COMPARATIVE STUDY OF SHEAR BOND STRENGTH AND SURFACE CHANGES WITH LABIAL AND LINGUAL BRACKETS-IN VITRO STUDY.

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In partial fulfilment for the degree of

MASTER OF DENTAL SURGERY

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DEPARTMENT OF ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

2017 – 2020

CERTIFICATE

This is to certify that the Dissertation entitled "**COMPARATIVE STUDY OF SHEAR BOND STRENGTH AND SURFACE CHANGES WITH LABIAL AND LINGUAL BRACKETS-IN VITRO STUDY"** by **Dr. A.SARANYA** Post Graduate student **MDS Orthodontics and Dentofacial Orthopaedics**, Madha Dental College & Hospital-Chennai - 69. Submitted to Tamilnadu Dr. M.G.R. Medical University the MDS Degree Examination April 2020 is bonafide research work carried out by her under my supervision and guidance.

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ENDORSEMENT BY HEAD OF THE DEPARTMENT /HEAD OF THE INSTITUTION

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DECLARATION OF THE CANDIDATE

I, **Dr. A. SARANYA** hereby declare that this dissertation titled "**COMPARATIVE STUDY OF SHEAR BOND STRENGTH AND SURFACE CHANGES WITH LABIAL AND LINGUAL BRACKETS -AN IN VITRO STUDY** " is a bonafide and genuine research work carried out by me under the guidance of **Dr.M.C.SAINATH MDS, MBA, PGDCR.,** Professor and HOD, Department of Orthodontics and Dentofacial Orthopaedics, Madha Dental College and Hospital, Chennai -600069.

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PLAGIARISM CERTIFICATE

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1.

2.

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ABSTRACT

AIM:

To evaluate and compare the shear bond strength of bonded labial and lingual stainless steel maxillary and mandibular brackets and to assess the surface changes in enamel using Profilometry.

MATERIALS AND METHODS:

40 extracted premolar teeth were selected for this study. These teeth were divided into 4 groups as 10 in each group. Group A- Labial maxillary premolar brackets; Group B-Labial mandibular premolar brackets; Group C- Lingual maxillary premolar brackets; Group D-Lingual mandibular premolar brackets. Freshly extracted teeth were cleaned to remove blood or any tissue debris and stored in distilled water solution till the time of bonding procedure. Teeth were then mounted on self-cured, color-coded acrylic blocks of dimensions 35 x 7 x 7mm. The acrylic blocks are color-coded to differentiate between the groups.

The enamel was etched with 37% phosphoric acid gel for 30 seconds, rinsed under running water for 20 seconds, and then dried with oil and moisture-free compressed air for 20 seconds. ORMCO primer was applied to the etched surface and the bracket base as well with the help of an applicator brush. ORMCO adhesive material was next applied to the bracket base directly from the syringe. The adhesive/bracket was cured using an LED (Light-emitting diode) curing

unit. The above procedure was done for all samples in Group-I to Group-IV by the same individual under the same environment.

Debonding was carried out with a universal testing machine (INSTRON, 8874). The samples were then stressed at a crosshead speed of 1mm per minute in a gingival incisal direction, and the maximum force at bond failure was recorded. Adhesive remnant index score was recorded using stereomicroscope.

The samples were then loaded on to optical profilometry to assess the surface roughness. With this, a 3-dimensional image is captured to identify the surface roughness in terms of extent (Sa) and depth (Sz)of enamel wear.

The following statistical analysis was done to evaluate the results using the software "statistical package for social sciences" SPSS (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY: IBM Corp. Released 2017). The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests were done.

RESULTS:

The results reveal that there is statistical significance seen in the mean shear bond strength value of labial brackets is 1.55mpa(±1.146) and lingual brackets are 2.80mpa(±1.542). The p-value is 0.010. There is statistically significant difference between the labial and lingual groups with regard to adhesive remnant score - p value is 0.002. There is statistically significant difference between the upper and lower groups also - p value is 0.044. The result for surface changes shows the mean value of labial brackets is 39.12 (±14.204)and lingual brackets are 72.67(±55.631). There is a statistically significant difference in Sa value between Labial brackets and lingual brackets (p-value is 0.006). The result for surface changes shows the mean value of labial brackets is 190.02 (±95.060) and lingual brackets are 407.68(±311.157). The p-value is 0.001 which reveals that it is statistically significant.

CONCLUSION:

In conclusion, this study shows that the shear bond strength for lingual stainless steel brackets is higher than labial stainless steel brackets and between groups, the labial upper stainless steel brackets have more shear bond strength than labial lower stainless steel brackets. Lingual lower stainless steel brackets have more shear bond strength than lingual upper stainless steel brackets. The adhesive remnant index reported that the failure zone was between the bracket adhesive interface. The surface changes show that the lingual stainless steel brackets show more damage to the enamel. Labial upper stainless steel brackets have more damage to enamel than the labial lower stainless steel brackets and lingual lower stainless steel brackets show more damage to the enamel than the lingual upper stainless steel brackets.

KEYWORDS : Shear bond strength, Instron, Profilometry

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INTRODUCTION

"Beauty is a greater recommendation than any letter of introduction", Aristotle, a famous Greek philosopher, said. Undeviating, beauty has a great influence on human feelings and judgments. Therefore, man has had a long sought to improve his appearance, including the beauty of smile and teeth, one of the first things someone will notice about others. Orthodontic treatment appears as a way to help achieve harmony and balance of the face, consequently bringing people more confidence in communication.

Recently, with the improvement in awareness related to oral health and developments of equipment, methods, and techniques in orthodontics, the new field of adult orthodontics has opened, aside from orthodontic therapy was for children and young adults. However, the adult patients, as well as any orthodontic patients who give importance to their appearance and for social or work reasons both, have higher demands for aesthetic results, especially during the treatment phase. Therefore, they would probably refuse visible orthodontic treatment therapy. For these cases, there is a growing request for esthetic orthodontic appliances. By the effect of this demand, most of the companies produced many new esthetic appliances. From the limited options of fixed appliances made from metallic materials, which is easily visible and less esthetic, nowadays, orthodontics has greatly developed regarding esthetics. Orthodontic brackets are becoming smaller and more diverse.

Moreover, esthetic appliances have been designed and broadly applied as an alternative for patients that are unwilling to use metallic appliances. Lingual orthodontics, clear plastic aligners (Invisalign) and esthetic braces, including esthetic brackets and esthetic archwires, are becoming the promising esthetic appliances of modern orthodontics.

Bonding is the mechanical locking of an adhesive to the irregularities in the enamel surface of the tooth and mechanical locks formed in the base of the orthodontic attachment. Surface bonding depends upon tooth surface and its preparation, a technique of bonding and bonding material. There are different types of resins available for orthodontic bonding – Acrylic resin and Diacrylate resins. Depending upon the curing types it is divided as Self cure composite and light cure composites. With the advent of newer techniques, new bonding materials and bonding techniques have also emerged. In spite of this bonding, failures have been reported during orthodontic treatment which is multifactorial. One of the main factors for bond failure is the application of force and strength of bonding material. There are different types of forces like tensile, compressive, shear.

Shear bond strength (SBS) is the main factor, concerned with the evolution of bonding materials. The sufficient bracket bond strength is essential for orthodontic treatment, which means that bonded brackets have to withstand the forces of occlusion during the treatment, mastication, and archwire stress while allowing for biomechanical control. The bracket bond must resist these multiple forces in the complex oral environment, within the moisture and the rapid temperature and pH changes. The poor bond strength and repeated bond failures result in increased treatment time and cost for the orthodontist and the patient. Hence in this study shear bond strength of the bonding material is analyzed with two brackets systems in two different areas of the tooth.

Failure in the bonding of the brackets is a hindering aspect in orthodontic treatment because it is inconvenient to the patient and the orthodontist. Some factors affecting bond strength are the improper procedure, moisture control, type of adhesive use, curing time, location and type of bracket, etc. Assessment and comparison of the frequency of bond failure in teeth treated with either lingual or buccal appliances are very important because it may influence treatment duration and costs. The shear bond strength of the orthodontic bracket must be able to withstand the forces applied during the orthodontic treatment. In this study shear bond strength is evaluated using a universal testing machine.

Enamel is the hardest substance in the human body and contains the highest percentage of minerals, 96% and 4% of water and organic material composing the rest. The primary mineral is hydroxyapatite, which is crystalline calcium phosphate. Remineralization of teeth can repair damage to the tooth to a certain degree but damage beyond that cannot be repaired by the body. The maintenance and repair of human tooth enamel are one of the primary concerns of dentistry.

The translucency of the enamel varies in color from light yellow to grey-white, it also varies in thickness over the surface of the tooth, often thickest at the cusp, up to 2.5 mm, and thinnest at its border with the cementum at the cementoenamel junction (CEJ).

Since enamel is semitranslucent, the color of dentin and any material underneath the enamel strongly affects the appearance of a tooth. A large amount of mineral in enamel accounts not only for its strength but also for its brittleness.

The surface is constituted of the form (profile), waviness and roughness. The form is the overall shape of a surface and is commonly quantified as vertical loss of step height. Waviness is the medium wavelength band within a surface, whereas three-dimensional areal surface roughness measurements give an indication of the nature of a surface and are deviations within the form. There are different ways to quantify surface roughness, with amplitude parameters being one such method. Amplitude parameters quantify the height deviations of measured surface, two-dimensional parameters are calculated from a single profile but may not be truly representative of complex surfaces such as teeth. In comparison, three dimensional parameters are calculated from the overall surface measured and provide a robust and more balanced description of the surface. This permits stable results to be obtained.

