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EFFICACY OF COMBINATION OF BIODENTINE AND SIMVASTATIN AS PULP CAPPING MATERIALS IN VITAL PULPOTOMY OF PRIMARY MOLARS: RANDOMIZED CLINICAL TRIAL

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KEYWORDS

Pulpotomy; Primary teeth; Biodentine; Simvastatin

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ABSTRACT

Introduction: Dental caries is a specific disease caused by long-term contact between the host, diet, and microorganisms on the tooth surface. This causes the inorganic parts of the enamel and dentin to break down. **Aim:** This study aimed to assess the clinical and radiological effectiveness of using Simvastatin in combination with Biodentine as a pulpotomy agent for vital primary molars. **Materials and Methods:** sixty primary molars in 20 children aged from 4-7 years old were selected from Outpatient Clinic of Pediatric Dentistry Department, Faculty of Dentistry, Suez Canal University and randomly allocated to three groups, Biodentine, Simvastatin and combination of Biodentine and simvastatin. All treated teeth were clinically evaluated at (1M,3Ms,6Ms,9Ms,12Ms) for presence of pain, tender on percussion, swelling/sinus or pathological tooth mobility and evaluated radiographically at (3Ms,6Ms,9Ms,12Ms) for loss of lamina dura, widening in periodontal ligament space presence of external/internal resorption or presence of periapical /furcation radiolucency. **Result:** The overall success rate was 100%, 5%, and 90% for Biodentine, Simvastatin, and the combination of Biodentine and Simvastatin groups, respectively. After a year of follow-up, the groups had a highly significant difference in overall success rates. **Conclusion:** After one year follow up Our findings demonstrated remarkable results of combination of Biodentine and simvastatin in pulpotomy of primary teeth. Therefore, combination of Biodentine and simvastatin may be considered as an effective material in pulpotomy of primary teeth because of its successful results. While Simvastatin showed failure clinically and radiographically.

Clinical Trial Registration: Registered on ClinicalTrials.gov under identifier number: NCT05582317, Protocol Record 2020-293, https://clinicaltrials.gov/ct2/show/NCT05582317.

INTRODUCTION

Dental caries is a specific disease caused by long-term contact between the host, diet, and microorganisms on the tooth's surface. This causes the inorganic parts of the enamel and dentin to break down [(1)]. The main objective of paediatric dentistry is to keep the baby teeth in place until the permanent ones come in. Primary teeth are needed to keep the arch length, chewing, speech, and appearance and stop bad oral habits [(2)].

Pulpotomy is the best way to treat severely decayed or damaged primary teeth that have no signs of pulpitis that can be fixed[3,4]. Several pulpotomy materials, such as Laser therapy, Calcium Hydroxide, Formocresol, Mineral Trioxide Aggregate (MTA), Ferric sulphate, Collagen, and Glutaraldehyde, have been studied clinically and with x-rays to find out how they work, when they should be used, and what are their benefits [5,6]. But there is no agreement on the best material for a pulpotomy. A good pulpotomy material should be able to seal well, be bioconductive, be biocompatible, and kill bacteria while keeping the radicular pulp healthy and helping it heal [7].

Biodentine is a commercial inorganic restorative cement made from tricalcium silicate (Ca_3SiO_5) and sold as a bioactive dentine substitute. The tricalcium silicate cement has superior physical and biological properties to Mineral Trioxide Aggregate MTA and Bioaggregate TM [8].

Simvastatin is a drug that lowers cholesterol by preventing 3-hydroxy-3-methylglutaryl coenzyme A reducer. Its long-term use as a medicine has demonstrated that it is a low-cost, highly safe option. It has pleiotropic effects that include anti-inflammatory properties and promotes angiogenesis and bone production [9]. Numerous studies in the field of dentistry have been carried out to examine the impact of Simvastatin in both in vitro and in vivo settings [10–12].

Given the positive results reported for Simvastatin in earlier studies, this research was designed to evaluate the effectiveness of the combination of Biodentine and Simvastatin as a pulpotomy agent for important primary molars following a 12-month follow-up clinically and radiographically.

MATERIALS AND METHODS

The current research was a randomized and controlled prospective blinded clinical trial in which both participants and the statistician were blinded .Sixty deep carious primary molars in twenty apparently healthy cooperative children (both sexes) aged from 4-7 years were selected from the Outpatient Clinic of Pediatric Dentistry Department, Faculty of Dentistry, Suez Canal University, following agreement of the Faculty of Dentistry, Suez Canal University's Research Ethics Committee (No.2020-293).

