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ORIGINAL RESEARCH

Effect of Three Different Core Materials on the Fracture Resistance of Endodontically Treated Deciduous Mandibular Second Molars: An *in vitro* Study

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ABSTRACT

Endodontic treatment makes the tooth brittle due to loss of bulk of tooth structure, decrease in the moisture content of dentin and dentin elasticity. The following study was carried out to evaluate the effect of endodontic treatment on the fracture resistance of the tooth and reinforcing ability of three different core materials.

The following study comprised of sample size of 30 deciduous second molars divided into control group (6) and test group (24). Access opening was done in 24 and 18th teeth with access opening were restored with three different core materials namely IRM (6), silver amalgam (6), GIC (6). All the 30 were subjected to fracture test using UTM (Universal testing machine)-Instron 95. Result showed a drastic reduction in the fracture resistance of the tooth on access opening (1/3rd) and out of the three core materials glass ionomer was shown to be the best core material giving the highest fracture registrance followed by silver amalgam and IRM.

Keywords: Endodontic treatment, Core materials, Fracture resistance.

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INTRODUCTION

Earlier a badly carious primary tooth was sentenced to the extraction forceps. But now due to advent of new materials and new techniques in field of pediatric endodontics, such teeth can be saved and restored to normal masticatory efficiency, esthetics and occlusal harmony, promoting normal growth and development of the jaws and succedaneous teeth.

But the main disadvantage of endodontic treatment[1,2] is that the teeth become weak and susceptible to fracture. This probably may be due to:

- Loss of bulk of tooth structure by the removal of large central portion of enamel and dentine including the roof of pulp chamber, all of which provide much of necessary support for natural tooth.[3]
- Decrease water content of dentine occur due to the exposed dentinal tubules and removal of pulp chamber during access cavity opening, making it brittle.[4]
- Decrease in dentine elasticity.[5]

Failure to protect such teeth may lead to fracture and ultimately loss of the tooth. Therefore, intracoronal strengthening of teeth is important to protect them against fracture, particularly in posterior teeth where stresses generated by occlusal forces can lead to fracture of unprotected cusps. Restoration of endodontically treated teeth is an important step that complements a technically sound endodontic treatment.[6] Thus, endodontic treatment should not be considered complete until a coronal restoration has been placed. An optimal final restoration (core materials are used) for endodontically treated teeth maintains esthetics, function, preventing tooth fracture under masticatory load, preserves the remaining tooth structure, give bulk to the tooth structure, reinforcing it and prevents microleakage.[7]

Various core materials, like amalgam, GIC, IRM, composite resin, miracle mix, etc. are routinely used in deciduous teeth.[8,9]

Although dental amalgam has favorable mechanical properties, it lacks adhesion to the tooth structure. This diminishes the fracture resistance of the remaining tooth structure due to microcrack propagation under fatigue loading,with the recent advancements in adhesive technology and stronger adhesive materials, it is now

possible to create conservative, highly esthetic restorations that are bonded directly to the tooth structure and strengthen it.[6]

This study was undertaken to determine the fracture resistance of:

- Sound tooth
- Access opened tooth
- Teeth restored with three different core materials namely:
  - Amalgam
  - Intermediate restorative material (IRM)
  - Glass ionomer cement (GIC).

MATERIALS AND METHODS

This study comprised a 30 sound deciduous mandibular second molars which were cleaned of all the debris and blood and stored in artificial saliva throughout entire course of the study.

Study also comprised of:

- 30 lathe cut iron rings of dimension 1" length and 3/4" diameter (Fig. 1)
- Pink self-cure acrylic resin
- A endodontic kit and a restorative kit.

All the teeth samples were mounted with their occlusal surface parallel to the base of the iron rings which were filled of self-cure resin. Care was taken that the acrylic resin extends only up to the cementoenamel junction of tooth as shown in the photograph (Fig. 2).

Out of total 30 samples, six teeth were taken as control group and remaining 24 samples as the test group. Test group was again subdivided into four groups of six teeth each.

Twenty-four samples in test group are subjected to six access cavity preparation and pulp extirpation and rest 18 access opened samples are restored with three different core materials (i.e. six teeth in each group) namely (Figs 3 and 4):

- Dental amalgam (high copper alloy)
- Intermediate restoration material (Dentsply)
- Glass ionomer cement (Fuji-II)

  Restorations were contoured.

Testing for fracture resistance was done at the material testing division of Automotive Research Association of India (ARAI), Pune, using Instron 1195–Universal testing machine compressive mode (Fig. 5). Sample was placed on loading platform, compressive pressure was applied at crosshead speed of 0.5 mm/min using a ball ended plunger touching the central fossa of tooth uniformly (Figs 6A and B). Failure was detected by fracture of the sample. Readings were obtained graphically which were interpreted numerically.

