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Evaluation and comparison of shear bond strength in different regions of tooth bonded with two different etchant systems- An in vitro study

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ABSTRACT

Objective: To assess and compare the shear bond strength of the bracket utilising a self-etching priming system and a traditional etching technique in three tooth locations: the incisal, middle, and cervical regions.**Material and method:**Thirty extracted human premolar teeth were employed, and the teeth were split into six groups. Three groups underwent conventional etch system bonding in the middle, incisal, and cervical thirds of the teeth. In a similar manner, the teeth in the other three groups were cemented in three different areas of the tooth using self-etching primer. Next, the shear bond strength of every group was assessed. For bonding, standard MBT metal premolar brackets were utilised.**Result:** Statically significant difference was found among the bond strength in cervical, middle and incisal third and also amongst conventional etching and self-etching primer.

Limitation: In present study different tooth types are not included.**Conclusion:**Bond strength is strongest in the incisal region, followed by the middle and cervical third, according to scanning electron microscopy, which also shows that all tooth types' cervical sections have less etch quality and more aprismatic enamel.It was also found that bond strength was more with conventional etchant when compared with self-etching primer.

Keywords:shear bond strength, tooth bonded, incisal region.

INTRODUCTION:

The mechanical process of bonding orthodontic brackets to tooth surfaces occurs through an intermediate resin component, which is produced when resin monomer polymerizes and penetrates the micro gaps in enamel that are formed by acid conditioning1. The depth to which resin penetrates enamel affects the bond strength of orthodontic brackets; therefore, it's important to take into account tissue variables that may have an impact on penetration. Bond strength may be impacted by ether chemical or morphologic predominance, or by enamel's inability to produce enough porosity for resin to penetrate and stay in it.2.

Enamel is a homogeneous material composed of two separate layers: a prismatic layer underneath and an upper layer of enamel known as "prismless." The optic axis of the prismless layer is almost exactly parallel to the enamel surface. Prismmatic enamel, on the other hand, features clear rod boundaries that are positioned perpendicular to the surface. 3, 4, 5. Through the process of etching, the outer aprismatic enamel is removed, revealing the underlying prismatic rods and creating a micromechanical resin bond between the bracket and the teeth.Six Scanning electron microscopy (SEM) investigations of etched buccal premolar and molar enamel have revealed that the incisal and middle thirds of etched premolar enamel exhibit unique prism-end, honeycomb-type formations, whereas the cervical region is predominantly made of prism less enamel.7,8

Numerous investigations have revealed that there are notable differences between etching systems. According to some of these studies, the shear bond strength of an orthodontic bracket bonded using a standard acid etching method is comparable to that of a self-etching priming system. 9.

According to certain research, the etching quality varies depending on the tooth's location. However, no research has been done to compare the impact on bond strength of a tooth region treated with a different etching procedure to date. Therefore, the goal of this study is to assess and compare the shear bond strength of brackets utilising standard etching systems and self-etching priming systems in three tooth areas: the incisal, middle, and cervical regions.

MATERIALS AND METHODS

Thirty extracted human premolars were gathered as a sample size from different dental clinics and kept in a 0.1% thymol solution. Following the acquisition of the entire sample size, it was sanitised for 24 to 48 hours in a 10% sodium hypochlorite solution. Premolars on the mandible and maxilla were found to have a complete enamel surface, free of cavities, decalcification, fluorosis, and enamel flaws. Thirty teeth that satisfied the requirements for inclusion were sorted, and each specimen's surface was cleaned using a mixture of water and nonfluoridated pumice powder using a polishing brush and rubber cup. The surfaces were then rinsed and allowed to air dry. Following the treatment, each tooth crown was separated into three sections, one third for the incisal, middle, and cervical regions, based on the vertical height of the crown.

Group A: - Bonding is done on Incisal one third with Conventional Etchant.
Group B: - Bonding is done on Middle one third with Conventional Etchant.
Group C: - Bonding is done on Cervical one third with Conventional Etchant.
Group D: - Bonding is done on Incisal one third with Self Etching Primer.
Group E: - Bonding is done on Middle one third with Self Etching Primer.
Group F: - Bonding is done on Cervical one third with Self Etching Primer.

