Effects of three different types of intracoronal bleaching agents on shear bond strength of stainless steel and sapphire brackets bonded to endodontically treated teeth (An in vitro study)

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ABSTRACT

Background: evaluate the effects of three different intracoronal bleaching agents on the shear bond strengths (SBS) and failure site of stainless steel and monocrystalline (sapphire) orthodontic brackets bonded to endodontically treated teeth using light cured orthodontic adhesive in vitro.

Materials and methods: Eighty extracted sound human upper first premolars were selected, endondontically treated and randomly divided equally (according to the type of the brackets used) into two main groups (n = 40 per group). Each main group were subdivided (according to the bleaching agent used) into four subgroups 10 teeth each; as following : control (un bleached) group, hydrogen peroxide group (Hp) 35%, carbamide peroxide group (CP) 37% group and sodium perborate (SP) group . The bleaching process was applied three times (4 days intervals) sequentially and the bleached teeth were stored in artificial saliva four weeks before bonding. Orthodontic brackets were bonded with a light cure composite resin and cured with LED light. After passing 24 hours of bonding procedure, the brackets were debonded by a Tinius-Olsen universal testing machine, to measure the shear bond strength. After debonding, each bracket base and the corresponding tooth surface were examined using a stereomicroscope and their Adhesive Remnant Index (ARI) was recorded.

Results: The ANOVA test showed that the SBS of stainless brackets was significantly reduced by intracornal bleaching agents. Furthermore, LSD showed no significant difference in SBS between the three types of bleaching agents used in stainless steel group. Whilst for sapphire group, the results The ANOVA test showed no significant difference in SBS between the bleached groups and the control group. Chi-square comparison no significant difference in failure site between bleached and control groups in both brackets types used.

Conclusion: The effect of intracoronal bleaching on SBS was reduced SBS of stainless steel and not for sapphire. However, the intracoronal bleaching had no effect on the failure site of orthodontic brackets used. (J Bagh Coll Dentistry 2014; 26(3):149-155).

INTRODUCTION

Radiant smile is the most beautiful ornament of facial esthetics. The most common reason for seeking the services of the "smile specialist -the orthodontist" is to improve the appearance of the teeth and face. Thus, esthetics has emerged as one of the prime goals of orthodontics and dentofacial orthopaedic (1).

Discoloration of teeth is one of the biggest esthetic concerns of dental patients. Tooth discoloration may be classified as intrinsic, extrinsic, or a combination of both. Scaling and polishing of the teeth remove many extrinsic stains. (2)

Harder/deeper extrinsic discoloration and intrinsic staining require various bleaching techniques (3). Bleaching defined as the treatment, usually involving an oxidative chemical that alters the light absorbing and/or light reflecting nature of the material /structure thereby increasing its value (whiteness) (4).With increasing demand for adult orthodontics, orthodontists often encounter patients who are unsatisfied not only with the alignment but also with the colour of their teeth and looking for comprehensive esthetic treatment.

Vital and non vital bleaching with various whitening agents has now gained worldwide acceptance among clinicians and patients for lightening teeth. (5). Bleaching techniques have improved dramatically in an increasing range of products for both vital and non vital bleaching. Progress has been made also in orthodontic brackets with the development of attractive materials and functional design. nonvital esthetic treatments such as crowning or the placement of veneers on discoloured teeth (6). Walking" bleach technique, is very efficient method to get desired results quickly, easily and economically acceptable (7). Today, the most commonly used tooth-bleaching agents contain hydrogen peroxide as the active ingredient. Hydrogen peroxide may be applied directly or produced by a chemical reaction from sodium perborate or carbamide peroxide (5).

Hydrogen peroxide acts as a strong oxidizing agent through the formation of reactive oxygen molecules; these reactive molecules attack long-chained, dark coloured chromophore molecules and split them into smaller, less coloured, and more diffusible molecules (6).

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However, the changes in enamel structure and composition induced by these bleaching agents may decrease the shear bond strength (SBS) of orthodontic brackets [8].

Bond strength can be defined as force per unite area required to break a bonded assembly with failure occurring in or near the adhesive/adherened interface, it is commonly reported in units of megapascals (MPa) [9, 10].
Almost all bond strength tests are categorized as tensile or shear bond strength. [11]

This study aimed to investigate the effects of three intracoronal bleching agent (Hydrogen peroxide 35%, Carbamide peroxide 37% and sodium perborate) on bond strength of two type of orthodontic brackets stainless: steel and ceramic (sapphire) brackets, and to determine the predominant site of bond failure Shear bond strength test was chosen in this study because it is the common procedure used for the evaluation the bonding efficacy of dental materials [12].

