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FRACTURE RESISTANCE OF ENDOCROWNS VERSUS PREFABRICATED ZIRCONIA CROWNS IN ENDODONTICALLY TREATED PRIMARY SECOND MOLAR TEETH: AN IN VITRO STUDY

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ABSTRACT

Objective: The purpose of the current study was to evaluate the fracture resistance of pulpotomized primary molars restored using hybrid ceramics endocrowns and prefabricated zirconia crowns. **Materials and methods:** Eight freshly extracted human mandibular second primary molars underwent pulpotomy procedure. Teeth were randomly divided into two groups according to the type of coronal restoration: Endocrown (EC) group (n=4) restorations made of CAD/CAM Milled Hybrid Ceramic blocks (VITA ENAMIC), and Zirconia crown (ZC) group (n=4) restored by prefabricated zirconia crowns (Nu Smile). A universal testing machine was used to evaluate fracture resistance of tested specimens. **Results:** There was no statistically significant difference (P=0.074) in the mean fracture resistance for EC group (1968.6±985.4) compared to the mean fracture resistance for the ZC group (890.9±142.5). **Conclusion:** Endocrowns can be used as a treatment option in pulpotomized primary molar teeth. VITA ENAMIC endocrowns can withstand the maximum intraoral masticatory force in the primary molars.

KEYWORDS: Primary Molar, Endocrowns, Prefabricated Zirconia Crowns

INTRODUCTION

Around the world, 60–90% of children are affected by dental caries. If neglected, caries could seriously may lead to destruction of the coronal part of the primary teeth partially or completely[(1)]. Primary molars are of paramount importance in terms of development of mastication and occlusal relationships, rendering their preservation a priority in clinical pedodontics practice. Endodontic treatment usually is the technique of choice, where pulpotomy possess a proper clinical long-term serviceability averting pulpectomy step [(2)], however, primary molars show a significant weakening following pulpotomy procedures due to diminishing remaining tooth substance, making these teeth more liable to fracture when subjected to normal occlusal forces [(1)]. The restoration of devitalized primary molars should improve their coronal seal, esthetics, functional and mechanical properties [(3,4)].

The use of stainless-steel crowns (SSCs) is the most well-known full-coverage restoration technique in pediatric dentistry [(5)]. Zirconia crowns

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(ZCs) were launched as an alternative to traditional restorative procedures. The long history of zirconia demonstrates its superior biocompatibility. Zirconia crowns' longevity and aesthetically pleasing appearance are two of their key benefits[6,7]. Zirconia crowns have some clinical limitations and drawbacks because they are costly, do not allow for color matching or shade choosing, and necessitate drastic tooth reduction. The tooth reduction needed for ZCs is roughly 20 to 30% more aggressive than the tooth reduction needed for SSCs. For primary molars, sufficient tooth reduction is a deciding element for ZC's passive fitting [6,7].

Endocrowns (ECs) require less circumferential tooth reduction than ZCs. Once the tooth has been reduced, the conclusion of the crown preparation terminates supragingival, which removes any potential discomfort or gingival stress. In contrast, the ZC ending line must protrude sub gingivally for 1 to 2 mm [7]. The use of endocrowns in pediatric dentistry is somewhat new. Therefore, this study aimed to assess and investigate the functionality of endocrowns for primary teeth in lab conditions. For this investigation, various outcome metrics were taken into consideration.

ETHICAL CONSIDERATION

This work was approved by the Ethical Committee of the Faculty of Dental Medicine, Al-Azhar University (Boys, Cairo), with the permission number EC Ref. No. (682/3904).

MATERIALS AND METHODS

Eight freshly extracted mandibular second primary molars from human patients.

The buccal, lingual and occlusal surfaces of all selected teeth were free of caries, no developmental disorders, no obvious cracks after extraction, no prior dental restorations.

Teeth selected were then inspected using a digital microscope under 50X magnification. Using an ultrasonic scaler soft tissue tags were scrapped off, then teeth were disinfected using 10% formalin to avoid affecting the fracture resistance then they were stored in distilled water till their use. Self-cured acrylic resin (Acrostone, Egypt) was used to fix the specimens in molds made of ready-made polypropylene tubes of dimensions 19ml x 17ml. Mounting teeth in their molds was done using a Mounting surveyor (Maarathon-103 Surveyor Saeyang Microtech Co. Ltd, Korea.) to ensure their proper positioning, where the teeth were fixed to the pin of the surveyor with pink wax in an upright position, then lowered into the molds centrally and vertically till the level of the resin was 2mm below the cementoenamel junction [5,6].

