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Fracture resistance of maxillary premolars restored with adhesive intraradicular and intracoronal materias.

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ABSTRACT

Aim To evaluate the fracture resistance of maxillary premolars obturated with different adhesive root filling materials and restored with different adhesive restorative materials.

Methodology 120 extracted maxillary premolars were selected. Standardized access cavities were prepared and root canals were instrumented using rotary files (taper 4%). Samples were divided into 6 groups (n=15): Group 1: ActiV GP (AGP) + Silorane based Composite (Comp), Group 2: ActiV GP + Nano filled Resin modified glass ionomer cement (nRMGIC), Group 3: ActiV GP + Temporary restorative material (Temp), Group 4: RealSeal (RS) + Silorane based Composite, Group 5: RealSeal + nRMGIC, Group 6: RealSeal + Temp, Group 7: unobturated teeth Group 8: Intact teeth.The specimens were mounted in Instron and compressive force applied at a crosshead speed of 1 mm/min.The data so obtained was statistical analysed using Student 't' test and one way ANOVA test.

Results. The mean values were 872.87 N, 676.47 N, 630.07 N, 578.53 N, 539.60 N, 482.33 N, 481.07 N, 293.80 N for group 8, group 2, group 4, group 5, group 1, group 3, group 6, group 7 respectively with significant difference between the groups.

Conclusions ActiV GP and RealSeal can be regarded as a viable choice to increase the fracture resistance of endodontically treated teeth. nRMGIC and silorane based composite showed nearly similar reinforcement.

KEYWORDS : ActiV GP, Fracture resistance, Nano-filled Resin-modified glass ionomer cement, RealSeal, Silorane based composite.

Introduction

The main aim of root canal therapy is to remove pathologic pulp tissue and its remnants; disinfect and shape the contaminated root canal system and obturate three dimensionally to prevent re-infection and promote healing (Walton & Torabinejad 2002)

Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. The reasons most often cited are dehydration of dentin after endodontic therapy (Helfer et al 1972), removal of tooth structure during endodontic procedures (Sornkul & Stannard 1992) , removal of anatomic structures such as cusps, ridges, the arched roof of the pulp chamber and excessive pressure used during obturation (Belli et al 2006).

One of the complications in root canal treated teeth is vertical root fracture which often leads to extraction (Reeh et al 1989). For preventing such complications, clinicians have long sought to reinforce the remaining tooth structure (Jhamb et al 2009). 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 (Fisher et al 2007).

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 (Karapinar Kazandag et al 2009, Costa JA et al 2010). It represents a secondary monoblock system in the root canal.

In 2007, another adhesive obturating system was introduced commercially known as ActiV GP (Brasseler USA, Savannah GA, USA) (Koch K & Brave D 2006). It represents a tertiary 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 (Donadio et al 2008).

Similar to intracanal strengthening, intracoronal strengthening of teeth is also important to protect the endodontically treated teeth against fracture (Monga et al 2009)

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 (Al Boni R & Raja OM 2010). 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 (Upadhay S & Rao A 2011, Gupta SK et al 2012)

The aim of the present study was to evaluate the fracture resistance of endodontically treated teeth obturated with Resilon/Epiphany (RealSeal) and ActiV GP adhesive obturation systems followed by post

obturation restoration with materials based on Silorane based composite and Nano filled Resin modified GIC.

Materials and methods

One hundred twenty intact maxillary premolar teeth of similar dimensions 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 (SPAC Systems, Japan). Teeth were stored in 1% chloramine-T (HiMedia Labs., India) solution for 12 hours and transferred to distilled water until use.

Standardized access cavity (3.0mm x 2.0mm) was prepared in each specimen for endodontic treatment. The working length was determined by placing a ISO#15 K- file (DENTSPLY, Maillefer, Switzerland) into the canal until it was just seen at the apical foramen and then 1mm was subtracted from this length. Root canals were then instrumented with Hyflex CM till #30 (taper 4%). Throughout the instrumentation, irrigation with 2 ml of 5.25% sodium hypochlorite followed by 5 ml of 17% EDTA and a final rinse of 10 ml distilled water to avoid the prolonged effect of EDTA. Root canals so prepared were dried with paper points. Samples were randomly divided into groups each having sample size of 15.

In Groups 1,2,3 - Root canal obturation was performed. Teeth were obturated with ActiV GP (Table 1). 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

In Groups 4,5,6 - Root canal obturation was performed. Teeth were obturated with RealSeal (Table 1). 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 provided by the manufacturer and excess primer was removed. Resilon cone was 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.

