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Radiographic Evaluation of Bioceramic Root Repair Versus Bio-MTA in Revascularization of Immature Young Permanent Teeth

Reda Mohammed Elsayed[1], Mohammed Abo-Elmaaty Mohammed[2], Ahmed Safaa Mohammed kamel[3].

[1] Assistant Lecturer of Pedodontics and Oral Health Department, Faculty of Dentistry, Al-Azhar University, Assiut Branch, Egypt.
[2] Professor of Pedodontics and Oral Health Department, Faculty of Dentistry (Cairo, Boyes), Al-Azhar University, Egypt.
[3] Associate Professor of Pedodontics and Oral Health Department, Faculty of Dentistry, Al-Azhar University, Assiut Branch, Egypt.

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Abstract

Aim: This randomized clinical trial (RCT) evaluated the benefits of two bioceramic cements (Bioceramic Root Repair and Bio-MTA) as coronal plug substances used for the revascularization of non-vital, immature, permanent teeth having apical periodontitis from a radiographic perspective. **Subject and Methods:** This RCT comprised twenty-eight non-vital immature permanent teeth having apical periodontitis in children aged seven to twelve. According to the coronal plug substances utilized, samples were randomly assigned to two groups: group I was Bioceramic Root Repair, and group II was Bio-MTA (mineral trioxide aggregate) (n = 14). For one year, the radiographic follow-up was caried out to assess the degree of effectiveness and measure alterations in the root length, root dentine thickness, and periapical lesion resolution. **Results:** For every individual studied group, there was a significant raise in dentin wall thickness and root length over time, nevertheless, the differences amongst both examined groups were not statistically significant ($P > 0.05$). Furthermore, following one year of therapy, the preapical lesion size significantly decreased in all patients; nevertheless, there was statistically nonsignificant variations amongst both research groups ($P > 0.05$). **Conclusions:** The revascularization of young permanent teeth having necrotic pulps and apical periodontitis may be possible with bioceramic cements as coronal plug materials.

Keywords: Bio-MTA, Bioceramic, Root Repair, Revascularization, Radiographic, Immature Permanent Teeth.

Introduction

Immature permanent teeth are those that have erupted but have not yet developed an occlusal connection or reached full morphological and structural maturity. Their traits include a trumpet-shaped apical foramen, short clinical crown, broad pulp cavity, thin tooth hard tissue, and short root (1). Endodontists have a significant problem when dealing with permanent immature teeth that have necrotic pulp and periapical lesion since these teeth's root canal area is challenging to clean and prepare using standard endodontic files. Root canal filling may create extra difficulties since the open apex lacks an apical barrier (2, 3). A crucial component of pulp revascularization is ensuring a coronal seal, which is usually accomplished using biocompatible material like MTA, which is preferred by 85% of clinical trials (4, 5).

A number of therapeutic approaches, including apexification with MTA or non-vital pulp therapy using calcium hydroxide, have been reported to address immature teeth [6]. However, these methods had certain disadvantages, for example, because the hard tissue barrier only develops at the apical area and prevents further root growth, the roots continue to have short and thin walls, even though they successfully healed the apical pathosis and achieved apical closure [7].

Several biocompatible materials were suggested to use for the regeneration processes [8]. Conventional MTA was first presented as a cement based on calcium phosphate, or as a hydraulic calcium silicate cement [9]. MTA was considered the gold standard regenerative material because it creates a superior seal, it was thought to be the best material to use over a blood clot during regeneration operations [10]. However, the conventional MTA was technically difficult to apply since the conventional MTA material was shifted apically throughout condensation procedures [11, 12]. Following treatment, tooth discoloration was noted along with to the prolonged setup time seen in a number of MTA devices [4].

In order to improve its qualities, Bio-MTA, a new generation of traditional MTA, has undergone several chemical changes. Because bismuth oxide, which was utilized in earlier MTA modifications, has adverse consequences, calcium tungstate is utilized as the radiopaque element in Bio-MTA [13, 14]. Additionally, this product's liquid contains organic plasticizer, which may be crucial for handling this substance. Furthermore, excellent chemical, physicochemical, and bactericidal qualities were shown by this substance [15].

Premixed bioceramic cement is thought to be the best alternative to MTA because of its superior antibacterial activity, sealing ability, biocompatibility, and physicochemical interactions with the local environment [8, 16]. Moreover, hard tissue restoration and pulpal regeneration are two typical endodontic procedures that employ Bioceramic [17, 18]. The putty Bioceramic cement (such as Bioceramic Root Repair) sealer formula was reported to have the potential to prevent mixing-related mistakes [15, 19]. According to a previous study, any variation or mistake in the ratio of powder to liquid during mixing may have an impact on the materials' physicochemical characteristics and setting time [15]. Premixed bioceramic cement is therefore crucial for the coronal seal in pulp revascularization of non-vital, immature teeth, and for radiographic and clinical assessment [14].

Typically, the root of young permanent teeth can gradually expand and complete within the first three to five years following the emergence of permanent teeth [1, 20]. For regenerative endodontics, pulp-capping chemicals that can stimulate the formation of new tissue are still necessary, despite significant advancements in the cytocompatibility of ceramic biomaterials. Comparing the efficacy of Bioceramic root healing material and Bio-MTA for revascularizing immature young permanent teeth was the aim of the current clinical investigation.

