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Original Research Article

An in-vitro comparison of bond strength of three different root end filling materials with Universal testing machine

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ABSTRACT

Background: Bacterial infection is widely known cause of apical periodontitis. Failure of conventional root canal treatment indicates the periapical surgery, this procedure requires root end resection. For the long term success of periapical surgery, root end filling materials are used.
Aim: To compare the push-out bond strength of Portland cement, ProRoot MTA and Biodentine used as root-end filling materials using Universal Testing Machine.
Materials and Methods: From the middle part of each root, three dentinal slices were made to produce 93 slices which were divided into 3 groups. In Group A: ProRoot MTA, In Group B: Biodentine and In group C: Portland cement were used and were further divided in subgroups based on soaking time in PBS solution i.e. 24hrs and 7 days before assessing the push out bond strength using Universal Testing Machine. The mode of bond failure of material to root dentin was analyzed using microscope. Data was analyzed using ANOVA and post-hoc tukey's test.
Results: After 24hrs, there was statistically non-significant difference but After 7 days, ProRoot MTA showed significantly higher bond strength as compared to other tested groups. While analyzing the mode of bond failure, ProRoot MTA had adhesive failure, Biodentine had cohesive failure and Portland cement had mixed type of bond failure.
Conclusion: All the tested materials showed comparable bond strength but ProRoot MTA had highest bond strength to root dentin among the other tested materials.

1. Introduction

Advancement in material sciences and innovative equipment had led to several modifications in the standard protocol of endodontic treatment because of increasing demand of the patients for saving their teeth.[1] Bacterial infection is the sole cause of apical periodontitis and the key factor which determines the healing or persistence of the apical lesion.[2] Failure of conventional root canal treatment is prior indication for apical surgery. This procedure requires the resection of apical root end and thus eliminates the contaminated portion of the root where the microorganisms resides in the form of a biofilm.[3] The retrograde filling materials seal the canal which further prevent passage of bacteria and their toxins from the root canal space into periradicular tissues. Infact, every tooth restorative material has been used as a root-end filling material. But, unlike orthograde root canal filling materials, these materials are in direct contact with periapical tissues.[4]

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Variety of root end filling products are available commercially which includes Portland cement, ProRoot Gray and White MTA, Viscosity Enhanced Root Repair material, MTA Angelus, Biodentine, Bioaggregates, MTA plus etc. Improved root end filling materials such as MTA, Biodentine were introduced in dentistry with better properties along with high biocompatibility and bioactivity of calcium silicates.[5]

In endodontics, Bioceramic materials has brought a big change in the prognosis of cases which were considered impossible. Mineral trioxide aggregate, a calcium silicate based cement introduced by Dr. Mahmoud Torabinejad and his co-workers in Loma Linda University in 1993, is considered as the gold standard material due to its ability to resist leakage and its superior marginal adaptation to dentinal walls for several clinical procedures.[1] Biodentine, a new bioactive calcium silicate based cement formulated from MTA-based cement technology is considered as a 'dentin substitute'. Biodentine might be an interesting and promising alternative to the existing materials for dentin pulp complex regeneration.[5] Biological interaction of root end filling materials to root dentin depends on the presence of phosphate in the biological tissue fluids and also on its chemical composition. Therefore, the measurement of bond strength of tricalcium silicate and phosphate based cements is crucial for the quantification of dentin/ material interaction.[6]

The aim of this study was to evaluate and compare the push-out bond strength of the root end filling materials including Portland cement, ProRoot MTA and Biodentine.

2. Materials and Methods

31 freshly extracted permanent maxillary single rooted anterior teeth were collected. Teeth selected for study should have single canal, mature roots, be free of caries, any other hard tissue lesion and defects. Multirooted teeth, Obliterated root canal, with open apex, developmental anomalies, Canal diameter more than 1.3 mm, primary teeth were excluded from the study. Teeth were cleaned and washed thoroughly to remove all soft and hard tissue deposits with the help of scaler and soaked in 5.25% NaOCl for 10 minutes. All the samples were washed thoroughly and stored in normal saline at room temperature.

