Effect of Overlying Material on Biodentine™ Setting Reaction in Primary Molar Pulpotomies

BY

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THESIS

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LIST OF ABBREVIATIONS

AAPD	American Academy of Pediatric Dentistry
ANOVA	Analysis of Variance
HK	Knoop Hardness
IRM	Interim Restorative Material
RMGI	Resin Modified Glass Ionomer
SSC	Stainless Steel Crown
ZOE	Zinc Oxide Eugenol

SUMMARY

Objective: The purpose of this *in vitro* study was to evaluate the effect of different overlying materials, such as Intermediate Restorative Material (IRM) or resin-modified glass ionomer cement (RMGIC) on the hardness of Biodentine™, used as a pulpotomy agent in primary teeth, as a function of its hardness 24 hours after final tooth restoration. **Methods:** Forty extracted primary molars were mounted in stone. The teeth were randomly selected into four groups of ten teeth each. Occlusal cavities were prepared to the furcation and pulpal debris was excavated in each sample. Group 1 was restored with Biodentine™, IRM, and a Stainless Steel Crown (SSC). Group 2 was restored with Biodentine™, Fuji II, and a SSC. Group 3 was restored with Biodentine™ and an SSC. Group 4 was restored with Biodentine™ only. All samples were stored in an incubator at 37°C and 100% humidity. After 24 hours, samples were sectioned mesio-distally and polished. The setting reaction was measured as a function of Knoop Hardness value (HK) using Leco Microhardness Tester. Each sample was measured at three zones with a 50gf load force for 30 seconds starting at one millimeter from the Biodentine™-material interface. The data was analyzed using One-Way ANOVA and post-hoc Tukey test. **Results:** There was no significant statistical difference in the mean value among the four groups ($p>0.05$), and among the three zones. **Conclusions:** In this *in vitro* study, Biodentine™ was a suitable restorative material for primary molar pulpotomies and the overlying material showed no influence on the hardness of Biodentine™ after 24 hours.

1 INTRODUCTION

1.1 Background

According to the American Academy of Pediatric Dentistry (AAPD) guidelines, a primary tooth pulpotomy involves the amputation of the coronal pulp followed by the treatment of vital radicular pulp tissue with medicaments such as Buckley's formocresol solution, ferric sulfate, calcium hydroxide, and mineral trioxide aggregate (MTA)[1]. Current pulpotomy agents present different advantages and disadvantages. Buckley's Formocresol solution was introduced in 1904 and has since become the most popular pulp medicament due to its high success rates[2]. However, concerns that formacresol has possible carcinogenic and mutagenic effects propelled a search for an alternative pulpotomy agent[2–4]. MTA, which was introduced in 1993, is a biocompatible calcium silicate material that stimulates odontoblastic activity leading to secondary dentin formation[3–5].

Biodentine™ (Septodont, Saint Maur des Fosses, Île-de-France, France) is a new calcium silicate material that also stimulates secondary dentin formation[3,4]. Studies have revealed that there is no difference in success rates of Biodentine™ and MTA[3,5]. Compared to MTA, however, Biodentine™ has higher compressive strength, lower porosity, and better color stability[5–7]. Despite the many desirable characteristics of Biodentine™, the long set time of the material remains an obstacle to its wide use in pediatric dentistry, a field in which working time relies heavily on patient's cooperation.

The manufacturer recommends that the Biodentine™ pulpotomy and the definitive restoration be completed in two visits due to the long set time.

A recent study has examined the placement of a definitive restoration on unset Biodentine™ with plastic teeth[8]. The study found that Biodentine™ displacement was minimal and that it is acceptable to place the definitive restoration three minutes after the Biodentine™ was mixed and placed[8]. Currently no similar evidence exists for natural teeth.

2 REVIEW OF LITERATURE

2.1 History of Pulpotomy Agents

The ideal pulpotomy medicament should be bactericidal, biocompatible, cost effective, promote pulpal healing, have easy handling, and should not interfere with physiologic root resorption[9–11]. Currently recognized pulpotomy agents include Buckley's formocresol solution, ferric sulfate, calcium hydroxide, and MTA. Each of these agents presents unique advantages and disadvantages.

2.1.1 Formocresol

Buckley's formocresol solution was introduced in 1904 for treatment of non-vital permanent teeth[2,10]. In 1930, formocresol was introduced as a pulpotomy medicament for primary teeth, consisting of 19% formaldehyde and 35% cresol in glycerin or water[10]. Formocresol remains a popular pulpal medicament today due to its high success rate of 89.6%[10,12]. While acknowledging formocresol's high success rate, it must also be mentioned that formaldehyde is classified as a probable carcinogen by the U.S. Department of Health and Human Services and the U.S. Environmental Protection Agency[12]. A study measuring formocresol and cresol levels in blood plasma of children before and after pulpotomy treatment under general anesthesia found that formaldehyde levels were undetectable above baseline plasma concentration and cresol levels were undetectable [13]. Despite the limited evidence that formocresol used in dental treatment poses a risk to patient health, the concerns of potential mutagenicity are enough to prevent it from being accepted as an ideal agent and has propelled a search for an alternative pulpotomy agent[2,3,10].

2.1.2 Glutaraldehyde

Glutaraldehyde was introduced as a potential replacement for formocresol in endodontic procedures by s'Gravenmade in 1975 and then in primary teeth pulpotomies by Kopel and colleagues. in 1980[9,14]. Glutaraldehyde is an attractive agent due to its superior fixative properties and its self-limiting penetration that leads to low antigenicity and low toxicity[9]. Glutaraldehyde is effective as a bactericidal agent at a pH of 7.5 to 8.5[9]. However, in its effective form, glutaraldehyde is unstable and has a shelf life of two weeks[9]. Therefore, the practicality of glutaraldehyde as a pulpotomy agent is limited by its short shelf life despite an average success rate of 82 to 95 percent[9].

2.1.3 Ferric Sulfate

Ferric sulfate, a hemostatic and preserving agent, reduces the incidence of inflammation-induced internal resorption by stimulating agglutination[9,15]. When applied to the canal orifices, the ferric and sulfate ions react with blood to achieve hemostasis. The resulting agglutination decreases the chances of an inflammatory response[9,15]. Still, radiographic observations of internal resorption can lead to premature exfoliation and subsequent arch length loss[15]. However, ferric sulfate success rates (84.8 percent) are comparable to that of formocresol (87.1 percent) at 24 months[12].

2.1.4 Sodium Hypochlorite

Sodium hypochlorite has predominantly been used as an irrigant in permanent tooth root canal therapies since the 1920s[2,9,12]. The antimicrobial properties of 3% to 5% sodium hypochlorite also make the irrigant an ideal disinfectant. In primary tooth

pulpotomies, sodium hypochlorite success rates (82.9 percent) are significantly lower than formocresol success rates (98.1 percent) at 18 months[12].

2.1.5 Calcium Hydroxide

Calcium hydroxide ($Ca(OH)_2$) was introduced in the 1930s[9]. Unlike its predecessors, $Ca(OH)_2$ has a regenerative effect. The regenerative effect of $Ca(OH)_2$ is due to its alkaline pH[9]. When applied to vital pulpal tissue, the high pH of $Ca(OH)_2$ can stimulate reparative dentin or an inflammatory cascade[9,16]. $Ca(OH)_2$ dissociates into calcium ions and hydroxyl ions that lead to cellular differentiation and hard tissue formation[11,16]. A superficial inflammatory reaction can initiate this repair process[17]. However, the solubility of $Ca(OH)_2$ can also result in a continuous inflammatory reaction that can lead to pulpal necrosis and subsequent internal resorption[4,17,18]. At 24 months, $Ca(OH)_2$ success rates (41.4 percent) are significantly lower than formocresol success rates (79.0 percent)[12]. Due to its low success rates and sequelae of internal root resorption, $Ca(OH)_2$ is not recommended for use in primary molar pulpotomies.

2.1.6 Mineral Trioxide Aggregate

MTA was first introduced in 1993 by Torabinejad as a medicament to repair canal perforations[9,12,19]. MTA is composed of Portland cement, bismuth oxide, dicalcium silicate, tricalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite[9,11,12,20]. MTA is a biocompatible material with bactericidal properties and a pH of 10.2 immediately after mixing and a pH of 12.5 three hours after mixing[21]. The mean set time of MTA is 2 hours 45 minutes $\pm$ 5 minutes [21]. The major advantage of MTA is that it can stimulate dentinal bridging[12]. Compared to $Ca(OH)_2$, which also induces hard tissue

formation, MTA can achieve the same effect in a shorter period of time and with less inflammation[4]. Studies show that MTA has been reported to have high success rates. MTA and formocresol have the highest pulpotomy success rates at 24 months (89.6 percent and 85.6 percent, respectively) compared to ferric sulfate (79.3 percent)[12]. MTA success rates are not significantly different than that of formocresol, but is significantly higher than that of ferric sulfate[12]. MTA's long set time, discoloration effects, and difficult handling properties are major disadvantages.

