European Annals of Dental Sciences
Official Publication of Ankara University, Faculty of Dentistry

EADS, 2022, 49 (2), 87–91

e-ISSN : 2757-6744
doi : 10.52037/eads.2022.0032

Article Received : January, 2 2022
Article Accepted : March, 28 2022

ORIGINAL RESEARCH ARTICLE

Effects of Surface Preparation with Sodium Hypochlorite on Shear Bond Strength and Residual Adhesive of Orthodontic Brackets on Primary and Permanent Teeth

Can Arslan [1,*], Nilüfer Üstün [2] and Emre Cesur [3]

[1]DDS, PhD,Yeditepe University, Faculty of Dentistry, Department of Orthodontics, Istanbul, Turkey. and [2]DDS, PhD, Istanbul Medipol University, Faculty of Dentistry, Department of Paediatric Dentistry, Istanbul, Turkey. and [3]DDS, PhD, Ankara Medipol University, Faculty of Dentistry, Department of Orthodontics, Ankara, Turkey.

[*]Corresponding Author; dt.canarslan@gmail.com

Abstract

Purpose: To investigate the effects of surface preparation with sodium hypochlorite (NaOCl) on bracket shear bond strength and amount of residual adhesive on primary and permanent teeth.
Materials & Methods: Twent-four permanent premolars, 12 in each group (groups I and III), and 24 primary molars, 12 in each group (groups II and IV) were included. In group I and II, 37% phosphoric acid was applied to the tooth surfaces, without using any other agent. In Group III and IV, 5.25% NaOCl was first applied. Following washing and drying, surface roughening was performed with phosphoric acid. The shear bond strengths (SBS) of the brackets bonded to the tooth surfaces was measured. After debonding, the base of each bracket was examined for adhesive remnant index (ARI) scores.
Results: There were no statistically significant differences in SBS values between primary and permanent teeth with and without preparation with NaOCl($P>0.05$). Mean SBS(18.55±14.98 MPa) was higher in permanent premolars subjected to surface deproteinization with NaOCl (group III) when compared with other groups, but the difference was not significant. There was no significant difference in ARI scores between the groups.
Conclusion: The bond strength of orthodontic brackets or the distribution of ARI scores were similar between groups with and without NaOCl pretreatment. Hence, it can be concluded that conventional bonding procedures applied without any additional preparation to primary teeth are sufficient and the debonding of brackets didn't cause any harm to enamel surfaces.

Key words: adhesive remnant index; shear bond strength; surface preparation

Introduction

It has been suggested that skeletal and dental malocclusions should be treated before the completion of permanent tooth eruption and skeletal development.[1] In early treatment to correct anterior crossbite, orthodontic brackets are bonded to permanent incisors, primary canines, and primary molars in order to level ectopic or impacted incisors. These teeth are used as anchoring units for fixed orthodontic treatment mechanics.[2,3] Furthermore, in cases of congenitally missing permanent teeth such as agenesis of the permanent second molar, preserving the primary second molar is a reasonable plan for patients with acceptable occlusion, as these teeth can be retained until the patient is in their early to late 20s at least. There are many reports of patients retaining primary molars until 40 to 60 years of age.[4–6] Even if it eventually needs to be replaced with an implant or bridge, retaining a primary molar as long as possible is an excellent way to protect the alveolar bone in that area.

Numerous factors impact the bond strength of orthodontic brackets attached using light-cured composite resin adhesives. These include enamel surface variations, tooth type, surface abrasive concentration and application time, primer and adhesive type, bracket type and base structure, and light source and application time.[7–10]

The main mechanism for bonding of adhesive materials to enamel is micromechanical interlocking via the polymerization of resin monomers filling micropores created by the removal of