2.1. *Sample preparation*

After cleaning, sectioning of teeth was done to obtain a uniform 10mm length of middle third of root. Then horizontal cross sectioning was done to make three root slices from each root having thickness (1 ± o.1mm) using diamond discs and digital caliper with accuracy of 0.001mm. A total number of 93 root slices were produced from this method. All the cavities were prepared using Gates Glidden burs of size 2 to 5 to obtain a standardized internal diameter of 1.3mm under continuous water irrigation. All the samples were then immersed in 2.5% NaOCl solution for 15 min. and then in double distilled water to neutralize the solution. Afterwards, 17% EDTA was used for 3 min. followed by double distilled water for 1 min. and 2.5% NaOCl for 1 min. Final immersion was done again in double distilled water for 1 min. and dried with paper points.

2.2. *Restorative procedure*

Before restoration, all the samples were randomly divided into three groups having 31 root slices in each group which were as follows:

Group A: Sample restored with ProRoot MTA (Dentsply Tulsa Dental Specialities, Konstanz, Germany).

Group B: Sample restored with Biodentine (Septodont Ltd, Saint Maur-des-Fosses, Paris, France).

Group C: Sample restored with Portland cement (Ultratech Pvt. Ltd., India).

All slices from single sample were stored in 1 test tube and restored with tested materials respectively. The dentinal slices were placed on vibrator to avoid bubble formation in the material. Excess material was removed with a plastic instrument and was allowed to set. Specimens were then immersed in Phosphate buffered saline solution for 24hrs and 7 days respectively at 37°C (pH 7.2) to measure the push out bond strength.

The push out bond strength of all materials was tested in a Universal testing machine (Figure 1) in such a manner that tested material was faced downwards and aligned to shaft. Samples were mounted in acrylic resin with hole in center to allow the free motion of stainless steel needle. A custom made jig with 0.6mm diameter cylindrical plunger tip was mounted on upper jaw of Universal Testing Machine. (Figure 2) The hole was aligned with the center of tested material which allowed the free motion of plunger tip through the bond between tested material and root dentinal wall. The tip clearance of approximately 0.2mm from the margin of dentinal wall was kept to ensure the contact with material. Compressive load at speed of 0.5mm/min. was applied. Maximum load applied to material at time of dislodgement was recorded in newtons and load × time curve was plotted using computer software program. The push out bond strength was calculated by dividing this force by the surface area of tested material i.e.

Surface area of material ($2\pi r \times h$)

π = constant (3.14)

R = radius of cavity with root canal material (1.3 mm)

H = height of material or thickness of each root dentin slice (1mm)

After testing the push out bond strength, all the samples were examined under compound microscope at 4X magnification to determine the mode of failure which were as follows:

1. Cohesive: Failure occurred within the material
2. Adhesive: Failure occurred at material/dentin interface.
3. Mixed: Combination of both failure mode.

3. Observation and Results

An in-vitro study was done on total number of ninety three root dentin slices having equal samples in each group to evaluate the push-out bond strength of different root end filling materials using ANOVA (One way analysis of variance) test and Tukey's Post-hoc HSD test.

Results were found statistically non-significant after 24hrs but significant difference was found between values after 7 days. Based on results, among all the tested root end filling materials, Biodentine showed better push out bond strength than ProRoot MTA and Portland cement after samples immersed in PBS for 24hrs. However, after 7 days, it was analyzed that ProRoot MTA had maximum push out bond strength to root dentin than other tested materials. The type of bond failure was judged to be cohesive in Biodentine and adhesive in case of ProRoot MTA. However, in Portland cement, the bond failure pattern was found to be mixed type.

4. Discussion

Successful endodontic treatment requires adequate apical as well as coronal seal for prevention of leakage, percolation of oral fluids or recontamination of disinfected canals. If orthograde endodontic therapy has failed to do so, periapical surgery is the treatment of choice with an appropriate retrograde filling material that contains good physicochemical properties and accomplish the criteria of cytotoxicity, apical seal, biocompatibility and marginal adaptation to prevent the leakage of bacteria and its by-products from root canals, thus ensuring the favourable outcome for any endodontic surgery.[3,7] It is important to maintain the integrity of material-dentin interface. The most important concern is adhesion of material to root wall dentin.[8]

The present in vitro study has been carried out to compare the push out bond strength of root end filling materials.

