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SEALING ABILITY OF DIFFERENT BIOCERAMIC MATERIALS USED TO REPAIR FURCAL PERFORATION: AN IN-VITRO SPECTROPHOTOMETER ANALYSIS

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ABSTRACT

Background: The choice of sealing material is a crucial factor that influences the outcome of endodontic treatment. Several materials such as IRM, composite, RMGIC were the most commonly used perforation repair materials. However, none of these materials were able to re-establish the normal architecture predictably in perforated furcations. Contemporary Bioceramic materials have been presumed to have promising result. The aim of this study was to compare sealing ability of different Bioceramic materials used to repair furcal perforation.

Methods: Sample size of 60 extracted maxillary and mandibular molars were taken. Access opening done and furcal perforation made with #4 carbide bur. The teeth were divided into two control groups i) Negative control with no furcal perforation and ii) Positive control where furcal perforation was sealed with GIC and four experimental groups where furcal perforation were repaired with i) ProRoot MTA, ii) MTA Angelus, iii) MTA plus and iv) Biodentine respectively, each group containing 10 teeth. Microleakage was evaluated by GLM using UV Spectrophotometer for duration of 20 days.

Results: The least microleakage was observed in Biodentine followed by MTA Plus, MTA Angelus and ProRoot MTA till 11th day whereas on 15th and 20th day the least microleakage was observed in MTA Plus followed by Biodentine, MTA Angelus and ProRoot MTA.

Conclusions: There is no significant difference between mean microleakage of MTA Plus and Biodentine emphasizing the fact that both materials are comparable in terms of its sealing ability.

INTRODUCTION

Natural dentition integrity is critical for full function and natural esthetics. Any derangement in this harmony requires dental therapy especially, endodontic therapy.[1] During endodontic treatment, a clinician may face many procedural accidents which can affect the prognosis of the treatment and among them, perforation of root canal system is also one.[2] Perforations can occur at any stage either during access cavity preparation leading to lateral surface or furcation perforations or during instrumentation procedures leading to canal perforations at cervical, mid-root or apical levels.

Many factors such as the location and size of perforation, time delay prior to perforation repair, sealing ability of the restorative material and the periodontal status of the tooth determined the long-term prognosis of tooth with perforation.[3] The outcome of treatment can be influenced by the choice of sealing material which is a crucial factor.[1] An ideal perforation repair material should provide an adequate seal, being biocompatible, bactericidal, not affected by blood contamination, should induce bone formation and healing, should be radiopaque, induce mineralization, cementogenesis, and easy in manipulation and positioning.[4] However, the divergent outcomes suggest that so far no material has satisfied all the ideal requirements.[5] Therefore, there is a necessity for the introduction of newer materials for perforation repair.[6]

Among the various materials tested, Mineral Trioxide Aggregate (MTA), newer materials like Biodentine and various modifications in the original form of MTA have been introduced with the aim of overcoming some of the disadvantages of the MTA, such as the difficulty in handling and long setting time. Thus, the present in-vitro study evaluated the sealing ability of ProRoot MTA, MTA Angelus, MTA Plus and Biodentine in repair of furcation perforations.

METHODS

The present in-vitro study was conducted with due approval of Institutional Review Committee (UCMS/IRC/037/18) of Universal College of Medical Sciences, Bhairahawa, Nepal. The experiment was conducted in Department of Conservative

dentistry and Endodontics from March 2019 to August 2019. Sixty freshly extracted human maxillary and mandibular permanent molars with separate and well-developed roots, intact furcation were selected with no distinction made between first, second or third molar, but the selection was made rather on degree of root separation. Each individual specimen was inspected and specimens with cracks, root caries, restoration, fracture, open apices were excluded. The teeth were sterilized in 10% formalin for 2 weeks. After removal of calculus and soft tissue by ultrasonic scaling, the teeth were stored at 4^0C in normal saline solution before use.

Access cavities were prepared using a number 2 round diamond bur then perforations made in the center of the pulp floor using a number 4 round carbide bur in high speed handpiece. The width of each perforation was standardized by the same diameter of the burs and its depth was dependent on the dentin–cementum thickness from the pulp floor to the furcation area. A moistened cotton pellet was placed in the furcation area. All teeth were stored in the incubator at 37^0C for 24 hours.

