Original Research Article

A comparative evaluation of fracture resistance of teeth obturated with a novel sealer: Chitra CPC with Endosequence BC sealer, MTA Fillapex and AH Plus

Abstract:

Background: Bonding of sealer to root canal walls is likely to increase the integrity of the sealer-dentin interface during mechanical stresses, thus increasing resistance to fracture. Chitra-CPC sealer is an indigenously manufactured bioceramic material and has been used as bone graft and perforation repair material. When used as a sealer, it has good potential to reinforce the root strength in addition to excellent biocompatibility.

Aim: To compare the fracture resistance of teeth obturated with novel Calcium phosphate cement-based sealer viz. Chitra CPC with Endosequence BC sealer, MTA Fillapex and AH Plus

Methods and Material:

The study was carried out in 100 single rooted extracted, decoronated mandibular premolars of length 11 mm. The teeth were randomly divided into 4 groups (n = 20 for each group). Other than Group 1A and group1B, all other groups were restored with various endodontic sealers and obturated with Gutta Percha. In group1A, the teeth were left unprepared and unfilled (negative control), in group 1B, the teeth were left unobturated (positive control) In group 2, Epoxy resin based sealer (AHPlus) ;In group 3, mineral trioxide aggregate–based sealer (MTAFill apex); In group 4, Calcium phosphate cement based sealer (Chitra-CPC);in group 5,Bioceramic based sealer(Endosequence BC) were used. After 2 weeks all specimens were tested for fracture resistance using 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 was analysed statistically.

Results: The fracture resistance values of Chitra –CPC and Endosequence BC sealer were significantly higher than that of positive control and comparable to negative control.

Conclusions: In contrast to MTA Fill apex and AH Plus, Chitra –CPC and Endosequence BC sealer increased the fracture resistance of teeth.

Key-words: Bioceramic sealer, fracture resistance, Root reinforcement, Root canal therapy,Endodontic Sealer.

Introduction:

11%– 13% of extracted teeth with endodontic treatment are associated with vertical root fractures rendering the second most frequent identifiable reason for loss of root-filled teeth after crown fracture [1,2]. 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. Therefore, the use of a root canal sealer possessing an additional quality of strengthening the root against fracture would be of obvious value [3]. New root canal obturation materials and sealers have been developed in an attempt to provide all of the favorable properties.

Calcium phosphate-based bioceramic sealers are emerging as promising candidates in endodontics because of their superior biocompatibility features. They satisfy most of the requirements for an ideal sealer [4-6]. In an indigenous venture, scientists at the Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Thiruvananthapuram, had developed a novel formulation of CPC [7]. This patented (Indian IPR) formulation, named ‘Chitra-CPC’, has enhanced viscous and cohesive properties than conventional CPC. Chitra-CPC could be mixed in varying consistencies, from mouldable putty to injectable paste. This flexibility provides an immense advantage in clinical application as a bone and dentine substitute [8]. In vitro studies have shown that it is ideal for dentistry in applications like furcation perforation repair, root canal filling/sealing, root apexification and alveolar ridge augmentation, and also as a bone-filler in gaps around oral implants. Chitra-CPC has been tested for safety and efficacy and proved to be safe for human use through toxicological studies [7]. However no studies have been done to test the fracture resistance of this material as a root canal sealer.

These are modified forms of self-setting CPC which is supplied in the form of powder and liquid. The optimum wetting ratio is 0.8 ml of liquid per gram powder that contain inorganic calcium and phosphate minerals (tetra- calcium phosphate (TTCP) and dicalcium phosphate dihydrate (DCPD) of size in the range of 100 μm, in equimolar ratio which upon wetting with an aqueous solution (disodium hydrogen phosphate in distilled water) in an optimized concentration of 0.2 M get converted to hydroxyapatite [7].

Hence, the present study was undertaken with the objective to evaluate fracture resistance of Indigenously prepared –novel CPC sealer (Chitra- CPC) and compared it with other proven bioceramic sealers like Endosequence BC sealer (Brasseler USA), MTA based-MTA Fillapex (Angelus) , and Epoxy Resin-based sealer AH plus (DENTSPLY) .

