapical stem cells. Then NaOCl was then flushed from root canal using 20 ml saline or distilled water to minimize any extended toxicity that may impair regeneration responses, minimize the possibility of precipitation, and eliminate residual debris and irrigant remains.

Pulp revascularization is more advantageous in a bacteria-free environment, which demands that the root canal system be cleansed prior to cell colonization. As in recent investigations, canal decontamination is accomplished by applying disinfecting solutions without the use of typical mechanical instrumentation. On the other hand, the present study disagreed with Alobaid et al. who suggested that passive disinfection with NaOCl may not be sufficient to eliminate contamination which they used only (TAP) for 2 weeks.

Because root canal infection is caused by numerous species of bacteria, it is improbable that a single antibiotic will be able to eradicate all these pathogens and maintain a sterile environment. However, Hoshino et al. observed that Three antibiotics (Metronidazole, Ciprofloxacin, and Minocycline) were used in TAP to eradicate microorganisms populating the dentin. Additionally, this paste eliminated germs within the deep layers of dentin, preventing infection within root canals while allowing ingrowth of new tissue necessary for root development.

Despite the promising results of TAP, there are some adverse effects, such as darkening of the crown, are caused by the presence of minocycline. Some authors suggested replacement of the minocycline.
cline with amoxicillin, cefaclor or clindamycin. Therefore, modified TAP consisted of metronidazole, ciprofloxacin and amoxicillin was used in this study. Dressing with TAP intra canal medication left for two - three weeks to complete canal disinfection and maintain stem cells vitality. Therefore, intra-canal modified TAP was applied for three weeks in the recent research.

Inducing bleeding inside the root canal by mechanical irritation of periapical tissues is easier when an anesthetic solution does not contain a vasoconstrictor. Therefore, local anesthesia without vasoconstrictor was used in this study. The bleeding should be allowed to reach a level of 2-3 mm below the cement-enamel junction to avoid dentin pigmentation by blood clot. Inducing bleeding into the canal may result in the production of stem cells capable of initiating dentin development. The blood clot is intended to operate as a matrix for migratory responsive cells to adhere and differentiate to repair the pulp–physiological dentine’s functions complex. So, this treatment protocol was followed in revascularization group.

MTA barrier over the formed blood clot was used because the material possesses an excellent sealing ability. The coronal edge of the MTA should be placed 1-2 mm apical to the cement-enamel junction to allow more root development rather than 3-4 mm as described by Banchs and Trope. Therefore, MTA was placed 1-2mm apical to cement-enamel junction in the present study. Then pulp chamber was finally sealed using GIC filling to avoid any bacterial contamination to blood clot and MTA inside the canal during its setting time.

On the other hand, in apexification, ortho-grade MTA obturation in immature non-vital teeth apexification represents “primary monoblock” with successful outcome and aimed to strength the remaining thin dentinal walls. Therefore, complete canal obturation with MTA was followed in apexification group.

CBCT showed very high accuracy in dental diagnosis with extremely high sensitivity and specificity results that reach 100% for both. Different radiographic measures can be obtained from CBCT, most of these radiographic assessments are linear measures, the transforming from linear measures to quantitative measures has a strong interest. At research conducted by Elboraey et al., 46 the 3D volume assessment of CBCT was evaluated. The study showed accurate and promising results for using 3D volume measurement instead of linear measurement, which may be of value especially for the reproducible assessment of bone defect topography for research purposes.

Problem of image segmentation is a very challenging problem during obtaining quantitative measures from 3D radiographic modalities. Because of segmentation challenges, there is no definite strategy or algorithm for object segmentation was used by different software. Numerous software packages are available for analysing the three-dimensional data collected during the CT or CBCT scan procedure used for volumetric measurement. ITK-SNAP software is an easy-use, free, with reliable package for measuring and extracting radiographic volumes. ITK-SNAP depending on artifical intelligent allows different modalities for identifying and outlining for the structure of interest depending on automatic segmentation or semiautomatic segmentation or self-expert outlining of the radiographic object with the option of isotropic identification for the voxels from pixels selection, in turn these allow an accurate measurement of the volume of interest.

Although MTA apexification had been used successfully, many documented drawbacks, such as, lack of continued root development and it does not strengthen the remaining root structure. Revascularization allows continued root growth, which may reduce the risk of fracture and the permanent tooth loss associated with traditional apexification, thus the potential of regenerative...
endodontic as the treatment of necrotic immature teeth is strongly recognized.\(^\text{50}\)

The size of the apical foramen is critical, particularly for regenerative endodontic treatment of permanent teeth prior to completion root growth.\(^\text{43}\) In the present study, the younger age patients (7-7.5 years old) had wider incisors apical canal ends that allowing the more numbers of periapical stem cells for better success results of revascularization. Immature teeth’s root structure (e.g., open apex, large root canal, and thin radicular dentin walls) may facilitate connection between canal space and periodontal tissue in order to accomplish apical healing with periodontal tissue. The results of this study agreed with Fang et al.\(^\text{51}\) Revascularization seems more predictable when the apical diameter exceeds 1 mm and is unlikely to occur in apical apertures less than 0.3 mm in diameter.\(^\text{52}\)

In the present study, group I (revascularization) showed significant increase in dentin volume and decrease in pulp space volume from 40±14 mm\(^3\) and 16±14.6 mm\(^3\) to 73.5±40.2 mm\(^3\) and 9.3±7.7 mm\(^3\) respectively. The results of intergroup comparison were in favor of group I over group II (Apexification) which showed non-significant increase in both dentin volume and pulp space volume, these reflect optimal regenerative response from MTA at revascularization cases over the apexification, proved by closure of apical foramen, increase in the dentine and decrease of pulp space, while for apexification regeneration was showed by apical foramen closure and increase of the root length, and these may be the explanation for non-significant increase of both dentin and pulp space volumes.

The present study findings agreed with Bose et al.\(^\text{53}\) in which regenerative endodontic treatment with MTA and TAP produced significantly greater increases in root length and dentin wall thickness than (MTA) apexification group. Moreover, the present study results was in agreement with Chen et al.\(^\text{54}\), Jeruphan et al.\(^\text{55}\), Sarris et al.\(^\text{56}\) and Jung et al.\(^\text{57}\) reported a high success rate root canal revascularization with increased root lengthening and narrowing of the canals (apical closure), cure of apical periodontitis, and lack of clinical signs and symptoms.

The effect of periapical stem cells in enhancing the proliferation of cementoblast, odontoblast and osteoblast cells to form new deposited tissue inside and outside the root rather than resorption. Another explanation for this MTA is that it not only meets the ideal requirement of being bacteriostatic, but also creates a challenging environment for bacterial survival, resulting in less persistent disease. This was in agreement with these studies.\(^\text{6,58,59}\) On the other hand, it was in disagreement with Alobaid et al.\(^\text{57}\) and Chueh.\(^\text{60}\) This difference may be attributed to the use of CaOH paste medication and short follow-up periods (3, 6 months).

CONCLUSION

Both apexification and revascularization techniques showed significant root apex closure and root regeneration for immature permanent incisors with a preference to revascularization as it showed better results and was also easily and rapidly applied when compared to apexification.

REFERENCES


GEOMETRIC ROOT CHANGES FOLLOWING TWO DIFFERENT TECHNIQUES


