Effect of intra - orifice barriers on the fracture resistance of endodontically treated teeth – An *Ex-Vivo* study

Renuka Nadar*, Aparna Palekar**, Basawaraj Biradar***, Sai Kalyan***, Saurabh Pawar*, Dhanashree .C.Thorat*

Abstract

Introduction:-*The study investigated and compared the root reinforcement potential of dual cure cement (Luxacore Z – Dual Automix, DMG], light cure glass ionomer cement (GC Light cure GIC), and nano hybrid flowable composite (Tetric-N-Flow, IvoclarVivadent) placed over root canals obturated with gutta-percha and AH plus sealer as intra-orifice barriers.*

Materials and methods:-*Fourty freshly extracted mandibular premolars were instrumented and obturated with corresponding guttapercha cones and AH plus sealer. Except for control group, the coronal 3 mm of root fillings of all other group specimens were removed and randomly divided into 4 groups of 10 specimens each. They were control group (no barrier), dual cure cement, light cure glass ionomercement andnano hybrid flowable composite. After 8 hours, all the groups were subjected to fracture resistance testing by using Universal testing machine.*

Results:-*The fracture resistance testing results obtained showed the following pattern - dual cure cement > light cure glass ionomer cement >nano hybrid flowable composite > Control group.*

Conclusion:-*The placement of an intra-orifice barrier can be regarded as beneficial for the reinforcement of an endodontically treated teeth .*

Keywords – *Intra-orifice barrier, Luxacore Z, Light cure glass ionomercement .*

Introduction

Dental sciences have undergone anenormous and noteworthy advancements. One such science is the field of endodontics which has provided dentistry with the opportunity to retain teeth that would have been extracted several decades ago.[1] However, numerous clinical studies have reported that 11-13% of endodontically treated teeth are prone to vertical root fractures.[2] Furthermore, Bender and Freedman also reported the increased incidence of vertical root fractures in teeth that have undergone endodontic therapy.[3]

The main aim of root canal treatment is to clean and disinfect the root canals from the bacteria to obtain a three dimensional fluid impervious obturation along the root canal from the coronal intra-orifice to the apical constriction.[4] There is a lack of conclusive evidence for the weakening of endodontically treated teeth, thus the aforementioned facts indicate that the main goal for endodontic therapy should be reinforcement of residual tooth structure.[5]

In-order to reinforce the roots, stress concentrations at dentin - material interface should be minimized by utilizing materials that have modulus of elasticity similar to dentine i.e. 14 - 16 gigapascals.[6] Root canal filling materials such as Resilon and gutta percha have low modulus of elasticity compared to dentine and thus have little or no capacity

*Post Graduate Student, **Prof and Head, ***Reader

Corresponding author:
Dr. Renuka Nadar, Post graduate student
Department of Conservative Dentistry &Endodontics
Rural Dental College, Pravara Medical Trust, LONI,
Taluka: Rahata, Dist: Ahemadnagar, Maharashtra – 413736
E-mail: renukanadar@gmail.com
Phone: 9619795370.

for root reinforcement.[7] Roghanizad and Jones suggested removal of 3mm of gutta percha from the orifice of the root canal and replacing it with a restorative material to reduce coronal leakage.[8]

This *ex vivo* study aims to compare and evaluate the fracture resistance of roots obturated with gutta-percha & AH plus sealer using the following intra-orifice barriers:

1. Luxacore Z (Dual Automix, DMG America).
2. Light cure glass ionomer cement (GC Light cure GIC) .
3. Tetric - N - Flow (Nano hybrid flowable composite)

Materials And Methods

Selection of Specimens

Human single canal mandibular premolars extracted for orthodontic purposes were collected from the department of Oral & Maxillofacial Surgery, Rural Dental College, Loni, Maharashtra, India.

Inclusion Criteria: Fourty freshly extracted mandibular premolars selected on the basis of their macroscopically similar size and straight roots were reduced to 14 mm from the coronal aspect. The selected premolars were stored in 10% chloramine solution for a period of 12 hours and transferred to the preservation container filled with distilled water until use.

Exclusion Criteria: Teeth with fracture, craze lines and curved roots were excluded.

