Research Article

AHB Advances in Human Biology

Adv Hum Biol 2014; 4(1):20-25.

Comparison of Shear Bond Strength and Surface Structure Between Acid Etching and Air-Abrasion Techniques

A Radhika Reddy[1*] Vijay Prasad Koganti[2]

[1]Professor, Department of Orthodontics, Rungta Dental College, Bhilai, Chattisgrah, India.
[2]Professor and Head, Department of Periodontics, Dr BR Ambedkar Institute of Dental Sciences, Patna, Bihar, India.

ABSTRACT

Aim: To compare shear bond strength and surface structure between acid etching and air-abrasion techniques

Materials and Methods: Sixty three extracted human premolar teeth were taken, divided into three groups and mounted with color codings. Group l was acid etched with 37% phosphoric acid. Group ll and lll –air abrasion was done with 50µ & 90µ Al_2O_3 particles respectively. After enamel preparation, from each group one tooth was selected for surface roughness study by scanning electron microscope (SEM). The other sixty teeth were selected to evaluate shear bond strength by Instron universal testing machine.

Results: Group I showed significantly higher shear bond strength (10.1± 3.6 Mpa) than Group II and Group III. In SEM study Group l etching pattern showed peripheral dissolution of the prisms. The enamel removal of Group ll was more regular, uniform and less as compared to Group lll. Adhesive remnant index showed that no adhesive material was left on the tooth surface of Group ll & lll as compared to Group l after debonding.

Conclusion: From the present study it was concluded that air abrasion can be used as an adjunct to acid etching but by itself it is not a potent enamel preparation agent.

Keywords: Phosphoric acid, Shear strength, Acid etching, Air abrasion.

INTRODUCTION

Maintaining the integrity of tooth structure has always been important in the field of orthodontics. Since the introduction of the acid etch technique by Buonocore in 1955[1], it has been widely accepted as an alternative to full banded orthodontics. He used 85% orthophosphoric acid to etch enamel surface for 35 seconds.

The iatrogenic factors involved in acid etching technique are loss of enamel caused by etching, retention of resin tags that can lead to possible discoloration of enamel, fracturing of enamel at time of debonding and a softer enamel surface with lower fluoride content more predisposed to decalcification[2-4]. These considerations make evident needs to develop an alternative to the current acid etch procedure.

Air abrasion technology introduced by Dr. Robert Black in 1940's[5,6] was examined for its potential application in dentistry. This technique uses a high speed stream of aluminum oxide particles propelled by air pressure. Air-abrasion is based on the law of kinetic energy which states that the harder the substance, the faster the cutting speed, the softer the substance, the slower is the

Received: May. 25, 2013: **Accepted:** July. 06, 2013
***CorrespondenceDr. A Radhika Reddy.**
Professor, Department of Orthodontics,
Rungta Dental College,Bhallai, Chattisgrah, India.
Email: radhikareddy.orthodontist@gmail.com

pISSN 2321-8568
eISSN 2348-4691

cutting speed. Hence, enamel will get abraded much faster than dentin or amalgam. Today it is viewed as an advantage in terms of protecting the oral soft tissues.

Acid etching technique is clinically effective and reliable. However, there are few drawbacks associated with this technique, mainly irritation of acid to oral soft tissues and time required to obtain the desired dissolution[2,7]. Air abrasion, on the other hand, possesses neither of these drawbacks, while having minimal effect on oral soft tissues, with typical tooth surface preparation time ranging from 0.5 to 3 seconds, without additional step of rinsing or drying[8,9]. Few studies have been done to evaluate the potential of air abrasion technique by Senay Canay et al (2000)[10]; Hogervorst, Albert J et al (2000)[11]; Petra Schmage (2003)[12].

This study was undertaken to evaluate the bond strength obtained with different methods of enamel preparation and also to study the enamel surface after such preparation, using scanning electron microscope (SEM).

MATERIALS AND METHODS

Sixty three human maxillary first premolars extracted for orthodontic treatment with intact buccal enamel not subjected to any pretreatment clinical agents, such as hydrogen peroxide, and no caries or cracks as the result of the extraction forceps were collected. Sixty teeth were mounted into acrylic blocks in such a way that they were embedded in the acrylic upto the cervical margin with the long axis of the tooth kept parallel to that of the central axis of the acrylic block. This is to simulate the natural position of the teeth in the oral cavity. These sample blocks were color coded with twenty blocks having the same color. One tooth from each group was left unmounted for SEM study.

Sample preparation for SEM study

Three teeth were selected for SEM study. Since the sensitivity of SEM machine is high, only one sample from each group was employed. The crowns of the teeth were sectioned from the roots with a carborundum disk. Then each crown was cut on a mesiodistal line from occlusal to cervical with a carborundum disk and the buccal surfaces were cut to 5mm thickness to facilitate the orientation on the aluminum stubs.