Subject and Methods

With a 1:1 allocation ratio and authorization code (745/1203), the protocol for this parallel, double-blinded (patients and assessors) randomized clinical study was authorized by the Research Ethics Committee of Al-Azhar University's Faculty of Dentistry (Assiut Branch). The research has been submitted to clinicaltrials.gov with the title Clinical and radiographic assessment of Bioceramic Root Repair vs. Bio-MTA in revascularization of immature young permanent teeth (NCT06630156).

Children aged between 7 and 12 years from both genders with 28 necrotic immature permanent teeth that required endodontic therapy were chosen to take part in this RCT from the Pedodontics and Oral Health Department Outpatient Clinic at Al-Azhar University's Faculty of Dentistry (Assiut Branch).

Following a screening by department staff, patients were forwarded to the lead investigator (A.S.) to ensure the involved teeth met the eligibility requirements that include; restorable permanent teeth whose roots are shorter than their crowns and having open apex as well as short roots, patient is not taking antibiotic and has not taken for the past 2 weeks. However, tooth with vital pulp, complete root formation, draining sinus, periodontal weak mobile teeth, or with root fracture or internal and/or external root resorption were excluded [4, 21].

When the lead investigator (A.S.) determined that the child was eligible for the research, the guardian of the enrolled children gave verbal approval and later accepted the clinical procedures by signing an official informed consent form that was translated into Arabic after they were informed about the trial's procedures, benefits, and potential risks. All patient data files were stored in places that only certain people could access. In order to protect the participants' civil rights and privacy, data collection and administrative files coded and numbered the patients rather than utilizing their names or other personally identifiable information in the records.

For this study, a sample size of 14 per group was established using a two sample, two tail t-test. Based on the outcomes of a prior research by Alobaid et al., the effect size (dz=1.929) and the required sample size were calculated with a 95% confidence interval and a confidence power of 0.5, assuming a normal distribution [21]. Using the website http://www.random.org/ to generate a random sequence in two columns, the involved teeth were randomly divided into 2 equivalent groups (n=14) according to the type of revascularization material with a 1:1 allocation ratio: group A consisted of teeth that had been cleaned with triple paste and treated with Bioceramic Root Repair material (intervention group); and group B consisted of teeth that had been cleaned with triple paste and treated with Bio-MTA material (control group).

Before treatment clinical by autoclavable dental mirror and a dental sickle probe, and radiographic examination by intraoral digital X-ray sensor (Vatech Ez sensor, Gyeonggi-do, Republic of Korea) utilizing a standardized paralleling approach were performed (Figure 1).

Preparing teeth for revascularization operations

On a dental chair, a postgraduate student (R. M.E.), carried out the clinical operations. Children were given a local anesthesia (3% mepivacaine and vasoconstrictor, Alexandria Co. for Pharmaceutical. Alexandria, Egypt). The involved teeth were isolated using a rubber dam (Flexi Dam, Coltene Roeko, Cuyahoga Falls, OH, USA), and any decay were removed and access cavity was prepared using a round diamond and an Endo-Z bur (Figure 2-a). The diagnosis of pulp necrosis was supported by the lack of hemorrhage [4, 22]. Preapical radiography was used to determine the working length [4]. The lightly irrigation of the pulp chamber and root canal were done by 20 mL of 1% NaOCl “sodium hypochlorite” (Clorox Co, 10th of Ramadan, Egypt) for about 5 minutes, afterword 20 mL of normal saline solution (NSS, FIPCO, Alexandria, Egypt) for about 5 minutes without mechanical instrumentation where an irrigating needle located 1 mm shorter from the root apex [4]. Then, sterile paper points were utilized to dry the root canals (Dia Dent, Chungcheongbuk-do, Korea).

Then, an inter-visit prescription for triple antibiotic paste that contains 500 mg ciprofloxacin and 500 mg cefaclor (European Egyptian Pharm. Ind, Alexandria, Egypt), 500 mg metronidazole (Aventis, Cairo, Egypt), (1:1:1) was inserted within the apical part using a syringe that was 2 mm less than the working length into the root canal of the canal and filled to right beneath the cemento-enamel junction (CEJ) (Figure 2-b). Since the triple antibiotic paste mix had to be prepared anew, all of the leftover mixture was disposed of [4]. The access cavity was sealed by dry sterile cotton and temporarily restored with 2 mm of glass ionomer cement (GIC) (Fuji IX, GC, Tokyo, Japan) as intermediate restorative material (IRM) and the patient received a four-week dismissal [4].

