Published online: 2019-09-04

Original Article

Effects of pulp capping materials on fracture resistance of Class II composite restorations

Ebru Kucukyilmaz[1], Bilal Yasa[2], Merve Akcay[1], Selcuk Savas[1], Fevzi Kavrik[1]

[1]Department of Pediatric Dentistry, Faculty of Dentistry, Izmir Katip Celebi University, Izmir, Turkiye, [2]Department of Restorative Dentistry, Faculty of Dentistry, Izmir Katip Celebi University, Izmir, Turkiye

Correspondence: Dr. Ebru Kucukyilmaz
Email: ebrukucukyilmaz@hotmail.com

ABSTRACT

Objective: The aim of this study was to investigate the effect of cavity design and the type of pulp capping materials on the fracture resistance of Class II composite restorations. **Materials and Methods:** Sixty freshly extracted, sound molar teeth were selected for the study. A dovetail cavity on the mesio-occlusal and a slot cavity on disto-occlusal surfaces of each tooth were prepared, and the teeth were divided 4 groups which one of them as a control group. The pulp capping materials (TheraCal LC, Calcimol LC, Dycal) applied on pulpo-axial wall of each cavity, and the restoration was completed with composite resin. The teeth were subjected to a compressive load in a universal mechanical testing machine. The surfaces of the tooth and restoration were examined under a stereomicroscope. The data were analyzed using factorial analysis of variance and Tukey's test. **Results:** For pulp capping materials, the highest fracture load (931.15 ± 203.81 N) and the lowest fracture load (832.28 ± 245.75 N) were calculated for Control and Dycal group, respectively. However, there were no statistically significant differences among all groups ($P > 0.05$). The fracture load of the dovetail groups was significantly higher than those of the slot cavity groups ($P < 0.05$). **Conclusion:** Dovetail cavity design shows better fracture resistance in Class II composite restorations, independent of used or not used pulp capping materials.

Key words: Composite resins, pulp capping agents, tooth fracture

INTRODUCTION

There is a growing demand for new restorative materials in dental treatment procedures. With the development of new adhesives, resin composites are rapidly becoming the primary restorative material for direct restoration of posterior or anterior teeth due to their ability to bond to the dental structure.[1,2] Especially for Class II restorations, resin composites are the first choice in clinics.

Resin composites are technique-sensitive materials. Thus, it is difficult to use them in the proximal boxes of Class II cavity preparations and in irregular internal surfaces.[3] Due to this difficulty, based on the low elastic modulus of flowable material, flowable resin composites have been recommended to create an intermediate layer between the tooth, and packable composite resins.[4-6] The reduced filler content, enhanced flow capacity, and easy handling properties of flowable composites result in better sealing by forming a stress absorbing layer.[4,6,7] This stress absorbing layer reduces not only the polymerization shrinkage of the materials, but also the functional stress on the restored teeth.[1,8] However, some studies indicated that the liner or based materials, such as flowable composite or resin-modified glass ionomer, not reduce the polymerization shrinkage.[9,10] On the contrary, these liners lead to more stresses and a possible adhesive failure. Hence, the benefit of the intermediate layer become disputable.[11]

Pulp capping is a procedure which is performed for maintaining the vitality of the pulp when vital pulp is exposed or the remaining thin layer of dentin over a nearly exposed pulp during cavity

How to cite this article: Kucukyilmaz E, Yasa B, Akcay M, Savas S, Kavrik F. Effects of pulp capping materials on fracture resistance of Class II composite restorations. Eur J Dent 2015;9:218-23.

Copyright © 2015 Dental Investigations Society.

DOI: 10.4103/1305-7456.156831

preparation and removal of carious dentine.[12,13] The pulp capping material applications can preserve the dentin-pulp complex against bacteria penetration due to microleakage and toxicity of restorative materials.[12] The success of the restorations, after pulp capping procedures, is closely related with protection of the dentin-pulp complex.[14] Pulp capping materials can also be used to show antibacterial activity, promote dentine bridge formation and protect the pulp tissue against thermal shocks.[12,13,15] Calcium hydroxide is the most widely used pulp capping material in restorative dentistry due to its new dentin formation-inducing ability, protecting the pulp against thermoelectric stimuli, antibacterial effects, and alkaline pH.[16] Despite its popularity, the physical properties of conventional calcium hydroxide, such as its water solubility, bond strength to dental hard tissues, and compressive strength, are relatively poor.[17] Due to these disadvantages, light curing pulp capping materials were developed to treat deep cavities and in case of pulpal damage. In addition to aiding pulp healing, these resin-based materials serve as an intermediary layer in the cavity walls similar to that of flowable composite.[18-20] The aforementioned light curing pulp capping materials generally contain calcium hydroxide, but nowadays a calcium silicate containing light curing pulp capping agent has been introduced.[18,21] According to one study, TheraCal LC is a calcium-releasing material able to induce the formation of apatite and represents a promising material in direct pulp capping clinical procedures.[21] The ability to form apatite may play a positive role in new dentin formation. Another study indicated that it displays low solubility, low cytopathic effects, and sustained alkalinity.[21] Moreover, due to the low-temperature changes during polymerization, it might be preferable as an indirect pulp capping material in deep cavities.[22]

