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CLINICAL AND CBCT COMPARISON OF MTA REVASCULARIZATION VERSUS APEXIFICATION FOR IMMATURE PERMANENT INCISORS

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ABSTRACT

Aim: Clinical and CBCT evaluation of the impact of MTA used by two different techniques (revascularization and apexification) in immature non-vital permanent incisors on root length, bone density around root apex and PDL space volume**.**

Material and methods: Immature permanent incisors with irreversible pulpitis or necrotic pulp were selected and randomly divided into 2 groups; revascularization group (Group I) and apexification group (group II). After complete rubber dam isolation, access opening was done for the selected incisor. 2.5% NaOCl then sterile saline and water were used for irrigation of pulp chamber with the same sequence. Triple antibiotic paste (TAP) was administered for root canal sterilization. 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: Revascularization and MTA apexification techniques resemble in all clinical criteria while different in bone density and PL space.

KEYWORDS: Apexification, Revascularization, MTA,3D Bone density, PDL space volume.

INTRODUCTION

One of the main challenges associated with endodontic treatment procedures includes the treatment of infected immature permanent teeth with wide canals, thin dentinal walls, and open apices. These characteristics of immature permanent teeth cause difficulty for the practitioner in instrumentation, determining the working length, and controlling irrigants and obturation materials[1].

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Apical width of the canal is also critical in management which often greater than the coronal canal diameter, making debridement difficult. Additionally, the absence of an apical stop results in root canal filling material extension, failure the seal of obturation extremely impossible in all directions. Finally, due to the root canal's thin, weak walls' proclivity for fracture, surgical treatment is often not a viable option[2,3,4].

Endodontically treated immature permanent teeth tend to have a poor long-term prognosis as they are more prone to fracture due to incomplete root development and weak dentinal walls[5].

American Association of Endodontists (AAE) in 2003 described apexification method 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[6,7].

MTA apexification does not improve the root strength, increase thickness of the root canal walls, or allow physiological apical closure, despite the advantage of fewer number of visits[1].

Another treatment supporting the ingrowth of tissues into the pulp canal space and root formation is known as revascularization. This treatment follows a customized disinfection technique that stimulates bleeding from the periapical tissues leading to a blood clot formation in the canal. This blood clot acts as a scaffold carrying stem cells and growth factors from the apical papilla to the pulp canal[1,4].

Clinical criteria are very important for evaluation, comparison between apexification and revascularization for traumatized or fractured teeth measuring Pain or discomfort, Tenderness to percussion, Mobility, Swelling and fistula[8].

Cone beam computed tomography (CBCT) underwent continuous improvement on image quality, increasing field of view and decreasing exposure dose, so CBCT became a good and highly reliable substitute for conventional CT in the utilized modality for radiographic examination of bone at the head and neck region[10-12].

Different software is provided for CBCT interpretation allowing rapid, easy, accurate, reliable, reproducible, and valid method for radiographic assessment. 3D volume radiographic assessment became an excellent and comprehensive substitute for linear assessment using CBCT. [12,13]

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. [14].

MATERIALS AND METHODS

This study employed a randomized controlled clinical trial design was done in Pediatric Dentistry Department Outpatient clinic, Faculty of Dentistry, Tanta University, Egypt.

The sample size was found to be N=12 upper incisors teeth (6 in each group) with extra 2 teeth to avoid sample attrition. The children (7-9 years old) teeth having irreversible pulpitis or necrotic immature permanent incisors. Teeth were examined clinically and radiographically using standardized parallel cone technique** of periapical x-ray (XCP: extention cone paralling)** at the start of the study then randomly divided into two groups.

Group assignment:

- Group I: "Study group" 6 teeth were treated with Pulp revascularization.

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* De Gotzen Varese Italy, 70 kVp.

** Dentsply Rinn, made in USA.

- **Group II**:" Positive control group" 6 teeth were treated with MTA apexification.

Inclusive 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 and Cooperative child. **While exclusion criteria**[15] included Simple carious lesions, Split 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 and Severe luxation injury**.**

Clinical examination was done to evaluate traumatized or fractured incisors for presence or absence of the following parameters: Pain or discomfort, Tenderness to percussion, Mobility Score[16] 0 = normal mobility, 1 = slight mobility, 2=sever mobility and Swelling or fistula.

