wjpmr, 2023,9(7), 276-299

SJIF Impact Factor: 5.922

WORLD JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.wjpmr.com

Review Article

ISSN 2455-3301

WJPMR

THE CONSENT FORM WAS NOT USED IN THE PRESENT STUDY AS THIS WAS AN IN-VITRO STUDY

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Article Received on 21/05/2023 **Article Revised on 11/06/2023** **Article Accepted on 01/07/2023**

INTRODUCTION

Fracture Resistance Of Teeth Obturated With Different Obturating Materials: An In-Vitro Study

Endodontically obturated teeth have lower fracture resistance depending on the obturating material and technique.[1] The reason most often reported have been the dehydration of dentin after endodontic therapy, excessive pressure during obturation and the removal of teeth structure during endodontic treatment.[2] Microorganisms and their products are the main aetiological factors in dentinal, pulpal and periapical pathosis (Kakehashi et al. 1965, Brannstrom & Nordenvali 1978, Fabricus et al. 1982, Barnett et al. 1990, Sundqvist 1992). The central aim of root canal treatment is the elimination of bacteria from the infected root canal and prevention of subsequent reinfection. This is mainly achieved by thorough irrigation and biomechanical preparation of the root canal, followed by a canal filling that should seal the canal system from bacterial ingress from the oral cavity and periradicular tissues. Long-lasting sealing ability and adaptation to the root canal walls are one of the prime requisites for a root canal sealer.[3]

Gutta-percha has been the most frequently used root canal filling material because of its biocompatibility, lack of toxicity and easy removal from root canal. It is used in conjugation with sealers mainly resin based sealer such as AH 26 and AH Plus because of their multiple advantage.[2] Flow is the ability of a sealer cement to penetrate into irregularities and accessory canals of the root canal system, and it is considered to be a very important property. The greater the flow, the greater the ability to penetrate into irregularities. Conversely, if the flow is excessive, the risk of material extravasation to the periapex is increased, which could damage periodontal tissues.[4] A study was done to compare the flowability of Sealer 26, AH Plus sealer and MTA Obtura showed that AH Plus showed superior flow values to Sealer 26, which was also seen by Siqueira et al. As discussed by Siqueira et al. these differences can be attributed to the peculiar chemical composition of each sealer. The greater concentration of epoxic resin in AH Plus is responsible for its high flow rate. Moreover, the presence of calcium hydroxide in Sealer 26 decreases its flow property. The flow ability is also influenced by the size of sealer particles. The smaller the particles, the greater the flow ability of the sealer.[5]

A root canal filling paste GuttaFlow is a modification of Roeko Seal sealer (Coltene/Whaldent, Langenau, Germany). GuttaFlow contains gutta-percha particles as filler. The material is flowable and sets within 10 minutes.[6] It is a cold flowable system that combines both the sealer and the gutta-percha in one product. The sealer is silicone-based polymethyl-hydrogen siloxane as its main component. The powder consists of finely ground gutta-percha (0.9 lm). It has shown good homogeneity and adaptation to the root canal walls owing to its better flow properties (Elayouti et al. 2005).

MTA was developed at Loma Linda University, California by Torabinejad in 1993. MTA showed excellent seal and hard tissue repair compared to that of other root end filling materials.[7] The main components in MTA are tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide. Bismuth oxide is used as radio-opacifier. The powder is composed of hydrophyllic particles thet set in presence of moisture. Hydration of powder forms a colloidal gel that hardens.[8] According to a clinical study done by Chong and Pitt ford in 2003 comparing MTA and IRM, the use of MTA showed a higher success rate. MTA has shown promising results due to its good sealing properties, bioactivity, and potential to stimulate cementogenesis. The main advantage of MTA are its biocompatibility and its osteogenic and regenerative potential.[9] MTA has shown better anti-bacterial properties against E. faecalis, S.aureus, P.aeruginosa compared to other materials.[9] MTA has better anti-bacterial action when used after mixing with 0.12% chlorhexidine.[10] The use of MTA has been shown to induce cementum formation and periodontal regeneration with induction of least amount of inflammation. Tissue culture experiment shows that MTA induces cementogenesis, permitted cementoblast attachment and growth. MTA shows no toxic effects on cells and is reported to cause an increase in cell proliferation and release calcium in high amounts.[11] One of the disadvantage is its slow setting and less resistance against washing out during placement.[8] MTA might have profound advantage when used as canal obturation material because of its superior physiochemical and bioactive properties. The original material(Pro-Root MTA;Dentsply Tulsa Dental, OK) was introduced to seal pathways of communication from the external surface of the tooth in perforation repair and as root a root-end filling material.

Biodentine is a tricalcium silicate based material designed as a permanent dentin substitiue. It is biocompatible and bioactive material. Biodentine application does not require conditioning of the dentin surface. It penetrates into the dentinal tubules forming tag-like structure.[12] The main component is a highly purified tricalcium silicate powder that contains small amount of dicalcium silicate, calcium carbonate and a radio-opaquer.[13] An in-vitro study was done to compare the sealing ability of MTA, Calcium phosphate and Biodentine. MTA showed the highest seal and less dye penetration compared to Biodentine, but higher than Calcium phosphate cement.[14] The interfacial properties of Biodentine – Dentin interface were studied under micro-scope and tag-like microstructure were detected.[13] Investigation of bioactivity of Biodentine revealed deposition of hydroxyapatite on the surface. This shows that Biodentine is a bioactive material.[15]

Ortho MTA (BioMTA, Daejon, Korea) is a newly developed calcium silicate material known to have short setting time and less heavy metal content when compared to Pro-Root MTA. Furthermore, the heavy metal component of Ortho-MTA was reported to be less than that of Proroot MTA. Chang et al revealed that ProRoot MTA contained traces of arsenic, whereas, Ortho-MTA did not. According to manufracturer Ortho-MTA prevents microleakage by forming an interfacing layer of hydroxyapatite between the material and the canal wall. It releases calcium ions through the apical foramen, which may induce regeneration of the apical periodontium. Yoo et al reported that Ortho-MTA has an anti-bacterial effect in infected root canals. Zirconium oxide is used as radio-opacifier to prevent tooth discoloration.[1] It has same clinical application as that of MTA. There are not many studies that have evaluated the efficiency of OrthoMTA in reinforcing the endodontically treated teeth when used as obturating material.

Hence, this study is taken up to study the effect of different obturating materials on the fracture resistance of teeth.

AIMS AND OBJECTIVES OF THE STUDY

Aim of the study

To study the effect of different obturating materials on the fracture resistance of the tooth.

Objectives

1. To study the fracture resistance of different obturating material on teeth.
2. To study the effect of fracture resistance of obturating material like Gutta Percha with AH Plus sealer, GuttaFlow, ProRoot MTA, OrthoMTA, Biodentine.

REVIEW OF LITERATURE

1. A vitro study was done to compare the fracture in One hundred and twenty single rooted mandibular human incisor with canals which was divided into 5 groups. After root canal shaping using K3 rotary instruments, root canals were filled as follows: Group 1-(-) control, Group 2: (+) control, Group 3: Gutta percha/AH Plus sealer, Group 4: Thermafil/AH Plus sealer, Group 5: Resilon/Ephiphany self-etch(Ephiphany SE), Group 6: Gutta percha /Ephiphany SE, Group 7: EndoREZ sealer/EndoREZ cone. After root canal sealer set, the apical 4mm portion of the specimen were embedded in cold curing acrylic and a fracture resistance test was applied in UTM. The records were analyzed using one-way ANOVA and Tukey's honestly significant difference test. Resilon/Epiphany SE vs EndoREZ sealer/EndoREZ cone groups had lower fracture resistance. Gutta percha/AH Plus, Thermafil/AH Plus and Gutta percha/Epiphany SE showed similar fracture resistance. There were no significant difference between fracture resistance of Resilon/Epiphany SE and EndoREZ sealer/EndoREZ cone and posyive control groups. This concludes that root canal shaping decreases the fracture resistance and lateral condensation performed with AH Plus sealer and Gutta percha and Thermafil technique was found to be more successful.[16]

2. An in-vitro study was done to compare the fracture resistance using a bioceramic sealer and an epoxy resin-based sealer. One hundred maxillary central incisors were randomly assigned to three experimental groups: AH Plus sealer using the single-cone technique, AH Plus sealer using the lateral compaction technique, SureSeal Root sealer, and two positive and negative control groups. Then the fracture resistance of the prepared tooth roots was determined. The data were analyzed with one-way ANOVA and Tukey Post Hoc tests. There were statistically significant differences between the five study groups ($P < 0.001$). There was no significant difference between the negative control and Sureseal groups ($P = 0.183$). There were significant differences between the SureSeal and AH Plus groups. SureSeal Root sealer significantly increased the fracture resistance of the teeth compared to AH Plus sealer.[17]