2.2 Biodentine™

Biodentine™ is a calcium silicate material that stimulates secondary dentin formation[3,4]. Biodentine™ is composed of powder and liquid components mixed to form a gel structure that polymerizes into a solid[6]. Its powder component is composed of tricalcium silicate, calcium carbonate, dicalcium silicate, calcium oxide, and iron oxide[6]. Its liquid component is composed of hydrosoluble polymer and calcium chloride[6]. When the powder and liquid components are mixed, the calcium silicate particles react with water to yield calcium, hydroxyl, and silicate ions[20]. The resulting calcium hydroxide increases the pH to 12 while the resulting calcium silicate hydrate gels polymerize over time to form a rigid structure[20]. The calcium silicate also interacts with phosphate ions in saliva to form apatite deposits that increase the sealing ability and decrease the microleakage of Biodentine™ [20].

At a cellular level, Biodentine™ promotes pulpal healing by increasing cell proliferation, migration adhesion, and mRNA expression of chemokines[22]. Biodentine™ also induces Transforming growth factor-Beta 1 secretion that results in increased

collagen synthesis and formation of new dentin. Biodentine™ is biocompatible, non-cytotoxic, and non-genotoxic, addressing the drawbacks of formocresol[23].

Studies have revealed that there is no difference in the success rates of Biodentine™ and MTA primary molar pulpotomies[3,5]. Compared to MTA, however, Biodentine™ has higher compressive strength, increased calcium ion release, lower porosity, better color stability, better handling, and a lower set time[5–7]. While the set time of Biodentine™ is more favorable than that of MTA, the manufacturer recommends that a Biodentine™ pulpotomy and the definitive restoration be completed in two separate visits. This remains an obstacle to its wide use in pediatric dentistry, a field in which working time relies heavily on patient cooperation.

The manufacturer recommends the placement of Biodentine™ directly on the pulp orifices up to the occlusal surface of the tooth on the first visit (Appendix B). After 12 minutes at initial set, the rubber dam and matrix may be removed. After one week to six months, a definitive restoration may be placed. A recent study has examined the placement of a definitive restoration on unset Biodentine™ using plastic teeth[8]. The authors found that Biodentine™ displacement was minimal and that it is acceptable to place the definitive restoration three minutes after the material was mixed and placed[8]. Currently, no similar evidence exists for natural teeth. This study investigates the hypothesis that Biodentine™ is a suitable material for use on a single-visit pulpotomy and definitive restoration procedure. The aim of the research is to assess the displacement and secondary set of Biodentine™ restored definitively with stainless

steel crowns in a single-visit and to compare the effect different liner materials on the displacement and secondary set of Biodentine™ in primary molar pulpotomies.

2.3 Measuring Microhardness

The setting reaction and strength of a material can be measured as a function of microhardness. Microhardness is a material's ability to resist permanent deformation when a prescribed load is applied[24]. Microhardness is a mechanical property that is affected by other properties of the material, including surrounding pH, particle size, temperature, yield and tensile strengths, and temperature[24]. There are two types of microhardness tests—Knoop and Vickers. These tests differ in the shape of the indenter used. The Knoop test involves the use of an elongated pyramid indenter and the Vickers test involves the use of a square pyramid diamond indenter[24]. The load and dwell time prescribed to the indenter are determined during a pilot test in which a clear indent is visible[24]. To increase visibility of the indent, the surface must be polished to remove the superficial layer and reveal a scratch-free area[24].

During indentation, the indenter applies the determined load force (F) for a determined dwell time. Following application of the load, the dimensions of the indentation are measured and the hardness is defined as the ratio of the load to the facet contact area[24]. Knoop hardness (HK) is calculated by the following equation:

$$HK = F/A$$

F is the load (kg^{-1}) and *A* is the area produced by the indenter[24]. A large HK value indicates low hardness.

3.1 Aims and Objectives

The purpose of this *in-vitro* study is to evaluate the setting reaction of Biodentine™, used as a pulpotomy agent, as a function of its hardness 24 hours after final tooth restoration. The objectives of the study are to compare the effect of different overlying materials such as Zinc Oxide Eugenol (ZOE) and Resin Modified Glass Ionomer (RMGI) cements on the setting reaction of Biodentine™ in primary molar pulpotomies restored definitively with stainless steel crowns (SSC) in a single visit. This *in vitro* trial will provide recommendations on appropriate restorative materials for Biodentine™ pulpotomies completed in a single visit.

3.2 Hypothesis

H(o): There is no difference in hardness of Biodentine™ in primary molar pulpotomies whether it is placed according to manufacturer recommendations, or restored in a single visit with SSCs, ZOE, or RMGI cements.

3 MATERIALS AND METHODS

3.1 IRB Approval

The protocol #2017-0179 was reviewed on February 22, 2017 by OPRS of IRB #7. The proposal does not involve “human subjects”, and thus an exemption was granted (Appendix A).

3.2 Overview

This *in vitro* study was conducted in the labs of Drs. Satish Alapati and Anakarina Bedran-Russo at the University of Illinois at Chicago College of Dentistry (801 S. Paulina St, Rooms 536 Chicago IL, 60612). The primary investigator (PI) prepared and tested all samples.

3.3 Dental Materials

The dental materials in this study were prepared according to manufacturer instructions.

- Biodentine™: five drops of liquid to one capsule of Biodentine™, triturated 4000 rotations/mm for 30 seconds
- Intermediate Restorative Material (IRM, Dentsply Caulk, Milford, Delaware, USA): one scoop powder to one drop liquid
- Fuji II LC (GC America Inc., Alsip, Illinois, USA): triturated for 10 seconds, lightcured for 20 seconds
- FujiCem2 Cement (GC America Inc., Alsip, Illinois, USA): applied to intaglio of SSC, excess removed

3.4 Selection and Mounting of Samples

Forty extracted primary molars were used for this study. Inclusion criteria included primary molars with caries, complete root development, and existing composite or amalgam restorations. Teeth that had gross caries compromising the integrity of the tooth, incomplete root development, or existing stainless steel crowns were excluded. The teeth were stored in 2% Chloramine-T solution. Each sample was mounted with rope wax to a plastic dappen dish. Laboratory stone was used to mount the samples.

3.5 Pilot

A pilot study was completed on 10 samples to determine the effective polishing grits and times and appropriate load force and dwell time for the Knoop hardness test.

3.6 Study Groups

Ten teeth were randomly assigned to each of four groups as follows:

Group 1: Biodentine™, ZOE (IRM), SSC with FujiCem2

Group 2: Biodentine™, RMGI (Fuji II LC), SSC with FujiCem2

Group 3: Biodentine™, SSC with FujiCem2

Group 4 (Control Group): Biodentine™ only

The study was done in two batches, with the first five samples of each group being completed during the first batch and the final five samples of each group being completed in the second batch.

3.7 Preparation of Samples

The clinical pulpotomy procedure was replicated in each sample. Occlusal cavities were prepared to the furcation with a round bur in a high speed handpiece and pulpal debris was

removed with a round bur in a slow speed handpiece and a spoon excavator. The pulp chambers were irrigated with 0.12% Chlorhexidine and dried with air and cotton pellets. The pulpal depth was recorded from the pulpal floor at the furcation to the cavosurface margin. Following cavity preparation and tissue excavation, the samples were restored according to assigned group as illustrated in Figure 1.

Group 1: Biodentine™, IRM, SSC

Biodentine™ was placed over the radicular orifices and pulpal floor to an approximate thickness of three mm and allowed to set for three minutes. IRM was placed in the remaining cavity and the tooth was then prepared to receive an SSC. An SSC was then fitted and cemented with FujiCem2.

Group 2: Biodentine™, RMGI, SSC

Biodentine™ was placed over the radicular orifices and pulpal floor to an approximate thickness of three mm and allowed to set for three minutes. Fuji II LC was placed in the remaining cavity and the tooth was then prepared to receive an SSC. An SSC was then fitted and cemented with FujiCem2.

Group 3: Biodentine™, SSC

Biodentine™ was placed over the radicular orifices and pulpal floor to the occlusal surface. The tooth was then prepared to receive an SSC. An SSC was then fitted and cemented with FujiCem2.

Group 4 (Control): Biodentine™ only

Biodentine™ was placed over the radicular orifices and pulpal floor to the occlusal surface with no definitive restoration.