CBCT was taken to measure the following criteria once at the start and the end of follow up period after 18 months:

- Mean of root length.
- Density of the bone surrounding the apex by H.U (Hounsfield Unit)[17].
- Periodontal ligament space volume.
- **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, the mean of four measurement was taken.
- **Density measurement:** Innovative use of a pre-existing feature in the Ondemand* software, which is bone density graph used during implant planning, through which bone density is measured in a three-dimensional manner from all directions around the virtual implant designed during implant planning. This method was used during this study by designing a virtual implant with the same dimensions of the apical third of the root in terms of length and width before treatment and fixing these dimensions during post measurement**.** Bone density is measured in three dimensions in all directions through the root at a constant depth of 2.5 mm in all directions before and after treatment.
- **Periodontal ligament space volume:** Using ITK-SNAP** software, Periodontal ligament space volume were measured from fixed reference point to the most apical point using the axial view depending on semi-automated option of self and isotropic voxel recognition of ITK-SNAP. Rechecking from coronal and sagittal view was done for dentin and pulp respectively.

Automatic calculation of the bone density and Pl space was done by the software.

Treatment Procedures:

First appointment

The tooth was isolated with a rubber dam after Local anesthesia was given using 2% Mepivacaine* then access opening done and debridement of coronal root third using hand stainless steel H-files[18]**.** Irrigation solution was 10ml. of 2.5% sodium hypochlorite (NaOCl) for 2-5 minutes[19] followed by sterile saline. Irrigation needle should be 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

* Ondemand 3D App project viewer, version 1, 2004-2017, U. S. cybermed Inc.

** ITK-SNAP version 3.8.0, Supported by the U.S. National Institute of Biomedical Imaging and Bioengineering.

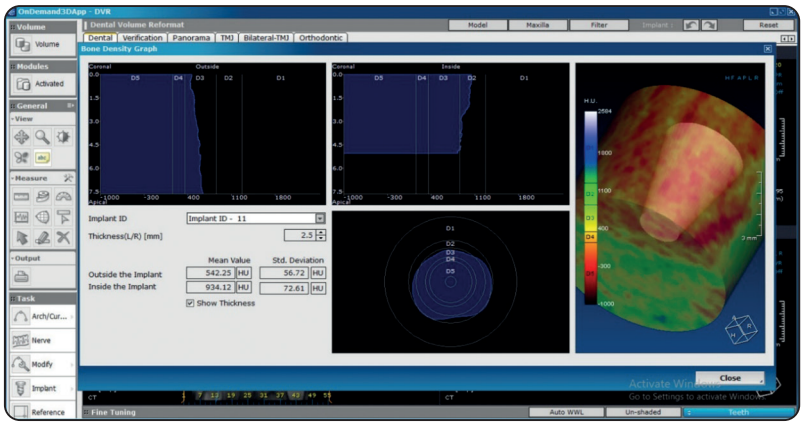


Fig. (1): 3D density measurement of the bone surrounding the apex by H.U using ondemand software.

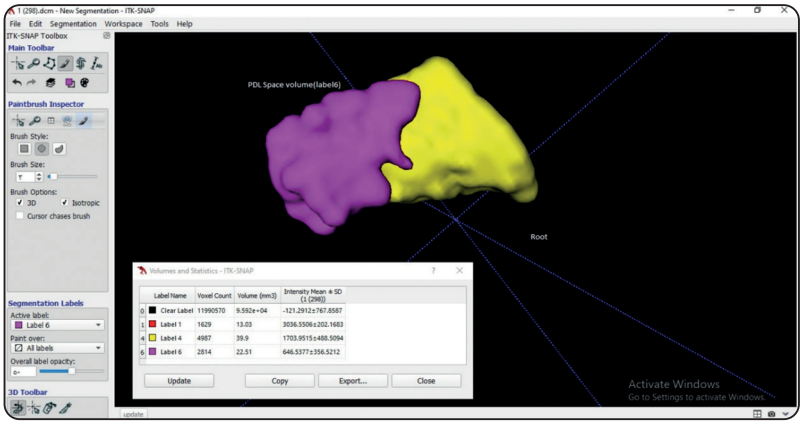


Fig. (2): PDL space volume measurement using ITK-SNAP software, PDL space (pink), root (yellow).

propylene glycol and Macrogol to form a creamy paste then inserted into the pulp chamber with a hand K- file and cotton pellet then cavity filled with Cavit temporary filling paste lifting for 2 weeks.

