Comparative Evaluation Of Post Obturation Materials On Reinforcement Of Peri-Cervical Dentin (PCD)-An Invitro Study

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ABSTRACT: Aim: To evaluate invitro the effect of post obturation materials on reinforcement of peri-cervical dentin (PCD) Materials and Method : Sixty extracted, maxillary premolar teeth were selected.After preparation of standardized access, crowns were resected so that a final dimension of 4 mm from one mm below highest point of proximal cervical line was achieved. Then, the enamel was carefully removed.After obturation with gutta percha and AH plus sealer, post obturation protocol was followed: Group 1: Obturation + nRMGIC, Group 2: Obturation + silorane composite , Group 3: obturation + temporary cement and Group 4: No obturation + temporary cement.The specimens were tested for fracture resistace in universal testing machine.Data was analysed with student 't' test and one way ANOVA. Results: Samples restored with nRMGIC and silorane composite presented with higher mean fracture resistance values of 941.20 & 929.17 N respectively when compared to obturated samples with tempoarary (490.50 N) followed by unbturated samples with temporary(396.11N) Conclusion: nRMGIC and silorane composite significantly reinforce PCD.Obturation also plays an important role in reinforcement of PCD.

Keywords: Fracture resistance, monoblock, Pericervical dentin,nanoionomer,Silorane composite

1 INTRODUCTION

Root canal treated teeth are considered to be more apt to fracture than the vital teeth. The greatest incidence of vertical root fractures occur in teeth that have undergone endodontic therapy [1]. High prevalence of vertical root fracture was reported in extracted teeth with endodontic treatment [2,3] rendering it the second most reported cause for loss of root-filled teeth[4.] Dehydration of dentin after endodontic therapy, excessive pressure during obturation and most importantly the removal of tooth structure during endodontic treatment are most common reasons [5,6,7]. The strength of an endodontically treated tooth is related directly to the method of canal preparation and to the amount of remaining tooth structure [8]. A significant weakening of roots with variable taper instruments is also reported by various researchers especially in cervical region of tooth [9,10,11]. On studying the forces responsible for fracture of teeth, the focus has shifted from coronal to the cervical area of the tooth. The dentin in this critical area of tooth called as Peri-Cervical Dentin (PCD) is the dentin near the alveolar crest. While the apex of the root can be amputated, and the coronal third of the clinical crown removed and replaced prosthetically, the dentin near the alveolar crest is irreplaceable. This critical zone, roughly 4 mm above the crestal bone and extending 4 mm apical to crestal bone, is quite important for the strength of the tooth. There are 3 reasons for this: (1) ferrule, (2) fracturing, and (3) dentin tubule orifice proximity from inside to out [12-15]. The research is unequivocal: long term retention of the tooth and resistance to fracturing are directly relational to the amount of PCD. The aforementioned facts clearly indicate that one major goal of endodontic therapy should be reinforcement of the residual tooth structure more importantly PCD. Use of materials with a modulus of elasticity similar to that of dentin [16,17] which is about 14–16 gigapascals[17,18] is ideally needed to reinforce tooth after root canal treatment. The filling materials such as Gutta-percha with low elastic modulus present little or no capacity in reinforcing roots after endodontic treatment [16,19]. Increasing fracture resistance of endodontically treated teeth was not a viable option with the use of bonded sealers [20-22]. Thus, there is a need for different materials and/or techniques to overcome the shortcomings of current endodontic filling materials to reinforce roots. Recently, adhesive materials have been applied to the field of endodontics with a specific focus on reinforcement of this critical portion of tooth i.e PCD. In a study done by Nagas et al, intraorifice barriers were shown to be quite effective in reinforcing the endodontically treated tooth [23]. Though, the authors did not mention PCD but indirectly it was reinforced as per methodology of the experiment. Intracoronal strengthening of PCD is important to protect the endodontically treated teeth against fracture [24-27]. In order to meet the above mentioned requirements, materials which are bonded directly to the tooth structure and strengthen the remaining tooth structure are advocated: Nano-filled Resin modified Glass Ionomer cements (nRMGIC) and Composite resins are amongst them. Composites based on Silorane technology were developed to overcome the shortcomings of conventional composites i.e. polymerization stress and shrinkage without compromising its physical and mechanical properties. Silorane based composites exhibit mechanical properties comparable to methacrylate resin based composites but have less marginal infiltration and better flexural strength [28]. Similarly, developments in the field of resin modified glass ionomer cements have led to the introduction of Nanoionomers (Ketac N100) which combine the benefits of resin modified glass ionomer together with nanofiller technology. Nano-filled RMGIC (nRMGIC) contains fluoroaluminosilicate glass, together with nanomers and nanoclusters as fillers. The primer in it ensures better adhesion of cement to the tooth [29] It is logical to think that the adhesive materials with optimal strength and good bonding ability to dentin can only provide good reinforcement to PCD and thus improve fracture resistance of tooth. There are studies in the scientific literature on coronal reinforcement of tooth structure alone and

