

CLINICAL, RADIOGRAPHICAL AND HISTOPATHOLOGICAL EVALUATION OF BIODENTINE VERSUS FORMOCRESOL IN PRIMARY TEETH PULPOTOMY

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ABSTRACT

Aim: The present study was conducted to compare effects of biodentine and formocresol as pulp-dressing agents clinically, radiographically and histopathologically in primary teeth.

Materials and Methods: Thirty healthy children aged from four to eight years, they were selected from patients attending outpatient clinic of Pediatric Dentistry Department. Each child had at least bilateral deep carious lower primary molar indicated for pulpotomy. Pulpotomy was done in both groups; where group I treated by biodentine while formocresol used in group II. The study cases were recalled after three, six, nine and twelve months for clinical and radiographic evaluation. For histopathological study sixteen lower primary first molars planned for serial extraction were selected, biodentine and formocresol pulpotomies were done, extraction of the treated teeth from each group was done after one and three-month intervals.

Results: The overall clinical success rate of biodentine group was 90%, while formocresol group was 80%. The two groups were clinically successful with no statistically significant difference between them ($P=0.278$). The radiographic success rate of biodentine group was 86.6%, while for formocresol group was 73.3%. There was no statistically significant difference between the two groups ($P=0.197$). Biodentine showed significantly better histopathological results compared to formocresol after three-month interval. Biodentine favored the formation of partial dentine bridge with normal pulpal architecture. The pulp tissue in formocresol group showed necrosis with no evidence of dentine bridge formation

Conclusion: The biodentine showed higher clinical, radiographic and histopathologic success rate compared to formocresol as a pulpotomy agent in primary molars. It can be considered as a biomaterial for vital pulp therapy of deep caries in primary teeth.

KEY WORDS: Biodentine , Formocresol, Primary Teeth, Pulpotomy.

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INTRODUCTION

The child's dentition is a dynamic entity, individually and always changing in nature, primary dentition has a significant role in maintaining dental arch spaces for succedaneous dentition. The complexity of such a phenomenon lies in the variety of physiological adaptations of occlusion during development and growth of the child. Subsequently, primary teeth exfoliation, succedaneous teeth eruption and occlusion occur in a harmonious sequence ^[1].

Maintenance of the primary dentition in a healthy condition is important for the well-being of the child as well as for proper mastication, esthetics, phonetics, space maintenance and prevention of bad oral habits ^[2].

Pulpotomy is one of the most widely accepted clinical procedures for treating cariously exposed pulp in primary dentition. The rationale of this technique is based on the healing ability of the radicular pulp tissue following surgical amputation of the affected or infected coronal pulp ^[3]. Pulpotomy can be performed using different techniques including; non-pharmacologic treatments or using pharmacologic approaches by dressing the pulp tissue with different medicaments or biological materials ^[4].

Formocresol (FC) has been the most widely used medicament universally taught and preferred for pulpotomized primary teeth; due to its bacteriostatic & fixative properties and its ease in use, also high clinical success rates up to 97% ^[5].

In spite of the high success rate of FC pulpotomy, there are some concerns about its potential health hazards ^[6], search for a medicament to replace formocresol became imperative after several negative reports questioning both its local and systemic toxic effect as well as its immunologic, biochemical, mutagenic effects and teratogenic changes in the host ^[7].

The use of biocompatible materials has become a major interest in modern dentistry, especially when direct contact with the dental tissues is necessary. ^[8]. Biodentine attracted attention in the field of dentistry due to its fast setting time, high biocompatibility, high compressive strength, excellent sealing ability, and ease of handling as well as its versatile usage in both endodontic repair and restorative procedures without causing any staining of the treated teeth . However, it has also been proved that biodentine has an excellent antimicrobial property due to its high pH ^{[9],[10]}.

Biodentine has many applications in dentistry such as crown and root dentine repair treatment, repair of perforations or resorptions, apexification and root-end fillings. The material can also be used in class II fillings as a temporary enamel substitute and as permanent dentine substitute in large carious lesions. The manufacturer claimed about the biocompatibility and the bioactivity of the material, which is important when used as indirect and direct pulp capping and pulpotomy. Furthermore, it preserves pulp vitality and promotes its healing process. ^{[11],[12]}. The current study was undertaken to evaluate biodentine clinically, radiographically and histopathologically as pulp dressing agent in primary teeth underwent pulpotomy

MATERIALS AND METHODS

This study was conducted as a randomized clinical trial.

It was carried out at Pediatric Dentistry Department, Faculty of Dentistry, Tanta University. The study was carried out on 30 healthy children, aged from four to eight years selected from patients attending outpatient clinic of Pedodontics Department complaining from deep carious primary molars indicated for pulpotomy. Each child had bilateral deep carious lower primary molars indicated for pulpotomy.

Sample size calculation

The sample size was calculated and power analysis was performed using Epi-info Software statistical package created by World Health Organization and Center for disease control and prevention version 7.