3. An in-vitro study was done to evaluate the influence of ProRoot MTA (Dentsply Sirona, Tulsa Division) and OrthoMTA III (BioMTA, Daejeon, Korea) as an obturating material on the fracture resistance of endodontically treated. Thirty extracted human maxillary central incisors were decoronated and instrumented using Protaper instruments (size F5). Irrigation was performed with 2.5% sodium hypochlorite between each instrument change followed by 7% maleic acid for one minute. Finally, canals were flushed with 5 ml of PBS solution for one minute. Samples were then divided into three groups. Group I- positive control (no root canal filling); Group II- obturation with ProRoot MTA; Group III- obturation with OrthoMTA III. Ten teeth were randomly selected as a negative control in which no treatment was performed. All the specimens were then subjected to fracture strength testing using universal testing machine. For evaluation of biomineralization, six maxillary central incisors were divided into two groups. Group I obturated with ProRoot MTA and group II obturated with OrthoMTA III. These samples were subjected to SEM analysis. Root canals obturated with OrthoMTA III had better fracture resistance and increased tubular biomineralization compared to ProRoot MTA. Since root canals obturated with OrthoMTA III had better fracture resistance, it can be used as a promising obturating material.[1]

4. An in-vitro study was done to assess different root canal filling systems in terms of fracture resistances of endodontically treated teeth. This study was conducted on eighty single-rooted permanent mandibular incisor teeth which were divided into five groups: Group I was negative control; Group II was positive control; Group III comprised of gutta-percha/AH Plus; Group IV comprised of Thermafil/AH Plus; and Group V Resilon/Epiphany SE. Universal testing machine measured fracture resistance. It was concluded that lateral condensation performed with AH Plus sealer and gutta-percha and the Thermafil technique were the highest among all other methods.[18]

5. An in-vitro study was done to evaluate effect of various obturating materials on fracture resistance of root canal treated teeth. Sixty freshly extracted human mandibular premolars were used. After standardizing the length to 13 mm, the teeth were biomechanically prepared and divided into four groups based on type of obturating materials used. Group 1 - AH Plus root canal sealer+Gutta-Percha, Group 2- The Resilon –Epiphany system, Group 3- Zinc-Oxide Eugenol with Gutta-Percha, Group 4 - Teeth in this group were left unobturated, serving as control. Teeth obturated with AH Plus and gutta percha showed higher fracture resistance than those obturated with Resilon-Epiphany. The results suggested that the group obturated with gutta percha and zinc oxide-eugenol sealer had the lowest fracture resistance.[19]

6. An invitro study was done to compare the flow of GuttaFlow (Coltène/Whaledent Inc, Cuyahoga Falls, OH) and gutta-percha into lateral grooves and depressions in the apical 7 mm of the root canal system. A maxillary canine was used to fabricate a split-tooth model with depressions and lateral grooves placed in the canal walls at 1 mm, 3 mm, 5 mm, and 7 mm from the working length. The model was obturated with GuttaFlow or gutta-percha and Roth’s 801 sealer (Roth International, Chicago, IL). Obturations with gutta-percha were performed by using warm vertical compaction with the System B plugger (Analytic Endodontics, Orange, CA) advanced to 5 mm, 4 mm, or 3 mm from the working length. All obturations with GuttaFlow showed extrusion of material beyond the apex. GuttaFlow completely obturated the grooves and depressions at all levels from the working length, and, at the 1-mm level, GuttaFlow flowed significantly better into grooves. GuttaFlow flowed better than gutta-percha into depressions at the 1-mm level when the System B plugger was inserted to 5 mm and 4 mm from the working length, but no significant differences were seen when the system B plugger was inserted to 3 mm from the working length. Gutta- percha flowed significantly better into grooves and depressions at the 1-mm level when the System B plugger was inserted 3 mm from the working length compared with 5 mm and 4 mm from working length.[20]

7. An in-vitro study was done to evaluate root reinforcement by four different sealers, namely, AH Plus, MTA Fillapex, Dia-ProSeal, and GuttaFlow 2, on endodontically treated teeth. Sixty human mandibular premolars were randomly divided into four groups of 15 teeth each, according to the type of sealer used: Group I AH Plus, Group II MTA Fillapex, Group III Dia-ProSeal, and Group IV GuttaFlow 2. All samples were decoronated to a length of 13 mm from the apex. Root canals were prepared by OneShape, 25/0.06 taper file and obturated with a matching single cone gutta percha (25/0.06) using the above-mentioned sealers. All samples were subjected to load by universal testing machine until a point at which root fractured, which was recorded. According to the results obtained from this study, obturation of roots with GuttaFlow 2 increased the resistance of root canal filled teeth to vertical root fracture.[21]

8. An in vitro study was done to evaluate the resistance vertical root fracture of MTA filled immature permanent roots by three different vehicles. Forty extracted human single rooted premolars were selected and root length was standardized to length of 9mm. for stimulation of immature tooth apices, peso reamers were introduced into the root canals. Three experimental groups were selected according to the vehicle used (distilled water-DW, prophylene glycol-PG, chlorhexidine and control group(n=10). To simulate a periodontal membrane, the apical 7mmof all roots were covered with wax to obtain a 0.2-0.3mm thick layer before embedding the roots into acrylic cylinders. A vertical force was applied using UTM and statistical analysis was performed using Kruskal-Wallis, Mann-Whitney U test. There were significant difference between fracture resistance of experimental groups with that of control group(P<0.05). No significant difference were found amongst the fracture strength values of the experimental groups(P>0.05). In all groups split fracture was most common mode of fracture. This concludes that MTA increases resistance of immature permanent teeth to Vertical Root Fracture(VRF). Based on the study it can be also concluded that mixing MTA with chlorhexidine or prophylene glycol-PG as vehicle do not alter VRF resistance.[22]

9. An in vitro study was done to measure the fracture resistance of over-flared roots filled with a variety of materials (gutta-percha-nano HA, resilon-epiphany, composite and mineral trioxide aggregate - MTA) using the Instron machine test and micro-computed tomography (Micro CT) Scan. In addition, scanning electron microscopy (SEM) images were used to illustrate the type of fracture patterns of the specimens. The result of this study showed the ability of MTA is highest amongst other groups to withstand vertical forces.[23]

10. An in vitro study was done on sixty single rooted maxillary central incisors which were cleaned and shaped by hand files and protaper rotary files followed by obturation. The root ends were resected at 3mm level. The root end cavity preparation of 3mm depth was done using Ultrasonic tips. The samples were randomly divided as Group 1- MTA Angelus; Group 2- ProRoot MTA; Group 3- Biodentine; Group 4- GIC. The root samples were coated with two coats of nail varnish and immersed in mythelene blue dye 2%for 48hrs. Longitudinal root resection was done and the depth of the dye penetration was evaluated with stereomicroscope to examine microleakage. Least amount of apical dye microleakage was seen in biodentine(0.16mm) followed by ProRoot MTA(0.68mm),MTA Angelus(0.74mm) and GIC(1.53mm). The best sealing ability was seen in biodentine.[24]

11. An in-vitro study was done on thirty immature sheep incisor teeth were tested for their fracture resistance after various treatment modalities using calcium hydroxide (CH) or a mineral trioxide aggregate material (MTA) as a root filling. The incisors, having approximately 80% of their root growth completed, were removed from jaws of slaughtered sheep and divided into four experimental groups. The pulps were extirpated from all the teeth through the open apexes. (a) Saline group: the teeth were preserved in saline for 100 days at 6 degrees C. (b) CH group: the root canals were filled with CH and sealed apically with IRM and stored as above. (c) MTA group: the canals were filled with MTA and stored in saline for 100 days at 6 degrees. (d) CH+MTA group: the canals were filled with CH and sealed with IRM. After 30 days, the CH was replaced with MTA and stored as above. At the end of the 100-day storage period, all teeth were embedded in plaster of Paris and tested for fracture strength at the cervical area in an Instron testing machine. The results showed a decrease in fracture resistance (a) of the incisors with CH in the root canals after 100 days of storage, compared to (b) teeth stored in intracanal saline and (c) teeth with 30 days of CH and then filled with MTA, and (d) those filled with MTA in the canals. In conclusion, when CH was kept in the canals of immature sheep teeth for only 30 days followed by root filling with MTA there was no significant decrease in strength of the root within an observation period of 100 days.[25]