How to cite: Arslan C, Üstün N, Cesur E. Effects of Surface Preparation with Sodium Hypochlorite on Shear Bond Strength and Residual Adhesive of Orthodontic Brackets on Primary and Permanent Teeth. EADS. 2022;49(2):87-91

inorganic minerals from hard tissues.[11] Because the enamel structures of primary and permanent teeth differ substantially, adhesion to these tissues occurs by different mechanisms. Enamel prisms extend horizontally or apically in permanent teeth but are oriented occlusally in primary teeth. In primary teeth, the enamel prisms form a wider angle to the surface than in permanent enamel.[12] The surface of primary teeth is also covered with an aprismatic enamel layer which is only found in the cervical third of permanent teeth. The aprismatic layer of primary tooth enamel is thicker than that of permanent teeth.[13,14] Due to the irregular prism structure in primary teeth, surface roughening is less effective, resulting in lower resin penetration and bonding success.[7,8]

Sodium hypochlorite (NaOCl) has an antibacterial effect and does not damage healthy tissue or dental structures. NaOCl is used in endodontics as an irrigant solution to noninvasively disinfect and flush residue and organic material from the root canals.[15,16] As a deproteinizing agent, NaOCl can enhance adhesion of orthodontic brackets to the enamel surface by removing organic elements from the enamel structure and the acquired pellicle from the enamel surface when applied before the acid etching process.[17]

To date, there have been few studies investigating the shear bond strength of orthodontic brackets applied to primary and permanent teeth.[18] Similarly, studies evaluating the impact of enamel surface preparation with NaOCl on bracket adhesion are limited in permanent teeth and nonexistent for primary teeth.[17] The aim of this study was to investigate and compare the effects of surface preparation with NAOCl on orthodontic bracket shear bond strength and amount of residual adhesive on primary and permanent teeth. The null hypothesis was there no difference between the groups.

Materials and Methods

This study was approved by the Yeditepe University Ethics Committee (10840098-772.02-E.34483). Informed written consent was obtained from each patient. Power analysis (GPower 3.1.0, Universität Düsseldorf, Düsseldorf, Germany), was performed to determine the sample size and it was found that at least 10 teeth for each group were needed to verify an effect with 80% power (α= 0.05). Therefore, a total of 24 permanent premolars and 24 primary molars were included in the study. When selecting teeth for the study, care was taken to ensure that the enamel surface for bracket bonding had no fractures, cracks, caries, or previous restoration. Therefore, primary molars and permanent premolars which were extracted only for orthodontic purposes were included to the study. Teeth meeting these criteria were washed with water to remove surface residue and stored in 0.1% thymol solution at 4°C until used in the study. The permanent premolars were divided into 2 groups of 12 (groups I and III) with equal numbers of maxillary and mandibular first and second molars in each group. The primary teeth were also divided into 2 groups of 12 (groups II and IV) with equal numbers of maxillary and mandibular first and second molars in each group.

All teeth were placed with their roots centered in 20 mm x 40 mm plastic cylinder molds and fixed with cold acrylic (Steady-Resin,Scheu-Dental GmbH, Iserlohn, Germany)(Figure 1) and they were brushed with pumice. In groups I and II, 37% phosphoric acid was applied to the tooth surfaces for 20 seconds, without using any other agent. The tooth surfaces were then washed with water for 20 seconds and dried with compressed air for 20 seconds. In groups III and IV, 5.25% NaOCl was first applied with a microbrush to the tooth surfaces for 1 minute for deproteinization. After the surfaces were washed and dried with compressed air, surface roughening was performed with 37% phosphoric acid. In all groups, 0.018-inch Gemini (3M Unitek,Monrovia,CA,USA) metal orthodontic brackets were bonded to the enamel surface of each tooth using a primer (Transbond XT Primer, 3M Unitek, Monrovia, CA, USA) to form a thin resin adhesive layer at first, and then a composite resin adhesive (Transbond XT,3M Unitek, Monrovia, CA, USA) according to the manufacturer's instructions. To simulate the intraoral environment, all teeth were stored in distilled water at 37°C for 24 hours after the procedure.

Shear Bond Strength (SBS)

The SBS of the brackets bonded to the tooth surfaces was measured by applying occluso-gingival force to the bracket-tooth interface using a universal testing device (AGS-X, Shimadzu, Kyoto, Japan). Bond strength was measured at a crosshead speed of 1 mm/min. The load applied at the time of debonding was recorded in newtons (N) and this value was divided by the surface area of the bracket base to obtain a value in megapascal (MPa).