Etching of tooth surface in first three group (group A, B and C) is done with 37% phosphoric acid for 20 seconds followed by application of thin layer of sealant and bonding agent and cured with LED light cure system , then bonded bracket to tooth surface with respect to group of the specimen . (figure 3)

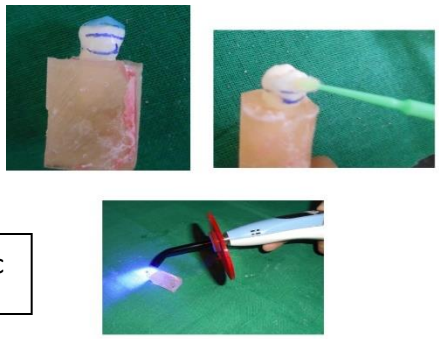

Fig 1:- application of a) etchant , b) primer and c) curing procedure .

In next three groups (group D, E and F) bonding done on three regions according to group of specimen with self-etching primer.
The universal testing machine was then used to assess the shear bond strength for each group. The bonding process involved the use of standard MBT 0.022 "slot metal premolar brackets. (Fig. 4)

Fig 2:- . Testing of bond strength on sample with universal testing machine.

Statistics:

A blinded investigator processed all sample results obtained by a universal testing machine, ensuring standardisation of the procedures. A statistical analysis was conducted using a.005 significant threshold. Normal distributions were displayed by the machine statistics for kurtosis and skewness. Preliminary evaluations using the data from the universal testing machine results indicated that there were no changes in jaw alignment. A statistically significant variation was seen in the bond strength between the self-etching primer system and the traditional etching system in the incisal ($p=0.0009$), middle ($p=0.031$), and cervical ($p=0.005$) third regions. To assess the variations between the etching system and tooth areas, a paired t-test was employed.

Results

Shear bond strength evaluated from the specimens with universal testing machine showed differences among the various regions of teeth and difference in two etching system.
Shear bond strength of bracket bond with conventional acid etching system on three regions of tooth showed the variability as bond strength on incisal one third is more with mean value of 8.9 MPa followed by middle one third with mean of 7.3 MPa followed by cervical one third with

mean 5.78 MPa , shows shear bond strength on cervical region is least among three region. (table 1)

While shear bond strength of bracket bond with self-etching primer system is comparatively low with conventional acid etching showing mean value of shear bond strength on incisal one third is 6.93 MPa followed by middle one third 6.36 MPa followed by cervical one third 4.89 MPa . (table 2)

Table 1 – Shear bond strength on three region of tooth when etched with conventional etching system.

		Group : A		**Group : B**		**Group : C**	
Sr. No.	Sample No.	Max. Load (N)	Shear Bond Strength (MPa)	Max. Load (N)	Shear Bond Strength (MPa)	Max. Load (N)	Shear Bond Strength (MPa)
1	1	154.00	8.62	120.50	6.75	102.50	5.74
2	2	165.50	9.27	117.00	6.55	97.00	5.43
3	3	159.50	8.93	126.50	7.08	108.50	6.07
4	4	156.30	8.72	119.30	6.69	100.08	5.66
5	5	163.46	9.02	123.33	6.92	106.27	6.01

		Group : D		**Group : E**		**Group : F**	
Sr. No.	Sample No.	Max. Load (N)	Shear Bond Strength (MPa)	Max. Load (N)	Shear Bond Strength (MPa)	Max. Load (N)	Shear Bond Strength (MPa)
1	1	128.00	7.17	109.5	6.13	87.50	4.90
2	2	120.50	6.74	115.0	6.44	93.50	5.24
3	3	125.30	6.02	112.02	6.22	84.06	4.72
4	4	131.06	7.26	116.45	6.49	91.52	5.03
5	5	134.00	7.50	117.0	6.55	81.50	4.56

Table 2 - Shear bond strength on three region of tooth bond with self-etching primer