12. An in-vitro study was done to evaluate the fracture resistance of simulated immature teeth, when the root canals were completely filled either with mineral trioxide aggregate (MTA) or Biodentine, comparing with that of roots filled with apexification procedure. Sixty mandibular premolar teeth with single, straight canals decoronated at cementoenamel junction were divided into five groups (n = 12 each). Group 1 samples served as negative control and remaining four groups root samples were shaped and cleaned using ProTaper rotary files. To simulate immature roots, a #5 Peeso reamer was passed beyond the apex so that apices were enlarged to a diameter of 1.5 mm. Group 2 and 4 samples were filled with 5 mm of MTA or Biodentine apical plug and backfilling with gutta-percha using AH Plus sealer. Group 3 and 5 root samples were completely obturated with MTA and Biodentine, respectively. All the teeth were loaded vertically until fracture, using the universal testing machine. It was concluded that complete root canal obturation with MTA or Biodentine has shown significantly higher fracture resistance ($P < 0.05$) when compared to apexification with MTA or Biodentine.[26]

13. An in-vitro study was done to access the bond strength of root-end placed MTA and Biodentine (Septodont, Saint Maur des Fossés, France) in the absence/presence of blood contamination. Forty-eight single-rooted maxillary incisors were used subsequent to root-end resection and apical preparation using ultrasonic retro-tips, the specimens were randomly separated into two groups according to the root-end filling materials: MTA (Cerkamed Medical Company, Stalowa, Poland) or Biodentine. The specimens were then separated into two subgroups according to storage condition (absence/presence of blood). It was concluded that Biodentine had better bond strength values compared to MTA, and the bond strength of both MTA and Biodentine as root-end filling materials was negatively affected by the presence of blood.[27]

14. An in-vitro study was done to investigate the effect of MTA root canal fillings on the resistance to vertical root fracture (VRF) over different time intervals. Freshly extracted anterior human teeth with single canals and minimal curvatures were decoronated, instrumented to

size 50/.05 ProTaper file, irrigated with 1%NaOCl and randomly allocated to one of three groups (n = 36): (i) filled with MTA, (ii) filled with gutta-percha and sealer and (iii) unfilled roots used as a negative control. Each group was subdivided into three subgroups (n = 12) according to the storage time of 48 h, 1 and 6 months at 37°C in synthetic tissue fluid (STF). Vertical loading was carried out with a ball-ended steel cylinder fitted on a universal testing machine at 1 mm/min crosshead speed. The study showed that MTA increases the resistance to VRF of endodontically treated teeth and influences the mode of fracture after 1 and 6 month of storage in STF compared with gutta-percha and sealer.[28]

15. An in-vitro study was done with the aim to assess the long-term fracture resistance of human immature permanent teeth filled with BioAggregate (BA), mineral trioxide aggregate (MTA) and calcium hydroxide (CH). A total of 28 immature premolars with average root length of 10.7 mm and apical diameter of 3 mm were included in the study. The teeth were randomly assigned to four groups: Group I: DiaRoot® BA (DiaDent, Burnaby, BC, Canada), Group II: Angelus MTA (MTA-A; Angelus, Londrina, Brazil), Group III: ProRoot® MTA (MTA-PR; Dentsply, Tulsa, OK, USA), Group IV: CH (Sultan Chemists Inc., Englewood, NJ, USA). The teeth were placed in saline solution at 4°C for 1 year. All specimens were loaded at a crosshead speed of 1 mm min^{-1} in an Instron testing machine and the peak loads up to fracture were recorded. The results of this study showed that DiaRoot-BA-filled immature teeth demonstrate higher fracture resistance than other groups at 1 year.[29]

16. An in-vitro study was done to compare the fracture strength of extracted human roots with apical plugs of mineral trioxide aggregate (MTA) mixed with either Ca- and Mg-free phosphate-buffered saline (PBS) or water, with and without calcium hydroxide (CH) canal pre-medication. A total of 180 single-rooted human teeth were prepared to resemble immature roots and divided into groups (n = 20). The negative control received canal irrigation only, and the positive control received intracanal treatment with CH for - MTA(W); (ii) after 2 weeks CH pre-medication - 2/52CH + MTA(W); and (iii) after 12-week CH pre-medication - 12/52 CH + MTA(W). MTA mixed with PBS was used in Group 2: (i) without CH pre-medication - MTA(PBS); (ii) after 2-week CH pre-medication - 2/52CH + MTA(PBS); and (iii) after 12-week CH pre-medication - 12/52 CH + MTA(PBS). A compressive force was applied to each root until the point of fracture. The results showed that mineral trioxide aggregate mixed with Ca- and Mg-free phosphate-buffered saline had a significant strengthening effect on the fracture resistance of structurally weak roots, even when short-term calcium hydroxide pre-medication had been used. MTA mixed with water lost its strengthening effect on human roots when 2- or 12-week CH pre-treatment had been used.[30]

17. An in-vitro study was done to evaluate using an experimental immature tooth model, the fracture resistance of bovine incisors submitted to different reinforcement treatments with mineral trioxide aggregate (MTA). The specimens were assigned to four groups (n = 10): GI-control (without filling); GII-apical MTA plug + filling with gutta-percha and endodontic sealer; GIII-filling with MTA; GIV-apical MTA plug + filling with MTA + metallic post (Reforpost I). A polyether impression material was used to simulate the periodontal ligament. The specimens were submitted to a compressive load. The results showed that the use of MTA + metallic post as an intra-radicular reinforcement treatment increased the resistance to fracture of weakened bovine teeth in an experimental immature tooth model.[31]

18. An in-vitro study was done to investigate the effect of different treatment options on immature maxillary central teeth simulated with two different apical diameters on fracture resistance. Forty-eight maxillary central teeth with a singular root canal were collected for this in-vitro study. All the specimens were randomly divided into two groups: 1,2mm group (G1) prepared with No. 4 Peaso Reamer and 1.8mm group, (G2) prepared with No. 6 Peaso Reamer. Each parent group is divided into 4 subgroups (n=6) to form treatment groups. The positive control group was prepared without the access cavity to simulate the immature tooth (P) and negative control (N) group was prepared and filled calcium hydroxide. In group 3 MTA was condensed with a hand plugger to obtain a 3mm thick apical plug and remaining parts of the canals were filled with Guttaflow Bioseal cold filling system (G). In group 4, simulated immature roots were filled completely MTA (M). All samples were kept at 37° C and % 100 humidity for four weeks. Fracture test was performed by applying a load at an angle 135 degrees to the long axis of the teeth until a fracture occured using a universal test device. The results showed that the backfilling with GuttaFlow Bioseal in large apical diameter teeth may be beneficial in terms of fracture resistance.[32]

19. An in-vitro study was done to evaluate the effect of root filling with White Mineral Trioxide Aggregate (WMTA) and Biodentine™ (BD) on the fracture resistance of simulated immature teeth over different time periods. Sixty sound-extracted human single-rooted premolars were randomly allocated into 3 groups, 2 experimental and 1 control group, with 20 teeth each. Simulation of roots into immature apices were done using Peeso reamers. After preparation, the root canals of teeth in the experimental groups were completely filled with either WMTA or BD. The control group was subdivided into positive controls (n = 10) which received no treatment and negative controls (n = 10) which were prepared the same way and filled with normal saline. The specimens were subjected to fracture testing using a universal testing machine after 2 weeks and 3 months. It was concluded that no significant difference in fracture

resistant of simulated immature teeth was observed after 3 months when they were filled with Biodentine or WMTA, indicating that Biodentine could be a suitable substitute for MTA.[33]

20. An in-vitro study was done to evaluate the long-term fracture resistance of simulated immature teeth filled with Biodentine (BD) and white mineral trioxide aggregate (WMTA) as pulp space barriers for regenerative endodontic procedures (REPs). Sixty extracted human maxillary anterior teeth were divided into four groups of 15 teeth each. Positive control teeth received no treatment. The remaining root canals were irrigated and disinfected according to AAE considerations for REPs. The canals were filled with either BD or WMTA. The negative control canals were left unfilled. There was no difference between WMTA and BD regarding the resistance to root fracture.[34]

21. An in-vitro study was done to evaluate the push-out bond strength of Biodentine (BD) in comparison with two available calcium silicate based materials, bioaggregate (BA) and ProRoot MTA (WMTA). One hundred and twenty-three Root dentin slices of freshly extracted single Rooted human teeth were randomly divided into three groups (n = 41) according to the used test material: WMTA, BA, BD. After canal space preparation, the filling materials were placed inside the lumen of the slices. After 72 hours, the maximum force applied to materials at the time of dislodgement was recorded and slices were then examined under a stereomicroscope at ×40 magnification to determine the nature of bond failure. The findings of the study imply that the force needed for BD displacement is similar to WMTA and significantly higher than the force required to displace BA.[35]