MATERIAL AND METHOD

120 freshly extracted human maxillary first premolars were collected which has been extracted from 18-25 years old Iraqi patients seeking orthodontic treatment examining the teeth with 10X magnifying lens), and transilluminating light [13], 80 teeth were selected according to the following criteria

1. No cracks or gross irregularities of the enamel structure from the extraction forceps

2. Intact buccal enamel surface

3. Not treated with a chemical agent such as alcohol, formalin, or hydrogen peroxide or any other form of bleaching (by giving instruction how to collect the teeth and asking the patients if they had teeth bleaching or not) [14-16].

Preparation of the sample

After extraction, the teeth were washed in tap water to remove any traces of blood [17] .Then each tooth was thoroughly rinsed to remove any soft tissue remnants and debris [13,17]. The collected teeth were stored in a solution of 0.9 % NaCl (normal saline) containing thymol crystals 0.1% (wt/vol), and the solution has been renewed systematically each week to prevent bacterial growth and dehydration till required [18-20].

Endodontic treatment of the teeth

Standard endodontic treatment for each tooth was done. After that *2 mm* of gutta-percha were removed determined by a periodontal probe and removed by gates drill / pesso reamers dental rotary instruments then a layer of resin modified glass ionomer cement (GIC) (Glass liner/ Germany) of *2mm* thickness was applied .The sealing material should reach the level of the epithelial attachment or the CEJ, respectively, to avoid leakage of bleaching agents cervically [21]

Mounting the teeth

Each tooth was fixed on a metal slide in a vertical position using soft sticky wax at the root apex so that the middle third of the buccal surface was oriented to be parallel to the analyzing rod of the surveyor [22, 23]. This kept the buccal surface of tooth parallel to the applied force during the shear test [24, 20, 25, 26].
Another two teeth were fixed on the metal slide about 2 cm away from the first tooth and oriented in the same manner in order to have three premolar teeth fixed on the glass slide 2 cm apart The occlusal surface of each tooth oriented to same height by using a stone disc bur [27] (Fig 1).

After fixing of the teeth, two L-shaped metal plates, were painted with a thin layer of separating medium (Vaseline) and placed opposite to each other in such way to form a box around the vertically positioned teeth with the crowns protruding .After setting of the self cured acrylic resin, the two L-shaped metal plates were removed, the sticky wax used for fixation of teeth in the proper orientation removed too and the resulting holes were filled with self cure acrylic.
After mounting, the specimens were marked and stored in a saline solution of 0.1% (weight/volume) thymol to prevent dehydration [28, 29,30].

A **B** **C**

Figure 1: Mounting of teeth, A: Fixation of the teeth n the metal plate using sticky wax, B: Buccal parallelism of the teeth with the vertical rod of the surveyor, C: Occlusal parallelism of the teeth using a stone disc bur

Bleaching procedure

In this experimental study, hydrogen peroxide (35%) intracoronal bleaching *(Opalacence Endo, Ultradent products Inc, South Jordan, Utah),* carbamide peroxide (37%) intracoronl bleaching *(Whiteness Super Endo, Dentscare) and* sodium perborate (tetrahydrate) intracoronal bleaching *(Sultan Healthcare, Englewood, NJ 07631).* After endodontic treatmet, the teeth randomly divided equally (according to the type of the brackets used) into two main groups (n = 40 per group). Each main group then subdivided (according to the bleaching agent used) into four subgroups 10 teeth each; as following : control (un bleached) group, hydrogen peroxide group (Hp) 35%, carbamide peroxide group (CP) 37% group and sodium perborate (SP) group .

For the control groups, the access cavity was rinsed with distilled water and dried, and the final composite restorations were applied.

The bleaching procedure of each sub group was done similarly according to the manufacturer instructions.

For the first group, intracoronal bleaching was performed with walking technique using 35% hydrogen peroxide as following (Fig 2.A):

1. The restorative temporary filling material were removed by round bur using a slow speed hand piece, to allow bleaching agent to contact the internal tooth structure
2. Rinsing the access cavity opening of the teeth was done with distill water and dried by dental air triple syringe.
3. Then the bleaching gel was applied by the delivery tip into the pulp champer of each tooth
4. Tiny cotton pellet was placed into gel, leaving 1.0 to 1.5mm of space to accommodate the provisional restoration.

