How to Cite:
Sawant, H. R., Gangurde, P. V., Gheware, A. G., Gaikwad, S. S., & Shetty, N. S. (2022). A comparative evaluation of shear bond strength of directly bonded brackets using three varieties of light cure systems: An in-vitro study. *International Journal of Health Sciences*, *6*(S8), 2463–2473. https://doi.org/10.53730/ijhs.v6nS8.12487

A comparative evaluation of shear bond strength of directly bonded brackets using three varieties of light cure systems: An in-vitro study

Dr. Hitesh Ramdas Sawant
Assistant Professor, Dept. of Orthodontics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Navi Mumbai
Corresponding author email: drhitesh247@gmail.com

Dr. Parag Vishnu Gangurde
Professor and Head of Department, Dept. of Orthodontics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Navi Mumbai
Email: drparaggangurde@gmail.com

Dr. Anjali Gourishankar Gheware
Professor, Dept. of Orthodontics, MGM Dental College and Hospital, Navi Mumbai
Email: anjaligheware@yahoo.co.in

Dr. Shashank Sharad Gaikwad
Professor, Dept. of Orthodontics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Navi Mumbai
Email: drshashankgaikwad@yahoo.co.in

Dr. Nityanand Shankar Shetty
Assistant Professor, Dept. of Orthodontics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Navi Mumbai
Email: drshettyortho@gmail.com

***Abstract*---**Context: Using Visible Light to bond orthodontic attachments is now an accepted norm, the progression being Halogens, Low and High Intensity Light Emitting Diodes (LED_s). Since, clinical use of bonded brackets is pragmatically linked with Shear Bond Strength (SBS) and chair-side time, adhesives with shorter curing time are a boon. Hence, the aforementioned facets bear a more detailed study. Settings and Design: 6 Groups (2 Halogens, 2 Low Intensity LED_s and 2 High Intensity LED_s); Each Group comprised of 10 assemblies of Metal Brackets (3M Unitek, Gemini Series) bonded to facial surface of extracted human Maxillary 1st bicuspids. Methods

and Material: Brackets were directly bonded using Standard Bonding Protocol to freshly extracted Human Maxillary Premolars. Shear Bond Strength (SBS) testing was done using Universal Testing Machine, Instron. The SBS values attained in Kg/F were converted into MPa and results subjected to a comparative evaluation. Results: Mean SBS values, in MPa, for Halogen Light Cure Systems were 8.51 and 8.86; for Low Intensity LED_s were 10.50 and 10.33 while for High Intensity LED_s 15.54 and 13.85. Conclusions: Mean Shear Bond Strength (SBS) of Light Curing Systems belonging to three Varieties tested were acceptable for Clinical Usage since they confirmed with norm of 6-8 MPa [8]. High Intensity LED_s resulted in shorter Curing Cycles, thus reducing chairside time without compromising the SBS value and may be preferred for Clinical Use.

***Keywords*---**shear bond strength, halogen light cure system, low intensity LED, high intensity LED.

Introduction

Orthodontics has embraced photocured composites in favour of chemical ones for bonding attachments, be it directly or indirectly. Use of photocured composites began as Halogens for them to be progressively replaced by Light Emitting Diode (LED) ones.[1-4] Arguably, this helped in reduced bond failures through increased intensity and hence a reduced duration of cure which concurrently improved the Shear Bond Strength (SBS) of the bonding adhesive used.[5] Since Light Cure Systems vary in intensity and recommended duration of Curing as prescribed by the manufacturer, the focus of this In-Vitro study was to evaluate and compare the efficacy of three varieties of Light Cure Systems; Halogen Light Cure Systems, Low Intensity LED_s and High Intensity LED_s, with variations in Curing time as affecting SBS of the adhesives used.

Subjects And Methods

Inclusion Criteria

i) Freshly extracted Human Maxillary Premolars collected over a period of 3 months.
ii) Stainless Steel (SS) Brackets, 3M Unitek, Mclauglin, Bennett and Trevisi (MBT), Gemini Series, 0.018 " x 0.025 " slot

Exclusion Criteria

i) Carious teeth.
ii) Teeth with irregular buccal anatomy.
iii) Fractured teeth.
iv) Teeth with any anomalies of size and shape.
v) Teeth with hypoplastic defects or developmental anomalies.
vi) Brackets other than Stainless Steel.
vii) Brackets other than 3M Unitek, MBT, Gemini Series, 0.018” x 0.025” slot.