22. An in-vitro study was done to compare and evaluate the effect of carbonic acid (CA) on the microhardness of MTA, BD, and root dentin (RD). Uniform MTA, BD, and RD discs were prepared under standardized conditions following the manufacturer's instructions. The preliminary microhardness of all the samples was tested after 24 h. All samples were soaked in CA for 5 min, and the microhardness was tested. It was observed that BD showed no statistically significant difference, whereas MTA and RD showed statistically significant differences in microhardness before and after exposure to CA.[36]

23. An in-vitro study was done to evaluate and compare the fractured resistance of simulated immature teeth and the effect of single visit apexification versus complete obturation using MTA and biodentine. Forty-five freshly extracted sound maxillary central incisors with single canal were selected. The apical 5 mm of each sample was then sectioned to simulate Cvek's stage 3 root development access cavity preparation, followed by preparation using peeso reamers. Irrigation was carried out followed by randomization of samples. Obturation was performed using Group 1 (n = 10):- Complete canal obturation with MTA, Group 2 (n = 10):- 5 mm apical plug of MTA, rest of the canal was obturated with gutta percha and AH Plus sealer, Group 3 (n =10):- Complete canal obturation with biodentine, Group 4 (n = 10):- 5 mm apical plug of biodentine, rest of the canal was obturated with gutta percha and AH Plus sealer, Control Group (n = 5):- The entire canal was obturated with gutta percha and AH Plus sealer using cold lateral compaction. The results showed that, group I (entire canal obturated with MTA) reported highest value of fracture resistance followed by group III (entire canal obturated with biodentine), group II, and group IV.[37]

24. An in-vitro study was done to investigate the effect of mineral trioxide aggregates (MTA) and Portland cement (PC) on fracture resistance of dentin. Thirty-six freshly extracted human single-rooted premolar teeth were selected. The crowns were removed and the roots were randomly divided into two experimental groups and one control group. The root samples were longitudinally divided into two halves and a dentin bar (2×2×10 mm) was cut from each root section for short-term (2weeks) and long-term (12 weeks) evaluations. The root sections in the experimental groups were exposed to MTA or PC, while keeping the control group specimens in physiologic saline. The fracture resistance of each specimen was measured using an Instron testing machine. The results showed that MTA increased the fracture resistance of root dentin, while PC had no significant effect on dentin fracture resistance.[38]

25. An in-vitro study was done to measure the fracture resistance of over-flared roots filled with a variety of materials (gutta-percha-nano HA, resilon-epiphany, composite and mineral trioxide aggregate - MTA) using the Instron machine test and micro-computed tomography (Micro CT) Scan. One hundred and twenty extracted human mandibular single-rooted premolars were selected. A total of 105 out of the selected teeth were prepared to the working length and over-flared, leaving the apical 5 mm undisturbed. Fifteen samples had no treatment and were used as a positive control group (Group +ve). The 105 test teeth were further divided into 7 groups of 15 samples each. One of the 7 groups was designated as negative control (Group -ve) where teeth were over prepared and left without obturation. Remaining groups were filled with gutta-percha-nanoHA (Group1), gutta-percha-nano HA+composite (Group 2), gutta-percha-nano HA+MTA (Group 3), resilon-epiphany (Group 4), resilon-epiphany +composite (Group 5), and resilon-epiphany+MTA (Group 6). Fracture resistance of all samples was measured using the Instron testing machine. Micro CT Scan and SEM analysis indicated the ability of MTA to withstand vertical force.[39]

26. An in-vitro study was done to evaluate the effect of prior application of several intracanal medicaments on the push-out bond strength of ProRoot MTA and

Biodentine. Sixty freshly extracted maxillary anterior teeth were sectioned below the cementoenamel junction, and the root canals instrumented using rotary files. Thereafter, a parallel post drill was used to obtain a standardized root canal dimension. The roots were randomly assigned into one of the following groups with respect to the intracanal medicament applied: group 1: calcium hydroxide (CH) powder (Merck, Darmstadt, Germany) mixed with distilled water; group 2: a mixture of metronidazole, ciprofloxacin and minocycline (triple antibiotic paste); group 3: a combination of amoxicillin and clavulanic acid (Augmentin; Champs Pharmacy, San Antonio, TX, USA); group 4: an antibiotic–corticoid compound paste (Ledermix; Riemser, Greifswald, Germany); and group 5: no medicament (control). Following removal of medicaments with instrumentation and irrigation, the roots were cut into 1-mm-thick parallel transverse sections in a coronal-to-apical direction (5 slices/tooth). Thereafter, the specimens were divided into two subgroups according to the calcium silicate cement applied (n = 30/group): (i) ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK, USA) and (ii) Biodentine (Septodont, Saint-Maur-des-Fosses, France). It was concluded that Biodentine had a higher bond strength to root canal dentine than ProRoot MTA. Prior CH in distilled water intracanal placement increased the dislodgment resistance of both calcium silicate cements.[40]

27. An in-vitro study was done to investigate the dislodgement resistance of EndoSeal MTA, a new pozzolan-containing calcium silicate-based material, in comparison with ProRoot MTA and Biodentine in the presence and absence of contamination with blood. Standard furcal perforations were created in 180 human mandibular first molars. The teeth were randomly allocated to 12 groups of 15 each. ProRoot MTA, Biodentine, and EndoSeal MTA were used to repair the perforations. In half of the samples, the walls of the perforated areas were contaminated with blood, whereas saline was injected into the other half. A push-out test was performed using a universal testing machine after 24 hours or 7 days. It was concluded that, ProRoot MTA and Biodentine showed higher values of bond strength than EndoSeal MTA and may thus be better options for the repair of root perforations.[41]

28. An in vitro study was done to compare the cytotoxicity of 4 root end filling material such as GIC(GIC; Fuji II, GC Corp, Tokyo, Japan), reinforced ZOE cement(IRM; Dentsply Tulsa Dental, Tulsa, OK) and two types of MTA. This study used MG-63 cells derived from human osteosarcoma. To evaluate the cytotoxicity of test materials, the 2,3-bis-(2-methoxy-4-nitro-5-sulfophenyl)-2H-tetrazolium-5-carboxanilide(XTT) assay was used. The cells were exposed to the extracts and incubated. Cell viability was recorded by measuring the optical density of each test. Each specimen was examined under scanning electron microscopy. The XTT assay showed that the cell viability of ProRoot MTA was higher than GIC and OrthoMTA. The SEM analysis showed that elongated, dense, and almost confluent cells were observed in the cultures of GIC, Ortho MTA, ProRoot MTA specimens. In contrast cell cultures of IRM were rounded in shape and the number and density of the cells were smaller then that in the other groups. This concludes that ProRoot MTA and GIC showed good biocompatibility than OthoMTA.[42]

29. Recently, several kinds of mineral trioxide aggregate (MTA)-based products have been introduced in endodontics. Ortho MTA (BioMTA, Seoul, Republic of Korea) is one of those products, which was developed for retrograde filling, perforation repair, orthograde root canal obturation, and direct pulp capping. The inclusion of heavy metals in MTA-based materials is of concern because they come into direct contact with hard and soft tissues. This study was done to investigate and compare the levels of arsenic (As), chromium (Cr), hexavalent chromium (Cr^{6+}), and lead (Pb) in Ortho MTA and ProRoot MTA. One gram of each MTA was digested using a mixture of hydrochloric and nitric acids and filtered. The As, Cr, and Pb in the resulting filtrates were analyzed by inductively coupled plasma–optical emission spectrometry. The level of Cr^{6+} was measured by the methods suggested in the Korean Standard L 5221. The results were statistically analyzed using the Mann-Whitney U test. The concentration of As in ProRoot MTA was 1.16 ppm, but As was not detected in Ortho MTA. Cr^{6+} and Pb were not detected in either MTA. Ortho MTA contained significantly less Cr than ProRoot MTA ($P < .05$). Ortho MTA and ProRoot MTA meet the ISO specification 9917-1 regarding the safety limits of As and Pb and are safe biomaterials when the purity of As, Cr^{6+}, and Pb is considered.[43]

30. A study was done to compare the bioactivity of Biodentine (BIO, Septodont), MTA Plus (MTA P, Avalon) and calcium silicate experimental cement (CSC) with resin (CSCR) associated with zirconium (CSCR ZrO_2) or niobium (CSCR Nb_2O_5) oxide as radiopacifiers. According to the relevance of osteoblastic cell response for mineralized tissue repair, human osteoblastic cells (Saos-2) were exposed to test materials and assessed for viability (MTT), cell proliferation, gene expression of alkaline phosphatase (ALP) osteogenic marker by real-time PCR (RT-qPCR), ALP activity assay and alizarin red staining (ARS) to detect mineralization nodule deposition in osteogenic medium. Unexposed cells acted as the control group (C). Statistical analysis was carried out using ANOVA and the Bonferroni post-test ($P < 0.05$). It was concluded that all materials had suitable biocompatibility and bioactivity. The MTA P, BIO and CSCR ZrO_2 groups had the highest viability rates and velocity of proliferation whilst the CSCR Nb_2O_5 group produced more mineralized nodules.[44]

METHODOLOGY

Collection of teeth

Sixty single rooted teeth that are indicated for extraction due to orthodontic reasons and periodontal problems will be collected from Department of Oral and Maxillofacial surgery, M.R.Ambedkar dental college and Hospital Bangalore-Karnataka, India with patients consent, Teeth will be carefully cleaned and stored in 10% buffered formalin. OSHA GUIDELINES will be followed in the collecting and storage of samples.