Adhesive Remnant Index (ARI)

After debonding, the base of each bracket was examined by stereomicroscope (Lumera T, Carl Zeiss AG, Oberkochen, Germany) at 20x magnification (Figure 2) and an ARI score was determined according to the criteria defined by Artun and Bergland.[19] The amount of residual adhesive on the base of the bracket is graded on a 4-point scale: 0=all adhesive remaining on the bracket base, 1=more than half of the adhesive remaining on the bracket base, 2=less than half of the adhesive remaining on the bracket base, 3=no adhesive remaining on the bracket base.

Statistical Analysis

Mean SBS and ARI values were analyzed using analysis of variance (ANOVA). Kruskal–Wallis H test was used to evaluate the differences in SBS between the groups. The categorical ARI scores of the 4 groups were compared using chi-square test. A $p<0.05$ was considered statistically significant.

Results

Comparison of the SBS values in the groups is shown in Table 1. There were no statistically significant differences in SBS values between primary and permanent teeth with and without enamel surface preparation with NaOCl ($P>0.05$). Mean SBS (18.55±14.98 MPa) was higher in permanent premolars subjected to surface de-

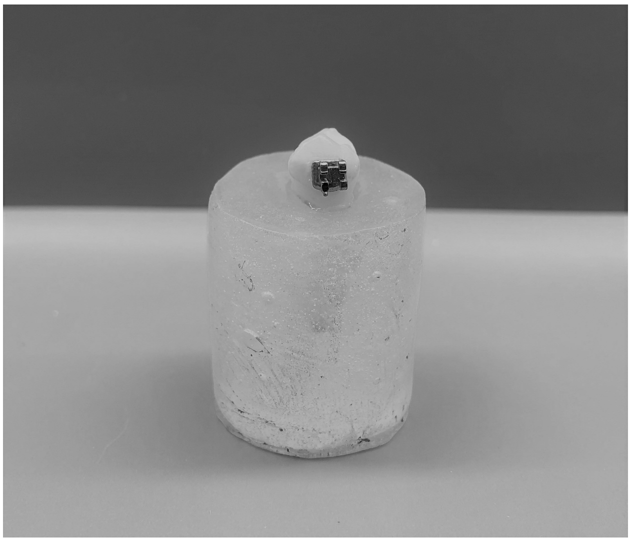

Figure 1. Teeth were placed with their roots centered in 20 mm x 40 mm plastic cylinder molds and fixed with cold acrylic (Steady-Resin, Scheu-Dental GmbH, Iserlohn, Germany)

Table 1. Comparison of shear bond strength (SBS) values between groups.

	n	SBS value (MPa)					Kruskal–Wallis H test		
		Mean	Median	Min.	Max.	±SD	Row mean	KWH	P
Group I	12	10.17	10.93	1.82	18.29	±5.67	22.92		
Group 2	12	11.28	9.13	2.75	32.51	±8.44	22.75		
Group 3	12	18.55	13.31	2.07	46.77	±14.98	29.67	2.18	0.536
Group 4	12	10.87	10.81	2.18	30.37	±7.08	22.67		
Total	48	12.72	10.46	1.82	46.77	±10.01			

SD: Standard deviation

Table 2. Distribution of ARI Scores in Each Group.

		Group I		Group 2		Group 3		Group 4		Total		Chi-Square
		n	%	*n*	%	*n*	%	*n*	%	*n*	%	**p**
ARI Score	***0***	1	8.3	2	16.7	3	25.0	3	25.0	9	18.8	0.341
	1	1	8.3	5	41.7	4	33.3	2	16.7	12	25.0	
	2	10	83.3	5	41.7	5	41.7	7	58.3	27	56.3	
	Total	12	100.0	12	100.0	12	100.0	12	100.0	48	100.0	

proteinization with NaOCl (group III) when compared with other groups, but the difference was not statistically significant. Mean SBS values were 10.17±5.67 MPa for permanent premolars without surface preparation with NaOCl (group I), 11.28±8.44 MPa for primary molars without surface preparation with NaOCl (group II), and 10.87±7.08 MPa for primary molars treated with NaOCl (group IV).

