COMPARISON OF FRACTURE RESISTANCE OF TEETH OBTURATED WITH DIFFERENT ROOT CANAL SEALERS –AN INVITRO STUDY

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CERTIFICATE

This is to certify that this dissertation titled **"COMPARISON OF FRACTURE RESISTANCE OF TEETH OBTURATED WITH DIFFERENT ROOT CANAL SEALERS –AN INVITRO STUDY"** is a bonafide record of work done by Dr**. REMYA VARGHESE** under my guidance and to my satisfaction during her postgraduate study period, 2014 – 2017. This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in partial fulfilment for the award of the degree of Master of Dental Surgery in Conservative Dentistry and Endodontics, Branch IV. It has not been submitted (partially or fully) for the award of any other degree or diploma.

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ABSTRACT

Introduction: The aim of this study was to evaluate the fracture resistance of teeth filled with 4 different endodontic sealers.

Methods: Hundred single rooted extracted mandibular premolars were decoronated to a length of 11 mm. The teeth were randomly divided into 6 groups (n = 20 for each group). In group1A, the teeth were left unprepared and unfilled (negative control), and in group 1B, the teeth were left unobturated (positive control). The rest of the roots were prepared by using the ProTaper System up to a master apical file size of F3.In group 2, Epoxy resin based sealer (AHPlus) + gutta-percha; In group 3, mineral trioxide aggregate–based sealer (MTAFill apex) + guttapercha; In group 4, Calcium phosphate cement based sealer (Chitra-CPC)+guttapercha and in group 5,Bioceramic based sealer(Endosequence BC) +guttapercha .All root specimens were stored for 2 weeks at 100% humidity to allow the complete setting of the sealers. Each specimen was then subjected to fracture testing by using a universal testing machine at a crosshead speed of 1.0 mm/min until the root fractured. The force required to fracture each specimen was recorded, and the data were analysed statistically.

Results: The fracture values of groups 4 and 5 (Chitra-CPC and Endosequence BC Sealer) were significantly higher than those of group 2 and 3($P < .05$). There was no significant difference between groups 4 and 5 ($P > .05$).

Conclusions: In contrast to MTA Fill apex and AH Plus,Chitra-CPC and Endosequence BC increased the force to fracture in root-filled single-rooted premolar teeth.

CONTENTS

INTRODUCTION

An endodontically treated tooth is weaker and more prone to fracture than vital teeth[1]. 11%– 13% of extracted teeth with endodontic treatment are associated with vertical root fractures rendering it the second most frequent identifiable reason for loss of root-filled teeth [2, 3]. There are several factors that affect the strength of endodontically treated tooth including loss of tooth structure because of caries or trauma, access cavity preparation, dehydration of dentin, overzealous instrumentation and irrigation of the root canal, excess pressure during root obturation, and preparation of intra-radicular post space [4, 5]. These factors interact cumulatively to influence tooth loading and distribution of stresses, ultimately increasing the possibility of catastrophic failure.

The most commonly used root canal filling material is gutta-percha in combination with sealer but the low elastic modulus of gutta-percha presents little or no capacity to reinforce roots after treatment [6, 7]. The ability of the present day sealer to bond to radicular dentin is advantageous in maintaining the integrity of the sealer-dentin interface during mechanical stresses, thus increasing resistance to fracture. The sealers used had shortcomings in that a fluid-tight seal along the dentinal walls was not routinely achieved and the adhesive strength between endodontic sealers, dentin, and Guttapercha was shown to be very weak [8, 9]. Therefore, the use of a root canal sealer possessing an additional quality of strengthening the root against fracture would be of obvious value[10]. New root canal obturation materials and sealers have been developed in an attempt to provide all of the favourable properties.

Growing interest in reinforcing the root canal system has led to the development of adhesive root canal sealers. It is thought that adhesion and mechanical interlocking between the material and root canal dentin will strengthen the remaining tooth structure, and thus reduce fracture risk[11]. The accepted technique is to obturate the root canal space using a solid or semi-solid material along with a sealer to obtain a fluid tight seal, occupying the interstitial spaces, foraminae, as well as accessory and lateral canals [12, 13, 14]. Guttapercha has been the standard obturation material used in root canal therapy[15]. One of the disadvantages of Guttapercha as a root canal obturation material is that it does not bond or adhere to the dentinal walls of the root canal resulting in an incomplete obliteration of root canal space [15, 16]. Differences in the adhesive properties of sealers to dentin may be expected for several reasons, including differences of root dentin between specimens, or even in different sites of the same root, the presence or absence of smear layer, and the sealer's chemical composition and interaction with dentin [17, 18].

Bio-ceramic materials have been seen as the dawn of a new era in dentistry. Although used mainly for dental implants and coatings for implants, their introduction into endodontics as mineralising materials has brought about enormous productive changes. The applications vary from their use for Pulp Capping, to apexogenesis, apexification, and furcation repair[19]. Bio-ceramics are biocompatible ceramic materials. They include alumina and zirconia, bioactive glass, glass ceramics, calcium silicates, hydroxyapatite and resorbable calcium phosphates, and radiotherapy glasses. The physical properties associated with bio-ceramics are very attractive to dentistry;absolute biocompatibility, osseo conductivity, ability to achieve excellent hermetic seal, formation of chemical bond with the tooth structure, insolubility in tissue fluids, good radio-opacity and easy handling characteristics have led to the widespread use of these materials in the area of endodontic science[19].

A new Bio Ceramic sealer Endosequence BC sealer (Brasseler, USA), has recently been introduced to the market. It is a premixed bioceramic endodontic sealer According to the manufacturer's description, it is a convenient, ready-to-use injectable white hydraulic cement paste developed for permanent root canal filling and sealing applications. Also, it is an insoluble, radiopaque, and aluminium-free material which requires the presence of water to set and harden[20].

Epoxyresin-based dental materials (AH Plus) have been proposed to be excellent agents to reinforce an endodontically treated tooth through the use of adhesive sealers in the root canal system.[11] However, despite several advantages exhibited by bonding agents and resins studied to date, they had problems in working properties (hydrophobic nature), radio-opacity and lack of re-treatability when used for endodontic purposes.[21, 22]

MTA Fillapex is the first MTA based salicylate resin sealer. It is a bioceramic type of sealer that can readily set in presence of moisture and is able to cause cementogenesis and thus helps in repair of apical tissue.[23] As it is known that MTA does not bond to dentin, the presence of resins in Fillapex sealer increases the flow properties, and the presence of MTA would cause interfacial deposition of hydroxyapatite, which would increase the frictional resistance of the obturating material.[24] However, MTA has certain drawbacks like difficulty in handling, degradation of type 1 collagen and alteration of micro hardness of dentin .[25]

Calcium phosphate based Bioceramic sealers are emerging as promising candidates in endodontics because of their superior biocompatibility features. They also satisfy most of the requirements for an ideal sealer.[12,14] These materials are modified forms of self-setting calcium phosphate cements (CPC) that contain inorganic calcium and phosphate minerals, which upon wetting with an aqueous solution get converted to hydroxyapatite. Biomedical Technology Wing of Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram have introduced a new calcium phosphate cement based root canal filling material (Chitra –CPC) which is supplied in the form of powder and liquid. The optimum wetting ratio is 0.8 ml of liquid per gram powder.[26]

It can be used for inducing hard tissue formation, pulp capping, apical barrier formation, and apexification and as regenerative scaffold. [27, 28]. Calcium phosphate based sealers have been found to be less cytotoxic than AH Plus[29], AH 26 and Zinc Oxide Eugenol (ZOE) sealers and have the potential to promote bone regeneration.[30] Various studies have showed that the bonding of endodontic sealers to inter-radicular dentin after obturation enhance the resistance to fracture of endodontically treated teeth.[31]Hence, the concept of bonded sealers used in conjunction with core filling material has been established to improve the fracture resistance.

Many root canal obturating systems are available to clinicians, yet no consensus exists regarding the superiority of any one in root canal obturation. Hence, the present study was undertaken with the objectives to evaluate fracture resistance of indigenously prepared CPC sealer (Chitra- CPC) with other proven bioceramic sealers like Endosequence BC sealer (Brasseler USA), MTA based-MTA Fillapex (Angelus) and Epoxy Resin-based sealer AH plus (DENTSPLY).

TABLE 1

Endodontic sealer	Composition	Manufacturer
Endosequence BC	Zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, filler and thickening agents.	Brasseler USA (Savannah, GA)
Chitra-CPC	Powder: tetra- calcium phosphate (TTCP) and dicalcium phosphate dihydrate (DCPD) in equimolar ratio Liquid: solution of disodium hydrogen phosphate in distilled water (Na2HPO4, in 0.2M concentration).	SCTIMST, Trivandrum
MTA Fillapex	MTA, salicylate resin, natural resin, bismuth oxide and silica	Angelus
AH Plus	Paste A: bisphenol- A and F as epoxy resin, calcium tungstate, zirconium oxide, silica and iron oxide pigments. Paste B: amine paste contains dibenzyldiamine,aminoadmantace, tricyclodecane – diamine, calcium tungstate, zirconium oxide, silica and silicone oil.	Dentsply,Maillefer, Switzerland

AIMS & OBJECTIVES

The purpose of this study was

- To assess the fracture resistance of root canals obturated with single-cone gutta-percha using AH Plus, MTA Fillapex, BC Sealer and CPC Sealer under Universal testing machine.