Specimen Preparation

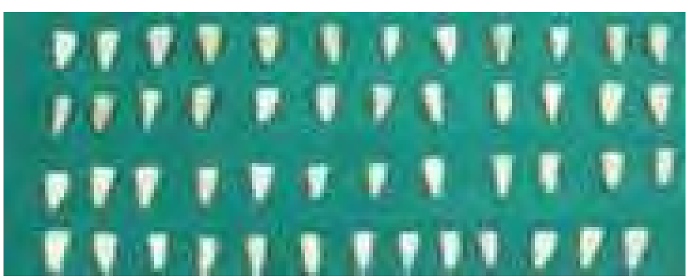


Fig. 1: Fourty selected tooth specimens.

Soft tissue & calculus were mechanically removed from the root surface of 40 selected specimens.**(Fig.1)**The teeth were reduced to 14 mm from the coronal aspect to standardize the specimens. After that all specimens were examined under a stereo- microscope to ensure the absence of cracks. A size 10 K-type file was placed into the canal until it was visible at the apical foramen. The working length was established 1 mm short of this length.

Instrumentation and obturation of root canals of selected premolars

After determination of the working length, root canals were instrumented with hand ProTaper universal system (Dentsply Maillefer, Ballaigues, Switzerland) in a sequential

Fig. 2: Armamentarium for instrumentation and obturation of root canals

manner till F3 using crown down technique (as per manufacturer's instructions).**Fig.2** illustrates the armamentarium for instrumentation and obturation of root canals.During instrumentation, canals were irrigated with 2 mL of 5.25% sodium hypochlorite after each change of file and final rinse was done with 5 mL 17% ethylenediaminetetraacetic acid (EDTA).mFinally, canals were flushed with 10 mL of distilled water and dried with paper points.Obturation was performed using corresponding gutta-percha (Dentsply Maillefer, Ballaigues,Switzerland) and AH Plus Sealer (Dentsply Malliefer).The samples were then stored in an incubator at 37°C for 8 h to allow complete set of the sealer.

Placement of Intra Orifice Barriers

Except for control group specimens, the coronal 3 mm of root fillings of all other group specimens were removed

Fig. 3: William's periodontal probe

Fig. 4: Removal of coronal 3mm of gutta percha with heated plugger

with the aid of heated plugger **(Fig.4)**and verified with the help of william's periodontal probe**(Fig.3)**. Obturated specimens were divided with respect to the intra- orifice barrier material placed over the root canal fillings into the following groups:

Group 1: (**No barrier- Control**) In this group, there was no removal of gutta-percha and no placement of intra-orifice barriers.

Group 2 : (LuxaCore Z) Prior placement of the composite restoration, xeno V adhesive was applied to enamel and dentine & light cured for 20 secs. LuxaCore dual cure core build up material was introduced into the root canal through the aid intraoral mixing tip and light cured with a light emitting diode (Bluephase C8 – Ivoclar Vivadent) for 20 seconds with an intensity of 1200mW/cm.

Group 3: (Light cure glass ionomer cement [GC Light cure GIC]) According to the manufacture's instructions , the specified amounts of powder and liquid was dispensed onto the paper padin the ratio of 3:1.The powder was divided into two equal parts. The first portion of the powder was mixed into the liquid with agate spatula and then the second portion was added into the remaining liquid. Mixed glass ionomer cement was placed into the canal orifices and it was cured for 20 seconds with Blue phase C8 curing light (Ivoclar Vivadent) at an intensity of 1200mW/cm.

Group 4 :(Tetric- N - Flow [Nano hybrid flowable composite]) Prior placementof composite restoration, xenoV adhesive was applied to the root canal orifices and light cured for 10 secs. Later , the flowable nanohybrid composite (Ivoclar vivadent) was syringed into the canal orifices and light cured for 20 sec with an intensity of 1200mW/cm.

Mounting and Testing of the specimen

The apical root end of each tooth was aligned vertically along their long axis in self-curing acrylic (Quick - Ashvin, Delhi, India) filled in 2cm diameter and 2.5cm height cylindrical polyvinyl tube, leaving 3 mm of each root exposed.**(Fig.5)**Periodontal ligament (PDL) simulation

Fig. 5: Specimen embedded in cylindrical acrylic block

was performed using light body elastomeric impression materials (Aquasil, Dentsply).

The specimens were mounted on a universal testing machine (Star Testing System, India, Model No. STS 248)and a compressive force was applied at a crosshead speed of 1 mm/min until fracture occurred.**(Fig.6)** The force

Fig. 6: Specimen mounted in universal testing machine for fracture resistance test

necessary to fracture each specimen displayed on the monitor was recorded in newton (N).

