Shear Bond Strength Of A Bracket-Bonding System Cured With Six Different Commercially Available A Light-Emitting Diode(Led)

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Abstract

Purpose: To evaluate and compare the shear bond strength (SBS) of metallic brackets bonded to enamel by Conventional Bonding System using six different light curing units.

Materials and methods: Sixty human permanent maxillary premolars were embedded in acrylic resin using PVC rings as molds and assigned to 6 groups. Each teeth bonded with transbond XT adhesives and cured with the LED light curing unit of the respected group. Ten Samples Of Group – 1 was cured with BLUEPHASE N , Group – 2 with BLUEPHASE NM ,Group – 3 with3M ESPE Elipar™S10, Group – 4 with 3MESPE Elipar™ Deepcure, Group – 5 with WOODPECKER B PLUS CURE and Group – 6 with WOODPECKER I LED were used and each sample was cured for about 3 sec. After bonding, the specimens were submitted to shear bond strength test using universal testing machine at a crosshead speed of 0.5 mm/min.

Results:* *The highest mean SBS was obtained with the samples cured with 3MESPE Elipar™ with a curing time of 3 sec(18.5 MPa). ANOVA test shows a statistically significant difference between the groups expect between group 1 and group 2 and between group 5 and group 6.

Conclusion: Polymerization with all the six LED curing lights resulted in SBS values that were clinically acceptable for orthodontic treatment in all groups. Curing with 3MESPE Elipar™ Deepcure gave a higher bond strength than other groups cured for a short time.

Keywords: *shear bond strength, light curing unit, LED-curing light, polymerization time*

INTRODUCTION

Initially for fixed-appliance therapy, brackets were welded to gold or stainless steel bands which had many adverse effects like creating gaps between the teeth, increased chair side time for clinician, unesthetic and uncomfortable to the patient with inflammation of gums and decalcification under the bands(1).this method is no longer used since acid-etching procedure has been introduced by Buonocorein 1955, and modified for orthodonticuse by Newmanand Retief et alin the 1960s.(2) At that time, only auto-polymerizing materials were available. With the introduction of light-activated adhesive systems, orthodontists could have sufficient time to position the bracket on enamel surface and remove the excess material. This evolution has allowed the emergence of several other bonding methods using different composites and light-curing devices. Light activated resins has Camphoroquinone that absorbs light with wavelengths in the range of 400 and 500 nm light and responds to irradiation by creating free radicals and initiates the polymerization process.(3) In the early days halogen bulbs with important characteristics, such as the wide-spectrum action, were used to cure these adhesives. During this process, monomer units bond with each other to build long and heavy polymers. Due to the increased use of optical composites, the importance of polymerization has become more prominent. One most desired result of bonding to any surface is that the attachment should be strong enough to endure the forces of orthodontic treatment and oral functions without any breakage and safe to the tooth surface during debonding .(4)The strength of these restorations depends on the degree of polymerization of composite resins. Incomplete polymerization produces adverse biological effects, increasing water absorption, composite solubility, and reducing hardness. Various factors contribute to the polymerization of the composites, and they include the wavelength and intensity of the output of light curing units, duration of radiation, dimension sand location of the dental cavity, direction and distance of the tip of the device (related to the composite), the composition of the composite, the wavelength and bandwidth of the curing light, the intensity of the curing light, the irradiation time, and colour and thickness of the composite. An appropriate intensity of light with the maximum absorption wavelength range of camphorquinone is the main factor in the polymerization of these resins. If the light output intensity decreases, it will adversely influence the clinical and cosmetic performance. The light intensity of curing devices is defined by the International Organization for Standardization as the ISO 4049 standard, which recommends an intensity of 300 mW/cm2 with a wavelength bandwidth of 400-515 nm on the tip of the light curing device. Although the halogen bulb curing units were widely in use it had many inherent disadvantages which includes shorter range of light, increased time for curing increased heat production and a noisy fan(5). in order to overcome these shortcomings, Mills and Nakamura et al introduced the LED (light-emitting-diode) as an alternative where two solid semiconductors joined together, and an electric charge is applied using a battery.(5) . Light cure resins set when light of wavelength of 460nm and 480nm within blue end of visible spectrum is used with an intensity of 300mW/cm2 that passes through enamel and produces free radicals by disruption of double bonds in alpha diketone initiator. LED devices have advantages like small size, ergonomic, less weight, reduced noise generation and heat, radiation source having longer life, lower power consumption, and light emission spectrum with total camphoroquinone absorption. Recently A number of LED units, claiming to possess the best of properties, have flooded the markets, so there is a need to evaluate and compare the efficiency of these different curing units available.

