EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 68, 2047:2055, July, 2022

Print ISSN 0070-9484 • Online ISSN 2090-2360

Orthodontics, Pediatric and Preventive Dentistry

Submit Date : 05-04-2022 • Accept Date : 10-05-2022 • Available online: 30-06-2022 • DOI : 10.21608/edj.2022.131591.2061

COMPARING THE FRACTURE RESISTANCE OF THREE ENDOCROWN MATERIALS IN PULPOTOMIZED PRIMARY MOLARS: AN IN-VITRO STUDY

Islam Yehia*, Noha Kabil **, Maged Zohdy*** *and* Ola Abd El Geleel****

ABSTRACT

Objective: The objective of this study is to evaluate and compare the fracture resistance of three different endocrown materials in pulpotomized primary molars .

Methodology: This in-vitro experimental study was carried out on a total of (n=24) primary second molar teeth. Pulpotomy was performed in all the specimens, then the teeth received a standardized preparation for an endocrown restoration, later they were randomly allocated into three groups (n=8 each), according to the material used for construction, first group: restored by CAD/CAM Milled Hybrid Ceramics (VitaEnamic), second group: restored by CAD/CAM Milled Poly-methyl methacrylate (Telio CAD), and the last group was restored by Nano hybrid Composite resin (Filtek Z250) using an indirect technique.

Results: Kruskal-Wallis test followed by Mann-Whitney U test were used to assess the fracture resistance of different endocrown groups. And the results showed that there was no statistically significant difference in fracture resistance mean values between (Vita Enamic: 1407.53±432.24 N, PMMA: 1399.98±264.18 N and Indirect Composite: 1215.17±207.63 N) between the different groups (P=0.375).

Conclusions: 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.

Keywords: pulpotomized primary molars, endocrowns, indirect restorations for primary molars, CAD CAM in pediatric dentistry

* Teaching assistant, Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, British University in Egypt, Cairo, Egypt.
** Professor and Head of the Department of Pediatric Dentistry & Dental Public Health, Faculty of Dentistry, British University in Egypt, Cairo, Egypt.
*** Associate Professor, Fixed Prosthodontics Dept., Faculty of Dentistry, Ain-Shams University, Cairo, Egypt.
**** Lecturer, Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Ain-Shams University, Cairo, Egypt. And at the Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, British University in Egypt, Cairo, Egypt.

INTRODUCTION

Pulpotomy is usually the treatment option when primary molars develop inflamed coronal pulps due to caries. This treatment option results in brittle and fragile remaining tooth structure as the technique involves amputation of the entire coronal pulp without leaving any residual tissue tags that could compromise the prognosis. Among other factors, the success rate of this treatment option is largely dependent on the coronal seal rendered by the final restoration [1].

Moreover, the selected final restoration should replace the missing tooth structure efficiently in an attempt to improve the functional and mechanical performance and thus their survival [2].

Stainless Steel crown has been considered as the gold standard for restoring primary molars following pulpotomy as it is capable of providing strength to the weakened tooth structure as well as coronal seal and resistance to microleakage. However, its inferior esthetics is considered a major shortcoming when the patient/parental satisfaction is considered [3,4].

On the other hand, the major advancements in the adhesive protocols have shifted the paradigm of teeth restoration following pulp therapy, so that full coverage is no longer required since indirect restorations as Endocrowns are now considered a viable alternative to full coverage restorations [5].

At the same time, CAD/CAM systems are becoming widely available in dental laboratories and offices nowadays, and they can easily provide milled restorations with adequate precision, quality and esthetics which further favor the indirect restorations over the conventional treatment modalities [6].

Among the advantages of Endocrowns is that they are more conservative as minimal tooth preparation is required for their construction. They are also esthetically pleasing, have high wear resistance, excellent marginal seal and can be adjusted to reproduce ideal proximal contact with the adjacent teeth [7].