For the second group, the same steps of walking bleaching technique used in group one were used but by using carabamide peroxide 37% instead of hydrogen peroxide 35% (Fig 2.B).

For the third group, the same steps of walking bleaching technique used in group one were used but by using sodium perboroate bleaching agent which prepared by the mixing of sodium perborate (tetrahydrate) and water in a 2:1 ratio (g/ml) giving the alkaline pH, then the bleaching agent was applied with an amalgam carrier into the pulp chamber [31] (Fig 2, C).

This procedure was repeated a further two times (once every four days). After 12 days, the temporary filling material was removed, the access cavity was rinsed with distilled water, and the final composite restoration was applied. The teeth were immersed in daily replaced artificial saliva and allowed to stand for 4 weeks before bracket bonding

A **B** **C**

Figure 2: Bleaching application, A: hydrogen peroxide, B: sodium perborate, C: carbamide peroxide

Bonding of the Brackets

The buccal surface of each tooth was polished using non-fluoridated pumice/water slurry in a rubber cup (for standardization one rubber cup used for each subgroup) attached to a low speed hand piece for 10 seconds [13, 25, 32], then each tooth was washed with water spray for 10 seconds, and dried with oil-free air for 10 seconds [32, 33, 34].

The etching agent (37% phosphoric acid gel) then applied to the buccal surface of each tooth for 30 seconds (according to the manufacturer instructions), and then washed with air water spray for 20 seconds, then dried with oil-free air for 20 seconds, the buccal surface of the etched tooth appeared chalky white in colour [35, 21].

The bonding was done by applying a very thin coat of sealant/bond enhancer (Ortho Solo™/ Ormco/Italy) on the etched enamel surface using a disposable brush in gingivo-occlusal direction and equal amount of the adhesive paste (Enlight LV/Ormco/Italy): was applied on the bracket base according to the manufacturer instructions.

Two types of Roth orthodontic brackets were used in this study; Stainless steel Brackets, DISCOVERY®,(Dentaurum Company/Germany with 8.71 mm² surface area and (Sapphire) brackets, Perfect Clear, (Hubit Co., Ltd / South Korea) with 12.2 mm² surface area .Each bracket is positioned on the proper site on the middle third of the buccal surface of each tooth parallel to the

long axis of the tooth by using a clamping tweezers , then, constant load of 300 gm was placed on the bracket for 10 seconds [36] applied by the vertical arm of the surveyor (which weigh 300 gm) after measuring it by a hand scale by fixing a hard rubber polishing bur in the lower part of the vertical arm of the surveyor and put it in contact with the bonded bracket, to ensure that each bracket was seated under an equal force and to ensure a uniform thickness of the adhesive and prevent air entrapment which may affect bond strength [37]. Any excess adhesive material was gently removed from around the bracket base with a sharp probe without disturbing the seated bracket [38].

For both sapphire and stainless steel brackets the light guide of the curing unit 'LED' was placed approximately 1 mm away from the bracket [23]. The light shined through the brackets for 40 second (10 seconds on each side: mesial, distal, occlusal and gingival**)** [39].

The intensity of the curing light was measured and fixed at 1000mW/cm² before each curing cycle (for standardization) by using a curing light meter [40]**.**

After completion of the bonding procedure the specimens were immersed in artificial saliva in a glass containers and stored in the incubator at 37º C for 24 hours prior to brackets debonding [41, 42, 38]

Shear Bond strength test

Each specimen was loaded into a Universal testing machine (Tinius-Olsen Universal testing machine) with a 5 KN load cell and a crosshead speed of 0.5 mm/minute and a custom made chisel rod [43, 5]**.** The test was carried out in laboratory of the Ministry of Science and Technology of Iraq, with the long axis of the specimen kept perpendicular to the direction of the applied force. The standard knife edge was positioned in the occlusogingival direction and in contact with the bonded specimen.. The values of failure loads (N) were recorded and converted into megapascals (MPa) by dividing the failure load (N) by the surface area of the bracket base.

Estimation of adhesive remnant index (ARI)

Once the brackets had been debonded, the enamel surface of each tooth was examined under 20X magnification with the stereomicroscope to determine the amount of residual adhesive remaining on each tooth [42].