Surface changes of enamel can be assessed using various methods like Stereomicroscope, Transmission Electron Microscope, and Scanning Electron Microscope. In this study, Profilometry is used to evaluate the surface roughness of the enamel in a 3dimensional image. Profilometry is a technique used to extract topographical data from a surface. This can be a single point, a line scan or even a full three-dimensional scan. The purpose of profilometry is to get surface morphology, step heights and surface roughness. This can be done using a physical probe or by using light.

Optical profilometers scan surfaces with optical probes that send light interference signals back to the profilometer detector via an optical fiber. Fiber-based probes can be physically located hundreds of meters away from the detector enclosure, without signal degradation. The additional advantages of using fiber-based optical profilometers are flexibility, long profile acquisition, ruggedness. With the small diameter of certain probes, surfaces can be scanned even inside hard-to-reach spaces, such as narrow crevices or small-diameter tubes. Because these probes generally acquire one point at a time and at high sample speeds, acquisition of long (continuous) surface profiles is possible. Scanning can take place in hostile environments, including very hot or cryogenic temperatures, or in radioactive chambers, while the detector is located at a distance, in a human-safe environment. Fiber-based probes are easily installed in-process, such as above moving webs or mounted onto a variety of positioning systems.

The purpose of this in vitro study is "TO EVALUATE THE SHEAR BOND STRENGTH OF BONDED LABIAL AND LINGUAL STAINLESS STEEL BRACKETS AND ASSESS THE SURFACE CHANGES IN ENAMEL USING PROFILOMETRY".

AIMS & OBJECTIVES

- To evaluate and compare the shear bond strength of bonded labial and lingual stainless steel maxillary and mandibular brackets.
- To evaluate the Adhesive Remnant Index.
- To assess the surface changes in enamel using Profilometry.

OBJECTIVES:

To compare shear bond strength, adhesive remnant index and surface changes between groups:

- Labial premolar stainless steel brackets versus Lingual premolar stainless steel brackets.
- Labial premolar stainless steel upper brackets versus Labial premolar stainless steel lower brackets.
- Lingual premolar stainless steel upper brackets versus Lingual premolar stainless steel lower brackets.
- Labial premolar stainless steel upper brackets versus Lingual premolar stainless steel upper brackets.
- Labial premolar stainless steel lower brackets versus Lingual premolar stainless steel lower brackets.

REVIEW OF LITERATURE

The review of the literature of our study consist of the evaluation of shear bond strength, adhesive remnant index and surface roughness using profilometry. Hence the review of the literature was analyzed under the following headings.

1. Review of shear bond strength of labial and lingual brackets.
2. Review of adhesive remnant index.
3. Review of surface roughness on enamel.

Review of shear bond strength of labial and lingual brackets:

- **M. Knoll et al [1] (1986)** conducted a study to determine the maximum shear strength of brackets bonded to anterior and posterior teeth. Micro Lok Edgewise metal orthodontic brackets were bonded to two groups comprising 12 incisor and 12 molar teeth. The teeth were cleaned with a watery slurry of flour of pumice, rinsed, and dried. A 37% phosphoric acid solution was applied for 60 seconds with gentle agitation. The teeth were then rinsed for 15 seconds and thoroughly air-dried. Mixed according to the manufacturer's recommendations, a bonding layer was applied to each tooth with a small brush. Composite resin was then applied to each bracket, pressing the resin into its undercuts. After storage in the water at 37 ° C for 10 days, each bracket was tested to failure in a shear mode in an Instron machine. These values, analyzed in a two-tailed test, were statistically different at the 0.01 level of confidence. They concluded that differences in etching patterns do not necessarily affect shear bond strength and that the predominantly weak link in the bonding chain was at the bracket/resin interface. The clinical incidence of orthodontic bracket bond failure is higher for posterior teeth. Various reasons have been postulated as causes for this difference including (1) the existence of greater masticatory forces in the posterior region of the mouth, (2) the different etching patterns produced on different teeth by acid conditioning, and (3) the increased difficulty in maintaining a dry field posteriorly. Orthodontic brackets were shown in vitro to have higher bond strengths when bonded to anterior teeth. This is in agreement with the clinical observation that brackets bonded to posterior teeth fail with greater frequency.

- **Wei Nan Wang et al [2] (1993)** conducted a study to compare the bond strength and the failure interfaces on lingual and buccal surfaces of young human premolars. Premolar buccal metal brackets were adapted and bonded on the lingual or buccal surfaces of crowns after etching with a 37% phosphoric acid solution for 15 seconds. Orthodontic composite resin was also applied to the bracket base. The bond strengths were 7.2 MPa and 7.0 MPa for lingual and buccal surfaces, respectively. The bond failure interfaces were located between the bracket and the resin, within the resin itself, or between the resin and the enamel. Tooth fragmentation was not found. There were no statistically significant differences. This indicates that it is not necessary to specially treat a lingual surface for increasing the bond strength. The bond strength and broken interfaces of a lingual surface were equal to the bond strength and broken interfaces of a buccal surface on young premolars. Therefore, it is not necessary to specially pretreat a lingual surface for increasing the bond strength.

- **Samir E. Bishara et al [3] (2001) conducted a** study to determine the effects of the use of a self-etch primer on the shear bond strength of orthodontic brackets and the bracket/adhesive failure mode. Brackets were bonded to extracted human teeth according to 1 of 2 protocols. In the control group, teeth were etched with 37% phosphoric acid. After the sealant was applied, the brackets were bonded with Transbond XT and light-cured for 20 seconds. In the experimental group, a self-etch acidic primer was placed on the enamel for 15 seconds and gently evaporated with air, as suggested by the manufacturer. The brackets were then bonded with Transbond XT as in the first group. The present in vitro findings indicate that the use of a self-etch primer to bond orthodontic brackets to the enamel surface resulted in a significantly lower, but clinically acceptable, shear bond force as compared with the control group. The comparison of the adhesive remnant index scores indicated that there was significantly more residual adhesive remaining on the teeth that were treated with the new self-etch primer than on those teeth that were bonded with the use of the conventional adhesive system. By reducing the number of steps during bonding, clinicians can save time and reduce the potential for error and contamination during the bonding procedure. The results were that a newly introduced self-etch primer, which contains both the enamel etchant and primer, has the potential to successfully bond orthodontic bracket.

- **Olivier Sorel et al [4] (2002)** study was to evaluate the bond strength of a new metallic orthodontic bracket with a laser structured base, and its effects on the site of the bond failure and the behavior of the enamel after debonding. One hundred and twenty recently extracted human premolars were bonded with 1 of 2 types of mechanical interlock base metal brackets: a standard system with a simple foil mesh pad and the Discovery bracket. A resin-based, chemically activated bonding system, No-mix was used as the adhesive system in this trial. A testing machine was used to evaluate tensile and fatigue bond strengths for both brackets. After debonding, the amount of residual adhesive on the bracket and enamel detachment was assessed according to the adhesive remnant index (ARI) and the enamel detachment index (EDI) with a scanning electron microscope and an energy dispersive X-ray spectrometer. The scores obtained from the ARI and the EDI showed that the laser structured base brackets had a significantly higher bond strength that was 2 times higher than that observed with the simple foil mesh. From the results obtained in study, concluded that: (1) the laser structured base brackets have a bond strength twice that of the simple foil mesh brackets (2) bond failure is located at the enamel-adhesive interface with the laser structured base, with an ARI score of 3 obtained in 80% of the specimens; (3) bond failure is located at the bracket-adhesive interface with the simple foil mesh base, with an ARI score of 0 obtained in 75% of the specimens; and (4) a small area of enamel detachment (less than 10%—EDI score of 1) with a depth of less than 1.5 mm was observed for both the simple foil mesh and the laser sculpted base.

- **Bishara SE, Ajlouni R et al [5] (2002)** assessed the effects of a fluoride-releasing primer compared to that of self-etching primer on the SBS of orthodontic brackets and concluded that the mean SBS of the fluoride-releasing primer and the self-etching primer was significantly lower than that achieved using the conventional acid-etch technique
- **Jason C. Dorminey et al [6] (2003)** conducted a study to compare the shear bond strength of orthodontic brackets bonded to enamel with a conventional, multistep adhesive system and a self-etching primer adhesive system. Also, a third group was included in which the air dispersion step in the self-etching primer system was omitted. Brackets were bonded to 108 extracted human molars according to 1 of 3 experimental

protocols—group 1: conventional multistep adhesive, group 2: self-etching primer system; group 3: self-etching primer system without air dispersion. Specimens were loaded to failure in a universal testing machine. Mean shear bond strengths in megapascals. However, there was no difference in mean shear bond strength between the conventional, multistep adhesive system and the self-etching primer system when the primer was dispersed correctly. Under the conditions of this study, there was no difference in the shear bond strength of orthodontic brackets bonded to teeth with a self-etching primer or a conventional, multistep bonding procedure. However, a significant decrease in shear bond strength was discovered when the self-etching primer solution was not air-thinned according to the manufacturer's directions. The omission of this step resulted in statistically lower shear bond strengths than in the other 2 groups.

- **Arndt Klocke et al [7] (2003)** evaluated bond strength for a custom base indirect bonding technique using a hydrophilic primer on moisture-contaminated tooth surfaces and concluded that the bond strength for the custom base indirect bonding technique with the hydrophilic primer was not significantly different in groups without contamination and with water or saliva contamination before application of the primer. Whereas, moisture contamination after application of the hydrophilic primer resulted in significantly lower bond strength measurements compared with bond strength for uncontaminated enamel.