In addition, these restorations are becoming strongly indicated in situations where there is an excessive loss of the remaining tooth structure and there is limited interocclusal distance, which complicate other treatment alternatives as the placement of zirconia crowns. Pediatric dentists usually encounter these obstacles when restoring pulpotomized primary molars [8].

Upon reviewing the existing literature, there is abundancy of studies on the application of Endocrowns restoring endodontically treated permanent teeth, however, there is paucity of data regarding their use in pulpotomized primary molars. Since it is crucial for pediatric dentists to make the best use of these advancements that could impact the quality of care provided for young patients in a favorable manner, more data should be available on their use in pediatric dentistry. In this perspective, this in-vitro study was conducted to compare different modalites and materials used to construct endocrowns applied to pulpotomized primary molars regarding the fracture resistance.

Study design

The study was designed following an in-vitro experimental model.

Sample size estimation

According to the results of Simsek and Derelioglu [9], assuming an Alpha (α) level =0.05 (5%) , and a Beta (β) level =0.20 (20%) i.e., power= 80%. The calculated sample size was set to a total number of 24 teeth (8 in each group) using EpiCalc program version 1.02.

Materials

All the materials utilized in the study are listed in the following table (Table, 1).

TABLE (1): Materials used in the study

Material	Commercial name	Manufacturer
Polymer infiltrated ceramic blocks/ Hybrid Ceramics	VITA ENAMIC for CEREC/ in Lab, Shade : 3M2 – HT	VITA Zahnfabrik, Bad Sackingen, Germany
Posterior Nano Hybrid Composite	Filtek™ Z250 Universal Restorative	3M ESPE.USA
99.5% PMMA Polymer	Telio CAD	Ivoclar Vivadent, Schaan, Liechtenstein
Self-Adhesive resin cement auto mix	Breeze self-adhesive resin cement	Pentron clinical USA
9.5 % buffered hydrofluoric acid gel	Porcelain etchant (9.5% HF)	Bisco, Inc. Shaumburg, USA
Porcelain Silane,	Ultradent – Silane	Ultradent Products USA
Self-etching adhesive	One coat 7 universal	Coltène/Whaledent GmbH Co./Germany
37% phosphoric acid etch	Any-Etch	Mediclus Co.,LtdKorea
Zinc oxide eugenol	i-ZOE	I- dent, Lithuania
Reinforced Glass ionomer	Fuji Equia Capsules	GC Tokyo, Japan.

Methodology

1. Selection of the specimens

Recently extracted upper primary molars were collected. The teeth were extracted for reasons other than this research. The selection of teeth that were included in this study was according to the following criteria:

- At least one third of the root was still intact, with intact floor.
- At least three of the axial walls were intact with a minimum of 1 mm of remaining sound tooth structure.

Teeth were examined under microscope and any molars displaying cracks or fractures were excluded [9].

2. Specimens' preparation

Using a hand scaler soft tissue tags were scrapped off, then the teeth were disinfected using 10% formalin to avoid affecting the fracture resistance then they were stored in distilled water till their use [10].

Acrylic resin was used to fix the specimens in molds made of ready-made polypropylene tubes of dimensions 5 cm x 8 cm. 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 (fig.1), then lowered into the molds centrally and vertically till the level of the resin was 2mm below the cemento-enamel junction [9].

Fig. (1): Specimen fixed by sticky wax to the moving rod of the Mounting Surveyor

Caries removal was done using (size 4) round bur (Mani Carbide Burs), mounted on a high-speed hand piece with profuse coolant. Access cavity was done then the walls were flared to facilitate undisturbed access to the canal orifices.

All the residual pulp tissue was removed by a sharp excavator (DENTSPLY, Germany), then a thick mix of (Zinc-oxide & Eugenol paste) was applied to seal the orifices, the material was allowed to set and excess material was removed.

A thin layer of Glass ionomer (Fuji Equia, GC Tokyo, Japan) was injected into the cavity floor to seal all the undercuts as well as to isolate the Zinc-oxide & Eugenol from the subsequent resin adhesives or restorations and leaving at least a 3 mm height of the pulp chamber to provide sufficient thickness of the final restoration [11].