The aim of this study was to evaluate the efficiency of six different commercially available light emitting diodes (LED) light curing devices that are commonly used for bonding orthodontic metal brackets using the shear bond strength (SBS).

Materials and methods

Sixty human extracted premolars without any defect in enamel surfaces were selected, adequately cleaned and stored in 0.1% (wt/vol) thymol at room temperature for 2 weeks. Inclusion criteria for the teeth were the extracted teeth should have an intact buccal enamel which include teeth extracted for orthodontic treatment or due to periodontal involvement on the other hand teeth having caries involvement, any pre-treatment done, with any cracks or attrited surface seen with eye, or with any developmental defects such as hypoplastic enamel were not considered in the study.

The root portion of the selected teeth were then mounted on cold curing fast settling acrylic block using an aluminium jig of dimension 150mm x 150mm(figure 2)so that it could properly be seated on the testing machine. Each tooth was mounted upto the CEJ vertically in acrylic resin block with the long axis of each tooth set vertically parallel to the jig and the crown remaining exposed. This helped to keep the buccal surface of the crown parallel to the chisel of the testing machine during debonding while measuring the shear bond strength.

Six commonly used light cure was evaluated in the study and was divided into six groups for which different colour coding were assigned. Each light cure's intensity was recorded was recorded using power curing tester (LM-1 LED light meter cure power curing tester) (figure 4).the power curing tester is a light compact design which is capable of measuring both LED and halogen curing light and is able to measure intensity up to 3500mw/cm2. The light source whose intensity is to be measured was placed over the detector window and the intensity is shown in the meter in mw/cm2.

The different light cures considered in the study with their colour coding and measured intensity are as follows (figure 5)

Group - 1: BLUEPHASE N given a colour coding of blue with a measured intensity of 1,200mw/cm2

Group – 2: BLUEPHASE NM given a colour coding of navy blue with a measured intensity of 800mw/cm2

Group – 3:3M ESPE Elipar^{TM}S10given a colour coding of red with a measured intensity of 1,200mw/cm2

Group – 4: 3MESPE Elipar^{TM} Deepcuregiven a colour coding of yellow with a measured intensity of 1,200 mw/cm2

Group – 5: WOODPECKER B PLUS CURE given a colour coding ofgreen with a measured intensity of 1,100mw/cm2

Group – 6: WOODPECKER I LEDgiven a colour coding of grey with a measured intensity of 1000mw/cm2.

The mounted samples were then randomly divided into six groups with 10 samples in each group. The samples were given stickers with colour coding of the respected group (figure 6).

Before placing the brackets the buccal surface of every sample were properly cleaned using rubber cup and pumice for 10 seconds and then washed thoroughly with water for another 10 seconds and dried using moisture-free compressed air. Buccal surface of each samples were then treated with 37% orthophosphoric acid gel (3M ESPE scotchbond^{TM} multi-purpose etchant)(figure 1) for 15 sec on the area marked for positioning the bracket followed by rinsing with water for 10 s and air dried until a characteristic chalky-white appearance. A thin coat of light-cured adhesive primer (3M Unitektransbond XT primer) (figure 1) was applied to etched enamel.An orthodontic composite resin (Transbond XTTM adhesive paste) (figure 1) was applied to the base of the metal bracket.