Methodology

Based on the advice of a qualified Bio-statistician that factored a 10% drop-out, 66 Human Maxillary Premolars, freshly extracted for therapeutic Orthodontic reasons, collected from the Department of Oral and Maxillofacial Surgery and from clinicians in the neighboring vicinity constituted the sample size for this study. The teeth were collected over a period of 3 months and confirmed with the aforementioned Inclusion and Exclusion Criteria. They were transported in numbered plastic containers carrying Normal Saline solution.

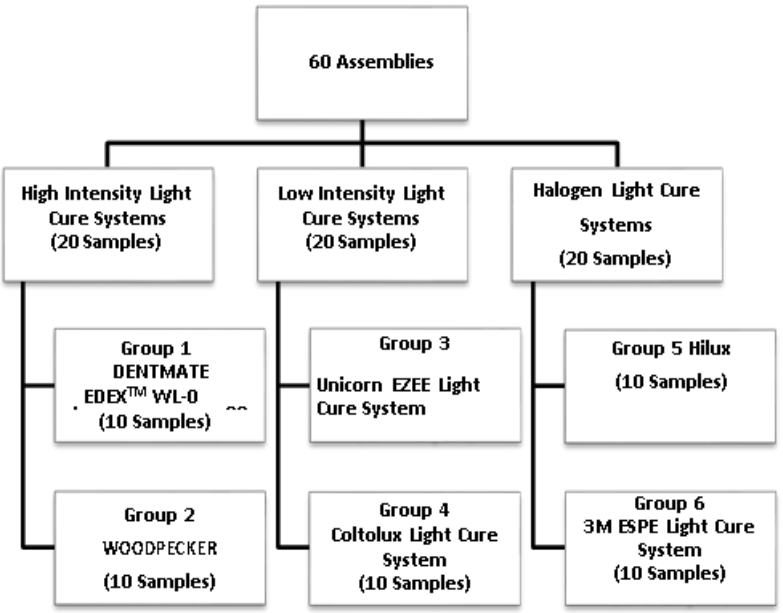
These extracted teeth were cleaned of all debris by scrubbing with a tooth brush under constant flow of saline. Hard deposits (calculus/tartar), if any, were removed by an Ultrasonic Scaler. Round End Taper Diamond air rotor bur was used for making grooves on the proximo-palatal aspect of the roots of these teeth to facilitate embedding in Acrylic through increased mechanical retention thus provided. The entire root length of every tooth till the Cemento Enamel Junction was embedded in an acrylic block made from Self Cure Acrylic Resin, Acralyn R, leaving only the crown exposed. Use of Luckhart's Mould facilitated making standardized Acrylic Blocks; Length 2.0 cm, Width 1.0 cm, Height 3.5 cm; to aid in SBS testing.

These acrylic block assembles, each carrying its embedded extracted tooth, were stored at 4°C in individually numbered plastic bottles containing 0.5% Thymol solution (used as a preservative that prevented bacterial growth). Twenty Four hours prior to directly bonding brackets, the teeth were washed with distilled water to eliminate traces of thymol; polished with aqueous slurry of plain inorganic pumice and a 3M Astropol Brush rotating at low speed in a micro motor. Using a standard bonding protocol detailed below, brackets were then bonded by the same operator on each of the 66 teeth over a 2 day period.

i) The buccal surface was etched using 3M ScotchbondTM Universal Etchant (37% Phosphoric Acid Gel) for 30 seconds. Thorough rinsing for 10 seconds by a 3 way syringe was followed by gentle blow drying with oil and moisture free air.
ii) Sealant/Primer was applied to the frosty white etched surface with a brush. Excess primer was blown away off the tooth with a blast of oil free compressed air and cured for 10 seconds with an appropriate curing light.
iii) Long axis of clinical crown was marked with 0.5 " lead pencil to assist in proper occluso-gingival orientation of the bracket.
iv) Transbond XT Adhesive was applied on the Bracket Base of the Stainless Steel (SS) bracket 3M Unitek, MBT, 0.018" x 0.025" slot size.
v) Accurate vertical bracket positioning was achieved by using the MBT Gauge.
vi) Bracket was pressed to the buccal surface of the tooth with sufficient finger pressure at the center of the bracket to expel the excess adhesive which was removed with a sharp explorer.
vii) The adhesive was then cured using appropriate type of light curing unit in a pre-decided manner with the needed duration of cure (as per study protocol).
viii) To avoid bias, the sequence of a tooth to be cured by a particular Light System was randomized.