REVIEW OF LITERATURE

Kirsten et al (2012)[32] investigated the mutagenicity of resin‑based endodontic sealer(1 epoxy resin–based endodontic sealer(AH Plus Jet) and 2 methacrylate-based endodontic sealers (EndoRez and Real Seal) and Calcicur, a Ca(OH)2-based sealer by evaluating their potential to induce DNA double‑strand breaks (DSBs) on extrusion into the periapical tissue. The gH2AX immuno fluorescence assay was used to microscopically detect DNA DSBs. They found that there were no indications for increased risk of genotoxicity of resin‑based root canal sealers caused by the induction of DNA DSBs.

Velugu et al (2016) [33] evaluated the fracture resistance of endodontically treated teeth obturated using lateral compaction technique with AH plus/Gutta‑percha, Resilon/RealSeal self‑etch (SE), and Endofill/Gutta‑percha using universal testing machine.Their study demonstrated higher fracture resistance values for Resilon/RealSeal SE than AH plus/Gutta‑percha, followed by Endofill/ Gutta‑percha.

Kaplan et al (1999)[34] investigated the antimicrobial effects of endodontic sealers (Apexit Vivadent), Endion(voco Germany), AH‑26(Dentsply), AH‑Plus (Dentsply), Procosol (Star dental,USA), and Ketac Endo(Espe Germany) at 2,20, and 40 days interval against Candida albicans, Staphylococcus aureus, Streptococcus mutans on agar plates and colony forming units were counted. They found out that AH Plus produced slight inhibition on streptococcus mutans at 20 days and on Actinomyces Israeli at every time interval but no effect was found on Candida albicans and Staphylococcus aureus.

Wadhwani and Gurung et al (2000)[35] evaluated the fracture resistance of root canals filled with Resilon and Epiphany(Pentron Clinical Technologies LLC, Wallingford), gutta-percha and AH plus(Dentsply DeTrey, Konstanz, Germany), gutta-percha with Endomethasone sealer using Instron Machine .They concluded that all materials significantly increased the fracture toughness of the instrumented roots after obturation

Pecora et al (2001) [36] compared the effect of Er:YAG laser(KaVo Key laser II, Warthausen, Germany at 2.25 W potency; 11 mm focal distance; 4 Hz frequency; 200mJ energy; 62 J total energy; 313 mean impulse) application and EDTAC on the adhesion of epoxy resin-based endodontic sealers -AH Plus(De Trey-Dentsply, Konstanz, Germany) ,Topseal (Dentsply-Maillefer) , Sealer 26 (Dentsply,Petrópolis, RJ, Brazil), AH 26 (Dentsply, Konstanz, Germany), and Sealer Plus (Dentsply, Petrópolis, RJ, Brazil) to human dentin. The adhesion was measured with a Universal testing machine. The results showed that the dentin treated with Er:YAG laser showed an adhesion of 4 MPa for AH Plus to dentin than EDTAC .

Ungor et al (2006)[37] compared the pushout bond strength of the resin-based Epiphany–Resilon root canal filling system, and AH Plus, gutta-percha using universal testing machine. They revealed that (Epiphany + gutta-percha) had significantly greater bonding strength than all the other groups. (AH Plus + gutta-percha) had significantly greater bonding strength than AH Plus + Resilon.

Emel , Uzunoglu et al (2015)[38] evaluated the effect of temperatures(220 C and 37oC) of QMix (Dentsply Tulsa Dental, Tulsa, OK, USA) and EDTA on the bond-strength of AH Plus (Dentsply DeTrey, Konstanz, Germany) . The QMix and 17% EDTA solutions that were at room temperature were heated by using a heating cup that had a digital temperature display (Oushiba, OB-009 280 mL, Guangdong, China).The specimens from each group were observed under scanning electron microscopic (QuantaTM 450 FEG, FEI,Oregon, USA) to evaluate smear layer removal after final irrigation procedures. Remaining roots were obturated and prepared for a push-out test using Instron Universal Testing Machine.They found that temperature of the final irrigant does affect the bond strength values of AH plus to root dentin irrigated with EDTA. Bond strength of AH Plus sealer to root canal dentin may improve with QMix.

Girish et al (2013)[39] compared the sealing ability of polymethylmethacrylate (PMMA) bone cement and Chitra Calcium phosphate cement (CPC-Chitra) with MTA when used as root end filling material using Rhodamine B dye and confocal laser scanning microscope .The study showed that PMMA bone cement was a better material than CPC-Chitra as root end filling material to prevent apical microleakage and MTA still continued to be a gold standard root end filling material showing minimum microleakage.

Jacob et al (2014)[29] histopathologically evaluated the periapical tissue reaction to Chitra-CPC as a root canal sealer/filler material in comparison with a resin sealer, AH Plus (Dentsply) at 1 month and 3 months interval .They found out that in the 1-month time period, CPC showed mild to moderate periapical tissue reaction but in the 3-month time period, the slides of CPC showed an absence of inflammation to mild inflammatory reaction in the periapical area than AH Plus.

Ratnakumari and Thomas B (2012)[40]evaluated the efficacy of Chitra-CPC as a pulpotomy agent in comparison with formocresol, through histopathologic responses of pulpal tissues of human deciduous teeth. The results did not reveal statistically significant difference between the two groups. But Chitra-CPC gave more favourable results, in respect of pulpal inflammation, dentin bridge formation, quality of dentin bridge and connective tissue in dentin bridge.

Nanjappa et al (2015) [41] compared the sealing ability of mineral trioxide aggregate (MTA), Biodentine, and Chitra-calcium phosphate cement (CPC) as root-end filling material using confocal laser scanning microscope and Rhodamine B dye. They evaluated the effect of ultrasonic retro prep tip and an erbium: yttrium aluminium garnet (Er:YAG) laser on the integrity of three different root-end filling materials and the result showed Root-end cavities prepared with Er:YAG laser and restored with Biodentine showed superior sealing ability compared to those prepared with ultrasonics.

Abad et al (2010)[42] compared the sealing ability of bone cement, mineral trioxide aggregate and calcium phosphate cement(CPC – Chitra) as furcation perforation repair material using stereomicroscope on extracted mandibular molars. They observed MTA showed minimum microleakage (mean 54.5%), calcium phosphate cement showed maximum microleakage (100%), and bone cement showed moderate microleakage (87.8%).

Gomes-Filho et al(2011)[43] evaluated the rat subcutaneous tissue reaction to implanted polyethylene tubes filled with MTA Fillapex , MTA-Angelus and Sealapex including their ability to stimulate mineralization at 7th 15th , 30th and 90th day. They found that all materials caused moderate reactions after 7 days, which decreased with time. The reactions were moderate and similar to that evoked by the control and Sealapex on the 15th day. MTA Fillapex and Angelus MTA caused mild reactions beginning after 15 days and concluded that MTA Fillapex was biocompatible and stimulated mineralization.

Sagsen et al(2011)[44] compared the push-out bond strength of an epoxy-based root canal sealer AH Plus (Dentsply DeTrey GmbH, Konstanz, Germany), with two new calcium silicate-based root canal sealers, I Root SP and MTA Fillapex, to root canal dentine of extracted teeth using Universal testing machine. They observed that IRoot SP and AH Plus had significantly higher bond strength values than the MTA Fillapex.

Mandava et al (2014)[24] assessed the influence of AH plus (Dentsply, Germany), MetaSEAL (Parkell, USA) and MTA Fillapex (Angeles, Brazil) sealers on the fracture resistance of endodontically treated teeth using universal testing machine. They concluded that MTA Fillapex as a root canal sealer was not able to reinforce the tooth against fracture.

Morgental et al.(2011)[45] evaluated the effect of two MTA-based root canal sealers (Endo CPM Sealer and MTA Fillapex) against E. faecalis by two different methods: the Agar Diffusion Test and the Direct Contact Test before and after setting, respectively. White MTA and Endofill were used as references for comparison. The pH values were also recorded and correlated to the antibacterial activity results. They concluded that MTA Fillapex and Endofill had an antibacterial effect against E. faecalis before setting, but none of the sealers maintained antibacterial activity after setting, despite the high pH of the MTA-based materials.

Bin et al (2012)[46] studied the cytotoxicity and genotoxicity of MTA canal sealer (Fillapex) compared with white MTA cement ((MTA Branco;Angelus) and AH Plus(Dentsply) , and found that white MTA group was the less cytotoxic material in this study. The Cytotoxicity and genotoxicity was evaluated by methol-thiazol-diphenyl tetrazolium assay in spectrophotometer and the micronucleus formation assay respectively. Both AH Plus and Fillapex MTA sealer showed the lowest cell viability rates and caused an increased micronucleus formation.