Pulpotomy procedures

Caries was removed with a high- speed handpiece with round diamond bur under copious irrigation. Then, access to the pulp chamber was obtained with carbide fissure bur. All access cavity walls were flared to allow complete exposure of the pulp chamber. Upon pulp exposure, the roof of the pulp chamber was removed with a high-speed diamond round bur. Then, the pulp chamber was thoroughly irrigated with saline. Then, a hand thick mix of Zinc-oxide and eugenol paste was applied to the prepared cavity to seal the orifices [5].

Sample size calculation

To Evaluate the fracture resistance of endocrown (hybrid ceramic) versus zirconia crown, t test or an equivalent non-parametric test will be used for comparison of between 2 groups. According to a previous study by Seddik and Derelioglu (2019)[8], The mean fracture resistance (N) was 1741±379.35 in endocrown group compared to (1126.5± 405.39N) in control.

Based on Seddik and Derelioglu (2019) [8] and using G power statistical power Analysis program (version 3.1.9.4) for sample size determination, A total sample size of 8 (4 in each group) will be sufficient to detect a large effect size (d) =2.84, with an actual power (1-β error) of 0.8 (80%) and a significance level (α error) 0.05 (5%) for two-sided hypothesis test.

Randomization and group annotation:

Teeth were randomly divided into two groups according to the type of restored crown. Each specimen was given a number from 1-8, then by the aid of an online randomizing program (www.randomizer.com), specimens were then randomly allocated in either of the two study groups such that each group received a different restorative material: 1. Endocrown (EC) group (n=4): restored by CAD/CAM Milled Hybrid Ceramic blocks (VITA ENAMIC). 2. Zirconia crown (ZC) group (n=4): restored by prefabricated zirconia crowns (Nu smile).

Prefabricated zirconia crowns tooth preparation and cementation:

The cavity was filled with resin modified glass ionomer (Promedica, Germany) to the top. Teeth were prepared according to manufacturer's recommendations for preparation of primary molars to receive zirconia crowns. A tapered stone (TR-12 Dia Bur Mani) attached to the milling surveyor was used to reduce the occlusal surface and central grooves to a depth of 1mm from central portion of the tooth. It was used to prepare the axial walls and do the proximal reduction to ensuring a passive fit of the selected crown, eliminating the height of contour and performing the axial preparation. This reduction performed gradually and on all planes of the tooth. This results in a preparation which is parallel to slightly converging occlusally, follows the natural contours of the existing clinical crown. The preparation margin refined to a feather edge so that no undercuts or ledges remain. Visualize the internal dimensions of the selected crown at the gingival opening and avoid excessive tooth reduction in the cervical areas for adequate crown retention. Line angles and point angles should be smoothed so that all surfaces of the prepared tooth are slightly rounded. Zirconia crown size was selected according to the dimension of the tooth ensuring a passive fit. For cementation of prefabricated zirconium crown resin modified glass ionomer cement was employed to cement zirconia crowns. Excess cement was removed with a scaler after setting time of glass ionomer [9].

Endocrowns tooth preparation, scanning, cementation:

A diamond wheel bur attached to milling surveyor. It was used to perform an occlusal reduction of 2 mm. To achieve a butt joint cervical margin, the bur was oriented along the major axis of the tooth and held parallel to the occlusal plane [3,7]. Then, the pulpal walls were prepared with 6° to 8° divergence toward the occlusal surface, and a 96° to 98° angle between the pulpal floor and pulpal walls were obtained by using tapered stone. Gingival seat was prepared 1mm above the cemento-enamel junction. After that, internal angles were smoothened and rounded. Then, the cavity floor was sealed with a layer of flowable composite (Nexcomp flow, Meta, Korea) to isolate the ZO/E from the successive resin-based restorations and adhesives [10].

Tooth scanning:

Prepared tooth was scanned with digital scanner (Scanner EDGE Dental System, DOF, Korea) and data were transferred to the software of the CAD/CAM (Imes-icore CAD/CAM Dental System, Germany). Then, the CAD/CAM milling machine was used to fabricate the endocrowns. Each tooth has its own numbering and each endocrown takes the same numbering for the same tooth so that each tooth corresponds to its endocrown and avoiding overlap between samples.

