A comparative Assessment of Push-Out Bond Strength Between MTA Bioputty and Ultrasonically Condensed Gutta-Percha in Radicular Dentin

Teena Jerry[1], Tony Daniel[*2], Priya K.C.[3], Jinitha G.C.[4], Afzal A[5], Vineet R.V.[6]

[1]MDS Student, Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
Email ID: teenajerry90210@gmail.com
[2]MDS Student, Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
[3]MDS Student, Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
Email.ID: drpriyachandrabanu@gmail.com
[4]MDS Student, Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
Email.ID: jinitha456gc@gmail.com
[5]Professor, Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
Email ID: afzalabdulsalim@gmail.com
[6]Professor, Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
Email ID: dr.vrv@rediffmail.com
***Corresponding Author:**
Tony Daniel
Email ID: tonydaniel98@gmail.com

ABSTRACT

Objectives: This study aimed to assess the push-out bond strength of MTA Bioputty and ultrasonically condensed gutta-percha combined with bioceramic sealer in radicular dentin.

Methods: A total of twenty intact human mandibular premolars, extracted for therapeutic purposes, were gathered. The teeth were decoronated and prepared following standard endodontic protocols, then randomly assigned into two equal groups (n=10). Group I was obturated with MTA Bioputty, while Group II received ultrasonically condensed gutta-percha along with Bio-C sealer. Horizontal sections, 2 mm thick, were taken from the middle third of each root. These specimens underwent push-out bond strength testing using a universal testing machine, and the results were statistically analyzed.

Results: The group treated with MTA Bioputty exhibited higher mean push-out bond strength values in comparison to the group treated with ultrasonically condensed gutta-percha. The difference was statistically significant ($P<0.05$), indicating that MTA Bioputty has superior adhesion to radicular dentin.

Conclusions: MTA Bioputty showed a significantly greater push-out bond strength than ultrasonically condensed gutta-percha with bioceramic sealer, highlighting its potential as a more dependable obturation material for improving the integrity of root canal fillings.

Keywords: *Adhesion; Bioceramic sealer; Gutta-percha; MTA Bioputty; Push-out bond strength*

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1. INTRODUCTION

Mineral Trioxide Aggregate (MTA) has been thoroughly researched for its diverse clinical uses, including root-end filling, pulp capping, perforation repair, root resorption management, and apexification, owing to its remarkable sealing capabilities and biocompatibility [1– 4]. Furthermore, MTA has been developed into variations such as MTA Bioputty to enhance handling properties while preserving its bioactivity [5]. An optimal endodontic material must endure functional and iatrogenic dislodging forces during mastication and restorative interventions [6]. Teeth that undergo endodontic procedures frequently become structurally weakened due to dentin dehydration, the removal of internal tooth structure during chemomechanical preparation, and vertical forces exerted during obturation [7]. Consequently, modern obturation methods not only strive to achieve a hermetic seal but also aim to strengthen radicular dentin to mitigate the risk of vertical root fractures [8]. MTA Bioputty, a calcium silicate-based substance, demonstrates advantageous characteristics such as bioactivity, dimensional stability, and significant bond strength to root dentin [1,9]. In addition, ultrasonically activated gutta-percha, when used alongside bioceramic sealers like Bio-C Sealer, has exhibited enhanced adaptation to canal walls, thereby improving resistance to dislodgement and microleakage [10 –12]. This research was undertaken to comparatively assess the push-out bond strength of MTA Bioputty and ultrasonically condensed gutta-percha with Bio-C Sealer, with the objective of evaluating their effectiveness in providing a dependable apical and radicular seal.

2. METHODS

Descriptive statistics were conducted to evaluate the mean standard deviation, frequency, and proportion of the respective groups. An independent T-test was employed to compare the variables between the groups. A statistical significance threshold was established at $p < .05$. Each group comprised 10 teeth, divided into two subgroups.

The Institutional Ethics Committee granted approval for the protocol. The data was analyzed utilizing the statistical software SPSS 26.0 (SPSS Inc., Chicago, IL). The removed teeth were first kept at a temperature of 4°C in a 0.1% thymol solution until they were utilized, in order to maintain their integrity throughout the storage period.