In this study, orthodontic premolar metal brackets (Gemini series, 3M Unitek) 0.022" slot were used (figure3). The average bracket surface area of the bracket base was determined to be 9.61 mm2,As provided by the manufacturer. The premolar bracket with the adhesive is firmly pressed on the buccal surface of teeth and the flash is removed from the edges of the bracket. All the brackets were placed by one single operator in order to avoid intraoperator error.

Group 1

The samples in group 1 was cured with bluephase N for 3sec at a distance of 2 mm from the buccal surface.

Group 2

Each sample in group 2 were cured with bluephase NM for 3 Secs at a distance of 2 mm from the buccal surface

Group – 3

Samples in group 3 were cured with3M ESPE Elipar^{TM}S10for 3 secs at a distance of 2 mm from the buccal surface

Group – 4

Each sample in group 4 were cured with 3MESPE Elipar^{TM} Deepcurefor 3 secs at a distance of 2 mm from the buccal surface

Group – 5

Samples in group 5 were WOODPECKER B PLUS CURE for 3 secat a distance of 2 mm from the buccal surface

Group – 6

Samples in group 6 were cured with WOODPECKER I LED used for about 3 sec at a distance of 2 mm from the buccal surface

After 24 hours, the specimens were subjected to testing for the shear bond strength. An Instron Universal Testing Machine (3M model number – 33R – 4467, UK) (figure 7)was used for the shear bond test at a crosshead speed of 1 mm/ min. The specimen was held tightly on the fixed lower part of the testing machine to restrict any movement while force is applied. Force was applied directly to the bracket– tooth interface using the flattened end of a steel rod.

The maximum load necessary to debond was recorded in N on A computer connected with the testing machine and then converted into MPa using the formula

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$$\text{SBS(MPa)} = \frac{\text{Peak load at failure(N)}}{\text{Specimen surface area mm2}}$$

Statistical analysis

Two-way ANOVA was used to verify intergroup differences of the data obtained. The results were evaluated within a 95% confidence interval and a p value of <0.05

Results

SBS values including mean and SD obtained for the six groups are obtained (table 1). The highest mean SBS was obtained for group 4 cured with 3MESPE Elipar^{TM} Deepcure (18.56 MPa) followed by group 3 cured with 3M ESPE Elipar^{TM}S10 (12.07MPa), group 2 cured using BLUEPHASE NM (7.93 MPa), group 1 cured with BLUEPHASE N (7.025 MPa), followed by group 5 cured with Woodpecker B Plus cure (4.66MPa) and least with group 6 cured using Woodpecker I LED (4.320 MPa) (graph 1).
ANOVA was used to compare the mean values of SBS obtained in each group. The test showed that the difference in the mean values of SBS was statistically significant (*p*=0.001) (table 2).

DISCUSSION

For the last many years in orthodontics, the changes have been dramatic: from brackets welded to fixed metal bands to clear removable plastic aligners moving the teeth. Such progress also has been seen in the bonding of orthodontic attachments: from messy, slow-setting, weak powder and liquid adhesives bonding large brackets to enamel, to single-paste, quick-setting adhesives that adhere to both enamel and nonenamel surfaces and also from conventional halogen lights to light emitting diodes (LED) curing lights offering reduced curing time and the potential for lower attachment failure rates have emerged(3).Dr George Newman, an orthodontist in Orange, New Jersey, and Professor Fujio Miura, chair of the Department of Orthodontics at Tokyo Medical and Dental University in Japan, pioneered the bonding of orthodontic brackets to enamel(1). In the early 1970s, Miura(6)developed a technique for bonding polycarbonate plastic brackets to phosphoric acid etched enamel using a restorative filling material developed by Masuhura et al,also at Tokyo Medicaland Dental University. The adhesive, Orthomite (Rocky Mountain Orthodontics, Denver, Colo), consisted of methyl methacrylate and polymethyl methacrylate with tri-n-butylborane as the catalyst.(1) In recent years, alternatives to halogen lights, including light emitting diodes (LEDs)and plasma lights,have been developed. LEDs incorporate 2 connected solid semiconductors, with an electric charge supplied from a battery. Energy is released almost exclusively as light energy, generating minimal heat. LEDs have longevity superior to that of halogen systems, little attenuation in intensity over time, and high emission intensity of up to 2300 mW(3). Now a days a lot of companies have been manufacturing light curing units and available in market at different cost, some of which are not even satisfying the required criterias.in this study we have compared the efficiency of six different commercially available light curing device with different intensity that affect the depth of curing using shear bond strength.