Group I (Acid etched; white color): The buccal surfaces of twenty one teeth were etched with a 37% phosphoric acid gel for 30 seconds.

Group II (50 μ Aluminum oxide particles: blue color): The buccal surfaces of twenty one teeth were air-abraded by using 50μ particles of aluminum oxide at 100 psi. Each tooth was abraded for 3 seconds at a distance of 10mm and then rinsed with a water spray for 30 seconds.

Group III (90 μ Aluminum oxide particles; maroon color): The buccal surfaces of twenty one teeth were air-abraded by using 90 μ particles of aluminum oxide at 100psi. Each tooth was abraded for 3 seconds at a distance of 10mm and then rinsed with a water spray for 30 seconds.

After enamel preparation, from each group the unmounted tooth was selected for surface roughness study by scanning electron microscope. The other sixty teeth were selected to evaluate shear bond strength and bond failure site. An Instron universal testing machine was used to test the shear bond strength of each tooth.

The debonding characteristics for each specimen were determined with the Adhesive Remnant Index (ARI) developed by Artun and Bergland[13]. This is a 4 - point scale used to assess the amount of composite remaining on tooth surface on debonding. The ARI rating assigned to each tooth ranged from 0-3, with 0 indicating that no adhesive remained on the tooth surface.

RESULTS

Shear bond strength:

The results of the analysis of variance (ANOVA) described that there was a significant difference in shear bond strength among Group I (acid etch) x =10.1 ± 3.6Mpa, Group II (50μ) x=2.3 ± l.2Mpa and Group III (90μ) x= 3.3 ±1.9Mpa (p = 0.0001). Group I showed significantly higher shear bond strength (10.1± 3.6 Mpa) than Group II and Group III.

Scanning electron microscope study (SEM) (Table 1):

Group I (Acid etched): Showed surface with pits measuring approximately 7-8μ which were semi lunar in shape. Etching pattern showed peripheral dissolution of the prisms (rods), which has been referred to as type II etching pattern. Debris was present (Figure 1).

Group II (50μ Al_2O_3 particles): Showed irregular undulating surface with pits measuring approximately 4-5μ on the measuring scale and the shapes of the irregular surfaces were square or triangular. Debris was present. The enamel removal was more regular and the surface had irregularities which were fairly uniform, and less enamel was removed compared to the Group III (Figure 2).

Group III (90μ Al_2O_3 particle): Showed irregular surface with pits measuring approximately 5-6μ, square or triangular in shape. The removal of enamel was random and did not have a regular pattern as in Group II (Figure 3).

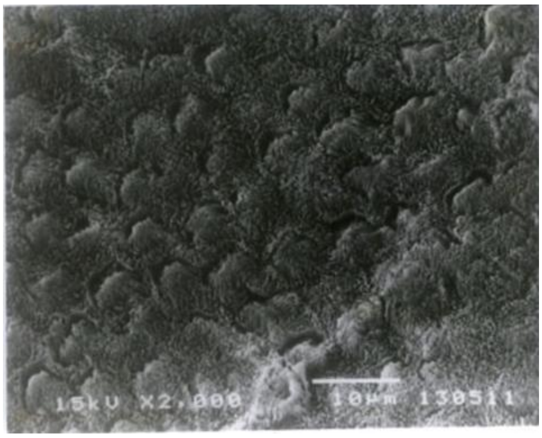

Fig 1: Acid etched surface as seen under SEM.