The ARI scale used to determine the bond failure sites has a score range between I and IV as described below according to **Wang et al** [44]**:**

- **Score I:** Between the bracket base and the adhesive.
- **Score II:** Cohesive failure within the adhesive itself, with some of the adhesive remained on the tooth surface and some remained on the bracket base.
- **Score III:** Between the adhesive and the enamel.
- **Score IV:** Enamel detachment.

Statistical analysis

Data were collected and analyzed using SPSS (statistical package of social science) software version 15 for windows XP Chicago, USA. In this study the following statistics were used:

A. **Descriptive statistics**: including means, standard deviations, minimum, maximum, and percentages.

B. **Inferential statistics**: including:

1. One way analysis of variance (ANOVA)

To test any statistically significant difference among the shear bond strength of three different types of intracoronal bleaching materials.

2. Least significant difference (LSD)

This is used to test any statistically significant differences between each two sub groups when the **ANOVA** a statistical difference within the same group or type of bracket.

3. Chi-square

To test any statistically significant differences between the groups for the failure site examination results. **P (Probability value)** level of more than 0.05 was regarded as statistically non-significant. While a P-level of 0.05 or less was accepted as significant as follows:

$0.05 \geq P > 0.01$ * Significant.

$0.01 \geq P > 0.001$**Highly significant.

RESULTS

Descriptive statistics for the SBS (MPa) of stainless and sapphire groups are showed in tables(1) and (2) respectively..For stainless steel group ANOVA indicated a significant difference between sub groups ($P<0.001$).LSD showed s a highly significant difference in shear bond strength between each variable compared with the control group($P<0.001$).While for sapphire group ANOVA indicated n o significant difference between sub groups ($P>0.05$). The frequency distribution of the ARI scores for the two groups presented in tables (3) and (4). Chi-square comparison revealed no significant difference between in the site of bond failure between the control group and the three variables (HP, CP and SP) in both stainless steel and sapphire groups.

Table 1: Descriptive data for shear bond strength test (Mpa) of stainless steel group

Groups	Mean	SD	Min.	Max.
Control	67.474	13.835	48.97	86.91
HP	41.424	14.843	10.33	66.02
CP	45.241	17.560	19.52	72.9
SP	42.838	20.737	11.31	69.12

Table 2: Descriptive data for the shear bond strength test (Mpa) of Sapphire group

Groups	Mean	SD	Min.	Max.
Control	31.031	7.548	16.80	41.15
HP	28.654	7.580	13.48	40.02
CP	29.356	8.694	17.70	45.66
SP	31.703	8.882	25.70	55.49

Table 3: Distribution and percentage of adhesive remnant index (stainless steel group)

Groups		Scores			
		I	**II**	**III**	**IV**
Control	**No.**	6	2	2	0
	%	60%	20%	20%	0%
CP	**No.**	1	5	4	0
	%	10%	50%	40%	0%
HP	**No.**	2	4	4	0
	%	20%	40%	40%	0%
SP	**No.**	1	5	4	0
	%	10%	50%	40%	0%

Table 4: Distribution and percentage of adhesive remnant index (sapphire group)

Groups		Scores			
		I	**II**	**III**	**IV**
Control	No.	0	5	4	1
	%	0%	50%	40%	10%
CP	No.	0	4	6	0
	%	0%	40%	60%	0%
HP	No.	0	2	8	0
	%	0%	20%	80%	0%
SP	No.	0	5	5	0
	%	0%	50%	50%	0%

DISCUSSION

Orthodontists may encounter patients who are unsatisfied not only with the alignment but also with the colour of their teeth, therefore; it is important when orthodontist faces patient who needs intracoronal bleaching with orthodontic treatment to know is there any undesirable effects of intraconal bleaching on shear bond strength(SBS) of orthodontic brackets.

It clearly obvious from the results of this study (table 1), that the teeth bonded with stainless steel brackets after intracoronal bleaching with all types of bleaching agents used showed lower mean value of shear bond strength than that of control group.

Effects of bleaching on shear bond strength of stainless steel brackets

The significant reduction in SBS could be due to changes in enamel and dentine structure that produced because of the low molecular weight of hydrogen peroxide (the active ingredient in all bleaching agents used in this study) that enable it to move through the tooth structure and so denature proteins; this increases tissue permeability and allows ions to move through the tooth [45]. The increased time of bleaching application increase porosity or reduce the micro hardness of dentin and enamel by the loss of calcium. These results fully agree with those of most previous studies [46, 47, 38].