The specimens were prepared to receive endocrowns, using regular wheel stone and tapered diamond stones attached to a straight hand piece mounted on the surveyor to standardize the preparations in all the teeth.

Occlusal reduction or clearance was achieved by a wheel stone (WR-13 Dia Bur Mani) of 2mm working length thickness, the vertical component was adjusted to allow 2mm reduction, the horizontal component however was flexible to allow clearance of the entire surface.

Axial wall flaring was done with a standard degree of divergence of 8 degree angle utilizing a tapered stone (TR-12 Dia Bur Mani), the vertical component was adjusted such that the stone almost touches the glass ionomer base, while the horizontal component was also kept flexible.

Gingival seat was prepared 1 mm above the cement-enamel junction.

3. Grouping of teeth

Each specimen was given a number from 1-24, then by the aid of an online randomizing program (www.randomizer.com), specimens were then randomly allocated in either of the three study groups such that each group received a different restorative material:

1. VitaEnamic Group (n= 8): restored by CAD/CAM Milled Hybrid Ceramics (VitaEnamic)
2. PMMA Group B (n= 8): restored by CAD/CAM Milled Poly-methyl methacrylate (Telio CAD)
3. Indirect composite Group C (n= 8): restored by Nano hybrid Composite resin (Filtek Z-250) using an Indirect technique.

4. Restoration fabrication

For first two groups, the restoration was prepared using the (CEREC AC system) (Sirona Dental Systems, GmbH, Bensheim, Germany). After the type of restoration has been selected on the software, the prepared specimens were scanned by Cerec Bluecam to obtain optical impressions to produce a 3D virtual models. This was followed by inspection and verification of the virtual die where the software blocks any undesirable undercuts and hence the path of insertion of the restoration being produced is adjusted. Later, in the design phase, the proposed design of the endocrown was displayed on the model and any final adjustments were made. After the suitable grinding instruments were secured, the milling order was activated, and the selected block placed in the milling chamber of the MC XL unit was ground. The milling process was later fol-

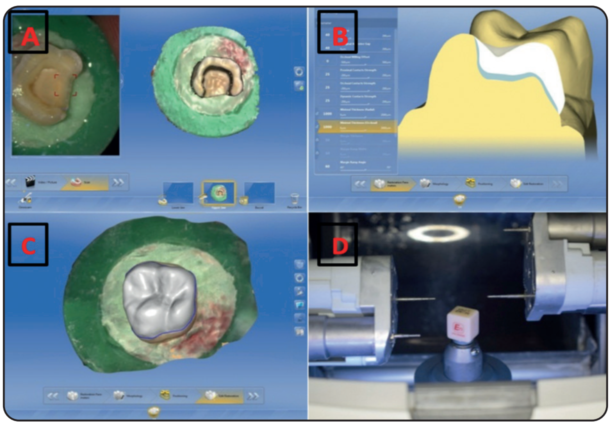

Fig. 2: A. Obtaining optical impression B. Adjusting restoration parameters C. Proposed design D. Block secured in CEREC machine ready for milling

lowed by finishing and polishing according to the manufacturer's instructions (fig. 2).

For the indirect composite group restorations, rubber-base impression materials were used to obtain gypsum models of the pre-prepared specimens, the models were sprayed with a separating medium to facilitate the separation of the restoration once finished [12]. The indirect restorations were built up following an incremental technique of a five to six increments each cured for 20 s, then the final restorations were finished by wet grinding with fine and extra fine grit diamond [13] (fig.3).

5. Cementation

All the prepared specimens were selectively etched by 37% Any-etch (Mediclus – Korea) for 30 s, rinsed thoroughly by water spray for 30 s and then gently dried for additional 30 s. An adhesive ONE Coat7 Universal (Coltene - Germany) was applied by a micro brush then air dried to remove excess then cured for 40 s [14].