Hatibovic‑Kofman et al(2008)[47] studied the effect of two endodontic materials; Calcium hydroxide (Ultradent–UltraCal XS, South Jordan, UT, USA) and ProRoot MTA system (Dentsply, Woodbridge, ON, Canada) on the fracture strength of root dentin after apexification treatment for different length of time(2 weeks, 2 months, and 1 year) using Instron Universal testing machine. They also histologically evaluated the degradation of dentin organic matrix at different time period and concluded that MTA treated teeth after the initial decrease in fracture strengths reverse the process, and the strength increased between 2 months and 1 year as MTA induced the expression of TIMP-2 in the dentin matrix.

Nikhil, Jha, and Suri (2016) [48] studied in vitro, the apical sealing ability of MTA combined with either distilled water or 2% chlorhexidine solution, in simulated immature teeth, using glucose penetration, fluid filtration, and dye penetration methods. They found that MTA mixed with chlorhexidine showed superior sealing as compared to MTA mixed with distilled water with exception of glucose penetration test, in which MTA mixed with distilled water showed better results.

Mestieri et al (2015) [49]in an invitro study evaluated the biocompatibility and bioactivity of MTA Plus (Avalon Biomed Inc., USA) and MTA Fillapex (Angelus Industry Dental Products S/A, Londrina, PR, Brazil) in primary culture of human dental pulp cells (hDPCs).They observed that MTAP showed more biocompatibility and bioactivity in the primary culture of cells from human dental pulp but MTAF showed initial cytotoxicity.

Kuga et al (2013)[50] evaluated pH , calcium release and antibacterial activity of MTA Fillapex sealer(Angelus, Brazil) compared to AH Plus(Dentsply De Trey, Konstanz, Germany) and Sealapex (Kerr and Sybron .USA) sealers. The pH and calcium release by endodontic sealers evaluated after 24 hours, 14 and 28 days by using pH Metre and atomic absorption spectrophotometer (AA6800, Shimadzu, Tokyo, Japan) respectively. The sealers antibacterial activity was evaluated against Enterococcus faecalis and Staphylococcus aureus by means of agar diffusion test. They concluded that pH values and calcium release provided by MTA Fillapex were lower than provided by Sealapex and higher than provided by AH Plus and its antibacterial action was similar to other endodontic sealers.

Mirhadi H et al. (2016) [51] in an invitro study evaluated and compared the effect of alkaline pH on the sealing ability of calcium-enriched mixture (CEM (BioniqueDent; Tehran, Iran) and mineral trioxide aggregate (MTA (Angelus; Londrina, Paraná, Brazil) apical plugs. The leakage was assessed by using the fluid filtration technique at 1, 7, 14, 30 days intervals. They observed that alkaline pH had no adverse effect on the sealing ability of MTA and CEM cement used as apical plugs and CEM cement had better sealing ability in alkaline pH.

Pawar , Pujar and Makandar (2014) [52] compared and evaluated the apical sealing ability of Endosequence BC Sealer (Brasseler, Savannah, USA)and two commonly used sealers - AH plus(Dentsply, De Trey Konstanz, Germany)and Epiphany sealer_ Real Seal SE (SybronEndo, Korea) on extracted human single rooted permanent teeth . The microleakage was examined using dye penetration method under stereomicroscope (Magnus) at 30X magnification at 2, 4 and 6 mm from the apex. They suggested that Endodontic-BC sealer and Epiphany sealer sealed the root canal better compared to AH plus Sealer.

Arora et al (2015) [53] in an invitro study compared the fracture resistance of roots obturated with three hydrophilic systems - novel CPoint system, Resilon/ Epiphany system, and EndoSequence BC sealer; and one hydrophobic gold standard gutta-percha/AHPlus system using universal testing machine . They concluded that hydrophilic systems showed higher fracture resistance than hydrophobic systems; among the hydrophilic systems C Point system and EndoSequence BC sealer had the highest fracture resistance.

Zhang et al (2009)[54] studied the antibacterial activity of 7 endodontic sealers AH Plus (Dentsply International Inc, York, PA), Apexit Plus (Vivadent Schaan, Liechtenstein) iRoot SP, Tubli Seal (SybronEndo Corporation, Orange, CA), Seal apex (Sybron Endo Corporation, Orange, CA), Epiphany SE (Pentron Clinical Technologies LLC, Wallingford, CT), and EndoRez (Ultradent, South Jordan, UT) against Enterococcus faecalis using Direct Contact Test 20 minutes after mixing (fresh samples) and 1, 3, and 7 days after mixing (set samples). They concluded that fresh iRoot SP, AH Plus, and EndoRez killed E. faecalis effectively.IRoot SP and EndoRez continued to be effective for 3 and 7 days after mixing. Sealapex and EndoRez were the only ones with antimicrobial activity even at7 days after mixing.

Loushine et al (2011)[55] investigated the setting time and micohardness of a premixed calcium phosphate silicate–based sealer (EndoSequence BC Sealer; Brasseler USA, Savannah, GA) in the presence of different moisture contents (0–9 wt%) and also evaluated the in vitro cytotoxicity of the sealer with an epoxy resin–based sealer.They observed BC Sealer required at least168 hours to reach the final setting using the Gilmore needle method, and its microhardeness significantly declined when water was included in the sealer.The cytotoxicity of AH Plus gradually decreased and became noncytotoxic, whereas BC Sealer remained moderately cytotoxic over the 6-week period. Further studies are required to evaluate the correlation between the length of setting time of BC Sealer and its degree of cytotoxicity.

Hess et al(2011)[56] evaluated the efficacy of solvent and rotary instrumentation in the removal of Bioceramic sealer when used in combination with gutta-percha (GP) as compared with AH Plus sealer (Dentsply, Tulsa, OK). Canals were retreated using heat, chloroform, rotary instruments, and hand files. The ability to regain the WL and patency were evaluated as well as the time required to remove obturation material via scanning electron microscopy. The result showed that conventional retreatment techniques were not able to fully remove Bioceramic sealer.

Candeiro et al (2012)[57] compared the physicochemical properties(Radiopacity, pH, release of calcium ions (Ca2+), and flow) of Endosequence BC Sealer with AH Plus cement. The radiopacity value was determined according to radiographic density (mm Al). The flow test was performed using a digital caliper. The release of Ca2+ and pH were measured at periods of 3, 24, 72, 168, and 240 hours with spectrophotometer and pH meter, respectively. They observed the bioceramic endodontic cement showed radiopacity (3.84 mm Al) significantly lower than that of AH Plus (6.90 mm Al). The pH analysis showed that Endosequence BC Sealer showed pH and release of Ca2+ greater than those of AH Plus ($P < .05$) during the experimental periods. The flow test revealed that BC Sealer and AH Plus presented flow of 26.96 mm and 21.17 mm, respectively ($P < .05$) and they concluded that Endosequence –BC sealer have exhibited favourable values for a root canal sealer.

Tuncel , Nagas , Cehreli , Uyanik , Vallittu ,and Lassila (2015)[58] in an in vitro study evaluated the effect of 17%Ethylenediamine tetra acetic acid (EDTA) (Pulp dent Corporation, Watertown, MA), 9% etidronic acid (Zschimmer & Schwarz Mohsdorf GmbH & Co. KG, Burgstädt, Germany), and 1% peracetic acid (PAA) (Sigma-Aldrich, Steinheim, Germany) chelating solutions on the bond strength of iRoot SP((Innovative BioCeramix Inc. Vancouver, Canada) and a resin-based root canal sealer (AH Plus(Dentsply DeTrey GmbH, Konstanz,Germany) to radicular dentin. The canal openings were sealed with Cavit™-G (3M ESPE, GmbH, Seefeld, Germany) and the push out bond strength was tested by using Universal Testing machine. They concluded that the tested chelating solutions do not improve the bond strength of AH Plus and iRoot SP to the radicular dentin.

Gade et al (2015) [59] evaluated the push-out bond strength of Endosequence BC sealer(Brasseler USA, Savannah, GA) with lateral condensation and thermoplasticized technique (Calamus obturating delivery system (DENTSPLY Tulsa Dental, Tulsa, OK) and comparing it with AH Plus sealer

(Dentsply DeTrey GmbH, Konstanz, Germany) and Endomethasone N sealer (Septodont). The shear bond strength was then tested with micro push-out technique by using universal testing machine (Star testing System, 248).They concluded that AH Plus sealer along with cold lateral condensation showed the highest bond strength than Endosequence BC sealer (P<0.05) but the push-out bond strength of Endosequence sealer was higher than AH Plus when thermoplasticized technique was used. (P < 0.05).

Madhuri et al. (2016)[60] compared the bond strength of four different endodontic sealers to root dentin, that is, Bioceramic sealer (Endosequence Brasseler, Savannah, GA, USA), MTA-based sealer (MTA Fill apex ,Angelus, Londrina, Brazil) epoxy resin-based sealer (MM-Seal ,Micro Mega, France)), and dual cure resin-based sealer (Hybrid Root Sealer, Mitsui Chemicals, New Delhi, India)) using universal testing machine at a speed of 0.5 mm/ min until deboning occurred. They concluded that the push-out bond strength of Bioceramic sealer was highest followed by resin-based sealer and lowest bond strength was observed in MTA-based sealer.

