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Comparison of Fracture Resistance of Teeth Presenting Non-Carious Cervical Lesions, Restored with Different Composite Materials

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Abstract. *The aim of our study was to compare the fracture resistance of teeth presenting non-carious cervical lesions restored with different types of esthetic composite materials. 20 extracted unspoiled maxillary first molars were mechanically cleaned and immersed in saline solution containing 0.1% thymol at 4°C for a period of 48 hours. Cervical cavities with a cervical-occlusal diameter of 2 mm and a mesial-distal diameter of 3mm were filled with ormocer, flow nano-composite, nano-composite and compomer. Fracture resistance was tested with a universal loading machine (Lloyd Instruments), with a maximum force of 5 kN and a crosshead speed of 1.0 mm/min; the authors used NEXYGEN Data Analysis Software and ANOVA method. For the group A (commercial grade ormocer), the smallest load that determined the sample failure was 650 N and the highest load was 1050 N, the mean value being 858 N ± 150.89 N. For the group B (commercial grade flow nano-composite), the smallest load is 530 N, the highest load is 800 N, mean value being 654 N ± 112.6 N. For the group C (commercial grade nano-composite), the smallest load is 680 N, the highest load is 1200 N, mean value being 926 N ± 209.35 N. For the group D (commercial grade compomer), the smallest load is 1100 N, highest load is 1250N, mean value being 1180 N ± 62.04 N. A p value of 0.000311 ($p<0.05$) shows that there are significant differences between the four groups. Conclusions. The best fracture resistance of teeth presenting non-carious cervical lesions, restored with different types of esthetic composite materials is assured by the compomer, followed by the nano-composite, which proved to be superior to ormocer. The flow nano-composite gives the lowest fracture resistance.*

Keywords*: noncarious cervical lesions, composites, fracture resistance*

1.Introduction

Non-carious cervical lesions (NCCL), defined as loss of dental tissue in absence of bacterial aggression, have a multifactorial etiology, implying abrasion, abfraction and acid erosion, acting independently or associated [1,2]; other causes are considered controversial, some implying the stress transmitted in cervical area by occlusal loads, especially at patients with a history of bruxism, or behavioral factors such as too intense tooth brushing techniques, diet factors such as a low salivary pH by consuming acidic food (for example, citrus fruits) and drinks and also contributing factors such as periodontal disease [3-5]. Prevalence of NCCL is over 85%, gravity and spread increasing among older ages [6]. Besides esthetic consequences, advanced NCCL are causing dentin hypersensitivity and risk of tooth fracture [7]. Studies show that NCCL's treatment is necessary only if they are wedge shaped and their dimensions exceeds 0.5 mm [8], consisting in identifying and eliminating the causes, followed

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by filling the cavity with restorative materials. The choice of the restorative material is influenced by the area that has to be restored, the patient's age and the qualities of the material regarding long-term resistance, wearing resistance, fracture resistance, marginal leakage, conservation of tooth structure, occlusal stress resistance, esthetics and cost [9]. Patients' increasing esthetic expectations determine an almost exclusively use of esthetic restorative materials and a continuous research for finding the best option. Choosing the most appropriate restorative material for a specific clinical situation is usually a challenge for the dentist. Also, restored NCCL have a great risk of failure because of the difficulties related to the isolation and lack of adhesion of the restorative material. This latter one has to present good polishing qualities in order to prevent plaque accumulation (at margins and on surfaces of the restoration) and secondary caries and also elasticity in order to resist flexural stresses [10]. Longevity of the restoration with a good abrasion resistance and fracture resistance can be achieved using nano-composites that have a higher elasticity modulus than other restorative materials and a greater flexural, compressive and diametral tensile strengths [11,12]. Still, good results were also obtained using micro-hybrid composites or flow composites that have a low elasticity modulus [2,13]. The type of restorative material used for filling the cavity influences the quality of the marginal adaptation and in consequence the risk of secondary caries and the longevity of the treatment. Studies showed that ormocers, all-ceramic-based restorative materials with high viscosity (inorganic-organic hybrid polymer) present a low contraction after polymerization, similarly to the high viscosity composites, but ensure a better marginal adaptation than hybrid composites; still, the differences found are not statistically significant [14,15]. Both materials as compomers, through their qualities, associated with appropriates adhesive materials, demonstrated that can ensure the long-term success of the treatment [16]. Esthetic restorative materials for NCCL fillings have been compared from the perspective of the cervical stress resistance, marginal adaptation and longevity, but the influence of these cervical fillings on the tooth resistance to occlusal load was not evaluated. The aim of this paper is to determine if the choice of the restorative material for NCCL influences the fracture resistance of the tooth and to achieve a ranking of these materials from this perspective. Considering that the authors were only interested in the complete damage of the restored teeth, electronical or optical microscopic images and also the failure mechanisms are out of the scope of this research.