The criteria used for sample size calculation were 95% confidence limit, 80% power of the study, ration of 1:1 for treatment and control group, expected outcome in treatment group 85%. The sample size based on the previously mentioned criteria was found at $N > 29$. The sample size per each group will be increased to 30 to increase validity of results.

Written consents for treatment were obtained prior to the clinical procedures after the details of the treatment procedure were clear to the child's parents or guardians according to the guidelines on human research adopted by Ethics Committee, Faculty of Dentistry, Tanta University.

Inclusion criteria:

A-Clinical criteria

- No evidence of clinical signs and symptoms of pulp degeneration such as; spontaneous throbbing pain, pain on percussion, tooth mobility, soft tissue swelling, fistula or sinus tract.
- Absence of pulp hyperemia that require additional procedure.
- Restorable teeth.
- Healthy children with absence of any relevant medical condition such as cardiac diseases or leukemia that contraindicate pulp therapy.
- Patient and parent cooperation.

B-Radiographic criteria

1. Absence of pathological external or internal root resorption.
2. Absence of calcific pulp degeneration.
3. Absence of furcal radiolucency.

Methods:

Clinical study

Clinical examination was done, pre-operative standardized periapical radiographs, size (0 or 1) to accommodate the pediatric mouth, were taken using Extension Cone Parallel technique (XCP) to all children participating in the study to assess the tooth condition and to ensure proper case selection.

Preparation of 1\5 concentration of formocresol:

This diluted form was prepared by adding 90 ml of glycerin and 30 ml of distilled water to 30 ml of Buckley's formocresol .

Clinical procedure

Complete isolation using rubber dam and saliva ejector was done, then a sterile high-speed bur No.330 with water spray was used to remove all the caries. Access opening was gained; roof of the pulp chamber was removed and all overhanging edges were eliminated. The coronal pulp was removed with a sharp spoon excavator and bleeding was arrested by a moistened cotton pellet gently pressed against the amputated pulp stump, the capping agents was applied over the amputated pulp stump.

The 60 selected primary molars out of 30 children were randomly divided by third partner into two groups of (30 teeth for each), according to the material used as follow:

Group I (Study group): Treated using biodentin as capping material .

- Group II (control group): Treated using FC as pulpotomy agent .

Group I (study group)

Biodentine (Septodont, Saint-Maur-des-Fosses, France) liquid will be added to a powder containing capsule and mixed for 30 seconds in amalgamator according to the manufacturer's instructions and

placed over the pulp stumps, and the cavity was sealed with reinforced zinc oxide eugenol (IRM® DENTSPLY International), stainless-steel crown (3M ESPE, USA) cemented with glass ionomer cement (Vidrion C, White Artigos Dentarios Ltda) at the same visit. Figure (1, 2).

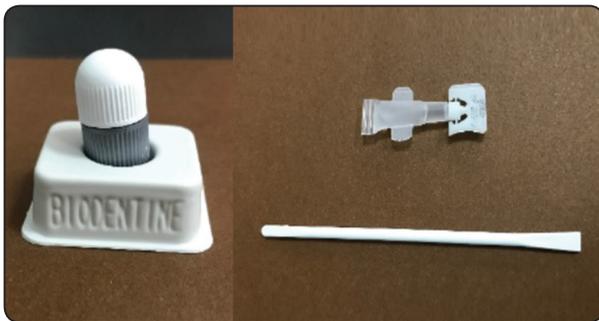


Fig (1) Biodentine liquid, powder and mixing spatula.

Group II (control group)

A small sterile pledget of cotton wool was moistened with 1\5 concentration of Buckley's formula and placed over the pulp stumps for one minutes, and the cavity was sealed with reinforced zinc oxide eugenol stainless-steel crown cemented with glass ionomer cement at the same visit as showed in Fig 3.

All the study cases were recalled after three, six, nine and twelve months for clinical and radiographic evaluation. All the data were collected briefly in pediatric examination chart.

Clinical evaluation:

- Absence of pain either spontaneous or induced by any stimulus.
- No abscess or fistula.
- Neither soft-tissue swelling nor pathological tooth mobility at the recall visit.

Radiographical evaluation:

- Normal periodontal ligament space
- Absence of internal and/or external root resorption.
- No periapical or intraradicular radiolucency.
- No pathological root resorption.