As for the restorations' surfaces, **Group (A) VitaEnamic:** Etching of the fitting surfaces of the endocrowns was done using Porcelain etchant (9.5% HF acid: Bisco USA) for 60 s, rinsed thoroughly for another 60 s then dried with air. Porcelain Silane (Ultradent USA) was then applied by special brush , dried with air then left to react for 60 s. For **Group (B) Telio CAD and Group (C) Indirect composite:** the restorations were sand blasted and primed [15,16].

Cementation was carried out by self-adhesive resin cement (Breeze Pentron – USA) applied to the fitting surface of the treated endocrowns and to the prepared teeth. The endocrowns were placed on their corresponding preparations by static finger pressure and were left for 5 minutes during which they were exposed to a brief light curing for only 2 seconds. Then excess cement was removed with a scaler, then light curing was done for 40 seconds for each side [17].

6. Fracture resistance testing

Using a universal testing machine; Lloyd, LR-5K (Ametek – USA), specimens were placed under mechanical loading by applying axial occlusal loading force to the center of the restoration's occlusal surface (central fossa) via a stainless steel ball (2.5mm in diameter) utilizing thrust speed of the machine was 0.5 mm/min until the specimens fractured, where the fracture force was scored in Newtons. Fracture was indicated only when the load suddenly dropped [18].

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics Version 2.0 for Windows. Data was presented as mean and standard deviation (SD). The

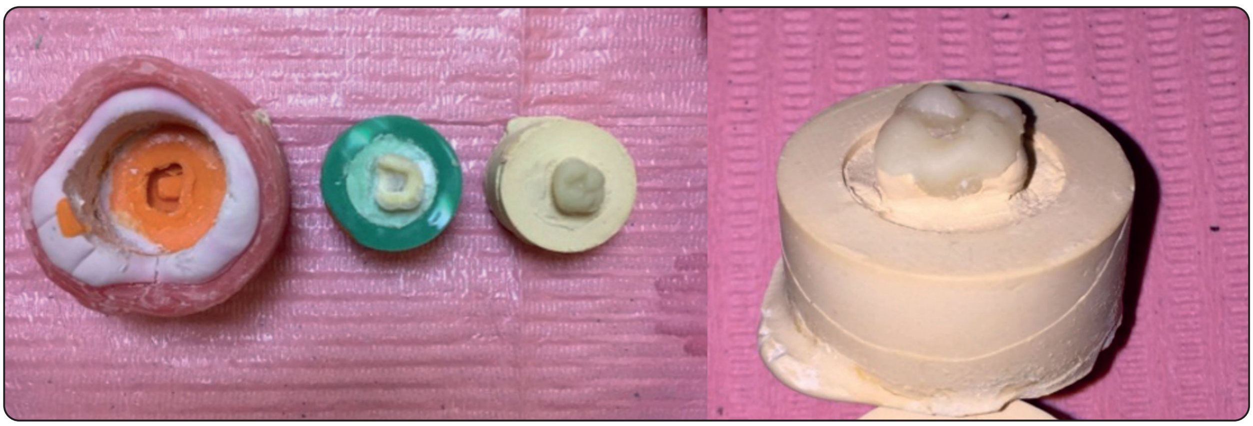

Fig. (3): Group C restorations: Rubber-base impression, prepared specimen, Final restoration on a stone model

TABLE (2): Mean ± SD of fracture resistance (N) of specimens restored with different endocrown materials

	Endocrown material						P-value
	Vita Enamic		PMMA		Indirect Composite		
Fracture resistance (N)	Mean	SD	Mean	SD	Mean	SD	
	1407.53	432.24	1399.98	264.18	1215.17	207.63	0.375 NS

P ≤ 0.05 NS: non-significant

significance level was set at P ≤ 0.05. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess data normality. Kruskal-Wallis test followed by Mann-Whitney U test were performed to compare the fracture resistance values of specimens restored with different endocrown materials.