The prepared teeth were color coded with different nail varnish for identification purposes and randomly divided into control group (Positive and Negative group) and 4 experimental group consisting 10 teeth in each group. The roots of teeth were then inserted into a moist sponge and the perforations were repaired with GIC, ProRoot MTA, MTA Angelus, MTA Plus and Biodentine in the respective groups. According to manufacturer's instructions, all materials were mixed. Finger pluggers were used for condensation of filling materials into the perforation areas and the adequacies of fillings were evaluated under RVG.

The leakage detection device proposed by Xu et al was used.[7] The coronal section of each tooth was fixed to the end of a 5 mL syringe with sticky wax (MDM Corporation). A suitable hole was made in the middle of the syringe through which a 15-cm-long plastic tube was placed into the pulp chamber of tooth. Sealing between the glass tube and the syringe was obtained with sticky wax. The furcations and roots of teeth protruding from the vial were immersed into 2 mL distilled water in a sterile 5 mL centrifuge tube that could be sealed completely. Moreover, to minimize the effect of side leakage from sealed tooth and to hold firmly between the test tube and syringe, white tape was applied. A glucose solution (1 mol L^{-1} containing 0.2% NaN_3) was injected into the pulp chambers through the glass tube until the top of the solution was 15 cm higher than the pulp floor. The models were then transferred to an incubator that provided 100% humidity at 37^0C. A 10 uL sample solution was drawn from the centrifuge tube at 1, 3, 5, 8, 11, 15 and 20 days, respectively. Because water in the centrifuge tube could evaporate at 37^0C, a corresponding amount of distilled water was added to maintain a constant volume of 2 mL either before or after drawing the sample. After enzymatic glucose oxidase was added into the sample separately, it was analysed with an Ebra Lisa Scan-II spectrophotometer (Erba Mannheim, Germany) at 500 nm wavelength.

Statistical analysis was performed using SPSS version 22.00 (SPSS Inc., Chicago IL) to compare the mean microleakage of the groups and determine the significance of differences between different groups. Quantitative statistical analysis was done for the parameters. One way ANOVA followed by post hoc Tukey HSD was used to analyse to compare mean ± SD. $p < 0.05$ was considered to be statistically significant.

RESULTS

All experimental groups demonstrated glucose leakage to varying degrees whilst the negative control group had none. Minimum microleakage was for Negative control group while maximum for GIC (Positive control group). From day 1 to day 20, the entire experimental group had tendency for increased microleakage throughout the experimental period except for MTA Plus which showed decreased microleakage from day 15. The microleakage was in decreasing order as: Negative control< Biodentine <MTA Plus < MTA Angelus <ProRoot MTA<GIC (Positive control) up to day fifteen but it changed in order as: Negative control< MTA Plus< Biodentine < MTA Angelus <ProRoot MTA<GIC (Positive control) up to 20 days of microleakage study.

The Mean±SD was observed to be statistically significant difference of the microleakage in the study materials (p=0.0001) in each day of examination. The lowest microleakage was observed in Negative control group. The microleakage of Biodentine followed by MTA Plus was comparable to that of Negative control group. The maximum microleakage was observed in GIC (Positive control) followed by ProRoot MTA. MTA Angelus showed intermediate leakage between MTA Plus and ProRoot MTA.

Table 1: Descriptive (Mean±SD) Concentration of Glucose (mg/dl) of microleakage in study materials in different days

Materials	n	1st day	3rd day	5th day	8th day	11th day	15th day	20th day
Negative control	10	7.58±2.90	8.55±2.81	9.13±2.62	10.21±2.72	9.51±2.38	9.60±3.02	11.48±3.62
Positive control(GIC)	10	35.70±14.57	43.05±12.07	48.80±11.72	51.49±11.88	55.01±13.03	61.80±16.71	66.61±15.91
ProRoot MTA	10	28.18±19.1	29.84±20.52	39.41±20.13	38.93±22.45	43.40±21.78	45.07±27.06	51.44±26.87
MTA Angelus	10	21.36±3.47	24.85±5.46	24.91±6.38	27.71±5.32	29.54±6.83	31.82±8.33	35.19±7.78
MTA Plus	10	15.44±4.97	19.50±4.90	22.88±5.06	21.43±4.59	24.20±5.64	20.30±5.55	20.07±6.21
Biodentine	10	12.17±3.54	15.86±5.50	19.71±5.45	20.52±3.86	23.61±4.76	25.66±5.81	29.99±6.24
Total	60	20.07±13.80	23.60±14.93	27.47±16.48	28.38±17.13	30.87±18.28	32.37±3.21.69	35.79±22.85
p-value		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

