Comparison of Shear Bond Strength of Bonded Brackets Between Two Light Curing Systems – An In Vitro Study

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Abstract

Introduction – LED lights have been successfully used to enhance the polymerization of photosensitive restorative materials and to shorten the curing time without compromising bond strength. Bond strength should be sufficient to withstand the masticatory forces and be low enough to allow for bracket debonding without causing damage to the enamel surface.

Aim and objectives

To compare the effect of different light cure systems on shear bond strength (SBS) of bonded orthodontic brackets at different exposure times.

Materials and method 100 extracted human premolar teeth were randomly divided into 2 groups according to 2 different light sources, i.e. Group I (Halogen), Group II (Coltolux LED) which were further subdivided into two subgroups on the basis of various exposure times (10sec, 15sec). After bonding procedure, the teeth were subjected to SBS testing by Instron machine. ANOVA and Tukey analysis done for adequate comparisons between different groups and subgroups. .

Results The mean SBS obtained for Group II > Group I for the 2 exposure times. Maximum SBS was noted for both the groups at 15sec. Mean SBS obtained with Coltolux and Halogen at 15sec was found to be within the clinically acceptable range. Statistically significant difference ($p<0.001$) was obtained at 15sec only.

Conclusions Though bond strength increases with the increase in curing time but clinically acceptable SBS can be obtained at 15 sec with Coltolux which confers worthwhile time savings with lower risk of contamination. Hence, using higher light intensity of acceptable wavelength for curing produces same SBS with much shorter exposure time.

Keywords SBS; LED; Coltolux; Halogen.

Introduction The direct bonding of orthodontic brackets has revolutionized and advanced the clinical practice of orthodontics that replaced banding of teeth during fixed orthodontic treatment. This also made the period of fixed mechanotherapy esthetically acceptable to the patient.However, improvements continue through the introduction of new materials and more effective light curing sources. These improvements minimize enamel loss, save time, and do not compromise bond strength. Most orthodontic bonding materials use as the activation mechanism the luminous energy, like Quartz Tungsten Halogen (QTH), Plasma arc, Argon laser, Light Emitting Devices (LED) for polymerization of light cured adhesives.[1,2,3] Halogen had many drawbacks such as high temperature and low power density, degradation of the lamp, filter and reflector, leading to decrease in blue light intensity and reduction in curing effectiveness over time, an increased risk of premature failure of bonded brackets and short service life (50-100 hours)[4,5,6,7] The plasma arc light curing devices or argon laser are complex and costly, so are not used routinely.[5,8,9,10,11] To overcome these shortcomings, Mills introduced LED curing units. Recently manufacturers have turned their attention to the high intensity LED light source (≥1000mW/cm^2) to improve curing effectiveness.[12,13,14,15,16] It may be due to the fact that LED emission spectrum is close to the maximum absorption peak of camphorquinone which is a photoinitiator used in light cured adhesives, hence polymerization in case of LED is better than halogen light.[6,17,18,19]

Bond strength should be sufficient to withstand the masticatory forces and be low enough to allow for bracket debonding without causing damage to the enamel surface (beyond 6-8 MPa).[9,12,20] The results of the previous studies that compared newer generation LED like Ortholux, Radii, Ortholite, Bluephase with conventional halogen lights at curing times ranging from 10sec to 40sec suggested that LED gave better bond strengths than halogen curing light.[6,14,15,21] According to the studies done till now, there were no published comparisons of SBS values of orthodontic brackets bonded with high intensity LED units,i.e. Coltolux with conventional halogen curing unit at various polymerization times. Amongst the curing lights selected for the study, Coltolux LED had an intensity of 1200 mW/cm^2 with timer settings of about 10sec, 15sec and20sec and QTH is a conventional curing unit with an intensity of 700 mW/cm^2 and timer settings of 20sec, 40sec and 60sec. The main objectives of the research on bonding procedures has been to seek the ways of reducing chairside time along with obtaining the desired bond strength. Considering this, it was decided to evaluate the SBS of orthodontic brackets cured with Coltolux LED and QTH curing light at different exposure times (i.e, 10sec and 15sec).

Materials & Methods

The present study was undertaken by our department in collaboration with Central Institute of Plastics Engineering and Technology (CIPET), Lucknow.The approval was taken from the Ethical Committee before conducting the study.