Techniques for revascularizing teeth

The same postgraduate operator evaluated the patient's reaction to therapy after four weeks. Success was said to have occurred when all indications and symptoms, such as discomfort, swelling, and sinus or fistula, completely disappeared. The children received a local anesthesia, their teeth were isolated using a rubber dam, and the temporary dressing was removed [4]. Sterile NSS was used to lightly wash the antibiotic paste outside of the canal when the access was reopened. A generous amount of soft irrigation using 10 milliliters of 17% EDTA solution (Prevest Den, Jammu, India). Following the measurement of canal dryness using size 45 paper points, hemorrhage was introduced into the root canal by turning a pre-curved sterile K-file (Mani Inc., Japan) 2 mm past the apical foramen, with the goal of filling the canal with blood all the way up to the CEJ [4]. To allow a blood clot to develop, a dry sterile cotton pellet was inserted into the canal at a depth of no more than 3–4 mm and left there for 7–10 minutes [4].

In Group A, the clot was carefully covered with 3–4 mm of Bioceramic Root Repair material, and in Group B, amalgam carrier was used to apply 3–4 mm of white Bio-MTA over the clot. For the coronal seal, the two materials were gently condensed with a moistened cotton pellet, and the access hole was temporarily shut with GIC [4]. The access cavity was permanently restored using resin composite.

Monitoring and assessment

Upon completion of the second appointment, a post-operative radiograph was acquired for each group utilizing a standardized paralleling approach using the radiographic stent, charge-coupled device size 1 imaging sensor, and ZT-Dental x-ray sensor holder [4]. The radiographic outcomes (root lengthening, root thickness, and periapical radiolucency) were evaluated following 3-, 6-, and 12-months periods of follow-up calls.

Radiographically, the root lengthening was measured in millimeters and percentage by image J software. From the CEJ to the tooth's radiographic apex, the root length measures were taken in a straight line in millimeters using image J software system (Figure 3). The following is an evaluation of the growth in root length (mm): based on the measurement of the root length between the pre-operative and 3,6, or 12-month follow-up images [4, 23]: Length increase in millimeters equals pre-operative root length minus 3,6, or 12-month follow-up root length. The following method was used to evaluate the lengthening of the roots [4, 23]: The percentage of length variation is calculated as follows: 12-month follow-up root length - pre-operative root length ×100.

However, with the occlusal, middle, and apical levels of the tooth, the root thicknesses and pulp diameter have been calculated on an identical fixed point (Figure 4). The pulp area was subtracted from the whole root thicknesses at an identical fixed point to determine the root dentine thicknesses at every point. The readings were subsequently averaged to determine the whole root dentine thicknesses in the following way: (occlusal root thickness — occlusal pulp width) + (central root thickness — central pulp width) + (apical root thickness — apical pulp width)/3. Calculations were used to determine the thickness differential and the growth in root dentine thicknesses [14].

Furthermore, the pointer was used to delineate the periapical radiolucency contour indicative of periapical lesions, and the data were automatically translated to square millimeters (mm^2) (Figure 5). Measurements of the periapical lesion's region were made before and after surgery, and the variance between the two was computed, followed by the area's percentage alteration [14].

Statistical analysis

The normality assumption of age was checked according to the Shapiro-Wilk Test ($\alpha=0.05$). Standards such as mean and standard deviation (SD) were used to describe quantitative data. The significant differences in the quantitative data were assessed using the t-test or Mann-Whitney U test. Frequencies and percentages were used to characterize qualitative data. To evaluate the significant differences between the qualitative data, the chi-square (χ^2) test was employed. $P \leq 0.05$ is the significance threshold. statistical analysis was caried out utilizing SPSS® (SPSS, Inc., an IBM Co., Armonk, NY, USA).

Results

The result of comparison of age and gender between Bioceramic Root Repair group and Bio-MTA group revealed that there was statistically insignificant variation amongst both groups according to the statistical results of independent t-test (Table 1).

The result of comparison of the change in the root length in mm regarding the time for Bioceramic Root Repair material as well as Bio-MTA material revealed that the root length in the Bioceramic Root Repair material as well as Bio-MTA material was significantly increase with time (3 months,6 months, and 12 months) (Table 2).

Moreover, the result of comparison of the root length in mm regarding the material between Bioceramic Root Repair material and Bio-MTA material revealed that there was statistically insignificant variation amongst both groups at the baseline as well as following 3 months, 6 months, and 12 months, however, the Bioceramic Root Repair material had the insignificantly higher mean root length value when compared with Bio-MTA (Table 3).

However, the result of comparison of the change in the root length in mm regarding the time between Bioceramic Root Repair group and Bio-MTA group revealed that there was a statistically significant variation amongst both groups at 3 months and at 6 months according to the statistical results of the Mann-Whitney U test, as well as at 12 months according to the statistical results of independent t-test, and the Bioceramic group had the significantly higher root length change value when compared with Bio-MTA after 3,6, and 12 months (Table 4).

The result of comparison of the root dentine thickness in mm regarding the time for Bioceramic Root Repair material as well as Bio-MTA material revealed that the root dentine thickness in the Bioceramic Root Repair material as well as Bio-MTA material was significantly increase with time (3 months,6 months, and 12 months) (Table 5).

Moreover, the result of comparison of the root dentine thickness in mm regarding the material between Bioceramic Root Repair material and Bio-MTA material revealed that there was statistically insignificant variation amongst both groups at the baseline as well as after 3 months, and 6 months, however, the Bioceramic Root Repair material had the significantly higher mean root dentine thickness value when compared with Bio-MTA after 12 months (Table 6).