Histological study

For histological examination, sixteen lower primary first molars from children aged between seven to eight years that formerly planned for serial extraction were selected according to previous inclusion criteria (this children have carious teeth needed to be managed before serial extraction and insertion of lower passive lingual arch). Written informed consents were obtained from the parents. Biodentine and formocresol pulpotomies were done as described above. Extraction of four treated teeth from each group was done after one and three-month intervals

All extracted teeth were fixed in 10% formalin after sealing the apical foraminae for about one week. The teeth then decalcified in 10% ethylene diaminetetraacetic acid (EDTA), dehydrated in ascending grades of ethanol and embedded in paraffin. 4 μ thick serial sections were obtained by cutting with a microtome. The sections were then deparaffinized in xylene and rehydrated in descending grades of ethanol. Staining with hematoxyline and eosin was done for all sections. The slides were mounted for microscopical examination using light microscope. The sections from both groups were evaluated for presence or absence of calcifications, inflammation and blood vessel formation. Moreover, the status of odontoblastic layer was checked. Other encountered histopathological changes in the pulp tissue were recorded [13].

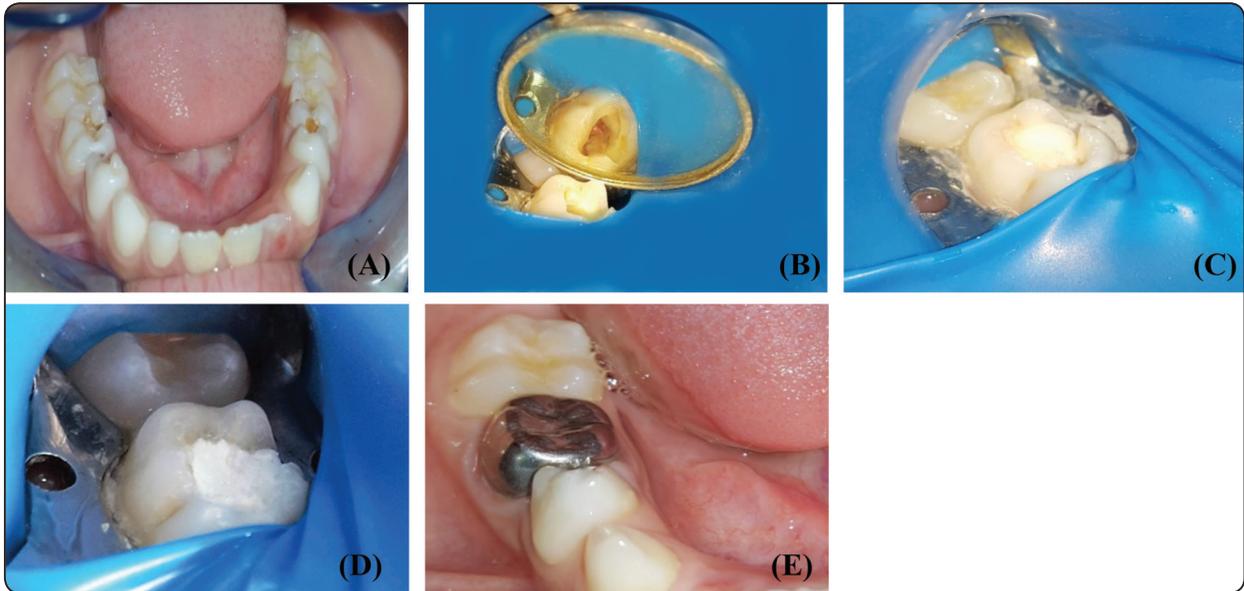


Fig. (2): Clinical procedure using biodentine. (A) Photograph shows the preoperative bilateral carious mandibular second molar. (B) Access opening of mandibular right second molar after removal of pulp tissue. (C) Applying biodentine in the pulp chamber. (D) Application of reinforced zinc oxide eugenol. (E) Stainless-steel crown in place at the same visit

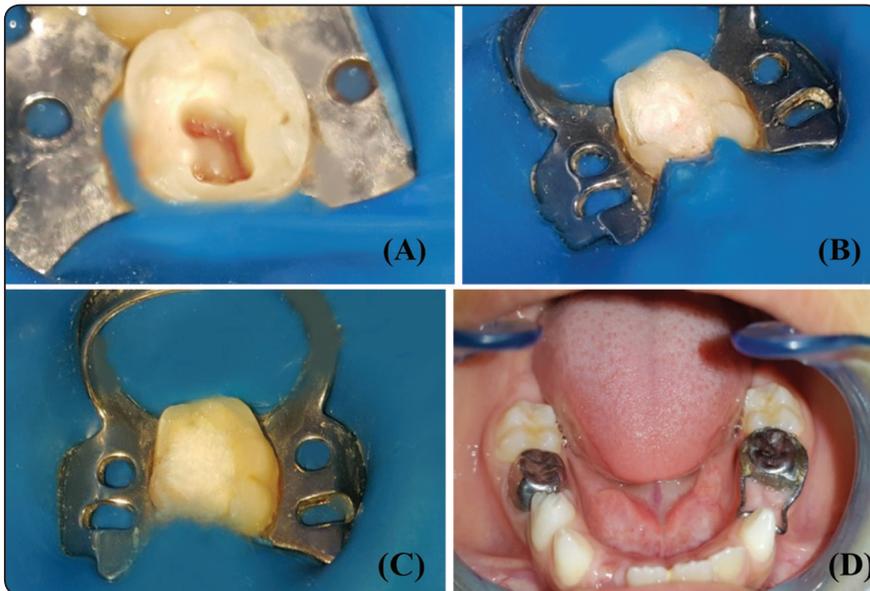


Fig (3): Clinical procedure using FC. (A) Access opening of mandibular second molar after removal of dead pulp tissue. (B) Application of cotton pellet moistened with 1% formocresol. (C) Application of reinforced zinc oxide eugenol. (D) Stainless-steel crowns in place at the same visit. Extraction of dead tooth and putting space maintainer in second visit.

