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EFFECT OF SANDBLASTING ON RETENTION OF LINGUAL FIXED RETAINERS: AN IN VITRO STUDY

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KEYWORDS

Fixed retainer,
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Wire

ABSTRACT

Introduction: Lingual fixed retainers are one of the commonest retention appliances used today. However, wires may debond or break causing relapse. Sandblasting was introduced as a method of enhancing bonding of wires to avoid these shortcoming. **Aim**: The aim of this study was to evaluate the effect of enamel sandblasting before acid etching and wire sandblasting on the retention of two different lingual fixed retainers. **Materials and Methods**: Fifty six acrylic blocks, each one contained two primary bovine incisor teeth contacting each others, were used in testing shear bond strength of 0.016x0.022 multistranded st.st. dead soft wire and twisted 0.032 coaxial wire. Blocks were divided equally into 2 main groups according to type of wire used; Each group was subdivided into 4 subgroups of 7 blocks to test the effect of sandblasting to either the wire or enamel on the shear bond strength of rectangular and round wire. Wires were bonded on lingual surfaces of teeth using Reliance LCR adhesive. Shear bond strength was tested using Instron testing machine. **Results**: It was found that there was statistically significant difference between sandblasted wire bonded to non-sandblasted enamel and non-sandblasted wire bonded to sandblasted enamel for both types of wires. This showed that enamel sandblasting before acid etching didn't increase bond strength of non- sandblasted wires. **Conclusions**: Sandblasted wires bonded to non-sandblasted enamel showed highest mean shear bond strength values over other groups. There was no significant difference in shear bond strength between both types of wires. Sandblasting enamel before acid etching didn't increase shear bond strength of the wires.

INTRODUCTION

Over years, retention has been a matter of concern to orthodontists. Although, one of orthodontic treatment goals is to align teeth in the most stable position, retention strategy is still necessary for different reasons. Firstly,Teeth are liable to return to their original pretreatment position. Secondly, Periodontal ligament of the teeth and bone surrounding them need time for reorganization in the new post-treatment position. Moreover, Every patient has his individualized arch form that should be maintained during orthodontic treatment otherwise relapse will occur especially in lower intercanine region[(1)].

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One of the most common forms of retainer is lingual fixed wires. Fixed retainers are used in cases of severe crowding, cases to be treated with increasing lower intercanine width and spacing cases. These wires reduce the need for patient compliance, have better aesthetic than removable retainers and allow physiologic tooth movement[2].

Despite their advantages, wires may debond or break. For these reasons, attempts were made to enhance the retention of lingual fixed retainer including right-angle bend, using adhesive promoters and sandblasting[3].

Sandblasting was found to increase bond strength when bonding to gold and amalgam, so it was recommended for lingual retainers before bonding to increase their bond strength[4]. To maximize their retention, it was also recommended for enamel to be sandblasted before bonding retainers.

Due to increased failure rate of lingual fixed retainers reported in follow up studies either by debonding or breakage[5], the present study was conducted to investigate the effect of sandblasting of both wire and enamel on increasing retention of lingual fixed retainers.

MATERIALS AND METHODS

This study was waived from the Research Ethical committee of Faculty of Dentistry, Suez Canal University (code: 97/2018).

Sample size Calculation

One hundred and twelve mandibular incisor bovine deciduous teeth were collected from sacrificed cattle for purpose of food consumption at a slaughterhouse related to Ministry of Agriculture, Egypt. Sampling was done using one-way analysis of variance power calculation for more than two groups via R statistical package, version 3.3.1 (21-06-2016). The sample size was calculated in each group as n (no. of wires) =7, based on two-sided significance level of 5% and at power of 90%. It was found that a total sample size of 56 wires would be adequate to reject the null hypothesis that the groups' means are equal i.e. with allocation to 8 groups; there would be 7 specimens in each group. This sampling was computed according to the study of Reicheneder *et al*. [6]

Inclusion criteria

All collected teeth were with intact lingual enamel surface, free of caries and cracks, no enamel demineralization nor defects, grooves or fractures.