Furthermore, the result of comparison of the change in the root dentine thickness in mm regarding the time between Bioceramic Root Repair group and Bio-MTA group revealed that there was a statistically insignificant variation amongst both groups at 3 months and at 6 months, however, the results showed that the Bioceramic Root Repair group had the significantly higher root thickness change when compared with Bio-MTA after 12 months according to the statistical results of the Mann-Whitney U test (Table 7).

The result of comparison of the change in the preapical lesion dimension in mm regarding the time for Bioceramic Root Repair and Bio-MTA materials revealed that there was a statistically significant variation amongst baseline preapical lesion dimension when compared with 3 months, 6 months, and 12 months and the preapical lesion dimension in the Bioceramic Root Repair and Bio-MTA materials was significantly decrease with time according to the statistical results of dependent t-test (Table 8).

The result of comparison of the preapical lesion dimension in mm between Bioceramic Root Repair group and Bio-MTA group revealed that there was statistically insignificant variation amongst both groups according to the statistical results of independent t-test at the baseline as well as after 3 months, and 6 months, however, the Bioceramic Root Repair group had the significantly lower mean preapical lesion dimension value when compared with Bio-MTA after 12 months (Table 9).

The result of comparison of the change in the preapical lesion dimension in mm regarding the time between Bioceramic Root Repair group and Bio-MTA group revealed that there was a statistically insignificant variation amongst both groups at 3 months according to the statistical findings of the Mann-Whitney U test as well as at 6 months and 12 months according to the statistical results of the independent t- test (Table 10).

Discussion

This trial chose a 12-month radiographic follow-up term because the AAE recommended a follow-up time spanning between six months and one year to track the resolution of apical radiolucency and 12–24 months to follow the growth in root wall breadth and length [14].

In this investigation the root length was investigated because it was reported that one of the most frequent issues with traumatized teeth is insufficient root growth, which occurs two years following the tooth emerges into the oral cavity [4, 14]. Moreover, in this study the dentine wall thickness was investigated because it was found that a root with weak dentinal walls develops when the pulp's vitality is lost before dentin deposition is fully completed, which raises the risk of root fracture [4, 14].

Since mechanical preparation might additional damage the delicate and thin dentin walls, without instrumentation operations were carried out in this trial. Moreover, the latest American Association of Endodontists (AAE) guidelines for revascularization treatments do not encourage the use of mechanical instrumentation [14, 24]. Moreover, in this investigation, 1.5% was used as the irrigation concentration due of the significant reduction in stem cell viability that higher concentrations of NaOCl solution induce [25, 26].

Triple antibiotic paste was used as a treatment in this RCT because it has been demonstrated to be effective in cleaning necrotic root canals [24, 27]. Moreover, in order to protect stem cells from the apical papilla, a dose of 5 mg/mL was administered [14].

In order to reduce the chance of insufficient intra-canal bleeding, the anesthetic was administered without the use of a vasoconstrictor during the second visit [24]. Subsequently, the superficial dentin layer was treated with 17% EDTA solution as a conditioning technique because of its demineralizing impact, which releases growth factors and removes the smear layer [28]. In order to generate a cross-linked fibrin meshwork that functions as a biological scaffold and contains vital growth factors for the migration, proliferation, and differentiation of endogenous stem cells, bleeding was artificially generated into the root canal [29, 30].

After 12-month of radiographic follow-up, there were statistically insignificant variations in the dentin wall thickness changes amongst both groups in this RCT. This is likely due to the similar osteogenic/dentinogenic properties of tricalcium silicate-based cement and calcium aluminosilicate cement [31]. The success of both of Bioceramic Root Repair and Bio-MTA groups in this investigation could be attributed to the fact that the both coronal plug materials were bioactive, biocompatible, noncytotoxic, and antimicrobial comes into direct contact with the blood clot [32].

The AAE recommended an interval of follow-up of 6–12 months to monitor the resolution of apical radiolucency and 12–24 months to monitor the growth in both the breadth and length of the root wall [14] . This may have contributed to the lack of statistically significant variations amongst both groups in terms of the preapical lesion diameter, dentin wall thickness, and root length after follow-up for 6 months in this investigation.

The outcomes of this RCT, Wikström et al. [33] and Shaker et al. [14] demonstrated insignificant increase in root width, while employing MTA or premixed bioceramic putty (calcium silicate based) in revascularization. This may be explained by the fact that Bio-MTA guarantees superior handling compared to powder-liquid materials and has better physical and chemical qualities than standard MTA [8].

The finding of this RCT showed that there was significant increase in root length and dentine wall thickness in both tested groups with time as well as significant preapical lesion dimension decrease with time for Bioceramic and Bio-MTA groups. This is likely due to the osteogenic/dentinogenic properties of tricalcium silicate-based cement and calcium aluminosilicate cement [31] as well as due to the antimicrobial activity and biocompatibility of the both groups [14].