RESULTS

The results showed that there was no statistically significant difference in mean values of fracture resistance between the three groups of teeth restored by different endocrown materials (P=0.375). However, the Indirect Composite endocrown group scored the least values with a Mean and SD of (1215.17±207.63 N) followed by PMMA group (1399.98±264.18 N), while the Vita Enamic group scored the highest Mean and SD values (1407.53±432.24 N) (Table 2 and fig.4).

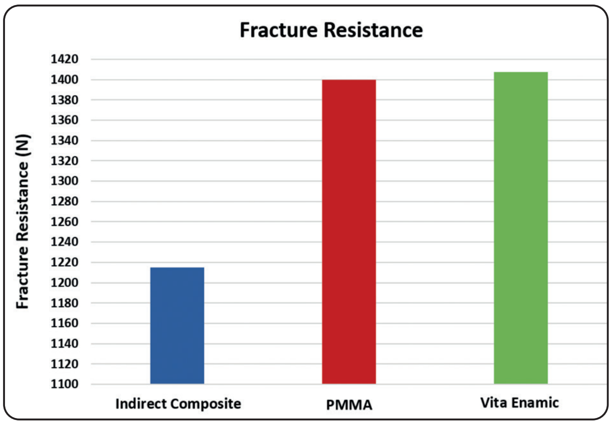

Fig. (4): Fracture resistance of primary molars restored by different endocrown materials

DISCUSSION

Although stainless steel crowns had been successfully used for restoring pulpotomized primary molars, both pediatric patients and their guardians have been seeking more esthetic options [19,20]. Prefabricated Zirconia crowns constitute an outstanding esthetic alternative, but there are limitations to their wide usage which include the need for extensive full tooth reduction, complicated handling and manipulation, risk of causing wear to the opposing teeth, and their relatively high cost [21,22].

On the other hand, Endocrowns with their esthetic properties and conservative approach are already applied in restoring endodontically treated permanent teeth and are considered as pertinent option especially with the huge development in CAD/CAM technology. These restorations showed higher fracture strength when compared to other treatment modalities like full direct composite resin, indirect (inlay/onlay) restorations or even coverage crowns [23, 24].

Evidence of significant chemical and morphological differences between permanent and primary dentition, such as a less mineralization and larger diameter of dentinal tubules [25] rather render the presumption that results of previous studies testing endocrowns on permanent teeth would also apply to primary teeth inaccurate.

Tooth/restoration fracture is usually encountered in carious teeth or in those with cavity preparations, where the tooth structure has already been weakened. Therefore, fracture resistance was assessed in this study since it is an important criterion in the long-term success of various restorative materials used in restoring pulpotomized teeth [26].

The results of the current study showed that, there was no statistically significant difference in the fracture resistance mean values between the tested groups. This finding came in agreement with the results of Simsek and Derelioglu [9] who also found no statistically significant difference between fracture resistance of endocrowns constructed by CAD/CAM milled Vita Enamic Blocks or those built-up from Composite using the indirect fabrication technique.

It is worth mentioning though that the values obtained in this study were remarkably higher than those obtained in similar previous studies by Simsek and Derelioglu [9] and by El Makawi & Khattab [11], this might be attributed to discrepancies in the test methods as the crosshead speed, ball diameter or type of load application by different testing machines or due to variation in cementation materials or techniques. However, the aforementioned studies in addition to ours, obtained fracture resistance values above the average biting force of a (5-10) year old child (375 Newtons) [27], which supports the notion that these restorations would perform favorably in children.

Despite of that, the mean fracture resistance values were much lower than those obtained by Altier et al. [28] who conducted their study on permanent teeth instead of primary molars , this variation could be resorted to inherent differences between primary and permanent teeth, a finding which adds another parameter to justify the diversity of values obtained in discrete studies.

In disagreement with our results, the previously mentioned authors found out that the mean fracture resistance values of ceramic based endocrowns utilized in their research were significantly higher than those of indirect composite endocrowns fabricated from two different micro hybrid composites (Solidex and Gradia) that were tested in their research. The higher filler content of Filtek™ Z250 (zirconia/silica fillers ,82% wt.) utilized in our research compared to the 53% wt. and 75% wt. of Solidex and Gradia respectively, could be a possible explanation to why indirect composite endocrowns performed preferably in the current investigation.