Fig. 2: Cementoenamel junction

Fig. 3: Dental amalgam and IRM

Fig. 1: Self-cure acrylic resin

Fig. 4: Lathe cut iron rings

Graph 1 results were tabulated, analyzed and compared statistically (Tables 1 and 2). Mean/standard deviation/ t-test/p-value was determined.

RESULTS

Table 1 shows mean and standard deviation for each category.

Using these mean values a simple bar graph was plotted showing the differences in fracture resistance values (Graph 1).

- Sound tooth gave a mean value of 1646.66 N.
- Access prepared tooth gave mean value of 686.66 N.
- Amalgam gave-1265 N, IRM-850 N, GIC-1745 N.

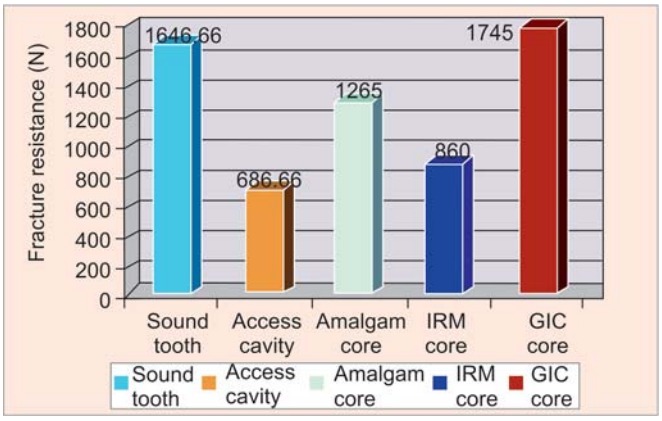
When we compare access prepared tooth with sound tooth its value is almost 1/3rd (Table 2). Values differ significantly with p-value <0.005. Students t-test was applied and significance noted.

It was found that when we compare the first two groups there was high statistically significant difference between them with p-value of <0.001. When we compare access cavity group with all other material they show a high statistically significant difference between them. Graph shows fracture resistance of access opened tooth is 1/3 to that of sound tooth due to loss of bulk of tooth structure (Graph 1). When we compared access cavity group with other core group, the later gave higher value thus, revealing the reinforcing property of GIC core gives highest fracture resistance because of chemical bonding to the tooth structure.[5,8,18] Also coefficient of thermal expansion of GIC is same as that of natural tooth. Amalgam has better compressive strength but does not bond to the tooth structure thereby amalgam core gives lower fracture resistance.[18,19] A more detailed research can be carried out using other aspects. Different core material can be tried out with different kind of access cavity preparation like mesio-occlusal (MO)/Disto-occlusal (DO)/Mesio-occlusal distal (MOD).

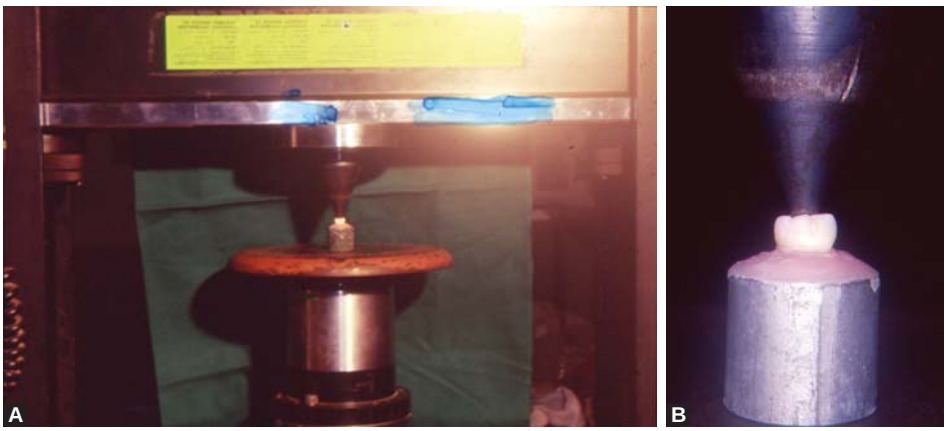
DISCUSSION

Tooth restoration is the final step in root canal treatment.[10] Numerous studies have been conducted to determine the ideal method to restore endodontically treated teeth as these teeth have decreased fracture resistance due to the loss of tooth structure during endodontic access and cavity preparation procedures. Cusp separation rarely occurs in noncarious, intact teeth because of the presence of the pulp