RESULTS

Vital pulpotomy was performed on 60 bilateral mandibular primary molars out of 30 children. The distribution of the sample according to the gender age and the type of teeth are shown in Table (1).

TABLE (1): Sample distribution according to gender and type of teeth.

Gender	Boys	16 (53.33%)
	Girls	17 (46.66%)
Age		4-8 years

I- Clinical results

At the end of the study, the overall clinical success rate of biodentine group was 90% while FC group was 80% The two groups were clinically successful with no statistically significant difference between them (P= 0.278).

TABLE (2): Overall clinical success rates of the tested materials after twelve months follow up.

Groups After 12 months N =30	Success N (%)	Failure N (%)	χ^2	P
Biodentine	27 (90%)	3 (10%)	1.183	0.278
Formocresol	24 (80%)	6 (20%)		

In biodentine group, during the follow up periods all cases showed no sign of pain, gingival swelling or mobility, except at nine and twelve months three cases came with pain and gingival swelling, Table (3). While, for formocresol group, two case represented with pain and gingival swelling at 3 months and another two cases at twelve months, Table (4). There was no statistically significant difference between the two groups at different follow up periods as showed in Table (2) . All the failed cases managed by pulpectomy or extraction and space maintainer.

TABLE (3): Clinical evaluation of biodentine group during the study periods.

Study Periods	Clinical Criteria					
	Pain		Gingival Swelling		Mobility	
	N	%	N	%	N	%
3 months	0	0.0	0	0.0	0	0.0
6 months	0	0.0	0	0.0	0	0.0
9 months	1	3.4%	1 ^s	3.4%	0	0.0
12 months	2	6.6%	2 ^s	6.6%	0	0.0
χ^2	3.762		3.762		-	
P value	0.288		0.288		-	

N: number of cases; χ^2 : Chi square test; s: same patient with different symptoms

TABLE (4): Clinical evaluation of formocresol group during the study periods.

Study Periods	Clinical Criteria					
	Pain		Gingival Swelling		Mobility	
	N	%	N	%	N	%
3 months	2	6.8	2 ^s	6.8	0	0
6 months	00	00	00	00	0	0.0
9 months	2	6.8	2 ^s	6.8	0	0.0
12 month	2	6.8	2 ^s	6.8	0	0.0
χ^2	2.113		2.113		0.000	
P	0.551		0.551		1.000	

N: Number of cases; χ^2 : Chi square test; s: same patient with different symptoms

II-Radiographic results

The overall radiographic success rate of biobentin group was 86.6%, while for FC group was 73.3%. There was no statistically significant difference between the two groups (P = 0.197) Table (5), fig (4 and 5).

TABLE (5): Overall radiographic success and failure in the study groups.

Groups After 12 months N =29	Success N (%)	Failure N (%)	χ^2	FE_p
Biodentine	26(86.6%)	4(13%)	1.668	0.197
FC	22(73.3%)	8(26.6%)		

N: Total number of cases; c^2 : Chi square test; FE: Fisher Exact for chi square test

Throughout the follow-up periods, treated teeth in biodentine group revealed no evidence of radiographic changes at three months follow-ups. While three cases teeth after six, nine months and twelve months showed furcation radiolucency, and one case exhibited periapical radiolucency at twelve months, Table (6).

In formocresol group, treated teeth showed no evidence of radiographic changes at three and six-month follow-up. While, four cases showed furcation radiolucency at nine and twelve months and three cases showed abnormal root resorption at nine and twelve months and one case showed widening of periodontal ligament space at nine and twelve months, Table (7).

Histopathological results

In formocresol treated group after 1 month, the specimens exhibited that the odontoblastic layer wasn't intact throughout the dentine-pulp complex with loss of odontoblasts in some areas.

TABLE (6): Radiographic assessment of the failure cases in biodentine group.

Radiographic signs	3 months		6 months		9 months		12 months	
	N	%	N	%	N	%	N	%
Furcation radiolucency	-	-	1	3.4	1	3.4	1	3.4
Periapical radiolucency	-	-	-	-	-	-	1	3.4
Abnormal root resorption	-	-	-	-	-	-	-	-
Widening of periodontal ligament	-	-	-	-	-	-	-	-
Total	-	-	1	3.4	1	3.4	2	6.6

N: Number of cases

TABLE (7): Radiographic assessment of the failure cases in formocresol group.