Methods

Teeth Selection, preparation and obturation

Hundred freshly extracted human single canal mandibular premolars were obtained and stored in physiological saline with patient consent. Preoperative radiographs were taken in the mesiodistal and buccolingual directions to confirm the presence of a single canal without previous root canal treatment, resorptions, or calcifications and immature apices.

All the tooth specimens were decoronated using a double-sided diamond coated disc, to adjust the remaining root length to a standardized length of 11 mm. The buccolingual and mesiodistal diameter of the coronal planes were gauged by means of a digital vernier caliper (Mituoyo-Japan Corp) and standardized to 5-7 mm.[9] Working length was determined 1.0 mm shorter than real root canal length. All the root canals, except those in the negative control group were instrumented with Protaper rotary files up to a master apical file size of F3.

Irrigation was performed with 5 mL 3% NaOCl and the final rinse was done with 5 mL 17% EDTA for 1min, followed by 5 mL of 0.9% Normal saline. Each of the root canal specimens was dried with sterile Protaper paper points and then were randomly assigned into 4 experimental (n = 20/each), positive control (n = 10, instrumented but unfilled), and negative control (n=10 neither instrumented nor obturated) groups. (Table1)

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

Group 1B: Positive control group – Roots were instrumented but 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 manufacturers' instructions and coated in the root canals using a lentulo spiral (DENTSPLY Maillefer) in a low speed hand piece. In Group 4, sealer was mixed according to the manufacturer's instructions 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 GP cone (ProTaper- F3) was coated with the sealer and was placed in to the canal.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

Obturation was completed by placing sealer-coated single cone gutta-percha points (ProTaper Universal-F3; Dentsply Maillefer) into the canals till the apex. The quality of the root canal obturation was confirmed with radiographs. 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 2 weeks to simulate invivo condititions ensured the sealers to set completely. To avoid any operator related variations, all the procedures were performed by a single operator.

Fracture Resistance Testing

The root surface of the samples were wrapped by an aluminium foil to simulate the periodontal ligament [10] .All the roots were then mounted vertically in copper moulds (4cm height, 3cm length and 2 cm width) using self-curing acrylic resin (Imicryl, Konya, Turkey), exposing 7 mm of the coronal parts of the roots . As soon as the acrylic hardened, the blocks were removed from the copper moulds. The acrylic blocks were mounted on a Universal testing machine (Instron, Carton, MA) and the fracture resistance of the tooth samples at a crosshead speed of 1mm/min was tested [Fig:1] . The maximum force required to fracture samples was recorded, tabulated and subjected to statistical evaluation. Analysis of variance was used to analyse the difference between various test groups. As it was observed that there was a statistically significant difference within the groups (P < 0.001), further analysis was done using Tukey's Post-Hoc Test. -

RESULTS

The mean values and their respective standard deviations of the force required to fracture the roots are presented in **Table2.** In the present study, the mean fracture resistance using Universal testing machine was found to be highest in the negative control group (no instrumentation and obturation) (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). The MTA Fill apex (287+/- 68.99) and AH Plus (299.93+/-63.27) showed lower fracture resistance. **(Table2)** .The least fracture resistance was shown by positive control group. (instrumented but not obturated)

When compared to the positive control all groups were showed highest fracture resistace which was highly significant (P value 0.009).However MTA Fill apex showed the least fracture resistance among all the groups .The other groups were marginally stronger than the positive control. **(Table 2)**

DISCUSSION

There is a cognizance that endodontic treatment weakens the tooth structure and predisposes teeth to fracture. However, recent studies have suggested that sealers which can adhere to the root canal dentin surface can strengthen the remaining tooth structure, thereby contributing to the long-term success of an endodontically treated tooth [11].

In order to standardize the samples, roots with similar size, length, and dimensions were used in this study. All the roots were enlarged up to apical diameter size of rotary protaper system- F3 which resulted in a more rounded cross section. This may have a positive effect on distribution of stresses and functional load [12]. In the present study, a single-cone obturation technique was used because it reduced the excessive dentin removal and wedging effect of spreaders [13]. Aluminium foil and acrylic resin blocks were used to simulate the periodontal ligament and alveolar bone [10]. A single load to fracture was applied vertically similar to other studies and evaluated the effect of root canal sealers on the fracture resistance of root filled teeth [14].