Kumar et al. (2016)[61] compared the push-out bond strength of the smart seal C-point obturating system (EndoTechnologies, LLC, Shrewsbury, MA, USA) with epiphany resilon obturation system (Pentron Clinical Technologies, Wallingford, CT) and the gold standard gutta-percha/AH plus system using universal testing machine .They concluded that C-point/bioceramic sealer showed the highest pushout bond strength followed by gutta-percha/AH plus and epiphany/Resilon.

Shokouhinejad et al. (2012)[62] compared push-out bond strength of EndoSequence BC sealer (Brasseler USA, Savannah, GA), used with gutta-percha in the presence or absence of phosphate-buffered saline solution (PBS) within the root canals for 7 days and 2 months. The push- out bond strength was evaluated using universal testing machine. In this in vitro study, they found that the presence of PBS within the root canals increased the bond strength of gutta-percha in combination with the EndoSequence BC sealer at 1 week. However, no difference was found between the bond strength of this obturation material in the presence and absence of PBS in the root canals at 2 months.

Zhang et al (2009)[84] compared the apical sealing ability of root canals of human anterior single rooted teeth that were prepared by ProTpaer files and obturated with two different sealers AH plus with continuous wave condensation technique and iRootSP sealer with either continuous wave or single cone technique. Evaluation was done by fluid filtration method at 24 hours, 1,4 and 8 weeks and apical leakage was qualitatively assessed by Scanning Electron Microscopy (SEM). It was concluded that there was no significant difference between the groups and iRootSP was equivalent to AH plus sealer in apical sealing ability thus suggesting that iRootSP could be a suitable cement paste for use in single-cone filling technique.

Borges et al (2011)[85] compared the changes in the surface structure and elemental distribution, as well as the percentage of ion release, of four calcium silicatecontaining endodontic materials : iRootSP, MTA Fillapex, Sealapex and MTA Angelus with a well-established epoxy resin based sealer AH plus, submitted to a solubility test in deionized water by using atomic absorption spectrophotometry. It was found that AH Plus and MTA-A were in accordance with ANSI/ADA's requirements regarding solubility whilst iRoot SP, MTA Fillapex and Sealapex did not fulfil ANSI/ADA's protocols. High levels of Ca2+ ion release were observed in all materials except AH Plus.

MATERIALS & METHODS

MATERIALS:

SAMPLES:

- Freshly extracted mandibular premolars were stored in physiological normal saline.

IRRIGANTS:

- Sodium Hypochlorite 3% **(Novo Dental Products PVT LTD, Mumbai)**
- Ethylene diamine tetra acetic acid - EDTA 17% **(DenoR , DenSMEAR, Red Gold Mines Bangalore)**
- Saline **(0.9% NS- 5OO ml, Claris Otsuka, Ahamedabad)**

OBTURATION:

- AH Plus. **(Dentsply,Switzerland)**
- Endosequence BC sealer. **(Brasseler,Savannah, USA).**
- Chitra-CPC root filling material. **(Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram)**
- MTA-FILLAPEX. **(Angelus)**
- ProTaper Gutta Percha cones – Size F3 **(Dentsply Maillefer; Ballaigues, Switzerland)**
- **Cavit (3M ESPE, Seefeld,Germany)**

ARMAMENTARIUM:

- Ultrasonic Scaler **(Satelec, Acteon Groups, U.K)**
- Diamond Saw
- Diamond Round Burs **(Mani, Japan)**
- Size 10, 15 – K Files **(Mani, Japan)**
- 5 ml Disposable syringe **(Dispovan, Hindusthan Syringes and Medical Device Faridabad, India)**
- ProTaper rotary files sizes - SX, S1, S2, F1, F2, F3 **(Dentsply Maillefer; Ballaigues, Switzerland)**
- X Smart EndoMotor **(DENTSPLY Maillefer; Ballaigues, Switzerland)**
- ProTaper paper points **(Dentsply Maillefer; Ballaigues Switzerland)**
- Aluminium foil
- Lentulo Spirals **(Dentsply Maillefer; Ballaigues, Switzerland)**
- Contra-angled Micromotor Hand Piece **(NSK, Japan)**
- Tweezers **(GDC)**
- Mixing pad, Spatula
- Hand Pluggers **(Dispodent, Chennai, India)**
- GP Condenser (**Dispodent, Chennai, India)**

METHODS:

Teeth Selection

Hundred freshly extracted human single canal mandibular premolar with a root length of at least 11 mm were collected from the Oral and Maxillofacial Surgery Department of Sri Ramakrishna Dental College and Hospital, Coimbatore and stored in physiological saline. Soft tissue remnants and calculus in the teeth were removed. They were confirmed by digital radiograph (RVG, Gendex) from buccal, lingual and proximal views to ensure that they had single canals. Teeth with immature apices, those that had undergone root canal treatment, or those that had root caries or restorations, two root canals, fractures, resorption and calcified canals were excluded from the study.

TOOTH PREPARATION:

All the teeth specimens were decoronated using a double sided diamond coated disc, to adjust the remaining root length to a standardized length of 11 mm. The bucco-lingual and mesio distal diameter of the coronal planes were measured with the help of Vernier callipers and standardized to 5-7 mm. **(Fig: 1)** In all the specimens, access openings were prepared using #4 round bur and working length was determined by placing a No 10 K file (Mani) in to the root canal, until it was just visible at the apical foramen. The length of the instrument was measured and one millimetre subtracted from it to establish the working length (11 mm). Ninety teeth were instrumented to a master apical file size of F3 using crown down technique with

ProTaper rotary instruments by using a 16:1 reduction hand piece with a torque controlled and speed controlled electric motor (X Smart DENTSPLY, Maillefer, Ballagigues, Switzerland)).The speed and torque values were set as recommended by the manufacturer.

Copious root canal irrigation using 5ml of 3 % sodium hypochlorite solution using a syringe and 27 gauge needle was performed after each instrumentation. Final flush with 5ml of 17% EDTA was done in order to remove the smear layer for 1-2 minutes. This was followed by a final irrigation with 5ml of 0.9% Normal saline. Each of the root canal specimens were dried with sterile Protaper paper points.

Ten teeth were randomly selected to serve as a negative control (Group 1A) and ten teeth were selected to serve as positive control (group 1B). The remaining eighty teeth were then obturated with sealer by using the matched single-cone technique.

All the 100 specimens were randomly allocated into 6 experimental groups

Group 1 A: Negative control group - Roots were neither instrumented nor obturated. (n=10)

Group 1B: Positive control group – Roots were not obturated. (n=10)

Group 2: Roots were obturated using gutta-percha and AHplus sealer (n=20).

Group 3: Roots were obturated using gutta-percha and MTA Fill apex (n=20).

Group 4: Roots were obturated using gutta-percha and Chitra - CPC root filling material (n=20).

Group 5: Roots were obturated using gutta-percha and Endosequence BC Sealer (n=20).

OBTURATION OF ROOT CANALS:

In Groups 2 and 3, sealers were mixed according to the manufactures instructions and coated in the root canals using a lentulo spiral (DENTSPLY Maillefer) placed in low speed hand piece. Lentulo spiral was introduced into the root canal to a location 2 to 3 mm short of the working length and then slowly withdrawn from the canal, with continuous rotation. For standardization, lentulospiral was used for ten seconds only in all the canals. Obturation was completed by placing sealer-coated single cone gutta-percha points (ProTaper -F3) (Dentsply Maillefer).

In Group 4. Sealer was mixed according to the manufacturer instruction to get an injectable paste form which was loaded in the syringe. The syringe was then placed in to the canal 3mm short of the working length .The cone was coated with the sealer and was placed in to the canal.**(Fig:6)**

In Group 5: BC sealer packaged in a pre-loaded syringe with disposable intra canal tips were placed in the root canal and it was deposited by compressing the plunger of the syringe **(Fig: 8)** Sealer was coated with master guttapercha and slowly introduced into the canal there by carrying sufficient sealer to the apex .The roots of this group were obturated with guttapercha.

For all the experimental root samples, post-obturation radiographs were taken in both labio-lingual and mesio-distal directions to ensure homogeneous adequate root filling without voids. After root filling, the coronal 1 mm of the filling materials was removed, and the spaces were filled with a temporary filling material (Cavit; 3M ESPE, Seefeld, Germany). The teeth were stored at 37^0C in 100% humidity for 14 days to allow the sealers to set. **(Fig: 9)**

MECHANICAL TESTING:

The root surface of the samples were wrapped around by an aluminium foil to simulate the periodontal ligament [63]. All the roots were then mounted vertically in copper blocks (4cm height, 3cm length and 2 cm width) and filled with self-curing acrylic resin (Imicryl, Konya, Turkey), exposing 7 mm of the coronal parts of the roots.**(Fig :10)** As soon as the acrylic hardened, blocks were removed from the copper blocks . A universal testing machine (Instron Corp, Canton, MA) was used for the strength test **(Fig: 11).** The acrylic blocks were placed on the lower plate of the machine. The upper plate consisted of a spherical steel tip with a diameter of 3mm. The tip was centred over the canal orifice, and slowly increasing vertical force was exerted (1 mm/min) until fracture occurred. **(FIG: 12)** The fracture moment was determined when a sudden drop in force occurred that was observed on the testing machine display. The maximum force required to fracture each specimen was recorded in Newtons. The data thus obtained was recorded, tabulated and subject to statistical evaluation. Analysis of variance was used to analyse the difference between various test groups. It was seen that there was a statistically significant difference within the groups (P = 0.001). Hence the further analysis was done using Tukey's Post-Hoc Test.