The fracture resistance of resin composites is a critical factor for the clinical success of restorations. The cavity design, anatomical contour of the tooth, pulp capping material used under the restoration, type of base and restorative material, type of bonding agent, configuration factor, composite placement technique, occlusal habits, and mastication forces affect the fracture resistance of composite restorations.[1,3,5,23,24]

Several researchers have investigated the fracture resistance of direct composite resin restorations in Class II preparations.[1-3,25,26] However, no study has investigated the effect of different pulp capping materials and cavity designs of Class II cavity preparation on the fracture resistance of composite restorations. Therefore, the purpose of this study was to investigate the effect of cavity design and the type of pulp capping materials on the fracture resistance of Class II composite restorations.

The null hypotheses were that (i) there would be no statistically significant difference among the various pulp capping materials used under the restoration, and (ii) there would be no statistically significant difference in their fracture resistance based on the cavity design.

MATERIALS AND METHODS

The present study was approved by the Research Ethics Committee of the Izmir Katip Celebi University, under report No. 2014/63. Sixty freshly extracted, sound, caries-free human molar teeth indicated for extraction because of periodontal problems were selected for the study. Calculus and soft tissue deposits were cleaned using a periodontal scaler and pumice slurry. The specimens were then immersed in thymol solution for 48 h for disinfection and stored in 4°C distilled water until used in the restorative and testing procedures. The buccolingual and mesiodistal dimensions of each tooth at the most prominent point of the tooth's surface were recorded using a digital caliper to determine the medium size range. The average buccolingual and mesiodistal mean widths were 10.83 mm and 9.68 mm, respectively. Each tooth was embedded in autopolymerizing acrylic resin (Vertex Dental, Zeist, The Netherlands) using a polyvinyl chloride cylinder (3 cm in height and 2 cm in diameter) up to 1 mm below the cement-enamel junction.

A dovetail cavity was made on the mesio-occlusal surface of each tooth and a slot cavity was made on the disto-occlusal surface of each tooth using a fissure type diamond bur, with a high-speed handpiece with oil-free water spray cooling. Standardized cavity preparations were prepared by a single operator. Facio-lingual dimension of the slot preparation was 3 mm, and mesiodistal dimension was 2.5 mm, the gingival floor was 1 mm above cementoenamel-junction. Facio-lingual dimension of the dovetail preparation was 3 mm (the narrowest part was 2 mm), the gingival floor was 1.5 mm wide, the axial wall was 2 × 2 mm and the gingival floor was 1 mm above cemento-enamel junction. The depths of the cavities were measured with a periodontal probe, and the widths of the cavities were measured with a

caliper. The prepared specimens were divided into four groups of 15 teeth, with approximately equal mean dimensions in each group:

Group 1 (control group)
After preparing the cavity, a metal matrix held by a Tofflemire retainer (S.S. White Dental Manufacturing Company, Philadelphia, PA, USA) was placed around the tooth. A self-etch adhesive (Clearfil SE Bond, Kuraray Okayama, Japan) was applied on the cavities with the tips of a disposable microbrush according to the manufacturer's instructions. Light curing was performed using a light-emitting diode light curing unit (Valo, Ultradent Products Inc., South Jordan, UT, USA) for 20 s. Increments of the composite resin were first applied (Clearfil Majesty Posterior, Kuraray Tokyo, Japan) to the gingival wall and then to the pulpal wall. The final increment was applied flush with the contour of the tooth. All the increments were light cured. Immediately after filling, the samples were finished with diamond burs at low speed with air-water spray and polished with a disc system (OptiDisc System, Kerr Corporation, Orange, CA, USA).