3.8 Storage of Samples

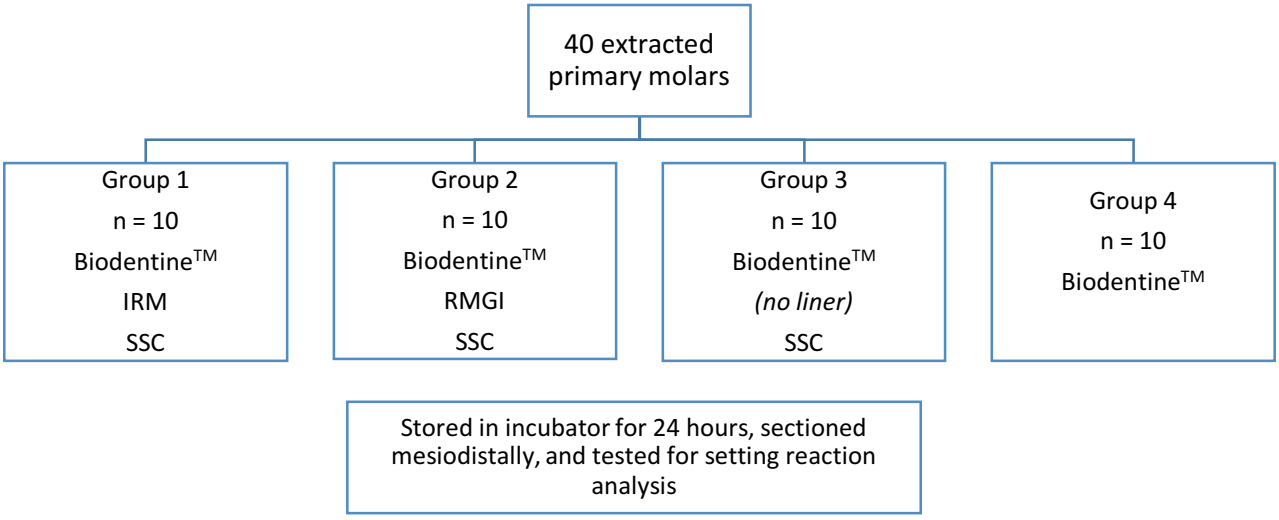
Following preparation, the samples were stored in pipette boxes at 100% humidity which were stored in an incubator at 37^{o}C (98.7^{o}F) for 24 hours to simulate the environmental conditions of the oral cavity.

3.9 Sectioning, Polishing, and Testing Samples

After 24 hours, the samples were sectioned mesiodistally with a diamond cut-off wheel, polished using a EcoMet 3000 Variable Speed Grinder-Polisher (Buehler, Lake Bluff, Illinois, USA) at 600 grit, 800 grit, and 1200 grit, and mounted to a slide with sticky wax.

Each sample was tested for hardness with a Leco Microhardness Tester LM700AT (LECO, Saint Joseph, Michigan, USA). Each sample was visualized under the light microscope at 10x magnification and the Biodentine^{TM} material interface was identified. Each sample was measured for microhardness with 50gf load force for 30 seconds in three zones: 1mm, 2mm, and 3mm from the Biodentine^{TM} material interface. The hardness was recorded in Knoop Scales (HK).

Figure 1: Study Design Flow Chart



3.10 Statistical Analysis

GraphPad Prism software (GraphPad Software, La Jolla California USA) was used to analyze the collected data. Analysis of Variance (ANOVA) with post-hoc Tukey multiple comparisons testing was used to compare the three zones within each group and each zone across groups.

4 RESULTS

This *in vitro* study included the preparation of 40 extracted teeth, with 10 teeth in each of the four groups. The hardness values (HK) were measured at three zones in each sample: 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3). HK at each zone was averaged in the four groups. Table 1, Table 2, and Table 3 report the hardness data and mean HK at Zones 1, 2, and 3 in Groups 1, 2, and 3 respectively.

4.1 Comparison of Zones Within Groups

Figure 2, 3, 4, and 5 illustrate the distribution of HK measurements in Zones 1, 2, and 3 for each group. The solid bar indicates the mean hardness and the line indicates the standard deviation. One-way ANOVA comparison of the three zones within each group showed no significant difference in hardness overall ($P>0.05$). Tukey's post-hoc comparison showed no significant differences in hardness between Zones 1 and 2, Zones 1 and 3, and Zones 2 and 3 of any of the groups.

4.2 Comparison of Zones Across Groups

ANOVA with Tukey's post-hoc was also completed to compare zones across all groups. Figure 6, 7, and 8 show the distribution of hardness values, mean value, and standard deviation in Zones 1, 2, and 3 for each group. There was no significant difference in hardness overall nor among groups in any of the zones ($P>0.05$). Figures 9, 10, and 11 display the confidence intervals for the difference between the means of hardness. The vertical line at zero represents the grand mean, or normalized mean. The grand mean falls within all the confidence intervals, which indicated that the difference between these means was not statistically significant. The

95% simultaneous confidence level indicated that the study was 95% confident that all these confidence intervals contained the true differences.

Table 1: Group 1 (BD-IRM-SSC) Hardness Values

Sample #	Zone 1	Zone 2	Zone 3
1	68.1	57.1	49.7
2	55.5	57.6	63.8
3	75.3	60.1	54.4
4	47.2	59.1	64
5	64.5	64.5	61.6
6	40.8	51.7	47.6
7	57.8	60.9	56.1
8	62.6	54.9	44
9	45.9	59.7	56.5
10	48.2	43.8	45.1
Mean	**56.59**	**56.94**	**54.28**
SD	**11.08577166**	**5.772001386**	**7.47214085**

Hardness values measured in Knoop Hardness (HK) at three zones in each sample: 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3); BD = Biodentine; IRM = Interim Restorative Material; SSC = Stainless Steel Crown; SD = standard deviation

Table 2: Group 2 (BD-RMGI-SSC) Hardness Values

Sample #	Zone 1	Zone 2	Zone 3
11	60.2	54.4	57.7
12	60.1	44.8	37.3
13	60.6	60.3	65.7
14	50.8	55.6	51.3
15	26.4	43.5	52.5
16	45.4	48.7	53.4
17	24.8	45.5	57.4
18	30.1	41.9	59.1
19	57.2	41.3	43.7
20	50.4	32.5	34.4
Mean	**46.6**	**46.85**	**51.25**
SD	**14.39374864**	**8.140195193**	**9.953028573**

Hardness values measured in Knoop Hardness (HK) at three zones in each sample: 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3); BD = Biodentine; RMGI = Resin Modified Glass Ionomer; SSC = Stainless Steel Crown; SD = standard deviation

Table 3: Group 3 (BD-SSC) Hardness Values

Sample #	Zone 1	Zone 2	Zone 3
21	57.9	58.9	56.8
22	75.6	73.5	68.8
23	80.7	62	92.5
24	90.6	86.1	93.1
25	81.4	55.1	83.8
26	35.5	35.4	48.6
27	46.1	38.7	32.8
28	48	41.2	54.9
29	44	50.6	52.5
30	59.6	60.6	49.3
Mean	**61.94**	**56.21**	**63.31**
SD	**18.93428401**	**15.81156047**	**20.44768121**

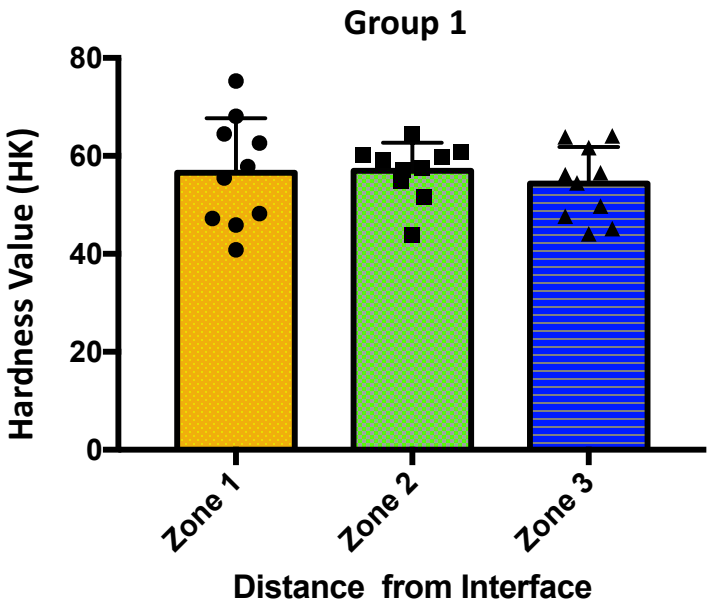
Hardness values measured in Knoop Hardness (HK) at three zones in each sample: 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3); BD = Biodentine; SSC = Stainless Steel Crown; SD = standard deviation