After obturation, post endodontic restoration was performed. In group 1 and 4, intracoronal restoration was done using Silorane based composite (Filtek P90). Primer was applied using applicator tip to the entire surface of cavity and massaged over the entire area for 15 seconds and cured for 10 sec. P90 adhesive bond was applied using applicator tip over the entire surface of the cavity and cured for 10 sec. Cavity was restored incrementally and the thickness of each increment was not exceeding 2.5 mm. Each increment was cured for 40 sec by holding the light tip guide as close as possible to the cavity.

In group 2 and 5, intracoronal restoration was done using Nano filled Resin modified GIC (Ketac N100). Primer was applied using applicator tip to the entire surface of cavity and massaged over the entire area for 15 seconds. A gentle stream of air was used to spread primer into a thin even film which was then cured for 10 sec. A metal cement spatula was used to mix the pastes for 20 sec until a uniform color was achieved and the cavity was restored incrementally in a depth of 2mm or less. Each increment was cured for 20 sec by holding the light tip guide as close as possible to the cavity.

TABLE 1: Materials Used For Intraradicular Obturation & Intracoronal Restoration

S.No.	INTRARADICULAR OBTURATION SYSTEMS	INTRACORONAL POST-OBTURATION MATERIALS
Group1	ActiV GP(Cone + sealer)	Silorane based Composite
Group 2	ActiV GP	nRMGIC
Group 3	ActiV GP	Cavit-G
Group 4	Resilon + Epiphany (RealSeal)	Silorane based Composite
Group 5	Resilon + Epiphany	nRMGIC
Group 6	Resilon + Epiphany	Cavit G
Group 7	Unobturated prepared tooth	Cavit G
Group 8	Intact tooth	

After restoration, each tooth was aligned vertically in self-curing acrylic (Quick Ashvin, India) filled in stainless steel blocks at a level 1mm apical to cement-enamel junction with polysiloxane impression material used as a simulation of periodontal ligament. A custom stainless steel loading fixture screwed to the top of machine and with a 2 mm spherical tip was centered.

A compressive force at a crosshead speed of 1 mm/min was applied to the occlusal inclines of the buccal cusps of tooth at 45° until fracture occurred. The force required to fracture each specimen was recorded in Newton (N).

Statistical method

Descriptive statistics including the mean, SDs and minimum and maximum values were calculated for each group tested. Comparisons of means were tested using ANOVA and Unpaired 't' test. Statistical analysis was performed using the SPSS software.

Results

The mean forces of fracture was higher in case of ActiV GP-nRMGIC, RealSeal-Composite amongst the experimental groups. For the negative control group, the mean force of fracture was highest (Figure 1).

There was a significant difference between the experimental groups and control groups ($p<0.01$). Significant difference was observed among the groups with higher fracture resistance and the control groups (Activ GP+ nRMGIC/ RealSeal + Silorane based composite vs positive and negative control). However, no statistically significant difference was observed among these experimental groups which received the higher mean fracture values. A highly significant difference was observed in control groups (prepared but unobturated teeth vs intact tooth).

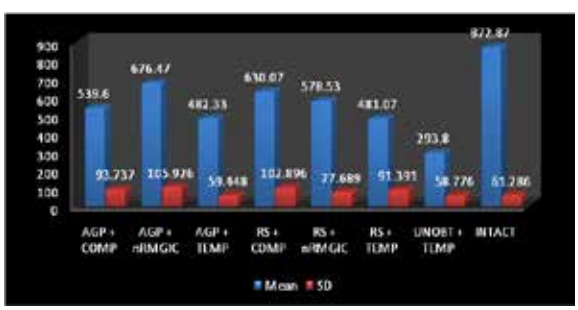

Figure 1: The figure shows **Mean and Standard Deviation values of the study and control groups**. Overall, the Intact variable had the highest Mean value (highest fracture resistance), followed by ActiV GP-RMGIC, Real Seal-Composite, and so on.

Discussion

Endodontic procedures have been suggested as precipitating factors for tooth fracture. It is generally accepted that removal of excessive amounts of dentin compromises the survival of root filled teeth and that the strength of an endodontically treated teeth is directly related to the amount of remaining sound tooth structure (Grande NM 2007 & Mandava J 2014). Reeh et al (1989) reported that the amount of coronal tooth structure, in particular marginal ridge integrity, seemed to be more important as the largest loss in stiffness is related to loss of marginal ridge integrity (Karapinar Kazadang 2009)

Gutta-percha has been the traditional endodontic obturating material but does not provide reinforcement of tooth. In recent years, dentin adhesion technologies have been introduced in an attempt to seal the root canal system and to reinforce the tooth effectively (Schwartz RS 2006)

Adhesive dentistry came into existence in endodontics by introducing

obturation systems with a focus on 'monoblock' in which the core material, sealer and root canal dentin forms a single cohesive unit (Patil AS et al 2013). To serve the monoblock concept, resin based dental materials have been proposed as a means to reinforce a root filled tooth through the use of adhesive sealers in the root canal system. Replacement monoblock created in the root canal spaces may be classified as primary, secondary, or tertiary depending on the number of interfaces present between the bonding substrate and the bulk material core.

