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Original Research

Fracture resistance of endodontically treated molars restored with resin composites

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ABSTRACT:
Introduction: To conserve tooth structure, adhesive composite restorations that can provide intracoronal reinforcement are advocated to restore endodontically treated teeth. **Aim:** The objective of the study was to compare the fracture resistance of endodontically treated molars restored with cuspal coverage restorations using different resin composites. **Materials and Method:** Sixty human mandibular molars were selected and divided into 3 groups (n=20): DIR specimens, restored with direct composite resin (Estelite Sigma) restorations; IND specimens, restored with indirect composite resin (Estelite Sigma) restorations, and control specimens, which remained intact. Endodontic treatment was performed using NiTi ProTaper rotary instruments, and teeth were filled using lateral condensation of gutta-percha and sealer. Extensive Class II MO cavities were prepared, and the 2 mesial cusps were reduced, allowing a 2-mm layer of composite resin. All teeth were prepared to the same dimensions, considering reasonable human variation. Specimens were loaded to failure and the fracture loads were recorded (N). The mode of fracture was determined usinga stereomicroscope and classified as favorable or unfavorable failure. The data were subjected to a Kruskal-Wallis test, multiple-comparison Mann-Whitney test, and a chi-square test (α=.05). **Results:** Significant differences (P<.001) were observed between the control group and both DIR and IND groups. However, no significant difference was found between the DIR and IND groups. The chi-square test did not show a significant difference in the frequencies of favorable/unfavorable failure modes among the 3 groups (P=.883). **Conclusions:** No significant difference was observed in the fracture resistance of endodontically treated molars restored to original contours with an extensive cusp-replacing direct or indirect composite resin restoration.

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INTRODUCTION

Esthetic dentistry continues to evolve through innovation in bonding systems, restorative materials,and conservative preparation designs. Increased use of composite resin materials for the restoration of the posterior dentition has drawn attention to technological advances in this field. A stable and durable bond between dental materials and tooth substrates is important from both a mechanical and esthetic perspective.[1] Such materials not only seal themargin,[2] but several studies have also shown that the use of adhesive material scan reduce the weakening effect of preparation designs.[3,4] In fact, cavity preparation procedures for dental restorations are a primary factor in most cuspal fractures,[5] especially for endodontically treated teeth.[6,7]

The goal of endodontic treatment is to maintain the tooth as a functional unit within the dental arch. The objectives of restoring endodontically treated teeth are to replace the missing tooth structure, maintain function and esthetics, and to protect the tooth against fracture and reinfection.[8]The loss of marginal ridges due to caries, removal of the pulp chamber roof along with inner dentin during access cavity preparation, and loss of the protective feedback mechanism in non-vital teeth contribute to the high fracture susceptibility of endodontically treated teeth.[9] As the restorative modality is critical for the long term success of endodontic treatment, the possible reconstruction materials and techniques are being debated. The advancements in adhesive technology and the improved strength of newer composites have made it possible to create a conservative and esthetic postendodontic restorations. The cusps of teeth restored with composite resin are mechanically splinted together reinforcing the teeth and thus, minimizes tooth fractures.[10]

Recently developed composite resins are superior to previous versions with regard to wear resistance and color stability.[11,12] However, the primary shortcoming of composite resins, polymerization shrinkage, remains a concern.[13] In posterior preparations, especially when the cervical margin islocated in dentin, the polymerization shrinkage effects can be significant, producing marginal defects and gaps despite careful application.[14] This result facilitates microleakage, which could promote secondary caries, marginal discoloration, and, in vital teeth, pulpal irritation and postoperative sensitivity.[15] To minimize the development of stresses, it is important to use incremental placement techniques, in which the composite resin is applied in thin or oblique layers and then polymerized throughout the cusps.[16] The composite resin inlay systems were introduced for large defects, with the aim of overcoming some of the problems associated with directly placed posterior compositeresin restorations, such as the polymerization shrinkage that occurs when using conventional incremental techniques.[17] The primary advantages of indirectly placed composite resin inlays and onlays are the minimization of polymerization stress due to the extraoral method of polymerization, better control of anatomic form and proximal contacts, and improved surface finish.[12,18] However, the unresolved problem with indirectly placed inlays/onlays is the bond between the composite resin cement and the restoration.[19] Adhesive systems with direct composite resin restorations provide superior bond strengths when compared to indirect restorations.[20-22]

MATERIAL AND METHODS

Sixty extracted human mandibular molars with completely formed apices, without caries or visible fracture lines, were selected from a tooth bank. The selection of specimens was based on the teeth having similar bucco-lingual (BL) and mesio-distal (MD) dimensions, as determined with a digital caliper. All external debris was removed with a hand scaler, and the teeth were stored individually in buffered saline plus 0.5% thymol at 37°C. Cleaned specimens were carefully inspected under a stereomicroscope (Stemi SV6; Carl Zeiss SpA, Arese, Italy) at x30 magnification to detect cracks in the teeth. Specimens that did not meet the criteria were replaced. The product (mm2) of the BL and MD dimensions was determined. On the basis of this value, the 60 specimens were sequenced according to decreasing values, and alternating specimens were subsequently allocated to 3 groups of 20 teeth each, so that the average tooth size in each group was as equal as possible to minimize the influence of size and shape variations on the results.