Selection of Samples

Inclusion Criteria

1. Teeth that are caries-free
2. Teeth with single root
3. Teeth with single canal, mature apex and without calcification
4. Teeth without restoration and any other surface defects.

Exclusion Criteria

1. Fractured or restored teeth
2. Carious teeth
3. Severely attrited/ abraded teeth
4. Root canal treated teeth
5. Incompletely formed apex
6. Curved canals.
7. Teeth with internal or external resorption.
8. Teeth with calcified canals.

Armamentarium

- Ortho Mta
- Pro Root Mta
- Gutta percha
- Ah plus sealer
- Gutta flow
- Biodentine
- Protaper rotary file
- Intraoral periapical radiograghs
- Ditilled water
- High speed contra-angle handpiece
- Slow speed endodontic handpiece
- 3% sodium hypochlorite
- 30 gauge endo irrigation side vent needle
- Digital stopwatch
- Tweezer
- Mouth mask
- Stainless steel milimeter scale
- Cotton holder
- Endogauge
- Endo box
- Gloves

Preparation of Samples

The procedure for preparation was standardized for all groups and performed by single operator to minimize experimental variables.

All the teeth were decoronated apical to the cementoenamel junction to standardize the canal length to 13 mm with a diamond disc under water coolant. The root samples were viewed under stereomicroscope to access any pre-existing external defects or cracks.

Samples were randomly divided into five groups based on the obturating material used. (n= 12 in each group)
Group 1:- Gutta Percha with AH Plus Sealer
Group 2:- Gutta Flow
Group 3:- ProRoot MTA
Group 4:- OrthoMTA
Group 5:- Biodentine

Working length of all samples were established by size 10 K-file inserted into the canal until the tip of the file become visible at the apical foramen.

Group 1: Teeth obturated with Gutta-Percha AH Plus sealer.

- Initial negotiation of the root canal space was performed using a size 15 manual K file using watch winding motion to assure the presence of a glide path.
- Root canal shaping procedure were performed with ProTaper rotarty files upto the size of F3.
- After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side vent. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration.
- The canal space was then obturated with Gutta-Percha with AH Plus sealer according to manufacturer's instructions.

Group 2: Teeth obturated with Gutta-Flow.

- Initial negotiation of the root canal space was performed using a size 15 manual K file using watch winding motion to assure the presence of a glide path.
- Root canal shaping procedure were performed with ProTaper rotarty files upto the size of F3.
- After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side vent. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration.
- The canal space was then obturated with Gutta Flow according to manufacturer's instructions.

Group 3: Teeth obturated with Pro-Root MTA.

- Initial negotiation of the root canal space was performed using a size 15 manual K file using watch winding motion to assure the presence of a glide path.
- Root canal shaping procedure were performed with ProTaper rotarty files upto the size of F3.
- After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side

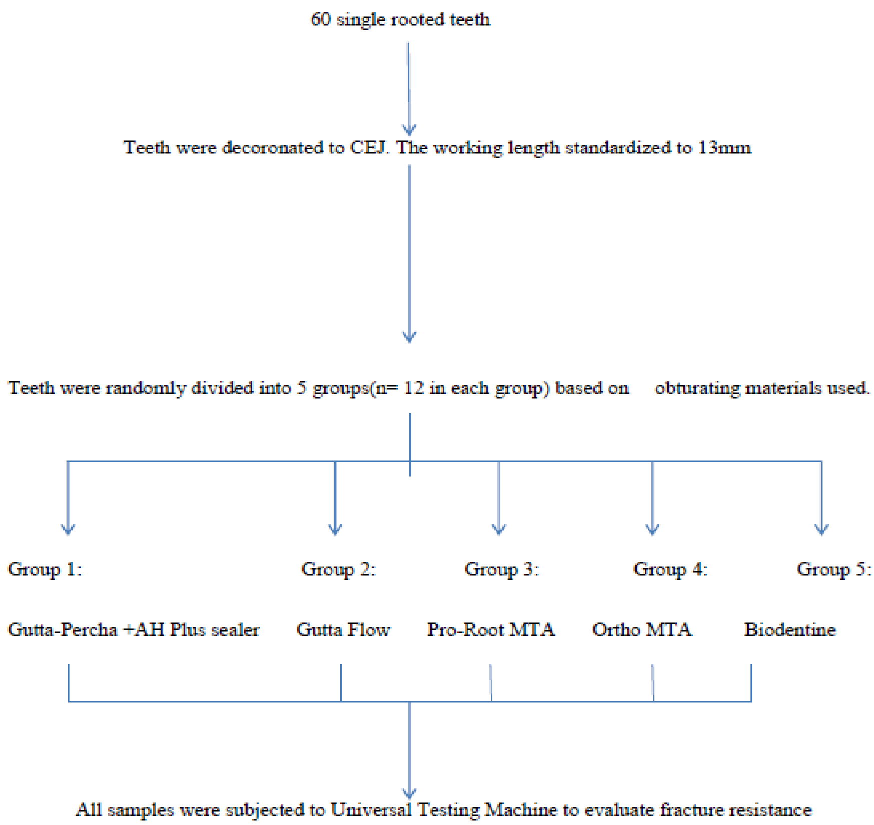
vent. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration.

- The canal space was then obturated with Pro-Root MTA according to manufacturer's instructions.
- Group 4: Teeth obturated with Ortho MTA.
- Initial negotiation of the root canal space was performed using a size 15 manual K file using watch winding motion to assure the presence of a glide path.
- Root canal shaping procedure were performed with ProTaper rotarty files upto the size of F3.
- After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side vent. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration.
- The canal space was then obturated with Ortho MTA according to manufacturer's instructions.

Group 5: Teeth obturated with Biodentine.

- Initial negotiation of the root canal space was performed using a size 15 manual K file using watch winding motion to assure the presence of a glide path.
- Root canal shaping procedure were performed with ProTaper rotarty files upto the size of F3.
- After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side vent. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration.
- The canal space was then obturated with Biodentine according to manufacturer's instructions.

STUDY DESIGN



DISCUSSION

Vertical root fracture is a complication of endodontic treatment that almost inevitably results in extraction of the tooth or resection of the affected root.[28]

Caries, loss of marginal ridges, access cavity preparation and root canal instrumentation result in loss of sound tooth structure, which is the major factor that determines the resistance of teeth to fracture.[45]

There are major differences between an endodontically treated teeth and an intact tooth. Dentine loss in anatomic structures such as cusps, shoulder and pulp chamber floor, reduction in dentine elasticity and loss of water content predispose teeth to fracture.[16]

The removal of Type I collagen, chondroitinesulphate and glycosaminoglycans in the dentine with organic tissue dissolving effect of NaOCl, causes structural changes in dentine leading to reduction of elasticity modulus and flexural strength.

Consequently, root-filled teeth are subjected to greater occlusal loading than their vital counterparts.[28]

Coronal restoration of endodontically treated teeth aims at restoring function, aesthetics, provides good coronal seal and reduces risk of fracture.[46]

However, vertical root fracture may occur well before the final coronal restoration is placed and may remain undetected for sometime before symptoms develop.[47]

One approach to prevent VRF in endodontically treated teeth is to reinforce the residual tooth structure by the root canal filling material.