Moreover, between the two groups, there was statistically insignificant variation in the percentage of lesion dimension reduction ($p > 0.05$). This could be as a result of the uniform cleaning techniques and the strong coronal seal that both materials were able to achieve [4]. These results were consistent with a large body of prior research reporting considerable clearance of apical lesions in revascularization operations using immature teeth and premixed bioceramic putty (based on calcium silicate) and MTA [34, 35].

Limitations

Limitation of this investigation include; patients that meet the mentioned criteria are harder to find, small sample size, and the 12-month follow-up time in the trial might not be long enough to evaluate the whole spectrum of regeneration results.

Conclusions:

When utilized in the revascularization process, both of Bioceramic Root Repair and Bio-MTA cements demonstrated acceptable clinical and radiographic outcomes. A longer follow-up time would offer important information on the stability and long-term effectiveness of pulp revascularization.

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List of Figures

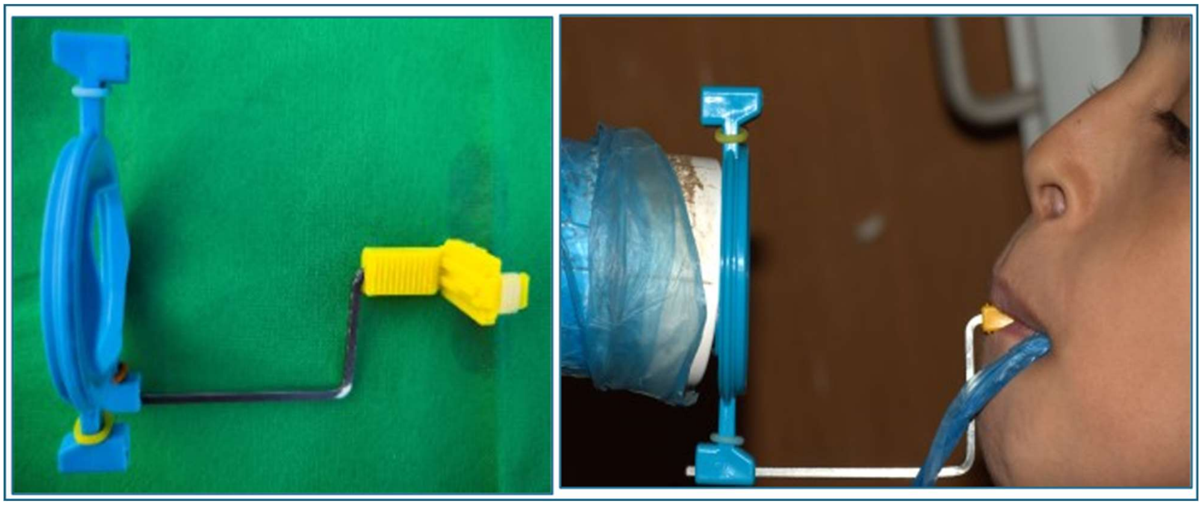

Figure (1): ZT-dental x-ray sensor positioning system

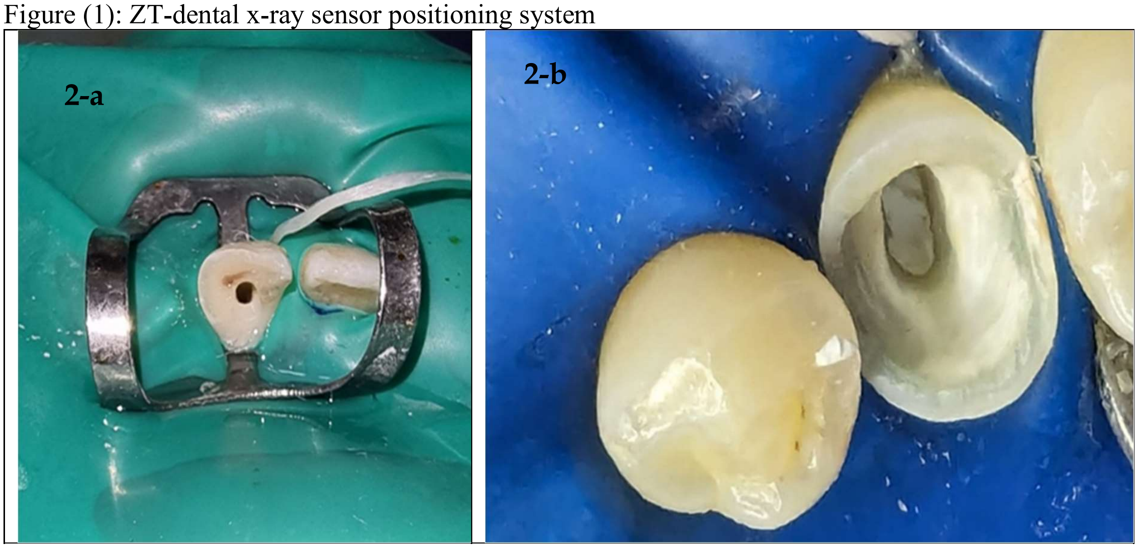

Figure (2): a) Access cavity preparation and b) Placement of the triple antibiotic paste into the canal.