only one study on the use of intraorifice reinforcement. But till date, there is no reported research on role of PCD and its reinforcement on fracture resistance of tooth. The present study has scientifically evaluated the effect of adhesive post obturation materials (siloranes and nRMGIC) on reinforcement of Peri cervical Dentin (PCD).

2 MATERIALS AND METHOD

A total of sixty extracted, intact maxillary premolar teeth of similar dimension were selected for this study. In order to standardize, Anatomic crowns were similar in dimension (7±1 mm mesiodistal and 8±1 mm buccolingual diameters) were measured with a digital caliper. Soft tissue deposits and calculus were removed with an ultrasonic scaler. Teeth were stored in 1% chloramine-T solution for 12 hours and transferred to distilled water until use.

Exclusion Criteria was teeth with

- Multiple canals.
- Previous root canal treatment.
- Roots with canal curvature greater than 15%.

All the teeth were examined under a stereomicroscope (Carl Zeiss, Italy) at 10 X magnification to ensure the absence of pre-existing fractures.

2.1 Endodontic access Cavity preparation:

Endodontic access Cavities were prepared with endodontic round bur # 245 and diamond straight fissure instrument were used in a high speed handpiece under constant water cooling. To standardize, a 3.0mm (buccolingual) x 1.0mm (mesiodistal) access cavity was prepared in each specimen for endodontic treatment**.** Crowns were resected so that a final dimension of 4 mm from one mm below highest point of proximal cervical line was achieved. Then, the enamel was carefully removed with a diamond abrasive point from all the surfaces. The working length was determined by placing a 15 K- file into the canal until it was just seen at the apical foramen and then 1mm was subtracted from this length. Root canal therapy was carried out following standardized procedures for all the samples. A size 15 K-file was used to negotiate the root canal. Root canals were then instrumented with protaper files (DENTSPLY, Maillefer, U.S.A.) till F2 (#25). During the process, patency and glide path verification was done with size 10 K- file (DENTSPLY, Maillefer, U.S.A.). During the procedure, 2 ml of 5.25% sodium hypochlorite was used to irrigate the prepared canals after every instrumentation. The root canals received a final irrigation of 5 ml 17% ethylenediaminetetraacetic acid , after which the canals were flushed with 10 ml distilled water to avoid the prolonged effect of EDTA. Root canals so prepared were dried with paper points. Obturation of the prepared root canals was done with single cone technique and AH plus sealer was used. A size 25 protaper cone was inserted into the canal upto working length and checked for the snug-fit (Tug-Back). Sealer was applied in the root canal using lentulospiral at 300 rpm at 2 mm short of working length. Cone was coated with AH plus sealer and inserted into the canal. Excess gutta-percha protruding out of the root canal coronally was seared off with a hot burnisher. The samples were then stored in an incubator at 37°C to allow complete set of the sealer. Obturation material was removed till a depth of 5 mm from cervical line followed by post endodontic restoration till that depth.

Group 1(n=15): Obturation followed by restoration with nano resin modified GIC
Group 2(n=15): Obturation followed by restoration with silorane based composite
Group 3(n=15): Obturation followed by restoration with non adhesive temporary cement (control group)
Group 4(n=15): Unobturated tooth and non adhesive temporary cement (control group)