When compared to Gutta-percha, resin based obturating material RealSeal (Resilon) allows the bonding agent (sealer) to attach to the resin core and the dentin wall, thus forming a secondary monoblock (Darrag AM & Fayyad DM 2011). Another obturating system which has been used in this study is ActiV GP which represents tertiary monoblock system. In a 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.

Intracoronal strengthening of teeth also plays an important role to protect them against fracture. Till date no study has been conducted to evaluate the fracture resistance of endodontically treated teeth restored using this continuum created by different intraradicular and intracoronal restorative materials based on monoblock concept for reinforcing the tooth.

With recent advancements in adhesive technology, new and stronger adhesive restorative materials are bonded directly to the tooth structure and strengthen it by creating conservative and highly aesthetic restorations (Sengun A et al 2008). For study to be clinically more relevant, the role of different post obturation restorative materials were also taken into an account.

It was preassumed that use of nRMGIC in conjunction with ActiV GP will create a continuum from apical part of restoration to the most coronal part (from apex to occlusal surface of teeth). Similar premise was assumed for RealSeal and Silorane based composites. , different combinations (ActiV GP – intaradicular + Silorane based composite – intracoronal / RealSeal – intraradicular + nRMGIC- intracoronal) among these materials have also been tested.

According to our findings, intact teeth (Group 8) had significantly higher mean fracture resistance (872.8 N) than endodontically treated teeth and the instrumented but unfilled teeth (Group 7) were weakest (293.80 N) amongst all groups ($P<0.05$).. 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 (Monga P et al 2009 & Sagsen B et al 2012)

On Comparison of group 3 (Activ GP + Temporary cement) and Group 6 (RealSeal +Temporary cement) having mean fracture resistance values of 482.33 N and 481.07 N respectively with Group 7 (unobturated prepared teeth+ Temporary cement) having mean fracture resistance value of 293.80 N, it was observed that there was a significant increase ($P<0.05$) in the fracture resistance values after obturation when compared with unobturated prepared teeth indicating a role of adhesive obturation system in root reinforcement. Most probable reasons for higher values of Group 3 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 (Darrag AM & Fayyad DM 2011, Royer K et al 2013). Amongst Group 3 and Group 6, 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).

Group 6 (RealSeal + temporary cement) 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.

Group 3 (482.33 N) and Group 6 (481.07 N) had the comparatively lower fracture resistance values when compared with groups which received the adhesive restorations such as nRMGIC and Silorane based composite. It was found that post endodontic restorative materials such as those based on Glass ionomers (nRMGIC) and Composites have significant potential to reinforce endodontically treated teeth. nRMGIC used in the study significantly restored the strength of the tooth as it has better chemical bonding to dentin as evidenced by Abd El Halim S (2011) .Secondly, the filler loading (69% by weight) with nanofilled particles must have contributed to higher strength values (Gupta SK et al 2012). 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 (monoblock in the root canal system extending upto coronal cavity)

However, same type of reinforcement was not observed in group 1 (ActiV GP + Composite) which showed mean high fracture resistance values of 539.60 N in experimental groups. The reason could be lack of formation of continuum and possibly difference in modulus of elasticity between tooth, nRMGIC and Silorane based composite when compared with nRMGIC. Other reason could be inadequate polymerization of resin composites as intensity of light drops in deep access cavity preparations, polymerization of resin composites is a limiting issue as intensity of light drops with increasing depths (Gambhir M & Tewari S 2005)

Conclusion Under the limitations of the study, it has been concluded that the fracture resistance decreases after biomechanical preparation and access cavity preparation.

The fracture resistance value of obturated teeth were significantly higher than the non obturated prepared teeth,however, no significant difference was observed among intraradicular obturation restorative materials (ActiV GP and RealSeal).Intracoronal restoration has an influence on the fracture resistance of endodontically treated teeth. The fracture resistance shown by Activ GP & nRMGIC and RealSeal & Silorane based composite was significant but less than intact teeth.

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