Clinical Trial Design and Registration

Registered on ClinicalTrials.gov under identifier number: NCT05582317, Protocol Record 2020-293; https://clinicaltrials.gov/ct2/show/NCT05582317. The trial was an interventional study, with a randomised parallel model assignment.

Sample Size:

A total of 60 samples, with 20 samples for each group, was the estimated minimum sample size (n). With an alpha (α) level of 0.05 and a beta (β) level of 0.05, the effect size was 0.53, and the power was 95%. G*Power 3.1.9.2 was used to determine the sample size.

Sample Grouping:

This study included sixty deep carious primary molars with essential pulpotomy indications. In accordance with the various capping materials used, molars were dispersed at random into three main groups:

Group (I): 20 deep primary molars (carious) that received Biodentine's critical pulpotomy treatment.

Group (II): includes 20 deeply primary molars (carious) treated with a Simvastatin essential pulpotomy procedure.

Group (III): A critical pulpotomy procedure using Biodentine and Simvastatin was used to treat 20 deeply primary molars (carious).

Randomization & allocation concealment:

Using 20 papers (20 for each item), every four times folded, bearing the name of one of the tested materials (20 envelop in each folded paper of each tested material were placed). An envelope containing the patient personal information was submerged when parents agreed to let their child take part in the trial. Randomisation sequence was applied using computer generated random number for selection of random samples and carried out by the observer.

To identify the sort of capping material before the dressing material was applied, the child, during treatment, randomly selected one of the folded papers from the sealed opaque envelope and unfolded it.

Because only one operator conducted the study using a standardized procedure for all patients, performance bias was eliminated.

Inclusion criteria: (22).

The children were all chosen based on the following inclusion criteria.

- Apparently healthy children aged from 4-7years of both sixes, free from any known systemic diseases.
- The parent gave informed consent and agreed to participate in the study.
- At least had three primary molars with deep decay that were supposed to be treated with vital pulpotomy. Inclusion criteria of selected molars didn't have any of the following: no history of spontaneous or induced pain; without clinical signs and or symptoms indicating a non-vital tooth; restorable tooth with potential for crown establishment; lack of pathologic or physiological mobility; there is no abnormal root resorption on the outside or inside; and lack of radiculitis.

Clinical Procedures:

Pulpotomy treatments were carried out following the American Academy of Pediatric Dentistry2020 recommendations [13]. After drying the area with gauze, each tooth was anesthetized locally with topical anesthetic gel benzocaine 20 percent (Deepak, Miami, USA); the application of local anesthesia using Mepivacaine Hydrochloride 2% with Levonordefrin 1:20000 (Scandonest®2%L, SP Septodent®, Saint-Maur des Fosses, France) to the tooth using the recommended method for treating each tooth; following that, the tooth was isolated using a rubber dam and powerful suction.

A large spoon excavator was used to remove all soft caries (DENTSPLY Limited, Hamm-Moor Lane, Surrey KT15 2SE, United Kingdom). Cavity outlines were performed using a contra-angle handpiece (NSK, Tokyo, Japan) at 30,000 rpm and a sterile #330 carbide bur (Dentsply-Maillefer, Oklahoma, USA). After the coronal pulp was amputated with a sterile sharp spoon excavator, the access was refined with a sterile high-speed fissure bur (DENTSPLY Limited, Hamm-Moor Lane, Surrey KT15 2SE, United Kingdom) until the stump orifices could be seen clearly without remnant tags.

The radicular pulp stumps were gently massaged for 2 to 3 minutes with a wet cotton pellet soaked in sterile saline (El Fath Pharmaceutical, Cairo,

Egypt) to achieve pulp hemostasis. If the bleeding did not stop after five minutes, the tooth was taken out of the study, and the necessary treatment was performed. Depending on group allocation, the pulp stumps of molars were dressed as follows:

Biodentine group: To spread the powder, a biodentine capsule (Saint-Maur des Fosses, France) was gently tapped against a hard surface. The capsule was filled with five drops of liquid from the single-dose dispenser, which was then mixed for 30 seconds in an amalgamator. The amalgam carrier introduced the Biodentine mixture into the pulp chamber. The pulp chamber floor was then evenly covered with the mixture, and a condenser was used to compact it (DENTSPLY Limited, Hamm-Moor Lane, Surrey KT15 2SE, United Kingdom).