The decreased adhesive potential of the resinous material to the bleached teeth, and the reduced average values for shear bond strength may be related to free oxygen radicals that released from peroxide based bleaching agents, which are known to have the potential to cause cellular change [48].In addition, sealing the pulp chamber and access cavities where the bleaching was applied before immersion in artificial saliva might retard the elimination the residuals of oxygen from the tooth structure [47], and these residual products suggested to interfere with resin infiltration into the bleached teeth or inhibits resin polymerization and thus reducing the bond strength [49, 50]. Consistent with these suggested explanations, SBS values were significantly lower in all of the bleached groups than in the control group.

On the other hand, these results were disagreed with two previous studies that suggested that bleaching with 10% carbamide peroxide or 35% hydrogen peroxide did not adversely affect SBS of brackets [18, 51], these results may be due different bleaching techniques used.

Effects of bleaching on shear bond strength of sapphire brackets

The results of this study showed no significant difference in bond strength values of sapphire brackets bonded to bleached groups with that bonded to control group ($p > 0.05$) .

Since there is no study evaluating the effects of inracoronal bleaching on SBS of sapphire brackets according to our knowledge we found the following suggested explanations of the results:

1. The presence of zirconia particles coating the bracket base creates millions of undercuts that

secure the bracket in place, by micro mechanical retention means.

2. The translucency that sapphire brackets have, gives a better chance for complete polymerization of the adhesive with light curing.

3. Sapphire brackets are Single-crystalline brackets so they are hard and offer great strength that prevents or reduces the peeling effects that may occur during brackets debonding thus give them high SBS values.

Failure site

The ARI score depend on many factors, which included the attachment base design and the adhesive type, and not only the bond strength at the interfaces. (52)

ARI scores are used to define the site of bond failure between the enamel, adhesive, and the attachment base through the remaining adhesive on the enamel surface (53).

In this study, the results of ARI score comparisons indicated no significant difference in failure site between bleached and control groups in both brackets types used. These findings was in agreement with that of Gungor et al.(38) and it perhaps due to the use of the same bracket type in each group according to Al-Naqash (54) that make no difference in the failure sites between bleached and non bleached groups.