Second appointment

The tooth was anaesthetized using anesthetic solution without vasoconstrictor[19], a rubber dam isolation of the tooth was done and gentle removing of the temporary filling. The TAP paste was washed out by copious irrigation of root canal with 2.5% sodium hypochlorite[20], rinsing the canal with sterile saline and water. Then root canal was dried using sterile paper point size 80.

Group I: Pulp revascularization: Fig.3 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 2-3mm below the cement-enamel junction[21].The estimated mean time required to form a stable blood clot is 5-10 minutes [22]. 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[12].

Group II: MTA Apexification: Fig. 3 MTA paste was carried inside the canal to reach 2mm. shorter than the root end[23] using the applicator or hand K-file instrument covered with cotton for condensation to reach a level below the CEJ[23], each increment was vertically compacted using hand plugger**. Then wet cotton pellet was placed on MTA paste until initial setting occurs after filling.

* Pro-Root MTA; Dentsply Tulsa Dental Specialties, Tulsa, OK, USA

** Dentsply, USA.

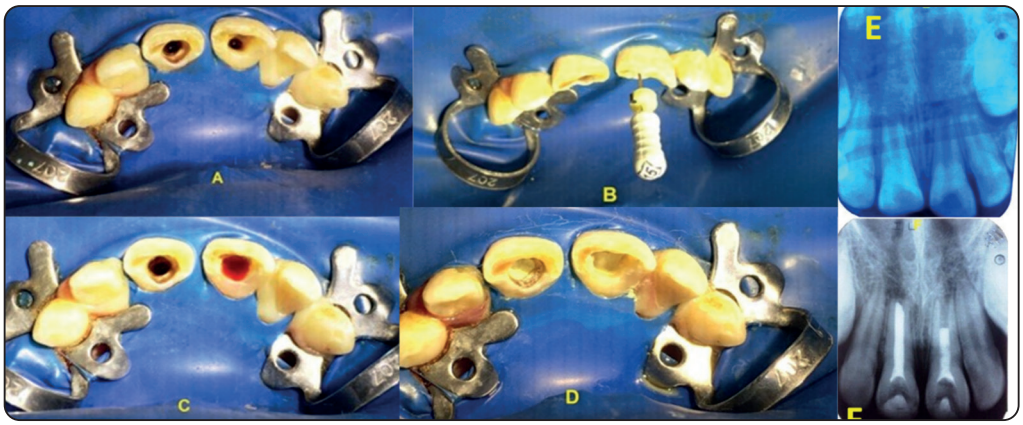


Fig. (3): A: Access opening done in upper bilateral traumatized immature centrals incisors. B: Bleeding enhancement by K File # 15 in upper left central incisor. C: Blood clot formed in upper left incisor. D: MTA condensed over the blood clot in upper left central incisor and MTA apexification in upper right. E: Preoperative x-ray film. F: Postoperative MTA 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 clinically and 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 study 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.

Clinical evaluation for group I and II.

When comparing between group I and II in terms of pain and discomfort, results revealed that, there was no statistically significant differences between two groups during follow up periods recording *P*-values of 0.309 at 3,6,9 months, 0.541 at 12 months and 0.067 at 15 and 18 months follow up periods as shown in table 1 and graph 1. Regarding tenderness on percussion, comparison was done between the two groups revealed no statistically significant differences at all follow up periods recording *P* -values 0.309 at 3,6,9 months, 1.0 at 12 months and 0.065 at 15,18 months follow up periods as shown in table 2.

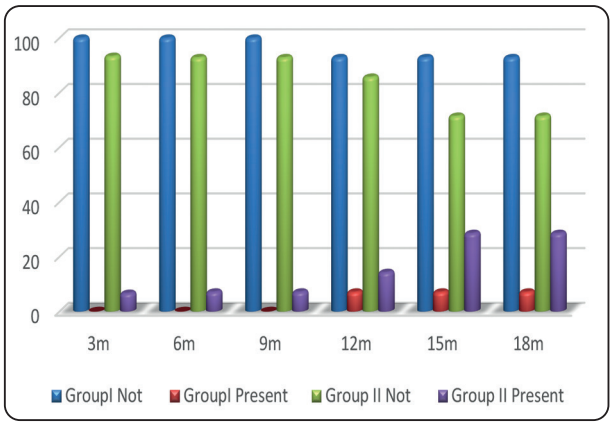
The mobility scores (0=not, 1=grade 1 mobility and 2=grade 2 mobility) were examined and compared during recall periods, there was no statistically significant difference between two groups at all follow up periods recording *P* -values 0.309 at 3,6,9,12 months and 0.280 at 15 and 18 months follow up periods as shown in table 3.