Collection Of Sample (Teeth)-100 human premolar teeth extracted for orthodontic purpose were collected. Informed consent was taken from all the subjects for using their teeth for the study. The teeth were thoroughly cleaned for any soft tissue debris or blood after extraction and then stored in 10% formalin at constant room temperature (37°C) for maximum of 3 months until they were subjected to testing.The criteria for tooth selection were as follows:

1) Premolars extracted for orthodontic purpose were selected for the study.
2) The crown was healthy with no evidence of anatomic or any gross irregularities.
3) All teeth had intact enamel, without the presence of hypoplastic areas, caries, fractures or cracks visible to the naked eye.
4) No previous history of orthodontic treatment of patient, trauma or any structural alteration caused by mechanical procedure.
5) The teeth should have not been subjected to any chemical agent, eg. Hydrogen peroxide.

Brackets 100 premolar metal brackets of Gemini MBT prescription (0.022" x 0.028″slot configuration) were used.

Materials Used For Bonding (Figure 1)

a) Etchant DPI Etchant gel (White, India, 37% phosphoric acid).
b) Adhesive Light curable orthodontic material Transbond XT adhesive (3M Unitek Corporation, Monrovia, Calif) supplied as a

single paste contained in a syringe.

c) Primer Transbond XT Primer (3M Unitek Corporation, Monrovia, Calif).

d) Light Cure Units **(Table 1)**

Table 1: Specifications of light cure unit)

S.No	Light Cure Unit	Code	Light Intensity (mW/cm^2)	Wavelength Range (nm)
1.	Quartz Tungsten Halogen (group I)	Dentsply model No.201RE, serialno.10346	700	400-500
2.	Coltolux LED (Group II)	Coltene, Whaledent	1200	450-490

Figure 1: Bonding Materials & Light Curing Units (Halogen, Coltolux LED)

Universal Testing Machine

The Universal testing machine (PTC/ME/08 Max 100KN) was used to measure the SBS at CIPET, Lucknow.

Methodology -Mounting Of Sample Teeth

The extracted premolar teeth were grooved at cementoenameljunction using a water cooled diamond disc before mounting them vertically in moulds with acrylic resin and positioned so that the buccal, lingual and proximal surfaces were perpendicular to the base of the mounting moulds andthen the autopolymerizingpolymethylmethacrylae was poured to the level of the grooved cementoenamel junction. These mounted teeth were stored in distilled water to keep them moist so that dessication did not affect the enamel surface.

Tooth Surface Preparation Organic pellicle and residual plaque were removed from enamel by cleaning and polishing buccal surfaces of the teeth with pumice and bristle brush for 5sec and rubber cups for 10sec using a slow speed hand piece and washed with abundant water spray for 15sec.Teeth were then dried with compressed oil free air spray for 5sec.

Table 2: Allocation of groups & time distri-bution for curing

Group I (yellow)		Group II (orange)	
Subgroups	Time Duration	Subgroups	Time Duration
Ia(n=25)	10sec	IIa(n=25)	10sec
Ib(n=25)	15sec	IIb(n=25)	15sec

Bonding Procedure

a) A 37% orthophosphoric acid was applied to the center of the clinical crown on the buccal surface of each tooth for 30sec, then thoroughly rinsed with distilled water for 20sec and then dried for 5sec with the compressed air until the buccal surface of the etched teeth had frosty appearance.

b) The primer was applied to the etched surfaces of the teeth and on bracket base then photopolymerized for 10sec.

c) A small layer of Transbond XT adhesive was placed on the bracket base before placing on the demarcated etched enamel surface. Bracket placement was done at the center of the clinical crown with gentle pressure perpendicular to the long axis of the crown

d) The bracket adhesive interface was cured with different light curing units and time durations as per the allocation of groups / subgroups. These bonded teeth are then stored for 24 hours in distilled water at 37 °C until they are as subjected to SBS testing.

Testing An occluso-gingval force was appl to the bracket, producing a shear force at the bracket-tooth interface using a chisel – edge plunger at a crosshead speed of 0.5mm/min.The force producing failure was recorded in Newtons by a computer and SBS was calculated (MPa= N/mm^2)

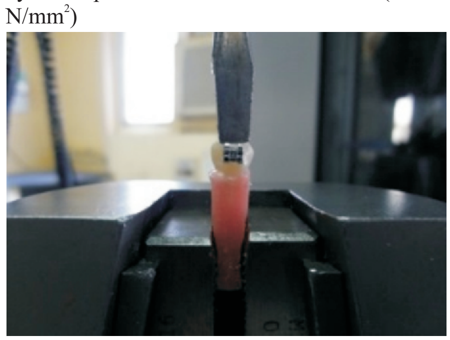

Figure 4:Plunger Applying Force In Occluso-gingival Direction On Mounted Sample

Results

Table 3: shows mean values of SBS for Group I, II at different exposure times.

Table 4: shows results of Tukey test for comparison of SBS between subgroups of Group I, II.

Table 5: shows results of Tukey test for comparison of SBS between subgroups of Group I, II at exposure times of 10sec and 15sec.