The distribution of ARI scores in each group are shown in Table 2. There was no significant difference in ARI distribution between the groups. Although not statistically significant, it was noted that a larger proportion of teeth in group I (83.3%) had ARI scores of 2 (less than half of the adhesive material remaining on the bracket base). An ARI of 2 was also the most frequent score in all groups, accounting for 41.7% in groups II and III and 58.3% in group IV.

Discussion

Primary teeth are sometimes retained in adults due to impaction or hypodontia of the permanent teeth.[20] This phenomenon is reported at an incidence of 0% to 9%.[21] When primary teeth retained due to impaction of permanent teeth are recognized early, different treatments can be successfully implemented to assist eruption of the impacted permanent tooth. Especially with agenesis of the permanent second molar, gap closure can be achieved by extracting the primary second molar at around 9 years of age.[22]

Figure 2. The base of each bracket was examined by stereomicroscope (Lumera T,Carl Zeiss AG,Oberkochen,Germany) at 20x magnification and an ARI score was determined according to the criteria defined by Artun and Bergland.[19]

Nordquist et al. found that the mandibular primary second molars were the most common primary tooth retained in adults, followed by maxillary primary canines.[23] Although extracting primary teeth is considered the first-line treatment option in adults, tooth extraction is not suitable for patients who do not have crowding, low angle, or deep-bite.[24] In such cases, it may be decided to leave the primary tooth in the mouth if it is in good condition. Long-term follow-up studies have reported primary teeth showing good prognosis in individuals in their 30s.[25] Therefore, fixed orthodontic mechanics that also include the bonding brackets to primary teeth can be used in daily practice.

To date, there has been no study comparing the SBS of orthodontic brackets on primary and permanent teeth after surface preparation with NaOCl. The bond strength of orthodontic brackets to the enamel surface should be sufficient to withstand the forces that will be applied during orthodontic treatment. In the literature, bond strength values of 6 to 8 MPa were reported to provide clinically adequate adhesion of brackets to the enamel surface.[26] In the present study, bond strength was 10.17 MPa and 11.28 MPa for permanent and primary teeth without NaOCl pretreatment versus 18.55 MPa and 10.87 MPa for permanent and primary teeth with NaOCl pretreatment. Therefore, it can be concluded that a sufficient bond was achieved in all groups.

In studies comparing bond strength on primary and permanent teeth, primary teeth were found to have a significantly lower bond strength compared to permanent teeth, which was proposed to result from the aprismatic layer that is more widely found in the outer surface of the primary enamel and from an excessive amount of adhesive material remaining between the enamel surface and bracket base.[13,14] Endo et al. stated that the thicker aprismatic layer on primary teeth may cause inadequate resin penetration and weak bond strength, and that this caused the enamel tissue structure formed through acid etching to be less resistant to shear forces compared to permanent teeth.[18] In the present study, no significant difference was observed in the bond strength of brackets attached to the enamel surfaces of primary and permanent teeth in the experimental groups, similar to the findings of Ergas et al.[27]

It is emphasized that the main factor affecting adhesion quality after acid etching is the contribution of permanent morphological changes in the enamel surface to retention.[28] However, studies have revealed that topographic alterations are not consistent across the entire adhesion area after etching the enamel surface with phosphoric acid. Hobson et al.[29] reported in their study that the desired effect was not observed in 69% of the acid-etched enamel and ideal roughening was achieved in only 2%. In order to avoid these limitations, the use of a deproteinizing agent prior to acid treatment of the enamel surface has been recommended. The deproteinization process, which eliminates the organic structure of both the enamel and the acquired pellicle, has been suggested as an adhesion-promoting alternative to achieve better bonding strength.[30] Studies have demonstrated that surface deproteinization with NaOCl improves the marginal seal of the bracket base to the enamel surface, thereby providing better bonding strength.[31] Elnafar et al. reported that 5.25% NaOCl applied to the enamel surface for 60 seconds significantly increased bond strength.[32] In the present study, although mean bond strength values were higher in permanent molars treated with NaOCl than in permanent molars without NaOCl surface preparation, the difference was not statistically significant. A possible explanation for the difference between our results and those of similar studies is the different types of adhesives used. In the literature investigating the effects of deproteinization on bonding strength, NaOCl was found to facilitate bracket adhesion with resin-modified glass ionomer cement (RMGIC).[32] However, the present study is the first to examine the effects of deproteinization with NaOCl on the bonding strength of brackets applied with composite adhesive to primary and permanent teeth.