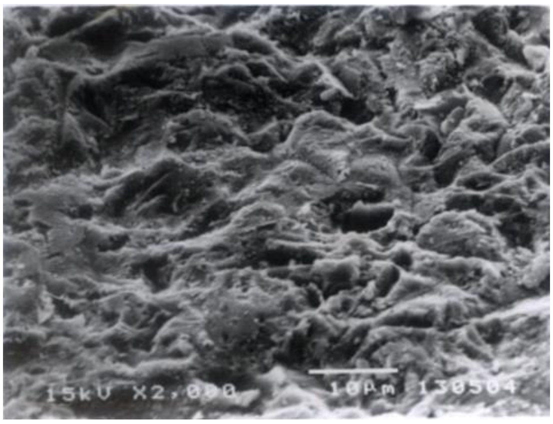

Fig 2: Air abraded surface with 50μ Al_2O_3 particles as seen under SEM

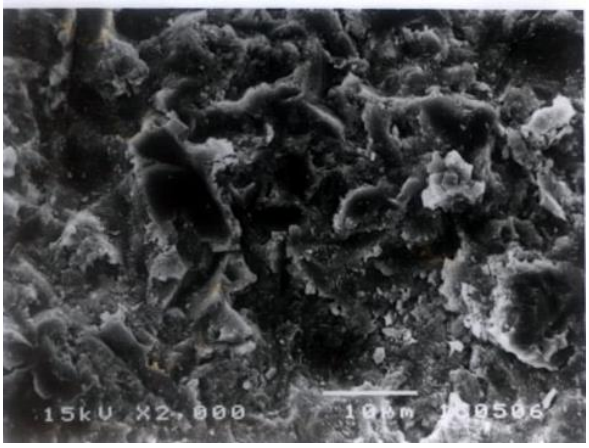

Fig 3: Air abraded surface with 90μ Al_2O_3 particles as seen under SEM.

Adhesive Remnant Index (ARI):

Chi square test was performed for this data and it suggested that there was a significant difference in ARI between the three groups (Table 2).

In Group I, for seventeen teeth bond failure occurred within the adhesive. For two teeth less than half of the material was on the tooth surface, one sample showed bond failure at the bracket base and adhesive.

In Group II, eighteen samples showed bond failure interface. This suggested that no adhesive material was left on the tooth surface. Two samples showed bond failure within the adhesive.

In Group III, seventeen samples showed bond failure at the enamel-adhesive interface, which suggested that no adhesive material was left on the tooth surface. For three samples bond failure occurred within the adhesive.

DISCUSSION

The present study employed the use of 37% H_3PO_4 gel for 30 seconds to etch the buccal surfaces of the teeth (Group I) which was in accordance with a study by Mardaga and Shanonn that proved 37% H_3PO_4 for 30 seconds provided good bond strength. Acid gel was used in the present study to provide better control than solution[14].

The enamel loss with acid etching ranges from 3 to10μ (Levitt & Zachrisson)[15]. These limitations have led to the search for newer, enamel friendly technique preparations. Air abrasion technology has been examined for enamel surface preparation prior to bonding the orthodontic attachments. This technology was introduced by Dr. Robert Black in the 1940s[5]. Aluminium oxide particles are biocompatible substances, long used in medicine and food industry[16].

Group-I (Acid-etched) showed higher bond strength (10.l7+3.69mpa) than the air abraded groups (Group II & Group III), suggesting that the acid etching treatment of enamel is more favourable than the air abrasion method, in providing better bond strength[17].

Table 1: Comparison between all three groups.

Groups	No of Specimen	Mean	Std. Dev	Range	F-Value
Group I	20	10.1	3.6	1.47 – 17.27	56.50 P=0.0001
Group II	20	2.3	1.2	0.43 – 4.27	
Group III	20	3.3	1.9	0.46 – 8.77	

Table 2: Chi square test.

Groups	Score				Chi Square Value = 44.1 (p<0.0001)
	0	1	2	3	
Group I	0	2	17	1	
Group II	18	1	1	0	
Group III	17	1	2	0	

The depth of etched enamel surface created by phosphoric acid may be a contributing factor to the higher shear bond strength[18].

In Group II (50µ Al_2O_3) and Group III (90µ $A1_2O_3$) mean shear bond strength values were 2.36 + 1.25 and 3.37 + 1.98 Mpa respectively.

Group II (50µ $A1_2O_3$) showed slightly decreased bond strength than Group III (90µ Al_2O_3). This was due to the finer aluminum particle size that caused a smoother surface and resulted in less mechanical retention. In contrast Roeder[19] observed that $A1_2O_3$ particle size had no influence on the bond strength. These two group values were below the optimal bond strength of 5.9 and 7.8 Mpa suggested by Reynolds[20] to withstand normal orthodontic forces. Though earlier reports by Wiltshire[21] and Zachrisson[22] showed optimum or increased bond strength when the air pressure was 100psi, it stood in contradiction to this study which also employed 100psi pressure to propel the Al_2O_3 particles. The bond strength also depends on the particle size, shape and hardness of the abrasive, the particle velocity and the microstructure of the surface being abraded[23].

The increased bond strength in the phosphoric acid group when compared to the air abraded groups as observed in this study were in conformity with previous work done by White[23], Olsen[8], Eakle[24] but they were not in agreement with Laurell's study[25]. An alternative method to increase bond strength with enamel preparation is by using sandblasting along with acid etch procedure. This produces optimal bond strength than sand blasting alone[8].

Senay Canay et al (2000) studied the effect of air abrasion on the retention of bonded metallic orthodontic brackets and concluded that it can be advocated as an enamel conditioner[10]. Hogervorst, Albert J et al (2000) results were consistent with the present study's results that the bond strength of the sandblasted groups was significantly lower than that of the etching groups[11]. Petra Schmage (2003) by their study concluded that bond strength of metal brackets to ceramic surfaces was highest with sandblasting group[12].