In the same line with our results, Mete et al. [29] reported that the mean fracture resistance force of Telio CAD (PMMA) endocrowns was 1245.1 N, a value which is a comparable to that obtained in this research. The researchers investigated the fracture resistance of endocrowns used to restore primary molar teeth milled from three different polymeric resin blocks, and they deduced that Telio CAD (PMMA) endocrowns yielded the highest fracture resistance values compared to modified PMMA or Resin nanoceramic endocrowns which represented the other two comparison groups in their study. The authors resorted the superior performance of PMMA to intrinsic weaknesses in the other two resin based materials as water degradation caused by their hydrophilic components since the specimens were already stored in water prior to the study commencement .

Although the current study provides data that might encourage clinicians to use endocrowns whenever the facilities for their construction are made available, yet there are some limitations which are related to the absence of certain factors that are present in the clinical situations, among which is the of the role of the periodontium which acts as a shock absorber that alters the impact of inbound stresses thus could serve the fracture resistance favorably [30]. Moreover, the force applied experimentally has an axial/vertical vector only, thus the lateral forces created by parafunctional movements are cancelled out, these forces however could have an adverse impact on the durability of restorations clinically [30].

CONCLUSION

Considering possible limitations of this study it could be concluded that, 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 data reflects that these restorations could be a viable alternative to other treatment modalities that could be less esthetic or less conserving to the tooth structure.

REFERENCES

1. Elhennawy K, Finke C, et al, . Selective vs stepwise removal of deep carious lesions in primary molars : 12-Months results of a randomized controlled pilot trial. J. Dent. 77, 72–77 (2018).
2. Rocca G, Krejci I, . Crown and post-free adhesive restorations for endodontically treated posterior teeth: from direct composite to endocrowns. Eur. J. Esthet. Dent. 8, 156–79 (2013).
3. H, Ludwig K, Fontana M, Vinson L A, Platt J A, Dean J A. The success of stainless steel crowns placed with the Hall technique: A retrospective study. J. Am. Dent. Assoc. 145, 1248–53 (2014).
4. Martin U, et al. Protocol for the Hall Technique study: A trial to measure clinical effectiveness and cost-effectiveness of stainless steel crowns for dental caries restoration in primary molars in young children. Contemp Clin Trials 44, 36–41 (2015).
5. Murphy F, Mcdonald A, Petrie A, Palmer G, Setchell D, . Coronal tooth structure in root-treated teeth prepared for complete and partial coverage restorations. J. Oral Rehabil. 36, 451–61 (2009).
6. Abdullah A O, Muhammed F K, Zheng B, Liu Y, . An Overview of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) in Restorative Dentistry. J Dent Mater Tech 7, 1–10 (2018).
7. Opdam NJM, Frankenberger R, Magne P, . From 'Direct Versus Indirect'' Toward an Integrated Restorative Concept in the Posterior Dentition'. Oper. Dent. 41, 27–34 (2016).
8. Bilgin M S, Erdem A, Tanrıver M, . CAD/CAM Endocrown Fabrication from a Polymer-Infiltrated Ceramic Network Block for Primary Molar: A Case Report. J. Clin. Pediatr. Dent. 40, 264–69 (2016).
9. Simsek H, Derelioglu S. In Vitro Comparative Analysis of Fracture Resistance in Inlay Restoration Prepared with CAD-CAM and Different Systems in the Primary Teeth. Biomed Res. Int. 2016, 1–6 (2016).
10. Michaud PL, Maleki M, Mello I. Effect of different disinfection/sterilizationmethods on risk of fracture of teeth used in preclinical dental education. JDent Educ. 82(1):84-87 (2018). doi:10.21815/JDE.018.012.
11. El Makawi Y & Khattab N. In Vitro Comparative Analysis of Fracture Resistance of Lithium Disilicate Endocrown and Prefabricated Zirconium Crown in Pulpotomized Primary Molars. Open access Macedonian journal of medical sciences, 7(23), 4094–4100 (2019). https://doi.org/10.3889/oamjms.2019.864
12. Yassen A A, Haridy M F, . Clinical Study on the Influence of Using Separating Medium and its Type On Indirect Resin Composite Microtensile Bond strength to Dentin. Egypt. Dent. J. 61, 1–9 (2015).
13. Ferreira M C, Vieira R S, . Marginal leakage in direct and indirect composite resin restorations in primary teeth: An in vitro study. J. Dent. 36, 322–25 (2008).
14. Villalta P, Oliveira L B, et al, . Indirect composite onlay restorations in primary molars: a clinical report. J. Clin. Pediatr. Dent. 31, 17–20 (2006).
15. Güleç L, Ulusoy N, Cengiz E, . Indirect resin composite restorations fabricated with chairside CAD/CAM systems. Cumhur. Dent. J. 19, 247–55 (2016).
16. Coldea A, Swain M V, Thiel N, . Mechanical properties of polymer infiltrated ceramic network materials. Dent. Mater. 29, 419–26 (2013).
17. Taha D. et al. Fracture resistance and failure modes of polymer in filtrated ceramic endocrown restorations with variations in margin design and occlusal thickness. J. Prosthodont. Res. 62, 293–97 (2018)
18. Alshiddi I F, Aljinbaz A,. Fracture resistance of endodontically treated teeth restored with indirect composite inlay and onlay restorations - An in vitro study. Saudi Dent. J. 28, 49–55 (2016).
19. Guelmann M , Shapira J , Silva D R, Fuks A B, . Esthetic restorative options for pulpotomized primary molars: a review of literature. J. Clin. Pediatr. Dent. 36, 123–6 (2011).
20. Dhar V, et al, . Evidence-based Update of Pediatric Dental Restorative Procedures: Dental Materials. J. Clin. Pediatr. Dent. 39, 303–10 (2015).