This study also evaluated the potential of brackets bonded to primary and permanent molars with and without NaOCl surface preparation to damage the enamel surface in case of debonding. The most important point to consider in this assessment is the adhesive fracture line formed during debonding of the bracket from the tooth surface. According to Artun and Bergland,[19] the enamel is protected if the adhesive fracture line is exclusively within the resin layer. Therefore, the ARI is an important indicator when evaluating the integrity of the enamel surface after debracketing. ARI scoring is conventionally performed by examining the bracket base or tooth enamel surface under 10x or 20x magnification.[33] Cehreli et al. conducted a study comparing the different methods used in ARI scoring and determined that visual examination under a microscope at 20x magnification yielded sufficient and reliable results.[34]

Abu Alhaija et al. investigated the effects of different surface etching times on the bond strength of brackets bonded to primary and permanent teeth and reported that bond failure occurred more frequently at the enamel-resin interface in primary teeth and at the bracket-resin interface in permanent teeth.[35] Pereira et al. reported significantly more remnant adhesive remaining on the enamel surface after debracketing from enamel surfaces that had undergone surface deproteinization with NaOCl.[36] Researchers have emphasized that by reducing surface tension, NaOCl facilitates deeper penetration of adhesive into the enamel surface, thereby improving bond strength. Similarly, in the present study, it was found that less than half of the adhesive material remained on the bracket base while the majority remained on the tooth surface in the NaOCl-treated groups (groups III and IV). This leads to the conclusion that the enamel surface may be protected from potential damage in the event of debonding.

Limitations

To increase the reliability of this study, the sample size of the groups would be expanded despite the fact that the power analysis concluded that they were sufficient. Moreover, a future study to further justify our results can be designed using micro-CT in order to observe the changes on tooth surfaces more clearly. In addition, the age of the individuals was not taken into consideration when creating the sample size in this study. However, with age, some changes may occur in the tooth infrastructure which may affect the results of our study. This should be taken into consideration in future studies.

Conclusion

Null hypothesis is accepted. The bond strength of orthodontic brackets bonded to primary and permanent teeth or the distribution of ARI scores were similar between groups with and without NaOCl pretreatment. Bond strength was high enough in all groups to provide sufficient adhesion of brackets to the enamel surface. Accordingly, it can be concluded that bonding brackets to primary teeth without additional surface preparation is as reliable as permanent teeth. Also, bracket debonding occured mainly as failure at the bracket-adhesive interface indicating that the enamel surface mostly stayed intact and the debonding of brackets didn't cause any harm to primary teeth enamel surfaces.

Author Contributions

C.A.: Study conception and design, acquisition of data, drafting of manuscript. N.U.: Acquisition of data, analysis and interpretation of data. E.C.: Analysis and interpretation of data, drafting of manuscript, critical revision.

Conflict of Interest

Authors declare that they have no conflict of interest.