Simvastatin group: Simvastatin powder (Al Debeiky Pharmaceutical, Cairo, Egypt) 1.5 mg was mixed with 3 drops of distilled water to get a homogenous paste [14]. A plastic tool was used to inject the Simvastatin mixture into the pulp chamber, which was then compressed with a condenser.

Combination of Biodentine and Simvastatin group: A measuring tool combined Biodentine and Simvastatin paste in a 1:1 ratio. A plastic delivery tool was used to transfer the mixture to the pulp chamber, and a condenser was used to compact it.

All groups treated molar access cavities were first restored with crowns made of stainless steel, then filled with restorative glass ionomer cement (Riva selfcure, Australia) (3M, ESPE, Unitek, United States).

Clinical follow-up was done after (1, 3, 6, 9, and 12) months. Digital Radiographic follow-up was done after 3, 6, 9 and 12 months. The actual study completion date was July, 25th, 2022 which represent Final data collection date for primary outcome measure.

Methods of Evaluation:

The pulpotomised teeth were deemed clinically successful if they fulfilled the following requirements: no tenderness, no pain on percussion, no pathological tooth mobility, no swelling/sinus; and radiographically successful if they fulfilled the requirements of no lamina dura loss, no external/ internal resorption, normal periodontal ligament space, and no periapical/furcation radiolucency.

Statistical Analysis:

To ensure that the samples had a normal distribution, all results were gathered, computed, tabulated, and normality was checked using the Kolmogorov-Smirnov test. Frequencies (n) and percentages were used to present the qualitative data (percent). The Chi-square test was used to evaluate the significance of a correlation between categorical variables. A p-value of less than 0.05 is used to describe statistical significance. All statistical analyses were done with version 26.0 of the SPSS software for Windows. (Statistical Package for Social Science, IBM Corp., Armonk, NY).

RESULTS

Clinical assessment:

A highly significant difference ($p<0.001$) between the three treated groups was discovered through statistical analysis. At one month, no patients in groups I or III had any pain, percussion tenderness, sinus swelling, or pathological mobility. While in group II 16 cases (80%) suffered from spontaneous pain and tenderness on percussion without the presence of swelling/ sinus, or pathological mobility.

No patients in groups I or III had any pain, percussion tenderness, sinus swelling, or pathological mobility at 3 months. Two more patients in group II had

sinus swelling but no pathological mobility, as well as spontaneous pain and tenderness on percussion.

In groups I and II, there were no patients with tenderness to percussion, pain, sinus swelling, or pathological mobility at 6 and 9 months, respectively. In group III, there was only one patient with pain at the 6-month evaluation.

At the end of the 12 months, no patient in group I had pain, tenderness on percussion, a swollen sinus, or pathological mobility. However, one patient in groups II and III had spontaneous pain and tenderness on percussion without a swollen sinus or pathological mobility (Table, 1).

Table (1) *Presence of different clinical signs in all treated groups at different evaluation periods.*

	Follow-up Month)	Groups	Present		Absence		Excluded		Chi-square	
			N	%	N	%	N	%	χ^2	P value
Pain Evaluation	1	**I**	0	0	20	100	0	0	43.63	<0.0001***
		II	16	80	4	20	0	0		
		III	0	0	20	100	0	0		
	3	**I**	0	0	20	100	0	0	51.42	<0.0001***
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	**I**	0	0	20	100	0	0	51.42	<0.0001***
		II	0	0	2	10	18	90		
		III	1	5	19	95	0	0		
	9	**I**	0	0	20	100	0	0	47.29	<0.0001***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	**I**	0	0	20	100	0	0	50.08	<0.0001***
		II	1	5	1	5	18	90		
		III	1	5	18	90	1	5		
Tenderness on percussion	**1**	**I**	0	0	20	100	0	0	43.63	<0.001***
		II	16	80	4	20	0	0		
		III	0	0	20	100	0	0		
	3	**I**	0	0	20	100	0	0	51.42	<0.001***
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	**I**	0	0	20	100	0	0	51.42	<0.001***
		II	0	0	2	10	18	90		
		III	1	5	19	95	0	0		
	9	**I**	0	0	20	100	0	0	47.29	<0.001***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	**I**	0	0	20	100	0	0	50.08	<0.001***
		II	1	5	1	5	18	90		
		III	1	5	18	90	1	5		