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 [15]. Yet, the ability of these materials to reinforce endodontically treated root is reported with some controversy. Some studies have showed lower fracture resistance of roots obturated with bioceramic sealers than unprepared and unfilled teeth; this could be due to the moisture in the dentinal tubules might not be enough for the setting of these materials [16].

Recently, some studies have showed low genotoxicity and bioactivity of bioceramic sealers when compared to AH Plus and MTA [17,18,19]. Calcium phosphate based sealers have already been proved for their bioactivity and low genotoxicity [7,20].

Chitra-CPC is been supplied as a dry powder pouch and a vial with wetting solution, both sterilized. The paste form of Chitra-CPC is fully injectable through a narrow cannula or a delivery needle of 18/19 gauge size [8]. It has a net calcium-to-phosphorous ratio of 1.67, which leads to the formation of hydroxyapatite [Ca10(PO4)6(OH)2] in the set mass. This cement possesses the combination of biocompatibility, osteoconductivity, mouldability and also shows neutral pH during setting [8]. Calcium phosphate based sealers have been found to be less cytotoxic than AH Plus and have the potential to promote bone regeneration [21]

Researchers have tested the performance of Chitra –CPC as furcation repair material, graft material for intraosseous defects and evaluated the sealing ability by dye penetration into the teeth [20,22]. Both studies have showed favorable results for this material. The high performance offered by Chitra-CPC in these studies could be due to the formation of submicron-sized particles of hydroxyapatite, inter-grown to form a homogeneous mass during cement setting [8] . However, no studies have been done so far to compare the fracture resistance of this material as a root canal sealer, longevity in the root canal and sealer penetration in to the dentinal tubules.

In the present invitro study, results revealed that the negative control group (group1A) had 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 followed by AH Plus sealer (424 N); MTA Fill apex showed the least fracture resistance (361 N) among the sealers.

In this study Chitra-CPC sealer reinforced the endodontically treated roots better than the other adhesive sealers. This could be attributed to the ability of the nano particles of the sealer to penetrate the dentinal tubules and achieve chemical adhesion. Bioceramic sealer may induce a chemical bond by hydroxyapatite crystal precipitation from a hydration reaction, which adheres to the dentin. The bioceramic nanoparticles also slightly expand after setting due to the hydrophilic property of the sealer. This phenomenon could make the sealer tags stronger thereby minimizing the microleakage [23].

Few authors have reported similar results with Endosequence BC and AH Plus sealer on root fracture resistance [15, 24]. According to many studies, the fracture resistance of teeth obturated with MTA Fill apex was low, owing to MTA's lack of adhesion to the dentin[25]. These findings were consistent with our research.

On the other hand, researchers have shown that teeth obturated with Endosequence BC sealer have low fracture resistance whereas teeth obturated with MTA Fillapex have higher fracture resistance [16, 26] .The study designs may also be to blame for the variations between the studies. The specimens exposed to force in the previous research were 9mm and 6mm in length, respectively, whereas 7mm roots were exposed to force in this study.

We used single rooted premolars in the study to assess fracture strength.Further studies may be done on other teeth in the arch as their anatomy is different and depth of penetration of sealer may vary.Long term outcomes of the current result in clinical scenario needs evaluation in further studies.

Nevertheless, our study highlights the root reinforcing property of CPC-Chitra, that has showed good biological properties and good osseoconductive properties in other studies [7,8]. Hence this sealer, that has been indigenously manufactured in India, may be considered a viable option for root canal obturation for endodontists.

CONCLUSION

Both Chitra-CPC and Endosequence –BC sealer improved the fracture resistance of endodontically treated teeth. However, there are limited independent publications about the properties and applications of Chitra- CPC as root canal sealer in endodontics. Further in vivo studies will throw light into the clinical application of this promising material in future endodontics.

Consent

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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Fig:1 Sample being tested in Instron Universal Testing Machine .