Table 6: shows results of Tukey test for comparison of SBS irrespective of groups between 10sec vs 15sec

Table 7: shows the results of Tukey test for comparison of SBS between groups irrespective of exposure time

Table 3: Mean values of SBS for Group I, II at 2 exposure times.

Groups	Subgroups	Exposure time	Mean ± SD (MPa)	95% CI	
				Lower	Upper
Group I	Ia(n=25)	10sec	4.95±1.04	4.53	5.38
	Ib(n=25)	15sec	6.74±0.79	6.41	7.07
Group II	IIa(n=25)	10sec	4.68±0.92	4.30	5.06
	IIb(n=25)	15sec	9.36±0.74	8.64	10.07

Table 4: Comparison of Shear Bond strength Between Subgroups (Tukey test) for Group I, II

Group	Comparison Between Subgroups	Mean Difference	"P"
Group I	Ia vs Ib	-1.79±0.23	<0.001
Group I	Ib vs IIb	-4.67±0.36	<0.001

(p> 0.05 NS, p <0.05 Significant, p <0.01 Highly significant, p <0.001 Very highly significant)

Table 5: Comparison of Shear Bond strength Between Subgroups (Tukey test) of Group I, II at exposure times of 10sec and 15sec

Time	Comparison Groups	Mean Difference	SE	"P"
10sec	Ia vs IIa	0.27±0.37	0.37	0.742
15sec	Ib vs IIb	-2.62±0.42	0.42	<0.001

(p> 0.05 NS, p <0.05 Significant, p <0.01 Highly significant, p <0.001 Very highly significant)

Table 6: Comparison of Shear Bond strength (Tukey test)

(Overall: Irrespective of group)

Comparison	Mean Difference	"P"
10sec vs 15sec	-3.08±0.43	<0.001

(p> 0.05 NS, p <0.05 Significant, p <0.01 Highly significant, p <0.001 Very highly significant)

Table 7: Comparison of Shear Bond strength between groups irrespective of exposure time

Comparison	Mean Difference	"P"
I vs II	-0.99±0.42	<0.050

(p> 0.05 NS, p <0.05 Significant, p <0.01 Highly significant, p <0.001 Very highly significant)

Discussion

Ever since the inception of bonding in Orthodontics, the materials used for bonding have undergone considerable improvement from time to time. In the present study, the general trend seen was that there were a gradual increase in mean SBS as light-curing time increased for all groups, as also reported in various previous studies as well.[1,2,6,7,8,10,22] (Table 3) Time and bond relationship is probably due to the greater conversion of monomer to polymer that occurs with the increase in exposure time.

Clinically acceptable limits of SBS had been suggested by Reynolds as 6-8 MPa and SBS of this range would be able to withstand masticatory and orthodontic forces that would be adequate for clinical orthodontic needs. In the present study, SBS for Group I and Group II at 15sec only was within the range of 6-8 MPa (Table 3). On comparing each curing light at different exposure time, statistically significant difference was observed for both the groups, i.e. Group I, Group II (Table 4). Previous studies had found statistically no significant differences on comparison of SBS of halogen with LED lights at their respective recommended exposure times,i.e. 20-40sec for halogen and 10-20sec for LED light.[3,2,6,14,17,23]

According to the authors LED light sources can demonstrate irradiance levels that are much lower than the traditional halogen lamps when measured on curing radiometers, and yet the composite is cured because the emission spectrum of the blue LED is very similar to the absorption spectrum of the primary photoinitiator, camphorquinone which is sensitive to the blue part of the visible light spectrum (360-520nm), with a peak activity centered around 465nm. The reason for halogen producing lower SBS is that larger part of irradiative power is wasted with halogen lamps.

Halogen lamps produce light when electric current flows through a thin tungsten filament (resistor) heated, emitting energy in the form of radiation. High temperatures must be reached in order to achieve visible light emission consuming large parts of intensity of halogen lights.LED lights at moderate cost with increased intensity and other advantages like portability, and the long life of its diode have made them more popular.

On comparing different curing lights at particular exposure time, statistically significant difference was observedwhen Group I (halogen) was compared with Group II (Coltolux) at 15sec but not significant difference was obtained at 10sec (Table 5). Furthermore, on overall comparison of mean SBS irrespective of light cure units at different exposure times, statistically significant difference was found between all exposure times with maximum SBS at 15sec and minimum at 10sec (Table 6). Lastly, when comparisons were made between and within different groups irrespective of exposure time, statistically significant difference was noted for both the groups (curing lights) (Table 7). Palomares et al had compared 3 LEDs (Ortholux, Radii, Bluephase) at 10sec exposure showed no significant differences.[16] David et al also showed no statistically significant difference when compared 3 LEDs Coltolux, Freelight, LEDemetron at 20sec, 40sec and 60sec.[1] This may be due to curing time was not same for all curing lights in these studies.