Though most manufacturers recommend photocuring from all sides, increasing the curing time for High Intensity LED_s may cause rise in pulpal temperature.[6,7] Moreover, intraorally, in crowded arches it is not possible to cure from all surfaces. To eliminate bias and maintain the uniformity of the bonding protocol, light was directed at the Occlusal surface interface between bracket and the tooth. The duration of curing time for the 6 Groups was: 20 seconds for both Hilux (Fig.1) and 3M ESPE Halogen Systems (Fig. 2); 15 seconds Curing Cycle for both Unicorn EZEE (Fig. 3) and Coltolux Systems (Fig. 4) and 3 seconds for Dentmate Ledex™ WL-090 (Fig. 5) and Woodpecker (Fig. 6).

The intensity of different Light Cure Systems used in this study was periodically assessed by a Radiometer to ensure correct levels of intensity being maintained throughout the study. Assemblies of bracket-carrying extracted teeth were divided into the following Groups:



Methodology Flow Chart

The assemblies were stored in distilled water at 37˚ Celsius. Shear Bond Strength (SBS) testing was done with a Universal Testing Machine, Instron at the neighboring Engineering Institution over a time period of 7 hours. (Fig. 7)

Fig. 1

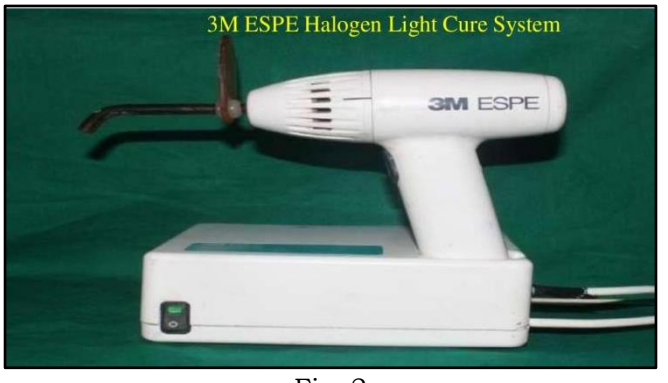


Fig. 2

Fig. 3

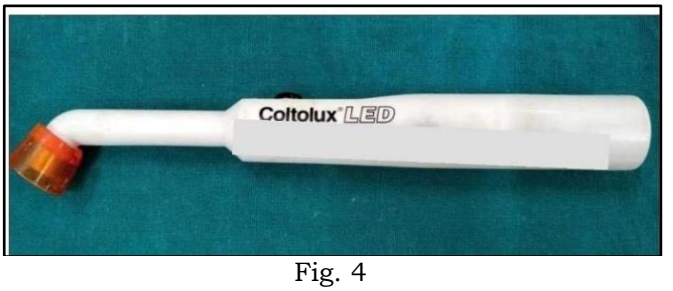


Fig. 4

Fig. 5

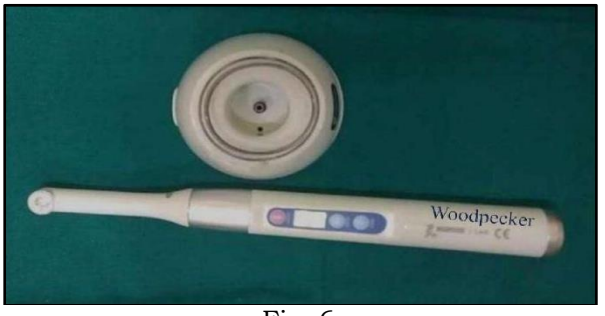


Fig. 6

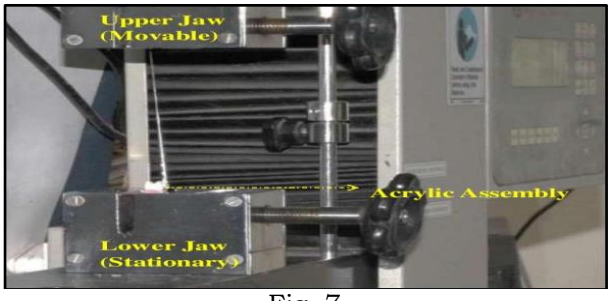


Fig. 7

Results

Sample	High Intensity 1 SBS (MPa)	High Intensity 2 SBS (MPa)	Low Intensity 1 SBS (MPa)	Low Intensity 2 SBS (MPa)	Halogen 1 SBS (MPa)	Halogen 2 SBS (MPa)
1	13.81	15.67	10.84	9.84	8.10	10.19
2	14.26	15.78	10.97	9.54	7.29	10.32
3	12.41	14.81	11.82	10.68	8.34	8.74
4	13.91	12.92	10.84	10.69	7.45	8.58
5	15.81	12.82	10.82	9.88	7.66	9.91
6	16.46	12.88	9.88	11.81	8.10	8.78
7	16.29	10.91	9.91	11.44	10.09	8.86
8	16.77	12.92	9.99	10.39	8.87	7.81
9	17.84	14.88	10.91	9.89	8.76	7.98