Statistical Analysis And Results

Data obtained was analysed using one way variance ANNOVA and inter group comparison was done by Turkey Kramer's test.

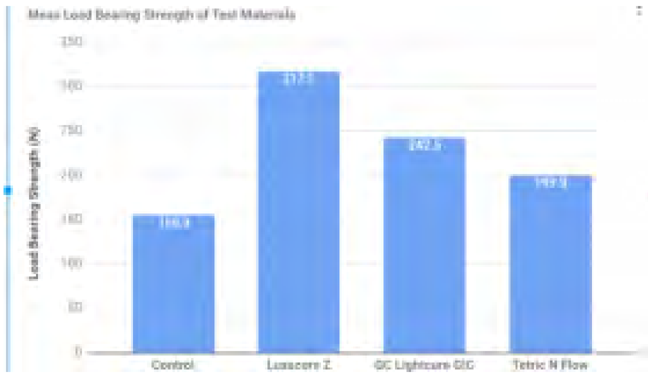
Table 1 showed the descriptive statistics of load bearing strength for each group. The ANOVA that compared the experimental groups revealed groups (p<0.001).Graph no.1 depicts the bar graph of load bearing values among the among the groups. Table no. 2 depicts the inter comparison of load bearing strength values among the groups.

Table No. 1 - Descriptive statistics of load bearing strength values among the groups

Groups	Mean	SD	Minimum	Maximum	F	P value
Control	155.3	31.52	112	200	41.12	< 0.001 (S)
Luxacore Z	317.1	42.87	245	364		
Light	242.5	28.65	201	291		
cureglass ionomer						
Tetric N Flow	199.9	21.21	171	239		
Total	914.8	124.25	729	1094		
Average	228.7	31.06	182.25	273.5		

Table No. 2 - Inter-comparison of load bearing strength values among the groups

Groups	Groups	Mean Differences	p-Value
Control	**Luxacore Z**	161.8	< 0.001 (S)
	Light cure GIC	87.2	< 0.001 (S)
	Tetric N Flow	44.6	< 0.01 (S)
Luxacore Z	**Control**	-161.8	< 0.001 (S)
	Light cure GIC	-74.6	< 0.001 (S)
	Tetric N Flow	-117.2	< 0.001 (S)
Light cure GIC	**Control**	-87.2	< 0.001 (S)
	Luxacore Z	74.6	< 0.001 (S)
	Tetric N Flow	-42.6	< 0.001 (S)
Tetric N Flow	**Control**	-44.6	< 0.01 (S)
	Luxacore Z	117.2	< 0.001 (S)
	Light cure GIC	42.6	< 0.001 (S)



Graph No. 1 - Bar graph depicting load bearing strength values among the groups

The highest (364 N) and the lowest (112 N) load bearing strength values were recorded for Luxacore Z and Control groups respectively.

The difference in the load bearing strength values of all the groups was highly significant (p<0.001).

The increasing order for load bearing strength values is Control < Tetric N Flow < light cure glass ionomer < Luxacore Z. [155.3 N < 199.9 N < 242.5 N < 317.1 N].

Inter -group comparison exhibitedthat Control group (155.3 N) had least load bearing strength value .When Control group was compared to Luxacore Z group (317.1 N) , light cure glass ionomer cement group (242.5 N) and Tetric N Flow group (199.9 N), the mean difference of the load bearing strength values exhibited high significance. (p<0.001).

When light cure glass ionomer cement group (242.5 N) was compared to Control group (155.3 N) , the mean difference of the load bearing strength value exhibited high significance (p<0.001).

The mean difference of the load bearing strength value of Control group (155.3 N) and Tetric N Flow group (199.9 N) revealed significance. (p<0.01)

When Control group (155.3 N) was compared to Luxacore Z group (317.1 N) , the mean difference of the load bearing strength value was highly significant. (p<0.001).

When Luxacore Z group (317.1 N) was compared to light cure glass ionomer cement group (242.5 N) , the mean difference of the load bearing strength value exhibited high significance (p<0.001).

