



Effect of Curing Time on Bond Failure rate Based on Two Light Cure Units used in Bonding Orthodontic Brackets

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Abstract: In routine orthodontic practice, we usually aim at having a reduced chair side time while bonding as well as an appropriate bond strength for the brackets till the treatment completion. This is dependent on several factors which affect the quality of bond obtained between the bracket and the tooth structure. One such is the depth of cure by using different curing lamps. This study aimed at comparing the rate of bracket bond failure of brackets when bonded using light cure units with different curing time (3S and 20S). This was a randomized control trial performed as a split mouth study among patients who came for orthodontic correction of malocclusion. Among them, 24 patients were selected and split mouth study was performed. For this dental arch of each patient was split among two groups (Group A and Group B). MBT Stainless steel orthodontic brackets were bonded in both the dental arches. Group A was cured with 3 second light cure unit in I and III quadrant and 20 second light cure unit in I and III quadrant and vice versa for group B. The number of bond failures at the end of 4 weeks and 8 weeks were assessed. Bond failures among both the groups were summarized. Independent t test was used to assess the statistical difference between the groups. Overall it was evident that the bond failure was greater clinically in the group cured with 20 second curing light especially in the mandibular arch and the posterior teeth.

Keywords: Light cure, bonding, 3 second light cure, bond failure, LED light cure.

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I. INTRODUCTION

Since 1955, the time when acid etch technique was first introduced by Buonocore¹ it has become widely popular in dentistry due to numerous reasons. Neuman pioneered the usage of the same in the field of orthodontics in the late 1960's. Direct bonding using composite resin had been in use from then². Several generations of bonding materials are now available of which the self-curing resin are the more recent ones. But the major drawback with these materials is that unlike restorative dentistry, bonding of orthodontic brackets would require an ample amount of time. Mixing the self-polymerizing resin repeatedly might be difficult and have a high degree of technique sensitivity. In such materials the process of polymerization begins just after the material is mixed like any dental cement. Hence having adequate time for bracket positioning and bonding become very delicate. Another complication is that air entrapment during the process of mixing might reduce the strength of the material being used. However, using light-cure composites provides extended working time for prompt bracket positioning and easier residue removal³. Few studies have shown that the bond strength of such light cured composites are better when compared to self-cured systems when used for orthodontic purpose.⁴ One commonly used method to achieve a good level of bond strength is the layering technique wherein the material is added in layers and cured so that the ratio of cured to uncured resin is kept within manageable limits. But the problem with bonding of orthodontic brackets is entirely different. The bracket base is made up of a mesh of Stainless-steel mesh, hence the degree of cure of material cannot be exactly determined. Incomplete polymerization of the material might lead to diminished bond strength.³ The best way recommended to overcome this is to cure the bracket in all possible directions. But it becomes difficult when dealing with posterior teeth where curing from all directions becomes a practical difficulty and might

compromise the strength of the brackets. For so long Quartz tungsten halogen units have been employed in achieving this polymerization as light curing device.³ Wide spectrum of action, low cost maintenance and ease in usage has made the halogen light curing system the more favorable curing system since decades. But they also have few shortcomings: Filters can undergo blistering, and reflectors can discolor. The prolonged curing time with halogen bulbs can be uncomfortable to the patient, impractical with children, and inconvenient for the clinician.^{5,6} More recently devices utilizing xenon plasma arc, argon laser and Light emitting Diode (LED) curing lamps please mention the name in detail for the first time have also been introduced. Studies have shown that the shear bond strength produced by halogen lamps and plasma arcs have no significant difference in all features except that plasma light is effective in reducing adhesive setting time per tooth from 20-40 sec to 2 sec.⁵ But all these recent inventions are costlier than the previously used ones. In Orthodontics, the use of LED was first suggested by Mills in the year 1995. LED devices have advantages as they poses easy hand holdable size and weight, ergonomic design, reduced noise and heat generation, lower power consumption, and light emission spectrum with total absorption of camphorquinone,^{7,8} Also compared to the chemical cure resins, the in vitro strength of the light cure resin was noted to be comparatively better⁹. Spectral profiles and light intensities vary among different light cure devices. Low intensities of the light might lead to failure in achieving adequate depth of cure and bond strength below acceptable levels, on the contrary light with a high-intensity results in excessive heat during polymerization leading to shrinkage of the resin material.^{10,11} The aim of the study was to determine if there was any difference in bond failure among orthodontic brackets bonded with LED light curing unit with a reduced curing time of 3 seconds and halogen light curing unit with a curing time of 20 seconds.