In group 1, Intracoronal restoration was done using **nRMGIC (Ketac N100)** Cavity was cleaned off to remove any loose particles. Primer was applied using applicator tip to the entire surface of cavity and massage over the entire area for 15 seconds. A gentle stream of air was used to spread primer into a thin even film. It was cured for 10 sec. A cement spatula was used to mix the pastes for 20 sec until a uniform color was achieved and the cavity was restored followed by curing for 40 sec by holding the light tip guide as close as possible to the cavity. In group 2,intracoronal restoration was done using **Silorane based composite (Filtek P90)** Etching was done with 37% phosphoric acid for 30 seconds on enamel and 15 seconds on dentin (split-etch technique) and then rinsed off with water for 10 seconds and a moist cotton pellet was used to remove excess water. Primer is applied using applicator tip to the entire surface of cavity and massage over the entire area for 15 seconds. A gentle stream of air was used to spread primer into a thin even film. It was cured for 10 sec. P90 adhesive bond was applied using applicator tip over the entire surface of the cavity. A gentle stream of air was used to spread bond into a thin even film. It was cured for 10 sec. A suitable metal instrument was chosen to fill the cavity in increments. The thickness of each increment was not exceeding 2 mm. Each increment was cured for 40 sec by holding the light tip guide as close as possible to the cavity. Simulation of Periodontal ligament was done with polysiloxane impression material Thereafter, the specimens were mounted on a universal testing machine A compressive force at a crosshead speed of 1 mm/min was applied to the center of tooth until fracture occurred. The force required to fracture each specimen was recorded in Newton (N) and thereafter stastical analysis was done.

Table 1. Composition of materials used for intracoronal reinforcement of PCD.

POST OBTURATION MATERIALS USED	COMPOSITION
Filtek P90 (silorane based composite)	Combination of monomers of siloxane and oxirane, cyclo 3,4-Epoxycyclohexylethylcyclopolymethyl Siloxanebis-3,4 poxycyclo-hexylethylphenylmethylsilane; silanized quartz; yttriumfluoride (0.01-3.50 µm) – 76% by weight.
Ketac N100 (Nanofilled RMGIC)	nRMGIC contains HEMA (hydroxyethyl-methacrylate) or BIS-GMA (bisphenol-glycidyl methacrylate) fluoroaluminosilicate glass together with nanofillers (5.25nm) and nanoclusters (1.0-1.6µm) – 69% by weight
Cavit-G (Temporary)	Zinc Oxide, Calcium sulphate, 2,2'-[Ethane-1,2 diylbis (oxy) bisethyldiacetate, barium sulphate, zinc sulphate, talc, poly (vinyl acetate)

3 RESULTS

The force required to fracture each specimen was recorded in Newton (N). The data so obtained was tabulated and statistically analysis was done using Student 't' test and One Way ANOVA The mean forces at fracture,the minimal and maximal values and the SD for each group are presented in table 2. According to the unpaired t test,there was significant difference observed between all the groups ($p<0.001$) except groups 1 and 2 There was no significant difference observed between groups 1 and 2. The force required to fracture specimens with adhesive reinforcements (group 1 and 2) was significantly higher than group 3 and 4.Group 4 exhibited least strength**.**

Table 2: Mean and standard deviation values obtained for the samples

Groups	n	Min	Max	Mean	Standard deviation
Group 1 (Obturation & nRMGIC)	15	878	1054	941.20	80.926
Group 2 (Obturation & Composite)	15	865	1061	929.17	81.061
Group 3 (Obturation & temporary)	15	406	585	490.50	48.776
Group 4 (No obturation & temporary)	15	345	460	396.11	41.11