Fig: 1 MANDIBULAR PREMOLARS AFTER DECORONATION AT CEMENTOENAMEL JUNCTION

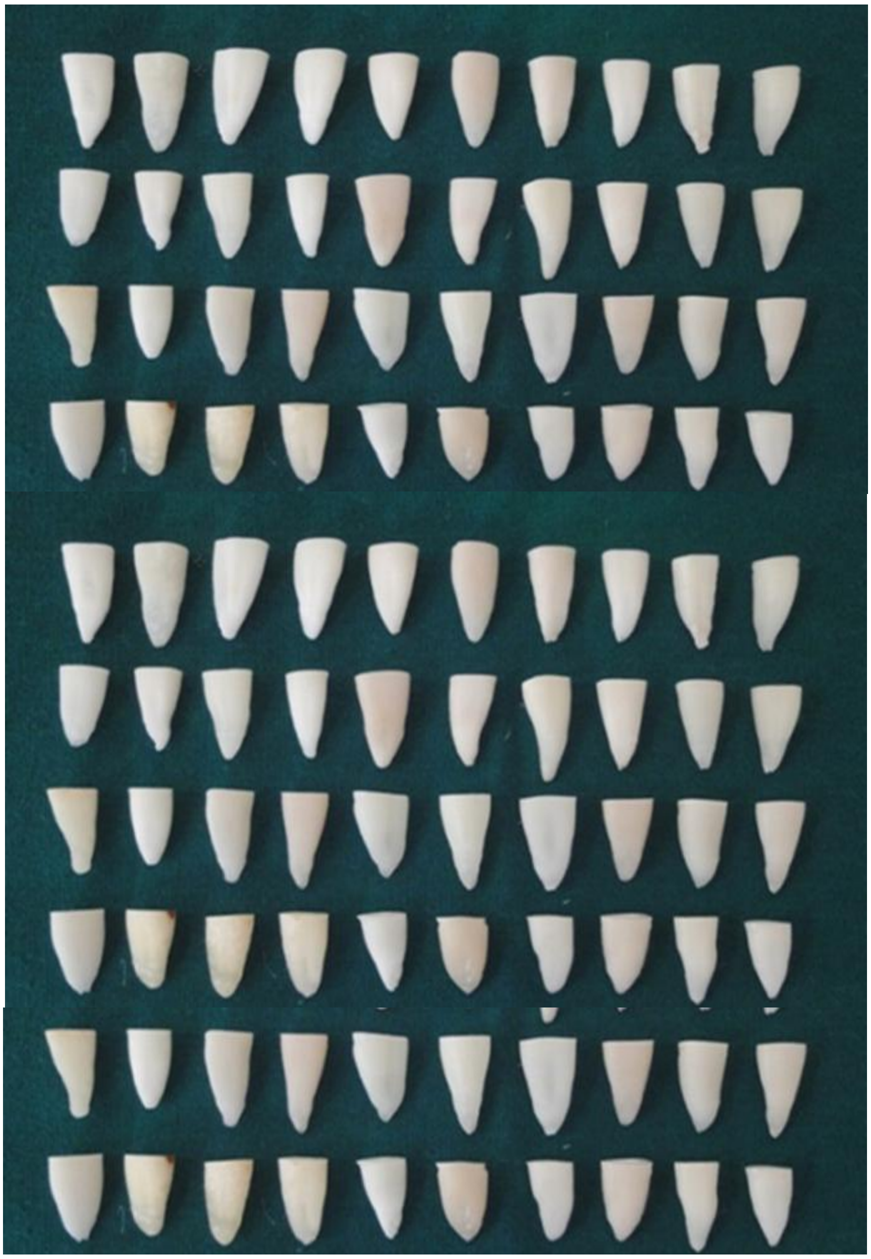


FIG: 2 MATERIALS USED FOR THE STUDY

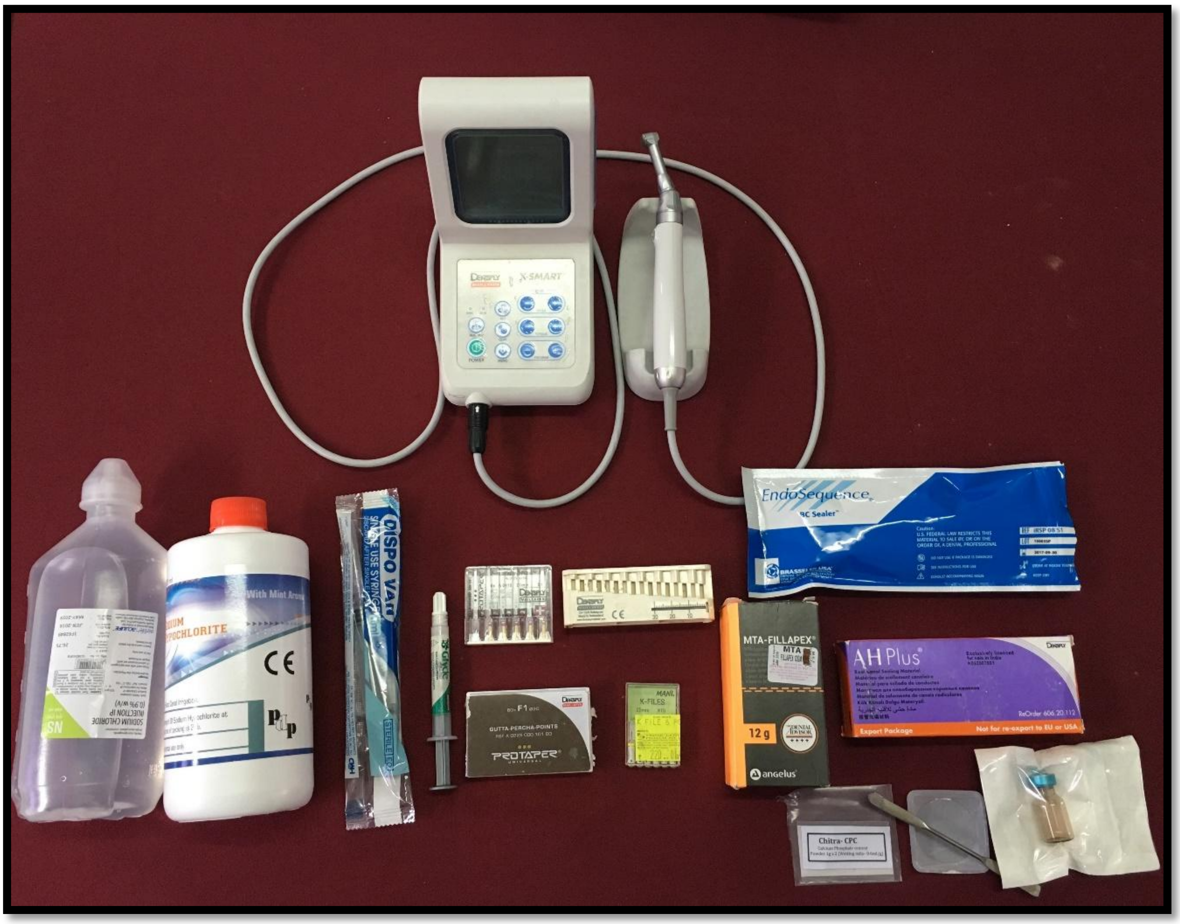


FIG: 3 AH PLUS SEALER WITH BASE AND CATALYST PASTE AND MIXING PAD

FIG: 4 MTA-FILLAPEX SEALER WITH BASE AND CATALYST PASTE AND MIXING PAD

FIG 5: CHITRA-CPC SEALER POWDER AND LIQUID ALONG WITH MIXING PAD, SPATULA AND INJECTION TIP

FIG: 6 CHITRA-CPC BEING INJECTED IN TO THE ROOT CANAL

FIG: 7 ENDOSEQUENCE BC SEALER IN PREMIXED SYRINGE ALONG WITH INJECTING TIP

FIG: 8 ENDOSEQUENCE BC SEALER BEING INJECTED INTO THE CANAL

FIG: 9 SAMPLES PLACED IN HUMIDITY CHAMBER FOR A PERIOD OF 1 WEEK TO ALLOW COMPLETE SETTING OF THE SEALERS

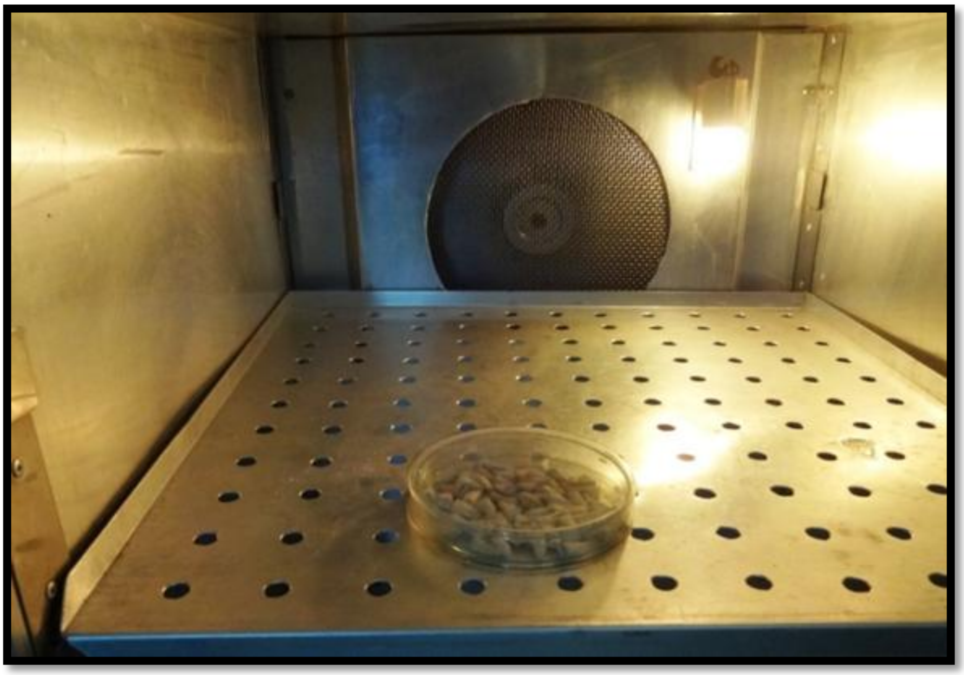


FIG: 10 TEETH MOUNTED IN ACRYLIC BLOCK FOR FRACTURE TESTING

FIG: 11 TEETH SAMPLE MOUNTED ON UNIVERSAL TESTING MACHINE FOR FRACTURE TESTING

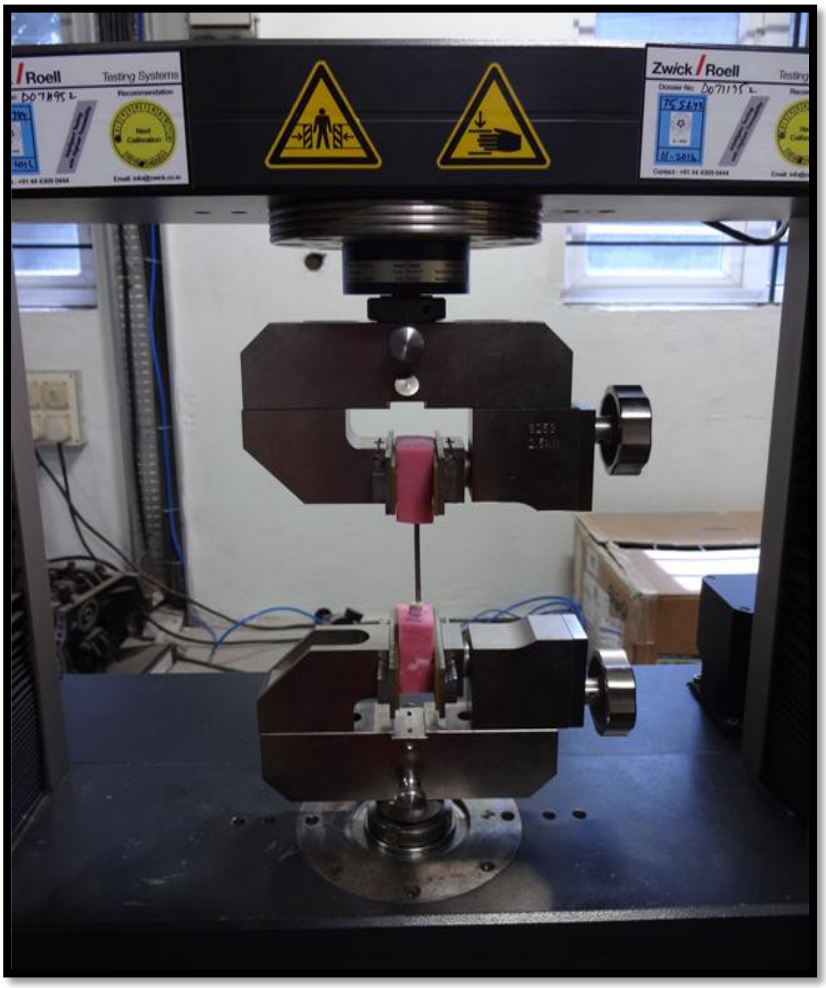


FIG: 12 TEETH SPECIMENS SHOWING FRACTURE IN THE LABIL LLINGUAL DIRECTION

RESULTS

The mean values and their respective standard deviations of the force required to fracture the roots are presented in Table2. The strongest mean force required to fracture the roots was seen in the negative control group (teeth left unprepared) whereas the weakest force required was seen in the positive control group (teeth prepared and unobturated).

In the present study, the mean fracture resistance using Universal testing machine was found to be highest in the negative control group (428.44+/-151.70), which was comparable to the mean fracture resistance of Chitra-CPC (391.60+/-77.19) and Endosequence-BC Sealer (361.84+/-73.04). However, the MTA Fill apex (287+/- 68.99) and AH Plus (299.93+/-63.27) showed lower fracture resistance.

In Comparison to the positive control, Chitra-CPC showed the highest fracture resistance followed by Endosequence-BC sealer, AH plus and MTA Fill apex. When compared to the positive control all groups were showing highest fracture which was highly significant. (P value 0.001). However MTA Fill apex showed the least fracture resistance among all the groups. The other groups were marginally stronger than the positive control.

In Comparison to the negative control, there was no statistically significant difference between Chitra-CPC and Endosequence –BC sealer as far as the fracture resistance is concerned. However MTA Fill apex and AH Plus were significantly weaker compared to the negative control, and the positive control being the weakest. (Table 3)