Fig 1. Woodpecker 3 second light cure



Fig 2. Woodpecker 20 second light cure

2. MATERIALS AND METHODS

A split mouth randomized control trial was designed and samples were randomly selected among patients who visited Saveetha Dental college for orthodontic treatment of mal-aligned teeth. A total of 24 patients were chosen for this study. Criteria considered for the inclusion in the study were i)Subjects with permanent dentition, ii)Patients who were selected for conventional MBT metal brackets, iii)The patients who were able to maintain adequate oral hygiene, iv)Patients without traumatic occlusion,(to avoid those bond failures occurring due to traumatic occlusion, v)Cooperative

patients who are willing to participate in the study. Exclusion criteria considered were i)Those with a previous history of systemic illness or orthodontic treatment done, ii) conditions like hypoplasia/fluorosis / restored teeth and iii)those who wish to have any other bracket prescription other than those mentioned in the study like ceramic or lingual brackets. Bonding protocol was as follows. Cleaning of teeth with pumice removes plaque and organic pellicle. Rinse thoroughly and dry teeth with oil / moisture free compressed air. After rinsing, the tooth to be bonded was isolated for etching. With the help of an applicator tip, etchant was applied over the surface of the teeth to be bonded. Care was taken to

avoid contact of the etchant with the soft tissue surfaces. After an etching time of 30 seconds, the area was cleansed and air dried to achieve a frosty white appearance over the etched surface of the tooth. Following this bonding agent was applied immediately after that, the bonding of the brackets was started. The adhesive used was the Transbond XT (Fig 1 & 2) A small amount of adhesive is added on to the bracket base and bracket is positioned on the tooth surface at the desired location. The excess adhesive was removed. Among the sample, random allocation in the two groups was done. Group A and Group B with 24 patients in each group in a split mouth study format.

Group A: Brackets cured with 3 second light cure unit in I and III quadrant and brackets cured with 20 second light cure unit in II and IV quadrants

Group B: Brackets cured with 20 second light cure unit in I and III quadrant and Brackets cured with 3 second light cure unit in II and IV quadrants

The number of bond failures were assessed at 4 and eight weeks. The number of bond failures were recorded during every review. All the observations were done with a single examiner. Data were analyzed statistically by independent t tests.

3. STATISTICAL ANALYSIS

The statistics for the study was performed with SPSS (version 19.0). The level of significance for the study was at 0.05. Frequency distribution was calculated for the bracket failure noted in each group and an independent samples t test was

performed to determine the statistical significance between both the groups.

4. RESULTS

Analysis of the data revealed that there was an average of 7.08% bond failure at four weeks in the 3second light cure group and an average of 10.83% bond failures in the 20 second light cure group. At eight weeks, there was an average of 0.78% bond failures in the 3 second light cure group and 1.35% bond failures in 20second light cure groups. Significant difference in the amount of bond failures between the three second and the twenty second light cure groups at four weeks. There was no significant difference between the three second and the twenty second light cure groups at eight weeks. The results of the study are tabulated in table 1. From table 4 it is evident that during the first 4 weeks, maximum number of debonding occurred in the mandibular arch especially in the posterior region in both the groups. On those teeth which were cured by using the 3 second curing lamp, bond failure noted in the maxillary and mandibular arches were 3.33% and 10.83% respectively, wherein in the anterior and posterior region of the dental arches was 3.7% and 12.5% respectively, In the other group where 20 second curing lamp was used, bond failure noted in the maxillary and mandibular arches were 4.16% and 17.5% respectively, wherein in the anterior and posterior region of the dental arches was 8.33% and 14.58% respectively, Statistical analysis reveals no statistical significance both at 4th and 8th weeks. (Table 3 and 4).

Table 1. Frrequency of bond Failure of Brackets polymerized with the Two Light curing units

Source	Brackets(N)	Frequency N			
	N=480	0-4 th week	0-4 th week	5 th -8 th week	5 th -8 th week
		Total number of Bracket Failure	Failure %	Total number of Bracket Failure	Failure %
3 second curing unit	240	17	7.08	2	0.78
20 second curing unit	240	26	10.83	4	1.35

Table 2. Statistical Analysis- 0-4TH Week

	CURING TIME	N	MEAN	Std.Deviation	Std.Error Mean	p value
Bracket Failure	3 Second Curing	240	1.93	0.257	0.017	0.151
	20 Secondcuring	240	1.89	0.311	0.020	

p value <0.05 – Statistically Significant.

Table 3. Statistical Analysis- 5TH-8th Week

	CURING TIME	N	MEAN	Std.Deviation	Std.Error Mean	p value
Bracket Failure	3 Second Curing	240	1.99	0.091	0.06	0.412
	20 Secondcuring	240	1.98	.128	0.08	

p value <0.05 – Statistically Significant.