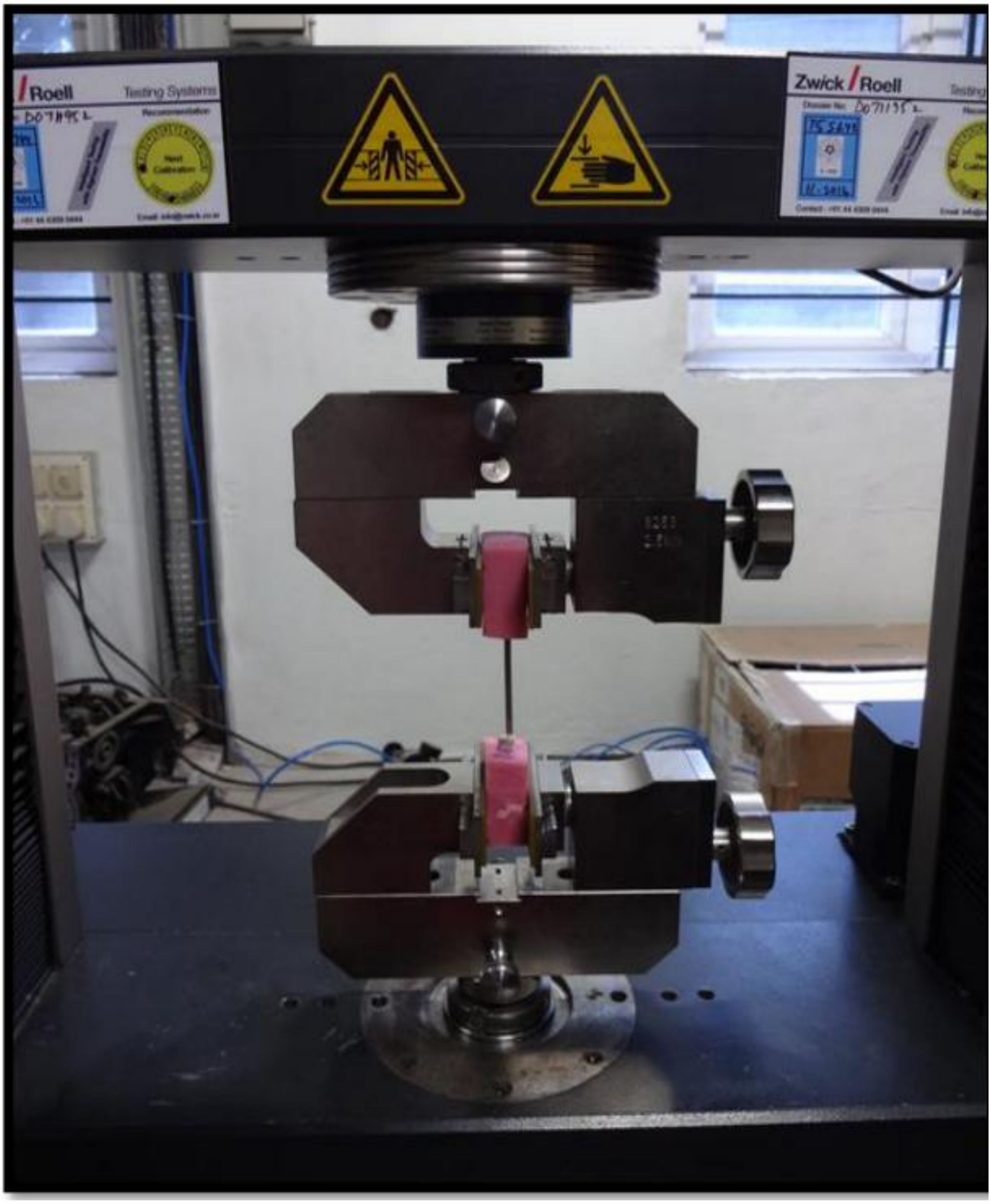

TABLE: 1 MEAN, STANDARD DEVIATION, MINIMUM AND MAXIMUM VALUES OF EACH GROUP.

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
AHPlus	20	299.93	63.27	235.66	424.29
MTA Fillapex	20	287.63	68.99	206.07	396.71

Table 2: Group wise comparative analysis

GROUPS	COMPARISION	MEAN	P VALUE

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

P<0.05 – STATISTICALLY SIGNIFICANT