PLASMA ARC VERSUS HALOGEN LIGHT CURING OF CERAMIC BRACKETS

Dr. Nadia M. El Harouni•

ABSTRACT:

Bond strength and debonding characteristics of plasma arc curing light compared to halogen curing light when used to bond mechanical base retention ceramic brackets were tested in this study. Brackets were bonded to 50 extracted human maxillary premolars with a composite adhesive and they were divided into two equal groups. A curing time of 3 seconds was used for curing with the plasma arc light, and 20 seconds per bracket with the halogen light. Thermocycling was performed to simulate oral cavity conditions.

For shear bond testing; Debonding of 15 brackets from each group was performed on a universal testing machine. There was no significant difference in the shear bond strength of brackets bonded by the two lights. Bond strength was 9.65 ±3.1 MPa for plasma arc curing light and 9.35 ± 2.33 MPa for the halogen light. In both groups the shear bond strength fell in the clinically acceptable range.

10 Brackets from each group were debonded using the debonding plier to test the debonding chraracteristics. Brackets consistently debonded at the bracket-adhesive interface with both types of curing lights. A reasonable amount of composite was always left on the enamel surface thus protecting enamel from detachments.

These results indicate that the plasma arc light with a 3 second curing time can be used with mechanical retention base polycrystalline ceramic brackets to produce acceptable bond strength and a safe pattern for bracket debonding. Shear bond strength and ARI score values were comparable to halogen light curing which requires longer curing time.

• Assistant Professor Orthodontic Department, Faculty of Dentistry, Alexandria University.

INTRODUCTION

During the sensitive procedure of bonding an extended working time is always welcome to the orthodontist to allow better bracket placement and more meticulous cleaning of excess. Light curing has the advantage of unrestricted working time over chemical curing. The first photosensitive light-cured resin was introduced by Buonocore[1] 1970 followed by visible light curing which was introduced in 1980[2.] The most common initiator used in visible light curing adhesives is camphoroquinone, which is sensitive to light in the blue region (450 to 500 nm) of the visible light spectrum, with the peak activity centered around 470-480 nm3. Most visible light curing units have a broad wavelength width between 400 and 520 nm, with a light intensity commonly about 400 mW/cm[2,3,4,5] The problem is that the increased working time comes with increased curing time which means more unnecessary chair time.

Because of its unique characteristics, plasma arc light has the potential to dramatically reduce the curing time of dental composites. The plasma arc light reduces curing time because it produces much more intensive light than does the halogen light[6]. A high-energy, high-pressure ionized gas in the presence of an electric current is used to create a light source, and this system has a filter that narrows the spectrum of visible light to a band centered on the 470 nm wavelength for activation of camphorquinone while producing a high light intensity of 1200 mW/cm[27.]

Curing time recommendations for plasma arc curing lights range from 2 to 9 seconds per bracket. [6,7,8,9] Manzo et al also recommended cure time of 3 seconds per metal bracket in their study[10] while Sfondrini recommended 2 seconds curing time per metal bracket .[11]

Ishikawa et a[12] and Jeffrey et al [13] compared plasma arc curing versus halogen light curing of composite resin with metal brackets and concluded that no significant differences existed between the shear bond strength of brackets bonded by either method.

Signorelli et al[14] didn't observe any significant differences in the site of bracket failure interface between the halogen and plasma arc curing lights, in both cases around 75% of the composite was left on the bracket base. Jeffrey et al concluded that there was a significant difference in the location of the bond failures of metallic brackets (ARI scores) among the 3 curing methods they tested. When the plasma arc light or the halogen light was used, less adhesive remained on the enamel surface than with argon light, making cleanup easier.[13]

Esthetic brackets are increasingly in use in today's Orthodontic practice. Ceramic brackets offer incomparable esthetics during treatment and their main disadvantages of difficulty in debonding and the risk of enamel fracture have been much overcome by the introduction of mechanical retention base brackets. These brackets offer better enamel safety during debonding. Grooves, undercuts or any pattern have been added by manufacturers to the base of ceramic brackets to allow mechanical interlocking between the bracket and resin. [16]

High intensity curing lights might be particularly efficient when bonding ceramic brackets because of light transmission through the bracket and not only through the mesial and distal sides thus further decreasing the curing time needed.[15] Klocke et al[9] recommended a curing time of three seconds on using plasma arc for curing composite with monocrystalline and polycrystalline ceramic brackets.