	Follow-up Month)	Groups	Present		Absence		Excluded		Chi-square	
			N	%	N	%	N	%	χ^2	P value
Swelling/ sinus	1	I	0	0	20	100	0	0	0.0	>0.999ns
		II	0	0	20	100	0	0		
		III	0	0	20	100	0	0		
	3	I	0	0	20	100	0	0	51.42	< 0.001***
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	I	0	0	20	100	0	0	51.42	<0.001***
		II	0	0	2	10	18	90		
		III	0	0	20	100	0	0		
	9	I	0	0	20	100	0	0	51.42	<0.001***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	I	0	0	20	100	0	0	50.08	<0.001***
		II	1	5	1	5	18	90		
		III	0	0	19	95	1	5		
Pathological mobility	1	I	0	0	20	100	0	0	0.0	>0.999ns
		II	0	0	20	100	0	0		
		III	0	0	20	100	0	0		
	3	I	0	0	20	100	0	0	43.63	<0.0001***
		II	0	0	4	20	16	80		
		III	0	0	20	100	0	0		
	6	I	0	0	20	100	0	0	51.42	<0.0001***
		II	0	0	2	10	18	90		
		III	0	0	20	100	0	0		
	9	I	0	0	20	100	0	0	51.42	<0.0001***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	I	0	0	20	100	0	0	47.29	<0.0001***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		

Test used: chi-square P<0.05 **, means significant

Radiographic assessment:

A highly significant difference (p<0.001) between the three treated groups was discovered through statistical analysis. In groups I and III, the lamina dura was lost, with no widening of the periodontal ligament space, no external, internal resorption, or periapical furcation radiolucency at three months. However, there was a loss of the lamina dura, the periodontal ligament space widening, external and internal resorption, and periapical furcation radiolucency in group II in two cases (10%).

At 6, 9, or 12 months, neither group I nor the two remaining cases in group II had any periapical furcation radiolucency or evidence of external, internal resorption. But in one case in group III, the lamina dura was lost, and the space between the periodontal ligaments got bigger simultaneously (Figures 1 ,2).

Table (2) *Presence of different radiographic signs in all treated groups at all evaluation periods.*

	Follow Up (Month)	Groups	Present		Absence		Excluded		χ^2	*p*-value
			N	%	N	%	N	%		
Loss of lamina dura	**3**	**I**	0	0	20	100	0	0	51.42	0.00002 ***
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	**I**	0	0	20	100	0	0	52.97	0.00001 ***
		II	0	0	2	10	18	90		
		III	1	5	19	95	0	0		
	9	**I**	0	0	20	100	0	0	47.29	0.00001 ***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	**I**	0	0	20	100	0	0	47.29	0.00001 ***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
Widening in periodontal ligament space	**3**	**I**	0	0	20	100	0	0	51.42	0.00000 1***
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	**I**	0	0	20	100	0	0	52.97	0.000008***
		II	0	0	2	10	18	90		
		III	1	5	19	95	0	0		
	9	**I**	0	0	20	100	0	0	47.29	0.000005***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	**I**	0	0	20	100	0	0	47.29	0.000005***
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
External internal resorption	3	**I**	0	0	20	100	0	0	51.42	0.0000018**
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	**I**	0	0	20	100	0	0	51.42	0.0000067**
		II	0	0	2	10	18	90		
		III	0	0	20	100	0	0		
	9	**I**	0	0	20	100	0	0	47.29	0.0000053**
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	**I**	0	0	20	100	0	0	47.29	0.0000053**
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
Periapical /furcation radiolucency	3	**I**	0	0	20	100	0	0	51.42	0.0000018**
		II	2	10	2	10	16	80		
		III	0	0	20	100	0	0		
	6	**I**	0	0	20	100	0	0	51.42	0.0000067**
		II	0	0	2	10	18	90		
		III	0	0	20	100	0	0		
	9	**I**	0	0	20	100	0	0	47.29	0.0000053**
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		
	12	**I**	0	0	20	100	0	0	47.29	0.0000053**
		II	0	0	2	10	18	90		
		III	0	0	19	95	1	5		