Teeth preparation and mounting

Teeth were supplied in their Jaws. For ease of extraction, jaws were immersed in boiling water for half an hour then teeth were gently extracted using lower anterior forceps. Teeth were cleaned thoroughly from debris and soft tissues under running tap water using soft brush. Teeth that didn't fulfill inclusion criteria were excluded. The collected 112 teeth that fulfilled the inclusion criteria were stored in distilled water at room temperature till the time of mounting.

Every two incisors teeth were embedded in cold cure acrylic resin blocks (Acrostone Co, Ltd, Egypt) using plastic artificial cylindrical template to form 56 blocks. The cylindrical template was filled with resin and teeth were set aligned in the middle, in contact with each other and roots perpendicular to the base of the cylinder to simulate teeth position intraorally. Every 7 blocks were grouped and coded with permanent marker according to sample grouping (I A, I B, I C, I D, II A, II B, II C, and II D). Each group was stored in distilled water at

room temperature in a separate coded plastic box. Distilled water was changed periodically in a weekly basis till time of bonding.

Sample grouping

The 56 acrylic blocks were equally divided into 2 main groups according to the type of the wire; each group was subdivided into 4 subgroups of 7 blocks as the following:

Group I : for testing 0.016x0.022 wire (Bond-A-Braid, Reliance orthodontics, USA)and was divided into 4 subgroups:

- **Group A**: no sandblasting to either enamel or wire. Retainer wire was bonded to teeth after enamel acid etching.
- **Group B**: Retainer wire was sandblasted and bonded to teeth after enamel acid etching.
- **Group C**: enamel was sandblasted then acid etched before bonding the retainer.
- **Group D**: enamel was sandblasted then acid etched before bonding the sandblasted retainer.

Group II: for testing 0.032 in. wire (3M Unitek, USA) and was divided into 4 subgroups:

- **Group A**: no sandblasting to either enamel or wire. Retainer wire was bonded to teeth after enamel acid etching.
- **Group B**: retainer wire was sandblasted and bonded to teeth after enamel acid etching.
- **Group C**: enamel was sandblasted then acid etched before bonding the retainer.
- **Group D**: enamel was sandblasted then acid etched before bonding the sandblasted retainer.

Enamel conditioning technique:

Lingual enamel surfaces were either acid etched or sandblasted followed by acid etching.

a. Acid etched groups:

Lingual surfaces of all teeth in both groups were etched using 37% phosphoric acid liquid etchant (Reliance Orthodontics, USA) for 30 seconds per tooth, rinsed with water for 20 seconds and air dried with moisture free air syringe for 20 seconds till having chalky white appearance.

b. Sandblasted plus acid etched groups:

Lingual surfaces of 28 teeth (14 for group I and 14 for group II) were sandblasted using MicroJato sandblaster (Bio-Art Dental Equipment, Ltd, Brazil) and 50μm aluminum oxide particles. The sandblaster was connected to air turbine supplied with controllable pressure and timer. Sandblaster automatically stopped when preadjusted time reached.

Lingual enamel surface was sandblasted for 3 seconds at 70 Psi at a distance of 5mm, rinsed for 20 seconds and air dried for 20 seconds[7,8]. Enamel sandblasting was followed by acid etching for 30 seconds, rinsed with water for 20 seconds and air dried for 20 seconds till having chalky white appearance.

Retainer sandblasting:

According to grouping, a 15 mm section of each wire (14 rectangular wires and 14 round wires) was sandblasted for 15 seconds at 90 Psi held by a tweezer at a distance of 3mm[3].