At baseline the two treatment groups showed nonsignificant differences regarding the parameters namely, PDL space volume, 3D bone density, root

length. This was evidenced by their baseline values as shown in table (4) as $p>0.05$.

Group I (Revascularization):

Results presented significant increase of in the mean value of root length in from 11.2 ± 1.7 mm to 12.6 ± 1.5 mm and significant decrease of PDL space volume from 53.3 ± 57.9 mm^3 to 8.7 ± 7.1 mm^3 as $p < 0.05$. While the results showed a increase of bone density from 484 ± 86.6 HU to 596.6 ± 127.5 HU but not statically significant increase as shown in table (4).



Graph (1): Bar chart comparison in pain and discomfort between two groups at recall follow up periods.

1- Pain or discomfort

TABLE (1): Shows the pain, discomfort comparison between two groups at follow up periods.

Groups	Group I		Group II		P value
Pain. Discomfort	**0**	**1**	**0**	**1**	
3m	100%	0%	93.33%	6.67%	**0.309**
6m	100%	0%	92.86%	7.14%	**0.309**
9m	100%	0%	92.86%	7.14%	**0.309**
12m	92.86%	7.14%	85.71%	14.29%	**0.541**
15m	92.86%	7.14%	71.43%	28.57%	**0.067**
18m	92.86%	7.14%	71.43%	28.57%	**0.067**

(0 = Not & 1 = Present)

2- Tenderness on percussion

TABLE (2): Shows tenderness on percussion comparison between two groups at follow up periods.

Groups	Group I		Group II		P value
Tenderness on percussion	**0**	**1**	**0**	**1**	
3m	100%	0%	93.33%	6.67%	**0.309**
6m	100%	0%	92.86%	7.14%	**0.309**
9m	100%	0%	92.86%	7.14%	**0.309**
12m	92.86%	7.14%	92.86%	7.14%	**1.0**
15m	92.86%	7.14%	64.29%	35.71%	**0.065**
18m	92.86%	7.14%	64.29%	35.71%	**0.065**

(0 = Not & 1 = Present)

3- Mobility scores

TABLE (3): shows the mobility score comparison between two groups at follow up periods.

Groups	Group I			Group II			P value
Mobility	0	1	2	0	1	2	
3m	100%	0%	0%	93.33%	6.67%	0%	**0.309**
6m	100%	0%	0%	92.86%	7.14%	0%	**0.309**
9m	100%	0%	0%	92.86%	7.14%	0%	**0.309**
12m	100%	0%	0%	92.86%	7.14%	0%	**0.309**
15m	100%	0%	0%	78.57%	21.43%	0%	**0.280**
18m	100%	0%	0%	78.57%	21.43%	0%	**0.280**

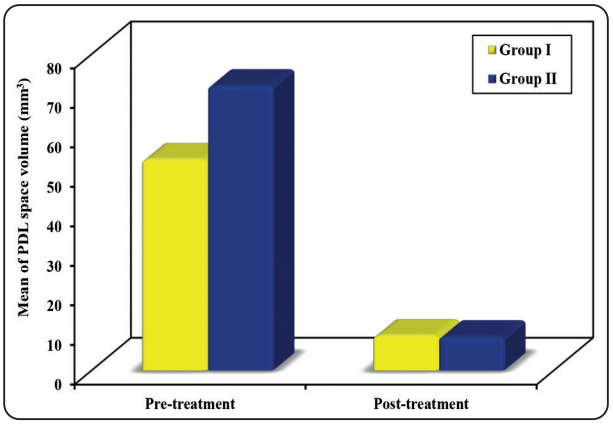
(0 = Not & 1 = Grade 1 & 2 = Grade 2)

Group II (Apexification):