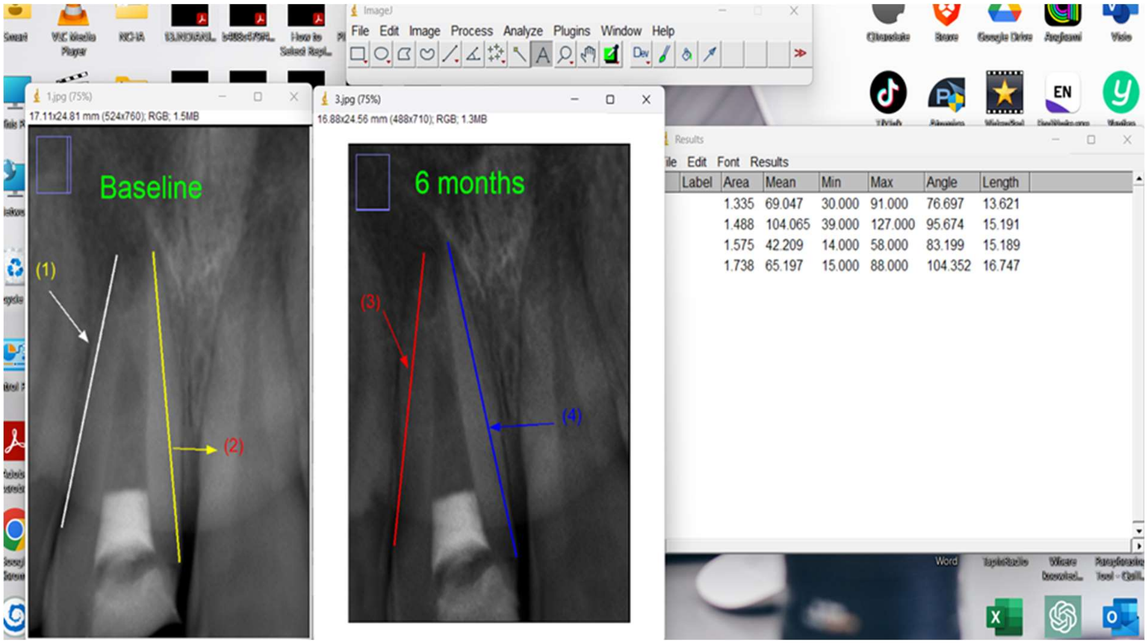

Figure 3: Digital measurements of root length using image J software.

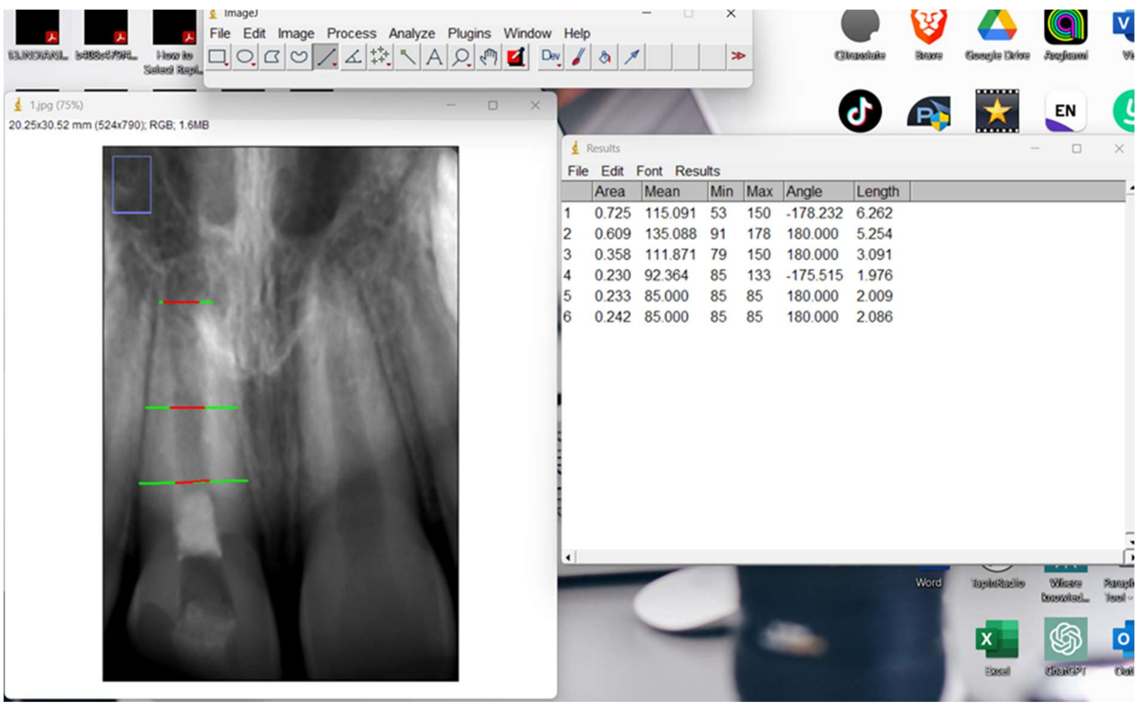

Figure 4: Digital measurements of root dentin thickness using image J software.