In this research, the selection of mandibular premolar teeth was conducted with strict compliance to established inclusion and exclusion criteria to ensure uniformity and reduce confounding variables. Only intact, single-rooted mandibular premolars that were extracted for therapeutic purposes were included. Teeth that displayed developmental anomalies, caries, restorations, fractures, or had undergone previous endodontic treatments were excluded to eliminate confounding factors. Furthermore, teeth with curved canals, open apices, or calcifications were not taken into account to maintain consistency in root canal morphology. Each selected tooth underwent standardized cleaning and disinfection procedures to eliminate any residual tissue and prevent microbial contamination. The access cavities were prepared using a high-speed handpiece with water cooling and an Endo Access Bur (Dentsply Sirona, Switzerland), ensuring uniformity in the preparation process. The working length (WL) was established by inserting a size #15 K-file into the canal until its tip was visible at the apical foramen. A rubber stopper was adjusted to the reference point, and the WL was set to 16 mm, which accounts for the average length of mandibular premolars. Root canals were prepared using the Protaper Gold rotary system (Dentsply Maillefer, Ballaigues, Switzerland) up to the F2 file.

In the first group, MTA Bioputty (Prime Dental Products PVT LTD, Thane, India) was employed as the filling material, while Angelus Bio-C Sealer (Brazil) acted as the root canal sealer; the sealer was injected into the canals utilizing the manufacturer's delivery tip, followed by the incremental introduction of MTA Bioputty, which was compacted intermittently with a plugger.

Figure 1. Bio-C Sealer injected into canal.

Figure 2. Incremental introduction of MTA Bioputty.

In the second group , ultrasonically condensed gutta-percha (Dentsply Sirona Maillefer, Switzerland) was utilized along with the same Bioceramic sealer, which was injected in a similar manner; subsequently, a size F2 gutta-percha cone was inserted into the canal. A Start-X 3 ultrasonic tip was employed until resistance was encountered and was activated in dry mode for three seconds, after which the gutta-percha was conformed to the canal walls using a size 25 spreader [13]. A size 25, 2% gutta-percha cone was then added, and the activation process was repeated. Following successive ultrasonic activation, lateral condensation of the plasticized gutta-percha was carried out with a spreader, and the gutta-percha was trimmed 1 mm below the canal orifice. All specimens were subsequently incubated for 72 hours at 37 °C, after which they were retrieved and sectioned at the middle and apical thirds of each tooth using a sectioning disc.

Figure 3. Bio-C Sealer injected into canal.

Figure 4. Gutta percha condensed ultrasonically.

Table 1 Composition of filling materials and sealer

Product	Manufacturer	Composition
MTA Bioputty	Prime Dental Products PVT Ltd., Thane, India	Tricalcium silicate, Dicalcium silicate ,radioopacifiers, paste forming agents, zirconium oxide,fillers
Gutta percha	Dentsply Sirona Maillefer, Switzerland	Gutta percha 20%,Zinc oxide 66%,Heavy metal sulfates 11%, waxes or resins 3%
Bio C Sealer	Angelus Londrina, PR, Brazil	Tricalcium silicate, Dicalcium silicate, Tricalcium aluminate, Zalcium oxide, Zirconia oxide, Silicon oxide, Polyethylene glycol, and Iron oxide [15]

Push-out bond strength test:

Specimens with a diameter of approximately 1.2 mm on both ends were chosen. The push-out test was conducted using a universal testing machine (Instron 8871, Servo Hydraulic System, Merlin 2 software, Instron®, Buckinghamshire, UK)

Dentin sections were positioned on a custom plate and aligned with the hole at the center of the plate [16]. This setup enabled the 1-mm thick stainless steel plunger to move freely under a consistent downward force at a rate of 1 mm/min. The plunger featured a flat tip that was specifically positioned to make contact solely with the test material. The force was applied until complete bond failure was achieved, and the results were recorded in Newtons (N). The following formula was utilized to compute the bond strength in MPa.

$$\text{Bond Strength (MPa)} = \frac{\text{Debonding force (N)}}{\text{Bonded surface area (mm2)}}$$

Where $\pi = 3.14$ (constant), r represents the radius, and h denotes the thickness of the dentin section.

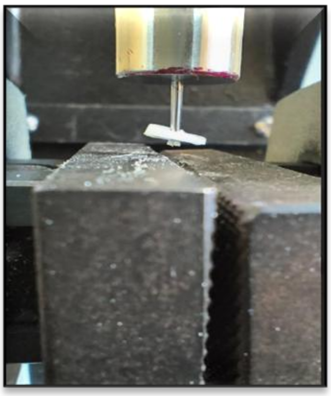

Figure 5. Push-out bond strength test using universal testing machine.