Human extracted teeth were used for the study which was stored in Distilled water with 0.1% (weight/volume) Thymol. Distilled water helped in maintaining the hydration of the teeth at the same time did not have any effect on the bonding and debonding procedures. Further the thymol solution helps in preventing the bacterial growth on the teeth(7). A standardised procedure for bonding the brackets onto the teeth of all groups by the same person were followed so that the materials used or the method used for bonding did not affect the shear bond strength. All the samples were etched after cleaning the surface using 37% phosphioric acid 3M ESPE scotchbond™ multi-purpose etchant for 15 sec which the recommended time for etching which was followed by The Transbond XT primer which is regarded as one of the standard adhesive systems in orthodontics. Transbond XT primer with a conventional acid etching technique can still be regarded as the gold standard for bonding brackets on enamel(8). The adhesive used is Transbond XT TM adhesive paste applied to the bracket base and pressed against the buccal surface with equal pressure and the flash was removed. Transbond XT mostly contains silane-treated quartz particles, with smaller amounts of bisphenol, a diglycidyl ether dimethacrylate (bisGMA) and bisphenol-A bis (2-hydroxyethyl ether) dimethacrylate(9).Curing of each samples were done with the light cure assigned to each group and a specific colour sticker were given to samples of each group so that the samples did not get mixed and was easy to identify the samples of each group.

Six different light cure which was easily available were studied and compared with each other in the study which includes BLUEPHASE N for group 1 ,BLUEPHASE NM ,3M ESPE Elipar™S10, 3MESPE Elipar™ Deepcure, WOODPECKER B PLUS CURE, WOODPECKER I LED for group 2,3,4,5,6 respectively. Intensity of each light cure was measured using the power curing tester for the respected time used for curing. High-intensity curing units provide the advantage of faster polymerization, according to Ilie et al.curing with high-intensity units induces high polymerization stresses which weaken the bond to tooth structure(10). With low-intensity curing, there is a decrease in the number of free radicals released and this increases the viscosity by extending the pre-gel state, allowing time for the material to undergo some flow before the polymer network reaches the gel stage, and thereby reducing the stress buildup at the tooth–bonding agent interface. Higher-intensity curing units have also been reported to cause pulpal injury,(11)which was found to be less with LED curing units as compared to the halogen curing units. The light tip was held at a distance of 2 mm from the bracket and was standardized using a measurement device. Lindberg et aland Cacciafesta et al. suggested that 0 mm distance of the light tip from the bonding surface produced the highest light intensity, which produced maximum rise in pulpal temperature, and at 0–3 mm distance there was insignificant rise in pulpal temperature.(12)

In vitro bond strength testing comprise shear, tensile and torsion tests. As failure of the bracket-tooth adhesion is assumed not to be a result of pure tensile and torsional stress, these tests are less often performed, while shear testing is most popular (13) and are a recognized in vitro testing procedure for measuring adhesive force. To allow better comparison of the results obtained, they are converted from N/mm2 into MPa(14). There are numerous testing parameters that can influence in vitro adhesiveness values—such as the type of adhesive used, the material properties of the bracket base, the way in which the test pieces are stored, the diameter of the adhesive gap, the shearing velocity of the test machine, the type and duration of light curing, and the dental or prosthetic material used(8). With theexception of the light cure units used, all of the other parameters were standardized in the study.