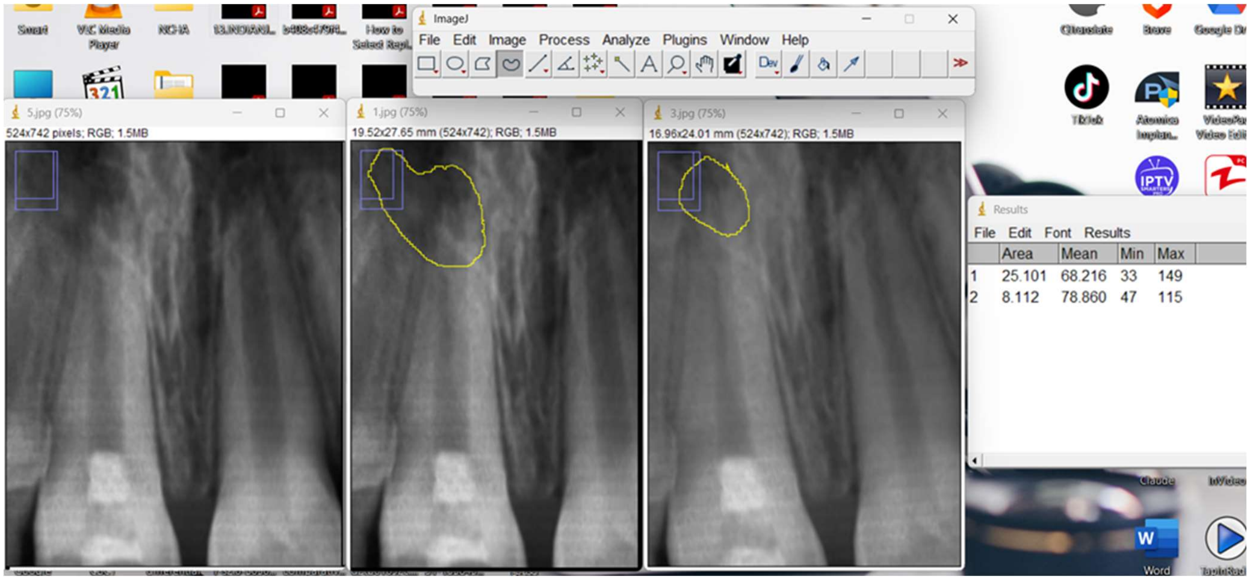

Figure 5: Digital measurements of the area of the periapical lesion using image J software.

List of Tables

Table 1: Comparison of age and gender in years between Bioceramic group and Bio-MTA group

Variables		Bioceramic Root Repair	Bio-MTA	t-value	P-value
Age	Minimum (Year)	7.4	7.4	-0.118	0.906 Ns
	Maximum (Year)	11.6	12		
	Range	4.2	4.6		
	Mean± SD	9.50±1.29	9.56±1.56		
Gender	Male (No; %)	9 (64.28%)	8 (57.14%)	0.149	0.698 Ns
	Female (No; %)	5 (35.72%)	6 (42.85%)		

*; Significant at P<0.05. Ns; Non-significant at P>0.05.

Table 2: Comparison of the change in the root length in mm regarding the time for Bioceramic Root Repair and Bio-MTA materials

Bioceramic Root Repair				
Variables	Mean± SD (mm)	Mean of change (mm) ± Sq. Dev.	t-value	P-value
Baseline vs. 3 months				
Baseline	9.88±1.88	+0.78±0.16	25.97	<0.0001**
3 Months	10.66±1.86			
Baseline vs. 6 months				
Baseline	9.88±1.88	+1.6±0.3	39.40	<0.0001**
6 Months	11.48±1.86			
Baseline vs. 12 months				
Baseline	9.88±1.88	+2.51±1.07	32.70	<0.0001**
12 Months	12.39±1.83			
Bio-MTA				
Baseline vs. 3 months				
Baseline	9.54±1.53	+0.65±0.11	25.85	<0.0001**
3 Months	10.19±1.53			

Baseline vs. 6 months				
Baseline	9.54±1.53	+1.35±0.25	36.06	<0.0001**
6 Months	10.89±1.52			
Baseline vs. 12 months				
Baseline	9.54±1.53	+2.20±0.5	38.42	<0.0001**
12 Months	11.56±1.51			

*; Significant at P<0.05. Ns; Non-significant at P>0.05. Sq: square. Dev. Deviation

Table 3: Comparison of the root length in mm regarding the material

Variables	Bioceramic Root Repair (mm)	Bio-MTA (mm)	t-value	P-value
Baseline	9.88±1.88	9.54±1.53	0.527	0.602 Ns
3 Months	10.66±1.86	10.19±1.53	0.733	0.47 Ns
6 Months	11.48±1.86	10.89±1.52	0.920	0.365 Ns
12 Months	12.39±1.83	11.56±1.51	1.30	0.203 Ns

*; Significant at P<0.05. Ns; Non-significant at P>0.05.