Table 4: Group 4 (BD) Hardness Values

Sample #	Zone 1	Zone 2	Zone 3
31	50.6	56.4	47.6
32	47.2	46.9	57.1
33	55.2	50.2	61
34	65.3	63	67.3
35	68.9	62.4	60.7
36	55.5	44.5	43.7
37	57.1	62.5	69.9
38	46.3	51.5	48.6
39	64.8	67.1	65.9
40	42.3	42.4	47.6
Mean	**55.32**	**54.69**	**56.94**
SD	**8.920612834**	**8.770715162**	**9.460702346**

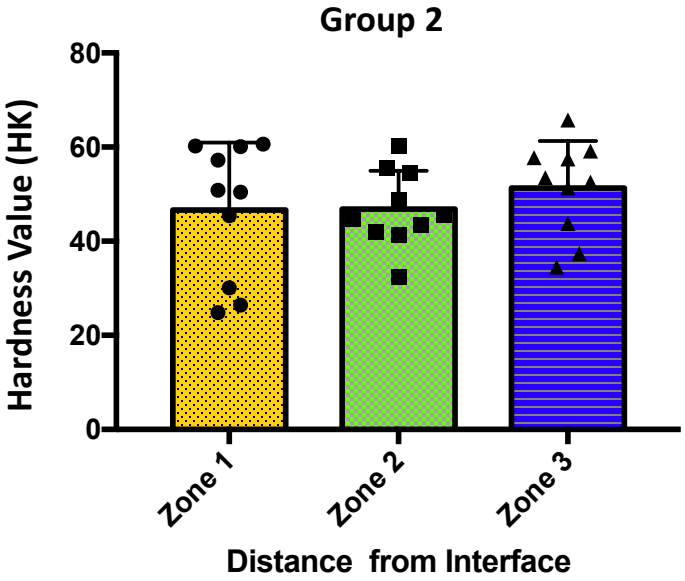
Hardness values measured in Knoop Hardness (HK) at three zones in each sample: 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3); BD = Biodentine; SD = standard deviation

Figure 2: Comparison of Hardness Value Distribution in Group 1



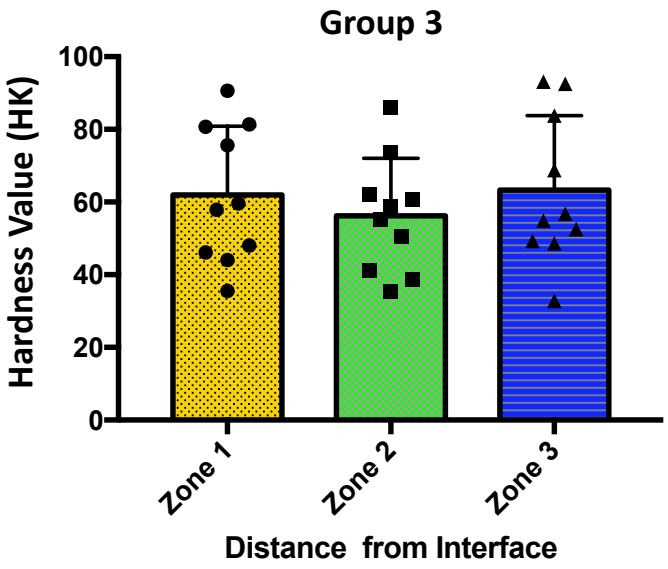
Hardness values measured in Knoop Hardness (HK) at three zones in Group 1 (Biodentine, Interim Restorative Material, and Stainless Steel Crown): 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3)

Figure 3: Comparison of Hardness Value Distribution in Group 2



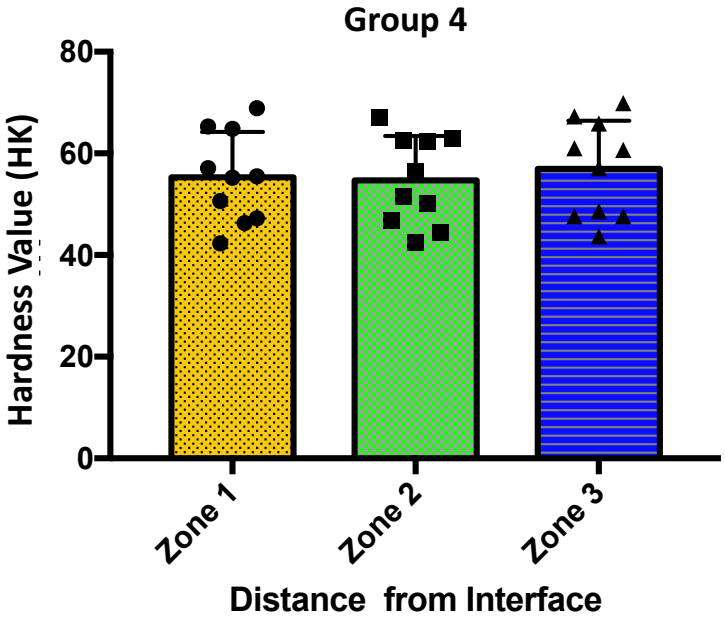
Hardness values measured in Knoop Hardness (HK) at three zones in Group 2 (Biodentine, Resin Modified Glass Ionomer, and Stainless Steel Crown): 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3)

Figure 4: Comparison of Hardness Value Distribution in Group 3



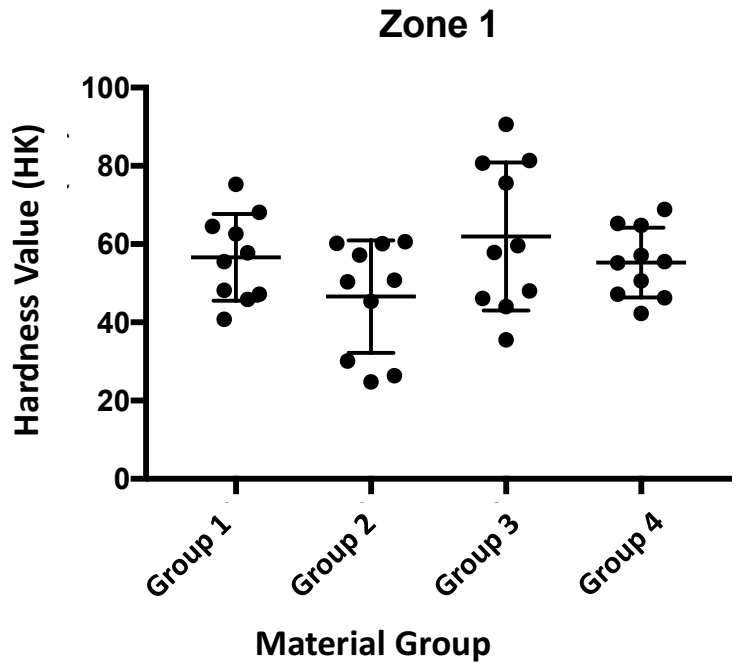
Hardness values measured in Knoop Hardness (HK) at three zones in Group 3 (Biodentine and Stainless Steel Crown): 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3)

Figure 5: Comparison of Hardness Value Distribution in Group 4



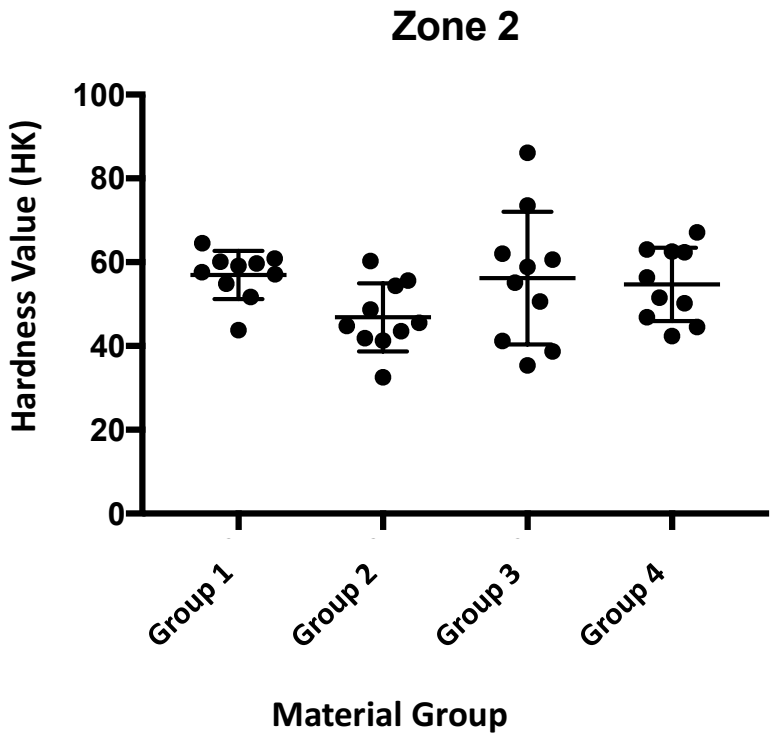
Hardness values measured in Knoop Hardness (HK) at three zones in Group 4 (Biodentine): 1mm (Zone 1), 2mm (Zone 2), and 3mm (Zone 3)