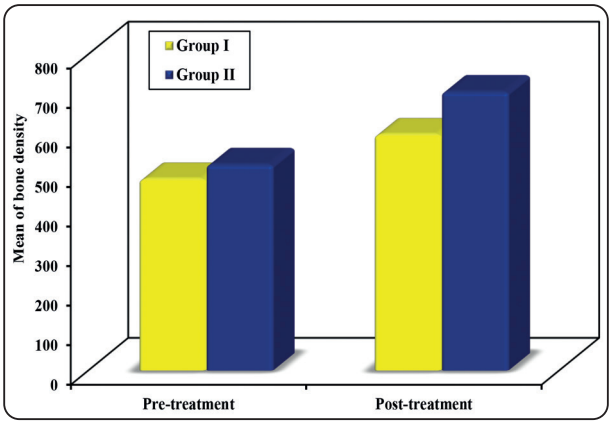
Results presented non-significant increase of in the mean value of root length in from 12.3 ± 1.4 mm to 12.7 ± 1.7 mm and significant decrease of PDL space volume from 72 ± 49.6 mm^3 to 8.5 ± 7 mm^3 as $p < 0.05$. While the results showed a significant increase of bone density from 521.4 ± 121.1 HU to 705.4 ± 73 HU as shown in table (4).

Intergroup comparison:

While not statically significant, the results showed increase of bone density and decrease of PDL space volume in the favor of group II (Apexification), but also showed non-significant increase of the mean value of root length in the favor of group I (Revascularization) as shown in table 4.



Graph (2): Comparison between the two studied groups according to Mean of PDL space volume.



Graph (3): Comparison between the two studied groups according to Mean of bone density.

TABLE (4): Comparison between the two studied groups according to Mean of root length, PDL space volume and bone density

		Group I (n = 9)	Group II (n = 6)	Test of Sig.	p
Mean of root length	Pre-treatment				
	Mean ± SD.	11.2 ± 1.7	12.3 ± 1.4	t=	0.194
	Median (Min. – Max.)	10.8 (9.5 – 14.4)	12 (10.5 – 14)	1.370	
	Post-treatment				
	Mean ± SD.	12.6 ± 1.5	12.7 ± 1.7	t=	0.924
	Median (Min. – Max.)	12.5 (9.9 – 14.6)	12.5 (10.9 – 14.9)	0.097	
	t0 (p0)	2.964* (0.018*)	1.741 (0.142)		
PDL Space volume (mm3)	Pre-treatment				
	Mean ± SD.	53.3 ± 57.9	72 ± 49.6	U=	0.456
	Median (Min. – Max.)	27.2 (5.9 – 185.1)	65.2 (17.5 – 134.3)	20.00	
	Post-treatment				
	Mean ± SD.	8.7 ± 7.1	8.5 ± 7	U=	0.864
	Median (Min. – Max.)	7 (1.5 – 24.5)	5.3 (4.5 – 22.5)	25.50	
	Z (p0)	2.310* (0.021*)	2.201* (0.028*)		
Bone Density	Pre-treatment				
	Mean ± SD.	484 ± 86.6	521.4 ± 121.1	t=	0.495
	Median (Min. – Max.)	486.3 (326 – 604.3)	492.5 (403 – 713.3)	0.702	
	Post-treatment				
	Mean ± SD.	596.6 ± 127.5	705.4 ± 73	t=	0.082
	Median (Min. – Max.)	573 (347.9 – 772)	725 (617.6 – 793)	1.881	
	t0 (p0)	2.107 (0.068)	3.027* (0.029*)		

SD: Standard deviation ***t: Student t-test*** ***U: Mann Whitney test***

t0: Paired t-test ***Z: Wilcoxon signed ranks test***

p: p value for comparing between Group I and Group II

p0: p value for comparing between Pre-treatment and Post-treatment in each group

****: Statistically significant at p ≤ 0.05*** ***Group I: Revascularization*** ***Group II: Apexification***

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[24].

The procedure of revascularization uses manual instruments and auxiliary chemical substances that are followed by final coronal restoration. This procedure renders recovery of the pulp vitality through continuous root development for immature necrotic teeth, with biological means; contrary to the artificial apical barrier techniques[1]. Nagata *et al*. presented the significance of revascularization as a valid treatment option for an immature necrotic tooth. The results depicted successful treatment outcome in the treatment of an immature tooth with periapical lesion as the tooth was presented asymptomatic and lesions resolved clinically and radiographically. These results clarified the fact that revascularization plays a significant role in the thickening of the dentin walls which prevents tooth weakening and fracture[25].

Another similar study conducted by Shah *et al*. assessed the efficacy of revascularization of infected immature teeth. The results showed that none of the individuals complained of pain, enlargement of preexisting apical pathology, or reinfection, representing a favorable outcome of revascularization[26]. These results were consistent with the present study as it showed complete healing after revascularization treatment of upper central incisors. Moreover, the patient was asymptomatic for 1.5 years after undergoing revascularization.