Retainer bonding technique:

After lingual enamel conditioning according to each group, a standardized length of 15 mm of each wire was bonded using L.C.R adhesive (Light Cure Retainer, L.C.R™, Reliance Orthodontics, USA). Light Bond primer was brushed onto the etched enamel and air-thinned by moisture free air syringe then cured for 10 seconds per each tooth in the

block. The mini mold wire bonder (MiniMold™; OrthoArch, Schaumburg, Ltd, USA)was filled with composite, wire section was then positioned in the middle of lingual surface of each tooth in the block, mold was pressed over the wire, excess composite was removed and adhesive was cured for 20 seconds per tooth using DTE light cure device (Guilin WoodPecker Medical Instrument Co, Ltd, China) (**Figure1**).

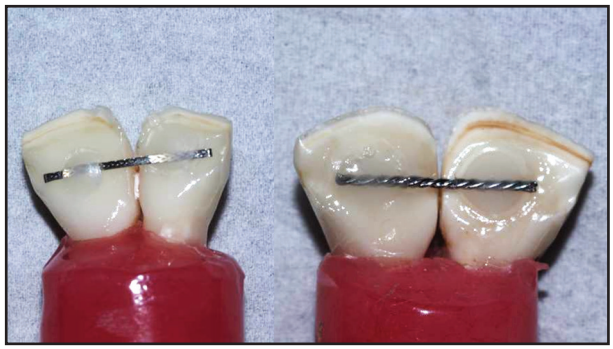

Fig. (1) A photograph showing bonding of rectangular(left) and round(right) wires.

Thermocycling:

All the bonded specimens were then stored for 72 hours in distilled water then subjected to thermocycling using AM 100 SD Mechanotronic Thermocycler between 4◦c and 60◦c for 100 cycles with a dwell time in each thermal bath of 1 minute[3].

IX. Shear bond strength test:

The specimens were tested using Instron universal testing machine. Each specimen was secured in the testing machine and the chisel edge was applied to the interdental segment of the wire (Figure 2). Continuous shear forces recorded in Newtons were applied on wire interdentally at a crosshead speed of 1mm per minute till specimen failure[3]. Data was recorded using computer software BlueHill Universal Instron, England.

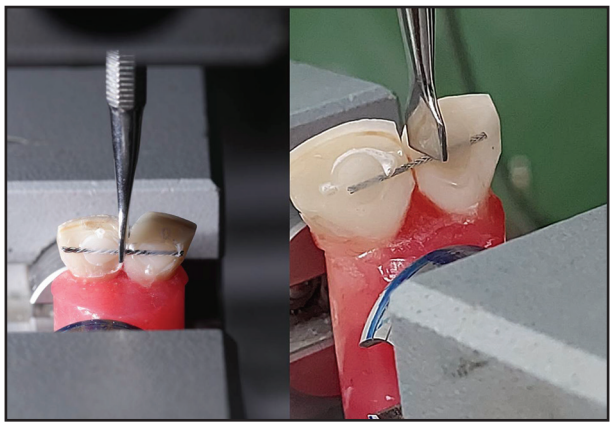

Fig. (2) A photograph specimen testing using Instron testing machine

RESULTS

a- Shear bond strength of 0.016x0.022 wire groups:

Sandblasted wire bonded to acid etched enamel (Group IB) resulted in the highest mean SBS value. There was significant difference in SBS between test groups (P = 0.032) (**Table 1**).

Table (1) *Comparison of Shear Bond Strength (SBS) of 0.016x0.022 wire among the study groups*

	Group I A (n=7)	**Group I B (n=7)**	**Group I C (n=7)**	**Group I D (n=7)**
Mean (SD)	101.11 N ± (25.86)	146.69N ± (53.72)	88.33N ± (33.07)	94.46N ± (32.44)
F test		3.462		
***P* value**		0.032*		

N: Newton

SD: Standard deviation

**Statistically significant at p value <0.05*

Post hoc comparisons were carried out to determine the significance between groups. The test showed significant difference between sandblasted wire bonded to acid etched enamel (GroupI B)

and non-sandblasted wire bonded to sandblasted enamel followed by acid etching (GroupI C) with (P=0.037) (**Table 2**).