Figure 6: Comparison of Hardness Value Distribution in Zones 1



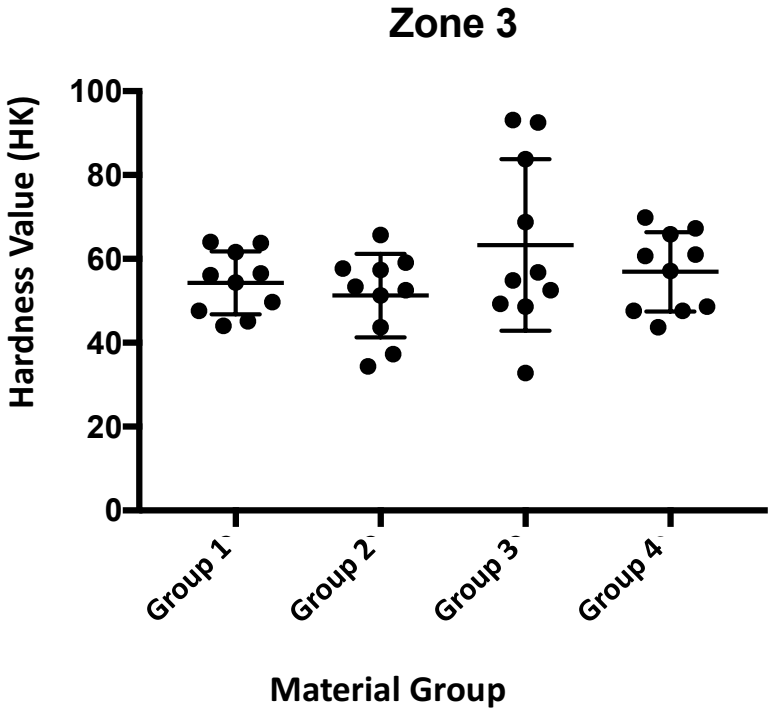
Group 1 = Biodentine, Interim Restorative Material, SSC; Group 2 = Biodentine, Resin Modified Glass Ionomer, SSC; Group 3 = Biodentine, SSC; Group 4: Biodentine

Figure 7: Comparison of Hardness Value Distribution in Zones 2



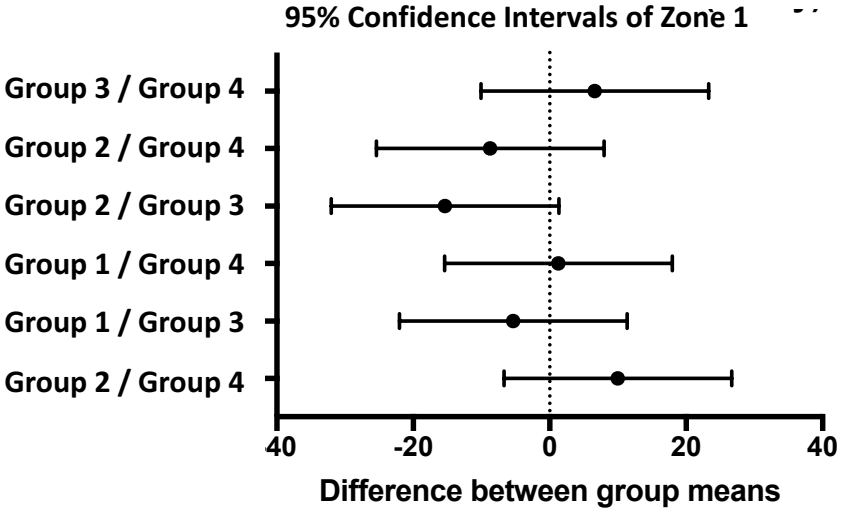
Group 1 = Biodentine, Interim Restorative Material, SSC; Group 2 = Biodentine, Resin Modified Glass Ionomer, SSC; Group 3 = Biodentine, SSC; Group 4: Biodentine

Figure 8: Comparison of Hardness Value Distribution in Zones 3



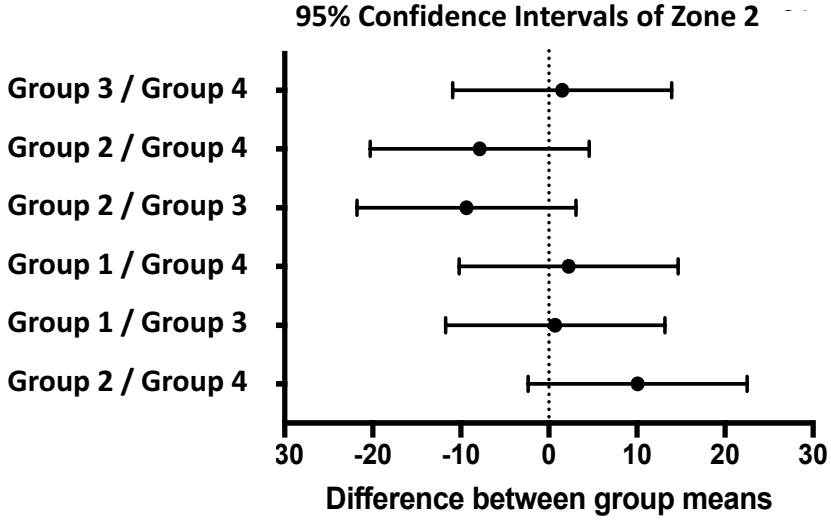
Group 1 = Biodentine, Interim Restorative Material, SSC; Group 2 = Biodentine, Resin Modified Glass Ionomer, SSC; Group 3 = Biodentine, SSC; Group 4: Biodentine

Figure 9: Zone 1 Confidence Intervals



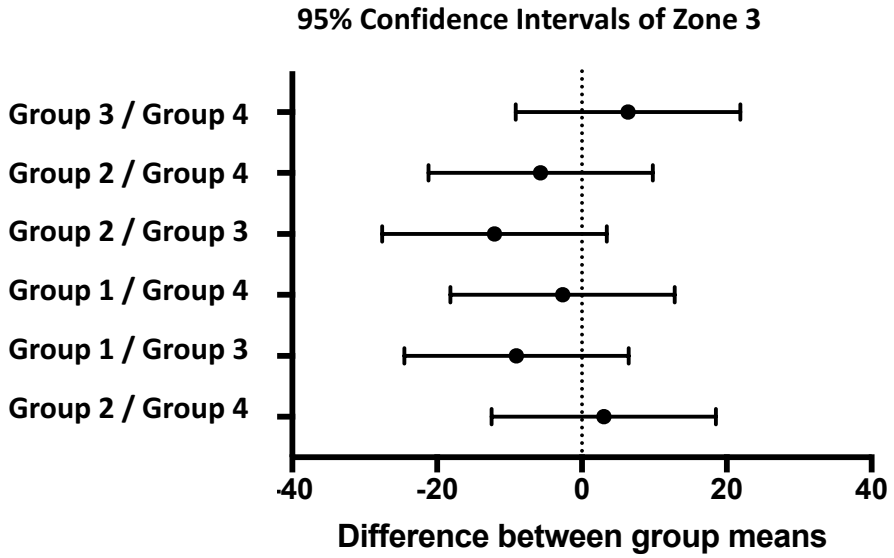
Group 1 = Biodentine, Interim Restorative Material, SSC; Group 2 = Biodentine, Resin Modified Glass Ionomer, SSC; Group 3 = Biodentine, SSC; Group 4: Biodentine

Figure 10: Zone 2 Confidence Intervals



Group 1 = Biodentine, Interim Restorative Material, SSC; Group 2 = Biodentine, Resin Modified Glass Ionomer, SSC; Group 3 = Biodentine, SSC; Group 4: Biodentine

Figure 11: Zone 3 Confidence Intervals



Group 1 = Biodentine, Interim Restorative Material, SSC; Group 2 = Biodentine, Resin Modified Glass Ionomer, SSC; Group 3 = Biodentine, SSC; Group 4: Biodentine

5 DISCUSSION

For young children who may be unwilling or unable to cooperate for extended periods of time and across multiple appointments, the duration and frequency of dental visits is a concern. This *in vitro* study examined the necessity of a postponing final restoration by comparing the effect of ZOE and RMGI as liners and the effect of a definitive SSC restoration on the setting reaction of Biodentine™ in primary molar pulpotomies. This study supports recent findings that a definitive SSC restoration can be seated on Biodentine, used as a pulpotomy agent, three minutes after mixing.[8] There have been no similar studies evaluating the setting reaction of Biodentine in primary molar pulpotomies restored in a single visit involving natural teeth. The results in this *in vitro* study indicate that there is no difference in hardness of Biodentine in primary molars restored in a single visit with or without either ZOE or RMGIC liners.

