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MICROLEAKAGE EVALUATION AND FRACTURE RESISTANCE OF PULPOTOMIZED PRIMARY MOLAR RESTORED WITH FIBER-REINFORCED COMPOSITE WITH AND WITHOUT STAINLESS-STEEL CROWN (IN-VITRO COMPARATIVE STUDY)

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ABSTRACT

Objectives: the objective of the current study was to assess the microleakage and fracture resistance of pulpotomized primary molars that were rebuilt with fiber-reinforced composite and either had or did not have a stainless-steel crown. **Subjects and Methods:** 96 carious primary molar teeth were categorized into four groups; the first group; primary molar teeth restored with fiber reinforced composite, the second group; primary molar teeth restored with fiber reinforced composite and stainless-steel crown, the third group; primary molar teeth restored with composite, the fourth group; primary molar teeth restored with composite and stainless-steel crown. Microleakage and fracture resistance were assessed using a stereomicroscope and universal testing machine respectively. **Results:** lower microleakage values were recorded in teeth restored with stainless-steel crowns, and the higher microleakage values were recorded in teeth restored without stainless-steel crowns. The higher fracture resistance values were recorded in teeth restored with stainless-steel crowns (1530.254±49.49), and the lower fracture resistance values were recorded in teeth restored without stainless-steel crowns (606.567±53.63). However, the teeth restored with fiber reinforced composite showed higher significant fracture resistance values when compared with the teeth restored with composite. **Conclusion:** SSC has received a high recommendation for primary molars that have undergone pulp treatment. FRC is advised in situations where parents have cosmetic concerns, provided that dental health is preserved.

KEYWORDS: Microleakage, Fracture Resistance, Pulpotomized Primary Molar, Fiber-Reinforced Composite

INTRODUCTION

Since pulpotomized teeth are more prone to fracture due to the large loss of tooth structure, one goal of dental materials research is to find the best restorative material for these teeth. The repair must be strong and long-lasting in order to maintain the tooth's residual structure and withstand masticatory pressures(1). Stainless-steel crowns are strongly suggested as the gold standard because they are the least likely to break the delicate cavity walls and limit the possibility of a pulpotomized tooth's marginal leaking. There are several negatives to

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using stainless-steel crowns, such as the need to remove a lot of good tooth material, interference with the first permanent molar's eruption course, and a metallic look that some parents find offensive. However, there is now a crucial need for aesthetics among both adults and children[2].

The improvement in primary molar repair brought about by the use of adhesive materials. A more careful approach to cavity preparation is made feasible by adhesive, helping to preserve more tooth structure and accelerating the healing process. Because of their increased strength and toughness, decreased heat conductivity, and outstanding aesthetics, the new composite resins appear ideal for replacing the occlusal and proximal surfaces of the posterior teeth[3,4].

Coronal restorations in teeth with significant coronal lesions still need to be reinforced, even if resin composite restorations increase a tooth's resistance to breakage. Fiber-reinforced composite (FRC), which has been developed, must possess strength, flexibility, and other mechanical qualities in order to be used successfully in the oral cavity. However, it is still challenging to find a useful substance to boost the pulpotomized primary molars' survival[2]. As a result, the objective of the current study was to assess the microleakage and fracture resistance of pulpotomized primary molars that were rebuilt with fiber-reinforced composite and either had or did not have a stainless-steel crown. We hypothesized that the teeth restored with fiber reinforced composite showed higher fracture resistance when compared with the teeth restored with composite. Null hypothesis, teeth restored with fiber reinforced composite showed a lower fracture resistance when compared with the teeth restored with composite.

SUBJECTS AND METHODS

Study design:

This study was designed as in vitro comparative experimental controlled study.

Study setting:

The Ethical Committee of the Faculty of Dental Medicine (Cairo, Boys), Al-Azhar University authorised the conduct of this study with regard to permission number (EC Ref No.656/3449). The Faculty of Dental Medicine (Cairo, Boys), Al-Azhar University's Pedodontics and Oral Health Department prepared the specimens. Less than 50% of the roots of the primary molar teeth that had been pulled for caries reasons were resorbed. These teeth were gathered from the outpatient clinic of the Pedodontics and Oral Health Department, Faculty of Dentistry, Al-Azhar University.

Sample size calculation:

Based on the previous study of Pultanasarn et al, 2020 [1] a power calculation of sample size indicated that a minimum of 12 teeth per group was required to detect a significant difference between groups. The effect size (dz=1.134) and the required sample size were calculated for an alpha (α) level of 0.05 and a power of (85%).

