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ORIGINAL RESEARCH

An *in vitro* Evaluation of Fracture Resistance of endodontically treated Teeth with Different Restorative Materials

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ABSTRACT

Aims: The aim of the present study is to compare and assess the fracture resistance of root canal treated teeth with different restorative materials.

Materials and methods: The present *in vitro* study was carried out on seventy-five freshly extracted, noncarious, single-canal human lower-first premolars with similar anatomic characteristics. Teeth were randomly assigned to five groups with 15 teeth being present in each group. Group I is control group (no alteration done), group II is restored with silver amalgam after endodontic therapy, group III is restored with posterior composite after endodontic therapy, group IV is restored with posterior glass ionomer cement (GIC) after endodontic therapy, and group V is restored with miracle mix after endodontic therapy. Universal testing machine was used to assess the fracture strength. Analysis of variance (ANOVA) test followed by Tukey's *post hoc* test were used to determine the significant difference between each group. A p-value of < 0.05 was considered as statistically significant.

Results: The mean fracture resistance of control group showed highest fracture resistance with a mean Newton of 1083.33 ± 136.78. Among the restorative material, the highest fracture resistance was shown by teeth restored by composite (845.46 ± 47.36), followed by silver amalgam (845.46 ± 47.36). There was statistically significant difference among all the restorative materials compared with the control group ($p < 0.05$). However, among the teeth restored with silver amalgam and miracle mix, there was no statistical significance ($p > 0.05$).

Conclusion: The present study concludes that composites are found to be having more fracture resistance followed by silver amalgam on endodontically treated premolar teeth.

Clinical significance: Restoring nonvital teeth represents a major challenge for clinicians as they are extensively damaged due to caries and endodontic access preparations. With various restorative materials in the market, it becomes difficult for the clinician to choose the better restorative material for postendodontic restoration.

Keywords: Access cavity, Coronal restoration, Fracture resistance, Root canal treatment.

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INTRODUCTION

Fracture resistance of an endodontically treated tooth is less when compared with natural tooth as in root canal treated tooth, there will be dehydration and loss of dentin after the procedure, and also some of the vital structures, such as cusps, ridges, and roof of the pulp chamber that provide the support for the natural tooth are distructed.[1] Hence, restoring the tooth to gain strength is important to protect against fracture. Hence postendodontic

restoration plays an important role in the success of root canal treated teeth. In addition, restoring root canal treated tooth is necessary to maintain esthetics, function, anatomy of tooth structure, and prevent micro leakage.[2] Therefore preparation for the access cavity restoration is the final step in root canal therapy.

Restoring nonvital teeth represents a major challenge for clinicians as they are extensively damaged due to caries and endodontic access preparations.

Clinicians suggests full crown coverage after endodontic procedure, however, restoring a root canal treated tooth to its original anatomy may provide good strength and fracture resistance without placement of full coverage restoration could provide potential periodontal and economic benefits to the patients.[3]

Several materials have been suggested as intracoronal restorative materials, such as glass ionomer cement (GIC); composite resins; miracle mix, coremax, and Hi-Dens, which are metal-reinforced GICs.[4]

Dental amalgam is a restoration of choice by many clinicians, but it has a mechanical adhesion to the tooth and also requires proper cavity preparation which may be difficult to consider for a tooth considered for endodontic purpose. Also, studies have reported micro crack propagation under fatigue loading;[5] hence, it may not provide good fracture resistance of the remaining tooth.

Recently, there are great advancements in adhesive restorative technology, which bonds to the tooth in a conservative and aesthetic manner[6] resulting in a good bond strength.[7] Recently, posterior GICs have been claimed to have good strength.

With various restorative materials in the market, it becomes difficult for the clinician to choose the better restorative material for postendodontic restoration. Hence, the present study was designed to compare and assess the fracture resistance of root canal treated tooth restored with silver amalgam, posterior composite, posterior GIC, and miracle mix as coronal restorative materials.

MATERIALS AND METHODS

Seventy-five noncarious, single-canal human lower-first premolars extracted for orthodontic reason having similar morphologic characteristics were selected from the Department of Oral and Maxillofacial Surgery, Panineeya Institute of Dental Sciences and & Research Centre, Hyderabad. All teeth were stored in saline at room temperature till the procedure was carried out.