- **Helen S. I. Grubisa et al [8] (2004)** conducted an in vitro study to evaluate the shear bond strengths and interoperator variability of self-etching primer, as compared with conventional phosphoric acid etching with 2 common orthodontic resins. Total of 214 teeth was bonded, according to the following protocols: group A: self-etching primer plus Transbond XT light-cured resin, group B: 35% phosphoric acid (15 seconds) plus Transbond XT resin; and group C: 37% phosphoric acid (15 seconds) plus Enlight bonding. Significantly higher bond strengths were seen in group B than in group A and group C. The mean shear bond strengths of group A were not significantly different from those of group C. When 3 orthodontists bonded a total of 60 premolars using the protocols of groups A and B, significant differences in shear bond strengths and strength ranking were found. The mean values they obtained using the self-etching primer were not significantly different, but significant differences in mean values were found between operators when the phosphoric acid-etching technique was used.
- **M Dolores Campoy et al[9] (2005)** did an in-vitro study to evaluate the effect of saliva contamination on the shear bond strength at different stages of the bonding brackets using Adper Prompt L-Pop (self-etching primer) and Transbond XT (resin orthodontic adhesive system). Seventy premolars were bonded

with brackets and were divided into four groups: group 1, uncontaminated control; group 2, saliva application before priming; group 3, saliva application after priming and group 4, saliva application before and after priming. Shear bond strength was measured with a universal testing machine. The results showed that there were significant differences observed between group 1 and group 2 and group 4. The shear bond strength of brackets contaminated before priming showed a significant difference from the control group.

- **Neslihan Eminkahyagil et al [10] (2005)** did an in-vitro study comparing the shear bond strength of a self etch primer adhesive and an antibacterial self etches primer adhesive for orthodontic metal brackets. They assigned twenty-four premolars into two equal groups. In group 1- Transbond Plus self-etching primer was used and in group 2- the antibacterial dentin bonding system was used. The results showed that the difference between the groups was not statistically significant. ARI score showed that the predominant mode of bracket failure for both groups was the bracket adhesive interface leaving less than 25% of the adhesive on the bracket base.
- **Raed Ajlouni et al [11] (2005**) compared the use of new self-etching primer/adhesive effects on shear bond strength of orthodontic metal brackets bonded to surface. Forty-five maxillary central incisor teeth were divided into 3 group - group 1(control), here porcelain teeth were bonded using 37%

phosphoric acid, a sealant, and composite adhesive. In group 2, micro leaching of porcelain teeth, use of hydrofluoric acid and silane coupling agent and composite agent and composite adhesive was used. In group III, the porcelain teeth were etched using phosphoric acid and a new self-etching primer/adhesive was applied before bonding. The results showed low shear bond strength in group I and II, group III showed no significant difference in shear bond strength. SEM study showed micro etching, the use of hydrofluoric acid produced the greatest damage to porcelain surface when compared with the new self etch / silane /adhesive combination.

- **Julio Pedra e Cal - Neto et al [12] (2006)** evaluated the influence of a new self-etching primer on bracket shear bond strength. Forty extracted human premolar were divided into two groups of 20 each. Group 1 (control), Phosphoric acid + Transbond XT primer and adhesive (3MUnitek) and group 2, Adper Prompt L Pop - self-etching primer, Transbond XT adhesive paste was used and cured with Ortholux XT(3M Unitek) visible light-curing unit. The Instron universal testing machine was used to calculate the shear bond test. The results showed no significant difference in the bond strengths of the two groups evaluated. The ARI was less for the new self-etching primer as the amount of adhesive on the enamel after debonding was significantly less than when using the phosphoric acid.

- **Manar K.A. Hajrassie et al [13] (2007)** conducted the study to measure and compare in-vivo and in-vitro bond strengths of orthodontic brackets bonded to human enamel and debonded at various times. An in-vivo debonding device was validated and used to measure bond strengths in the oral environment. For the in-vitro study, mini-twin metallic premolar brackets precoated with Transbond XT composite resin were bonded to 60 extracted premolars. The teeth were divided into 4 groups of 15, and shear bond strength was tested on a universal testing machine at 4 time periods: 10 minutes, 24 hours, 1 week, and 4 weeks. For the in-vivo test, 60 premolars in 22 volunteers from King Saud University were bonded with Mini-Twin metallic premolar brackets and divided into 4 groups; bond strengths were measured at 10 minutes, 24 hours, 1 week, and 4 weeks. Statistical analysis showed no significant differences among the in-vitro or the in-vivo groups. Two-way ANOVA was used to compare the in-vitro results with the in-vivo results; the in-vivo group had significantly lower mean bond strength values. Also, survival analysis used to calculate the probability of bond failure, confirmed the significant difference between in-vitro and in-vivo environments. Reported bond strength values are not time-dependent.
- **Nir Shpack et at [14] (2007)** conducted a study to examine the ultimate accuracy of bracket placement in labial vs. lingual systems and indirect vs. indirect bonding techniques. Forty pre-

treatment dental casts of 20 subjects were selected. For each dental cast, four types of bracket placement were compared: labial direct (LBD), labial indirect (LbI), lingual direct (LCD), and lingual indirect (LGI). Direct bonding was performed with the casts held in a mannequin head. Labial brackets were oriented with a Boone gauge, and lingual brackets were oriented with the Lingual-Bracket-Jig System. Torque error (TqE) and rotation deviation (RotD) were measured with a torque geometric triangle and a toolmaker's microscope, respectively. Labial and lingual systems have the same level of inaccuracy The indirect bonding technique was significantly (twofold) more accurate than the direct technique for all teeth in both labial and lingual orthodontics. This is valid for both TqE and RotD. In both TqE and RotD, no statistical difference was found between the labial and lingual systems for each direct and indirect technique. This suggests that the LBJ is a reliable method for lingual bracket placement. The distal off-center RotD in the mandible is most likely caused by the Ponzo visualization illusion.

- **Tancan Uysal et al [15] (2009)** conducted an *in vitro* study to evaluate the shear bond strength (SBS) of different metallic and ceramic bracket bonding combinations using self-etching primers (SEPs). Eighty freshly extracted human premolar teeth were randomly divided into four equal groups for bonding with ceramic or metallic brackets as follows: group 1, metallic brackets bonded with conventional acid etching; group 2, metallic brackets bonded with Transbond Plus Self-Etching primer; group 3, ceramic brackets bonded as per group 1; group 4, ceramic brackets bonded as per group 2. The SBS of these brackets was measured and recorded in megapascals (MPa). The adhesive remnant index (ARI) scores were determined after bracket failure. The bond strength of group 3 was significantly higher than group 4, group 1 and group 2. No significant differences in debond locations were found among the groups. Bearing in mind the shortcomings of an *in vitro* setting, the results of this laboratory study showed: 1. The use of SEPs for conditioning enamel in the bonding of ceramic orthodontic brackets significantly decreased the SBS values compared with the conventional acid-etching method. 2. Although bonding brackets to enamel prepared with TPSEP or the conventional method did not significantly alter the site of failure, ceramic brackets bonded with SEP can be beneficial due to the bond failure location occurring generally between the resin–resin interface.

- **Elham S. J. Abu Alhaija et al** [16] **(2009)** studied the factors affecting the shear bond strength (SBS) of metal and ceramic brackets bonded to different ceramic surfaces and concluded that the type of surface treatment was the only factor that significantly affected SBS. The pattern of bond failure of metal brackets was at the adhesive–restorative interface, whereas for the ceramic brackets it was at the adhesive–bracket interface

- **Yasser Lotfy Abdelnaby et al [17] (2010)** this study was conducted to evaluate the effect of applying early orthodontic force on the shear bond strength (SBS) of orthodontic brackets bonded with 4 adhesive systems. Eighty stainless steel brackets were bonded to the enamel surfaces of extracted premolars with 4 adhesive systems. For each adhesive, 10 brackets were bonded without application of force (groups 1, 3, 5, and 7), and another 10 were subjected to a 120-g force with a coil spring (groups 2, 4, 6, and 8). This force was applied 30 minutes after bonding and maintained for 24 hours. Groups 1 and 2 had Rely-a-bond primer and Rely-a-bond adhesive (Reliance Orthodontic Products, Itasca, Ill). Groups 3 and 4 had Transbond XT primer and Transbond XT adhesive. Groups 5 and 6 had Transbond Plus Self Etching Primer and Transbond XT adhesive. Groups 7 and 8 had RelyX Unicem. After thermocycling, SBS testing was performed by using a universal testing machine. The results of SBS testing for all adhesives were analyzed by 2-way analysis of variance and the Duncan test. The unpaired Student t-test was used to compare the effect of force on the SBS of each adhesive. adhesive systems, orthodontic force up to 120 g can be applied within the first hour after bonding with no deleterious effects on bond strength. Regardless of the application of force, the Transbond XT primer and Transbond adhesive system yielded a significantly higher bond strength compared with the other studied systems.

- **Mohammed Al-Saleh et al [18] (2010)** determined the shear bond strength (SBS) of metallic and ceramic orthodontic brackets with new self-adhesive cement. One hundred extracted premolars were used. They were sterilized and their roots embedded in stone bases, with the facial surfaces perpendicular to the bottom of the bases. The teeth were divided into 2 main groups, to receive metallic or ceramic brackets. In each group, the specimens were further divided into 5 subgroups according to the cement used. The specimens were stored in distilled water at 37_C for 7 days and subjected to 3000 thermocyclers between 5_C and 55_C. The brackets were then debonded in shear with a testing machine. The SBS values of brackets cemented with etchant- rinse cement were significantly higher than those of the 3 self-adhesive types of cement. However, when the self-etch adhesive, Esthetic Cement system, was used with ceramic brackets, no significant difference was found in the SBS compared with Transbond XT.
- **Rondell Blakey and James Mah et al [19] (2010)** tested in vitro, the effect of different surface treatments on the shear bond strength of metal and ceramic orthodontic brackets bonded to temporary polycarbonate crowns and suggested that - Etching polycarbonate crowns with 9.6 hydrofluoric acids were completely ineffective for increasing the shear bond strength and Ceramic brackets bonded to sandblasted polycarbonate crowns produced the highest shear bond strength, although below a level

that was comparable with other clinically acceptable bond strengths.