The other studies have assessed the influence of same light cure unit at different exposure times. As in our result, no significant difference was seen when comparedthe 2 lights at 10sec, EliparFreelight LED at 10sec, 20sec, 40sec and OrtholuxXT at 5sec, 10sec, 40sec also shows the same.[8,10] Sharma et al who used Radii LED at 15sec and 30sec found no significant difference.[15]

The limitation of this or any in vitro study on evaluation of SBS are same. It is unlikely that our patient will be occluding at such lower rate as that ofcrosshead speed of Instron (0.5mm/min). There is no substitute for in vivo testing of bonding variables. Despite these limitations, the summary of results of the present study suggests that Coltoluxprovides better bond strength than halogen at the same exposure time. From a clinical point of view, this time reduction is advantageous due to the shorter chair time, allowing the orthodontist to attend a large number of patients within shorter period of time and lower risk of contamination by saliva, thus increasing bond strength and reducing the rate of orthodontic bracket debonding with least chances of enamel damage.When increased SBS is required such as for curing of posterior molar buccal tubes or for sometimes for lingual button or curing brackets on impacted tooth, it is desirable to increase exposure time so as to have better SBS value, henceColtolux at 15sec can provide increased bond strength required in such cases. Further it should be taken into account that for better bond strength at shorter exposure time, more researchshould be done to evaluate bond strength when using newer adhesives, newer etching materials like Self Etching Primer (SEP), newer generation of primers like Moisture Insensitive Primer (MIP) and on different brackets available with variation in bracket mesh base surface.

Conclusion

Following conclusions can be drawn from the present study :

a) The mean SBS obtained with Coltolux and Halogen at 15sec was found to be within the clinically acceptable range (6-8 MPa) as suggested by Reynolds.
b) At exposure time of 10sec and 15sec mean SBS was maximum for Group II (Coltolux)and minimum for Group I(Halogen) .
c) Irrespective of groups, the mean SBS was maximum for 15sec and minimum for 10sec of exposure time and statistically significant differences was found between them at 15sec only .
d) Irrespective of exposure time, Group II had maximum SBS and Group I had minimum with statistically significant differences between them.

Further studies can aim at comparing other newer curing lights used with newer adhesives and etchants to check their efficacy in reducing the curing time while maintaining clinically acceptable bond strength.

References

References are available on request at editor@healtalkht.com

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which specific genes in the dental follicle that surrounds the unerupted tooth are either upregulated or downregulated at critical times to bring about the osteoclastogenesis and osteogenesis needed for eruption.

Several local factors such as mechanical obstruction from soft tissue overgrowth, supernumerary teeth, gingival fibromatoses, crowding, rotation of tooth buds, retained primary teeth, and pathological lesions are the most common reasons for teeth impaction. The clinical and radiographic examinations of our case revealed that the causes of impacted canines are due to retained deciduous canines and lack of space.

Management of retained deciduous teeth depends upon several factors such as dental age of the patient, presence or absence of succedaneous teeth. If successor is present with root formation is not yet completed, then the space should be maintained / created and teeth will come to oral cavity by its eruptive forces. In other situation where successor is present and root formation has been completed then the tooth should bring orthodontically to its normal position. If root and coronal structure are good, the tooth if functionally and aesthetically acceptable, and there is no compelling orthodontic need for extraction, a primary tooth may be retained intact. Where root and crown structure are good but infra-occlusion has occurred or aesthetic improvement is required, the primary tooth may be retained and reshaped. If the arch is well aligned but the prognosis of the primary tooth is poor due to root resorption, caries, periodontal or periapical disease or inadequate aesthetics, extraction and prosthetic replacement may be necessary. In our case all deciduous teeth should be extracted and canines along with other permanent teeth should be aligned orthdontically in the arch.

conclusion

Although the presence of multiple over-retained primary teeth along with normally erupted permanent successors and impacted teeth is rare, but it seems to be a very severe malocclusion in first instance. But a proper history, clinical and radiographic evaluation can lead to much simpler treatment plan for the case. This emphasizes the importance of having patience in orthodontic treatment planning and proceeding for extractions of over-retained deciduous teeth judiciously.

References

References are available on request at editor@healtalkht.com

Figure legends

Figure 1: Extraoral photographs of the patient

Figure 2: Intraoral photographs of the patient

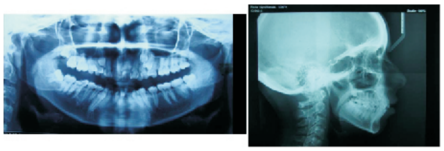

Figure 3: Orthopentomogram and lateral cephalogram of the patient