10	14.91	14.97	9.10	9.10	10.55	7.45

Table 1: Shear Bond Strength (SBS) for 6 different groups

		N	Mean	SD	SE	95% C.I. for Mean		Minimum	Maximum
						Lower	Upper		
Value1	HILC	10	15.2470	1.66360	.52608	14.0569	16.4371	12.41	17.84
	LILC	10	10.5080	.77581	.24533	9.9530	11.0630	9.10	11.82
	HLC	10	8.5120	1.07976	.34145	7.7396	9.2844	7.29	10.55
	Total	30	11.4223	3.10816	.56747	10.2617	12.5829	7.29	17.84
Value2	HILC	10	13.8550	1.58703	.50186	12.7197	14.9903	10.91	15.78
	LILC	10	10.3360	.84807	.26818	9.7293	10.9427	9.10	11.81
	HLC	10	8.8620	.99817	.31565	8.1479	9.5761	7.45	10.32
	Total	30	11.0177	2.41924	.44169	10.1143	11.9210	7.45	15.78

Table 2: Descriptive statistics for all experimental groups

The mean bond strength was compared between the six groups using One-way Analysis Of Variance (ANOVA). Post-hoc pairwise comparisons was done using Tukey Cramer's method. All testing were done using two-sided tests at Alpha (α) = 0.050. (Table 3,4)

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Value1	HILC	LILC	4.73900*	.54987	<0.0001	3.3756	6.1024
	HLC		6.73500*	.54987	<0.0001	5.3716	8.0984
	LILC	HILC	-4.73900*	.54987	<0.0001	-6.1024	-3.3756
		HLC	1.99600*	.54987	0.003	.6326	3.3594
	HLC	HILC	-6.73500*	.54987	<0.0001	-8.0984	-5.3716
		LILC	-1.99600*	.54987	0.003	-3.3594	-.6326
Value2	HILC	LILC	3.51900*	.53130	<0.0001	2.2017	4.8363
	HLC		4.99300*	.53130	<0.0001	3.6757	6.3103
	LILC	HILC	-3.51900*	.53130	<0.0001	-4.8363	-2.2017
		HLC	1.47400*	.53130	0.026	0.1567	2.7913
	HLC	HILC	-4.99300*	.53130	<0.0001	-6.3103	-3.6757
		LILC	-	.53130	0.026	-2.7913	-.1567

			1.47400*				

*. The mean difference is significant at the 0.05 level.

Table 3: Tukey Honestly Significant Difference Test for comparison of SBS of different groups