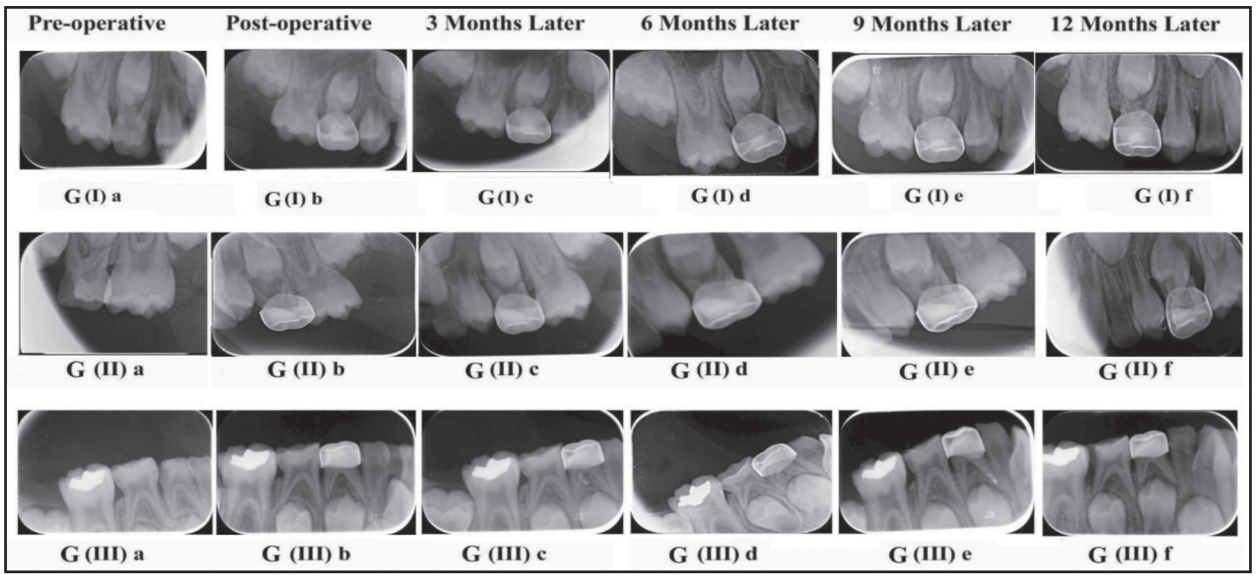

Fig. (1) Radiographic showing Biodentine pulpotomy on upper right E (GI), Simvastatin pulpotomy on upper left E (GII), and combination of Biodentine and Simvastatin pulpotomy on lower right D (GIII) at different evaluation period.