REFERENCES

1. Chandrashekar MH, Parekh J, Shendre S. Effect of office bleaching agents on the shear bond strength of metallic brackets Bonded Using self-etching primer system at different time Intervals –an in-vitro study. Int. J Clinical Dental Sci 2011; 2(2): 84-72.
2. Hattab FN, Qudeimat MA, al-Rimawi HS. Dental discoloration: an overview. J Esthet Dent 1999; 11: 291–310.
3. Khan T, Ahad B, Tahir Khan A, Nasser A. The effect of bleaching on shear bond strength of orthodontic brackets. Pakistan Oral & Dental J 2012; 32(1): 99-103.
4. American Association of Endodontists. Glossary of Contemporary terminology for Endodontists. 6th ed. Chicago; 1998.
5. Gungor AY, Ozcan E, Alkis H, Turkkahraman H. Effects of different intracoronal bleaching methods on shear bond strengths of orthodontic brackets. Angle Orthod 2012; (5): 942–6.
6. Dahl JE, Pallesen U. Tooth bleaching-a critical review of the biological aspects. Crit Rev Oral Biol Med 2003; 14: 292–304.
7. Stanković T, Popović M, Karadžić B. The Efficacy of "Walking" Bleach Technique in Endodontically Treated Teeth – Case Report. Srbije. 2011; 58(3):163-7.
8. Turkkahraman H, Adanir N, Gungor AY. Bleaching and desensitizer application effects on shear bond strengths of orthodontic brackets. Angle Orthod 2007; 77(3):489–93. (IVSL).
9. ISO/TS Technical Specification 11405. Technical specification; dental materials testing of adhesion to tooth structure. 2nd ed, 2003. pp. 1-15.
10. Eliades G, Watts DC, Eliades T. (Eds). Dental Hard Tissues and Bonding, Interfacial Phenomena and Related Properties. Berlin: Springer-Verlag. Heidelberg; 2005.
11. Roberson TM, Heymann HO, Swift EJ. Sturdevant's art and science of operative dentistry. 4th ed. Mosby Inc.; 2002.
12. Retief DH. Standardizing laboratory adhesion tests. Am J Dent 1991; 4(5): 231-6.
13. Attar N, Taner TU, Tűlűmen E, Korkmaz Y. Shear bond strength of orthodontic brackets bonded using conventional vs one and two step self-etching/adhesive system. Angle Orthod J 2007; 77(3): 518-23.
14. Habibi M, Nik TH, Hooshmand T. Comparison of debonding characteristics of metal and ceramic orthodontic brackets to enamel: an in vitro study. Am J Orthod Dentofacial Orthop 2007; 132(5): 675-9.
15. Bishara SE, Ostby AW, Laffon JF, Warren JF. A self-conditioner for resinmodified glass ionomers in bonding orthodontic brackets. Angle Orthod 2007; 77(4): 711-5.
16. Uysal T, Sisman A. Can previously bleached teeth be bonded safely using self-etching primer systems? Angle Orthod 2008; 78(4): 711–7.
17. Vicente A, Bravo LA. Shear bond strength of precoated and uncoated brackets using self-etching primer. Angle Orthod 2007; 77(3): 524-7.
18. Bishara SE, Oonsombat C, Soliman MM, Ajlouni R, Laffoon JF. The effect of tooth bleaching on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2005; 128(6): 755–60.
19. Turk T, Elekdag-Turk S, Isci D, Cakmak F, Ozkalayci N. Saliva contamination effect on shear bond strength of selfetching primer with different debond times. Angle Orthod 2007; 77: 901–6.
20. Öztaş E, Bağdelen G, Kılıçoğlu H, Ulukapı H, Aydın I. The effect of enamel bleaching on the shear bond strengths of metal and ceramic brackets. Eur J Orthod 2012; 34(2): 232-7.
21. Steiner DR, West JD. A method to determine the location and shape of an intracoronal bleach barrier. J Endod 1994; 20: 304–6.
22. Scougall-Vilchis RJ, Saku S, Kotake H, Yamamoto K. Effects o 6 self – etching primers on shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2009; 135(4): 424.el-e7.
23. 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. Semin Orthod 2010; 16 (1): 66-75.
24. Pithon MM, Santos RLD, Ruellas ACO, Sant'Anna EF.One component self-etching primer: a seventh generation of orthodontic bonding system? Eur J Orthod 2010; 32: 567-70.
25. Goyal A, Shivalinga BM, Jyothikiran H. Effect of drying the etched tooth surface with warm air on shear bond strength of metallic orthodontic brackets: An in Vitro study. Indian J Dental Sci 2012; 4(1): 13-16.
26. Sfondrini MF, Fraticelli D, Gandini P, Scribante A. shear bond strength of orthodontic brackets and