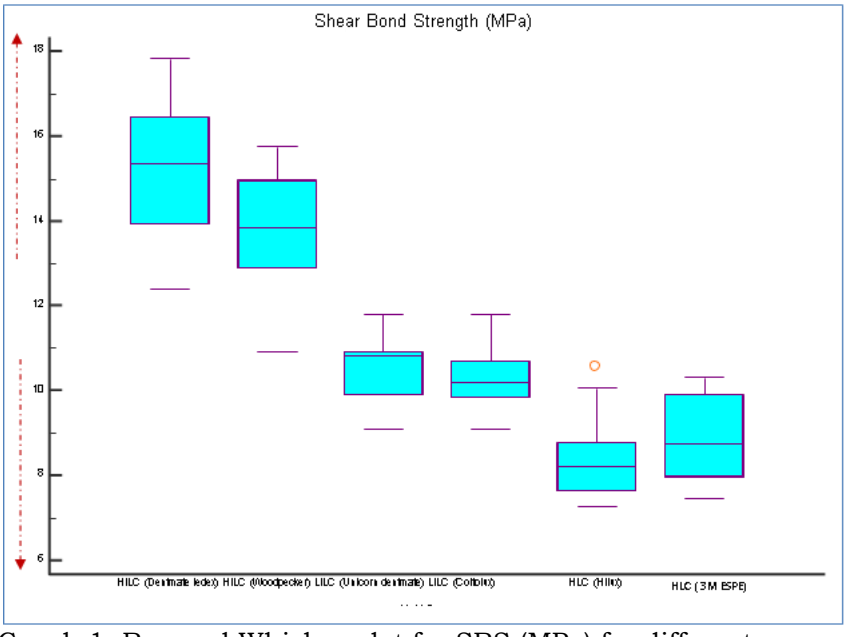
Multiple Comparisons

Dependent Variable: SBS (Mpa)
LSD

(I) Light Cure Type (II)	(J) Light Cure Type	Mean Difference (I-J)	SE	Sig. (p)	95% C.I. for diff.	
					Lower	Upper
HILC (Dentmate ledex)	HILC (Woodpecker)	1.39200*	.54067	0.013	.3080	2.4760
	LILC (Unicorn dentmate)	4.73900*	.54067	<0.0001	3.6550	5.8230
	LILC (Coltolux)	4.91100*	.54067	<0.0001	3.8270	5.9950
	HLC (Hilux)	6.73500*	.54067	<0.0001	5.6510	7.8190
	HLC (3M ESPE)	6.38500*	.54067	<0.0001	5.3010	7.4690
HILC (Woodpecker)	HILC (Dentmate ledex)	-1.39200*	.54067	<0.0001	-2.4760	-.3080
	LILC (Unicorn dentmate)	3.34700*	.54067	<0.0001	2.2630	4.4310
	LILC (Coltolux)	3.51900*	.54067	<0.0001	2.4350	4.6030
	HLC (Hilux)	5.34300*	.54067	<0.0001	4.2590	6.4270
	HLC (3M ESPE)	4.99300*	.54067	<0.0001	3.9090	6.0770
LILC (Unicorn dentmate)	HILC (Dentmate ledex)	-4.73900*	.54067	<0.0001	-5.8230	-3.6550
	HILC (Woodpecker)	-3.34700*	.54067	<0.0001	-4.4310	-2.2630
	LILC (Coltolux)	.17200	.54067	0.752	-.9120	1.2560
	HLC (Hilux)	1.99600*	.54067	0.001	.9120	3.0800
	HLC (3M ESPE)	1.64600*	.54067	0.004	.5620	2.7300
LILC (Coltolux)	HILC (Dentmate ledex)	-4.91100*	.54067	<0.0001	-5.9950	-3.8270
	HILC (Woodpecker)	-3.51900*	.54067	<0.0001	-4.6030	-2.4350
	LILC (Unicorn dentmate)	-.17200	.54067	0.752	-1.2560	.9120
	HLC (Hilux)	1.82400*	.54067	0.001	.7400	2.9080
	HLC (3M ESPE)	1.47400*	.54067	0.009	.3900	2.5580
HLC (Hilux)	HILC (Dentmate ledex)	-6.73500*	.54067	<0.0001	-7.8190	-5.6510
	HILC (Woodpecker)	-5.34300*	.54067	<0.0001	-6.4270	-4.2590
	LILC (Unicorn dentmate)	-1.99600*	.54067	0.001	-3.0800	-.9120
	LILC (Coltolux)	-1.82400*	.54067	0.001	-2.9080	-.7400
	HLC (3M ESPE)	-.35000	.54067	0.520	-1.4340	.7340
HLC (3M ESPE)	HILC (Dentmate ledex)	-6.38500*	.54067	<0.0001	-7.4690	-5.3010
	HILC (Woodpecker)	-4.99300*	.54067	<0.0001	-6.0770	-3.9090
	LILC (Unicorn dentmate)	-1.64600*	.54067	0.004	-2.7300	-.5620
	LILC (Coltolux)	-1.47400*	.54067	0.009	-2.5580	-.3900

	HLC (Hilux)	.35000	.54067	0.520	-.7340	1.4340

*. The mean difference is significant at the 0.05 level.