The manufacturer recommendation for Biodentine use in pulpotomy procedures is to place the Biodentine on the pulpal orifices and floor to the occlusal surface, to serve as both a pulpotomy agent and a temporary restoration.[25] In this study, Biodentine was placed to a thickness of three mm in Groups 1 and 2, and to the occlusal surface in Groups 2 and 3. A comparison of Biodentine thickness showed no significant difference in hardness. Therefore, contrary to the manufacturer recommendations, three mm is an adequate material thickness. Clinically translated, less Biodentine material can be used, introducing a more cost-effective protocol for the practitioner.

Setting reaction was measured as a function of microhardness for this study. The Knoop test measures for indentation created by a predetermined load force and dwell time.[23,24] The Knoop test requires only a small sample and causes minor damage to the sample, however,

error may arise from the polishing pressure that may cause microdefects resulting in increased microhardness values.[24] However, each sample was polished with the same protocol (600 grit, 800 grit, and 1200 grit for 10 minutes each), which would make the microdefects uniform across all samples.

Other measures of setting reaction for future studies may include the Gillmore needle test, compressive strength studies, and analysis of porosity. The Gillmore needle tests for setting time of a cement material by repeatedly applying a weighted needle onto the material surface and measuring the elapsed time from the mixing to when an attempted indentation is unsuccessful.[21,24] The Gillmore test was not appropriate for this study, as the liners and restorations were placed three minutes after mixing.

While preparing the samples to receive SSCs, Biodentine washout was observed, consistent with a recent study that reported Biodentine demonstrated greater washout compared to Bioaggregate or Intermediate Restorative Material (**IRM**).[23] The low washout rates of IRM is attributed to the eugenol liquid that is not water miscible.[23] IRM was used as the ZOE liner in this study. This would suggest that IRM as a liner would be effective to prevent Biodentine washout when preparing the tooth to receive a SSC. In addition to washout, subjecting the unset Biodentine to water could increase the water to cement ratio and introduce voids. Measuring voids proves to be challenging because pores are multi-dimensional and difficult to identity and classify in a cross-section surface view.[24] Biodentine, like other calcium silicate cements, require moisture to set.

This study design aimed to replicate the pulpotomy and restorative techniques used in the clinical setting. However, the availability of resources created limitations to fully simulate

the clinical setting and complexity of the oral environment, such as blood and saliva contamination, changing thermal and pH conditions, and chewing forces that may affect dental material setting reactions. The variability of these conditions affect the material's reported microhardness.[24] Microhardness is a mechanical property that is affected by other properties of the material, including surrounding pH, yield and tensile strengths, and temperature.[24]

While oral conditions were simulated with samples stored in 100% humidity at 37°C in this study, access to a saliva medium or thermal cycling chambers would more accurately replicate natural oral conditions in which eating would expose the human mouth to a range of temperatures and salivary gland stimulation. Furthermore, altering the surrounding pH and applying mechanical occlusal forces to the samples would enhance the likeness to natural intraoral conditions. Introduction of a saliva medium would provide phosphate ions that interact with calcium silicate to form apatite deposits; this formation increases the sealing ability and decreases the microleakage of Biodentine.[20,26] Therefore, no difference in findings is expected with a saliva medium. Further investigation is necessary to determine the clinical success of this study's findings. Future studies may investigate the clinical and radiographic success rates of primary molars that have pulpotomies and definitive restorations completed on the same visit with or without liners.

Biodentine samples were donated by Septodont for this study. The authors did not receive any additional funding and report no conflicts of interest.

6 CONCLUSION

The following conclusions can be made based on the results of this study:

1) IRM, RMGI, and SSCs as overlying liners and restorative materials have no effect on the quality of setting reaction of Biodentine™.
2) Biodentine™ pulpotomies can be restored definitively during the same visit with no effect on setting reaction

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APPENDIX A

Determination Notice
Research Activity Does Not Involve "Human Subjects"

February 22, 2017

Chi-Lan Pham
Pediatric Dentistry
801 S. Paulina Street
M/C 850
Chicago, IL 60612
Phone: (312) 996-7532 / Fax: (312) 413-8006

RE: Research Protocol # 2017-0179
"In Vitro Evaluation of Biodentine Material Displacement in Primary Molar Pulpotomy Procedure"

Sponsor(s): None

Dear Chi-Lam Pham:

The above proposal was reviewed on February 22, 2017 by OPRS staff/members of IRB #7. From the information you have provided, the proposal does not appear to involve "human subjects" as defined in 45 CFR 46. 102(f).

The specific definition of human subject under 45 CFR 46.102(f) is:

> *Human subject* means a living individual about whom an investigator (whether professional or student) conducting research obtains
>
> (1) data through intervention or interaction with the individual, or
> (2) identifiable private information.
>
> *Intervention* includes both physical procedures by which data are gathered (for example, venipuncture) and manipulations of the subject or the subject's environment that are performed for research purposes. *Interaction* includes communication or interpersonal contact between investigator and subject. *Private information* includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, and information which has been provided for specific purposes by an individual and which the individual can reasonably expect will not be made public (for example, a medical record). Private information must be individually identifiable (i.e., the identity of the subject is or may readily be ascertained by the investigator or associated with the information) in order for obtaining the information to constitute research involving human subjects.

All the documents associated with this proposal will be kept on file in the OPRS and a copy of this letter is being provided to your Department Head for the department's research files.

If you have any questions or need further help, please contact the OPRS office at (312) 996-1711 or me at (312) 355-2908.

Sincerely,
Charles W. Hoehne, B.S.

Assistant Director, IRB # 7
Office for the Protection of Research Subjects

cc: Marcio Da. Fonseca, Pediatric Dentistry, M/C 850
Ian Marion, Pediatric Dentistry, M/C 850

APPENDIX B

EN

COMPOSITION
Tricalcium silicate powder
Aqueous calcium chloride solution and excipients

PROPERTIES
Biodentine® is a bioactive dentin substitute from the « Active Biosilicate Technology® » innovation.
1/ Biodentine® has mechanical properties similar to the sound dentin and can replace it both in the crown and in the root, without any preliminary conditioning of mineral tissues
2/ Biodentine® contains high-purity, monomer-free mineral ingredients and is highly biocompatible.
3/ Biodentine® creates the optimal conditions for maintenance of pulp vitality, by providing a very tight seal on the dentin surface. It therefore reduces **the risk of postoperative sensitivity and the longevity of restorations in vital teeth.**
4/ Biodentine®, being bioactive, stimulates the pulp cells to build 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.
5/ Biodentine® offers an initial setting time reduced down to 12 minutes from start of mix, for optimal use in the crown.

INDICATIONS
In the crown:
- Permanent dentin restoration under composites or Inlay/Onlay
- Temporary dentin-enamel restoration.
- Restoration of deep and/or large coronal carious lesions (sandwich technique).
- Restoration of cervical radicular lesions.
- Pulp capping.
- Pulpotomy.

In the root:
- Repair of root perforations.
- Repair of furcation perforations.
- Repair of perforating internal resorptions.
- Repair of external resorption
- Apexification.
- Root-end filling in endodontic surgery (retrograde filling).

Biodentine® is not to be used for permanent obturation or sealing of the root canal.

CONTRAINDICATION
Allergy to one of the ingredients.

LIMITS OF USE
- Restoration of large loss of tooth substance subjected to high stresses.
- Esthetic restoration of anterior teeth.
- Treatment of teeth with irreversible pulpitis.

SIDE EFFECTS
- No known side effects.

INSTRUCTIONS FOR USE (FOR EACH INDICATION)
Biodentine® mixing instructions
1) Take a capsule and gently tap it on a hard surface to loosen the powder.
2) Open a capsule and place it on the white capsule holder.
3) Detach a single-dose container of liquid and gently tap on the sealed cap to force all the liquid down the container.
4) Twist cap to open. Be careful that no drop of liquid falls out of the single dose container.
5) Pour 5 drops from the single-dose container into the capsule.
6) Close the capsule. Place the capsule on a mixing device, such as Technomix, Tac 400 (Lineatac), Silamat, Cap-Mix, Rotomix, Ultramat etc., at a speed of 4000 – 4200 rotations/min.
7) Mix for 30 seconds.
8) Open the capsule and check the material's consistency. If a thicker consistency is preferred, wait for 30 sec to 1 min before checking again. Do not exceed the working time.
9) Collect Biodentine® with the instrument supplied in the box. Depending on the desired application, you may handle Biodentine® with an amalgam carrier, a spatula or a Root Canal Messing Gun.
Rapidly rinse and clean the instruments to remove any residual material.