Radiographic signs	3 months		6 months		9 months		12 months	
	N	%	N	%	N	%	N	%
Furcation radiolucency	-	-	-	-	2	6.6	2	6.6
Periapical radiolucency	-	-	-	-	-	-	-	-
Abnormal root resorption	-	-	-	-	2	6.6	1	3.4
Widening of Periodontal ligament	-	-	-	-	1	3.3	1 ^s	3.4
Total	-	-	-	-	5	16.6	3	10

N: Total Number of cases; s: same patient with different symptoms

An inflammatory reaction was elicited in the pulp tissue, the latter revealed small, medium and large sized blood vessels. Areas of mild fibrosis were also seen in the pulp tissue. In addition, irregular dentinal wall with evidence of internal resorption was detected (Fig 6). After three months, areas of severe inflammation and necrosis of pulp tissue were demonstrated. Complete absence of odontoblastic layer and replacement of pulp tissue with necrotic one were clearly demonstrated (Fig 7).

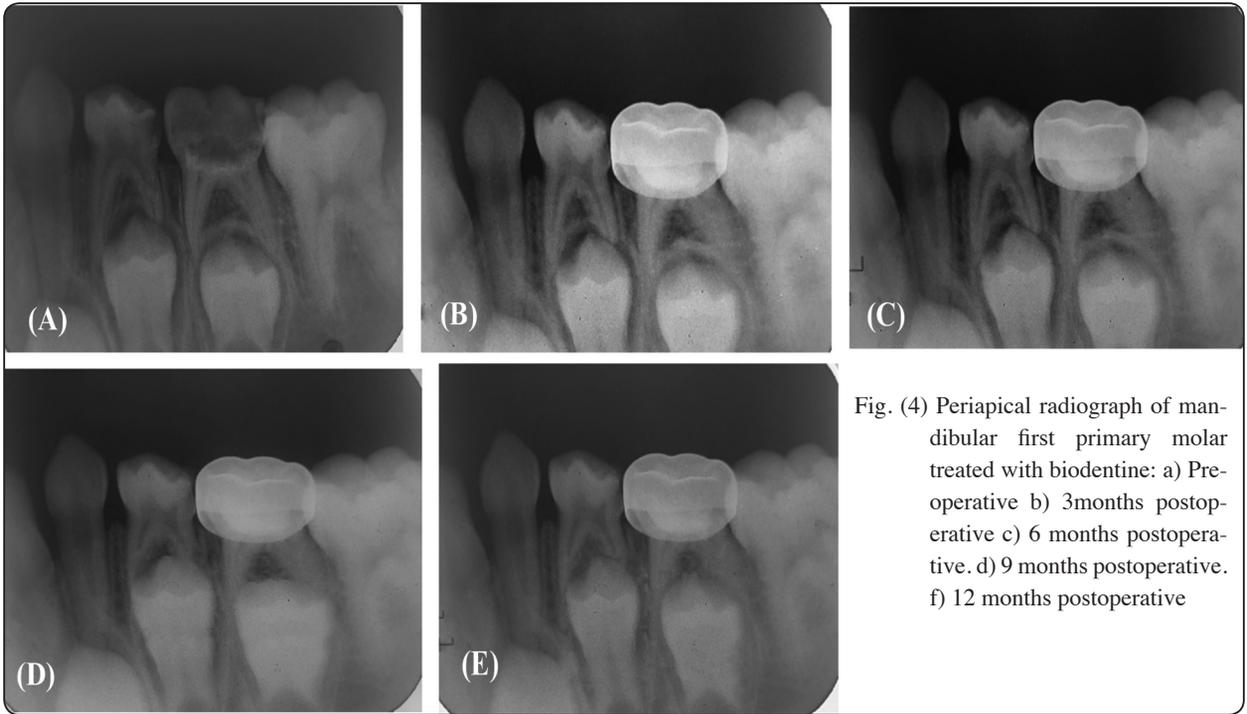


Fig. (4) Periapical radiograph of mandibular first primary molar treated with biodentine: a) Preoperative b) 3months postoperative c) 6 months postoperative. d) 9 months postoperative. f) 12 months postoperative

