Effect of Adhesive Obturation and Post Obturation Monoblock Systems on Reinforcement of Peri-Cervical Dentin (PCD)

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Abstract

Aim: To evaluate invitro the effect of adhesive obturation and post obturation monoblock systems on reinforcement of peri-cervical dentin (PCD)

Materials and Method : A total of forty five extracted, intact maxillary premolar teeth were selected.After preparation of standaridized 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 with a diamond abrasive point from all the surfaces.Following obturation, obturation material was removed till a depth of 5 mm from cervical line followed by post endodontic restoration till that depth

Group 1:Activ GP + nRMGIC, Group 2:Real seal + silorane composite and Group 3:No obturation + temporary cement.The specimens were embedded and tested for fracture resistace in universal testing machine.Data was analysed with student t test and one way ANOVA.

Results: Samples restored with Activ GP and nRMGIC ;Realseal and silorane composite presented with higher mean fracture resistance values of 1018.20 & 992.17 N respectively when compared to unrestored samples with tempoarary cement (630.50 N).

Conclusion: Adhesive obturation and post obturation monoblock systems significantly reinforce PCD .

*Keywords***— Activ GP, Fracture resistance, monoblock, Pericervical dentin,Realseal, nanoionomer,Silorane composite**

I. INTRODUCTION

Endodontically treated teeth are widely considered to be more susceptible to fracture than are vital teeth. Bender and Freeland (1983) reported that the greatest incidence of vertical root fractures occur in teeth that have undergone endodontic therapy [1]. Previous clinical studies have shown that 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 [2,3,4]

The reasons most reported have been the dehydration of dentin after endodontic therapy, excessive pressure during obturation and most importantly the removal of tooth structure during endodontic treatment [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]. Furthermore, the advancements in rotary nickel-titanium instruments over the last decade have led to greater apical enlargements and increased canal taper. A significant weakening of roots with variable taper instruments is reported by various researchers especially in cervical region of tooth [9,10,11].

With improved understanding of the forces responsible for fracture of teeth, the focus, now-a-days, 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 sacred. 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.

To reinforce roots, stress concentration at the dentin-material interface should preferably be minimized by using materials with a modulus of elasticity similar to that of dentin, which is about 14–16 gigapascals [16-18]. The low elastic modulus of filling materials such as Gutta-percha presents little or no capacity of reinforcing roots after treatment [16,19]. Nevertheless, the adhesive potential of Gutta-percha to radicular dentin has been shown to be far from satisfactory. Bonding endodontic sealers to obturation materials and radicular dentin is another approach which was not successful in increasing fracture resistance of endodontically treated teeth [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, concepts of adhesive dentistry have been applied to the field of endodontics with a specific focus on obtaining a "MONOBLOCK" in which the core material, sealing agent and the root canal dentine form a single cohesive unit [23]. Based on this monoblock concept, some new obturating materials have come up in the market.

In 2004, Resilon/Epiphany (Pentron Clinical Technologies, Wallingford, CT) was introduced under the name RealSeal (SybronEndo,Orange,CA,USA). It is a dual curing third generation resin based sealer. This system uses a self etching primer and comprises a Resilon cone which is a thermoplastic synthetic material (polycaprolactone) that contains bioactive glass, bismuth oxychloride and barium sulphate to replace guttapercha and conventional sealers. It represents a secondary monoblock system in the root canal where there are two interfaces; one between the sealer and the primed dentine and the other between the sealer and Resilon [24].

In 2007, another adhesive obturating system was introduced commercially known as ActiV GP (Brasseler USA, Savannah GA, USA). It is a root filling system marketed as a monoblock system by using conventional Guttapercha cones that are surface coated with glass ionomer fillers composed of barium aluminosilicate glass powder and polyacrylic acid using a proprietory technique. By doing so, a stiffer Guttapercha cone is achieved that transforms it into a Guttapercha core/cone, enabling it to be functional as both the tapered filling cone and its own carrier core, thus avoiding the need for a separate interior carrier of plastic or metal. It is bonded to root dentine via a glass ionomer sealer creating a ''single cone monoblock obturation [25,26]. It represents a tertiary monoblock system in which there are 3 interfaces between the bonding substrate and bulk material core.

Similar to intracanal strengthening, intracoronal strengthening of teeth is also important to protect the endodontically treated teeth against fracture [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.

Recently, a novel composite based on Silorane was developed to overcome the disadvantages of conventional composites i.e. polymerization stress and shrinkage without compromising its physical and mechanical properties. Silorane based composites are more biocompatible and 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 obturation (Resilon/Epiphany (RealSeal) and ActiV GP) and postobturation (siloranes and nRMGIC) monoblock systems on reinforcement of Peri cervical Dentin (PCD)

II. MATERIALS AND METHOD

aa A total of forty five 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 .