2. Materials and methods

20 extracted unspoiled maxillary first molars, having no cavities or fillings, were collected from the Clinic of Oral and Maxillo-Facial Surgery of the Faculty of Dentistry (UMF "Carol Davila" Bucharest) and from 7 private dental clinics from Bucharest. The teeth were mechanically cleaned in order to remove the remaining soft tissues after extraction and then immersed in saline solution containing 0.1% thymol at 4°C for a period of 48 hours. After that, on the vestibular surface of each tooth were prepared cervical cavities with a cervical-occlusal diameter of 2 mm and a mesial-distal diameter of 3 mm (Figure 1.a). In this experiment the authors created all the cavities with the same size and form, so the amount of tissue that was excavated was similar. In order to obtain this similar shape and sizes, the authors used a digital caliper with an accuracy of 0.01 mm (Mitutoyo, Japan) and 20 identical ISO 101-012 diamond ball dental burs, with a diameter of 1.2 mm, a new one for each molar. After preparation, the cavities were cleaned and dried and the restorative material was applied in accordance with the manufacturer's indications. The prepared teeth were divided in four classes (A, B, C, D) of 5 teeth each, one for each restorative material the authors used, as follows: A – commercial grade ormocer (organically modified ceramics), B – commercial grade flow nano-composite (nanoparticle reinforcement of fiber reinforced composites with flow properties), C – commercial grade nano-composite (nanoparticle reinforcement of fiber reinforced composites) and D – commercial grade compomer (polyacid modified composite resins having the chemical composition of composites and glassionomers) (Figure 1.b). For the experiment, the authors introduced the teeth roots in resin parallelepiped supports. The extracted molars were subjected to increasing loads; values were registered automatically by the machine, until the complete

separation of the fragments occurred. In order to evaluate the fracture resistance of the teeth, the authors used a universal loading machine (Lloyd Instruments), with a maximum force of 5 kN and a crosshead speed of 1.0 mm/min; the results were recorded with NEXYGEN Data Analysis Software. A representative fractured specimen is shown in figure 1.c. The graphics show data regarding the fracture force values till fracture.

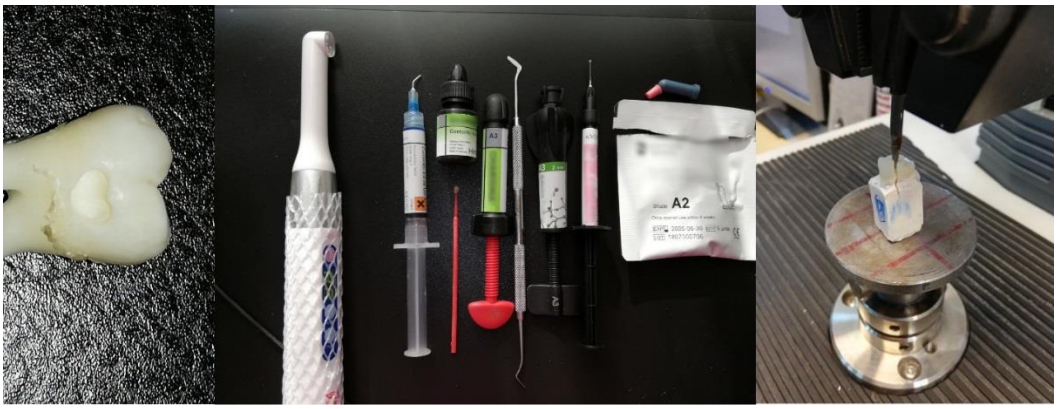

Figure 1.a Cervical cavity on the vestibular surface of the molar; b. restorative materials used in the experiment; c. completely fractured specimen in the universal loading machine

3.Results and discussions

For the group A: the smallest load that determined the sample failure was 650 N and the highest load was 1050N, the mean value being 858 N ± 150.89 N (standard deviation).