Graph 1: Box and Whisker plot for SBS (MPa) for different groups

Discussion

To recapitulate the present study in brief, Shear Bond Strength (SBS) Values for brackets directly bonded with a single adhesive (Transbond XT) were determined; variations being type of Light Cure Systems and curing time. This adhesive of proven quality permits to effectively evaluate relative performance of the variables studied in a predefined manner. Visible Light Cure Systems, broadly classified as Halogen Light Cure Systems and Light Emitting Diode (LED) vary in intensity. Ones with high intensity (1800-2600 mW/ cm^2) have greater number of photons reaching the adhesive. This results in generation of higher number of free radicals which convert monomer into polymer and leads to a complete cure of the resin. In the present study, intensity for Halogen Light Cure Systems used was 900 mW/cm^2 and 800mW/cm^2; for Low Intensity Light Cure Systems was 1200 mW/cm^2 and for the two systems in High Intensity LED Group was 2400 mW/cm^2 and 2200 mW/cm^2. All aforementioned Light Curing Units fulfilled the recommended 'gold standard' needs for SBS (6-8 MPa) [8] for bonded attachments and thus were worthy for clinical usage. LED_s, Low as well as High Intensity types, showed statistically significant superiority over Halogen ones (Table 3). Few Studies [3,4,9,10,11] have found no difference in bond failures with Low Intensity LED_s over Halogen Light Cure Systems. Though SBS with use of High Intensity LED_s and Low Intensity LED_s were comparable [12,13,14] and significantly higher than clinically needed values, since using the former saves chair-side time and reduces chances of moisture contamination [5], the same are the best ones for clinical use.

Conclusion

1) The Mean Shear Bond Strength (SBS) of all Light Curing Systems tested were found acceptable for clinical use as the SBS Values were confirming to the expected norm of 6-8 MPa[2].
2) High Intensity LED$_s$, with their shorter curing time and reduced chairside time needed without compromising the SBS are ideally suited for clinical use.

Key Message

Clinical efficacy for use being of paramount importance, among the available Light Curing Systems for orthodontic use, High Intensity LED$_s$ are best suited for orthodontic bonding of attachments.

References

1. Bishara SE, Ajlouni R, Oonsombat C. Evaluation of a new curing light on the shear bond strength of orthodontic brackets. Angle Orthod 2003;73:431–5.
2. Dunn WJ, Taloumis LJ. Polymerization of orthodontic resin cement with light-emitting diode curing units. Am J Orthod Dentofacial Orthop 2002;122:236–1.
3. Farfán, R. F. M., Zambrano, T. Y. M., Badillo, F. R. A., & Solís, A. A. H. (2020). Design and construction of an industrial ship conditioning system. *International Journal of Physical Sciences and Engineering*, *4*(1), 29–38. https://doi.org/10.29332/ijpse.v4n1.423
4. Krishnaswamy NR, Sunitha C. Light-emitting diode vs halogen light curing of orthodontic brackets. A 15-month clinical study of bond failures. Am J Orthod Dentofacial Orthop 2007: 132:518-3.
5. Kurachi C, Tuboy AM, Magalhaes DV, Bagnato VS. Hardness evaluation of a dental composite polymerized with experimental LED based devices. Dent Mat 2001;17:309-5.
6. Mills RW, Jandt KD, Asworth SH. Dental composite depth of cure with halogen and blue light emitting (LED) technology. Br Dent J 1999;186:388-1.
7. Mirabella D, Spena R, Scognamiglio G, Luca L, Gracco A, Siciliani G. LED vs halogen light-curing of adhesive-precoated brackets. Angle Orthod 2008;78:935–0.
8. Oberholzer TG, Makofane ME, Preez I, George R. Modern high powered led curing lights and their effect on pulp chamber temperature of bulk and incrementally cured composite resin. Eur J Prosthodont Restor Dent 2012;20:50-5.
9. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1975; 2: 171-8.
10. Silta YT, Dunn WJ, Peters CB. Effect of shorter polymerization times when using the latest generation of light emitting diodes. Am J Orthod Dentofacial Orthop 2005;128: 744–8.
11. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. *International Journal of Health Sciences*, *6*(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949
12. Tanya, T., Dandekeri, S., Shetty, S., Mohammed, Z., Mohammed, F., Ragher,

M., & Hegde, S. (2022). Effect of silanization on shear bond strength between high translucency zirconia and resin cement: An in-vitro study. *International Journal of Health Sciences*, *6*(S1), 6801–6815. https://doi.org/10.53730/ijhs.v6nS1.6438

13. Usumez S, Buyukyilmaz T, Karaman AI. Effect of light emitting diode on bond strength of orthodontic brackets. Angle Orthod 2004:38:385-7.
14. Verma P. Curing efficiency of three light emitting diodes at different curing profiles. Indian J Dent Res 2016; 27:168-3
15. Ward J, Wolf B, Leite L, Zhou J. Clinical effect of reducing curing times with high-intensity LED lights. Angle Orthod 2015;85:1064-9.
16. Ward J, Wolf B, Leite L, Zhou J. Clinical effects of reducing Curing time with high-intensity LED lights. Angle Orthod 2015;85:1064–9.
17. Zach L, Cohen G. Pulp response to externally applied heat. Oral Surg Oral Med Oral Pathol 1965;19:515–0.