Table 4: Comparison of the change in the root length in mm regarding the material

Variables	Bioceramic Root Repair (mm)	Bio-MTA (mm)	Z/t-value	P-value
3 Months	0.78±0.11	0.65±0.09	2.98	0.002 *
6 Months	1.60±0.15	1.35±0.14	3.38	<0.01*
12 Months	2.51±0.29	2.02±0.19	5.22	<0.01*

*; Significant at P<0.05. Ns; Non-significant at P>0.05.

Table 5: Comparison of the change in the root thickness in mm regarding the time for Bioceramic Root Repair and Bio-MTA materials

Bioceramic Root Repair				
Variables	Mean± SD (mm)	Mean of change (mm)± Sq. Dev.	t-value	P-value
Baseline vs. 3 months				
Baseline	1.14± 0.20	+0.74±1.33	8.67	<0.0001**
3 Months	1.88±0.35			
Baseline vs. 6 months				
Baseline	1.14± 0.20	+1.35±1.09	17.40	<0.0001**
6 Months	2.49±0.32			
Baseline vs. 12 months				
Baseline	1.14± 0.20	+2.09±1.57	22.53	<0.0001**
12 Months	3.23±0.34			
Bio-MTA				
Baseline vs. 3 months				
Baseline	1.11±0.18	+0.65±0.28	16.72	<0.0001**
3 Months	1.76±0.15			
Baseline vs. 6 months				
Baseline	1.11±0.18	+1.28±0.66	21.17	<0.0001**
6 Months	2.38±0.20			
Baseline vs. 12 months				
Baseline	1.11±0.18	+1.86±0.81	27.90	<0.0001**
12 Months	2.97±0.18			

*; Significant at P<0.05. Ns; Non-significant at P>0.05. Sq: square. Dev. Deviation

Table 6: Comparison of the change in the root thickness in mm regarding the

Variables	Bioceramic Root Repair (mm)	Bio-MTA (mm)	t-value	P-value
Baseline	1.14± 0.20	1.11±0.18	0.480	0.634 Ns
3 Months	1.88±0.35	1.76±0.15	1.25	0.226 Ns
6 Months	2.49±0.32	2.38±0.20	1.05	0.302 Ns
12 Months	3.23±0.34	2.97±0.18	2.54	0.017*

*; Significant at P<0.05. Ns; Non-significant at P>0.05.

Table 7: Comparison of the change in the root thickness in mm regarding the material

Variables	Bioceramic Root Repair (mm)	Bio-MTA (mm)	Z/t-value	P-value
3 Months	0.74±0.32	0.65±0.14	0.97	0.329 Ns
6 Months	1.35±0.29	1.28±0.22	0.64	0.516 Ns
12 Months	2.09±0.34	1.86±0.25	1.99	0.045*

*; Significant at P<0.05. Ns; Non-significant at P>0.05.

Table 8: Comparison of the change in the pre-apical lesion dimension in mm regarding the time for Bioceramic Root Repair and Bio-MTA materials

Bioceramic Root Repair				
Variables	Mean± SD (mm)	Mean of change (mm)± Sq. Dev.	t-value	P-value
Baseline vs. 3 months				
Baseline	15.41±1.62	-5.64±4.95	-34.20	<0.0001**
3 Months	9.76±1.64			
Baseline vs. 6 months				
Baseline	15.41±1.62	-10.36±7.83	-49.92	<0.0001**
6 Months	5.05±1.14			
Baseline vs. 12 months				
Baseline	15.41±1.62	-14.25±18.86	-44.26	<0.0001**
12 Months	1.16±0.59			
Bio-MTA				
Baseline vs. 3 months				
Baseline	15.48±1.40	-5.19±14.42	-18.42	<0.0001**
3 Months	10.30±1.56			
Baseline vs. 6 months				
Baseline	15.48±1.40	-9.86±16.27	-32.96	<0.0001**
6 Months	5.62±1.06			
Baseline vs. 12 months				
Baseline	15.48±1.40	-13.71±15.75	-46.60	<0.0001**
12 Months	1.77±0.74			

*; Significant at P<0.05. Ns; Non-significant at P>0.05. Sq: square. Dev. Deviation

Table 9: Comparison of the change in the preapical lesion dimension in mm regarding the material

Variables	Bioceramic Root Repair (mm)	Bio-MTA (mm)	t-value	P-value
Baseline	15.41±1.62	15.48±1.40	-0.136	0.892 Ns
3 Months	9.76±1.64	10.30±1.56	-0.884	0.384 Ns
6 Months	5.05±1.14	5.62±1.06	-1.381	0.178 Ns
12 Months	1.16±0.59	1.77±0.74	-2.41	0.022*

*; Significant at P<0.05. Ns; Non-significant at P>0.05.

Table 10: Comparison of the change in the preapical lesion dimension in mm regarding the material

Variables	Bioceramic Root Repair (mm)	Bio-MTA (mm)	Z/t-value	P-value
3 Months	-5.64±0.62	-5.18±1.05	-0.89	0.36 Ns
6 Months	-10.35±0.77	-9.85±1.12	-1.37	0.18 Ns
12 Months	-14.24±1.20	-13.71±1.00	-1.23	0.22 Ns

*; Significant at P<0.05. Ns; Non-significant at P>0.05.