For the group B: the smallest load that determined the sample failure was 530 N and the highest load was 800 N, the mean value being 654 N ± 112.6 N (standard deviation).

For the group C: the smallest load that determined the sample failure was 680 N and the highest load was 1200 N, the mean value being 926 N ± 209.35 N (standard deviation).

For the group D: the smallest load that determined the sample failure was 1100 N and the highest load was 1250 N, the mean value being 1180 N ± 62.04 N (standard deviation).

The diagram representing the minimum and the maximum values for each group is illustrated in figures 2 and 3.

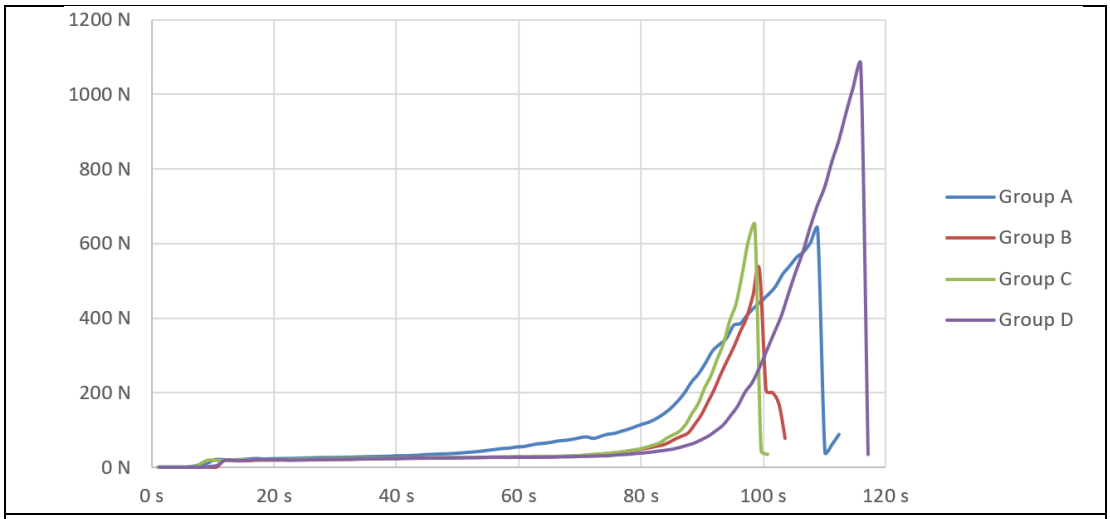

Figure 2. Load versus time for the tests giving the lowest value at fracture for the four groups