Mean,minimal and maximal forces at fracture values (Newtons) and SD

4 DISCUSSION

Endodontic and restorative procedures have been suggested as precipitating factors for tooth fracture. There is an appreciable loss of tooth structure while preparing an access cavity for endodontic treatment which results in weakening of tooth. In fact, it is generally accepted that the removal of excessive amounts of dentin compromises the survival of root filled teeth and that the strength of endodontically treated teeth is directly related to the amount of remaining sound tooth structure[30]. More recently,the focus is shifting towards preservation of tooth structure in cervical portion of tooth as this portion is considered to be most susceptible to fracture fron occlusal forces.The dentin in this critical portion has been called as pericervical dentin which extends from 4mm above and below the level of alveolar bone [12-15].Clark D and Khademi J (2009) stated that PCD was shown to be a vital structure responsible for strength of tooth [12].Lot of research is being conducted to study strategies to reinforce post endodontic tooth or indirectly PCD but this study is unique as this study was directly conducted to evaluate the effect of reinforcement on PCD.Though ,there are no direct studies to support or disagree with our results,we have indirectly correlated our results with studies on reinforcement of either root specimens or post endodontic access preparation or tooth. This study was conducted presuming to be more clinically relevant as till date no study has been conducted to evaluate the fracture resistance of endodontically treated specimens with reinforced PCD. According to our findings, the instrumented but unfilled samples (Group 4) were weakest amongst all groups. The results were statistically significant ($P<0.05$). Thus, indicating that there is a significant reduction in fracture resistance after endodontic access cavity preparation and instrumentation with rotary system. Reasons for this can be attributed to removal of tooth structure during endodontic procedures and removal of important anatomic structures. Assif D et al (2003) reported that reduction in tooth bulk and loss of sound dentin resulting from tooth preparation causes weakening of teeth [31]. Bassir MM et al (2013) also reported that extensive cavity preparation and endodontic treatment are the most common reasons for tooth fragility [32]. Amongst Group 1 and Group 2, there was no statistically significant difference ($P>0.05$) observed indicating that both nRMGIC and composite have almost same effect on root reinforcement and there is no additional advantage of chemical bonding as theoretically accepted when compared with composite. Most probable reasons for comparatively higher values of Group 1 (nRMGIC) could be attributed to the chemical adhesion between calcium ions in hydroxyapatite dentin crystals and polyalkenoic acid in the material as well as limited demineralization of dentin with subsequent infiltration and mechanical locking [33]. This combined effect of chemical and mechanical bond might have resulted in significantly higher fracture resistance values. This result is in accordance with a similar study by Abd El Halim (2011) [34]. Modulus of elasticity of RMGIC matches to that of dentin. Secondly, the filler loading (69% by weight) with nanofilled particles must have contributed to increase strength values. Similar results were obtained by Gupta SK et al (2012) who reported that higher filler loading in nRMGIC resulted in lower polymerization shrinkage and lower coefficient of thermal expansion, thus improving long term bonding to tooth structure [35]. Similarly, Group 2(silorane composite) showed reinforcement of PCD and the reason could be micromechanical bonding of resin based sealer with the root dentine and chemical bonding with the resin Sealer..Composite significantly reinforce endodontically treated teeth because of its improved mechanical and physical properties as a restorative material comparable to that of intact tooth and more importantly due to formation of micromechanical bond with tooth structure. Hamouda et al (2011) demonstrated that the use of low shrinkage composite restorations significantly strengthen maxillary premolars with MOD preparations under compression loadings [36]. Mittal N et al (2011) reported that the specimens restored with coronal radicular restoration of composites had better fracture resistance than restored with composite resin without coronal radicular extension [37] Comparative slightly lower values for composite as compared to nRMGIC can be attributed to under curing of composite especially in deeper layers close to the obturating material. Secondly,t he lack of chemical adhesion also limits reinforcement to some extent. On comparison of group 3 and 4, it was found that group 3 exhibited higher mean fracture resistance indicating the role of bonded sealer AH plus in reinforcement Secondly.on comparison with groups I and 2 , it was evident that higher values attained were a combined effect of reinforcement by bonded obturation and restorative materials.On comparison of group 4 with groups I and 2 , it was evident that significantly higher values so attained favour the use of these restoratives for reinforcement of PCD. An unobturated tooth with temporisation is quite weak to sustain masticatory forces and needs added reinforcement of mainly PCD for long term favourable prognosis.Morever,Obturation alone with bonded sealer is not enough as a reinforcement to strengthen

PCD and needs to be followed by an adhesive restorative material for post obturation restoration. Though there are some of the limitations that cannot be avoided in invitro studies eg. compositional and structural difference of radicular and coronal dentin which varies amongst individuals, age group and region. In our study, we standardized the access, biomechanical preparations and exposed PCD unlike most of the studies in literature which are based on testing of specimens after removal of coronal portion of teeth for standardization. Under the limitations of the study, it has been concluded that the fracture resistance decreases after access cavity and biomechanical preparations. Adhesive Obturation systems significantly improve the fracture resistance. Further placement of post obturation restorative material also potentiates the reinforcement of PCD.

5 Conclusion

Root canal preparation techniques and non-adhesive post obturation materials significantly decrease the fracture resistance and weaken PCD. Obturation with bonded sealers such as AH plus also provide limited reinforcement Adhesive restorations with nano RMGIC and silorane composite significantly reinforce PCD with nRMGIC slightly better than composite.

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