Sample grouping:

This study employed 96 carious primary molar teeth with less than half of their roots resorbed. The involved primary molar teeth were separated into four equal major groups, each with 24 primary molars restored with:

- **Group A:** FRC only.
- **Group B:** FRC and stainless-steel crown.
- **Group C:** conventional composite only.
- **Group D:** conventional composite and stainless-steel crown.

The samples from each main group were then split into two equal subgroups (n=12), depending on the type of test (microleakage and fracture resistance).

» **Randomization:** Using random.org software, the teeth samples were randomly separated into four groups.

» **Blinding:** The laboratory technicians were blinded throughout the various measurement processes. A statistician was blinded during the data management process as well.

» **Eligibility criteria for teeth selection**[3, 4]**:**

• **Inclusion criteria:** Primary molars with MOD cavities. Primary molars with root resorption are less than 1/2 of their length. Primary molars those free of cracks and developmental defects.

» **Exclusion criteria:** Primary molar teeth have caries on the buccal and lingual surfaces. Primary molars with root resorption are more than 1/2 of their length. Primary molars with visible macro-cracks and/or developmental defects.

» **Sample Preparation (fig 1, 2):**

- All teeth had a thin film of wax covering their root surfaces by immersing the root in molten wax for one time [2].

- The next step involved placing each tooth into a mould constructed of a thin, self-curing acrylic resin mixture. Acrylic resin was put up to 1-2 mm below the cementoenamel junction on the tooth surface to simulate the height of healthy alveolar bone (CEJ) [63].

- The root surface's wax was then removed with boiling water to provide the illusion of a periodontal ligament, and a rubber-base silicone impression material paste was then placed 1 mm apical to the CEJ in the area between the root surface and acrylic resin[4].

- The initial width of the occlusal component preparation for each tooth's MOD access cavity was equal to the inter-cuspal distance, and the diameter of each proximal box was 1 mm larger (the distance between the buccal and lingual cusps) [3].

- The pulp chamber was accessible using the high-speed bur once the cavity's contour was complete. The pulp chamber's final convenience shape was finished with a round bur in a slow-speed handpiece, revealing the canal orifices[4].

- Following air drying of the pulpotomized champers, a coating of zinc oxide and eugenol (ZO/E) cement was applied to seal the canal orifices.

- Then, the ZO/E cement was covered with a lining of glass ionomer cement (GIC) to prevent eugenol's inhibitory effect on resin polymerization[4].

» **Restoration Protocol:**

- For the first and second groups, the flowable composite (Bulk-fill composite, Dentsplay Sirona), USA was put into each ready cavity, the glass fibre (Sanadent, Dental Engineering, Italy) was cut (2 mm in width and 4 mm in length), and it was inserted there. The flowable composite was then exposed to LED light for 40 seconds to cure it[3, 42].

- For the 3rd and 4th groups, the conventional composite (3M ESPE, Dental Products, U) was placed in the cavity in incremental layers with a maximum 2mm thickness. Each composite increment was cured with LED light-cured for 40 seconds[3].

- After, the restored teeth in the 2nd and 4th groups were restored with stainless-steel crowns; a standard tooth preparation for stainless-steel crowns was carried out (reduction from 1.5 to 2.0mm of the occlusal surface, and Proximal surfaces were reduced using a 69 L/ tapered fissure bur at high speed to make room for the crown and establish a feather finish line cervically. Pronounced enamel convexity reduced by a small amount from buccal and lingual surfaces), and stainless-steel crown cementation was performed with resin cement

(SDI Riva set is a self etching, self adhesive, resin cement). All restored teeth were stored in artificial saliva at 37˚C in an incubator (for one month before being subjected to thermocycling).

- **Thermocycling:** All restored teeth in both tested groups were then subjected to thermocycling in distilled water at 5 ºC-55ºC for 500 cycles in a thermocycler with a dwell time of 30 seconds[5].