The resistance of roots to fracture can be affected by the materials placed in the root.[28]

Gutta-Percha has been the most frequently used root canal filling material for years for its multiple advantages such as biological compatibility, lack of toxicity or allergic effects and easy removal from the root canal walls by itself.[16]

Gutta-Percha was introduced by Bowman in 1867. It is a trans-isomer of polyisoprene, existing in alpha and beta crystalline forms.[48]

Friedman described its composition as consisting of 20% gutta-percha matrix, 60% zinc oxide filler, 11% heavy metal sulphates as radio-opacifiers and 3% wax as plasticizer.[48]

Gutta-Percha is known to have poor sealing abilities it has to be used with a sealer during root canal obturation.[8]

Gutta-Percha as a root filling material cannot sufficiently strengthen the root against vertical root fracture due to its low modulus of elasticity.[49]

One of the aims of filling of root canal is to reinforce the root canal dentine to increase the fracture resistance.[50]

Therefore, the use of root canal sealer possessing an additional quality of strengthening the root against the fracture would be of obvious value.[51]

Sealer are necessary to seal the space between the dentinal wall and the obturating material.[52]

The ability of the sealer to bond to dentine and penetrate the dentinal tubules is an advantage that results in the integrity of the intracanal structure, increasing root fracture resistance.[52]

Epoxy-resin based sealer have easy handling, better wettability of dentine surface, good sealing and good dentinal tubule penetration.[53]

AH Plus sealer is an epoxy resin-based sealer that is commonly used with Gutta-Percha.[19]

AH Plus sealer is a two component sealer comprising base and catalyst in which a polymerization reaction of epoxy-resin amine with high molecular weight, including bisphenol A and bisphenol b occurs.[21]

When Gutta-Percha used in conjunction with resin based sealant or bonding agent, it forms a monoblock within the canals that bonds to the dentinal walls.[54]

As per the monoblock concept, the restoration and the tooth act as single unit under occlusal stress. Because the resin core sealant and the dentinal walls are all attached it appears logical that they have the potential to strengthen the walls against fracture.[55]

AH Plus sealer has better penetration into micro-irregularities because of its creep because of its creep capacity and long setting time, which increases the mechanical interlocking between the sealer and root dentine.[56]

Other studies have also reported the antimicrobial activity of AH-Plus sealer (Kayaoglu et al. 2005, Eldeniz et al. 2006). The antimicrobial effect of the resin-based sealer AH-Plus may be related to bisphenoldiglycidyl ether, which was previously identified as a mutagenic component of the resin-based sealer (Heil et al. 1996). In addition, it has been reported that the material releases formaldehyde during polymerization (Leonardo et al. 1999).[3]

In the present study, Gutta-Percha along with AH Plus sealer showed the least fracture resistance compared to all the other groups.

The result of this study is in accordance with the study done by PawanDarak et al in 2019 according to which the result of their study showed highest value of fracture resistance for the canal entitelyobturated with Biodentine followed by other groups.[37]

Similar kind of result was also seen in the study done by Bobbin Gill et al in which study was done to evaluate and compare the effect of single visit apexification with GuttaPercha AH Plus sealer or full obturation of mineral trioxide aggregate (MTA)/ Biodentine on fracture resistance and pattern of fracture of simulated immature teeth. The result of their study showed that complete obturation with MTA and Biodentine showed significantly higher fracture resistance than MTA and biodentineapexification groups.[57]

Another study which showed similar kind of result where OzgurLlkeUlusoy et al investigated the fracture resistance of roots with simulated internal resorption cavities and obturated with different hybrid techniques. The material used in this study were AH Plus sealer with high temperature thermoplastisized injectable guttapercha, DiaRoot Bioaggregate, Biodentine and MTA Fillapex. The results of this study showed that Biodentine had highest fracture resistance compared to that of other materials used in the study.[58]

In 2004, Coltene/WhaldentInc(Cuyahoga Falls, OH) introduced a cold, flowable, self-curing obturation material for root canals that combines gutta-percha and sealer into one injectable system.[20]

Gutta-Flow contains gutta-percha in particle form combined with a polydimethylsiloxane-based sealer.[20]

Gutta flow is available in capsule and can be injected directly into the canal. It is used in combination with a master gutta-percha cone and does not require any form of manual compaction for placement.[20]

The material is believed to flow into lateral canals and completely fill the space between the root canal walls and the master cone.[20]

In addition, because no heat is used with the placement of the material, no shrinkage is believed to occur, and the manufacturer reports that the material expands 0.2% upon curing.[20]

Gutta-Flow has apatite forming and bio-active abilities due to its low solubility, good alkanizing activity combined with light calcium release.[20]

In the present study, Gutta-Flow showed better fracture resistance than Gutta-Percha AH Plus sealer. This result was in accordance with the study where Varsha Maria Sebastian et al evaluated root reinforcement by four different sealers i.e AH Plus, MTA Fillapex, Dia-pro seal and Gutta-Flow. The result of their study showed that teeth obturated with Gutta-Flow which has powdered Gutta-Percha showed the highest fracture resistance.[21]

Another study done by SumanMakam et al showed similar result. In this study canals were obturated with Thermafil with AH Plus sealer and Gutta Flow with single cone guttapercha. It showed that Gutta Flow reinforced the root better than thermafil with AH Plus sealer obturation.[59]

Pro-Root MTA is a hydrolic cement that consists of fine hydraulic particles of tricalcium oxide, tricalcium silicate, bismuth oxide, dicalcium silicate, tricalcium aluminate, and calcium sulfate dehydrate.[1]

In presence of water or moisture it forms a colloidal gel that solidifies to form hard cement.[1]

Pro-Root MTA have shown to have particle that ranges from 2.44-3.05um.[60]

Pro-Root MTA sets through hydration reaction of calcium silicates, which forms colloidal gel that turns into hard structure in 2hr 45min.[61]

This setting reaction is complex but mainly involves the formation of dicalcium and tricalcium silicate hydrates and calcium hydroxide.

The hydration reactions of ProrootMTA can be explained as follows

(A) $2[3CaO.SiO2] + 6H2O \rightarrow 3CaO.\ 2SiO2.\ 3H2O + 3Ca(OH)2$

(B) $2[2CaO.\ SiO2] + 4H2O \rightarrow 3CaO.\ 2SiO.\ 3H2O + Ca(OH)2$[1]

The tricalcium silicate hydrates rapidly and is responsible for early strength and hardening of the material.[62]

The hydration reaction of dicalcium silicate is a slower process and is responsible for the increase in strength over the subsequent week.[62]

Dentine is constituted primarily of porous tubules that leach fluid throughout the life of the tooth.[63]

It is likely that the tissue fluid may penetrate through these tubules and reach the Pro-Root MTA root filling.[64]

The result is the formation of hydroxyapatite layer at the interface between dentine and MTA.[64]

Because hydroxyapatite is the major constituent of dentine the formation of layer between MTA and dentine suggests that chemical bonding has created, which is according to sarkar et al.[64]

According to a study done by Chong and Pitt Ford in 2003 comparing MTA and IRM, the use of MTA showed higher success rate. MTA has shown promising results due to its sealing properties, bioactivity and potential to stimulate cementogenesis.[9]

The main advantage of MTA is its biocompatibility and its osteogenic and regenerative potential.[9]

MTA has been demonstrated to have better anti-bacterial property against E.*feacalis,* S.*aureus*and P.*aeruginosa.*[9]

Tissue culture experiment suggests that MTA induces cementogenesis, permitted cementoblast attachment and growth.[65]

MTA shows no toxic effect on cells and reported to cause an increase in cell proliferation and release calcium in high amounts.[65]

A disadvantage is its slow setting and less resistance against washing out during placement.[8]

In this study Pro-Root MTA showed better fracture resistance than Gutta-Percha AH Plus sealer.

This result was in accordance with the study done by Ahmad M. EL-Ma'aita et al in which he compared the resistance to vertical fracture in teeth obturated with Gutta-Percha with a sealer and MTA. The results of their study showed MTA had better fracture resistance than Gutta-Percha with sealer.[28]

A study done by Karri Girish et al showed similar results in which the aim of the study was to compare fracture resistance of simulated immature teeth where root canals were completely filled either with MTA or Biodentine with that of apexification groups. The result of their study showed that complete obturation with MTA or Biodentine showed higher fracture resistance than that of apexification group.[26]

Biodentine is a calcium silicate based material introduced in 2010 as a material for crown and root dentine repair, repair of perforations, apexifications, resortion repair and root end filling.[66]

The main component is a highly purified tricalcium silicate powder that contains small amounts of dicalcium silicate, calcium carbonateand a radio-opaquer.[67]

The inter-facial properties of dentine-biodentine interface were studied under microscope and tag-like structure were detected.[66] The flowable consistency of biodentine penetrates dentinal tubules and helps in mechanical properties of interphase.[66]

The main advantage of biodentine is its reduced setting time.[44]

Biodentine has suitable biological properties such as dentine bridge formation when used in pulp capping(Nowicka et al. 2013).[44]

The material also increases OD-21 pulp cell viability and induced the expression of important molecular markers involved in mineralization process such as alkaline phosphatase, stimulating calcium deposition(Zanini et al.2012).[44]

MTA and biodentine have similar chemical compositions, both are composed mainly of tricalcium and dicalcium silicate. However, the liquid of biodentine differs from that of MTA, containing calcium chloride as an accelerator and hydrosoluble polymer.[27]

Elnaghy indicated that biodentine showed higher bond strength compared to that of MTA after exposure to different values.[68]

The higher content of calcium releasing products in biodentine than in MTA promotes to higher biomineralization and higher bond strength.[15,69,70]

The difference in bond dtrength may also be attributed to differences in particle sizes, which may effect on penetration of cement into dentinal tubules.[71]

Compared to MTA smaller particle size of biodentine cause the formation of tag-like structure and better micromechanical adhesion to dentine.[27]

But, study conducted by R. Yasin et al, it showed that there was no significant difference in fracture resistance of simulated immature teeth after 3 months when they were filled with Biodentine and MTA.[33]

In the present study, Biodentine showed better fracture resistance than Pro-Root MTA, but with no significant difference with that of Pro-Root MTA.