Authors' ORCID(s)

C.A. 0000-0003-0176-8970
N.U. 0000-0001-5489-6883
E.C. 0000-0003-0176-8970

References

1. Bishara S, Justus R, Graberc T. Discussions on early treatment. American Journal of Orthodontics and dentofacial Orthopedics. 1998.
2. McKeown HF, Sandler J. The two by four appliance: a versatile appliance. Dent Update. 2001;28(10):496–500. doi:10.12968/denu.2001.28.10.496.
3. Tal E, Kupietzky A. Orthodontic alignment of permanent incisors following previous trauma of a primary tooth. Pediatr Dent. 2000;22(1):71–2.
4. Gill DS, Barker CS. The multidisciplinary management of hypodontia: a team approach. Br Dent J. 2015;218(3):143–9. doi:10.1038/sj.bdj.2015.52.
5. Laverty DP, Fairbrother K, Addison O. The Current Evidence on Retaining or Prosthodontically Replacing Retained Deciduous Teeth in the Adult Hypodontia Patient: A Systematic Review. Eur J Prosthodont Restor Dent. 2018;26(1):2–15. doi:10.1922/EJPRD_01721Laverty14.
6. Tischler M. Replacing hopeless retained deciduous teeth in adults utilizing dental implants: concepts and case presentation. Dent Today. 2005;24(11):90, 92–4; quiz 94.
7. Cacciafesta V, Sfondrini MF, Scribante A, Boehme A, Jost-Brinkmann PG. Effect of light-tip distance on the shear bond strengths of composite resin. Angle Orthod. 2005;75(3):386–91. doi:10.1043/0003-3219(2005)75[386:Eoldot]2.0.Co;2.
8. Evans LJ, Peters C, Flickinger C, Taloumis L, Dunn W. A comparison of shear bond strengths of orthodontic brackets using various light sources, light guides, and cure times. Am J Orthod Dentofacial Orthop. 2002;121(5):510–5. doi:10.1067/mod.2002.121558.
9. Rajagopal R, Padmanabhan S, Gnanamani J. A comparison of shear bond strength and debonding characteristics of con-