disinclusion buttons: effect of water and saliva contamination. Biomed Res Int 2013; 180137.
27. Linn BJ, Berzins DW, Dhuru VB, Bradley TG. A comparison of bond strength between direct and indirect- bonding methods. Angle Orthod 2006; 76: 289-94.
28. Millett DT, Letters S, Roger E, Cummings A, Love J. Bonded molar tubes- An In vitro Evaluation. Angle Orthod 2001; 71(5): 380-5.
29. Coups-Smith KS, Rossouw RE, Titley KC. Glass Ionomer Cements as Luting Agents for Orthodontic Brackets. Angle Orthod 2003; 73:436–444.
30. Cozza P, Martucci L, De Toffol L, Penco SI. Shear bond strength of metal brackets on enamel. Angle Orthod 2006; 76(5): 851-6.
31. Rani A, Gotarkar M. Waliking bleaching –still relivant; review with- a case report. Indian J Dental Sci 2009;1(2): 31-7
32. Al-Khateeb HM. Shear bond strength of different lingual buttons bonded to wet and dry enamel surfaces with resin modified glass ionomer cement (in vitro comparative study). A master thesis, College of Dentistry, University of Baghdad, 2012.
33. Montasser M, Drummond J, Roth JR, Al-Turki L, Evans CA. Rebonding of orthodontic brackets. Part II, an XPS and SEM study. Angle Orthod 2008; 78(3): 537-44.
34. Garma NMH, Kadhum AS, Yassir YA. An in vitro evaluation of shear bond strength of chemical and light-cured bonding materials with stainless steel,ceramic, and sapphire brackets J Bagh coll Dentistry 2011; 23: 133-138.
35. Katona TR, Long RW. Effect of loading mode on bond strength of orthodontic brackets bonded with 2 systems. Am J Orthod Dentofacial Orthop 2006; 129(1): 60-4.
36. Bishara SE, Ostby AW, Laffoon JF, Warren JJ. Enamel cracks and ceramic brackets failure during debonding in vitro. Angle Orthod 2008; 78(6): 1178-83.
37. Nemeth BR, Wiltshire WA, Lavelle CLB. Shear/ peel bond strength of orthodontic attachments to moist and dry enamel. Am J Orthod Dentofac Orthop 2006; 129(3): 396-401.
38. Gungor AY, Ozcan E, Alkisa H, Turkkahramana H. Effects of different bleaching methods on shear bond strengths of orthodontic brackets. Angle Orthod 2013; 83(4): 686-90.
39. Wendle B.and Droshl H. Acopmaritive invitro study of the directly bonded brackets using different curing techniques. Eur J Orthod 2004; 26: 535-545.
40. Xiaojuna D, Jingb Lu, Xuehuac Guo, Hongd R, Youchenge Yu, Zhangyuf Gu, Sung J. Effects of CPP-ACP Paste on the Shear Bond Strength of Orthodontic Brackets. Angle Orthod 2009; 79: 945–50.
41. Scougall-Vilchis RJ, Saku S, Kotake H, Yamamoto K. Effects o 6 self – etching primers on shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2009; 135(4): 424.el-e7.
42. Souza-Gabriel AE, Vitussi LOC, MILANI C, Alfredo E, Messlas D. CF, Silva-sousa YTC. Effect of bleaching protocols with 38% hydrogen peroxide and post-bleaching times on dentin bond strength. Braz Dent J 2011; 22(4): 317-21
43. Scougall-Vilchis RJ, Saku S, Kotake H, Yamamoto K. Influence of different self-etching primers on the bond strength of orthodontic lingual buttons. Eur J Orthod 2010; 32: 561-6.
44. Wang WN, Meng CL, Tarng TH. Bond strength: a comparison between chemical coated and mechanical interlock bases of ceramic and metal brackets. Am J Orthod Dentofacial Orthop 1997; 111(4): 374-81.
45. McEvoy SA. Chemical agents for removing intrinsik stains from vital teeth. II. Current techniques and their clinical application. Quintessence Int 1989; 20: 379-84.
46. Uysal T, Er O, Sagsen B, Ustdal A, Akdogan G. Can intracoronally bleached teeth be bonded safely? Am J Orthod Dentofacial Orthop. 2009; 136(5): 689–94.
47. Uysal T, Ertas H, Sagsen B, Bulut H. Ozgur ER and Ustdal A. Can intra-coronally bleached teeth be bonded safely after antioxidant treatment? Dent Mater J 2010; 29(1): 47–52.
48. Weitzman SA, Weitberg AB, Stossel TP, Schwartz J , Shklar G. Effects of hydrogen peroxide on oral carcinogenesis in hamsters. J Periodontol 1986; 57: 685-8.
49. Miles PG, Pontier JP, Bahiraei D, Close J. The effect of carbamide peroxide bleach on the tensile bond strength of ceramic brackets: an in vitro study. Am J Orthod Dentofacial Orthop. 1994; 106(4): 371–5.
50. Titley KC, Torneck CD & Ruse ND.The Effect of Carbamide-Peroxide Gel on the Shear Bond Strength of a Microfil Resin to Bovine Enamel. J Dent Res 71(1): 20-24, 1992.
51. Uysal T, Basciftci FA, Usumez S, Sari Z, Buyukerkmen A. Can previously bleached teeth be bonded safely? Am J Orthod Dentofacial Orthop. 2003; 123(6): 628–32.
52. O′Brien KD, Watts DC, Read MJF. Residual debris and bond strength- is there a relationship? Am J Orthod Dentofac Orthop 1988; 94(3): 222- 30
53. Santos BM, Pithon MM, Ruellas ACO, Sant'Anna EF. Shear bond strength of brackets bonded with hydrophilic and hydrophobic bond system under contamination. Angle Orthod 2010; 80: 963-7.
54. Al-Naqash Gs. The effect of temperature variation of composite orthodontic adhesive on shear bond strength. A master thesis, College of Dentistry, University of Baghdad 2011.