Klocke et al[9] observed that both the polycrystalline and the monocrystalline brackets when cured with plasma arc light consistently debonded at the bracket-adhesive interface, thus reducing the risk of enamel fractures

On studying the literature available for curing ceramic brackets with plasma arc light it was found to be pretty scarce so the aim of this study was to analyze shear bond strength and debonding characteristics of mechanical retention ceramic brackets when bonded with two different light units;

1- Ortholux halogen light-curing system* which emits visible light intensity of 400mW/cm2 with a 7 mm light guide.

2- Plasma arc light-curing device power PAC** which emits visible light intensity of 1200mW/cm2 with an 8 mm light guide.

---

* Ortholux XT, 3M Unitek Monrovia, CA)
** Ameriacan dental technologies)

Materials and Methods

Fifty freshly extracted human premolars were collected. The criteria for selection included noncarious and nonrestored buccal surfaces with no visible enamel cracks and no chemical pretreatment e.g. Hydrogen peroxide. Teeth were cleansed of tissue and debris and stored in normal saline. Then polished using oilfree, non-flouridated pumice on a low speed brush and thoroughly rinsed.

Before bonding, the teeth were randomly divided into two groups each containing 25 teeth. Where group I was cured using Halogen light and group 2 using plasma arc. 20/40m polycrystalline ceramic brackets* were used with grooves and undercuts in the base to supply mechanical retention.

Fig (1) The 20/40m bracket base

The enamel surface was etched with 37% phosphoric acid gel for 30 seconds and rinsed with distilled water. The surface was thoroughly dried, and a thin layer of Transbond XT sealant** was applied. Composite was placed on each bracket then and a bracket positioner was used to seat the

* American Orthodontics
** 3M Unitek

brackets with a constant force. Excess adhesive was removed, and the bracket adhesive was light-cured with the designated curing unit. Each curing unit was tested and calibrated according to the manufacturer's instructions to ensure that maximum intensity output was obtained. After two days of boning thermocycling between 5°C in a refrigerated circulating bath and 55°C in a heated water bath with a dwell time in each bath of 30 seconds and a transfer time of 10 seconds was performed.

Next, the teeth were embedded in acrylic to approximately the level of the cementoenamel junction. To ensure that all the brackets were mounted in the same orientation relative to the acrylic cylinder, two .021 × .028 inch stainless steel archwires were soldered perpendicular to each other and tied in two bracket slots on each side of the vertical wire. The teeth were then lowered in the acrylic resin using a dental surveyor to ensure that the vertical part is parallel to the floor. This mounting procedure ensured consistency for the point of force application and direction of the debonding force. The samples were then stored in saline until testing.

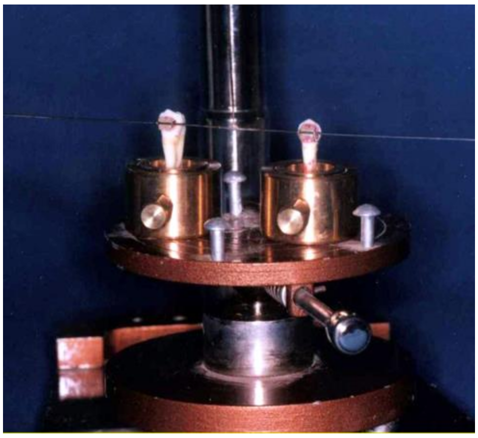

Fig (2) Mounting of the teeth in acrylic blocks

Shear bond testing

15 premolars from group 1 and 15 from group 2 were used for shear bond strength testing. Debonding forces were determined by using the Instron

universal testing machine.* with a crosshead speed of 0.5 mm/minute. The specimens were mounted on a positioning ring on the lower jaw of the machine to ensure that the applied force was parallel to the long axis of the tooth. The chisel bound to the upper jaw was aligned so that it was between the bracket wing and the base. The bond strengths in newtons were recorded on a monitor. To calculate shear bond strength, the debonding force values (in newtons) were converted to stress values (MPa) by taking into account the surface area of the bracket base. (10.24 mm2)

