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A stereo microscopic study on the sealing ability of three different furcation perforation repair materials: In-vitro insights

Abstract:

Introduction: Endodontic perforation is a challenging complication that impacts tooth prognosis. Early detection, accurate diagnosis, and biocompatible repair improve tooth prognosis.

Aim: The purpose of this study is to compare the sealing ability of powder liquid MTA(Angelus), Premixed MTA Putty(SafeEndo) and Biodentine (Septodont) when used as furcal perforation repair materials.

Material And Methods: This study uses 60 extracted permanent mandibular first molars in vitro. The pulpal floor has standard furcal perforations in the centre. Three repair materials were used: Group A-Biodentine (Septodont), Group B- powder-liquidMineral Trioxide Aggregate (Angelus),Group C-Premixed Mineral Trioxide Aggregate Putty (SafeEndo). Samples were in 1% basic fuchsin dye for 24 hours after perforation repair.A 15X stereomicroscope was used to evaluate linear dye penetration from mesial to distal buccal and lingual walls.

Statistical Analysis: Data were organised in Microsoft Excel 2021 and statistically analysed in Graph Pad Prism for Windows, Version 10.1.2.An alpha level of 5% was considered as the level of statistical significance.

Result: Biodentine,while powder liquid MTA and Premixed MTA Putty offered comparable but relatively inferior performance.

Conclusion: Within this study's limitations, Biodentine performs better than Premixed MTA Putty and powder liquid MTA for perforation repair.

Key-words: Furcal perforation MTA, Biodentine, MTA Putty.

Introduction:

In 9.6% of cases, perforations cause endodontic treatment failure.[1]Ingle defines an endodontic perforation as an artificial opening formed in the tooth or root by the clinician during access to the canal system, or by a biological event such as caries or pathological resorption, that enables communication between the root canal and periodontal tissue.[2] Internal and external resorption, dental caries, and iatrogenic factors are among the causes[3]. The worst prognosis is for perforation of the furcation area, which opens into the periodontal space along the root's mid-curvature.[4]

Perforation repair materials should have properties such as strong sealing ability, short setting time, non-toxicity, non-carcinogenicity, bacteriostatic activity, biocompatibility, ready availability,ease of use, able to stimulate cementogenesis and osteogenesis in thearea.[5,6] Recently studied bioactive bioceramics include MTA, Biodentine, Endosequence, and BioAggregate.[7]

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Powder-liquid MTA (Angelus), has proven to be an excellent perforation-repair material owing toits biocompatibility and hydrophilicity.[8] The slow setting time and complicated handlingmade it difficult to use. [9,10]

Premixed Biostructure MTA Putty(SafeEndo)addressed the drawbacks associated with powder-liquid MTA. It is

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radiopaque, resin-free, and does not discolour the teeth. It consists of a glycerol-based vehicle.

Tricalcium silicate, calcium carbonate, zirconium oxide, and a water-based liquid with calcium chloride as the setting accelerator and water-reducing agent composedBiodentine (Septodont), is a high-purity calcium silicate-based dental material.[11]

Studies on premixed MTA Putty for furcation perforation repair, are limitedly reported.This study compares three perforation repair materials' sealing abilities.

Materials And Method:

The institutional ethics committee received a comprehensive protocol explaining the purpose and procedure of the study, and ethical approval was provided withReg. no. – EC/NEW/INST/2023/3191

Sample Selection:

Dr. R Ahmed Dental College and Hospital, Kolkata, Department of Conservative Dentistry and Endodontics, conducted this in vitro research.Sixty human permanent mandibular first molars with well-developed, nonfused roots and sufficient coronal and radicular structure were selected.

Sample Size Determination:

G*Power Software 3.1.9.7(Heinrich Heine University, Düsseldorf, Germany) using an ANOVA model was utilised(effect size: 0.42, alpha error: 0.05, power: 80%, two-tailed significance level: 0.05) and a minimum sample size of 60 specimens(N=60) with 20 specimens per group was determined. A previous effect size study was acknowledged by De et al. (2024).

Specimen Preparation:

We stored all removed teeth in sterile solution at room temperature until use. Periodontal scalers removed root tissue and kept teeth in 0.9% normal saline.