Group 2 (Dycal Group)
The pulpoaxial wall of each Class II cavity was lined with a self-setting calcium hydroxide pulp capping material (Dycal® Dentsply Caulk, Milford, DE, USA) using a 1 mm diameter ballpoint instrument. The matrix band was placed and secured using a Tofflemire matrix retainer, and the remainder of the cavity was then restored with Clearfil SE bond and Clearfil Majesty Posterior as described for Group 1.

Group 3 (Calcimol LC Group)
The pulpoaxial wall of each Class II cavity was lined with a light curing calcium hydroxide pulp capping material (Calcimol LC, Voco GmbH, Cuxhaven, Germany) as described for Group 2. The restoration was then completed with Clearfil SE bond and Clearfil Majesty Posterior as described for Group 1.

Group 4 (TheraCal LC Group)
The pulpo-axial wall of each Class II cavity was lined with a light curing resin-modified calcium silicate pulp capping material (TheraCal LC, Bisco Inc., Schaumburg, IL, USA) as described for Group 2. The restoration was then completed with Clearfil SE bond and Clearfil Majesty Posterior as described for Group 1.

After the restoration procedures, the teeth were subjected to a compressive load in a universal mechanical testing machine (Shimadzu, Model AGS-X5kN, Shimadzu Corporation, Kyoto, Japan) connected to a personal computer with specially designed software. A 5 kN load cell was used, and the crosshead speed was kept constant at 1 mm/min. The load was applied at the marginal ridge of the restoration, making 13.5° angles with the longitudinal axis of the tooth. A special steel mold was prepared to hold the long axis of the teeth at a 13.5° angle to the vertical plane. A smooth cylindrical head (3 mm in diameter) was mounted in a specially constructed testing head. An increasing load force was applied until the restoration failed. The failure load of the restorations was recorded in Newton (N). The surfaces of the tooth and the restoration were examined microscopically and classified as adhesive, cohesive, or mixed fractures.

Statistical analysis
Prior to the data collection, a power analysis was performed with G*Power 3.0.10 (Franz Faul, Christian-Albrechts-Universität, Kiel, Germany) to estimate the sample size. The analysis indicated that a sample size of 15 teeth per group for eight groups achieved 90% power, with a medium effect size, and a significance level of $\alpha = 0.05$l.

The results of the fracture resistance and failure modes were analyzed using the IBM SPSS Statistics version 20.0 statistical package (SPSS, Chicago, IL, USA). The dependent variable across the groups was examined in terms of existence normality assumption by performing a Shapiro–Wilk test and Levene's test for constant homogeneous variances. Accordingly, the data were analyzed statistically using a factorial analysis of variance and *post-hoc* Tukey's test at a significance level of $P < 0.05$.

RESULTS

The mean values for all the pulp capping materials and the cavity design types are presented together in Table 1. In the evaluation of cavity design factor, independently of others factors, the mean fracture resistance values of the dovetail and slot cavity groups are presented in Table 2. The fracture load of the dovetail group was significantly higher than that of the slot cavity group ($P < 0.05$).

For the pulp capping materials, the highest fracture load (931.15 ± 203.81 N) and the lowest fracture load (832.28 ± 245.75 N) were calculated for the control group and the Dycal group, respectively. However,

there were no statistically significant differences among all groups ($P > 0.05$) [Table 3].

The predominant fracture mode for all preparation groups was mix fracture (45.0%), for dovetail preparations was adhesive (45.0%) and mix fracture (43.3%), for slot cavity preparations was mixed fracture (46.7%) occurring in all four restorative procedures. The details of all the fracture modes are presented in Table 4.

DISCUSSION

Increasing demand for esthetic restorations has led dental researchers to focus on the development of materials that exhibit natural durability and strength. Among these, composite resins are clinically the most popular materials for the restoration of anterior and posterior teeth. However, for Class II cavities, the primary reason for the failure of composite resin restoration is fracture of the tooth or the restoration, wear off, loss of the bond between the tooth and the restoration, or loss of marginal adaptation.[3,24,27,28] Many studies have investigated the fracture resistance of Class II composite restorations because of their clinical relevance.[1-3,25,26] However, no study has investigated the effect of different pulp capping materials and the cavity design of Class II cavity preparation on the fracture resistance of composite restorations. Therefore, the main objective of this study was to evaluate the effect of cavity design and the type of pulp capping materials on the fracture resistance of Class II composite restorations.