Table 4: Frequency distribution of bracket failure (0-4th week)

Source		Total number of brackets	Failures	Frequency %
Dental arch				
3 second curing source	Maxilla	120	4	3.33
	Mandible	120	13	10.83
20 second curing source	Maxilla	120	5	4.16
	Mandible	120	21	17.5
Tooth type				
3 second curing source	Anterior	144	5	3.47
	Posterior	96	12	12.5
20 second curing source	Anterior	144	12	8.33
	Posterior	96	14	14.58

5. DISCUSSION

In the present study, intensity of the LED'S were measured to be in the recommended range for acquiring an optimum polymerization as in the previous studies (300 mW/cm²). Power variation among the devices can justify the difference in shear bond strength. However, the bond strength values recommended by Reynolds were achieved from the curing devices. Interestingly it was found that the intensity values measured intensity values did not correspond to the values provided by the manufacturer.¹²⁻¹⁹ In this study, LED with a curing time of three second showed lesser bond failure rate than those cured with 20 second curing light during the first few weeks after the initial bonding was done. Studies using shear bond strength tests are frequently difficult to be compared because of several variables such as type of light sources, exposure time, adhesive system used, enamel characteristics, and different methodological approaches. In order to eliminate the influence of these variables in the present study, a split mouth study was undertaken and the bond failures were assessed instead of bond strength, similar to studies that assess bond failure rate Both the groups received the same procedures applied to the experimental groups according to the most acceptable methodologies used in the literature.¹⁹ Bond failure rates below 10% are generally considered clinically acceptable. Direct comparison with similar studies isn't possible due to the variety of techniques, materials, research designs and trial durations. In any time-scale, the overall failure rates for a clinical sample can be calculated. This could provide a straight-forward statement of the overall percentage of failures in a sample over a certain time, or it can be used to compare variables in a sample. One of the widely acceptable ways is to calculate failure rates over a period of time ranging from few weeks to months.²⁰⁻²³ Even in such vivo studies, other patient factors including the socioeconomic and dental status of patients, malocclusion classification and resultant mechanotherapy may affect the outcome of the overall treatment result and affect the bond failure. Variation in the occlusal forces with different facial type, culturally influenced dietary habits, and sex differences may also have an effect on the result. Previous studies have shown that LED devices display equal or even superior performance compared to halogen light curing units for 40 second curing time.^{24,25} On the other hand, Usume et al.¹⁴ found significantly lower values for LED devices compared to halogen light units for photo-activation time of 10 s. Silta et al.¹⁶ found significant differences compared to halogen and LED units at different polymerization times (20 s, 10 s and 6 s); the shorter the curing time, lower the shear bond strength. Marquesan et al.²⁰ found no significant differences in the bond strengths when

using the new Whitening Lase Ortho curing light for 40 s for a half arch compared to conventional halogen and LED curing lights used for 20 s per tooth. Another factor observed in relation to survival time was that, in the present study, the maximum number of bond failures occurred during the initial 4 weeks of treatment. The most common reasons cited by the patients for the bond failures were hard brushing and biting on a hard food substance. O'Brien et al suggested three reasons that were possibly responsible for the bond failure during the initial few months after bonding. Reduced bond strength due to any reason involving individual bracket/adhesive combination would become evident within this initial period of treatment.^{13,26-28} The initial period of adaptation and experimentation for concerning the maintenance of braces and type of food in-take fixed orthodontic appliances. The initial phase of forces applied might be too occlusally placed and result in bond failures. Extensive research regarding the quality of bond obtained and the region where failure occurs can help us improve on faster and easier ways of bonding.^{14,29}

6. CONCLUSION

The LED unit with a three second curing time showed a better reduction in the bond failure during the initial period of four weeks when compared to those which were cured using the curing unit 20 second curing time. Even though there was no statistical significance in the values obtained showing that the three second curing light was efficient in reducing bond failure initially, clinical parameter suggest a better outcome with 3 second LED curing lamps. At 8-week review appointment no significant difference was noted in failure rate thus concluding that the bond failure due to reduced strength happened during the very first month. With practical advantage of use like reduced curing time, better moisture control, effective bracket positioning etc. hence it can be suggested from this study that the LED with three second curing time can be efficiently used in orthodontic bonding of brackets.

7. AUTHORS CONTRIBUTION STATEMENT

Dr Nivethigaa B had conceptualized, and gathered data to this work, initial drafting. Dr Aravind kumar analyzed the progress at all levels, the data collection and provided necessary reviews towards compiling and final drafting of the available data.

8. CONFLICT OF INTEREST

Conflict of interest declared none.

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