On comparing the fracture resistance between the 4 groups of sealants, the variability in the mean difference of fracture resistance was not statistically significant. Though Chitra –CPC showed a higher difference in fracture resistance compared to MTA Fill apex which was statistically significant. (Table 4)

To summarise,

- Chitra-CPC and Endosequence-BC sealer have comparable fracture resistance to negative control.
- Chitra-CPC had significantly high fracture resistance compared to positive control.
- AH Plus sealer showed higher fracture resistance than MTA Fillapex but lower than Chitra-CPC and Enosequence BC Sealer.
- MTA Fill apex showed the least fracture resistance and had statistically significant lower fracture resistance compared to negative control and almost significantly lower fracture resistance compared to Chitra -CPC

TABLE: 2 MEAN, STANDARD DEVIATION, MINIMUM AND MAXIMUM VALUES OF EACH GROUP.

GROUPS	***n***	***MEAN***	***STD. DEVIATION***	***MINIMUM N***	***MAXIMUM N***
NEGATIVE CONTROL	10	428.44	151.70	230.42	600.84
POSITIVECONTROL	10	243.29	55.08	185.83	317.09
Chitra-CPC	20	391.60	77.14	299.60	549.34
Endosequence BC	20	361.84	73.04	229.52	462.83
MTA Fillapex	20	287.63	68.99	206.07	424.29
AHPlus	20	299.93	63.27	235.66	396.71

TABLE: 3 DIFFERENCE BETWEEN THE STUDY GROUPS USING ANOVA TEST

GROUPS	*N*	*MEAN*	df	F	P value
NEGATIVE CONTROL	10	428.44	5	4.936	0.001
POSITIVECONTROL	10	243.29			
Chitra-CPC	20	391.60			
Endosequence BC	20	361.84			
MTA Fillapex	20	287.63			
AH Plus	20	299.93			

P<0.05 – Statistically Significant

Analysis of variance was used to analyse the difference between various test groups. It was seen that there was a statistically significant difference within the groups (P = 0.001). Hence the further analysis was done using Tukey's Post-Hoc Test. (Tukey's Post-Hoc test to analyse the difference between the groups.) (TABLE 4)

TABLE 4: MULTIPLE COMPARISONS

GROUPS	COMPARISION	MEAN DIFFERENCE	P VALUE
NEGATIVE CONTROL	POSITIVECON TROL	185.15*	**.009**
	CPC	36.84	.959
	BIO	66.60	.659
	MTA	140.81*	**.029**
	AH+	128.51*	**.048**
GROUPS	**COMPARISION**	**MEAN DIFFERENCE**	**P VALUE**
POSITIVE CONTROL	CPC	-148.31*	**.019**
	BIO	-118.55	.097
	MTA	-44.34	.913
	AH+	-56.64	.791
GROUPS	**COMPARISION**	**MEAN DIFFERENCE**	**P VALUE**
CPC	BIO	29.75	.961
	MTA	103.96	**.042**
	AH+	91.66	.132
GROUPS	**COMPARISION**	**MEAN DIFFERENCE**	**P VALUE**
BIO	MTA	74.20	.325
	AH+	61.90	.526
GROUPS	**COMPARISION**	**MEAN DIFFERENCE**	**P VALUE**
MTA	AH+	12.30	.999

$P<0.05$ – STATISTICALLY SIGNIFICANT

Tukey's post hoc analyses shows that there is statistically significant difference between the values of negative control and positive control, MTA and AH+ with p values 0.009, 0.029 and 0.048 respectively.