This result was in accordance with the study done by HuseyinAkcay et al et al in which he evaluated the bond strength of root end placed MTA and Biodentine in presence and absence of blood contamination. The results of this study showed that Biodentine has better bond strength than MTA and it was negatively affected by the presence and absence of blood in it.[27]

Another study done by AlirezaAdi et al compared that dislodgement resistance of new Prozzolan based Cement(EndoSeal MTA) compared to Pro Root MTA and Biodentine in presence or absence of blood. The result of their study showed that BIodentine had higher bond strength compared to that of ProRoot MTA and EndoSeal MTA with not much significant difference with that of Pro Root MTA.[72]

Ortho-MTA is a newly developed calcium silicate cement which is known to have shorter setting time and have less heavy metal content compared to that of Pro-root MTA.[1]

Arsenic is known to be carcinogenic and has been reported that it inhibits cellular functions and distorts intracellular microstructures.[43]

Chang et al revealed that Pro-Root MTA contained traces of arsenic(1.16ppm), whereas Ortho MTA did not.[1]

According to the manufacturer, OrthoMTA prevents microleakage by forming an interfacial layer of hydroxyapatite between the material and canal wall.[1]

Furthermore, it releases calcium ions through the apical foramen, which may induce regeneration of the apical periodontium.[73]

Yoo et al. reported that, the OrthoMTA-PBS paste has an antibacterial effect in infected root canals. Recently, OrthoMTA (BioMTA) has been has been launched. Zirconium oxide has been used a radiopacifier to prevent tooth discoloration.[73]

The main composition of OrthoMTA is Tricalcium silicate, (CaO)3 SiO2; Dicalcium silicate, CaO)2 SiO2; Tricalcium aluminate, (CaO)3 Al2O3; Tetracalciumaluminoferrite, (CaO)4 Al2O3 Fe2O3; Free calcium oxide, CaO; and Zirconium oxide, ZrO2.[1]

The hydration reactions of OrthoMTA III can be explained as follows

(A) 2[3CaO .SiO2] + 6H2O → 3CaO. 2SiO2. 3H2O + 3Ca(OH)2

(B) 2[2CaO .SiO2] + 4H2O → 3CaO. 2SiO. 3H2O + Ca(OH)2

(C) 6CaHPO4 .2H2O + 3Ca(OH)2 → Ca9(HPO4)(PO4)5(OH) + 17H2O[1]

During Ortho MTA setting reaction, high pH will be decreased to almost neutral value. As a result of this reaction, enough end product water can be produced and supply the humidity to dentine through dentinal tubules. The toughness of dentine in the hydrated state is significantly higher than the dehydrated state.[74]

The presence of water in the hydrated dentine results in a stress strain response characteristics of tough material, while loss of free water resulted in stiffening and response characteristic of brittle material.[75]

Long time calcium hydroxide [Ca(OH)2] intracanal medicament will weaken the dentin dramatically and cause the root fracture.[76]

One of end products of hydration of MTA is Ca(OH)2. Initial pH of ProRoot MTA is 12.5. This high alkaline pH is enough to dissolve the collagen matrix of the dentin.[1]

Hydration equation of OrthoMTA consumes Ca(OH)2 and finally pH will be decreased to neutral. Therefore, it may prevent the weakening of dentin after its application.[1]

Another reason for the better fracture resistance of OrthoMTA when compared to ProRoot MTA may be due to the interfacial bonding between MTA and root canal dentin walls.[1]

OrthoMTA shows better biomineralization effect under current conditions.[1]

This enhanced biomineralization effect may induce the stronger interfacial bonding.[1]

In a study, petals-like precipitates were formed within the dentinal tubules.[1]

However, the amount of precipitate is higher with OrthoMTA when compared to ProRoot MTA.[1]

This could be attributed to the small particle size (nono size) of OrthoMTA which induce more stable precursors for guiding an effective diffusion of the ions than the higher molecular weight particles of ProRoot MTA.[77]

Also, the nano particle size of OrthoMTA provides initial advantages in compressive and flexural strengths.[78]

In the present study Ortho-MTA showed highest fracture resistance than any other group.

This result was in accordance with the study done by NidamburVasudevBallal et al in which he compared the fracture resistance of Ortho MTA with that of Pro-Root MTA in which OrthoMTA showed better fracture resistance.[1]

SUMMARY

The aim of this study was to compare the fracture resistance of teeth obturated with different obturating materials.

Sixty single rooted teeth with mature apices were collected and cleaned and stored in distilled water. All the teeth were decoronated apical to the cementoenamel junction to standardize the canal length to 13 mm with a diamond disc under water coolant. The root samples were viewed under stereomicroscope to access any pre-existing external defects or cracks.

Samples were randomly divided into five groups based on the obturating material used. (n= 12 in each group)

Group 1:- Gutta Percha with AH Plus Sealer

Group 2:- Gutta Flow

Group 3:- ProRoot MTA

Group 4:- OrthoMTA

Group 5:- Biodentine

Working length of all samples were established by size 10 K-file inserted into the canal until the tip of the file become visible at the apical foramen.

Root canal shaping procedure were performed with ProTaper rotarty files upto the size of F3.

After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side vent. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration.

The root canal samples were obturated based on different group of obturating materials.

All the obturated root canal samples were subjected to Universal Testing Machine (UTM) to evaluate its fracture resistance.

The results obtained from the Universal Testing Machine (UTM) were subjected to ANOVA test followed by Tukey's post hoc analysis.

The result of the study showed that Ortho MTA has highest fracture resistance followed by Biodentine, Pro-Root MTA, GuttaFlow, Gutta-Percha+AH Plus sealer.

ANNEXURES

Figure 03: Teeth Samples.

Figure 04: Micromotor and Straight Handpeice.

Figure 05: Armamentarium for decoronation.

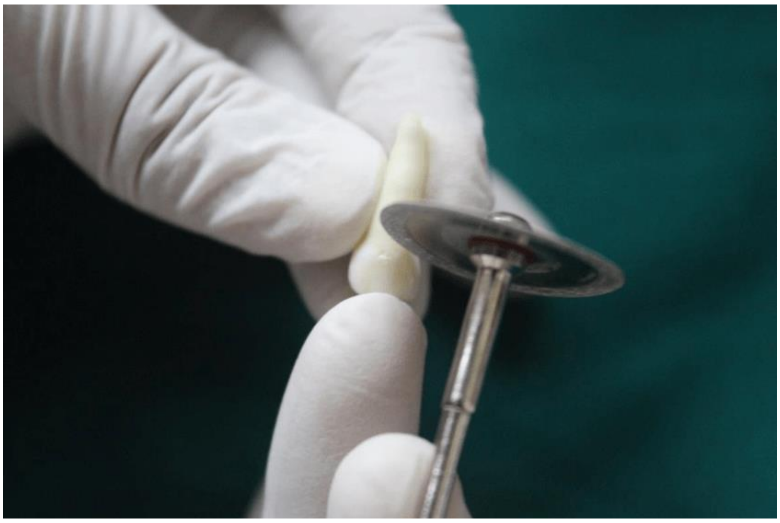


Figure 06: Decoronation of Tooth Sample.

Figure 7: Measurement Using Vernier Calliper.