For this study, human molar teeth extracted for periodontal problems were selected. While the differences between the anatomies of the teeth tested, such as the structure of the dental tissue, thickness of the enamel, geometry of the pulp chamber and external crown size, molar teeth which have comparable external crown size were selected, because the other variables could not be controlled. In the present study, the fracture resistance of composite restoration has been investigated. Because of the failure load of the restorative materials is associated with the bond strength of used bonding agent,[29] the same bonding system has was used in all the groups. Experimental comparative studies of the bond strength of various self-etching systems demonstrated superior adhesive performance of MDP-based bonding agents to enamel and superficial/deep dentine.[30,31] Thus, an MDP based self-etching system was used in the current study to maintain ideal bond strength.

Table 1: Mean and SD of the fracture load (Newton) of each group

	Mean±SD	
	Dovetail	Slot cavity
Control group	978.44±246.48^{a,A}	883.86±143.18^{a,A}
Dycal	946.53±260.99^{a,A}	718.03±170.35^{a,A}
Calcimol LC	1016.15±208.51^{a,A}	694.47±167.33^{a,A}
TheraCal LC	1065.94±293.59^{a,A}	714.50±104.51^{b,A}

*Different small letters label statistically significant differences between cavity designs, *Different capital letters label statistically significant differences between pulp capping materials (P<0.05). SD: Standard deviation, LC: Light curing

Table 2: The fracture load (Newton) for cavity design factor and results of ANOVA, independent of other factors

Cavity design	*n*	Mean±SD
Dovetail	60	1001.77^{a}±251.72
Slot cavity	60	752.72^{b}±164.01

*The letters sign statistically different groups (P<0.05). SD: Standard deviation, ANOVA: Analysis of variance

Table 3: The fracture load (Newton) for pulp capping materials factor and results of ANOVA, independent of other factors

Pulp capping materials	*n*	Mean±SD
Control group	30	931.15^{a}±203.81
Dycal	30	832.28^{a}±245.75
Calcimol LC	30	855.31^{a}±247.52
TheraCal LC	30	890.22^{a}±280.76

*The letters sign statistically different groups (P<0.05). SD: Standard deviation, LC: Light curing, ANOVA: Analysis of variance

Table 4: The distribution of fracture modes for all groups

Group	Cavity design	Adhesive fracture	Cohesive fracture	Mix fracture
Control group	Dovetail	8	2	5
	Slot cavity	2	5	8
Dycal group	Dovetail	8	1	6
	Slot cavity	7	4	4
Calcimol LC group	Dovetail	6	3	6
	Slot cavity	11	1	3
TheraCal LC group	Dovetail	5	1	9
	Slot cavity	1	1	13
Total		48	18	54

LC: Light curing

To assess the influence of the type of pulp capping materials and cavity design on the fracture resistance of Class II composite restorations, a compressive test was conducted. The load was applied at the marginal ridge of the restoration, making a 13.5° angle with the longitudinal axis of the tooth. This angle is the typical loading angle used in dental applications.[3]

According to the results of the present study, the first null hypothesis was accepted because the type

of pulp capping material used under the restoration did not affect the fracture resistance of the Class II composite restorations. The use of pulp capping materials, which may act as flowable composite, did not significantly improve the fracture resistance of the composite restorations. As stated earlier, there is no study in the literature on the effect of pulp capping agents on the fracture resistance of composite restorations. However, the results of the present study are consistent with similar studies that used a flowable composite as a liner under restorations.[3,32] Ozgünaltay and Görücü compared the fracture resistance of Class II packable composite restorations with and without flowable liners and found no significant difference between the groups.[3] In that study, a micro hybrid flowable composite was used as a liner in the pulpoaxial wall of Class II slot restorations in a similar way with the present study. In another study, it has been reported that the fracture resistance of endodontically treated maxillary premolars has not been affected the use flowable composite as a base under composite restorations.[32] On the contrary, Akbarian *et al*. reported that the use of flowable liners increased the fracture resistance of teeth with MOD cavity preparations.[5] The discord between these studies may be related to the cavity design of the preparation, the site of the pulp capping material, the thickness of the material, and the design and application area of the cylindrical head.

Considering the findings of the present study, the second null hypothesis was rejected. We hypothesized that the cavity design of Class II cavity restorations does not affect the fracture resistance of composite restorations. The results of the study suggest that the dovetail cavity preparation may increase the fracture resistance of composite restorations. Contrarily, the resistance of the slot cavity preparations was not as strong as that of the dovetail preparations. This was apparently due to the dovetail preparations enhancing the bonding between the composite and dentin by increasing the available surface area. In the literature, some studies reported that the cavity design of the restorations influenced the fracture resistance of composite restorations[33,34] and others reported that the type of cavity preparation does not affect the force required to cause fracture.[35,36]

Today, the preservation of a sound tooth structure during cavity preparation is considered important. Thus, in the restoration of caries limited with approximal areas, slot cavity preparations are generally preferred. However, to increase the bond strength of the restorations, generating a secondary retention may play a vital role.[37,38] Considering the data obtained from the present study, especially in cases where it is necessary to increase the durability of the restorations against occlusal forces, such as bruxism, part functional oral habits, grinding or clenching, dovetail preparations may be preferred for restoration of Class II approximal caries.