Additional silicone impression material held teeth. After a round bur created a typical endodontic access opening, an Endo Z bur (Dentsply) extended the cavity laterally and finished the walls. Negotiating canal orifices with modelling wax. To simulate pulpal chamber perforation, use a #2 round carbide bur and a high-speed, water-cooled handpiece.

Three groups of specimens were randomly allocated (n = 20):

Group A: Biodentine (Septodont) furcal perforation repair

Group B: Powder-liquid MTA(Angelus) furcal perforation repair

Group C:Premixed MTA putty(SafeEndo) furcal perforation repair

Perforation repair was done using the following materials.Roots were kept moist with moist cotton pellets to emulate the clinical situation.After 24 hours, temporary restorative material filled the access cavity.

Preparation Of Specimens For Dye Penetration:

A double layer of varnish was applied uniformly to the teeth, leaving a 1 mm space around each perforation to allow dye to enter only through that site. The varnish was polished off after a 24-hour immersion in 1% basic fuchsin dye and a 40-minute wash under running water. Finally, a diamond-disk high-speed lathe sectioned the teeth bucco-lingually.

Dye Penetration Analysis::

Linear dye penetration from mesial or distal walls along buccal and lingual walls was assessed.Perforated walls were measured in millimetres for length and linear dye penetration.Percentages of the two were used to express the ratio. A stereomicroscope with 15X magnification and a digital camera was used to evaluate dye penetration from the repair material's coronal level to the perforation's apical end.

Statistical Analysis:

All groups were standardised according to Shapiro-Wilk test and histograms, Q-Q plots, box plots. Brown-Forsythe ANOVA has been used to evaluate group differences due to unequal variances. $P<0.05$ was used for post hoc comparisons using Dunnett's T3.

Results:

Dye penetration test results are displayed in Table 1. Group A (Biodentine) had the lowest mean value of 14.14 ± 1.10% (range: 11.88–16.02%), indicating favourable sealing capacity. The percentage of dye penetration revealed a clear gradation among the groups. Group B (MTA) demonstrated a considerably higher percentage penetration of 18.90 ± 4.24% (range 11.14–24.72%), while Group C (Premixed MTA Putty)showed an intermediate performance with a mean of 17.81 ± 2.85% (range 7.13–20.55%).

The dye penetration of the three materials varied considerably (Brown-Forsythe ANOVA: $F(2, 36.32) = 13.63$, $P<0.0001$). In Dunnett's T3 post hoc testing, Group A revealedless penetration than Group B (mean difference - 4.753, P =

0.0002) and Group C (mean difference - 3.668, P < 0.0001), showing higher sealing capacity. Groups B and C, however, performed similarly, with no significant difference between them (mean difference 1.085, P = 0.72).

TABLE 1 - Descriptive statistics and Inter-group comparisons of percentage of dye penetration among the study groups.

Group	*n*	Mean ± SD	Range	F (DFn, DFd)	*P* value *
Group A	20	14.14±1.1	11.88-16.02	13.63	<0.0001*
Group B	20	18.9±4.24	11.14-24.72	(2.000,	
Group C	20	17.81±2.85	7.13-20.55	36.32)	

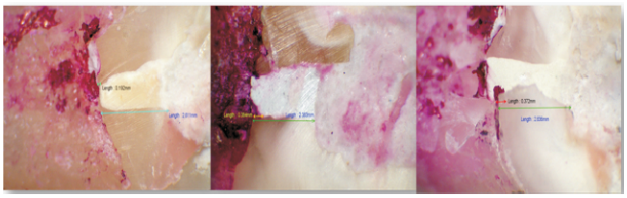

Figure 1: Representative stereo microscopic photomicrographs (×15 magnification) showing linear amount of dye penetration in (A) Biodentine (Septodont) (B) Powder-liquid MTA (Angelus) (C) Premixed MTA Putty (SafeEndo)

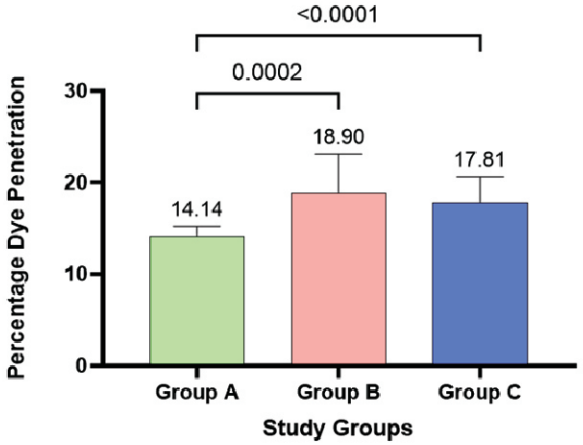

Figure 2: Bar Graph: Mean (±Standard Deviation) percentage of dye penetration for the study groups. Statistically significant pairwise comparisons are indicated overhead by the corresponding P values (adjusted).