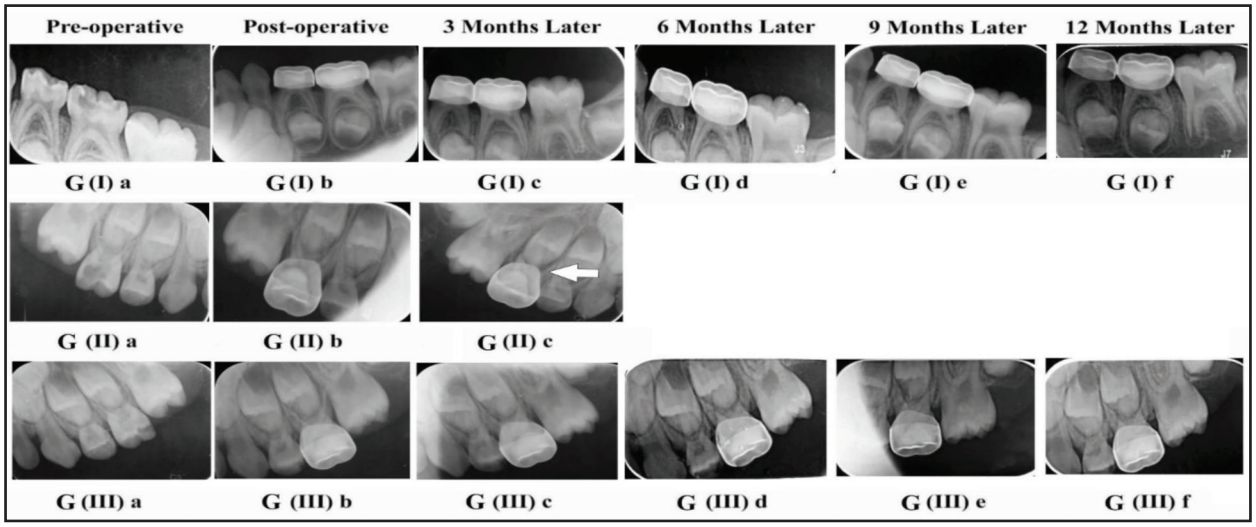

Fig. (2) Radiographic showing Biodentine pulpotomy on lower left D&E (G1), Simvastatin pulpotomy on upper right E (GII), and combination of Biodentine and Simvastatin pulpotomy on upper left E (GIII).

Success rate:

The Biodentine group demonstrated 100 percent clinical and radiographic success at all evaluation periods. In contrast, Simvastatin treated group demonstrated very low clinical success rates of 20%, 10%, 10%, 10%, and 5% clinical success at months 1, 3, 6, 9, and 12, respectively, and very low radiographic success rates of 10%, 10%, 10%, and 10% radiographic success at months 3, 6, 9, 12 respectively. The outcomes of the Biodentine and Simvastatin combination treatment group showed 100%, 100%, 95%, 95%, and 90% clinical success at months 1, 3, 6, 9, and 12, respectively, and 100%, 95%, 95%, 95%, and 95% radiographical success at months 3, 6, 9, and 12 respectively, Fig (3,4) and Table (3,4).

Table (3) *Clinical success rate of different groups at all evaluation periods.*

Evaluation	Follow Up (month)	Groups	Success		Failure		Excluded		χ^2	P value
			N	%	N	%	N	%		
Clinically	**1**	**I**	**20**	100	**0**	0	**0**	0	43.63	0.000003***
		II	**4**	20	**16**	80	**0**	0		
		III	**20**	100	**0**	0	**0**	0		
	3	**I**	**20**	100	**0**	0	**0**	0	51.42	0.000001***
		II	**2**	10	**2**	10	**16**	80		
		III	**20**	100	**0**	0	**0**	0		
	6	**I**	**20**	100	**0**	0	**0**	0	51.42	0.000001***
		II	**2**	10	**0**	0	**18**	90		
		III	**19**	95	**1**	5	**0**	0		
	9	**I**	**20**	100	**0**	0	**0**	0	47.29	0.000005***
		II	**2**	10	**0**	0	**18**	90		
		III	**19**	95	**0**	0	**1**	5		
	12	**I**	**20**	100	**0**	0	**0**	0	50.08	0.000003***
		II	**1**	5	**1**	5	**18**	90		
		III	**18**	90	**1**	5	**1**	5		

Test used: chi-square P<0.05 **, means significant

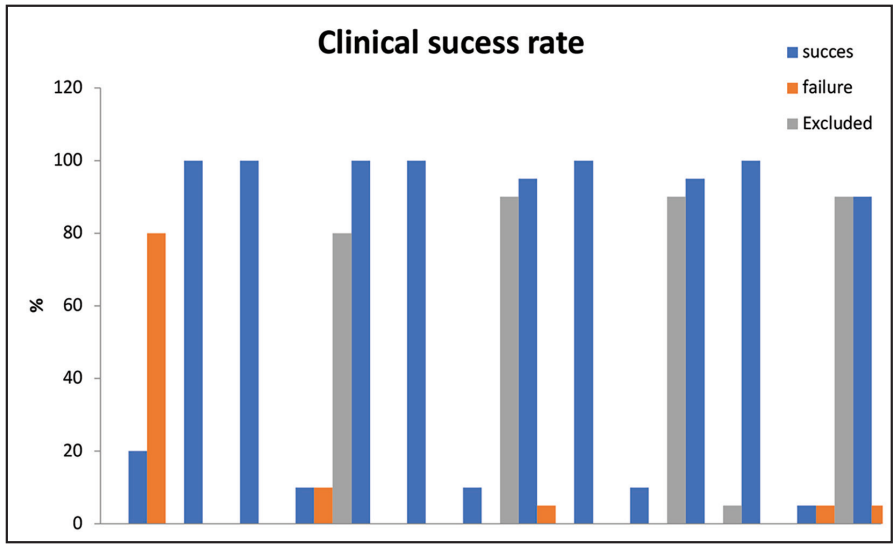

Fig. (3) A bar chart showing clinical success rate of different groups at all evaluation periods.