Inclusion Criteria

- Freshly extracted tooth
- Tooth with single canal
- No evidence of root resorption.

Exclusion Criteria

- Tooth with wasting diseases (attrition, abrasion, erosion)
- Decayed tooth
- Evidence of fracture.

After collecting required number of teeth, the teeth were randomly divided into five experimental groups of 15 teeth each.

Group I: Control group (no alteration done).
Group II: Restored with silver amalgam after endodontic therapy.
Group III: Restored with posterior composite after endodontic therapy.
Group IV: Restored with posterior GIC after endodontic therapy.
Group V: Restored with miracle mix after endodontic therapy.

Procedure

Similar type of endodontic access cavity was prepared by using F0001 and F0199 burs on all the teeth except control group which was kept without alteration. Biomechanical preparation was done till 50 sized k-file and was obturated with gutta-percha and AH-plus root sealer using cold lateral compaction technique. After obturation, the access cavity was restored by different restorative materials as mentioned above.

Teeth in all the groups were stored at 37°C for 3 days. Self-cure acrylic blocks of 4 × 4 cm were fabricated onto which the teeth were mounted.

A universal testing machine was used to assess the fracture strength of root canal treated tooth. Load was given vertically down the long axis of the tooth by considering the occlusal inclines of buccal and lingual cusps. The force in Newton needed to fracture each tooth was recorded.

Statistical analysis was done using analysis of variance (ANOVA) to compare different restorative materials followed by Tukey's *post hoc* for multiple comparisons. A p-value < 0.05 was considered as statistically significant.

RESULTS

Table 1 shows the mean fracture resistance of different restorative materials. Control group showed highest fracture resistance with a mean Newton of 1083.33 ± 136.78. Among the restorative materials, highest fracture resistance was showed by teeth restored by composite (845.46 ± 47.36) followed by silver amalgam (845.46 ± 47.36). Least fracture resistance was exhibited by GIC (671 ± 47.36) and miracle mix had slightly better fracture resistance than GIC (774 ± 35.02) but less than composite and silver amalgam. An ANOVA revealed highly statistical difference among the restorative materials and compared with control group (unobturated teeth).

Table 1: Mean fracture resistance of different restorative materials

Groups	*Mean*	*SD*	*f-value*	*p-value*	*Significance*
I	1,083.33	136.78			
II	845.46	47.36			
III	969.06	48.44	73.783	0.000	HS
IV	671.33	44.98			
V	774.66	35.02			

p <0.05; HS: Highly significant

Table 2: Multiple comparisons using Tukey HSD

Group	*Compared with*	*Mean difference (I–J)*	*Sig.*	*95% Confidence interval*	
				Lower bound	*Upper bound*
I	Group II	237.86*	0.000	163.35	312.37
	Group III	114.26*	0.001	39.75	188.77
	Group IV	412.00*	0.000	337.49	486.50
	Group V	308.66*	0.000	234.15	383.17
II	Group III	123.60*	0.000	198.10	49.09
	Group IV	174.13*	0.000	99.62	248.64
	Group V	70.80	0.070	3.70	145.30
III	Group IV	297.73*	0.000	223.22	372.24
	Group V	194.40*	0.000	119.89	268.90
IV	Group V	103.33*	0.002	177.84	28.82

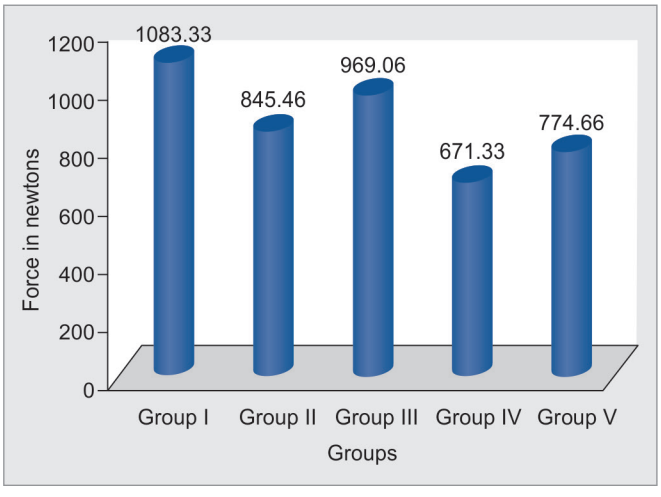
*Significant; p <0.05

Table 2 shows multiple comparisons among the restorative materials. There was statistically significant difference among all the restorative materials compared with the control group (p<0.05). However, among the teeth restored with silver amalgam and miracle mix, there was no statistical significance (p>0.05).