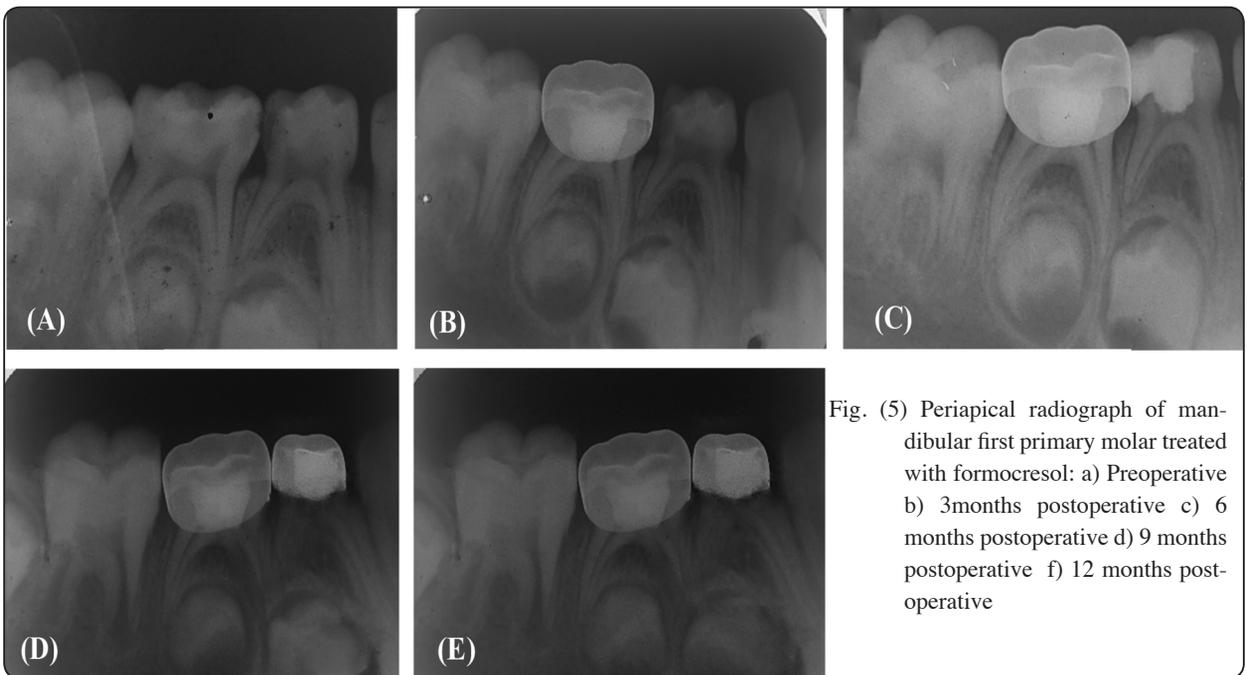


Fig. (5) Periapical radiograph of mandibular first primary molar treated with formocresol: a) Preoperative b) 3months postoperative c) 6 months postoperative d) 9 months postoperative f) 12 months postoperative

In biodentine treated group, favorable histopathological findings were demonstrated after one month; normal pulpal architectural pattern with few or no inflammatory cell infiltration was seen. In some cases, irregular dentinal wall with internal resorption was seen with the appearance of odontoclast-like cells in the resorbed areas (Fig 8). Small areas of pulp calcification were noted scattered

throughout the pulp tissue (Fig 9). After three months, delicate pulp tissue with normal architecture was seen. The odontoblastic layer showed a continuous regular arrangement with intact odontoblasts. The pulp calcification was seen as globular mass of osteodentine partially bridging the pulp tissue (Fig 10). No calcification was detected in formocresol treated group.



Fig. (6): A photomicrograph of formocresol treated group after one month showing odontoblastic layer with loss of odontoblasts in some areas and internal resorption of dentinal wall (arrow). Mild fibrosis and an inflammatory infiltrate are also detected (H&E \times 200)

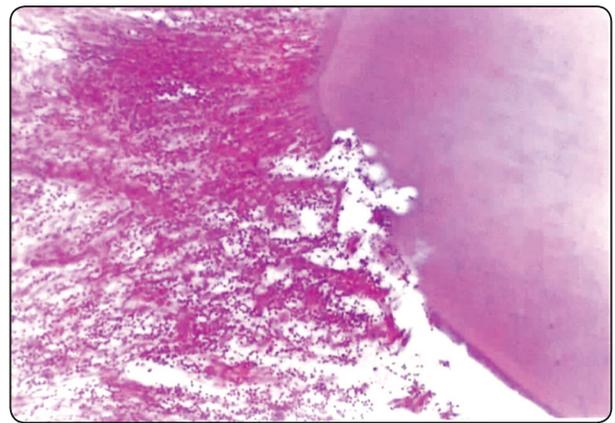


Fig. (7) : A photomicrograph of formocresol treated group after three months exhibits severe inflammation and necrosis of pulp tissue. Irregular dentinal wall and absence of odontoblastic layer are also seen (H&E \times 200)