DISCUSSION

Effective and prompt management of perforation greatly implies the prognosis of the tooth. Of all unsuccessful cases, 9.62% are due to perforations accounting as second highest cause. Therefore, this communication between the root canal system and the periodontal apparatus should be sealed with a biocompatible material as soon as possible. The furcal perforation can be managed either surgically or non-surgically depending on clinical and radiographic findings, and if the problem is well diagnosed and the defect is properly repaired with a material which can provide proper sealing ability and biocompatibility the prognosis is generally excellent.[8]

Several methods like dye penetration, fluid filtration, bacterial and protein leakage models, dye extraction method have been used to assess microleakage. New alternative methods are introduced recently such as artificial caries, neuron activation analysis, scanning electron microscopy, analysis with radioactive isotopes and electrical conductivity.[8]

In the present study, a new method for analysis of endodontic microleakage based on filtration rate of glucose was employed as described by Xu et al.[7], a glucose filtration test, where glucose is used as a tracer.[9] A glucose leakage model was chosen for this study because it was possible to quantify endodontic microleakage continuously over time**.** The total amount of microleakage was the cumulative value of leaked glucose.

The results of the present study showed that all Bioceramic materials ProRoot MTA, MTA Angelus, MTA Plus and Biodentine exhibited microleakage, but there was a difference in the leakage value at different time intervals.

In the present study, the Mean±S.D was found to be statistically significant difference (p=0.0001). However, while comparing ProRoot MTA and MTA Angelus with Negative control, it shows the significant difference in the microleakage but comparing MTA Plus and Biodentine with Negative control it shows statistically non-significant difference representing that MTA Plus and Biodentine have better sealing ability as compared to ProRoot MTA and MTA Angelus.

In our study, the microleakage was in the ascending order: Negative Control< Biodentine <MTA Plus< MTA Angelus < ProRoot MTA < GIC (Positive Control) upto 11^{th} day but on 15^{th} and 20^{th} day, MTA Plus showed less leakage than Biodentine with statistically non-significant difference.

According to Bansal et al.[9] MTA Plus had finer particle size and had an advantage of the presence of an anti-washout gel that increases its washout resistance as compared to ProRoot MTA. The result of their study is in accordance to our study where MTA Plus had increased sealing ability as compared to ProRoot MTA.

The superior sealing ability exhibited by MTA Plus and Biodentine might be attributed due to smaller particles size, decreased pore volume and porosity, improved adaptation to cavity walls and faster setting time.

Studies have shown that the marginal seal of GIC compromised because of its dissolution in tissue fluid and its being technique sensitive.

Correlating to our study, Ajas et al.[8] evaluated and compared the sealing ability of MTA and Biodentine as furcation perforation repair materials and the result showed that Biodentine exhibited significantly less microleakage compared with white MTA Angelus.

Also, Katge et al.[6] compared sealing ability of MTA Plus™ and Biodentine™. There was not statistically significant difference even though the dye leakage of Biodentine™ was less when compared to MTA Plus™. Thus, both MTA Plus™ and Biodentine™ can be used as furcal repair perforation materials. This result is in agreement with present study.

Pathak et al.[2] also analyzed the sealing ability and microleakage of different materials (RMGIC, MTA Angelus and Biodentine) as a furcation repair material and concluded that RMGIC, MTA & Biodentine exhibited microleakage with Biodentine showing the least microleakage of all. The result of their study is in accordance to our study.

Similarly, in contrast to our study, where ProRoot MTA had showed maximum leakage, Övsay et al.[10] evaluated the microleakage of repair materials applied on furcal perforations and the result showed ProRoot MTA as the most successful in terms of preventing microleakage when compared with IRM and Biodentine.

Also, Hassa et al.[11] concluded white ProRoot MTA and Biodentine performed equally well as a furcation perforation repair material which was in contrast to our study as there was significant difference between ProRoot MTA and Biodentine.

Thus, according to the findings of our study, Biodentine had good sealing ability in the initial phase but with the advance of time, MTA Plus showed least microleakage. However, no literature has been found comparing the microleakage of the Bioceramic materials for long duration of 20 days in furcal perforation as conducted in our study. Hence, no comparison could be made for longevity of the sealing properties.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that Biodentine and MTA Plus showed best sealing than all the other tested material with the resultant microleakage of both materials to be statistically non-significant difference as compared to Negative control. However, further in vitro and in vivo studies are recommended to confirm and correlate the findings of this study to a clinical scenario.

CONFLICT OF INTEREST: None

FINANCIAL DISCLOSURE: None

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