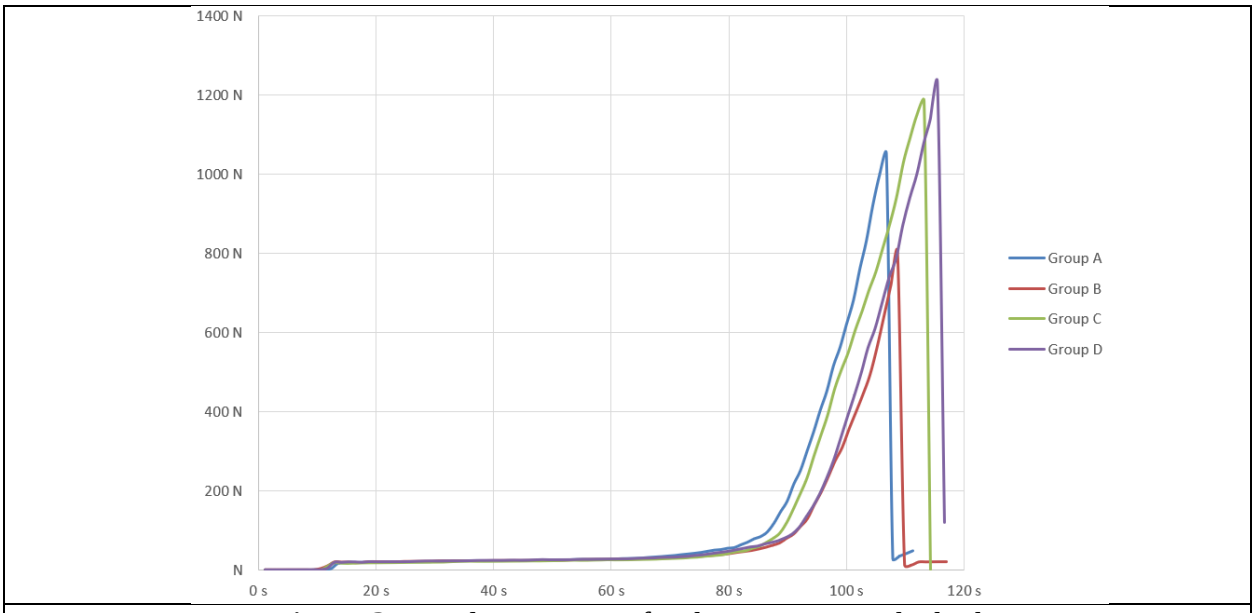

Figure 3. Load versus time for the tests giving the highest value at fracture for the four groups

The teeth from the group D presented the highest mean value whereas the Group B presented the lowest one. Regarding the fracture resistance of the maxillary first molars restored with esthetic materials, the highest resistance was obtained for molars with cavities restored with compomer, followed by nano-composite and ormocer and the lowest resistance was obtained for molars with cavities restored with flow nano-composite (figure 4). The results were analyzed using the ANOVA method to understand the relevance of the study. It was found that the results are statistically relevant, with a p value of 0.000311 ($p<0.05$) (Table I), which means that there are significant differences between the four groups.

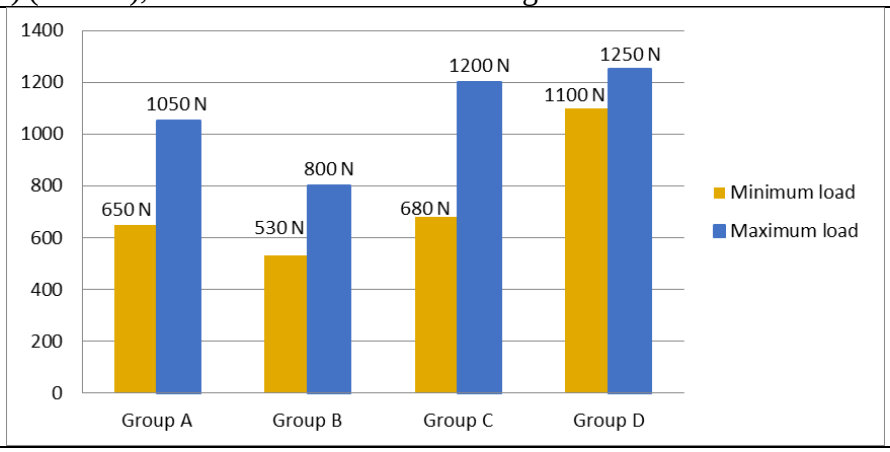

Figure 4. Fracture resistance values of the maxillary first molars restored with four groups of esthetic materials

Table 1. ANOVA: p-value

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
A	5	4290	858	22770
B	5	3270	654	12680
C	5	4630	926	43830

D	5	5900	1180	3850		

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	706375	3	235458.3	11.32964	0.000311	3.238872
Within Groups	332520	16	20782.5			
Total	1038895	19				

The influence of the restorative materials and techniques on fracture resistance of the teeth is analyzed in many studies in literature. In 2013, Bashir *et al.* showed that adhesive restorative materials are significantly increasing the fracture resistance for endodontically treated premolars [17]. In 2018, Biswas *et al.* showed that the presence of an occlusal cavity is significantly decreasing the fracture resistance of the mandibular molars, while the type of the material used for filling is influencing a lot this resistance; glassionomer proved to be the best, but compomers also ensured a higher resistance comparing to amalgam [18]. Eakle (1986), Dalpino (2002), Kikuti (2012) and Torabzadeh (2013) studied the influence of the different types of materials and techniques on the fracture resistance of the teeth presenting mesio-occlusal-distal cavities [19-22]. The influence of the endodontic post material on the fracture resistance of the tooth was also evaluated [23]. Still, despite the numerous clinical cases that have been studied, no other research on the influence of the restorative material on the fracture resistance for the teeth presenting non-carious cervical lesions (NCCL) was found by the authors.