CONCLUSION

Enamel preparation plays a vital role in the strength of bonded orthodontic attachments. Air abrasion compliments the acid etch procedure, but by itself is not suitable for optimal enamel preparation for routine orthodontic use. Further clinical trials are needed to exemplify the same.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 1955;34:849-53.

2. Diedrich P. Enamel alterations from bracket bonding and debonding: A study with the scanning electron microscope. Am J Orthod 1981;79:500-22.

3. Donnan MF and Ball IA. A double-blind clinical trial to determine the importance of pumice prophylaxis on fissure sealant retention. Br Dent J 1988;165:283-6.

4. Lehman R, Davidson CL. Loss of surface enamel after acid etching procedures and its relation to fluoride release. Am J Orthod 1981;80:73-82.

5. Black RB. Technique for non-mechanical preparation of cavities and prophylaxis. J Am Dent Assoc 1945;32:955-65.

6. Black RB. Application and reevaluation of air abrasion technique. J Am Dental Assoc 1955;50:408-14.

7. Triolo PT Jr, Swift EJ Jr, Mudgil A, Levine A. Effects of etching time on enamel bond strengths. Am J Dent 1993;6:302-4.

8. Olsen ME, Bishara SE, Damon P, Jakobsen JR. Comparison of shear bond strength and surface structure between conventional acid etching and air abrasion of human enamel. Am J Orthod Dentofacial Orthop 1997;112:502-6.

9. Reisner KR, Levitt HL, Mante F. Enamel preparation for orthodontic bonding: A comparison between the use of a sandblaster and current techniques. Am J Orthod Dentofacial Orthop 1997;111:366-73.

10. Senay C, Iiken K, Ela A. The effect of enamel air abrasion on the retention of bonded metallic orthodontic brackets. Am J Orthod Dentofacial Orthop 2000;117:15-9.

11. Wendela L. Van Waveren Hogervorst, Albert J Feilzer, Birte Prahl-Andersen. The air-abrasion technique versus the conventional acid-etching technique: A quantification of surface enamel loss and a comparison of shear bond strength. Am J Orthod Dentofacial Orthop 2000;117:20-6.

12. Schmage P, NergizI, Herrmann W, Ozcan M. Influence of various surface-conditioning methods on the bond strength of metal brackets to ceramic surfaces. Am J Orthod Dentofacial Orthop 2003;123:540-6.

13. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid etch enamel pretreatment. Am J Orthodontics 1984;85: 333-40.

14. Garberoglio R, Cozzani G. In vivo effect of oral environment on etched enamel: Scanning electron microscopic study. J Dent Res 1979;58:1859-65.

15. Levitt HL, Zachrisson BU. Orthodontic bonding In: Marks MH, Corn H, Editors. Atlas of adult orthodontics: functional and esthetic enhancement. Philadelphia: Lea & Febiger; 1989. pg 506-51.

16. Goldstein RE, Parkins FM. Air abrasive technology: its new role in restorative dentistry. J Am Dent Assoc 1994;125:551-7.

17. Chow LC, Brown WE. Phosphoric acid conditioning of teeth for pit and fissure sealants. J Dent Res 1973; 52: 1158.

18. Haris AM, Joseph VP, Rossouw PE. Shear peel bond strengths of esthetic orthodontic brackets. Am J Orthod Dentofacial Orthop 1992;102:215-9.

19. Roeder LB, Berry EA, You C, Powers JM. Bond strength of composite to air - abraded enamel and dentin. Oper Dent 1995;20:186-90.

20. Reynolds IR, Von Fraunhofer JA. Direct bonding of orthodontic attachments to the teeth: The relation of adhesive bond strength to gauze mesh size. Br J Orthod 1976;3:9l-5.

21. Wiltshire WA. Tensile bond strengths of various alloy surface treatments for resin bonded bridges. Quintessence Dent Technol 1986;10:227-32.

22. Zachrisson BJ. Third - generation mandibular bonded lingual 3-3 retainer. J Clin Orthod 1995;29:39-48.

23. White SN, Zhaokun, Xiao Yu Zhao. High - energy abrasion: an innovative esthetic modality to enhance adhesion. J Esthetic and Rest Dent 1994;6:267-73.

24. Eakle WS, Goodis FIE, White JM, Do HK. Effect of microabrasion on dentin permeability and bond strength. J Dent Res 1994;73:131 [Abstract no. 239].

25. Laurell K, Lord W, Beck M. Kinetic cavity preparation effects on bonding to enamel and dentin. J Dent Res 1993;72:283 [Abstract no. 1437].