Discussion

According to Dietschi *et al*, the susceptibility of endodontically treated teeth to fracture was directly proportional to coronal tissue lost as a result of carious lesion or restorative procedures.[9] Hence, there is a direct association between the amount of residual tooth structure and its potential to resist occlusal forces. Myriad of previous studies have stated the significance of an adequate coronal restoration for a favourable periapical health.[10]In the present study, the core material (gutta percha) combined with the tested endodontic sealer (AH Plus) was not able to increase the root fracture resistance significantly in all the groups including the control group. Zandbiglari et al also proposed that the roots were noticeably weakened with the employment of greater taper instruments and obturation with AH plus sealer did not enhance the fracture resistance.[11]

An array of materials have been utilized as intra - orifice barriers in earlier studies such as bonded amalgam, Mineral trioxide aggregate (MTA), calcium enriched mixture cement, resin modified glass ionomer cement , flowable composite ,etc. Bonded amalgam, MTA , calcium enriched mixture cement although have been routinely used for restorative procedures due to good sealing capacity, but poor physical properties have led them not to be used in the current study.As there is paucity of information regarding the use of dual cure cements as intra - orifice barrier, the current study evaluated the fracture resistance of endodontically treated teeth obturated with gutta percha and AH plus sealer , with the placement of dual cure intra-orifice barrier in a group and nano-hybrid flowable composite as well as light cured glass ionomer cement in other groups.

LuxaCore Z is a dual cure composite used for core build up as well as post cementation. LuxaCore Z yielded highest fracture resistance of an endodontically treated teeth as an intra - orifice barrier as it had a flexural strength and modulus of elasticity close to the dentin. Thus, the material can withstand a large amount of stress before transmitting the load to the root. With the proportion of zirconia , it has an excellent compressive strength of 380 MPa.The material's supreme flow properties guarantees optimum adaptation to the cavity walls. Fluoride release ensures prevention of development of secondary caries and 72% filler loading provides excellent wear resistance and strength, decreasing polymerization shrinkage.[12] As Luxacore Z is a dual cure material , it undergoes optimal polymerization within the root canal orifice compared to Tetric N Flow and light cure glass ionomer cement .

Light cure glass ionomer cement introduced in the late 1980, contains some methacrylate components common in resin composites. It sets by two mechanisms: acid-base reaction common to all glass ionomers and a photochemical polymerization of water soluble monomers and methacrylate groups.[13]Light cure glass ionomer cement demonstrated remarkable performance by providing an adequate coronal seal caused by water sorption of the material as a result of setting expansion. It has a high flexural strength and modulus of elasticity close to natural dentine, further more chemical bonding with the dentinal surface yielded it as a fracture resistant intra-orifice barrier material.

Flowable resin based composites are conventional composites with filler loading less than 60% by volume that alters its viscosity.[14] The flowable nanohybrid composite was utilized in the present study as the manufacturer's claimed to offer higher flow, better adaptation to the internal cavity wall, easier insertion and greater elasticity than conventional composites. Tetric N Flow is a light-curing, radiopaque, flowable nano-hybrid composite . It has a compressive strength of 230 MPa and it's modulus of elasticity is 5.3 GPa which is significantly lower than that of natural dentine.[14] Reduced filler loading leads to enhanced polymerization shrinkage causing coronal leakage. In the current study, its ability to reinforce the root with adequate coronal seal is significantly poor as compared to Luxacore Z and light cure glass ionomer cement as a result of reduced physical properties and greater polymerization shrinkage.

In the present study performed, Luxacore Z yielded the highest fracture resistance of endodontically treated teeth as LuxaCore Z is superior to both Tetric N Flow and light cure glass ionomer cement with respect to physical properties as well as it undergoes optimal polymerization within the root canal orifices being a dual cure material. Light cure glass ionomer cement demonstrated better performance as an intra-orifice barrier compared to Tetric N Flow as a result of favourable physical properties and optimum coronal seal provided by water sorption of the setting cement.The present study does not take into account the influence of sealer on the bonding of restorations to the root canal walls. Further studies are necessary to precisely correlate the results of this study to clinical success.

Conclusion

Within the limitations of the study, it can be concluded that the endodontically treated teeth with an intra-orifice barrier are more resistant to fracture compared with those without a barrier. LuxaCore Z followed by light cure glass ionomer and Tetric N Flow significantly increased the fracture resistance of endodontically treated teeth. LuxaCore Z yielded highest fracture resistance as an intra-orifice barrier of an endodontically treated teeth as a result of enhanced physical properties and dual cure setting mechanism.

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