In the present study where the efficiency of six different light cure is compared, the shear bond strength values of samples were compared statistically using ANOVA. ANOVA test shows the results obtained is highly significant statistically.

Shear bond strength shown by samples in group 4 which was cured with 3MESPE Elipar™ Deepcure (18.5MPa) was higher than other groups compared in the study with the least shear bond strength shown by sample in group 6 cured with WOODPECKER I LED (5.32MPa).

Samples in group 3 cured using 3M ESPE Elipar™S10 showed the second best SBS in the present study(12.07MPa) followed by group 2 samples cured using BLUEPHASE NM (7.93MPa). Sample in group 1 cured using BLUEPHASE N showed the next best SBS which was followed by samples in group 5 cured with WOODPECKER B PLUS CURE (5.66MPa).

Mean shear bond strength of each group is compared with every other group included in the study (table3). In This comparison show that mean difference between group 1 and group 2 is not a statistically significant. Also the mean difference between group 5 and group 6 is not statistically significant. Comparison of group 3 and group 4 with all other groups shows a statistically significant difference in mean SBS.

Limitations

The study is an invitro study, in lab assessment of the SBS cannot be compared with clinical performance fully. As oral conditions which has an effect on the bonding strength, the complexity of the interactions involved(15) and the forces like masticatory and occlusal stress seen in clinical situations could not be simulate in the laboratory, the results obtained should be interpreted with caution in the clinical practice and further clinical studies are necessary for validation. Also evaluating bond strength is a sensitive experimental procedure and the same bonding materials can yield different results due to variations in experimental conditions.(10)

CONCLUSION

A comparative evaluation of the shear bond strength was undertaken with six different light curing units cured for a particular sec for each light cure and standardizing all other parameters gives the following conclusion:

1. All the curing lights considered in the study showed a clinically acceptable shear bond strength.
2. 3MESPE Elipar^{TM} Deepcure cured for 3 sec shows a higher shear bond strength than all other groups compared in the study followed by 3M ESPE Elipar^{TM}S10.
3. There was no significant difference shown in the bond strength of bonding done using BLUEPHASE N and BLUEPHASE NM and between woodpecker B plus cure and woodpecker I LED

Descriptives

shearbondstrength

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
BluephaseN	10	7.0250	.63912	.20211	6.5678	7.4822	5.80	8.00
BluephaseNM	10	7.9310	.52376	.16563	7.5563	8.3057	6.80	8.50
3MESPEELIPARS10	10	12.0770	.83477	.26398	11.4798	12.6742	10.50	12.80
3MESPEELIPARDEEPCURE	10	18.5660	1.44569	.45717	17.5318	19.6002	16.52	20.68
WoodpeckerBPlus cure	10	5.6690	.56357	.17822	4.2658	6.9722	3.50	6.50

Woodpecker I LED	10	5.3200	.45105	.14263	3.9973	5.6427	3.50	6.20
Total	60	9.0980	5.04578	.65141	7.7945	10.4015	3.50	20.68

table 1: SBS values including mean and SD obtained for the six groups

ANOVA

shearbondstrength

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1466.220	5	293.244	440.889	.000 HS
Within Groups	35.916	54	.665		
Total	1502.137	59			