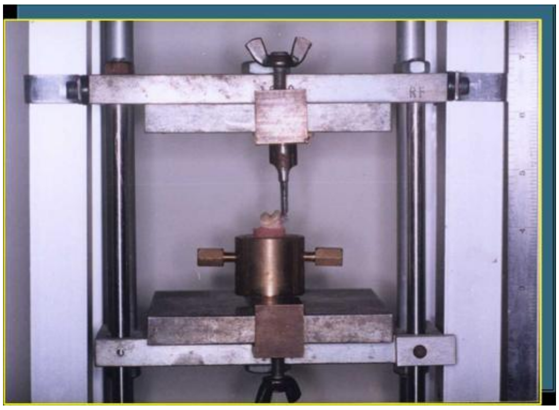

Fig (3) Shear bond testing on the instron machine

The adhesive remnant index ARI

To analyze the amount of composite left on the tooth surface, 001-E346RT direct bond bracket remover was used to debond the ceramic brackets.

The wide dual chisel tips were wedged between the bracket base and the tooth mesial and distal lifting the bracket with no stress on the tooth. Each bracket was examined visually and the amount of adhesive left on the tooth was scored according to the ARI score1 [17,18]

* Comten industries inc. Florida USA model No.942D10-20

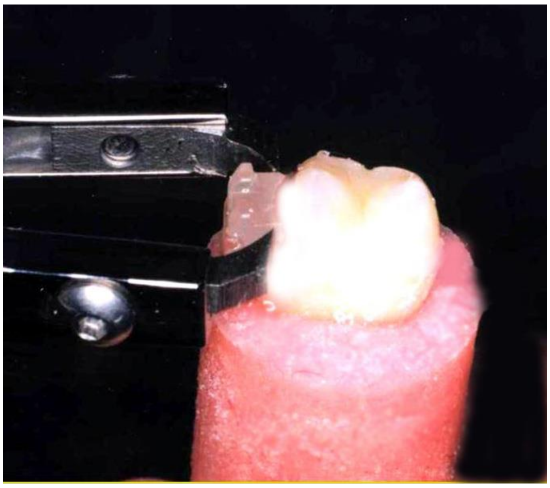

Fig (4) Plier debonding for ARI scoring

Score	Definition
1	All adhesive left on the enamel with distinct impression of the bracket base
2	More than 90% of the adhesive left on the enamel surface
3	More than 10% but less than 90% of the adhesive left on the enamel surface
4	more than 90% of the adhesive left on the enamel surface
5	No adhesive left on the enamel surface

RESULTS

Shear bond strength testing

Using the T-test no Statistically significant differences were found in the shear bond strengths between brackets bonded with the 2 types of curing lights (Table 1)

Table 1: Mean shear bond strength for test groups

	no	Light source	Total curing time	MPa	sd
1	10	Ortholux XT	20 seconds	9.35	2.33
2	10	PAC	3 seconds	9.65	3.1
T test P value				0.25 0.81 NS	

NS: Not statistically significant

Bracket-failure interface

The ARI scores of adhesive remaining on the bracket after debonding for the 2 groups are shown in Table II. No significant difference was found between the scores.None of the brackets had all the composite on it on debonding, and most of the brackets in both groups left between 10% and 90% of the composite on the enamel surface.