Fig. 5: Instron 1195—Universal testing machine



Graph 1: Effect of three different core materials on the fracture resistance



Figs 6A and B: Ball-ended plunger touching the central fossa of tooth

chamber's roof and marginal ridges, which can be considered to be tooth-reinforcing structures. The presence of palatal and buccal cusps with intact mesial and distal marginal ridges forms a continuous circle of tooth structure which reinforces and maintains the integrity of the tooth.[11]

The concept of a ferrule is an important altering factor in the performance of endodontically treated teeth. A ferrule is a circumferential ring of sound tooth structure with a minimal sound dentin height of 1.5 to 2.0 mm that is enveloped by the cervical portion of the crown restoration. The presence of adequate ferrule proves to affect the success of the types of restorations used, showing that the purpose of a core restoration, with or without a post, is to replace lost dentin and protect against cervical root fracture.[12]

It has also been shown that the weakening of teeth due to restorative and endodontic procedures increases with the reduction of tooth structure.[6,13] Endodontic procedures reduce the relative rigidity of the tooth by 5%, which is contributed entirely by access opening.

Traditionally, endodontically treated teeth have been restored with stainless steel crowns which include cusp coverage to improve the fracture resistance.[14] To further increase the fracture resistance, several attempts have been made to restore endodontically treated teeth with different postsystems to increase the fracture resistance of the root structure. However, some studies have proved that these posts decrease the fracture resistance instead of increasing it. Endodontic posts do not reinforce the crown as enlargement of the root canal space after completion of root canal treatment can weaken the tooth structure. Another method that has been used is cusp reinforcement with the use of pins. Although restored teeth can be as strong as intact teeth, these pins create stress and suffer corrosion in the dental tissue.[15]

The above-mentioned techniques to restore the endontically treated teeth is used in cases of highly destructed carious teeth, however, in cases where teeth have sufficient tooth structure the restorative materials are used to replace the missing tooth structure due to access cavity opening and reinforcing them. Numerous materials have been used as substitutes for dental tissues. Amalgam, for

Table 1: Mean and standard deviation

Sr. No.	*Category*	*Fracture resistance (N)*	*Mean (N)*	*Standard deviation*
1	South tooth	• 1630 • 1540 • 1960 • 1500 • 1550 • 1700	1646.66	169.43
2	Access cavity	• 710 • 690 • 650 • 705 • 670 • 695	686.66	22.73
3	Amalgam core	• 1330 • 1349 • 1150 • 1250 • 1220 • 1300	1265	72.86
4	IRM core	• 860 • 960 • 780 • 910 • 800 • 790	850	73.20
5	GIC core	• 1670 • 1500 • 1900 • 1850 • 1750 • 1800	1646.66	169.43

Table 2: Access prepared tooth with sound tooth

Sr. no.	*Groups*	*Mean (N)*	*Standard deviation (N)*	*t-value*	*p-value*	*Significance*
1	Sound	1646.66	169.43	12.5584	<0.001	HS
	Access cavity	686.66	22.73			
2	Sound	1646.66	169.43	0.9889	>0.05	NS
	GIC	1746	144.05			
3	Access cavity	686.66	22.73	16.9453	<0.001	HS
	amalgam	1266	72.86			
4	Access cavity	686.66	22.73	0.54444	>0.05	NS
	IRM	860	73.20			
5	Access cavity	686.66	22.73	16.2291	<0.001	HS
	GIC	1745	144.05			
6	Amalgam	1265	72.86	8.9857	<0.001	HS
	IRM	850	73.20			
7	Amalgam	1265	72.86	0.6495	<0.01	S
	GIC	1745	144.05			
8	IRM	850	73.20	12.3866	<0.001	HS
	GIC	1745	144.05			

HS: Highly significant, NS: Not significant, S: Significant

instance, is the most common material used for more than 100 years in posterior restorations. Although amalgam has high compressive strength, it does not adhere to the dental structure. Cuspal fractures in amalgam restoration result from the fatigue caused by crack diffusions subjected to repeated loading. Also, the presence of mercury and the types of interactions among its metal components make this material exhibit higher deformation levels when submitted to occlusal load application.[11]

Glass ionomer cements are also used as core material for deciduous teeth and few advantages like fluoride release, low coefficient of thermal expansion and chemically bonds to the tooth structure,[16] whereas another author has referred GIC as easy to place and provides a good seal.[17]

In this study, we have used GIC, amalgam and IRM as core materials to restore the endodontically treated mandibular deciduous second molar and glass ionomer cement showed the highest resistence to fracture.

CONCLUSION

1. Endodontic treatment decreases strength of the tooth approximately 1/3rd of the sound tooth in case of occlusal access cavity preparation.
2. GIC core gives the highest fracture resistance value followed by amalgam and IRM.

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