- **Valiollah Arash et al** [20] **(2013)** conducted this study to determine the shear bond strength and de-bonding characteristics of metallic and ceramic brackets bonded with two types of bonding agents. In an experimental study done in 2013 in Babol, Iran, 120 extracted human maxillary premolar teeth were randomly divided into four groups as follows: HM group: metallic bracket/conventional bonding agent; SM group: metallic bracket/Transbond self-etching primer; HC group: ceramic bracket/conventional bonding agent; SC group: ceramic bracket/Transbond self-etching primer. Twenty-four hours after thermocycling, the shear bond strength values were measured. The amount of resin remaining on the tooth surface was determined under a stereomicroscope. The enamel detachment index was evaluated under a scanning electron microscope. Obtained results demonstrated that metallic brackets had significantly higher bond strengths compared with ceramic brackets. The self-etching primer method in comparison with the conventional method was able to create weaker bond strengths. However, this difference was not statistically significant, but it can be acceptable in clinics. According to ARI scores, it appears no concerns about enamel damage in the course of de-bonding with the two types of brackets and two bonding types used.

- **HR. Fattahi et al [21] (2013)** conducted a study to Compare Shear Bond Strength of Orthodontic Brackets Bonded with Core Max II and Transbond XT in Fluorosed Teeth and Evaluation of Enamel Damage after Debonding. In this *in-vitro* study, 60 fluorosis and nonfluorosed teeth were divided into two subgroups. The standard edgewise metallic brackets were bonded to the teeth with Transbond XT in the first and third groups, and with Core Max II in the remaining groups. After bonding, the SBS of the brackets was tested with a universal testing machine. Fluorosis significantly decreases the shear bond strength of orthodontic brackets to teeth. Core Max II can increase the shear bond strength of orthodontic brackets to fluorosis teeth. The greatest enamel damage was observed in fluorosis teeth following the use of Core Max II for bonding.
- **Luca Lombardo et al [22] (2013)** performed a study to evaluate Frictional resistance exerted by different lingual and labial brackets: an in vitro study. A plaster model of a pretreatment oral cavity was replicated to provide 18 identical versions. The anterior segments of each were taken, and the canine and lateral and central incisors were mounted with either lingual brackets. Mechanical friction tests were performed on each type of bracket using a universal testing machine. The maximum force necessary to displace NiTi wires of two different diameters was measured, using both elastic and metal ligatures with conventional brackets. The frictional force necessary to displace the wires

increased as the diameter of the wire increased in all tested brackets. Friction was significantly higher with elastic ligatures, as compared with metal ones, in all conventional brackets. In the lower lingual group, significantly lower friction was generated at conventional lingual New STb brackets ($p < 0.01$) and ORJ lingual brackets ($p < 0.05$) than at self-ligating In-Ovation L lingual brackets. A significant statistical correlation between and friction was detected in the lower labial bracket group. Friction resistance is influenced not only by the bracket type, type of ligation, and wire diameter but also by geometric differences in the brackets themselves.

- **Mateus Rodrigues-Tonetto et al [23] (2017)** conducted this study to evaluate the shear bond strength (SBS) and adhesive remnant index (ARI) of experimental brackets bonded with self-adhesive resin cement. Ninety bovine teeth were randomly distributed according to the groups: G1 - metal brackets bonded with Transbond™ XT; G2 – APC metal brackets bonded without additional adhesive system; G3 - APC metal brackets bonded with self-etching adhesive system; G4 - metal brackets bonded with RelyXU200; G5 - experimental brackets bonded with Transbond™ XT; G6 - experimental brackets bonded with RelyXU200. Shear bond strength test of the brackets was carried out and after their removal, the ARI was observed. The results showed that the means values of SBS values found in the experimental brackets groups were higher compared to the ones that were not modified. These results suggest that the experimental brackets are interesting options for future use in orthodontics.

- **Blerim Mehmeti et al [24] (2017)** compared the shear bond strength of metallic and ceramic orthodontic brackets bonded to all –zirconium ceramic crowns and concluded that metallic brackets created stronger adhesion with all zirconium surfaces due to their better base surface design or retention mode. The ceramic brackets showed higher fragility during debonding.
- **Sudhir Sharma et al [25] (2017)** conducted this study to evaluate and compare the SBS of orthodontic brackets bonded with four different orthodontic adhesives. Stainless steel Siamese premolar brackets were used, with the 0.022 slots. The surface area of the bracket base was 11.15 mm^2 and the mesh size was 80 gauge. Based on this study, the highest SBS was observed in Transbond XT, followed by Xeno V with Xeno Ortho, Rely-a-Bond and lowest in Transbond Plus with Transbond XT. In Transbond Plus with Transbond XT group and Xeno V with the Xeno Ortho group, most of the adhesive remained on the bracket (ARI scores of 0 and 1), indicating failure at the enamel-adhesive interface. Whereas, in the Transbond XT group and Rely-a-Bond group, most of the adhesive remained on the tooth (ARI scores of 2 and 3), indicating failure at the bracket-adhesive interface. Under the SEM, enamel surfaces of Transbond XT and Rely-a-Bond seemed more porous and rough

with the type III etching pattern after debonding. However, in Transbond Plus with Transbond XT and Xeno V with Xeno Ortho, enamel surfaces presented smooth and almost clean surfaces after debonding. The latest generation self-etching primer Xeno V with Xeno Ortho showed clinically acceptable SBS and less amount of residual adhesive left on the enamel surface after debonding.

- **Dennis Pham et al [26] (2017)** conducted this study to compare and evaluate the orthodontic bracket base shapes on shear bond strength and adhesive remnant index. In this *in vitro* bond strength study, SBS in Newtons (N) and Megapascals (MPa) of seven orthodontic bracket base shapes were measured with an Instron testing machine and compared. The control group consisted of an orthodontic bracket with a traditional rectangular base shape. The test groups were comprised of shaped brackets with six different base shapes; flower, soccer (round), heart, diamond, star, and football. 140 maxillary central incisor orthodontic brackets (n=20/shape) were used in this study for all shapes due to its minimal curvature within the bracket base. In conclusion, based on the data obtained from this study, it can be concluded that the bracket base shape affects SBS. When SBS is reported in Newtons, higher bond strength was observed for rectangle, flower, and football shape. These geometrical shapes may allow for superior force distribution within the enamel-resin-base system when compared to round, star, diamond and heart. Round and star shape yielded marginally superior bond strength than diamond and heart. The orthodontic bracket with one converging tip over the vertical axial plane within the incisal base has shown to exhibit lower bond strength.

- **Sunil Kumar M et al** [27] **(2017)** conducted a study to Compare Biomechanics of Labial versus Lingual Fixed Appliances**.** Lingual orthodontics is a great transition from the conventional labial orthodontics that eliminates the visibility of the fixed appliance by avoiding the orthodontic attachments on the labial surface of the teeth, to meet the esthetic demands of the patients. This lingual technique is quite challenging in terms of treatment approach as compared to labial orthodontics due to working in areas with poor accessibility, variable morphology of lingual surfaces posing difficulty in bracket positioning, different mechanical considerations for the position of orthodontic attachments having different relationship with the center of resistance, patient irritability due to tongue irritation. Lingual treatment can be as successful and as satisfying as the latter. Maintenance of aesthetics during treatment is a major issue in orthodontics, particularly for adult patients, and it is imperative on clinicians to be aware of the necessity to fulfill the patients' concerns and expectations not only relative to the final result, but also in their desire to receive the most aesthetically available or rather invisible appliance.

- **Ahmad Alobeid et al [28] (2018)** conducted a study to evaluate the efficacy of tooth alignment with conventional and self-ligating labial and lingual orthodontic bracket systems. We tested labial brackets (0.022″ slot size) and lingual brackets (0.018″ slot size). The labial brackets were: (i) regular twin brackets (ii) passive self-ligating brackets including Ortho classic H4™ FLI®SL and (iii) active self-ligating brackets and SPEED. The lingual brackets included (i) twin bracket systems (ii) passive self-ligating bracket system and (iii) active self-ligating bracket system. The tested wires were Thermalloy-NiTi 0.013″ and 0.014″. The archwires were tied to the regular twin brackets with stainless steel ligatures 0.010″. The malocclusion simulated a displaced maxillary central incisor in the x-axis and the z-axis. The effectiveness of lingual brackets in correcting vertical and anteroposterior displacement achieved during the initial alignment phase of orthodontic treatment is lower than that of the effectiveness of labial brackets. This study showed that the lingual brackets were less efficient in correcting initial tooth alignment than in the labial brackets. No relevant differences were found for the efficacy of tooth alignment correction between active or passive self-ligating brackets and conventional brackets for either labial or lingual brackets. Increasing the archwire diameter from 0.013″ to 0.014″ did not increase the correction of malaligned central incisor either lingual or labial brackets.

REVIEW OF ADHESIVE REMNANT INDEX:

Artun and Bergland [29] (1984) experimented clinical trials with crystal growth conditioning a an alternative to acid etch enamel pre treatment in bracket bonding which combines optimal bond strength with quick easier debonding and little damage to enamel and reducing less chair side time for clean up procedures. Different solutions containing sulfate induce crystal growth and concluded that failure rate was lowest with 37% phosphoric acid and highest with enamel conditioning with solutions containing sulfate, but within clinical acceptable range. The authors also proposed adhesive remnant index system (ARI) to evaluate the amount of adhesive left on the tooth after debonding.