n:sample size per group

SD:Standard deviation

F: statistic derived from Brown-Forsythe ANOVA test

DF: Degrees of freedom

n:numerator, d:denominator

NS:not significant(P>0.05)

* Mean ± SD

Discussion:

Perforations should ideally be promptly treated using a biocompatible material to avoid microbial ingress. [12] Tooth prognosis depend on location of perforations and their repair. The furcation area joins the pulp chamber, periodontal tissues, and coronal tooth structure and is exposed to functional stress, making treatment more difficult and requiring precise execution to restore integrity and promote healing. [13,14]

The current study used dye penetration to examine three calcium silicate cements for furcal perforation repair to determine the strongest seal.

Biodentine had the lowest dye penetration in this research, indicating a favourable seal. Previous research by Sinkar, Katge, and Shaheen [15,16,17] has shown that Biodentine seals furcation perforations effectively. Hasan et al. [18] found ProRoot MTA and Biodentine to be comparable for perforation repair. Biodentine's hydration enables it to seal. The liquid-phase calcium chloride accelerates hydration, and the water-reducing polymer lowers the water-to-powder ratio, making the calcium-silicate-hydrate matrix denser. Calcium carbonate can also act as a nucleation site, resulting in a denser microstructure and reduced leaching [19]. On the contrary by using the the glucose penetration method, Shetty et al. found that Bio-C repair sealed best, followed by MTA and Biodentine.[20]These discrepancies may be due to differences in experimental methodology, leakage assessment techniques and material characteristics.

Powder-liquid MTA penetrated dye most effectively in this study. Koç et al. found that MTA Angelus, Endocem MTA, and EndoSequence BioCeramic Root Repair Material Fast Set Putty (BC–RRMPutty) all prevented microleakage at 24 and 72 h. At 72 hours as opposed to 24 hours, only MTA Angelus demonstrated noticeably superior sealing performance.[21] Kumar A et al. reported MTA Angelus AND Bio-C Repair effective furcation repair materials. [22]Yahya MM evaluated similar results to the present study where Biodentine showed better sealing ability than MTA and GIC.[11] MTA pertains to clinker made from a raw mix with an inappropriate thermal profile and low burnability, leaving unreacted calcium oxide and silicon oxide, resulting in a smaller amount of reactive tricalcium and dicalcium silicates.Calcium oxide hydration produced many small Portlandite plates, making the microstructure more porous and reducing sealing ability.[19]

Premixed MTA Putty penetrated dye more effectively than Biodentine but less than MTA Putty. Extremely fine Tricalcium/Dicalcium silicate powder increases surface area,

speeding hydration and reducing porosity.It is designed to set in vivo and helps with precise placement in the perforation area.De S et al.reported that NeoPutty MTA (premixed bioceramic putty) exhibited lower microleakage than MTA Angelus, which is contrary to this research.[23]This research confirmed Wang Z et al.'s findings that premixed MTA's fine particle size and increased surface area made it more adaptable and faster.[24]This study confirmed Abdelmotelb MA et al.'s findings that premixed bioceramic putty outperformed MTA in sealing and clinical performance.[25]

Microleakage can be characterised and material sealing performance assessed using a variety of experimental methodologies. Dye penetration method was selected for this study because it is affordable and simple to administer. However, it fails to evaluate dye penetration in three dimensions.

Clinical implications of this study include the need for material selection to enable early detection and isolation of the perforated area, thereby improving prognosis.

Conclusion:

This in vitro study found that Biodentine (Septodont) seals furcation perforation better than powder-liquid (Angelus) and Premixed MTA Putty (SafeEndo).Premixed MTA Putty (SafeEndo) exhibited a sealing pattern similar to that of MTA Angelus, indicating that both behaved similarly. Further clinical studies are required to validate these findings under in vivo conditions.

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