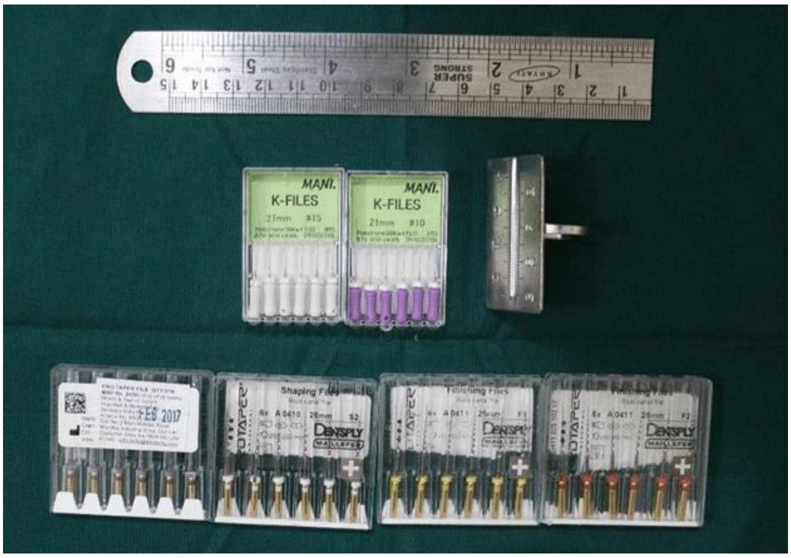


Figure 8: Armamentarium for Cleaning and Shaping of the Canals.

Figure 9: 3% Sodium Hypochlorite and 0.9% Saline Solution.

Figure 10: Endomotor.

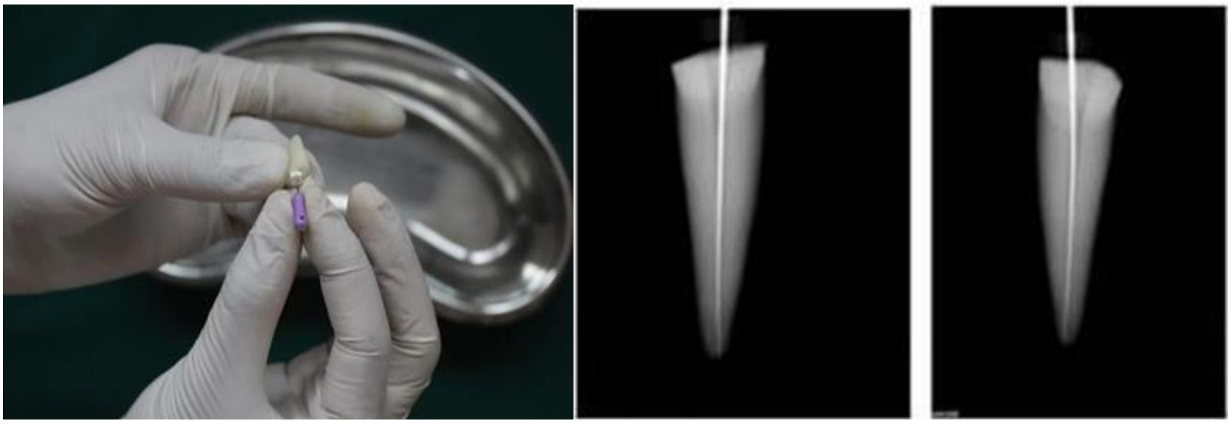


Figure 11: Working Length Estimation Using Radiograph.

Figure 12: Cleaning and shaping of the canal.

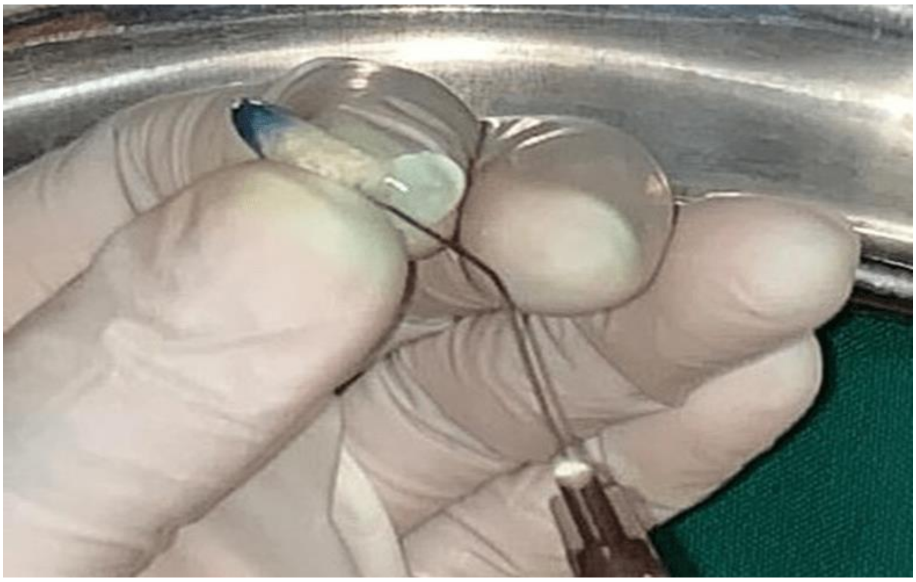


Figure 13: Irrigation of the canal.

Figure 14: Obturation of the canal with gutta-percha ah plus sealer.

Figure 15: Teeth Obturation with Gutta Flow.

Figure 16: Teeth Obturation with Pro-Root Mta.

Figure 16: teeth obturation with biodentine.

Figure 17: Teeth obturation with ortho mta.

Figure 19: Armzamentarium for mounting the teeth sample.

Figure 20: Mounted samples.

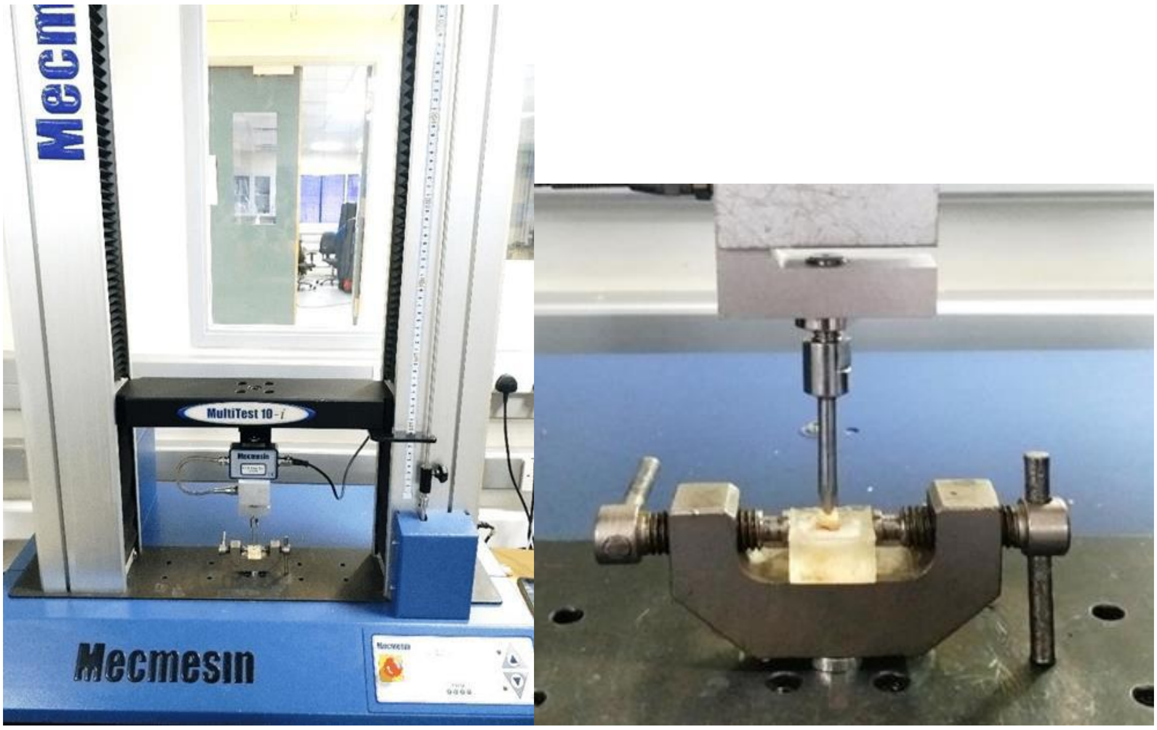


Figure 21: Evaluation of fracture resistance using universal testing machine.

CONCLUSION

Under the limitations of this in-vitro study, it can be concluded that

1. All the obturating materials were able to produce some amount of fracture resistance.
2. Among all the obturating materials used in this study, Otho MTA showed the highest degree of fracture resistance.
3. The order of the fracture resistance of different obturating materials used in the study goes like:

OrthoMTA>Biodentine> Pro-Root MTA >Gutta-Flow > Gutta-Percha with AH Plus sealer.

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