3. DATA ANALYSIS

The data was examined utilizing the statistical software SPSS 26.0 (SPSS Inc., Chicago, IL). Descriptive statistics were conducted to evaluate the mean standard deviation, frequency, and proportion of the respective groups. An independent T-test was employed to compare the variables across the groups.

RESULTS

The bond strength between MTA bioputty and bioceramic sealer, as well as between gutta percha and bioceramic sealer in the middle and apical third regions, is illustrated in the table below.

Table 1. Comparison of Push out bond strength - Between group

Location	Groups	N	Mean	Std. Deviation	Std error	Mean Difference	P Value (T test)
Middle	Bio putty	5	26.0980	2.58677	.81801	4.51	0.0001*
	Gutta percha	5	21.5800	.88303	.27924		
Apical	Bio putty	5	17.9580	1.33136	.42101	11.48	0.0001*
	Gutta percha	5	6.4700	2.27452	.71927		

MTA Bioputty exhibits a notably higher bond strength compared to Ultrasonically condensed Gutta Percha in both the middle and apical regions. In the middle region, bio putty shows a mean bond strength of 26.0980 with a standard deviation of 2.58677, which is significantly greater than the gutta percha group, which has a mean of 21.5800 and a standard deviation of 0.88303. The mean difference of 4.51 is statistically significant, with a P value of 0.0001, indicating that bioputty outperforms in this area. In the apical region, bio putty again demonstrates superior performance with a mean bond strength of 17.9580 and a standard deviation of 1.33136, in contrast to gutta percha, which has a mean of 6.4700 and a standard deviation of 2.27452. The mean difference of 11.48 is also statistically significant, with a P value of 0.0001. In summary, these results indicate that bioputty offers significantly enhanced push-out bond strength compared to gutta percha in both evaluated locations.

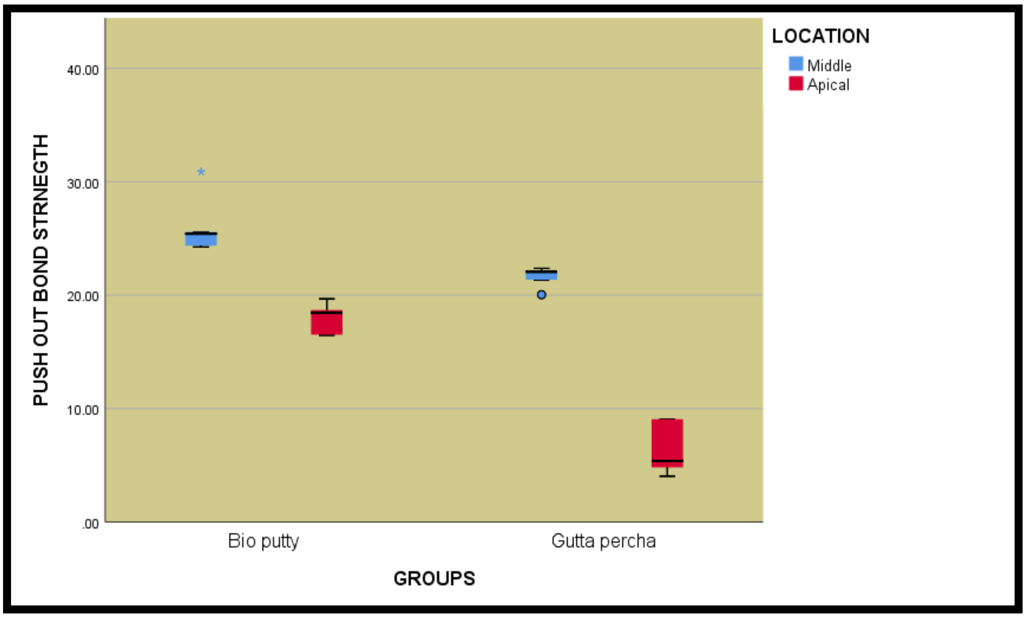

Figure 6. Push-out bond strength comparison between Bio Putty and Gutta Percha at middle and apical thirds of the root canal.