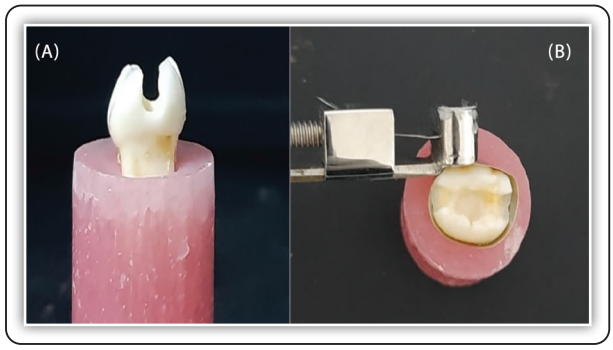

FIG (1) (a) MOD access cavity,(b) Pulpotomized primary molar teeth

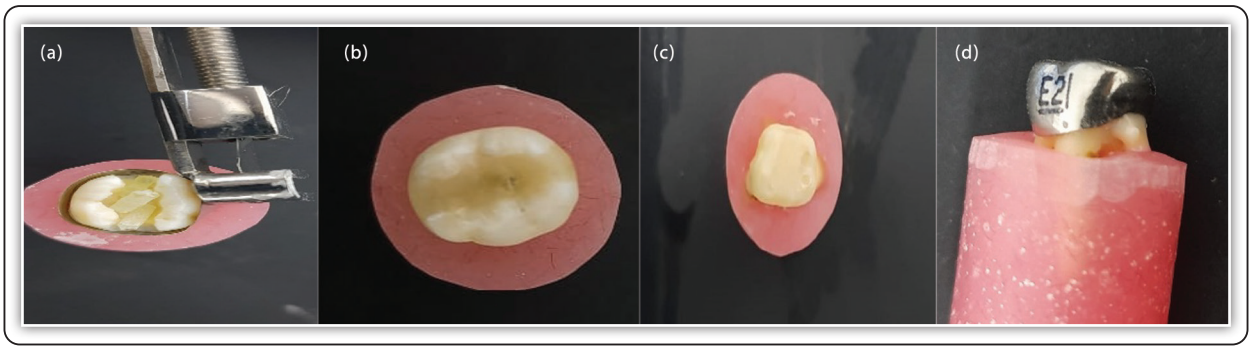

FIG (2) (a)Fiberglass post placement in the primary molar teeth ,(b) Primary molar teeth resorted with FRC,(c)Crown Reduction for SSC, (d)SSC cementation.

» **Testing procedures:**

1. Evaluation of microleakage:

– After thermocycling, two coats of nail polish were applied to the crowns of the teeth with FRC restorations, extending up to 1mm from the restoration edge. Following that, the repaired teeth in both test groups spent 24 hours submerged in 1% methylene blue.

– After that, samples were properly washed using tap water.

– Using a water-cool diamond saw and cutting in a buccolingual orientation (by dividing the distance mesiodistally using caliper), one longitudinal segment was created through the resin repair. Each tooth was divided into two parts, which were examined using a stereomicroscope at a magnification of X 40.

The tooth-resin composite interface was assessed, and each section was assigned a microleakage score from 0 to 3 based on dye penetration as follows: Score 0; no dye penetration was observed. Only enamel-specific dye penetration received a score of 1. Dye penetration up to the dentino-enamel junction received a score of two (DEJ). Dentine dye penetration received a 3 out of 10. After looking at both areas, the greatest microleakage score was recorded for each tooth.

2. Evaluation of fracture resistance:

On a universal testing machine, the resistance of the repaired teeth to fracture was evaluated using a constant compressive force applied by a crosshead moving at a speed of 0.5 mm/min by a circular metal bar in contact with the

buccal and lingual cusps' occlusal slopes. Using computer software, the peak stress that caused a tooth fracture was measured in Newtons (N) and translated to megapascals (MPa).

Statistical Analysis

With the help of SPSS® statistics Version 20, data were gathered, tabulated, and statistically examined. For regularly distributed quantitative variables, the F-test (ANOVA) was employed to compare more than two groups. The Chi-squared test (2) of Pearson was used to assess the qualitative data. The significance threshold was established at P<0.05.

RESULTS

1. Microleakage:

Based on the results of the **Chi-square test**, the difference between all tested groups was statistically significant (P=0.00066). The results of the microleakage scores showed that higher success percentages were recorded in both groups of teeth that were restored with SSC (FRC/SSC and composite/SSC) with a percentage of 75%, followed by the group of teeth that were restored with FRC with the percentage of 25%, while, the group of teeth that restored with composite alone showed the lower success percentage of 8.3%. **Table (1)**

TABLE (1) Comparison of the microleakage success and failure percentages in different groups.

Variables	Success N;(%)	Failure; N; (%)	Chi-square	P-value
FRC	3 (25%)	9 (75%)	17. 12	0.00066*
FRC/SSC	9 (75%)	3 (25%)		
Composite	1 (8.3%)	11(91.7%)		
Composite/SSC	9 (75%)	3 (25%)		

**; significant at P<0.05; ns; non-significant*

2. Fracture resistance

Based on the results of the **One-Way ANOVA test**, the difference between all tested groups was statistically significant (P<0.0001). The group of teeth that were restored with FRC/SSC showed higher mean values (1586.567±73.58), followed by the group of teeth that were restored with composite/SSC (1530.254±49.49), and the group of teeth that were restored with FRC alone (867.560±72.71). However, the group of teeth that were restored with composite alone showed lower mean values (606.567±53.63). The multiple comparisons by Tukey's test showed statistically significant differences in-between groups (P<0.05), except between the groups that restored with FRC or composite with SSC (P>0.05). **Table (2)**

TABLE (2) Comparison of fracture resistance in different groups.