table 2: ANOVA test result showing high statistically significant difference

Multiple Comparisons

Dependent Variable: shearbondstrength
Bonferroni

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
BluephaseN	BluephaseNM	-.90600	.36472	.242	-2.0262	.2142
	3MESPEELIPARS10	-5.05200(*)	.36472	.000	-6.1722	-3.9318
	3MESPEELIPARDEEPCURE	-11.54100(*)	.36472	.000	-12.6612	-10.4208
	WoodpeckerBPlus cure	2.35600(*)	.36472	.000	1.2358	3.4762
	Woodpecker I LED	2.70500(*)	.36472	.000	1.5848	3.8252
BluephaseNM	BluephaseN	.90600	.36472	.242	-.2142	2.0262
	3MESPEELIPARS10	-4.14600(*)	.36472	.000	-5.2662	-3.0258
	3MESPEELIPARDEEPCURE	-10.63500(*)	.36472	.000	-11.7552	-9.5148
	WoodpeckerBPlus cure	3.26200(*)	.36472	.000	2.1418	4.3822
	Woodpecker I LED	3.61100(*)	.36472	.000	2.4908	4.7312
3MESPEELIPARS10	BluephaseN	5.05200(*)	.36472	.000	3.9318	6.1722
	BluephaseNM	4.14600(*)	.36472	.000	3.0258	5.2662
	3MESPEELIPARDEEPCURE	-6.48900(*)	.36472	.000	-7.6092	-5.3688

	WoodpeckerBPlus cure	7.40800(*)	.36472	.000	6.2878	8.5282
	Woodpecker I LED	7.75700(*)	.36472	.000	6.6368	8.8772
3MESPEELIPARDEE PCURE	BluephaseN	11.54100(*)	.36472	.000	10.4208	12.6612
	BluephaseNM	10.63500(*)	.36472	.000	9.5148	11.7552
	3MESPEELIPARS10	6.48900(*)	.36472	.000	5.3688	7.6092
	WoodpeckerBPlus cure	13.89700(*)	.36472	.000	12.7768	15.0172
	Woodpecker I LED	14.24600(*)	.36472	.000	13.1258	15.3662
WoodpeckerBPlus cure	BluephaseN	-2.35600(*)	.36472	.000	-3.4762	-1.2358
	BluephaseNM	-3.26200(*)	.36472	.000	-4.3822	-2.1418
	3MESPEELIPARS10	-7.40800(*)	.36472	.000	-8.5282	-6.2878
	3MESPEELIPARDEE PCURE	-13.89700(*)	.36472	.000	-15.0172	-12.7768
	Woodpecker I LED	.34900	.36472	1.000	-.7712	1.4692
Woodpecker I LED	BluephaseN	-2.70500(*)	.36472	.000	-3.8252	-1.5848
	BluephaseNM	-3.61100(*)	.36472	.000	-4.7312	-2.4908
	3MESPEELIPARS10	-7.75700(*)	.36472	.000	-8.8772	-6.6368
	3MESPEELIPARDEE PCURE	-14.24600(*)	.36472	.000	-15.3662	-13.1258
	WoodpeckerBPlus cure	-.34900	.36472	1.000	-1.4692	.7712

* The mean difference is significant at the .05 level.

Table 3:Mean shear bond strength of each group is compared with every other group

figure 1: **Transbond XT primer, Transbond MIP primer and Transbond adhesive and Etchant [3M, Unitek]**

Figure 2:Aluminium jig

An aluminium-mounting jig of 150mm x 150mm was selected and Tooth was embedded in the jig .

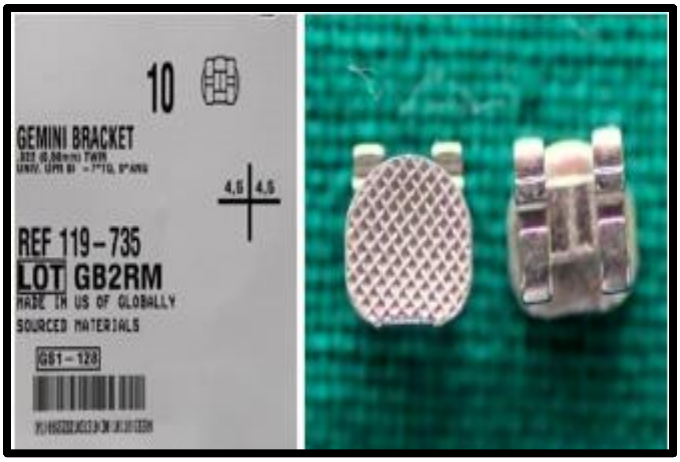


Figure 3: Orthodontic metal upper premolar brackets: 0.022 x 0.028 slot (Gemini series, 3M Unitek) with base surface area of 9.61 mm2