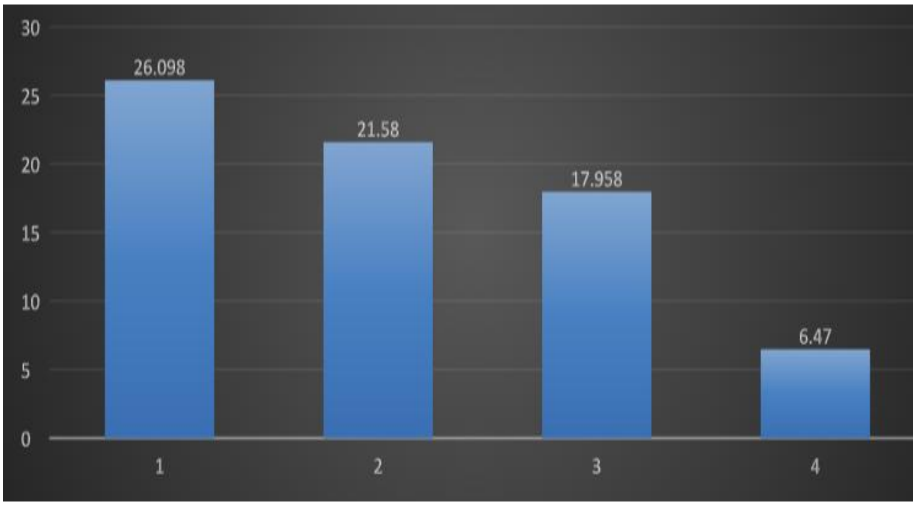

Figure 7. Mean push-out bond strength values for the tested groups at different root canal locations. 1-MTA Bioputty (middle 3rd) 2-MTA Bioputty (apical 3rd) 3-Ultrasonically condensed gutta percha (middle 3rd) 4-Ultrasonically condensed gutta percha (apical 3rd)

4. DISCUSSION

The results of this in vitro investigation indicate that MTA Bioputty exhibits a markedly higher push-out bond strength to radicular dentin when compared to ultrasonically condensed gutta-percha, both utilized alongside a bioceramic sealer. These findings are consistent in both the middle and apical thirds of the root canal.

The enhanced adhesive capabilities of MTA Bioputty can be largely ascribed to its distinctive characteristics as a calcium silicate-based material. Upon hydration, MTA-based substances undergo a biomineralization process, resulting in a crystalline structure that is recognized for establishing a strong interfacial bond with dentin [16]. This process, which entails the development of a tag-like structure within the dentinal tubules and the deposition of a hydroxyapatite-like layer at the interface between the material and dentin, offers a robust and enduring seal that effectively withstands dislodgment forces, surpassing the purely mechanical adaptation provided by gutta-percha [17,18].

Although ultrasonic condensation serves as an effective method for enhancing the compaction and adaptation of gutta-percha, our results suggest that this mechanical improvement still falls short of the chemical and adhesive advantages presented by MTA Bioputty. The increased bond strength noted in the apical region with MTA Bioputty is particularly significant, as this area poses considerable challenges in achieving a fluid-tight seal due to its intricate anatomy and a reduced density of dentinal tubules [19]. The capacity of MTA Bioputty to sustain a superior bond in this crucial region indicates a potential for enhanced long-term clinical outcomes by mitigating the risk of apical microleakage and secondary infections.

In light of these findings, MTA Bioputty represents a promising alternative to traditional gutta-percha obturation, offering a more stable and durable seal. This study provides valuable evidence for its potential to enhance the prognosis of root canal treatments, particularly in cases where achieving a strong bond to dentin is paramount.

The research regarding bioputty is somewhat limited. Therefore, there exists an opportunity for further investigation into different facets of this specific material.

5. CONCLUSION

This research illustrates that MTA Bioputty shows a markedly higher push-out bond strength in comparison to ultrasonically condensed gutta-percha, both in the middle and apical areas of the root canal. The statistically significant variations in bond strength suggest that MTA Bioputty may offer superior adhesion to dentin, which could enhance the long-term sealing capability of root canal fillings. These results imply that MTA Bioputty might serve as a more effective substitute for thermoplasticized gutta-percha, contributing to the stability and durability of endodontic fillings. This study represents one of the initial evaluations of premixed MTA Bioputty as an obturation material, assessing its push-out bond strength against thermoplasticized gutta-percha and emphasizing its potential for enhanced adhesion and long-term stability in root canal fillings.

6. CONFLICT OF INTEREST

No potential conflict of interest pertaining to this article has been disclosed.

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