Endocrown cementation:

Endocrown try-in was checked for seating gently by loading device under pressure, the intaglio surfaces of the endocrowns were cleaned using phosphoric acid then etched with porcelain etchant (9.5% HF acid, BISCO, USA) for 30 seconds, then rinsed thoroughly for 60 seconds then dried with air. Then, porcelain Silane (BISCO, USA) was applied to the intaglio surface of the endocrowns by a micro brush and allowed to dry for 60 seconds. Then, the enamel boundary of the prepared tooth was etched selectively by 37% phosphoric acid (Meta, Korea) for 20 sec and rinsed thoroughly by air-water spray for 40 seconds then air-dried without desiccating dentinal walls. Then the dual-cure resin cement (BISCO, USA) was applied using auto mix syringe to the fitting surface of the previous surface-treated endocrowns and the prepared teeth. The endocrowns was placed on their corresponding preparations by loading device pressure. The bonded endocrowns was exposed to light curing for 2-3 seconds to tack cure excess cement. Excess cement was removed with a scaler, margins were covered by an air blocker and then light-curing was done again for additional 40-seconds for each side.

Thermocycling:

All specimens were stored in a distilled water at 37°C for 1 week. After that, teeth were subjected to 500 thermal cycles between 2 water baths of 5° and 55°C with a dwell time of 30 s at each temperature in the thermocycling device [11].

Fracture resistance test:

Each specimen was individually mounted on a computer-controlled universal testing machine (Instron model 3345 universal testing machine, England) with a load cell of 5 KN and data was recorded using computer software (BlueHill universal Instron, England). Then, the sample was secured to the lower fixed compartment of the testing machine by tightening screws. Fracture test was done by compressive mode of load applied occlusally using a metallic rod with a round tip (3.6 mm diameter) attached to the upper movable compartment of testing machine travelling at cross-head speed of 1mm/min with tin foil sheet in-between to achieve homogenous stress distribution and minimization of the transmission of local force peaks. The load at failure manifested by an audible crack and confirmed by a sharp drop at the load-deflection curve recorded using computer software. The load required to fracture will be recorded in Newton (N).

Statistical analysis

Statistical analysis was performed using a commercially available software program (SPSS Chicago, IL, USA). The level of significance will be set at P≤0.05. Numerical data were described as mean and standard deviation (±). Comparisons between the two groups were performed using independent tests for normally distributed variables and Mann Whitney test for not normally distributed data.

RESULTS

Fracture resistance

Numerical data of fracture resistance test results measured in newton (N) were described as mean and standard deviation (±), and are summarized in table (1) and graphically drawn in figure(1). Data were explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. A P-value of less than 0.05 were set as the level of statistical significance. Data were analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 27 (SPSS Inc., Chicago, IL). According to independent T test, there was no statistically significant difference (P=0.074) in the mean fracture resistance for EC group (1968.6±985.4 with a range of (829.3-3038.7)) compared to the mean fracture resistance for the ZC group (890.9±142.5 with a range of (745.3-1071.7)).

TABLE (1) Fracture resistance comparison among the studied groups.

				95% CI				
		Mean	**SD(±)**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**	**P value**
Group (1)	**EC**	1968.6	985.4	400.5	3536.6	829.3	3038.7	0.074
Group (2)	**ZC**	890.9	142.5	664.1	1117.7	745.3	1071.7	

EC:Endo Crowns, ZC: Zirconia Crown , SD: Standard deviation, CI: confidence interval, p<0.05 is considered significant

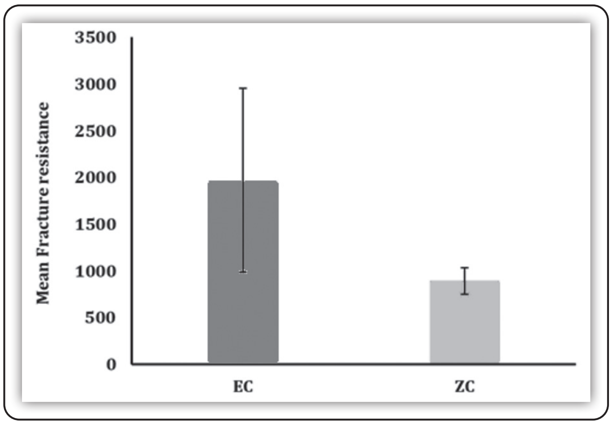

FIG (1) A column Chart representing mean and SD (±) of fracture resistance among the studied groups.