To allow the ease of standardization and to reduce variations in the experimental samples, single rooted teeth are preferred over multi rooted teeth. Elemam RF et al demonstrated that the success rate was lower in multirooted teeth as compared to single rooted teeth due to its various anatomical variations.[9]

Ricucci D et al observed that ramifications occurred most commonly in apical one third of root in posterior teeth. It was found that in 73.5% cases, ramifications were observed in apical part, 11% in middle third and 15% in coronal third of root.[10] As in the middle one third of root, presence of accessory or lateral canals were less as compared to coronal

Figure 1: Universal testing machine

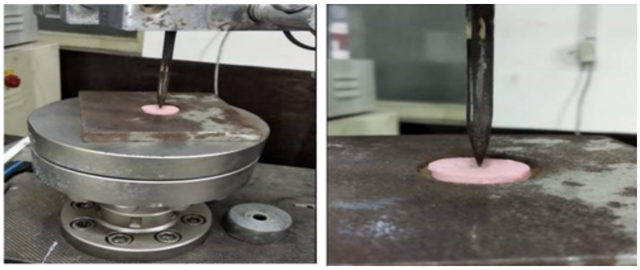

Figure 2: Custom made jig and plunger tip

and apical one third of root so the experimental samples were decoronated and apical one third of root was resected to use the middle portion of root for experimental purpose.

Barbizam JV et al stated that dentin thickness of root slices may vary from 0. 6 mm to 7.0 mm, when used to check push out bond strength test. But 1.0 mm root dentin slice thickness was preferred to obtain large number of samples with high bond strength values.[11] Therefore, in this study, the middle third of root of 10 mm of uniform length were obtained which were further divided into three equal sections of 1 mm each for standardization of samples.

Pedroche et al found high successability rate when apicoectomy was followed by placement of root-end fillings, in case of unsuccessful non-surgical endodontic treated cases.[12] In addition to this, Song et al concluded that various factors such as inappropriate use or absence of root end filling materials or inadequate root end cavity preparations during endodontic surgery were also responsible for treatment outcome failure. Christiansen et al also supported the fact that endodontic treatment success rate was significantly increased with use of appropriate root end fillings in comparison to the treatment done without using root end filling material.[13]

Till now, various types of materials were developed which were claimed to be an ideal material for retrograde root fillings that could increase the success rate of endodontic surgeries or apicoectomy procedure. In recent time, most of the root end filling materials were calcium silicate based. Keeping this in consideration, different commonly available materials were choosen for experimental purpose in this study. Thus, Portland cement, ProRoot MTA and Biodentine were material of choice.

Saidan et al analyzed that the morphology and number of L929 cells found in both MTA and Portland cement were statistically insignificant.[14] As this cement is commercially available and checked biocompatibly. It is considered as base for all other calcium silicate based cement. Thus the older material, Portland cement was considered to be comparative to newer materials like MTA and Biodentine.

In the present study, when evaluated the push out bond strength of the samples stored in PBS for 24hrs, Biodentine was found to be in higher limits as compared to ProRoot MTA and Portland cement. But the push out bond strength values got decreased after 24hrs to 7 days.

Cechella BC et al concluded that the values of bond strength of Biodentine increases upto 3 days. The reason behind this could be that Phosphate buffered saline solution when comes in contact with Biodentine allowed higher water absorption and thus, altering water-powder ratio. So the results of our experimental groups may be in accordance to above study. Thus, it can be concluded that push out bond strength of Biodentine increases in first 24hrs and then shows the decrease in push out bond strength values.[15]

While the push out bond strength of the samples immersed in PBS for 7 days shown statistically significant results for higher push out bond strength in ProRoot MTA followed by Biodentine and Portland cement. Reason behind this could be due to higher precipitate formation with increased storage time. These increased number of precipitates filled the gaps between material and dentin and also got deposited within the dentinal tubules that could further increase the displacement resistance of material to root dentin.[16]

Portland cement gave least push out bond strength for both 24hrs and 7 days. The variation in bond strength may be attributed to particle size of cements. The material with smaller particle size have higher mechanical strength because of difference in grit size. The heterogenous particles affect the marginal adaptation of Portland cement to dentinal walls. During the immersion of samples in phosphate buffered saline solution restored with Portland cement, diffusion controlled reaction between dentin and Portland cement form chemical bond which is weaker bond as compared to chemical bond and tag like structures formed in MTA and Biodentine.[17]

5. Conclusion

It can be concluded from the above results that amongst all the tested root end filling materials, Biodentine showed maximum push out bond strength value after 24hrs of immersion in PBS. However, with increased storage time upto 7 days, the results were more in favour of ProRoot MTA. As this study is being done in in-vitro conditions, these conditions are different from what a material experience in oral cavity.

6. Conflict of Interest

None.

7. Source of Funding

None.

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