Apart from that there was also statistically significant difference between positive control and CPC with p value of 0.019.

FIG: 13 DISTRIBUTION OF MEAN VALUES OF DIFFERENT GROUPS.

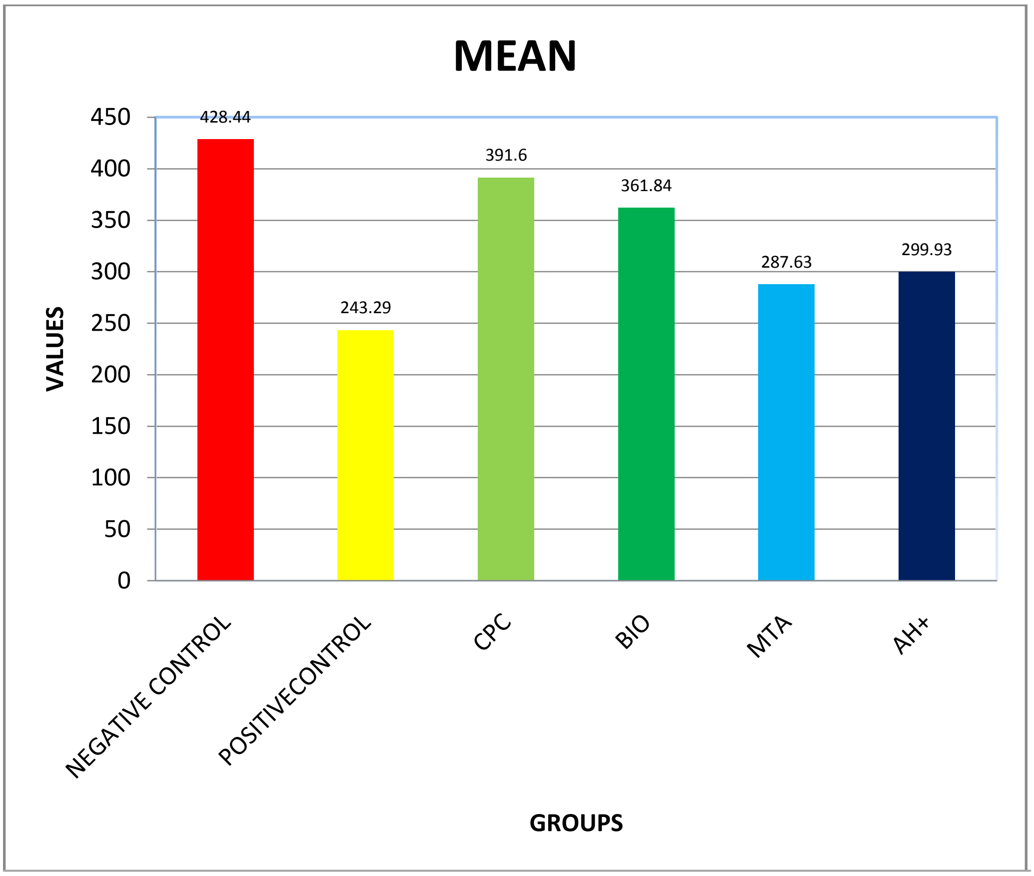
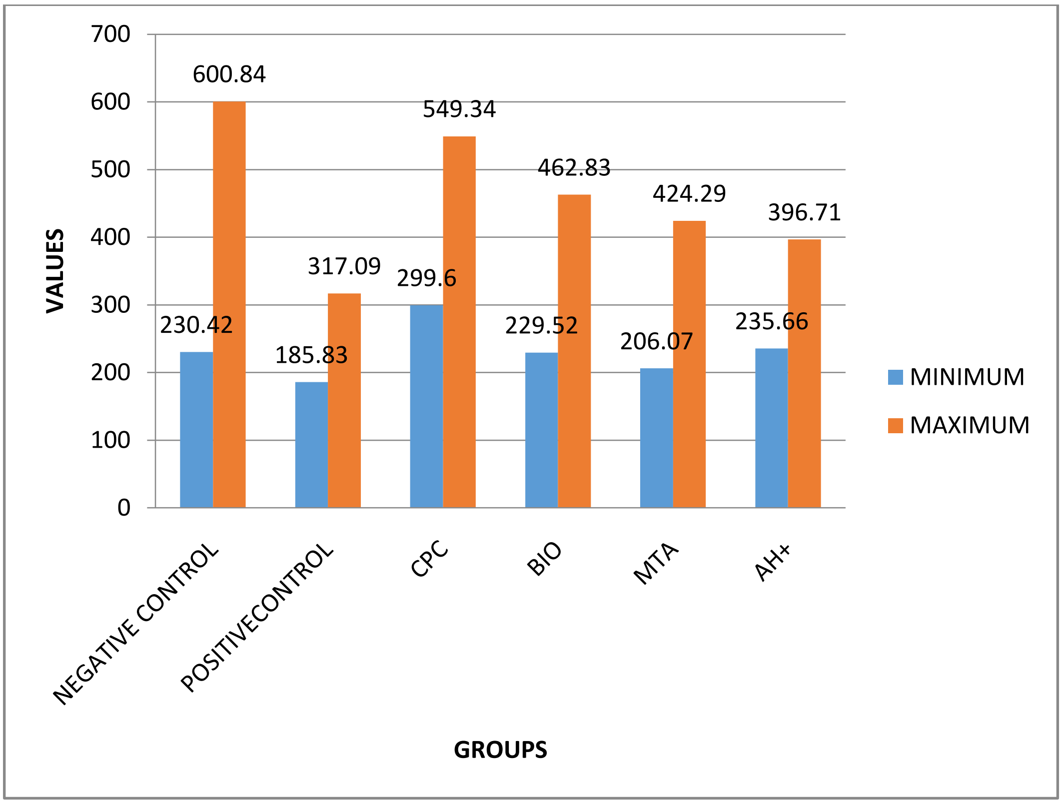


FIG:14 MINIMUM AND MAXIMUM VALUES IN EACH GROUPS



DISCUSSION

Root canal instrumentation is an essential stage in endodontic treatment. There is a cognizance that endodontic treatment weakens the tooth structure and predisposes teeth to fracture. **Zandbiglari et al** and **Schafer et al** demonstrated that 'Enlarged but unfilled roots are significantly weaker than filled roots, thus more susceptible to fracture.'[67]

Reinforcement of the remaining tooth structure after endodontic procedures is an important extension of root canal therapy [11]. Most root canal filling methods use a root canal sealer as a complementary part of the obturation technique. The root canal sealer fills the gaps between gutta-percha cones and the walls of the root canal and also fills the voids between individual gutta-percha cones applied during obturation of the root canal system [64]. Some studies have claimed the ability of different root canal filling materials to significantly strengthen the roots[65], where as in other reports these materials did not increase the fracture resistance of root filled teeth [66]. However, recent studies have suggested that sealers can adhere to the root canal dentin surface and strengthen the remaining tooth structure, thereby contributing to the long-term success of an endodontically treated tooth [67, 68].

Previous researchers showed that epoxy resin–based sealers (AH plus sealer) had higher mechanical adhesion to root canal dentin and deeper penetration into dentinal tubules than zinc oxide-eugenol–based and glass ionomer–based sealers [69, 70]. As a result of the benefits of epoxy resin–based sealers, resistance to fracture would increase. **Cobankara et al** reported that sealers exhibiting chemical bonding (Endosequence BC sealer, Brasseler, USA) enhances the fracture resistance of teeth[71].

Recent researchers have considered Endosequence BC sealer (Brasseler, USA) and AH plus sealer (epoxy resin based sealer) as “Gold Standard” for sealers because of their potential to adhere to the dentin. According to **Topcuoglu et al** teeth obturated with chemically bonding Endosequence BC sealer (Brasseler, USA) by using single cone technique showed significantly higher fracture resistance than AH plus sealer.[72]

In the present study, we intended to find out the fracture resistance of roots sealed with indigenously prepared Chitra-CPC root filling material in comparison with AH Plus sealer, Endosequence-BC Sealer and MTA Fill apex, by using single cone technique.

AH Plus is an epoxy based endodontic sealer that is used with gutta percha. It has good adhesion to dentin and to gutta percha. **Neto and Mamootil et al** in their study showed that epoxy resin–based sealers had higher adhesion to root canal dentin and deeper penetration into dentinal tubules than zinc oxide-eugenol–based and glass ionomer–based sealers [69, 70].