When evaluating the results of this study, it should be noted that the direct application of *in vitro* results to *in vivo* settings may not be possible. Basic laboratory methods are mainly employed to test the fracture resistance of teeth and restorations. The experimental method of occlusal loading during the fracture test is important, but forces applied in laboratory tests differ from intraoral forces. Such tests cannot simulate the repeated stress that occurs during oral functioning, in addition, axial and lateral forces. However, this methodology is largely employed in the literature, and it provides important information about the fragility of the various components. The real performance of restorations can be determined only in clinical trials. Thus, additional clinical studies are required to support the clinical application of slot or dovetail preparations and the use of pulp capping materials.

CONCLUSION

Dovetail cavity design shows better fracture resistance in Class II composite restorations, independent of used or not used pulp capping materials.

REFERENCES

1. Güray Efes B, Yaman BC, Gümüstas B, Tiryaki M. The effects of glass ionomer and flowable composite liners on the fracture resistance of open-sandwich class II restorations. Dent Mater J 2013;32:877-82.
2. Geurtsen W, Schoeler J. 4-year retrospective clinical study of Class I and II composite fillings. J Dent 1997;25:229-32.
3. Ozgünaltay G, Görücü J. Fracture resistance of class II packable composite restorations with and without flowable liners. J Oral Rehabil 2005;32:111-5.
4. Sadeghi M, Lynch CD. The effect of flowable materials on the microleakage of Class II composite restorations that extend apical to the cemento-enamel junction. Oper Dent 2009;34:306-11.
5. Akbarian G, Ameri H, Chasteen JE, Ghavamnasiri M. Fracture resistance of premolar teeth restored with silorane-based or dimethacrylate-based composite resins. J Esthet Restor Dent 2014;26:200-7.
6. Kemp-Scholte CM, Davidson CL. Marginal integrity related to bond strength and strain capacity of composite resin restorative systems. J Prosthet Dent 1990;64:658-64.
7. Cavalcanti AN, Mitsui FH, Ambrosano GM, Marchi GM. Influence of adhesive systems and flowable composite lining on bond strength of class II restorations submitted to thermal and mechanical stresses. J Biomed Mater Res B Appl Biomater 2007;80:52-8.
8. Castañeda-Espinosa JC, Pereira RA, Cavalcanti AP, Mondelli RF. Transmission of composite polymerization contraction force through a flowable composite and a resin-modified glass ionomer cement.