Discussion

Etching quality of maxillary arch tooth and mandibular arch tooth do not show any significant difference in between them, while the different tooth types like that of incisors, canines , premolars and molars teeth shows the qualitative difference in etching qualities according to the results of scanning electron microscopy. [11,12] As per the results of scanning electron microscope, the etching pattern is better in anterior teeth as compared to that of posterior teeth. [13] However in previous studies the focus of all has been on the center of the tooth surface even if study is carried out on different tooth type or tooth of different arches. But there are variations in the vertical positioning of brackets; they are not always positioned on the center of tooth. [14]As in deep bite cases bracket positioning is not at the center of the tooth it sets more incisaly while in open bite cases it sets more cervicaly, and in shorter crown heights, a greater percent of brackets are bonded at cervical region of molar and premolar. [15] By considering the variation of vertical bracket positioning in account, present study is focusing, not only on the center of the tooth, but

it is done on three different regions of tooth like incisal, middle and cervical one third. As per the pattern of development of enamel, which stated that mineralization starts in the incisal region and continued towards the cervical region, which may lead to less dense mineralization in cervical region or, it can be due to changes in pattern of amelogenesis at the end of process. [5] As due to the orientation pattern at cervical region is parallel to enamel surface rather than perpendicular, to achieve better quality of etching, etchant should penetrate to the more depth of prismless enamel.[16]

Etching quality depends upon considerable removal of thickness of aprismatic enamel. Similar to mature enamel, the mineral phase makes up over 95% of the material weight, with only 5% coming from organic materials and water (the remaining 20% coming from other biological mineralized tissues). The mineral phase occupies roughly 87% of the entire volume of enamel tissue. 3-5% of the volume is held by the network of channels that gave rise to porosities.

As per results obtaind by uCT , posterior teeth showed less changes in material density than that of the anterior teeth which leads to poor etching quality, which is responsible for bond failure . There is significant difference found in topography of prismatic and prismless enamel following acid etching.[10,17]

The etching system has a considerable impact on the bracket's shear binding strength to the enamel surface. In traditional acid etching, surface demineralization happens at 5–10 μm. In contrast, it is 1.2 μm in the self-etching primer technique. Acid erosion of enamel results in a specific demineralization that raises the free surface energy. 17 Adhesion, or the bonding to the enamel, is dependent on the resin's capacity to permeate the gap between the crystal prisms, resulting in macro-mechanical retention.Many studies have shown that using self-etching primer instead of 37% phosphoric acid results in a softer etch pattern. Even though using self-etching primer reduces enamel loss more than traditional acid etching of the enamel surface

Numerous earlier investigations demonstrated that the traditional method's shear bond strength was significantly greater than or comparable to that of the self-etching primer and resin system. According to Hitmi L. et al., the control acid etched group's value was higher than that of the self-etching primer. According to Cacciafesta V et al., Dorminey JC et al., Aljubouri YD et al., and Romano FL et al., the amount of self-etching primer was either substantially less or comparable to that of those bonded by a traditional etching technique. According to earlier research, the traditional group's shear bond strength values (37% phosphoric acid) were noticeably higher than those of the other groups. After enamel conditioning with any of the groups, Transbond XT can be used successfully for bracket bonding, and all groups may exhibit clinically meaningful shear bond strength values.

There is significant difference found in bond strength among different tooth types. According to some studies greatest mean bond strength is found on lower first molar, even though it is surprising, as lower first molars supposed to have more bond failure due to masticatory forces and weakest on the upper first molars but this findings were not similar with the study of whittaker et al, as aprismatic enamel on posterior teeth and lesser etching quality on posterior teeth expected to show lesser bond strength on posterior teeth. [10]

All previous studies talked about etching qualities and shear bond strength in different tooth types. In present study the report has been given on how etching quality will affect shear bond strength at three different region of teeth when it is etched with conventional etching system and self-etching primer, that bonded at three different region of tooth that are cervical one third , middle one third, incisal one third of same tooth type.

According to a contemporary study finding, the shear bond strength of a bracket varies depending on where in the tooth it is bonded, and the etching system has a major impact. When comparing the groups of self-etching primer and conventional acid etching, it can be seen that the latter has a deeper demineralization process and a stronger bond. The mean bond strength of group bonded on incisal surface etched with conventional acid etched is the 8.90 MPa, highest among all group followed by bracket bonded on incisal surface with self-etching primer system 6.9 MPa, on middle surface with conventional acid etching system 6.7MPa, on middle surface with self-etching primer 6.3 MPa, on cervical surface with conventional etching system 5.7 MPa and least found on cervical surface with self-etching primer 4.8 MPa.