Score 0 : No adhesive left on the tooth

Score 1 : Less than half of adhesive left on the tooth

Score 2 : More than half of adhesive left on the tooth

Score 3 : All adhesive left on the tooth, with distinct impression of the bracket mesh.

REVIEW OF SURFACE ROUGHNESS :

- **X.Z. Zhang et al [30] (1999)** conducted a study to evaluate the Optical Profilometric Study of Changes in Surface Roughness of Enamel during in vitro Demineralization**.** this study has shown that changes in the surface roughness of enamel during in vitro demineralization can be quantified by optical profilometric measurements of Ra. Other surface roughness parameters can be defined which are derived from the probability density function of the deviation of the profile from the average centerline. These are Sk and K, the skewness and kurtosis of the density function, respectively. These parameters give information about deviations of the density profile from a Gaussian function. Their study needs to be included in future investigations to obtain detailed information about the character of the increase in roughness as a result of acid treatment.

- **C. Ganss et al [31] (2000)** This study sought to compare the depths of erosive lesions in samples from different tooth sides as well as from enamel, dentine and root surfaces, and to examine the effect of preparation and polishing of specimens on erosive demineralization. From 30 impacted human third molars, two enamel samples from the mesial, distal, buccal and oral aspects, and similar samples from the radicular dentine, were prepared. One of each pair of samples was polished whereas the other was left untreated. Four samples were also prepared from the coronal dentine. For erosive demineralization, all samples were immersed in 0.05 M citric acid for 3 h and the erosion depth was calculated photometrically. In general, natural surfaces showed significantly smaller erosion depths than polished surfaces (p R 0.001) and enamel samples showed greater depths than coronal dentine (not signi®cant) and root dentine (p R 0.001). The erosion depths of the four tooth sides correlated significantly for polished enamel and coronal dentine samples but not for natural enamel specimens. There was no correlation between erosion depths for enamel and coronal dentine and only a weak correlation between enamel and root dentine.

- **Hyun-Suk Cha et al [32] (2004)** The objectives of this study were to determine the wear resistance of dental resin composites and to evaluate the influence of wear-simulating apparatus on wear. Nine commercial resin composites were studied. Wear was simulated with an oral wear simulator (Proto-Tech), which simultaneously incorporates the wear mechanism of attrition and abrasion in three-body wear mode, and with a pin-on-disk type friction tester (Rhesca, Japan). Composite specimens were subjected to 50,000 cycles of wear against a dental porcelain antagonist. After wear simulation, parameters for the determination of wear amount, such as wear volume, maximum wear depth, mean of maximum wear depth, and average wear depth were measured with the use of a 3D profilometer. For the oral wear simulator, the range of wear volume was 4.3–9.2 _ 10_2 mm3, and there were significant differences among the composites ($p < 0.05$). In other parameters, there were no significant differences among the composites. For the pin-on-disk tester, the range of the mean of maximum wear depth was 7.5–26.3 _m, which was significantly different among the composites ($p < 0.05$). The correlation coefficient (r) between the wear volume from the oral wear simulator and the mean of maximum wear depth from the pin-on-disk tester was 0.52.

Conclusively, dental resin composites showed significantly different wear resistance. Wear simulating apparatus influenced the amount of wear, and suitable parameters for the determination of wear amounts should be selected in each apparatus.

- **Seong-Sik Kim et al [33] (2007)** The purpose of this study was to determine the utility of sandblasting to remove composite remnants after orthodontic bracket debonding. The sample consisted of 20 human premolars extracted for orthodontic purposes. The buccal surface of each premolar was divided into 3 parts: the upper half (control surface group, CS), the lower half left (LS group), and the lower half right (SS group). A composite resin paste (volume, 5 _ 3 _1mm3) was bonded onto the LS and SS surfaces. Then it was removed by using 1 of 2 methods: low-speed handpiece with tungsten carbide bur in the LS group and sandblasting in the SS group. Temperature change and removal time were recorded, and surface profiles were examined with 3-dimensional profilometry. An independent *t*-test showed a statistically significant difference in temperature change between the LS and SS groups (*P* _.01). ANOVA showed no significant difference in surface profile between the LS and SS groups (*P* _.5). The results suggest that intraoral sandblasting might be an alternative to rotatory instruments for resin remnant removal after orthodontic bracket debonding.

- **E.B. Las Casas et al [34] (2008)** this work aims to propose a characterization method of dental enamel topography through quantitative analysis by 3D profilometry, to allow relating changes in enamel texture with activewear mechanisms. Four extracted teeth, including an intact third molar tooth, were evaluated. The bearing area ratio curve was obtained and the functional and spatial parameters Spk, Sk, Svk and Str were extracted. Abrasive wear mechanism tended to increase the amplitude of irregularities until a certain point when the material removal was capable of reaching the central zone of enamel, where the hydroxyapatite prisms are randomly oriented. The action of chemical agents was also observed, even when the abrasive wear was predominant. A relationship may exist between the variation of the irregularities' directional pattern and the wear mode. The study presents micrographs of the analyzed surfaces to support the discussion
- **Fabiano G. Ferreira et al [35] (2013)** this study aimed to undertake a qualitative and quantitative evaluation of changes on enamel surfaces after debonding of brackets followed by finishing procedures, using a high-resolution three-dimensional optical profiler and to investigate the accuracy of the technique. The labial surfaces of 36 extracted upper central incisors were examined. Before bonding, the enamel surfaces were subjected to profilometry, recording four amplitude parameters. Brackets were then bonded using two types of light-cured orthodontic

adhesive: composite resin and resin-modified glass ionomer cement. Finishing was performed by three different methods: pumice on a rubber cup, fine and ultrafine aluminum oxide discs, and microfine diamond cups followed by silicon carbide brushes. The samples were subsequently re-analyzed by profilometry. Wilcoxon signed-rank test, Kruskal–Wallis test ($p < 0.05$) and a posteriori Mann–Whitney U test with Bonferroni correction ($p < 0.0167$) revealed a significant reduction of enamel roughness when diamond cups followed by silicon carbide brushes were used to finish surfaces that had remnants of resin-modified glass ionomer adhesive and when pumice was used to finish surfaces that had traces of composite resin. Enamel loss was minimal. The 3D optical profilometry technique was able to provide an accurate qualitative and quantitative assessment of changes on the enamel surface after debonding. Clinical relevance Morphological changes in the topography of dental surfaces, especially if related to enamel loss and roughness, are of considerable clinical importance. The quantitative evaluation method used herein enables a more comprehensive understanding of the effects of orthodontic bonding on teeth.

- **Francesca Mullan et al [36] (2017)** To determine if Sa roughness data from measuring one central location of unpolished and polished enamel were representative of the overall surfaces before and after erosion. Twenty human enamel sections (4x4 mm) were embedded in bis-acryl composite and randomized to either a native or polishing enamel preparation protocol. Enamel samples were subjected to an acid challenge (15 minutes 100 mL orange juice, pH 3.2, titratable acidity 41.3mmol OH/L, 62.5 rpm agitation, repeated for three cycles). Median (IQR) surface roughness [Sa] was measured at baseline and after erosion from both a centralized cluster and four peripheral clusters. Within each cluster, five smaller areas (0.04 mm2) provided the Sa roughness data. Measuring one central cluster of unpolished and polished enamel samples to determine Sa roughness is sufficient for subsequent studies. Polished enamel becomes significantly rougher after erosion and unpolished enamel becomes significantly smoother after erosion. These observations suggest that surface roughness derived from optical profilometry at a relatively low lateral resolution, utilizing replica methodologies, maybe a relevant in vivo measure of enamel erosion. Measuring one central cluster of unpolished and polished enamel was representative of the overall enamel surface roughness, before and after erosion.

There is no literature evidence to compare the labial and lingual shear bond strength and surface changes. Hence in our study comparison of shear bond strength and surface changes of labial and lingual brackets has been evaluated.

MATERIALS AND METHODS

STUDY DESIGN:

- Analytical - IN VITRO STUDY

STUDY AREA:

- Department of Orthodontics And Dentofacial Orthopedics, Madha Dental College And Hospital, Kundrathur, Chennai, Tamilnadu, India.
- C.I.P.E.T ,ARSPTC ,GUINDY ,CHENNAI .

In this in vitro study evaluation of the shear bond strength of orthodontic brackets and assessment of the surface changes in enamel is carried out.

A**. Inclusion criteria for the sample:**

- Anatomically and morphologically well-defined teeth.
- No caries maxillary and mandibular premolar teeth with intact buccal enamel, extracted for orthodontic purposes.

B. **Exclusion criteria for the sample:**

- Teeth with restorations
- Enamel cracks
- Fractured crowns
- Flurosed teeth
- Hypoplastic teeth.

ETHICAL CLEARANCE:

- This study was approved by the Institutional Review Board and Human ethical Committee of Madha Medical College And Hospital.

SAMPLE SIZE:

- The sample size calculation is done .40 samples would provide adequate statistical power to detect a significant difference between the groups. A total of 40 premolar teeth were taken for the study.

Sample preparation:

- Freshly extracted teeth were cleaned to remove blood or any tissue debris and stored in distilled water solution till the time of bonding procedure. Teeth were then mounted on self-cured, color-coded acrylic blocks of dimensions 35 x 7 x 7 mm such that the roots are completely embedded into the acrylic block up to cement enamel junction and the buccal surface of the crown is perpendicular to the base of the block. The acrylic blocks are color-coded to differentiate between the groups.