Variables	Mean	SD	F-ratio	P-value
FRC	867.560^{B}	72.71	590.786	<0.00001*
FRC/SSC	1586.567^{A}	73.58		
Composite	606.567^{C}	53.63		
Composite/SSC	1530.254^{A}	49.49		

**; significant at P<0.05; ns; non-significant. Different uppercase letters indicate significance in the same column*

- P1; between FRC and FRC/SSC.
- P2; between FRC and composite.
- P3; between FRC and composite /SSC.
- P4; between FRC/SSC and composite.
- P5; between FRC/SSC and composite /SSC.
- P6; between composite and composite /SSC.

DISCUSSION

FRC is a novel option for posterior composite repair that provides all the advantages of composite restoration, including aesthetics, superior handling characteristics, and one-session treatment for dentists [4, 6]. The primary molar teeth that had been pulpotomized in this study were restored using FRC instead of SSC by encasing the fibres within the composite. This is due to the fact that FRC material is made up of two parts: the fibre and the matrix, which together serve as the reinforcing element providing support and strength for the process.[7].

According to the findings of this study, FRC had much less marginal leakage than traditional composite alone. This is due to the composite's volumetric contraction being slightly but noticeably reduced overall as a result of certain components being replaced by fibres, which also lowers the shrinkage stress[8]. Additionally, Thomas et al. 2020[9] noted that because to the larger hybrid layer in deciduous teeth, adhesive resin's ability to enter the dentin is reduced, which may have contributed to the greater microleakage of traditional composite in this study. Thermocycling, which was utilised in this investigation, presumably had an effect on the bonding strength of the adhesive interface at the cervical margin underneath the CEJ in addition to the amount of age.[10].

Likewise, as compared to FRC and composite alone, the SSC exhibited fewer microleakage outcomes, according to the findings of this study. This may be as a result of the SSC restoration's capacity to offer superior material adaption characteristics and as a result of the investigation's usage of resin cement [7].

The findings of this study revealed that FRC had a substantially higher fracture stress than conventional composite alone. This might be explained by the fact that, in the event of deformation of a fiber compartment of the fiber mesh, the fracture in FRC is either avoided or greatly slowed down at that point due to the associated stresses being passed to the next intact fiber mesh [8]. This may also be because the fibers are embedded in the composite, which forms a complex at the fiber-resin interface that absorbs shock without causing stress and prevents fracture initiation or propagation past the fiber layer. Furthermore, the cuspal splinting that follows the use of fiber may be the cause of the FRCs' increased fracture resistance [6].

These results supported those of Zareiyan et al. 2020 [4], who discovered that FRC had better fracture resistance than conventional composite resin due to the modification of the stress dynamics brought about by the existence of a fiber network at the restoration/adhesive resin interface. Therefore, compared to earlier tests, the MOD preparation in the current research produced a larger hollow [6]. This validates the statistically significant difference between the composite and FRC groups, emphasizes the role of fiber in mending tooth's ability to survive fracture, and emphasizes the advantages of using FRCs in teeth with more severe damage [4].

The findings of this study showed that when compared to FRC and conventional composite, the application of SSC had a much greater fracture strength, independent of the under-restoration. This could be because of the SSC's durability and robustness, which have earned it high praise in primary molars that have undergone pulp therapy. It is especially recommended for high-risk children who have significant lesions on both the front and rear of their main teeth [7].

The mean masticatory force for children aged 7 to 20 with normal occlusion was 219 144.21 N for girls and 309.50 193.75 N for males, according to studies. The rate for men in this age group was 186.2 N, while the rate for females was 203.4 N [12, 13]. Because it was equivalent to the largest load delivered by the machine throughout our experiment, the mean fracture resistance was larger than the typical masticatory forces. In practice, masticatory stresses are exerted for extended periods of time, at various

speeds, and in a variety of orientations, leading to a diversity of fracture patterns [13, 14]. In contrast to our study, where applied forces increased slowly until fracture occurred with a consistent rate and direction, According to our study, the mean fracture resistance value was much higher than the actual masticatory forces. The mean fracture resistance value in the control group was noticeably greater than the rates in permanent teeth, suggesting that all of the experimental restorative materials are more durable than the clinical guidelines for youngsters (considering the highest recorded stresses).

In the present study we reject the Null hypothesis, teeth restored with fiber reinforced composite showed a higher fracture resistance when compared with the teeth restored with composite.

CONCLUSION

SSC has received a high recommendation for primary molars that have undergone pulp treatment. FRC is advised in situations where parents have cosmetic concerns, provided that dental health is preserved.

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