Figure 4: LM-1 LED light meter cure power curing tester

GROUPS	**CATEGORY**	**COLOR CODE**
GROUP 1	**BLUEPHASE N**	**BLUE**
GROUP 2	**BLUEPHASE NM**	**NAVY BLUE**
GROUP 3	**3M ESPE Elipar™S10**	**RED**
GROUP 4	**3MESPE Elipar™ Deepcure + S**	**YELLOW**
GROUP 5	**WOODPECKER B PLUS CURE**	**GREEN**
GROUP 6	**WOODPECKER I CURE**	**GREY**

Figure 5: groups with their colour coding and respective light cures used

Figure 6: samples in each group with their colour coding

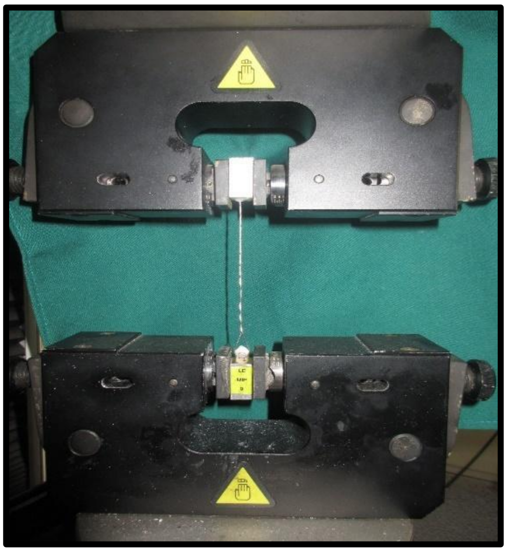
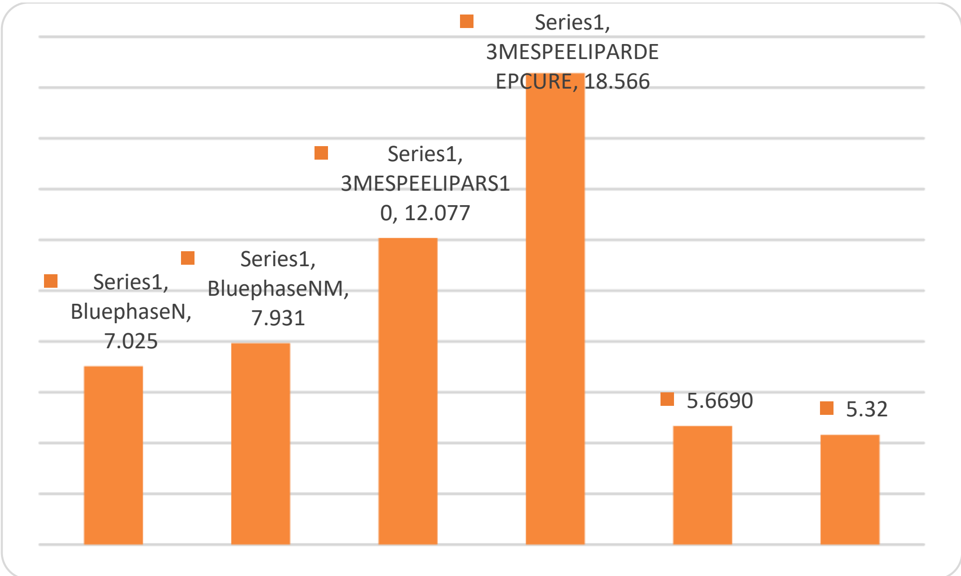


Figure 7: :Instron universal testing machine



Graph 1: SBS mean values ploted on a graph for the six groups

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