Table (2) *Post hoc comparisons of Shear Bond Strength (SBS) of 0.016x0.022 wire between the study groups pairs*

Groups	Compared to	*P* value
Group I A	Group I B	0.136
	Group I C	0.920
	Group I D	0.987
Group I B	Group I C	**0.037***
	Group I D	0.071
Group I C	Group I D	0.990

**Statistically significant at p value <0.05*

b- Shear bond strength of 0.032 wire groups:

Sandblasted wire bonded to acid etched enamel (Group II B) showed highest mean 136.83 N. There was significant difference in SBS between test groups (P < 0.022) (**Table 3**).

Table (3) *Comparison of Shear Bond Strength (SBS) of 0.032 wire among the study groups*

	Group II A (n=7)	Group II B (n=7)	Group II C (n=7)	Group II D (n=7)
Mean (SD)	110.56N± (24.85)	136.83N± (42.61)	88.43N± (22.15)	85.56N± (34.58)
F test	3.843			
***P* value**	0.022*			

**Statistically significant at p value <0.05*

Post hoc comparisons between groups showed significant difference between sandblasted wire bonded to acid etched enamel (Group II B) and non-sandblasted wire bonded to sandblasted enamel followed by acid etching (Group II C) with (P< 0.044). There was also significant difference between (Group II B) and sandblasted wire bonded to sandblasted enamel followed by acid etching group (Group II D) (P<0.030) (**Table 4**).

Table (4) *Post hoc comparisons of Shear Bond Strength (SBS) of 0.032 wire between the study groups pairs*

Groups	Compared to	*P* value
Group II A	Group II B	0.435
	Group II C	0.578
	Group II D	0.478
Group II B	Group II C	**0.044***
	Group II D	**0.030***
Group II C	Group II D	0.998

**Statistically significant at p value <0.05*

c- Comparison of Shear Bond Strength (SBS) of 0.016x0.022 and 0.032 wires within each study group*:*

No statistically significant difference in SBS was found between 0.016x0.022 and 0.032 wires groups (**Figure 3**).

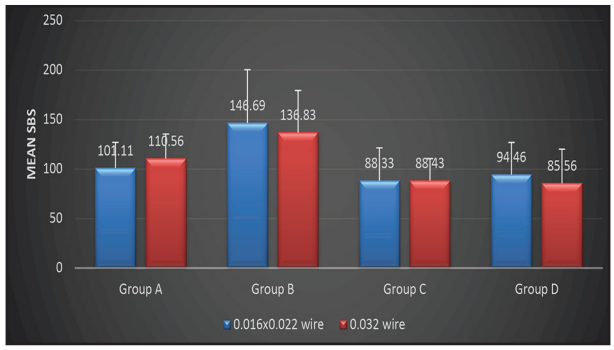

Fig. (3) A bar graph showing mean of SBS in Newton of 0.016x0.022 and 0.032 wire within each of the study groups

DISCUSSION

Fixed lingual retainers have been advocated after orthodontic treatment to prevent relapse. In order to maintain treatment objectives they were recommended for long term retention protocol. They showed the longest survival period when compared with Hawley retainers and vacuum formed retainers[9]. One of the common disadvantages of these appliances is that they fail in the form of detachment, deformation or breakage. Failure rates reported in follow up studies varied greatly according to wire type, size, adhesive used, follow-up periods and whether wire was bonded directly or indirectly[10,11]. For these reasons, this study was conducted to evaluate the effect of sandblasting two different retainers and sandblasting enamel before acid etching on increasing shear bond strength of these retainers.

Continuous shear forces were applied on the wire interdentally at a crosshead speed of 1mm per minute till specimen failure. This testing protocol was coincident with the testing protocol of *Oesterle et al* [3], *Baysal et al* [12] and *Aldrees et al*[13]. Detachment forces were expressed in Newton as Pascals unit requires an even distribution of forces over the bonded surface area. Moreover, when vertical forces are applied over a wire, it may induce shear, torsion and tensile forces concomitantly [14].