Table II: Mean ARI score for test groups and Mann Whitney U test for comparing the scores

Scores	Ortholux		PAC	
	N	%	N	%
Score 1	1	10	1	10
Score 2	3	30	1	10
Score 3	4	40	5	50
Score 4	2	20	3	30
Score 5	0	0	0	0
TOTAL	10	100%	10	100%
Z of MWU test P value	0.80 0.42NS			

MWU: Mann Whitney U test

NS: Not statistically significant

DISCUSSION

The use of plasma arc light to cure composite for only 3 seconds to bond mechanical retention ceramic brackets bonding proved to be comparable to halogen light curing for 20 seconds. The shear bond strengths of both methods (9.65 Mpa and 9.34 Mpa) were above the clinically adequate range to withstand clinical Orthodontic purposes which was specified to be from 5.9 to 7.8 Mpa by Reynolds. [18]

Klocke et al[9] tried the xenon plasma arc curing light for bonding ceramic brackets at several curing times and agreed that 3 seconds of curing composite are sufficient to produce clinically acceptable shear bond strength with polycrystalline brackets. Mean shear bond strength values for the polycrystalline bracket ranged between 9.68 and 10.73 MPa. They also tried halogen light curing at only ten seconds and found that it supplied enough shear bond strength with no significant difference from using plasma arc light for 3 or 6 seconds. Their results were very near to those of the present study as they also used thermocycling to simulate oral conditions.

Signorelli[14] evaluated the mean shear bond strengths of metal brackets bonded with plasma arc and halogen light after 24 hours of thermocycling. No significant difference was found between brackets bonded with the halogen light for 20 seconds and brackets bonded with the plasma arc light for six seconds. Although the 2-second curing time with the plasma arc light was significantly lower than the 6 and 10 second times, its mean shear bond strength of 9.6 MPa still exceeded the clinically acceptable range. While the mean shear bond strength of 6 and 10 second curing exceeded the results of the current study ,this actually supports the present study as it is expected that the 6 and 10 second curing of plasma arc would supply more shear bond strength than the 3 seconds curing time. And also the difference in bracket material has an influence.

Bishara et al[20] also tested halogen light-cured polycrystalline brackets and found shear bond strength values averaging 10.4 MPa when they used a curing time of 20 seconds.

Jeffrey et al[13] agree with the results of this study. As they concluded that curing orthodontic adhesives with a plasma arc light for 5 seconds produces shear bond strength that is comparable with or greater than that produced by the halogen light or the argon laser, depending on the type of adhesive used. They used metal brackets which may have caused actual shear bond strength values elicited to be less than those obtained in this study. Their values were actually less than many another studies also using metal brackets and they attributed the difference to using thermocycling which affects the bond strength.

On debonding of the brackets none of them was broken. The bracket failure was mainly at the bracket adhesive interface thus none of the brackets removed all the composite with it hence decreasing the risk of enamel detachments. In both groups most of the brackets left a reasonable amount of composite on the enamel surface thus ensuring its integrity (scores 2 and 3), although the plasma arc cured brackets left less composite on the teeth allowing easier cleansing.

Bishara et al[20] analyzed the debonding characteristics of polycrystalline Clarity brackets after curing with a halogen light source and showed that most specimens failed at the bracket-adhesive interface, indicating a reduced chance of enamel damage. Both studies found a greater tendency for residual composite to be left on the tooth, which potentiates the results of this study

Jeffrey et al also agree that when the plasma arc light, halogen light or argon laser curing was used , some adhesive remained on the enamel surface i.e. the brackets failed mainly at the bracket –adhesive interface , although they found that using Halogen or Plasme arc light leaves less adhesive on the enamel surface thus making cleanup easier.[13]

CONCLUSIONS

1- Plasma arc light was used at a curing time of three seconds so that its time saving quality is enhanced - as recommended by several authors- and proved to supply enough shear bond strength to withstand clinical Orthodontic forces. The shear bond strength was comparable to that obtained with halogen light curing. The brackets in an arch need a curing time of only about 36 seconds with the plasma arc light versus 4 minutes with the halogen light.

2- On debonding the brackets both kinds of light caused the brackets to fail at the bracket adhesive interface thus decreasing the risk of enamel fracture or detachments.

Therefore, curing with the plasma arc light saves considerable time for doctor and patient and decreases the risk of moisture contamination. The use of mechanical retention base ceramic bracket with it would ensure esthetic qualities, fast and more accurate bonding and more safety on debonding.