In accordance with the results of the research realized by Awet *et al.*, showing that most non-carious cervical lesions appear on the posterior maxillary teeth, the first molar being one of the most affected, the present study used the first maxillary molar in order to determine the influence of the restorative material on the fracture resistance of the teeth having such lesions [24]. Similarly to Kikuti (2012), in this experiment the authors kept the extracted teeth in saline solution containing 0.1 % thymol, at 4°C [22]. In accordance with the study realized by Torabzadeh in 2013, the uniformity of the shape and form of the cavity dimensions was realized using a digital caliper with an accuracy of 0.01 mm (Mitutoyo, Japan) [21]. Similar with other authors, this research team selected a universal testing machine [19-23]. In this study, the authors applied only a vertical axial force on the tooth, similar with other papers having as aim the evaluation of the fracture resistance of the teeth [19].

In a study realized in 2017, Hegde *et al.* demonstrated that the use of composites in mesial-occlusal-distal cavities increases the fracture resistance of the teeth [25]. For many studies available in the literature, the aim was to make easier the choice of a material that ensures a better reinforcement of the teeth, from the large variety of composites available for restorative procedures. Our study shows that, used in NCCL, nano-composites and hybrid composites demonstrated little differences regarding fracture resistance of the teeth. In 2018, Alzaika *et al.* stated that, when used in non-carious cervical lesions, both nano-composites and hybrid composites demonstrated similar performances, also with little differences regarding restoration failure [26]. Still, this experiment showed that, among the hybrid composites, the compomer ensures a better resistance of the teeth as compared to the nano-composite. Moreover, the compomer that the authors used ensured the best fracture resistance among all four included materials. Besides this, Biswas *et al.* shows that the same compomer is superior to amalgam in what concerns the fracture resistance [18]. The present study shows that there are no major differences between the compomer and the nano-composite in increasing the fracture resistance of the teeth presenting NCCL; still, the compomer, the nano-composite and even the ormocer proved superior to flow nano-composite in that respect. Another study showed that in this type of lesions, the flow nano-composite is preferred because of the low elasticity modulus [2]. This study demonstrated that, albeit it is relatively new on the market, having good esthetic qualities and assuring a good marginal adaptation,

the ormocer (organic modified ceramics) provides a better fracture resistance for teeth presenting NCCL than the flow nano-composite.

4.Conclusions

Within the limits of the present study, the authors can conclude that in regards non-carious cervical lesions, the best fracture resistance of these teeth is assured by the compomer (group D), followed closely by the nano-composite (group C), which proved to be superior to ormocer (group A). The flow nano-composite (group B) gives the lowest fracture resistance.