So according to the results, Whichever etchant is been used, the bond strength remains more in the incisal and occlusal area due to the more parallel pattern of prismatic enamel rods seen in these area compare to cervical rods, which makes the shear bond strength increase as we bond more incisaly, as in cases of deep bite where as in open bite cases the bond achieves less shear strength as by placing the brackets cervicaly.

The present study that the shear bond strength in the cervical area in both conventional and self-etching primer systems is less than that of the prescribed value. The recommended shear bond strength for orthodontic brackets is 5.9–8MPs. Therefore, the orthodontist should use extra caution while gluing teeth in the neck region.

Conclusion

There is difference between etching quality of same tooth in three different regions which affect on shear bond strength of orthodontic bracket. Bond strength in higher on incisal one third of tooth for both conventional etching and self-etching primer system, while it less than recommended on cervical region of tooth in both conventional and self-etching primer system.

Conflict of interest -The authors declare no conflict of interest.

Ethical information -There was no need for ethical consideration as this study was in vitro studied which didn't included any human sample.

References

1 Ali H. Alzainal, Ahmed Shehab Majud, Abdulfatah M. Al-Ani, Adil O. Mageet, "Orthodontic Bonding: Review of the Literature", International Journal of Dentistry, vol. 2020, Article ID 8874909, 10 pages, 2020.

2 Bakhadher W, Halawany H, Talic N, Abraham N, Jacob V. Factors Affecting the Shear Bond Strength of Orthodontic Brackets - a Review of In Vitro Studies. Acta Medica (Hradec Kralove). 2015;58(2):43-8.

3 Simmer JP, Hu JC. Dental enamel formation and its impact on clinical dentistry. J Dent Educ. 2001;65:896–905.

4 . Ripa LW, Gwinnett AJ, Buonocore MG. The ‘‘prismless’’ outer layer of deciduous and permanent enamel. Arch Oral Biol. 1966;11:41–48..

5 Kodaka T. Scanning electron microscopic observations of surface prismless enamel formed by minute crystals in some human permanent teeth. Anat Sci Inter. 2003;78:79–84.

6 Goldberg M. Understanding Dental Caries From Pathogenesis to Prevention and Therapy. Cham, UK: Springer International; 2016.

7 Galil KA, Wright GZ. Acid etching patterns on buccal surfaces of permanent teeth. Pediatr Dent. 1979;1:230–234.

8 Arakawa Y, Takahashi Y, Sebata M. The effect of acid etching on the cervical region of the buccal surface of the human premolar, with special reference to direct bonding techniques. Am J Orthod. 1979;76:201–208.
9 Hitmi L, Attal JP, Degrange M. Evaluation of acidic adhesive for orthodontic bonding. *J D Res*. 2000;79:507(abs).
10 Elisabeth C. Barnhart et al The quality of etched enamel in different regions and tooth types and its significance in bonding and the development of white spot lesions Angle Orthodontist, Vol 91, No 5, 2021.
11 Mattick CR, Hobson RS. A comparative micro-topographic study of the buccal enamel of different tooth types. J Orthod. 2000;27:143–148.
12 Hobson RS, Rugg-Gunn AJ, Booth TA. Acid-etch patterns on the buccal surface of human permanent teeth. Arch Oral Biol. 2002;47:407–412.
13 Whittaker DK. Structural variations in the surface zone of human tooth enamel observed by scanning electron microscopy. Arch Oral Biol. 1982;27:383–392.
14 Silverstone LM, Saxton CA, Dogon IL, Fejerskov O. Variation in the pattern of acid etching of human dental enamel examined by scanning electron microscopy. Caries Res. 1975;9:373–387.
15 By Johnny Holanda de Gauw et al Bracket Placement According to Malocclusion IJO ν VOL. 26 ν NO. 3 ν FALL 2015.
16 O¨ zcan M, Sadiku M. Analysis of structural, morphological alterations, wettability characteristics and adhesion to enamel after various surface conditioning methods. J Adhesion Sci Tech. 2016;30:2453–2465.
17 *Vladan Mirjanić, et al., Changes on dental enamel after acid etching Contemporary Materials, VII−2 (2016).*
18 Amit Zope, etal .Comparison of Self-Etch Primers with Conventional Acid Etching System on Orthodontic Brackets. Journal of Clinical and Diagnostic Research. 2016 Dec, Vol-10(12).