Tooth dimensions were assessed with 1-way analysis of variance (ANOVA) to determine significant differences between groups. The control group contained teeth that remained intact; the teeth of the other 2 groups were subjected to the endodontic and restorative procedures. Two preliminary radiographs were made in bucco-lingual and mesio-distal directions to determine root canal anatomy. Endodontic treatment was performed using NiTi rotary instruments (ProTaper; Dentsply Maillefer)

The data were analyzed using statistical software (SPSS 11.0; SPSS Inc, Chicago, Ill). Data were subjected to a Kruskal-Wallis test to determine significant differences in failure loads among groups. When the Kruskal- Wallis test indicated a significant difference, multiple comparisons were performed using the Mann-Whitney test to determine which group differed from the others. Percentages were determined for the mode of failure, and statistical evaluation was completed using a chi-square test to determine significant differences in the mode of failure among groups.

A preset alpha level of .05 was used for all statistical analyses.

RESULTS

Mean (SD) bucco-lingual and mesio- distal dimensions of the teeth were 8.9 (0.46) mm and 10.5 (0.54) mm for DIR specimens, 8.88 (0.41) and 10.12 (0.59) mm for IND specimens, and 8.97 (0.51) and 10.60 (0.54) mm for control specimens, respectively.

The mean sizes of the teeth in the 3 groups were not significantly different for bucco-lingual (P=.797) or mesiodistal(P=.627) dimensions. The Kruskal-Wallis test showed that there were significant differences among the groups in their resistance to fracture under load (P=.001).

The Mann-Whitney test showed significant differences (P<.001) between the control group and both DIR and IND groups. No significant difference was found between DIR and IND groups (P=.532). The specimens fractured, respectively, at a mean (SD) failure load of 1432.4 (339.5) N and 1345.8 (276.3) N. The mean fracture strength of the control group was 2359.2 (570.9) N.

Teeth restored with direct and indirect restorations had a decreased fracture resistance of 41% and 44%, respectively, compared to intact teeth.

Almost 65% of failures for all groups were unfavorable (DIR, 68%; IND, 68%; control group, 61%). Disagreements between the 2 independent observers were resolved by discussion For 2 specimens, because the location of the fracture line was difficult to define with respect to the level of bone simulation.

The chi-square test did not show a significant difference in frequencies of favorable/unfavorable failure modes between the 3 groups (P=.883). All failures of the restored teeth were fractures of the composite resin restorations in combination with tooth

material (cohesive failures); no purely adhesive failures were observed.
Disagreements between the 2 independent observers were resolved by discussion for 2 specimens, because the location of the fracture line was difficult to define with respect to the level of bone simulation.

Group	Favorable	Unfavorable
DIR (direct)	32% (n = 4)	68% (n = 16)
IND (indirect)	32% (n = 4)	68% (n = 16)
Intact teeth	39% (n = 9)	61% (n = 11)

DISCUSSION

The results of the present study support the null hypothesis that there is no difference in the resistance to fracture and the mode of failure between direct and indirect composite resin restorations in endodontically treated molars prepared with an extensive loss of tooth structure. Numerous studies have been conducted to determine the ideal method to restore endodontically treated teeth. Endodontic treatment is considered to weaken teeth, resulting in increased susceptibility to fracture. Consequently, authors suggest that cuspal coverage with cast restorations is necessary for predictable restorative success of endodontically treated posterior teeth.[7]
Metal onlays and crowns have traditionally been recommended for large restorations, including cusp coverage. More recently, the use of indirect composite resin techniques has been indicated as well.[28,29] However, biomechanically, there is no evidence that indirect composite resin restorations are superior to direct restorations, and there are few longitudinal studies on the clinical behavior of extensive composite resin restorations.[27,30-33]
Complex direct composite resin restorations exhibit durability and have been shown to have sufficient strength to withstand occlusal forces and protect the remaining tooth structure.[8,27]Both direct and indirect restorations had a decrease in fracture resistance, respectively, of 42% and 44%, compared to intact teeth. These results are in agreement with other studies reporting that restored teeth had a significantly lower resistance to fracture.[3,23-25]
This confirms that cavity preparation reduces the rigidity of teeth and that the restorative process, even when adhesive techniques are associated with cuspal coverage, is not able to restore the resistance to load to the level of nonrestored, noncarious molars.[3,6,29,34]

CONCLUSION

Within the limitations of this in vitro study, endodontically treated molars prepared with an extensive loss of tooth structure and restored to their original contours with direct composite resin restorations presented a resistance to fracture under simulated occlusal load not significantly different than that of indirect composite resin restorations. Restored teeth had a decrease in fracture resistance compared to intact teeth. Furthermore, no differences were found in the mode of failure of the restored and intact teeth

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