References

1.MATHIAS C, FERRAZ LN, LIMA DANL, MARCHI GM. Treatment of non-carious lesion: Diagnosis, restorative materials and techniques. Braz J Oral Sci. 2018; 17:1-12.
2.PEREZ CR, GONZALEZ MR, PRADO NAS, MIRANDA MSF, MACEDO MA, FERNANDES BMP. Restoration of Noncarious Cervical Lesions: When, Why, and How. Int J Dent 2012; 2012: 687058.
3.KOLAK V, PEŠIĆ D, MELIH I, LALOVIĆM, NIKITOVIĆA, JAKOVLJEVIĆ A. Epidemiological study of non-carious cervical lesion and possible etiological factors. J Clin Exp Dent. 2018; 10(7):e648-e656.
4.EL-MARAKBY AM, AL-SABRI FA, ALHARBI SA, HALAWANI SM, BIN YOUSEF MT. Noncarious Cervical Lesions as Abfraction: Etiology, Diagnosis and Treatment Modalities of Lesions: A Review Article. Dentistry 2017. 7:6 DOI: 10.4172/2161-1122.1000438.
5.SADAF D. AHMAD Z. Role of Brushing and Occlusal Forces in Non-Carious Cervical Lesions (NCCL). Int J Biomed Sci. 2014; 10(4):265-68.
6.BARTLETT DW, SHAP P. A critical review of non-carious cervical (wear) lesions and the role of abfraction, erosion and abrasion. J Dent Res. 2006; 85:306-12.
7.NEGUYEN C, RANJITKAR S, KAIDONIS JA, TOWNSEND GC. A qualitative assessment of non-carious cervical lesions in extracted human teeth. Aust Dent J. 2008; 53:46-51.
8.VENKATESAN K, KUZHANCHINATHAN M, PRAKASH P. Critical review of noncarious cervical lesions. SRM J Res Dent Sci. 2018; 9(2):74-78.
9.TALU S, ALB SF, PARVU AE, DUDEA D, LAINOVIC T, GASPARIK C, ALB C. Factors influencing the choice of dental material and procedure for crown restoration of posterior teeth-design of a "decision guide,,. Human & Veterinary Medicine - International Journal of the Bioflux Society. 2016; 8(3):141-7.
10.FAHL N JR, DENEHY GE, JACKSON RD. Protocol for predictable restoration of anterior teeth with composite resin. Oral health. 1998; 88(8):15-22.
11.SACHDEVA S, KAPOOR P, TAMRAKAR AK, NOOR R. Nano-composite dental resins: an overview. Annals of Dental Specialty. 2015; 3(2):52-5.
12.KHURSHID Z, ZAFAR M, QASIM S, SHAHAB S, NASEEM M, ABUREQAIBA A. ADVANCES in Nanotechnology for Restorative Dentistry. Materials (Basel).2015; 8(2):717-31.
13.YANG SE, LEEH, JIN SH. A combined approach to non-carious cervical lesions associated with gingival recession. Restor Dent Endod. 2016; 41(3):218-24.
14.RAVI RK, ALLA RK, AHAMMAS M. Dental Composites - A Versatile Restorative Material: An Overview. Ind J Dent Sci. 2013; 5(5):111-15
15.KALRA S, SINGH A, GUPTA M, CHADHA V. Ormocer: An aesthetic direct restorative material; An *in vitro* study comparing the marginal sealing ability of organically modified ceramics and a hybrid composite using an ormocer-based bonding agent and a conventional fifth-generation bonding agent. Contemp Clin Dent. 2012; 3(1):48-53.
16.STOJANAC IT, PREMOVIC BD, DROBAC MR, STOJSIN IM, PETROVIC LM. Noncarious Cervical Lesions Restored with Three Different Tooth-Colored Materials: Two-Years Results. Operative Dentistry. 2013; 38(1); 12-20.

17.BASSIR MM, LABIBZADEH A, MOLLAVERDI F. The effect of amount of lost tooth structure and restorative technique on fracture resistance of endodontically premolars. J Conserv Dent. 2013; 16(5): 413-17.
18.BISWAS I, SHIL R, MAZUMDAR P, DESAI P. Comparative evaluation of fracture resistance of dental amalgam, Dyract-XP composite resin and Cention-N restauration in class I cavity. Int J Innov Res Dent Sci. 2018; 3(2):384-92.
19.DALPINO PHP, FRANCISCHONE CE, ISHIKIRIAMA A, FRANCO EB. Fracture resistance of tooth directly and indirectly restored with composite resin and indirectly restored with ceramic materials. Am J Dent. 2002; 15(6):389-94.
20.EAKLE WS. Fracture resistance of teeth restored with class II bonded composite resin. J Dent Res. 1986; 65(2):149-53.
21.TORABZADEH H, GHASEMI A, DABESTANI A, RASMAVAR S. Fracture Resistance of Teeth Restored with Direct and Indirect Composite Restorations. J Dent (Teheran). 2013; 10(5):417-25.
22.KIKUTI WY, CHAVES FO, DI HIPOLITO V, RODRIQUES FP, D'ALPINO PHP. Fracture resistance of teeth restored with different resin-based restorative systems. Braz Oral Res. 2012; 26(3):275-81.
23.MARGARIT R, MARIN S, TANASESCU A, OPREA RM, ANDREI OC. Fracture Resistance of Prosthetic Restored Teeth with Fiberglass Posts versus Metallic Posts. Appl Mech Mater. 2014; 658:435-40.
24.AW TC, LEPE X, JOHNSON GH, MANCL L. Characteristics of noncarious cervical lesions: a clinical investigation. J Am Dent Assoc. 2002; 133(6):725-33.
25.HEGDE V, SALI AV. Fracture resistance of posterior teeth restored with high-viscosity bulk-fill resin composites in comparison to the incremental placement technique. J Conserv Dent. 2017; 20(5):360-4.
26.ALZAIKA H, BURROW MF, MAGHAIREH GA, TAHA NA. Nanofilled Resin Properties and Clinical Performance: A Review. Oper Dent. 2018; 43(4):E173-E190.

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