J Appl Oral Sci 2007;15:495-500.
9. Kwon Y, Ferracane J, Lee IB. Effect of layering methods, composite type, and flowable liner on the polymerization shrinkage stress of light cured composites. Dent Mater 2012;28:801-9.
10. Oliveira LC, Duarte S Jr, Araujo CA, Abrahão A. Effect of low-elastic modulus liner and base as stress-absorbing layer in composite resin restorations. Dent Mater 2010;26:e159-69.
11. Braga RR, Hilton TJ, Ferracane JL. Contraction stress of flowable composite materials and their efficacy as stress-relieving layers. J Am Dent Assoc 2003;134:721-8.
12. Modena KC, Casas-Apayco LC, Atta MT, Costa CA, Hebling J, Sipert CR, *et al.* Cytotoxicity and biocompatibility of direct and indirect pulp capping materials. J Appl Oral Sci 2009;17:544-54.
13. Langeland K. Effect of various procedures on the human dental pulp. Oral Surg Oral Med Oral Pathol 1961;14:210-33.
14. Hilton TJ. Keys to clinical success with pulp capping: A review of the literature. Oper Dent 2009;34:615-25.
15. Conrado CA. Remineralization of carious dentin. I: *In vitro* microradiographic study in human teeth capped with calciumhydroxide. Braz Dent 2004;15:59-62.
16. Cohenca N, Paranjpe A, Berg J. Vital pulp therapy. Dent Clin North Am 2013;57:59-73.
17. Cox CF, Sübay RK, Ostro E, Suzuki S, Suzuki SH. Tunnel defects in dentin bridges: Their formation following direct pulp capping. Oper Dent 1996;21:4-11.
18. Gandolfi MG, Siboni F, Prati C. Chemical-physical properties of TheraCal, a novel light-curable MTA-like material for pulp capping. Int Endod J 2012;45:571-9.
19. Ulusu T, Oztas N, Tulunoglu O. Comparison of the effect of insertion techniques of a resin composite on dentinal adaptation of two visible light-cured bases: Direct evaluation versus a replica technique. Quintessence Int 1996;27:63-8.
20. Subramaniam P, Konde S, Prashanth P. An *in vitro* evaluation of pH variations in calcium hydroxide liners. J Indian Soc Pedod Prev Dent 2006;24:144-5.
21. Hebling J, Lessa FC, Nogueira I, Carvalho RM, Costa CA. Cytotoxicity of resin-based light-cured liners. Am J Dent 2009;22:137-42.
22. Savas S, Botsali MS, Kucukyilmaz E, Sari T. Evaluation of temperature changes in the pulp chamber during polymerization of light-cured pulp-capping materials by using a VALO LED light curing unit at different curing distances. Dent Mater J 2014;33:764-9.
23. Huang MS, Li MT, Huang FM, Ding SJ. The effect of thermocycling and dentine pre-treatment on the durability of the bond between composite resin and dentine. J Oral Rehabil 2004;31:492-9.
24. Dietschi D, Argente A, Krejci I, Mandikos M. *In vitro* performance of Class I and II composite restorations: A literature review on nondestructive laboratory trials – Part II. Oper Dent 2013;38:E182-200.
25. Roberts HW, Vandewalle KS, Charlton DG, Berzins DW. Fracture resistance of amalgam/glass-polyalkenoate open sandwich Class II restorations: An *in vitro* study. J Dent 2008;36:873-7.
26. Kikuti WY, Chaves FO, Di Hipólito V, Rodrigues FP, D'Alpino PH. Fracture resistance of teeth restored with different resin-based restorative systems. Braz Oral Res 2012;26:275-81.
27. Goldstein GR. The longevity of direct and indirect posterior restorations is uncertain and may be affected by a number of dentist-, patient-, and material-related factors. J Evid Based Dent Pract 2010;10:30-1.
28. Braga RR, Ferracane JL. Alternatives in polymerization contraction stress management. Crit Rev Oral Biol Med 2004;15:176-84.
29. Brosh T, Pilo R, Bichacho N, Blutstein RJ. Effect of combinations of surface treatments and bonding agents on the bond strength of repaired composites. J Prosthet Dent 2007;19:90-8.
30. Kaaden C, Powers JM, Friedl KH, Schmalz G. Bond strength of self-etching adhesives to dental hard tissues. Clin Oral Investig 2002;6:155-60.
31. Elkassas DW, Fawzi EM, El Zohairy A. The effect of cavity disinfectants on the micro-shear bond strength of dentin adhesives. Eur J Dent 2014;8:184-90.
32. Oskoee SS, Oskoee PA, Navimipour EJ, Shahi S. *In vitro* fracture resistance of endodontically-treated maxillary premolars. Oper Dent 2011;12:30-4.
33. Suwatviroj P, Messer LB, Palamara JE. The effects of cavity preparation and lamination on bond strength and fracture of tooth-colored restorations in primary molars. Pediatr Dent 2003;25:534-40.
34. Xu H, Jiang Z, Xiao X, Fu J, Su Q. Influence of cavity design on the biomechanics of direct composite resin restorations in Class IV preparations. Eur J Oral Sci 2012;120:161-7.
35. Yaman SD, Yetmez M, Türköz E, Akkas N. Fracture resistance of Class II approximal slot restorations. J Prosthet Dent 2000;84:297-302.
36. Liu X, Fok A, Li H. Influence of restorative material and proximal cavity design on the fracture resistance of MOD inlay restoration. Dent Mater 2014;30:327-33.
37. Rathnam A, Nidhi M, Shigli AL, Indushekar KR. Comparative evaluation of slot versus dovetail design in class III composite restorations in primary anterior teeth. Contemp Clin Dent 2010;1:6-9.
38. Seraj B, Ehsani S, Taravati S, Ghadimi S, Fatemi M, Safa S. Fracture resistance of cementum-extended composite fillings in severely damaged deciduous incisors: An *in vitro* study. Eur J Dent 2014;8:445-9.

Access this article online

Quick Response Code:

Website: www.eurjdent.com

Source of Support: Nil.
Conflict of Interest: None declared