Distribution of the sample:

- Teeth to be bonded with different approaches were grouped as given below.

GROUPS	COLOR CODING	SAMPLE SIZE	MATERIAL USED AND METHODOLOGY
A	Pink	10	Labial maxillary premolar brackets
B	Clear	10	Labial mandibular premolar brackets
C	Red	10	Lingual maxillary premolar brackets
D	Yellow	10	Lingual mandibular premolar brackets

ARMAMENTARIUM USED:

The following materials and equipment were used for the above study. 20 maxillary and 20 mandibular premolar teeth extracted for orthodontic treatment were used.

1. Distilled water solution to store extracted teeth.
2. Cold cure acrylic material (DPI RR) for mounting the extracted teeth.
3. Labial stainless steel premolar bracket-mesh base(ORMCO) .
4. Lingual stainless steel premolar bracket-mesh base (ORMCO).
5. Light Emitting Diode (LED) curing light .

BONDING ACCESSORIES

1. Etchant (37% Phosphoric Acid-D tech).
2. ORTHO SOL (ORMCO PRIMER).
3. ENLIGHT (ORMCO COMPOSITE).
4. Applicator brush.
5. Airway syringe.
6. Bracket holder and positioner .
7. Air motor and handpiece with polishing cup.
8. Prophylaxis paste.

FOR EVALUATION OF SHEAR BOND STRENGTH:

1. Instron 8874 machine.

FOR EVALUATION OF ADHESIVE REMNANT INDEX:

1. Steromicrosope.

FOR EVALUATION OF SURFACE CHANGES IN ENAMEL

1. Profilometry - surface roughness measurement in Taylor and Hobson machine.

METHODOLOGY:

BONDING PROCEDURE

The buccal surface of the teeth was polished with pumice slurry using a rubber cup mounted on the low-speed handpiece. After polishing, the teeth were washed with distilled water and dried using oil and moisture free air from the three-way syringe. The enamel was etched with 37% phosphoric acid gel for 30 seconds, rinsed under running water for 20 seconds, and then dried with oil and moisture-free compressed air for 20 seconds. The samples were then inspected for the characteristic dull, white, frosted appearance of adequately etched enamel.

ORMCO primer was applied to the etched surface and the bracket base as well with the help of an applicator brush. The primer was air thinned on the tooth surface before light-curing the primer for 20 seconds.

ORMCO adhesive material was next applied to the bracket base directly from the syringe. The bracket was held and carried to the tooth surface by a bracket holder. The bracket was then positioned on the predetermined tooth surface along the long axis of the tooth at a distance of 4mm from the occlusal surface. The positioning was achieved with the help of a bracket positioner.

The bracket was pressed firmly onto the enamel surface with the reverse end of the bracket holder. The flash around the bracket was removed with an explorer.

The adhesive/bracket was cured using an LED (Light-emitting diode) curing unit. The adhesive was cured on the occlusal, gingival, mesial and distal aspects for 10 seconds each.

The above procedure was done for all samples in Group-A to Group-D by the same individual under the same environment.

I. Storage of the sample:

II. All the samples were stored in distilled water in a dark incubator at 37˚C between bonding and testing.

EVALUATION OF BOND STRENGTH

Deboning was carried out with a universal testing machine (INSTRON, 8874). The machine has two vertically placed jaws. The samples were placed in the lower jaw of the testing machine so that the bracket base was parallel to the direction of a force. A stainless steel wire loop attached to the upper jaw of the testing machine was engaged under the gingival bracket wings to produce shear/peel stress parallel to the bracket base. The samples were then stressed at a crosshead speed of 1mm per minute in a gingival incisal direction, and the maximum force at bond failure was recorded. The bond strength is measured in mpa.

EVALUATION OF ADHESIVE REMNANT INDEX:

The amount of residual adhesive was classified using the adhesive remnant index developed by Artun and Bergland.

This consist of a 4 point scale of 0 to 3

0-Indicates no adhesive left on the tooth

1-Indicates less than half of adhesive left on the tooth

2-Indicates more than half of adhesive left on the tooth

3-Indicates all of adhesive on the tooth including a distinct impression of the bracket mesh.

EVALUATION OF THE SAMPLE FOR PROFILOMETRY ANALYSIS:

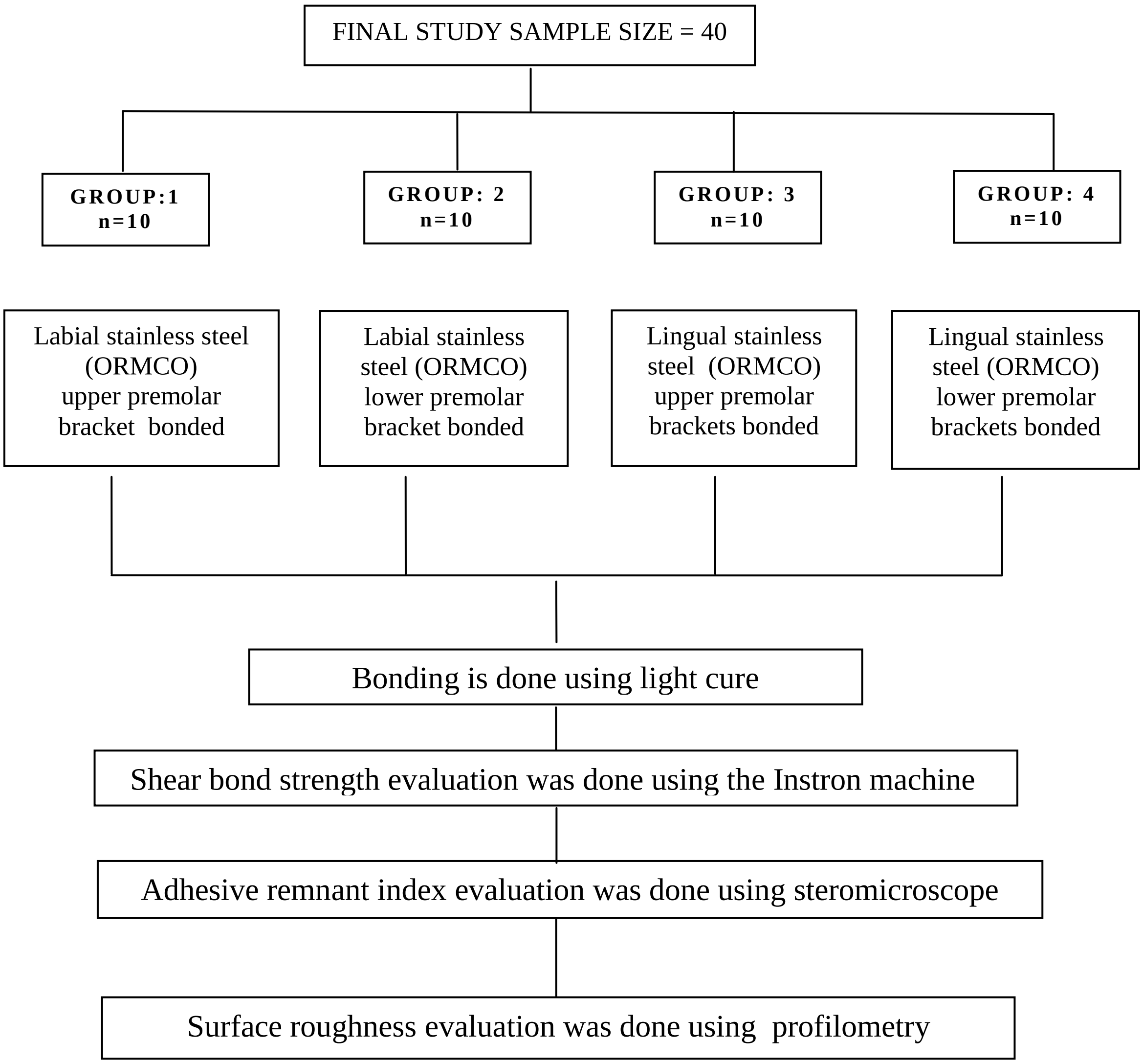
The samples were then loaded on to optical profilometry to assess the surface roughness. Optical profilometers scan surfaces with optical probes that send light interference signals back to the profilometer detector via an optical fiber. With this, a 3-dimensional image is captured to identify the surface roughness in terms of extent (Sa) and depth (Sz)of enamel wear.

STATISTICAL ANALYSIS:

The following statistical analysis was done to evaluate the results using the software "statistical package for social sciences" SPSS (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY: IBM Corp. Released 2017).

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks test results reveal that the variables do not follow Normal distribution. Therefore, to analyze the data non-parametric method is applied. To compare values between groups (main and sub) Mann Whitney test is applied. To analyze the data SPSS (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY: IBM Corp. Released 2017) is used. Significance level is fixed as 5% ($\alpha = 0.05$).Statistical analysis is carried on for the result.