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 2.0mm (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

MATERIALS USED	COMPOSITION
ActiV GP (Cones + Sealer)	ActiV GP core material- Glass ionomer impregnated and coated guttapercha cones. ActiV GP sealer composed of 90% bariumaluminosilicate glass powder and 10% polyacrylic acid
RealSeal (Cones + Sealer)	RealSeal core material - 57% polyester polymer polycaprolactone, 42% bioactive glass and radioopaque fillers. RealSeal sealer mixture of urethane dimethacrylate resin (UDMA); polyethylene glycol dimethacrylate (PEGDMA) ethoxylatedbisphenol-A dimethacrylate, and 2,2-bis[p-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane (Bis-GMA) resins, silane treated barium borosilicate glass, barium sulphate, silica, calcium hydroxide, bismuth oxychloride with amines, peroxide, photoiniator, and pigments
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 (n RMGIC)	nRMGIC contains HEMA (hydroxyethylmethacrylate) 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)

with Hyflex CM till 0.4 taper #30. 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 in groups with different intradicular restorative materialsas shown below. 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) : Activ GP and nRMGIC

Group 2(n=15) : Realseal and silorane based composite

Group 3(n=15) : Unobturated tooth and non adhesive temporary cement (control group)

TABLE I : MATERIALS USED IN THE STUDY

Root canal obturation and restoration in Group 1 (Obturated with ActiV GP)

A size 30, .04 taper ActiV GP 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. ActiV GP cone was coated with ActiV GP 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 for 8hours 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.

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. followed by curing for 40 sec by holding the light tip guide as close as possible to the cavity.

Root canal obturation and restoration in group 2 (Obturated with RealSeal)

A size 30, .04 taper Resilon cone was placed in the prepared canal to appropriate working length and checked for the snug-fit (Tug-back).Epiphany primer was applied with applicator tip as provided by the manufacturer and excess primer was removed with 30, 0.4 tapered absorbent points.

Subsequently, Epiphany sealer was placed into the root canal using lentulospiral at 300 rpm at 2mm short of working length provided by manufacturer. Resilon cone is dipped in resin sealer and inserted into the root canal till working length.

Subsequently, the tip of curing light was placed close to the coronal area to light cure the sealer for 40 seconds to achieve an instant coronal seal. Excess resilon cone was seared off using hot burnisher. Further,Obturation material was removed till a depth of 5 mm from cervical line followed by post endodontic restoration till that depth.

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).The data so obtained was tabulated and statistical analysis was done using student 't' test and one way ANOVA.

III.RESULTS

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 groups 1 and 3 & group 2 and 3 (p<0.001).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 .

TABLE II. TABULATED STASTICAL DATA

Groups	n	Min	Max	Mean	Standard deviation
Group 1 Activ GP & nRMGIC	15	940	1130	1018.2	47.926
Group 2 Realseal & Compsite	15	890	1081	992.17	51.061
Group 3 Unobturated with temporary	15	563	697	630.50	58.776

The mean forces at fracture,the minimal and maximal values and the SD for each group

IV.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 restored using this continuum created by different intraradicular and intracoronal restorative materials based on monoblock concept for reinforcing the tooth.

According to our findings, the instrumented but unfilled samples (Group 3) 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 ActiV GP and RealSeal have almost same effect on root reinforcement and there is no additional advantage of tertiary monoblock in ActiV GP group and chemical bonding is not very effective as theoretically accepted when compared with secondary monoblock (RealSeal group)**.**Most probable reasons for comparatively higher values of Group 1 (ActiV GP + 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. This combined effect of chemical and mechanical bond of ActiV GP might have resulted in significantly higher fracture resistance values. This result is in accordance with a similar study by Fisher MA et al (2007) which showed that bond strength of Activ GP to the canal walls were significantly higher over other obturation systems [23]. In a similar study by Kazadang MK et al (2009), it was observed that reinforcement with ActiV GP and RealSeal (Resilon) was significant when compared with unobturated prepared root [25]. Ghoneim AG et al (2011) reported that ActiV GP sealer used with normal Gutta Percha cone led to lower fracture resistance values as compared to ActiV GP sealer used with ActiV GP cone [33]. Thus presenting a strong case in favour of presence of tertiary monoblock formation as suggested in literature with added reinforcement.

To further enhance the reinforcement,nRMGIC also played a vital role to improve the strength of the samples. This better bonding along with improved properties of material must have led to formation of a continuum starting from the apical part of restoration to the most coronal part resulting in a significant increase of fracture resistance of tooth. The reason attributed for this could be the monoblock created in root canal system extending upto the coronal cavity. The surface coating of Glass Ionomer particles on ActiV GP core material purportedly allows them to be bonded to glass ionomer sealer in the root canal system, thereby improving seal between the root filling material, sealer and the root canal wall. nRMGIC has better chemical bonding to dentin as evidenced 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(RealSeal + silorane composite) showed reinforcement of root dentin and the reason could be micromechanical bonding of resin based sealer with the root dentine and chemical bonding with the resin core material. Thus, leading to formation of secondary monoblock. In a study by Texiria et al (2004), it was reported that groups filled with Resilon cones and Epiphany sealer (RealSeal) were more resistant to fracture than groups filled with AH 26 and gutta percha. They attributed the reinforcing effect of Resilon groups to the 'monoblock' that forms within the root canal [36,37].. In a similar study by Baba SM et al (2010) found that root canals obturated with Resilon/Epiphany resulted in higher fracture resistance to fracture when compared with gutta percha/ AH plus and also with the instrumented but unfilled roots [38]. Another study by Abdo SB et al (2013) reported that roots obturated with Resilon required a higher loading force to fracture compared to those obturated with Gutta percha [39]. Composite used as post obturation restorative material (Group 2) also improved results due to the continuum formation as RealSeal and composite share the similar chemical composition.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 the use of low shrinkage composite restorations significantly strengthen maxillary premolars with MOD preparations under compression loadings [40]. 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 [41]. 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.

V.CONCLUSION

Root canal preparation techniques and non-adhesive post obturation materials significantly decrease the fracture resistance and weaken PCD. Adhesive restorations based on monoblock concept - Activ GP and nRMGIC ; Real seal and silorane composite significantly reinforce PCD .

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