Graph 1 shows mean fracture resistance exhibited by different restorative materials and control group.

DISCUSSION

We have considered extracted mandibular premolars for the study, but there can be variations which cannot be controlled between the teeth, hence we have standardized the procedure by considering patients in the same age group going for orthodontic extraction, randomly distributing the teeth to different groups, and making a uniform access cavity preparation mesiodistally and buccolingually as much as possible.



Graph 1: Mean fracture resistance exhibited by different restorative materials and control group

An endodontically treated tooth can be expected to survive in the oral cavity for long duration based on the final restoration that we provide; hence tooth restoration is the final and vital step to determine the success of endodontic treatment. There is evidence that endodontically treated teeth have reduced levels of proprioception which could impair normal protective reflexes that ultimately leads to fracture.[8]

Ability of root canal treated tooth to withstand forces in *in vivo* condition is different when compared to *in vitro* as in oral cavity force applied to the tooth may depend upon the position of adjacent teeth, extent of tooth structure remaining, opposite occlusal contacts, periodontal status of the tooth, and many other factors, so more *in vivo* studies are required before considering the restoration of choice after root canal treatment. Tooth with extensive caries will provide least fracture resistance. Reduction of crown structure during root canal treatment is the reason for weakening of tooth structure.[5] So preserving tooth structure is a vital step.

Many studies[9-11] have been done with an intention to know the ideal restorative material for a root canal treated tooth as these teeth are having less fracture resistance because of endodontic access and cavity preparation procedures.

In our study we have included the most commonly used restorative materials that are usually given preference by practicing dentists for core buildup after endodontic treatment, hence we considered composite, silver amalgam, GIC, and miracle mix. We considered maxillary premolars as they are the most prone teeth for fracture.[12,13]

Intact teeth were having highest fracture resistance, which clearly indicates that structural integrity of tooth is of paramount importance for fracture resistance. This was an expected result as cusp separation rarely occurs because of presence of pulp chambers roof and marginal ridges.

In our study fracture resistance exhibited by composite restoration was less when compared to that of normal intact tooth, but more when compared to all other restorative materials used. The results are similar to studies done by Ashika Riswana and Kumari[10] and Reddy et al.[11] Also, many studies have shown that composites are having better bonding to tooth structure by micromechanical bonding[14,15] and exhibit higher mechanical and physical properties compared to various core buildup materials.[16]

Most of the time, prognosis of root canal treated tooth depends not only on the endodontic procedure, but also on the restorative material used for the postendodontic restoration. Choosing the best restorative material according to functional needs and considering remaining tooth structure are key factors for success. Based on these points, different materials have been proposed of which we found composite restoration as having more fracture resistance followed by silver amalgam. The main difference for fracture resistance among GIC and composite may be due to physical and mechanical properties and among composites and miracle mix is incorporation of metallic fillers.

In the present study, miracle mix exhibited more fracture resistance compared to GIC, which is in contrast to the study by Reddy et al.[11] The reason could be that incorporation of metallic fillers may provide additional advantage over conventional GIC. Also, miracle mix has an added advantage of fluoride ion release.[17]

The limitations of this study are considering procedure in *in vitro* condition, which may not replicate the oral conditions; also, single-rooted tooth was considered. Hence, fracture resistance offered by restorative material for multirooted tooth can be difficult to conclude. Thus, studies under clinical conditions should be considered further to interpret the result of this *in vitro* study.

CONCLUSION

From the result of present study, composites are found to be having more fracture resistance followed by silver amalgam on endodontically treated premolar teeth. However, the results of *in vitro* studies are difficult to interpret in the clinical setting as endodontically filled tooth is influenced by factors like occlusal contact of opposite tooth, tooth position in the arch, extent of caries involvement, strength of cuspal remain. Hence, long-term *in vivo* studies are required with similar cavity design and different restorative material.

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