IMMEDIATE ENAMEL RESTORATION:
Assess pulp vitality by the usual tests: Biodentine® is not indicated for the treatment of teeth with irreversible pulpitis.
1) Isolate the tooth with a rubber dam.
2) Remove the infected dentin with a round bur and/or a hand excavator. Leave the affected dentin.
3) Adapt a matrix around the tooth if a wall is missing.
4) Prepare Biodentine® as indicated above (Biodentine® mixing instructions)
5) Insert Biodentine® in the cavity, so that the volume of missing dentin is replaced by the same volume of Biodentine® avoiding to trap air bubbles. Flatten the material without excessive pressure and ensure good adaptation to the cavity walls and margins.
6) Wait until the end of the setting time (12 minutes) before performing the permanent enamel restoration. Biodentine® is compatible with all direct crown restoration techniques and particularly with all types of bonding systems.

NON-IMMEDIATE ENAMEL RESTORATION
Assess pulp vitality by the usual tests: Biodentine® is not indicated for the treatment of teeth with irreversible pulpitis.
1) Isolate the tooth with a rubber dam.
2) Remove the infected dentin with a round bur and/or a hand excavator. Leave the affected dentin.
3) Adapt a matrix around the tooth if a wall is missing.
4) Prepare Biodentine® as indicated above (Biodentine® mixing instructions)
5) Insert Biodentine® in the cavity avoiding trapping air bubbles. Ensure good adaptation of the material to the cavity walls and margins. Do not apply excessive pressure on the material.
6) Model the surface of the restoration
7) Wait until the end of the setting time (12 minutes) before removing the matrix
8) To optimize the mechanical properties of the material and facilitate removal of the matrix, a varnish can be applied onto the surface of the restoration.
9) Check occlusion.
10) Within one week to six months after placement of Biodentine®, prepare the cavity according to the criteria recommended for the selected restorative material. The remaining Biodentine® material can be considered as sound artificial dentin and permanently left in deep areas of the cavity and in areas adjacent to the pulp chamber. Biodentine® is compatible with all direct or indirect crown restoration techniques, and particularly with all types of bonding systems.

PULP CAPPING:
Assess pulp vitality by the usual tests: Biodentine® is not indicated for the treatment of teeth with irreversible pulpitis
1) Isolate the tooth with a rubber dam.
2) Remove the infected dentin with a round bur and/or a hand excavator. Leave the affected dentin.
3) Adapt a matrix around the tooth if a wall is missing.
4) If there is bleeding in the pulp, hemostasis must be achieved before applying Biodentine®.
5) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
6) Place Biodentine® directly on the exposed pulp avoiding trapping air bubbles. Ensure good adaptation of the material to the cavity walls and margins. Do not apply excessive pressure on the material.
7) Perform the immediate or non-immediate enamel restoration as indicated above.

PULPOTOMY:
1) Isolate the tooth with a rubber dam.
2) Remove the infected dentin with a round bur and/or a hand excavator.
3) Gain access to the pulp chamber and clean out the pulp.
4) If there is bleeding in the pulp, hemostasis must be achieved before applying Biodentine®.
5) Adapt a matrix around the tooth if a wall is missing.
6) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
7) Place Biodentine® directly in the pulp chamber and ensure good adaptation to the cavity walls and margins.
8) Model the surface of the restoration.
9) Wait until the end of the setting time (12 minutes) of the material before removing the matrix.
10) To optimize the mechanical properties of the material and facilitate removal of the matrix, a varnish can be applied onto the surface of the restoration.
11) Check occlusion.
12) Within one week to six months after placement of Biodentine®, prepare the cavity according to the criteria recommended for the selected restorative material. The remaining Biodentine® material can be considered as sound artificial dentin and permanently left in deep areas of the cavity and in areas adjacent to the pulp chamber. Biodentine® is compatible with all direct or indirect crown restoration techniques, and particularly with all types of bonding systems.

REPAIR OF ROOT PERFORATIONS:
1) Isolate the tooth with a rubber dam.
2) Prepare the root canal alternately using suitable endodontic instruments and a solution of sodium hypochlorite.
3) Dry the canal with paper points and use a chlorhexidine solution or a calcium hydroxide paste for disinfection between visits. Tightly seal the access cavity with a temporary cement to protect the temporary filling.
4) At the next visit (usually after one week), place a rubber dam and remove the temporary crown restoration. Clean the canal alternately using a solution of sodium hypochlorite and suitable endodontic instruments. Dry the canal with paper points.
5) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
6) Dispense Biodentine® over the perforation site using a suitable instrument.
7) Condense Biodentine® with a plugger.
8) Take an X-ray to check that the material is correctly positioned.
9) Remove excess material and place a temporary filling.
10) Complete root canal treatment at the next visit according to current recommendations.

REPAIR OF FURCATION PERFORATIONS:
1) Isolate the tooth with a rubber dam.
2) Rinse the cavity with a solution of sodium hypochlorite to disinfect the area.
3) If there is bleeding, hemostasis must be achieved before applying Biodentine®.
4) Dry the pulp chamber.
5) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
6) Dispense Biodentine® and condense. Perforation repair and crown restoration are performed in a single step.
7) Take an X-ray to check that the material is correctly positioned.
8) Remove excess material.
9) At a subsequent visit, if all clinical signs of a successful treatment are present, the possibility of a permanent restoration can be considered.

REPAIR OF PERFORATING INTERNAL RESORPTIONS:
1) Isolate the tooth with a rubber dam.
2) Prepare the root canal alternately using suitable endodontic instruments and a solution of sodium hypochlorite.
3) Dry the canal with paper points and use a calcium hydroxide paste for disinfection between visits. Tightly seal the access cavity with a temporary cement to protect the temporary filling.
4) At the next visit (usually after one week), place a rubber dam and remove the temporary crown restoration. Clean the canal alternately using a solution of sodium hypochlorite and suitable endodontic instruments. Dry the canal with paper points.
5) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
6) Dispense Biodentine® over the resorptive defect using a suitable instrument.
7) Condense Biodentine® with a plugger.
8) Take an X-ray to check that the material is correctly positioned.
9) Remove excess material and place a temporary filling.
10) Complete root canal treatment at the next visit according to current recommendations.

APEXIFICATION:
1) Isolate the tooth with a rubber dam.
2) Prepare the root canal alternately using suitable endodontic instruments and a solution of sodium hypochlorite.
3) Dry the canal with paper points and use a calcium hydroxide paste for disinfection between visits. Tightly seal the access cavity with a temporary cement to protect the temporary filling.
4) At the next visit (usually after one week), place a rubber dam and remove the temporary crown restoration. Clean the canal alternately using a solution of sodium hypochlorite and suitable endodontic instruments. Dry the canal with paper points.
5) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
6) Dispense Biodentine® in the root canal using a suitable instrument.
7) Condense Biodentine® with a plugger.
8) Take an X-ray to check that the material is correctly positioned.
9) Remove excess material and place a temporary filling.
10) Complete root canal treatment at the next visit according to current recommendations.

ROOT-END FILLING IN ENDODONTIC SURGERY:
1) Gain access to the operative site following the current recommendations in endodontic surgery.
2) Using a specific ultrasonic tip, prepare a root-end cavity, 3 to 5 mm deep in the apical portion of the root canal.
3) Isolate the area. Achieve hemostasis. Dry the cavity with paper points.
4) Prepare Biodentine® as indicated above (Biodentine® mixing instructions).
5) Dispense Biodentine® in the cavity using a suitable instrument. Condense Biodentine® with a small plugger.
6) Remove excess material and clean the surface of the root.
7) Take an X-ray to check that the material is correctly positioned.

WARNINGS AND PRECAUTIONS FOR USE
- Ensure that the rubber dam is properly placed so as to completely isolate the operating field.
- Water contamination slows the setting of the material. Prevent exposure to water and fluids during the initial setting stage, i.e.12 minutes.
- Single-use product: this product is designed to be used for one single patient. Reusing it would create a risk of contamination.

STORAGE
- Store in a dry place.

PRESENTATION
- Box containing 15 capsules and 15 single-dose containers.

For professional dental use.

Caution: Federal law restricts this device to sale by or on order of a dentist.