Shear bond strength for 0.016x0.022 wire groups: Sandblasted wire bonded to non-sandblasted enamel (Group I B) resulted in the highest mean SBS value 146.69N.However, there was no significant difference between (Group I B) and non –sandblasted wire bonded non sandblasted enamel (Group I A) 101.11N. This showed that sandblasting the wire did not have any advantage over non- sandblasting of wire. This was in agreement with *Kilinic and Sayar* [15] who reported no significant difference in shear bond strength between sandblasted and non-sandblasted wires. *Sunna and Rock* [16] reported no significant difference between failure of sandblasted and non- sandblasted brackets. However, *Oesterle et al*[3] reported highest tensile bond strength of sandblasted .030 inch wires bonded to bovine enamel 246.1Mpa when compared with same wires having right angle bends and wires treated with silane and metal primers as methods of enhancing bond strength of the wire. Transbond LR was used to bond specimens.

There was a significant difference between sandblasted wire bonded to non-sandblasted enamel (GroupI B) and non-sandblasted wire bonded to sandblasted enamel (GroupI C) with (P= 0.037). This showed that sandblasting enamel before acid etching did not increase shear bond strength of the retainer. This was in agreement with *Robles Ruiz et al* [8], *Brosh et al* [17], *Patcas et al* [18] and *Daratsianos et al*[19]. According to a systematic review there was no increase in shear bond strength of bonded bracket on lingual enamel surfaces treated with sandblasting before acid etching[20].

In contrast to this finding, *Reichender et al*[6], Canay et al[21] and *Cal-Neto et al*[22] reported increased bond strength of stainless steel surfaces bonded to sandblasted enamel before acid etching. This difference in results might be due to using different teeth with different morphology and different protocols in sandblasting, bonding and force application. *Reichender et al* [6] used Transbond LR adhesive for bonding Bond –A- Braid wire on sandblasted before acid etched enamel of bovine incisors. *Canay et al* [21] and *Cal-Neto et al*[22] used chemical cured adhesive to bond brackets with increased bonding surface area on sandblasted before acid etched enamel of human premolars.

Shear bond strength for 0.032 wire groups**:** Sandblasted wire bonded to non -sandblasted enamel (Group II B) yielded the highest mean shear bond strength value 136.83 N over other groups. This was in agreement with *Oesterle et al* [3]. However, there was no significant difference between (Group II B) and non –sandblasted wire bonded to acid etched enamel (Group II A) 110.56N. This showed that sandblasting the wire had a non-significant increase of shear bond strength of the wire. This was in agreement with *Kilinic and Sayar* [15].

However, there was significant difference between this group (Group II B) and non -sandblasted wire bonded to sandblasted enamel (Group II C) 88.43N with (p=0.044). This showed that enamel sandblasting before acid etching didn't increase shear bond strength of the wire as reported by several studies [8,17,19]. This was against *Reichender et al* [6], *Canay et al* [21] and *Cal- Neto et al* [22] and due to using different teeth, testing different materials and applying different protocols in sandblasting, bonding and forces.

Comparison of shear bond strength of 0.016x0.022 wire and 0.032 wire groups**:** Sandblasted 0.016x0.022 wire groups (I B 146.69N and I D 94.46N) showed slightly higher mean shear bond strength values than sandblasted 0.032 wire groups (II B 136.83N and II D 85.56N). This may be due to increased surface area of 0.016x0.022 wire with good adaptability to teeth in comparison with 0.032 wire with its great stiffness and rigidity due to increased thickness. This was in agreement with *Zachrisson*[23] who reported that the thicker the wire the higher the failure rate due to increased rigidity. Therefore, 0.032 wire was used in literature in the form of canine and canine retainer i.e bonded at canines only. However, there was no significant difference between both wires groups when compared to each other.

CONCLUSION

Based on the results of the current study, Sandblasted wires bonded to non- sandblasted enamel showed the highest mean shear bond strength values over other groups. There was no significant difference in shear bond strength between both wires. Sandblasting enamel before acid etching didn't increase shear bond strength of the wires.

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