21. Choi J, Bae I , et al, . Wear of primary teeth caused by opposed all- ceramic or stainless steel crowns. J. Adv. Prosthodont. J Adv Prosthodont 8, 43–52 (2016).
22. Shuman I , et al, . Pediatric Crowns : From Stainless Steel to Zirconia. Dent. Econ. 106, 65–74 (2016).
23. Sedrez-Porto J A, et al, . Endocrown restorations: A systematic review and meta-analysis. Journal of Dentistry 52, 8–14 (2016).
24. Biacchi G, Basting R, . Comparison of fracture strength of endocrowns and glass fiber post-retained conventional crowns. Oper dent 37, 130– 36 (2012).
25. Ruschel H C, Ligocki G D, Flaminghi D L, Fossati A C M, . Microstructure of Mineralized Tissues in Human Primary Teeth. J. Clin. Pediatr. Dent. 35, 295–300 (2015).
26. Ban S, Anusavice KJ. Influence of test method on failure stress of brittle dental materials. Journal Dent Res 69,12, 1791–1799 (1990).
27. Bakke M, Holm B, Jensen BL, Michler L, Möller E. Unilateral, isometric bite force in 8-68-year-old women and men related to occlusal factors. Scand J Dent Res 98, 149-58(1990).
28. Altier M, Erol F, Yıldırım G, Dalkilic EE, . Fracture Resistance and Failure Modes of Lithium Disilicate or Composite Endocrowns. Niger J Clin Pr. 21, 821–26 (2018).
29. Mete A, Yilmaz Y, Derelioglu SS,. Fracture Resistance Force of Primary Molar Crowns Milled from Polymeric Computer-Aided Design/Computer-Assisted Manufactured Resin Blocks. Niger J Clin Pr. 21, 525–30 (2018).
30. Quintas AF, Oliveira F, Bottino MA, . Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: an in vitro evaluation. J Prosthet Dent 92, 250–57 (2004).