REFERENCES

1- Buonocore MG. Adhesive sealing of pits and fissures for caries prevention with use of ultraviolet light, J Am Dent Assoc. 1970 80: 324–328.

2- Strassler H. Light-curing renaissance makes materials popular: Technological upgrades boost quality in light-curing devices, Dentist 1980 68: 23–27.

3- Zachrisson B.J. A posttreatment evaluation of direct bonding in orthodontics, Am J Orthod. 1977; 71: 173–189

4- Cook W.D. Spectral distribution of dental photopolymerization sources. J Dent Res. 1982; 61: 1436–1438.

5- Fan P.L.,. Wozniak W.T, Reyes W.D. and Stanford J.W. Irradiance of visible light-curing units and voltage variation effects, J Am Dent Assoc. 1987;115: 442–445.

6- Oesterle L.J., Newman S.M. and Shellhart W.C.: Rapid curing of bonding composite with a xenon plasma arc light. Am J Orthod Dentofacial Orthop. 2001; 119: 610–616.

7- Cacciafesta V, Sfondrini M.F. and Sfondrini GA: A xenon arc light-curing unit for bonding and bleaching, J Clin Orthod. 2000; 34: 94–96.

8- Pettemerides AP, Ireland AJ,Sherriff M: An ex vivo investigation on the use of plasma arc lamp when using a visible light curing composite and a resin modified glass polyalkenoate cement in orthodontic bonding: J orthod. 2000; 28:237-244.

9- Klocke A, Korbmacher HM, Huck LG, Ghosh J, Kahl-Nieke B: Plasma arc curing of ceramic brackets: an evaluation of shear bond strength and debonding characteristics.Am J Orthod Dentofac Orthop. 2003;124:309-15.

10- Manzo B., Liistro G. and De Clerck H., Clinical trial comparing plasma arc and conventional halogen curing lights for orthodontic bonding, Am J Orthod Dentofacial Orthop. 125 (2004), pp. 30–35.

11- Sfondrini M.F.,. Cacciafesta V, Pistorio A. and Sfondrini G., Effects of conventional and high-intensity light-curing on enamel shear bond strength of composite resin and resin-modified glass-ionomer, Am J Orthod Dentofacial Orthop. 119 (2001), pp. 30–35.

12- Ishikawa H, Komori I, Kojima I,Ando F:Orthodontic bracket bonding with plasma arc light and resin reinforced glass ionomer cement. Am j Orthod Dentofac Orthop. 2001;120 :58-63.

13- James J, Miller B, English J, Tadlock L, Buschang P: Effects of high-speed curing devices on shear bond strength and microleakage of orthodontic brackets Am j Orthod Dentofac Orthop. 2003;123:555-561.

14- Signorelli MD, Kao E, Ngan P and Gladwin MA: Comparison of bond strength between orthodontic brackets bonded with halogen and plasma arc curing lights: An in-vitro and in-vivo study. Am J Orthod Dentofacl Orthop. 2006 129; 277-28.2.

15- Eliades T, Johnston W.M.and Eliades g: Direct light transmittance through ceramic brackets. Am J Orthod Dentofacial Orthop. 1995; 107: 11–19.

16- Bordeaux JM, Moore RN, and Bagby MD. Comparative evaluation of ceramic brackets base designs. Am J Orthod Dentofac Orthop. 1994; 105: 552-60.

17- Bishara S, Trulove T. Comparisons of different debonding techniques for ceramic brackets:An in vitro study. Part 1. Am J Orthod Dentofacial Orthop. 1990; 98: 145-53.

18-Artun J and Bergland S. clinical trials with crystal growth conditioning as an alternative to acid etch enamel pretreatment. Am J Orthod. 1984; 85: 333-40.

19- Reynolds I. A review of direct orthodontic bonding. Br J Orthd. 1975; 2:171-8.

20- Bishara SE, Olsen ME, Wald LV and Jakobsen JR. Comparison of the debonding characteristics of two innovative ceramic brackets. Am J Orthod Dentofacial Orthop. 1999; 116: 86–92.