ventional, moisture-insensitive, and self-etching primers in vitro. Angle Orthod. 2004;74(2):264–8. doi:10.1043/0003-3219(2004)074<0264:Acosbs>2.0.Co;2.
10. Sorel O, El Alam R, Chagneau F, Cathelineau G. Comparison of bond strength between simple foil mesh and laser-structured base retention brackets. Am J Orthod Dentofacial Orthop. 2002;122(3):260–6. doi:10.1067/mod.2002.125834.
11. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res. 2005;84(2):118–32. doi:10.1177/154405910508400204.
12. Simonsen RJ. Pit and fissure sealant: review of the literature. Pediatr Dent. 2002;24(5):393–414.
13. Gwinett AJ. The ultrastructure of the "prismless" enamel of deciduous teeth. Arch Oral Biol. 1966;11(11):1109–16. doi:10.1016/0003-9969(66)90168-3.
14. Gwinnett AJ. The ultrastructure of the "prismless" enamel of permanent human teeth. Arch Oral Biol. 1967;12(3):381–8. doi:10.1016/0003-9969(67)90222-1.
15. Ercan E, Ozekinci T, Atakul F, Gül K. Antibacterial activity of 2hypochlorite in infected root canal: in vivo study. J Endod. 2004;30(2):84–7. doi:10.1097/00004770-200402000-00005.
16. Grandini S, Balleri P, Ferrari M. Evaluation of Glyde File Prep in combination with sodium hypochlorite as a root canal irrigant. J Endod. 2002;28(4):300–3. doi:10.1097/00004770-200204000-00010.
17. Elnafar AAS, Alam MK, Hassan R, Purmal K. Enamel surface preparations and shear bond strength of orthodontic brackets: a review. Int Med J. 2015;22(3):194–8.
18. Endo T, Ozoe R, Shinkai K, Shimomura J, Katoh Y, Shimooka S. Comparison of shear bond strengths of orthodontic brackets bonded to deciduous and permanent teeth. Am J Orthod Dentofacial Orthop. 2008;134(2):198–202. doi:10.1016/j.ajodo.2006.05.045.
19. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment. Am J Orthod. 1984;85(4):333–40. doi:10.1016/0002-9416(84)90190-8.
20. Roper O, Ravn JJ. [Persistence of primary teeth]. Tandlaegebladet. 1972;76(8):732–40.
21. Dachi SF, Howell FV. A survey of 3,874 routine full-mouth radiographs. I. A study of retained roots and teeth. Oral Surg Oral Med Oral Pathol. 1961;14:916–24. doi:10.1016/0030-4220(61)90003-2.
22. Mamopoulou A, Hägg U, Schröder U, Hansen K. Agenesis of mandibular second premolars. Spontaneous space closure after extraction therapy: a 4-year follow-up. Eur J Orthod. 1996;18(6):589–600. doi:10.1093/ejo/18.6.589.
23. Nordquist I, Lennartsson B, Paulander J. Primary teeth in adults–a pilot study. Swed Dent J. 2005;29(1):27–34.
24. Santos LL. Treatment planning in the presence of congenitally absent second premolars: a review of the literature. J Clin Pediatr Dent. 2002;27(1):13–7. doi:10.17796/jcpd.27.1.5q06x95w2p657107.
25. Sletten DW, Smith BM, Southard KA, Casko JS, Southard TE. Retained deciduous mandibular molars in adults: a radiographic study of long-term changes. Am J Orthod Dentofacial Orthop. 2003;124(6):625–30. doi:10.1016/j.ajodo.2003.07.002.
26. Reynolds I. A review of direct orthodontic bonding. British journal of orthodontics. 1975;2(3):171–178.
27. Ergas RP, Hondrum SO, Mathieu GP, Koonce JD. In vitro evaluation of an adhesive monomer as a bonding agent for orthodontic brackets to primary teeth and nickel-chromium ion crowns. Pediatr Dent. 1995;17(3):204–6.
28. Espinosa R, Valencia R, Uribe M, Ceja I, Cruz J, Saadia M. Resin replica in enamel deproteinization and its effect on acid etching. J Clin Pediatr Dent. 2010;35(1):47–51. doi:10.17796/jcpd.35.1.u425308167271132.
29. Hobson RS, Rugg-Gunn AJ, Booth TA. Acid-etch patterns on the buccal surface of human permanent teeth. Arch Oral Biol. 2002;47(5):407–12. doi:10.1016/s0003-9969(02)00008-0.
30. Panchal S, Ansari A, Jain AK, Garg Y. Effects of different deproteinizing agents on topographic features of enamel and shear bond strength - An in vitro study. J Orthod Sci. 2019;8:17. doi:10.4103/jos.JOS_26_19.
31. Justus R, Cubero T, Ondarza R, Morales F. A new technique with sodium hypochlorite to increase bracket shear bond strength of fluoride-releasing resin-modified glass ionomer cements: comparing shear bond strength of two adhesive systems with enamel surface deproteinization before etching. In: Seminars in Orthodontics. vol. 16. Elsevier; 2010. p. 66–75.
32. Elnafar AA, Alam MK, Hasan R. The impact of surface preparation on shear bond strength of metallic orthodontic brackets bonded with a resin-modified glass ionomer cement. J Orthod. 2014;41(3):201–7. doi:10.1179/1465313314y.0000000097.
33. Montasser MA, Drummond JL. Reliability of the adhesive remnant index score system with different magnifications. Angle Orthod. 2009;79(4):773–6. doi:10.2319/080108-398.1.
34. Cehreli SB, Polat-Ozsoy O, Sar C, Cubukcu HE, Cehreli ZC. A comparative study of qualitative and quantitative methods for the assessment of adhesive remnant after bracket debonding. Eur J Orthod. 2012;34(2):188–92. doi:10.1093/ejo/cjq191.
35. Abu Alhaija ES, Irshaid SM, Alwahadni AM. Shear bond strength of orthodontic brackets bonded to deciduous teeth with different etching times. Eur J Paediatr Dent. 2012;13(3):203–8.
36. Pereira TB, Jansen WC, Pithon MM, Souki BQ, Tanaka OM, Oliveira DD. Effects of enamel deproteinization on bracket bonding with conventional and resin-modified glass ionomer cements. Eur J Orthod. 2013;35(4):442–6. doi:10.1093/ejo/cjs006.