MTA presents a higher long-term success rate because it avoids several of the disadvantages of standard calcium hydroxide apexification methods, such as reduced treatment time and patient visits, and prompt restoration of the tooth, which results in a decreased risk of fracture[27] and a boost in patient compliance[28] 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[29]. 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.[24]. 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 [30] 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[31]. 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[32]. The AAE recommends the use of as low a concentration of sodium hypoclorite irrigant as possible due to the possibility of its extrusion through the open apex causing cytotoxicity to the apical stem cells[33]. 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[34]. 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[32].

Pulp revascularization is more advantageous in a bacteria-free environment, which demands that the root canal system be cleansed prior to cell colonisation[31]. As in recent investigations, canal decontamination is accomplished by applying disinfecting solutions without the use of typical mechanical instrumentation.[4,35,36]. On the other hand, the present study disagreed with Alobaid et al[35] 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 [34]. However, Hoshino et al[37] 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.[38].

Despite the promising results of TAP, there are Some adverse effects, such as darkening of the crown, are caused by the presence of minocycline[34]. Some authors suggested replacement of the minocycline with amoxicillin, cefaclor or clindam[39]. Therefore, modified TAP consisted of metronidazole, ciprofloxacin and amoxicillin was used in this study[40]. Dressing with TAP intra canal medication left for two - three weeks to complete canal disinfection and maintain stem cells vitality[34]. Therefore, intracanal 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[31]. 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[41].

Inducing bleeding into the canal may result in the production of stem cells capable of initiating dentin development[31]. 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[4,31]. 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[41,42]. 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[43]. 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[41].

On the other hand, in apexification, orthograde MTA obturation in immature non-vital teeth apexification represents "primary monoblock" with successful outcome[23] and aimed to strength the remaining thin dentinal walls. Therefore, complete canal obturation with MTA was followed in apexification group.

This study evaluated the outcomes of both revascularization and apexification treatments based on clinical evaluation criteria. Regarding revascularization group, the clinical evaluation results revealed absence of pain/ discomfort, tenderness to percussion and swelling/fistula in 92.8% while absence of mobility was 100%. While in MTA apexification revealed absence of pain/ discomfort in 71.4%, absence of tenderness to percussion was 64.2% with healing of swelling/ fistula and absence of mobility was 78.5%. These results may be explained by the effect of modified TAP in canal disinfection, effective ortho-grade mono-block of MTA material, proper GIC filling sealing which prevent any bacterial invasion to canal orifice[8].

CBCT showed very high accuracy in dental diagnosis with extremely high sensitivity and specificity results that reach 100% for both[44], 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.,[44] 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[45].

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 a easy-use, free, with reliable package for measuring and extracting radiographic volumes, ITK-SNAP depending on artifical intelligent allows different modalities for identifing and outlining for the structure of interest depending on automatic segmentation or semiautomatic segmentation or self-expert outlining of the radigraphic 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[14,46].

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[47].

Prominent increase in bone density around the root apex in apexification group was more than in revascularization group and this may be attributed to close contact of MTA to the high active periapical stem cells around the root apex for differentiation into cementoblast, odontoblast and osteoblast cells that could lead to more tissue deposition around the root apex. This result agreed with the findings of several studies[48,49].

The size of the apical foramen is critical, particularly for regenerative endodontic treatment of permanent teeth prior to completion root growth [41]. 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[50]. 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 [51].

In the present study the strength of 2 different root canal contents between root filling materials in MTA apexified teeth and biological tissues in revascularized teeth including cementum like tissue, bone like tissue, and periodontal tissue filling the root canal with MTA did not provide additional strength to the immature root after apexification[52]. However, whether further root development with biological tissues in the root canal after revascularization can increase the strength of the root against future fracture[53].

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[47,54,55]. On the other hand, it was in disagreement with Alobaid et al[35] and Chueh[56]. This difference may be attributed to the use of CaOH paste medication and short follow-up periods (3, 6 months).

In revascularization and apexification, the periodontal ligament space was decreased from start to end follow up period around normal level which could be explained by normal tissue deposition around the root surface and vital remaining Hertwig epithelial root sheath (HERS) that allow normal new periodontal tissue attachment with normal occlusion function forces and this was in agreement with several studies[41,50,57].

CONCLUSION

Both apexification and revascularization techniques showed non-significant clinical criteria changes while significant increase in bone density and decrease in PL space for immature permanent incisors performance.

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