Bioceramic-based materials have been recently introduced in endodontics, mainly as repair cement and as root canal sealer. Studies have showed that bioceramics have enhanced biocompatibility, result in the increased strength of the root after obturation, have a high pH during the setting process (which is strongly antibacterial pH12), are easy to use, (particle size is so small it can be used in a syringe and they set quickly (three to four hours). Bioceramic root canal sealers also exhibit chemical bonding to root canal dentin walls. Therefore, EndoSequence BC Sealer (Bioceramic Sealer), which is based on a calcium silicate composition, has the potential to adhere chemically to dentin decreasing the marginal leakage and gaps and increased fracture resistance of teeth.[20]

MTA Fillapex is the first MTA based salicylate resin sealer. It has suitable physiochemical properties such as good radiopacity, flow and alkaline pH. It has a working time of 35 minutes.[23] It is a bioceramic type of sealer that is compatible with moisture and tissue fluids. It can readily set in presence of moisture and is able to cause cementogenesis and thus helps in repair of apical tissue and is biocompatible.[73]

Calcium phosphate cement (CPC) based sealers are emerging as promising candidates in endodontics because of their superior biocompatibility features. It is an example for bioresorbable material (that upon placement within the human body starts to dissolve (resorb) and slowly be replaced by advancing tissue (such as bone). [74]They also satisfy most of the requirements for an ideal sealer.[12, 13] The past two decades saw numerous attempts to manufacture a calcium phosphate sealer suited for its use in endodontic therapy and tested with focus on the development of a non-mutagenic, non-carcinogenic, and an overall tissue-friendly material.

In this study we have used a novel indigenous formulation of CPC: ‘Chitra-CPC’ which has been developed at the Biomedical Wing of Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Thiruvananthapuram. These materials are modified forms of self-setting calcium phosphate cements (CPC) that contain inorganic calcium and phosphate minerals (tetra- calcium phosphate (TTCP) and dicalcium phosphate dihydrate (DCPD) in equimolar ratio) which upon wetting with an aqueous solution (disodium hydrogen phosphate in distilled water) get converted to hydroxyapatite[28].

The cement has been tested for safety and efficacy and approved for human clinical use by the Institutional Ethics Committee of Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Thiruvananthapuram[75]. Compared to conventional CPC it has enhanced viscous and cohesive properties. Chitra-CPC could be mixed in varying consistencies, from moldable putty to injectable paste. This flexibility provides immense advantage in clinical application as a bone and dentine substitute and root filling material [28, 75, 26]. Besides this, it has a neutral pH during setting, is highly adaptable and adheres to the root canal surface. [76]It is also dimensionally stable, easy to handle and has the property of osteotransductivity (i.e., active resorption at bony sites, facilitating bone remodelling).[77]

In the present in vitro study, results revealed that the negative control group (group1A) has highest fracture resistance values (600.84 N) and the positive control group (group 1B), the lowest (317.09N). Statistically significant higher fracture resistance was offered by the indigenously prepared CPC formulation Chitra – CPC (549 N) and Endosequence BC sealer (462 N), which was comparable to the negative control and highly significant than the positive control, followed by AH Plus sealer (424 N). MTA Fill apex showed the least fracture resistance (361 N) in comparison with the negative control.

The mean fracture resistance of Chitra-CPC in the current study was higher (549 N) than the mean fracture resistance of Endosequence BC sealer (457.61 N) as reported by **Topcuoglu et al**[72], AH Plus (248.36 N) as reported by **Khanet al**[78] and MTA Fillapex (261.47 N) as reported by **Mandava et al**[24]. Therefore the mean fracture resistance with Chitra-CPC in our study was favourable and higher compared to mean fracture resistance of various other sealants.

Singh et al [79] tested the performance of Chitra –CPC as a repair material and evaluated the microleakage by using dye penetration method and showed favourable result for this material. The high fracture resistance offered by Chitra-CPC could be due to the formation of submicron-sized particles of hydroxyapatite, inter-grown to form a homogeneous mass during cement setting as stated by **Komath et al**[26].However no studies have been done so far to compare the fracture resistance of this material, longevity in the root canal and sealer penetration in to the dentinal tubules.

In contrast to our study, **Celikten et al** [80] and **Jainaen et al**[81] demonstrated low fracture resistance for teeth obturated with Endosequence BC sealer, and AH Plus sealer respectively. According to **Celikten et al,** [80] the reduced fracture resistance offered by Endosequence BC sealer could be due to the reduced moisture in the dentinal tubule required for the setting of sealer. **Jainaen et al**[81] stated that reduced fracture resistance of AH Plus was due to the reduced compressive and tensile strength of AH Plus in comparison with dentine.

Hatibovic and **Kofman et al** [47]assessed the fracture resistance of root dentine in open apex cases for longer duration and they demonstrated an increase in fracture resistance; however in closed apex cases MTA showed a reduction in fracture resistance [26] which was similar to our study. Various Studies have showed that fracture resistance of teeth obturated with MTA Fill apex was low probably due to lack of bonding of MTA to the dentin. [15] These results are similar to our study result with MTA Fill apex

Researchers have analysed and concluded that single circular canals have lower and more uniform stress distribution than oval canals in which greater stresses are present at the labial and lingual canal extensions and at the cervical and middle thirds. [9] In all of the premolar samples used in the present study, had a circular cross-section, which would have resulted in uniform distribution of load and also simulated the clinical situation where chewing forces are maximum.

Some studies have suggested that lateral condensation creates stresses in the root during obturation, which could lead to subsequent fracture. Single cone Obturation technique is a simple and time efficient technique which has become popular after the advent of NiTi rotary instruments. **Ersev et al** [82] reported that the group in which AH Plus was used with the matched taper single-cone technique showed significantly higher fracture resistance than the instrumented but not obturated roots. The major advantage of using single cone obturation technique is that it forms a uniform mass in combination with endodontic sealers thereby preventing failures observed among multiple cones as in cold lateral condensation technique[63]. In the present study, a single-cone obturation technique was used because it excluded both the excessive dentin removal required to facilitate the plugger's insertion during vertical compaction and the wedging forces of the spreaders during lateral compaction. In the present study aluminium foil and acrylic resin blocks were used to simulate the periodontal ligament and alveolar bone and a single load to fracture was applied vertically as in many other studies that evaluated the effect of root canal sealers on the fracture resistance of root filled teeth.

In summary, the results from the present invitro study shows that both indigenously prepared, cost effective Chitra-CPC and Endosequence –BC sealer have improved the fracture resistance of endodontic ally treated teeth. However, there are limited independent publications about the properties and applications of Chitra- CPC root canal sealers in endodontics. Further invivo studies will throw light into the clinical application of this promising material in future endodontics.

SUMMARY AND CONCLUSION

This in vitro study aimed to evaluate the fracture resistance of roots obturated with single-cone gutta-percha using Chitra-CPC root filling material, AH Plus, MTA Fill apex, Endosequence-BC sealer under Universal testing machine.

Hundred mandibular premolars with single canal were collected and decoronated at cementoenamel junction (CEJ). Cleaning and shaping was done with Protaper **(Dentsply Maillefer; Ballaigues, Switzerland)** up to size F3 using 3% Sodium Hypochlorite as irrigant, EDTA as lubricant and saline for final rinse. Teeth were randomly divided into 6 groups; 20 in each group (Group 2-Group 5) and 10 in Group 1 A and Group 1B.

Group 1 A: Negative control group - Roots were neither instrumented nor obturated.(n=10)

Group 1B: Positive control group – Roots were not obturated. (n=10)

Group 2: Roots were obturated using gutta-percha and AHplus sealer (n=20).

Group 3: Roots were obturated using gutta-percha and MTA Fill apex (n=20).

Group 4: Roots were obturated using gutta-percha and Chitra - CPC root filling material (n=20).

Group 5: Roots were obturated using gutta-percha and Endosequence BC Seale (n=20).

The samples were then mounted in acrylic blocks and tested in a Universal testing machine for testing the fracture at a cross head speed of 1mm/min until fracture occurred. The maximum force required to fracture each specimen was recorded in newtons.

The data thus obtained was recorded, tabulated and subject to statistical evaluation. Analysis of variance was used to analyse the difference between various test groups. It was seen that there was a statistically significant difference within the groups (P = 0.001). Hence the further analysis was done using Tukey's Post-Hoc Test.

The results showed that

- Chitra-CPC showed the highest fracture resistance values.
- Enosequence BC Sealer showed intermediate value between Chitra - CPC and AH Plus sealer.
- AH Plus sealer showed higher fracture resistance than MTA Fillapex but lower than Chitra-CPC and Enosequence BC Sealer.
- MTA Fill apex showed the least fracture resistance values.

Within the limitations of this study we conclude that that both indigenously prepared, cost effective Chitra-CPC and Endosequence –BC sealer have improved the fracture resistance of endodontically treated teeth. Although little is known about this indigenously prepared CPC sealer (Chitra- CPC) in the dental community, in vivo and invitro studies show calcium phosphate cement as a promising material for pulpotomies, grafting and furcation repair. Further research is necessary to take advantage of the excellent biological properties of this cement under clinical applications. Additional invitro, ex vivo, and invivo research must be conducted to evaluate the performance of this new material and to confirm its use in endodontic therapy and the possibility of retreatment.

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