Table (4) *Radiographic success rate in different treatment groups at all evaluation periods.*

	Follow Up (month)	Groups	Success		Failure		Excluded		χ^2	P value
			N	%	N	%	N	%		
Radiographic Evaluation	**3**	**I**	**20**	100	**0**	0	**0**	0	51.42	0.000001 ***
		II	**2**	10	**2**	10	**16**	80		
		III	**20**	100	**0**	0	**0**	0		
	6	**I**	**20**	100	**0**	0	**0**	0	52.97	0.00008 ***
		II	**2**	10	**0**	0	**18**	90		
		III	**19**	95	**1**	5	**0**	0		
	9	**I**	**20**	100	**0**	0	**0**	0	47.29	0.00005 ***
		II	**2**	10	**0**	0	**18**	90		
		III	**19**	95	**0**	0	**1**	5		
	12	**I**	**20**	100	**0**	0	**0**	0	47.29	0.00005 ***
		II	**2**	10	**0**	0	**18**	90		
		III	**19**	95	**0**	0	**1**	5		

Test used: Chi-square P<0.05 **, means significant

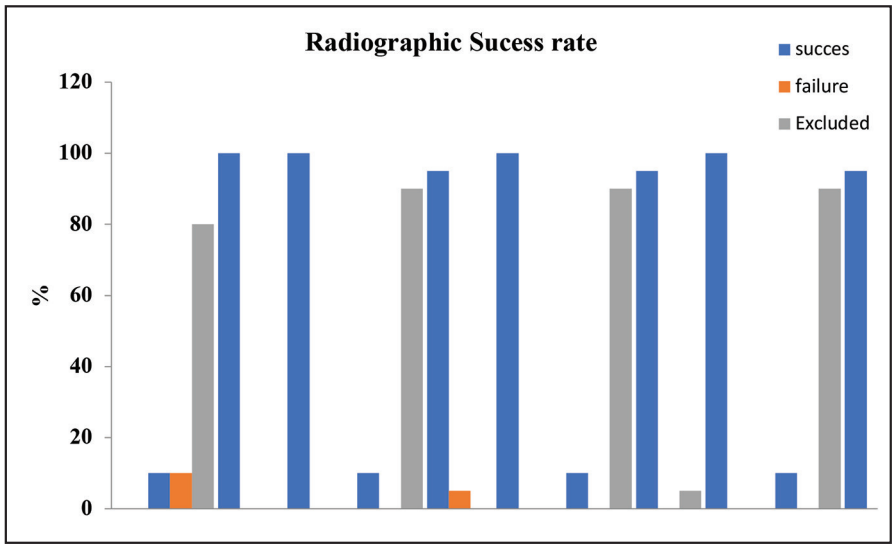

Fig. (4) A bar chart showing radiographic success rate in different treatment groups at all evaluation periods.

DISCUSSION

This study looked at the clinical and radiographic effects of combining Biodentine and Simvastatin as a pulpotomy agent on 60 deeply decayed primary molars in 20children between the ages of 4 and 7 from the outpatient clinic of the Paediatric Dentistry Department, Faculty of Dentistry, Suez Canal University.

According to Niranjani *et al*. [15] and Guagnano *et al*. [16] in these studies, tricalcium silicate (Biodentine) was used, which resembles natural dentin in characteristics, has bioactive properties and doesn't cause moderate to a severe inflammatory response that could result in permanent changes to the pulp status [15,16]. It permits the induction of growth factors that encourage odontoblast differentiation and

dentinogenesis, as well as the development of a chemical structure similar to primary dentin and a reparative dentin bridge with dentin tubules [16–18].

Simvastatin was used in the current study as it has a beneficial action on DPSC differentiation and potent anti-inflammatory action that can enhance pulpal regeneration [19,20(. It has pleiotropic effects, such as inducing angiogenesis and bone formation, as well as anti-inflammatory properties [9].According to Sharaan *et al*. [12], due to its affordability, Simvastatin is suggested as a potential pulpotomy medication for primary molars, superior marginal adaptation, and we favour using it as a material for direct pulp capping.