FR

COMPOSITION
Poudre à base de silicate tricalcique
Solution aqueuse de chlorure de calcium et excipients

PROPRIÉTÉS
Biodentine® est un substitut dentinaire bioactif issu de l'innovation « Active Biosilicate Technology® »
1) Biodentine® possède des propriétés mécaniques similaires à la dentine saine et peut la remplacer tant au niveau coronaire qu'au niveau radiculaire,sans traitement de surface préalable des tissus calcifiés.
2) Biodentine® contient des éléments minéraux de haute pureté et exempts de monomère et est parfaitement biocompatible.
3) Biodentine® réalise les conditions optimales pour la conservation de la vitalité pulpaire en assurant une étanchéité au niveau dentinaire. Il réduit ainsi le risque de sensibilités post-opératoires et la pérennité des restaurations sur dents à pulpe vivante.
4) Biodentine®, bioactif, stimule les cellules pulpaires à former de la dentine réactionnelle. Les ponts dentinaires sont créés plus rapidement et sont plus épais qu'avec les matériaux dentaires équivalents, conditions nécessaires à une excellente cicatrisation pulpaire.
5) Biodentine® offre un temps de prise initial réduit à 12 minutes à partir du début du mélange pour une utilisation optimale dans la couronne.

INDICATIONS
Au niveau coronaire :
- Restauration dentinaire définitive, sous composite, inlay ou onlay.
- Restauration amélo-dentinaire non définitive.
- Restauration des lésions carieuses coronaires profondes et/ou volumineuses (technique sandwich).
- Restauration des lésions cervicales radiculaires.
- Coiffage pulpaire.
- Pulpotomie.

Au niveau radiculaire :
- Réparation des perforations radiculaires.
- Réparation des perforations du plancher pulpaire.
- Réparation des résorptions perforantes internes.
- Réparations des résorptions externes
- Apexification.
- Obturation apicale en endodontie chirurgicale (obturation a retro).

Biodentine® n'est pas destiné à être utilisé pour l'obturation définitive des canaux radiculaires

CONTRE INDICATION
Allergie à l'un des constituants.

LIMITES D'UTILISATION
- Restauration des pertes de substance étendues soumises à de fortes contraintes.
- Restauration esthétique du secteur antérieur.
- Traitement des dents présentant une pulpite irréversible.

EFFETS INDÉSIRABLES
- Aucun effet indésirable connu à ce jour.

MODE D'EMPLOI (POUR CHAQUE INDICATION)
Mise en oeuvre de la capsule Biodentine®
1) Prendre une capsule et la taper légèrement sur une surface dure pour détasser la poudre.
2) Ouvrir la capsule et la placer sur le support blanc.
3) Détacher une monodose de liquide et tapoter légèrement au niveau du bouchon scellé afin de faire descendre la totalité du liquide au fond de la monodose.
4) L'ouvrir en tournant le bouchon scellé en prenant garde de ne pas laisser échapper de goutte.
5) Verser 5 gouttes de la monodose dans la capsule.
6) Refermer la capsule. Placer la capsule sur le vibreur, de type Technomix, Tac 400 (Lineatac), Silamat, CapMix, Rotomix, Ultramat etc., ayant une vitesse de l'ordre de 4000 à 4200 oscillations/mn.
7) Mélanger durant 30 secondes.
8) Ouvrir la capsule et vérifier la consistance du matériau. Si une consistance plus épaisse est souhaitée, attendre 30 secondes à une minute avant de tester à nouveau, sans dépasser le temps de travail.
9) Récupérer le matériau Biodentine® à l'aide de la spatule livrée dans le coffret. En fonction de l'utilisation souhaitée, il est possible de manipuler Biodentine® à l'aide d'un porte amalgame, d'une spatule, d'un dispositf de type Root Canal Messing Gun.
Veillez à rincer et nettoyer rapidement les instruments utilisés afin d'éliminer les résidus de matériau.

RESTAURATION AMÉLAIRE IMMÉDIATE:
Évaluer la vitalité pulpaire à l'aide des tests habituels : Biodentine® n'est pas indiqué pour le traitement des dents présentant une pulpite irréversible
1) Mettre en place le champ opératoire.
2) Retirer la dentine cariée à l'aide d'une fraise boule et/ou d'un excavateur. Conserver la dentine affectée.
3) Mettre en place un coffrage en cas de paroi manquante.
4) Préparer Biodentine® comme indiqué ci-dessus (Mise en oeuvre de la capsule Biodentine®)
5) Placer Biodentine® dans la cavité, de sorte que le volume de dentine manquante soit remplacé par un volume équivalent de Biodentine® en évitant l'inclusion de bulles d'air. Aplanir sans compression le matériau et veiller à sa bonne adaptation au niveau des parois de la cavité.
6) Attendre la fin du temps de prise du matériau (12 minutes) avant de procéder à la restauration amélaire définitive. Biodentine® est compatible avec toutes les techniques de restauration coronaire directe et en particulier avec tous les types de systèmes adhésifs.

RESTAURATION AMÉLAIRE DIFFÉRÉE :
Évaluer la vitalité pulpaire à l'aide des tests habituels : Biodentine® n'est pas indiqué pour le traitement des dents présentant une pulpite irréversible
1) Mettre en place le champ opératoire.
2) Retirer la dentine cariée à l'aide d'une fraise boule et/ou d'un excavateur. Conserver la dentine affectée.
3) Mettre en place un coffrage en cas de paroi manquante.
4) Préparer Biodentine® comme indiqué ci-dessus (Mise en oeuvre de la capsule Biodentine®)
5) Placer Biodentine® dans la cavité en évitant l'inclusion de bulles d'air. Veiller à la bonne adaptation du matériau au niveau des parois de la cavité et des bords de la restauration. Ne pas exercer de compression excessive sur le matériau.
6) Procéder au modelage de la surface de la restauration.

Biodentine®
Active Biosilicate Technology®
Bioactive dentin substitute
Substitut dentinaire bioactif
Substituto dentinario bioactivo

septodont

Made by / Fabriqué par / Fabricado por:
SEPTODONT
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France

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VITA

CHI-LAN T. PHAM, DDS

EDUCATION

University of Illinois at Chicago College of Dentistry July 2016 – Present
Chicago, IL
Residency: Pediatric Dentistry
Expected June 2018: Certificate and M.S. Oral Sciences

Howard University College of Dentistry August 2012 – May 2016
Washington, D.C.
Doctor of Dental Surgery

University of Virginia August 2007 – May 2011
Charlottesville, VA
Bachelor of Science, Biology

THESIS & RESEARCH

Effect of Overlying Material on Biodentine Setting Reaction in Primary Molar Pulpotomies
Thesis Defense: April 3, 2018

LICENSURE & CERTIFICATION

CDCA ADEX Boards Certified	March 2016
State of Illinois Temporary Dental Training License	Current
CPR Certified	Current
Pediatric Advanced Life Support	Current
ABPD Qualifying Examination	Scheduled: May 7, 2018

DENTAL & PROFESSIONAL EXPERIENCE

Free Clinic of Central Virginia August 2015
Lynchburg, VA
Extern

POSITIONS HELD

Students United for America's Toothfairy March 2014 – March 2016
Howard University College of Dentistry
Washington, D.C.
President

Students United for America's Toothfairy March 2013 – March 2014
Howard University College of Dentistry
Washington, D.C.
Secretary

Volunteer Evening Clinic May 2014 – May 2016
Howard University College of Dentistry
Washington, D.C.
Committee Member & Volunteer

COMMUNITY SERVICE

ADA Give Kids a Smile Day, Volunteer February 2014 – 2017
SNDA Oral Cancer Walk, Volunteer March 2014 – 2016
Jamaica Dental Mission, Volunteer July 2015
March Mouth Gladness!, Volunteer March 2015
Girl Scouts Healthy Living Fair, Volunteer February 2015
Vietnamese Medical Society of the Northeast America July 2010 – 2011, 2013

TEACHING EXPERIENCE

UIC College of Dentistry Pre-Doctoral Pediatric Clinic May 2017 – Present
Post-Graduate Instructor

ADEA Academic Dental Careers Fellowship Program January 2015 – May 2016
Fellow

C2 Education December 2011 – June 2012
Gainesville, VA
Tutor

Prince William County Public Schools January 2012 – June 2012
Substitute Teacher

Day in the Life at Buford Middle School August 2010 – June 2011
Charlottesville, VA
Tutor & Mentor

HONORS & AWARDS

Omicron Kappa Upsilon, Pi Pi Chapter May 2016 – Present
National Dental Honor Society
Fleming Durel Long Scholarship 2014, 2015
Howard University Trustee Scholarship 2013, 2014, 2015

PROFESSIONAL AFFILIATIONS

American Academy of Pediatric Dentistry	2015 – Present
American Dental Association	2016 – Present
Chicago Dental Society	2016 – Present

SPECIAL SKILLS

Vietnamese – Conversational