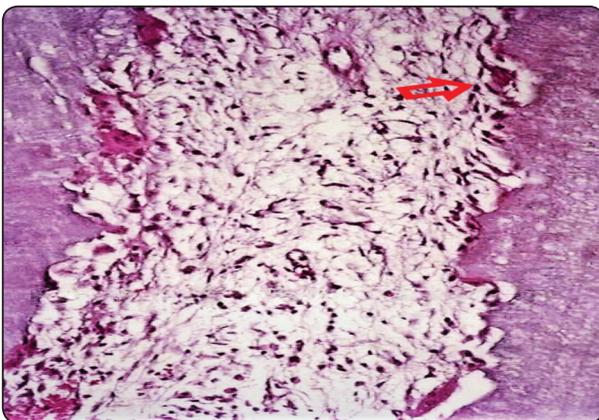


Fig. (8) A photomicrograph of biodentine treated group after one month shows irregular odontoblastic layer associated with internal resorption of dentinal wall with odontoclast-like cells in these areas (arrow). Delicate pulp tissue with normal architecture and mild inflammation are also detected (H&E \times 100)

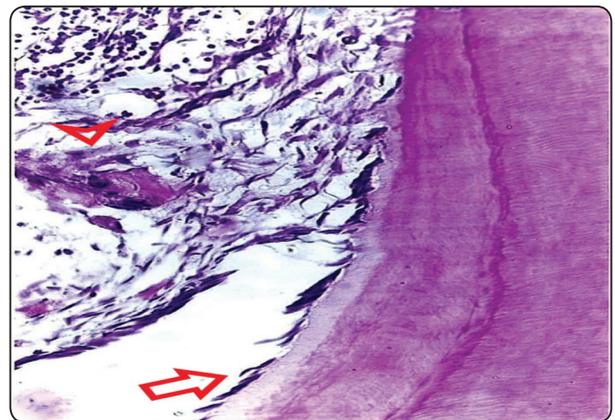


Fig. (9): A photomicrograph of biodentine treated group after one month reveals normal pulpal architectural pattern with odontoblastic layer and intact odontoblasts (arrow). An area of calcification (osteodentine) is detected (arrow head) (H&E \times 200)

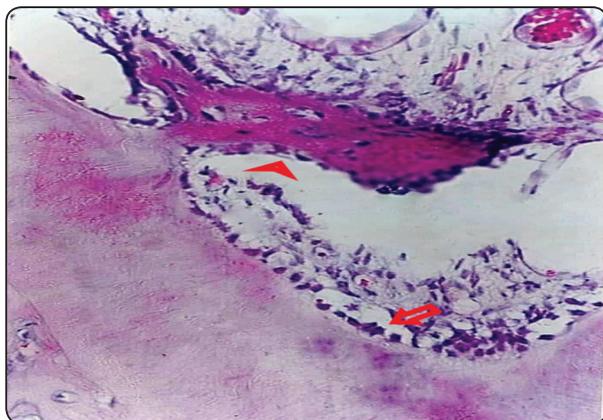


Fig. (10): A photomicrograph of biodentine treated group after three months showing large area of calcification in the form of osteodentine (arrow head) partially bridging the pulp tissue. The pulp tissue is delicate and shows normal architecture. Regular odontoblastic layer with intact odontoblasts (arrow) is also seen (H&E \times 200).

DISCUSSION

An ideal pulpotomy medicament or agent must preserve healthy radicular pulp tissue, be highly biocompatible, prevent bacterial micro leakage, has the ability to promote healing and should not interfere with the physiological root resorption. Advances in biomedical research open avenues for design of producing new materials for pulpotomy treatment, aiming at regeneration of dentin- pulp complex. So, this study was conducted to assess the efficacy of biodentine as a pulpotomy agent compared to formocresol in primary teeth.

The age group selected for this study was from four to eight years (but from 6 years the roots of primary molars may have started physiologic resorption) to preserve the primary molars till the time of exfoliation. Also, the selected cases had bilateral deep carious primary molars, to perform the treatment of both groups under the same environmental factor.

In the current study, formocresol was used for comparison because it is still considered the gold

standard when compared with all pulpotomy agents and medicaments due to its bacteriostatic, fixative properties and high clinical success rates ⁽⁵⁾.

It seems very important to identify effective pulpotomy agents to increase the rate of success of pulpotomy procedures. Therefore, several studies have been used to evaluate the clinical and radiographical success of the variable pulpotomy agents in primary teeth, such as the presence of pain or swelling as well as the indication of periapical or bifurcation change seen in radiograph ^[14,15].

In this study, clinical as well as radiographic and histopathological examination were used during follow up, since the clinical and radiographic study of applied novel material are not sufficient. For overall evaluation, histopathological examination has long been suggested as the best method to evaluate the effectiveness of a biomaterial at the cellular and pulp tissue levels which may be difficult to feasible in the human especially in pediatric age group ^[16,17].

The extracted teeth were decalcified and examined histologically after staining with hematoxyline and eosin to evaluate the histopathological changes in pulp tissue following pulpotomy with biodentine.