In the present research, 1.5 mg of Simvastatin was used according to Dianat *et al*. [19], who used 1.5% Simvastatin gel below MTA and found active pulpal repair with well-formed dentine when placed as a DPC material. In addition, 1.5 mg of Simvastatin had superior marginal adaptation and is preferred for use as a direct pulp capping material [12]. Simvastatin, on the other hand, increased the rates of cell death at higher concentrations [12,19,21].

Four to seven years old children were involved in this study as they are more cooperative with easier behaviour management [22]; this age is suitable for treating primary molars as it is away from the age of physiological resorption. The teeth used in this study and the treatment were chosen based on the AAPD guidelines for pulp therapy in primary and immature permanent teeth [23].

In this study, direct digital radiography was used to reduce X-ray exposure time due to the higher sensitivity of the image detectors compared to conventional radiography. Furthermore, digital radiographic systems eliminate the need for a darkroom processing step [24,25].

The clinical and radiographic success of Biodentine treated group at all evaluation periods may be attributed to Biodentine's excellent antimicrobial properties as it has high pH (pH=12), high biocompatibility, and bioactivity [24,26], and coincides with Collado Gonzalez *et al*.[27] who said that Biodentine had better cytocompatibility and bioactivity on stem cells from primary human teeth that had fallen out, which led to its use for pulpotomy on primary teeth. This was in line with the results of several studies that tested Biodentine on primary molars and found that it worked better overall [16,24,28–30].

In present study, the Simvastatin group had a lower success rate, which was in line with Aminabadi *et al*. [21] and Okamoto et al. [31] found that using statin as a direct pulp capping material as opposed to calcium hydroxide resulted in a lower success rate with severe inflammation and less hard tissue formation. Moreover, this agrees with Sabandal et al. 2020 [32], who exhibited an adverse effect of Simvastatin on osteoblast differentiation, revealed a decrease in cell viability when using it in the proliferation and mineralization of human primary osteoblasts.

Our findings contradicted those of Min *et al*.[33], who claimed that Simvastatin was effective in promoting reparative dentinogenesis and the regeneration of damaged dental pulp tissues and that Simvastatin stimulates angiogenesis and odontoblastic differentiation in HDPCs by activating hemoxygenase-1 (HO^{-1}) and the carbon monoxide it produces (CO). Furthermore, Aripirala et al. [10] showed that after 12 months, Simvastatin had the same clinical and x-ray success rate as Diode laser for primary tooth pulpotomy.

In their study of the effectiveness of 3Mixtatin (Simvastatin + 3Mix antibiotic) as a new pulp capping biomaterial in DPC of human primary

molars, Aminabadi et al. [34] concluded that the radiographic and clinical results of the 3 Mixtatin group showed it to be a good alternative for DPC of primary molar teeth. Moreover, Abd Elmegeid *et al*. [35] concluded that Simvastatin and Antioxidant mix pulpotomy are more cost-effective, handled easily, and biocompatible. It has been shown to have the potential to be an excellent pulpotomy agent when treating young, important permanent teeth.

The Biodentine/Simvastatin-treated group achieved clinical and radiographic success, we believe this is due to Biodentine's bioactive properties and its ability to stimulate growth factors that promote odontoblast differentiation, dentinogenesis, and formation of reparative dentin bridge, in addition to the beneficial action of Simvastatin on DPSC differentiation and its potent anti-inflammatory action that can enhance pulpal regeneration. After 6 months, there was one clinical and radiographic failure in the Biodentine and Simvastatin treated group, and another clinical failure at 12 months, which could be attributed to improper case selection or poor manipulation of capping material and or final restoration.

Such discrepancies in results might be due to Different study designs, concentrations, and forms of the Simvastatin combination.

CONCLUSION

This study's findings allow us to draw the following conclusions:

1. Biodentine demonstrated extremely high clinical and radiographic success rates.
2. Simvastatin show failure clinically and radiographically.
3. The combination of Biodentine and Simvastatin showed good clinical and radiographic.

RECOMMENDATIONS

- Further clinical study with longer follow up periods and larger sample sizes on applying the combination of Biodentine and Simvastatin as a pulp capping material in vital pulpotomy of primary molars
- More research is needed to show how the pulp responds to different concentrations of Simvastatin as a pulp capping material in vital pulpotomy..
- More experimental studies should be done to evaluate the effect of Simvastatin on the physical and chemical properties of Biodentine.

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