DISCUSSION

The purpose of the current study was to evaluate the fracture resistance of pulpotomized primary molars restored using hybrid ceramic endocrowns and prefabricated zirconia crowns. In vitro study was employed because it overcomes many limitations associated with clinical testing such as individual human variation by establishing a controlled environment. These tests provide a guideline about the load-bearing capacity of the different systems on a prosthetic restoration like crowns may provide information that is closer to the clinical situation than testing material properties on standardized samples [12]. Human teeth were selected for this study to mimic better the clinical situation where the contour of the pulp chamber and root canals, and the ratio between the crown and root would be more accurate than on artificial teeth. The enamel and dentin surface that is accessible for bonding determines how Monoblock the endocrowns work, and the surface preparation of both the restorations and the tooth surface has a significant impact on the specimens' ability to fracture resistance and microleakage [13]. It was compared with prefabricated zirconia crown since it is commonly used by many pediatric dentists. To achieve consistency in the preparation, teeth were prepped using a specific milling surveyor in accordance with clinically accepted preparation requirements for all-ceramic endocrowns [14].

The fracture resistance data revealed that the mean fracture resistance for the EC group did not differ statistically significantly (1968.6±985.4) compared to the mean fracture resistance for the ZC group (890.9±142.5). Khattab et al., [7] compared endocrowns' (IPS e.max Press/Ivoclar Vivadent) clinical performance, gingival health, and parental satisfaction to those of prefabricated zirconia crowns (ZCs) over a 24-month of follow-up. Endocrowns' clinical performance and gingival health were comparable to those of ZCs. Parental satisfaction with both restorations was quite similar, with the exception of the colour, which favoured endocrowns. In pulpotomized primary molars, Yehia et al. 2022 (15) investigated and compared the fracture resistance of three different endocrown materials. The results demonstrated that there was no statistically significant difference in the mean values of fracture resistance between the four groups (Vita Enamic: 1407.53432.24 N, PMMA: 1399.98264.18 N, and

Indirect Composite: 1215.17207.63 N; P=0.375). Primary molar teeth restored by endocrown materials whether CAD/CAM milled Vita Enamic or PMMA as well as indirect nano hybrid composite, demonstrated comparable fracture resistance mean values with no statistically significant difference between them, and this reflects that these restorations could be viable alternatives to other treatment modalities that could be less esthetic or less conserving to the tooth structure.

Sevimli et al., [16] evaluated equal stresses during mastication in molars repaired with endocrowns against posts and cores. According to simulations, ceramic endodontic crowns that are correctly cemented in molars are more resilient to failure and fracture under physiological pressures than traditional restorations like fiber-reinforced composite (FRC) posts. However, The study's findings by Kamel et al. [17] indicated that prefabricated zirconia crowns had statistically significantly superior mean fracture resistance than composite endocrowns.

In contrast, Sabbah and Kamel [18] compared the strength of primary molars with endocrown restorations to zirconia crowns that were already made. In comparison to Endocrown, Zirconia Crown demonstrated statistically substantially greater mean fracture resistance (P = 0.001).Compared to primary molars restored with endocrowns, pulpotomized teeth with Zirconia crowns shown considerably higher mean fracture resistance; nonetheless, both restorations demonstrated mean fracture resistance greater than the maximal biting force in children. El Makawi and Khattab et al. [1] revealed that compared to lithium disilicate endocrowns, Nusmile zirconia crowns had statistically significantly superior fracture resistance.

Sabbah and Kamel [18] assessed the fracture resistance of primary molars restored with Endocrowns (ceram.x SphereTEC one universal, Dentsply Sirona, USA). El Makawi and Khattab [1] assessed the fracture resistance of primary molars restored with Endocrowns (IPS e.max Press/ Ivoclar Vivadent). but in the present study we used Endocrowns VITA ENAMIC.

According to the results of these study, prefabricated zirconia crown showed statistically significantly higher mean fracture resistance than endocrown. The mean occlusal load that causes fracture of prefabricated zirconia crowns is in consistency with those founded by El Makawi and Khattab [1] and Vinson et al. [19] which were (1420.893 ± 308.39 N) and (1214 ± 82 N) respectively, while the results of fracture resistance weren't in agreement with the study done by Altier et al.2018 which was 2366.50b ± 420.86, as this study was performed on permanent teeth [20].

In the current study, the mean fracture loads used with both materials were higher than the ultimate force of mastication reported. Thus, it can be assumed that both materials tested could bear up the ultimate intraoral masticatory forces in the posterior area, enabling both types of restorations to be successful for restoring pulpotomized primary molars. Meanwhile endocrown restorations have the advantage of conservation of tooth structure compared to zirconia crowns. These observations imply that the endocrown preparation and cementation method significantly increased the restoration's strength, likely due to a more homogeneous structure and more favorable distribution of forces over the Endocrown restoration rather than the zirconia crown.

CONCLUSION

Endocrowns can be used as a treatment option in pulpotomized primary molar teeth. VITA ENAMIC endocrowns can withstand the maximum intraoral masticatory force in the primary molars.

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