In the present study, the overall clinical success rate of biodentine after one year was 90%. Most of the cases were clinically free from pain sensation, mobility and gingival abscess formation. These results may be contributed to that biodentine has excellent antimicrobial properties because of its high pH (pH = 12), has high biocompatibility and bioactivity.^[18,19]. This result coincides with Collado-Gonzalez et al. ^[20] they reported that biodentine exhibited better cytocompatibility and bioactivity on stem cells from human exfoliated primary teeth, this has prompted its use for pulpotomy of primary teeth.

The role of SSC restoration over pulpotomized teeth is to protect the underlying pulp against

microleakage^[21]. Croll and Killian have recommended SSCs for final restoration of treated molars based on the assumption that there is less leakage in crowned teeth than those restored with amalgam. They recommended SSCs for the restoration of pulpotomized primary molars to minimize the leakage for the long-term success of pulp therapy ^[22].

In the present study, radiographic success rate of biodentine was 86.6% , this results in accordance with Kusum et al. ^[22] they revealed radiographic success rate of 80% after 9 months with biodentine. In another study, the clinical success rate of biodentine pulpotomy is 97% and 95% radiographic success rate of twelve month follow-up periods ^[24]. El Meligy et al. ^[19] also compared the success rates of biodentine and formocresol and found a 100% success rate for both treatments; however, the follow-ups in their study were (3 and 6 months) only .

Radiographic failures were higher than clinical ones and for this reason it is important to perform a radiographic evaluation of treated teeth even in absence of clinical signs. The recommendation of the study is that the choice of the correct medication may slightly decrease the failure rate of pulpotomies in primary teeth. However, correct diagnosis and correct clinical procedures are necessary in addition to the treatment type ^[25].

Regarding formocresol evaluation in the present study, the clinical success rate was 80%. These findings showed variations from other studies like , Eidelman et al. ^[26] they reported 93.3% success rate , Farsi et al. ^[27] 98.6% and Noorollahian ^[28] 100% success rate. While radiographic finding in formocresol group was 73.3% there is no statically significant difference between two groups. These findings agreed with the results obtained by Farsi et al. ^[27] ; Huth et al. ^[29] , and Mesut et al. ^[30] .

The explanation for the difference in the overall clinical and radiographic success rates of both group in this study may be attributed to the fact that the clinical and radiographic success not always correspond. It means that the clinical case may come with no any sign which is differ with their x ray which represented slight inflammation of resorption especially with formocresol. Fuks et al. ^[3] reported that chronic inflammation of the pulp may be present without periapical or interradicular abscess formation and the tooth may be clinically and radiographically normal.

Furcation radioluceny and abnormal root resorption were observed as common radiographic findings in formocresol group in the current study. These findings were in accordance with Ibricevic & Qumasha ^[31]; Holan et al. ^[32] ; Ruby et al. ^[33] ; Havale et al. ^[34]; Yildirim et al. ^[35], they contributing the radiographic changes after Formocresol pulpotomy to different factors such as the possibility of penetration of formaldehyde through the pulpal floor with subsequent damage to the interradicular area.

Regarding the histopathological results, in the current study, biodentine treated teeth after three months showed normal soft tissue organization of pulp tissue with mild inflammation. This finding may be attributed to the anti-inflammatory repairing capacity, highly biocompatibility and bioactivity of biodentine. Pulp calcifications were seen as globular masses of osteodentine partially bridging the pulp tissue; this may be due to the stimulation of biodentine for the pulp cells to build a high quality and quantity of reactionary dentin. The dentin bridges are created faster and are thicker than with similar dental materials and represent the necessary condition for optimal pulp healing without any threat on body tissues ^{[36][37]}. This results agreed with Nowicka et al. ^[38] , they concluded that biodentine

has ability of formation of dentine bridge and there is absence of inflammatory pulp response in all specimens .

In formocresol treated group after three months, odontoblastic layer wasn't intact throughout the dentine – pulp complex with loss of odontoblasts in some areas, mild fibrosis was also seen in the pulp tissue and irregular dentinal wall with evidence of internal resorption. In other specimens, areas of severe inflammation and necrosis of pulp tissue were demonstrated. These findings are in agreement with Cotes et al.^[39] they found fibrous granulation tissue in the root canal after formocresol pulpotomy. In addition, Haghgoo and Abbasi ^[40] , El-Meligy et al.^[19] reported severe inflammation and destruction of pulp tissue with formocresol pulpotomy.

The pulp tissue damage seen in formocresol group may be related to the penetration of formaldehyde into the pulp which resulted in fixation of the tissue followed by coagulation necrosis as it diffuses apically. This coagulation necrosis was followed by liquefaction necrosis of the pulp. This liquefaction is attributed to release of hydrolytic enzymes from dying neutrophils.^{[13],[41]} .

CONCLUSION

According to the results of the present study, biodentine is an excellent material with innumerable qualities required of an ideal material, its showed excellent pulpal responses in terms of controlling inflammation and it can be an alternative to formocresol in pulpotomy because of the tissue irritating, cytotoxic and mutagenic effects of formocresol which are solved with biodentine.

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