FLOW CHART SAMPLING METHOD



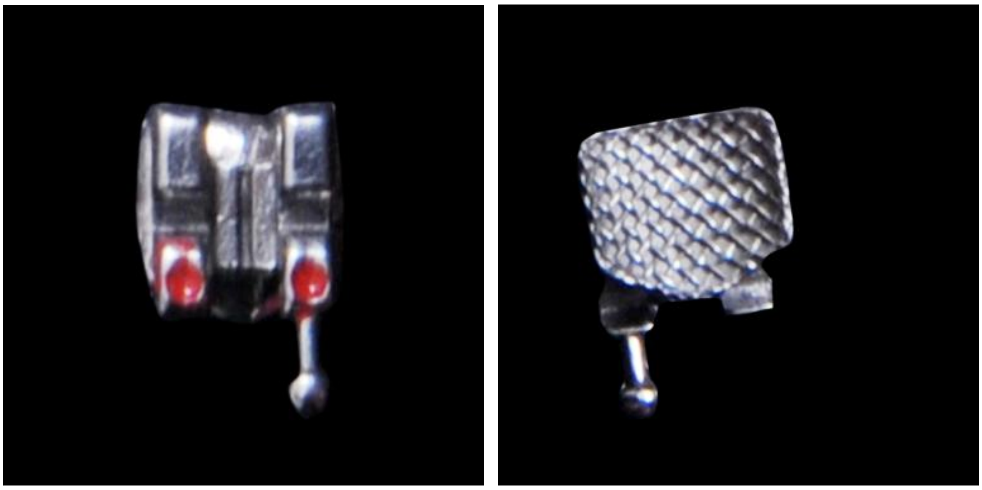
PHOTOGRAPHS

COLOUR PLATE 1:

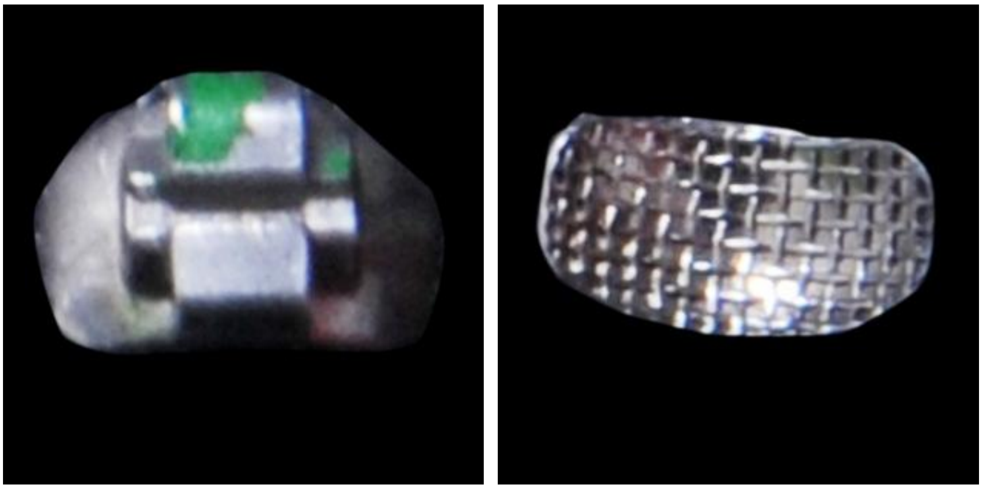
1a : EXTRACTED MAXILLARY AND MANDIBULAR PREMOLAR

1b : DISTILLED WATER SOLUTION

1c:COLDCURE ACRYLIC MATERIAL

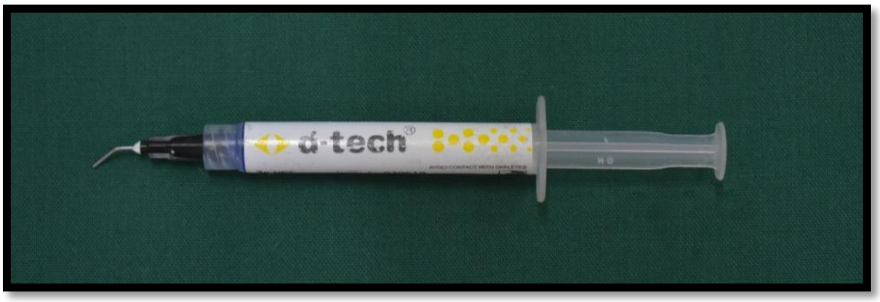


1d : ORMCO METAL LABIAL BRACKET



1e : ORMCO METAL LINGUAL BRACKET

COLOUR PLATE 2

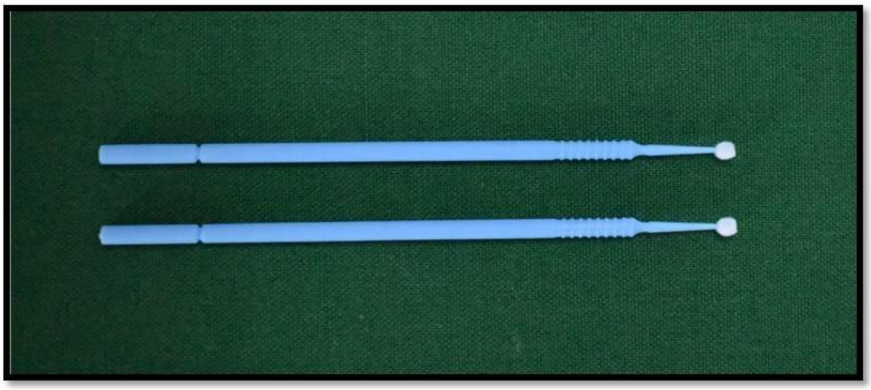


2a : ACID ETCHANT

2b : ORMCO PRIMER

2c : ORMCO ADHESIVE

COLOUR PLATE 3



3a : APPLICATOR BRUSH

3b : AIRWAY SYRINGE

3c : BRACKET HOLDER

3d : LED CURING LIGHT (BLUE DENT)

COLOUR PLATE 4:

4a : Group I - PINK COLOUR

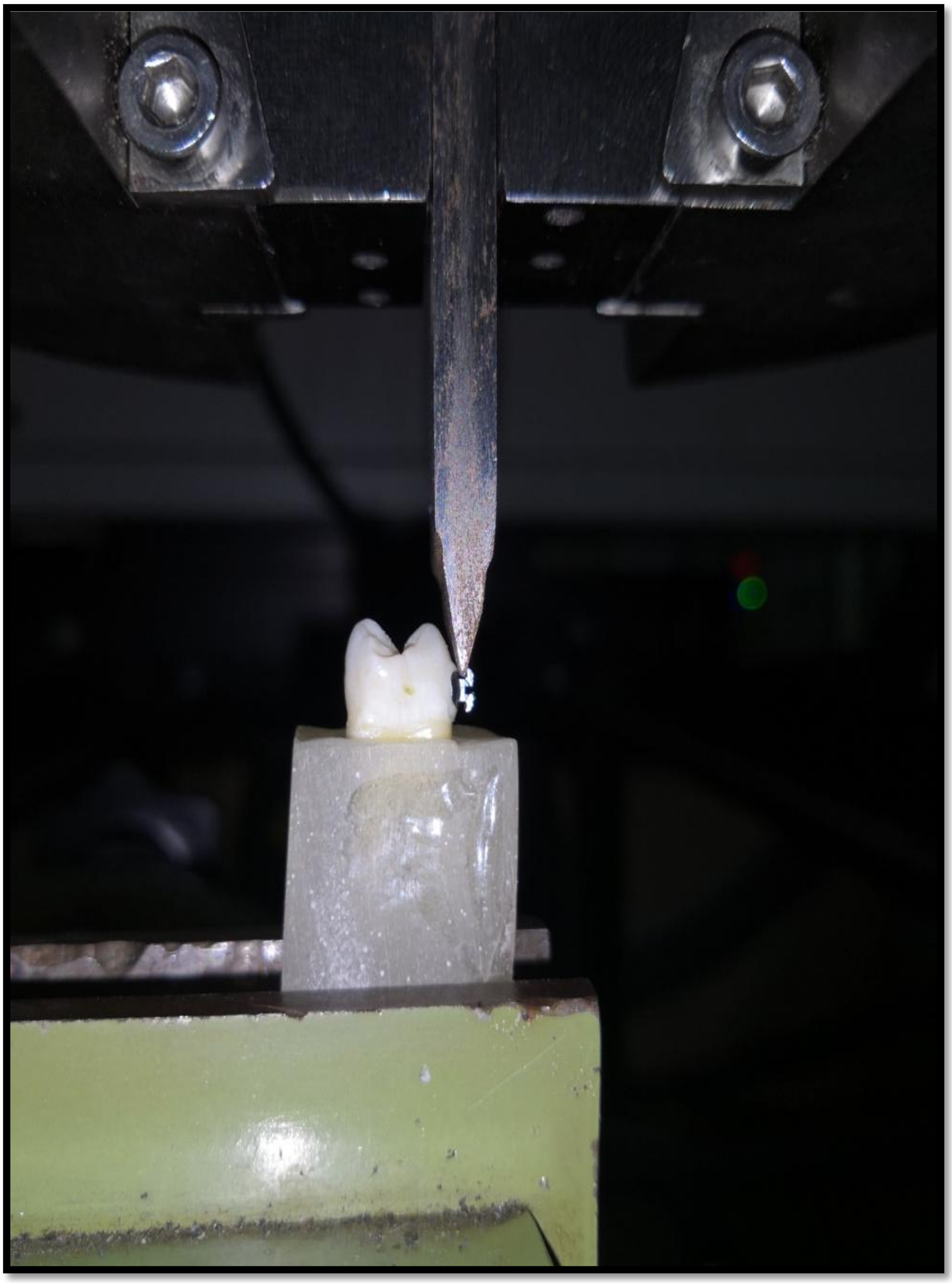
4b : Group II - TOOTH COLOUR (CLEAR)

4c : Group III - RED COLOUR

4d : Group IV - YELLOW COLOUR

COLOUR PLATE 5:

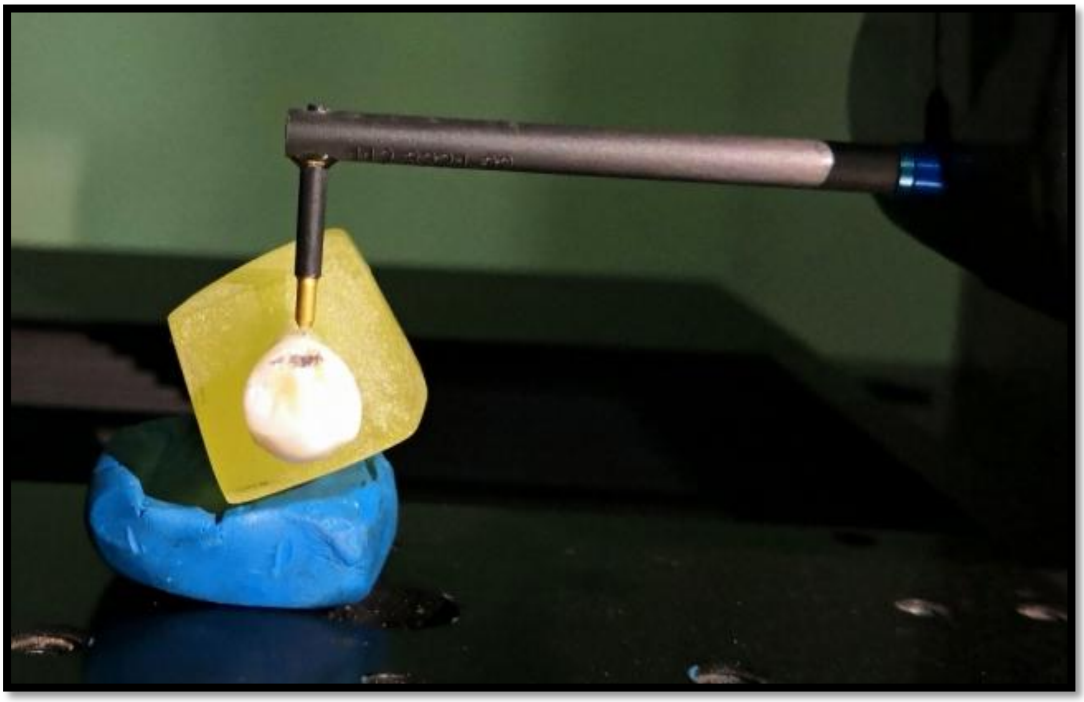
5a : INSTRON MACHINE

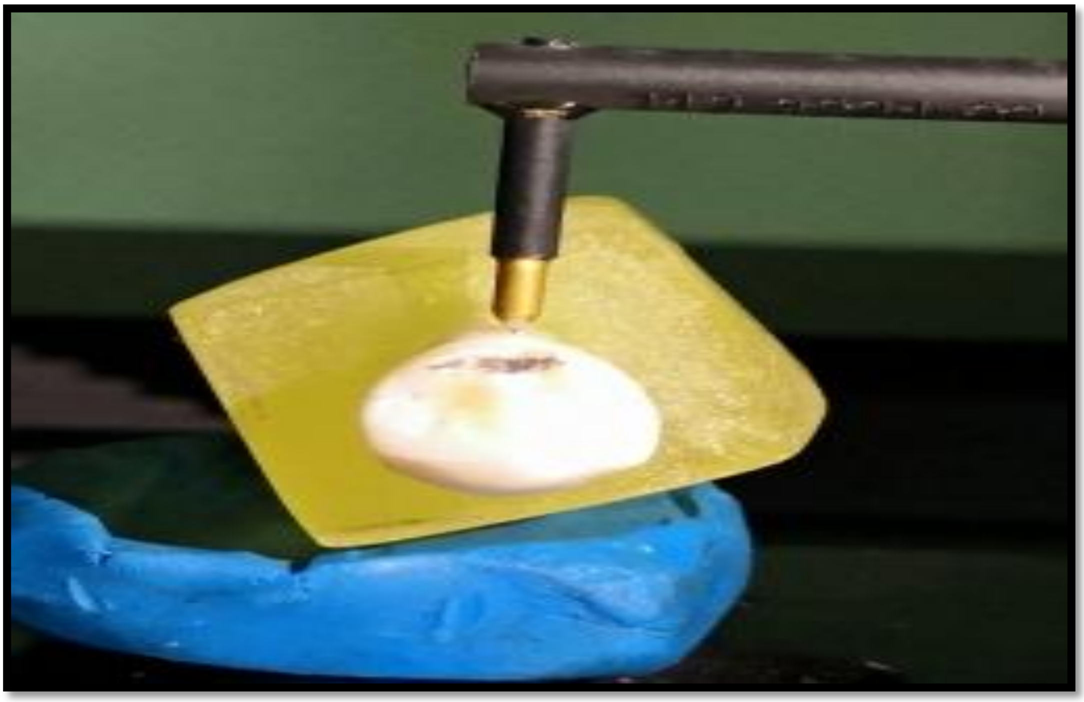


5b: INSTRON MACHINE WHEN LOAD IS GIVEN TO THE TOOTH TO MEASURE THE SHEAR BOND STRENGTH

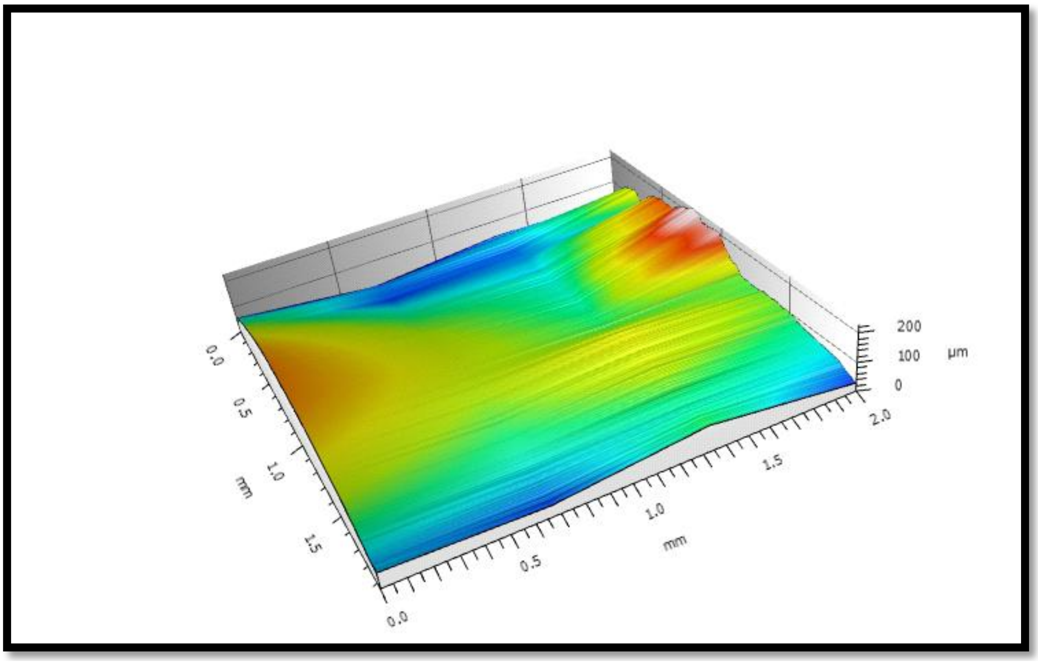
COLOUR PLATE 6:

6a :SURFACE PROFILOMETRY MACHINE

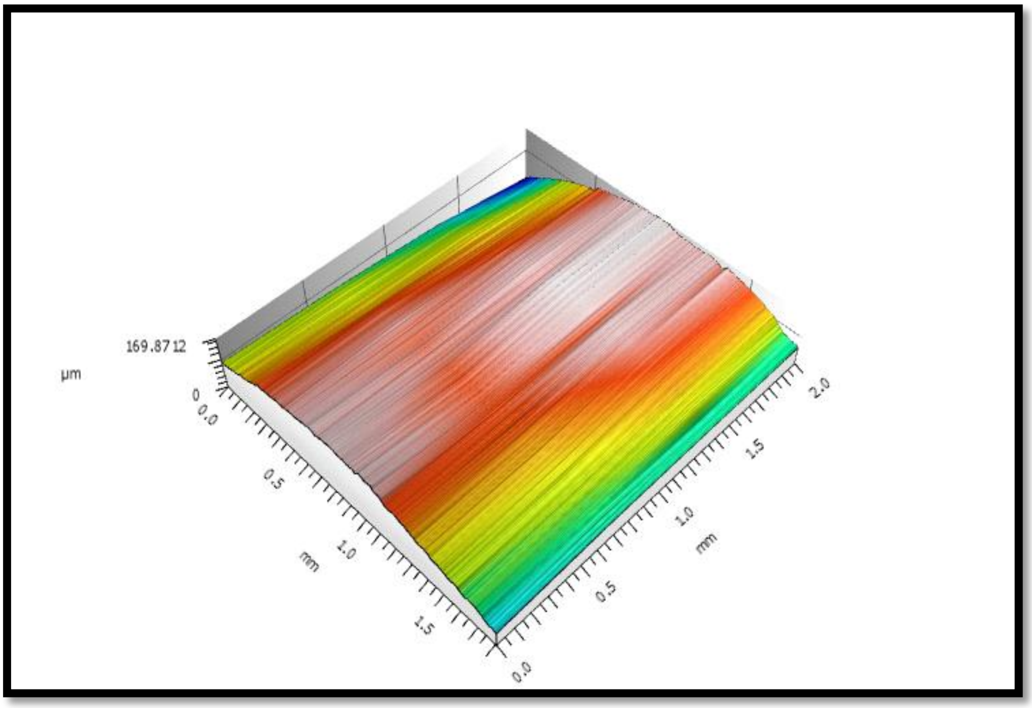




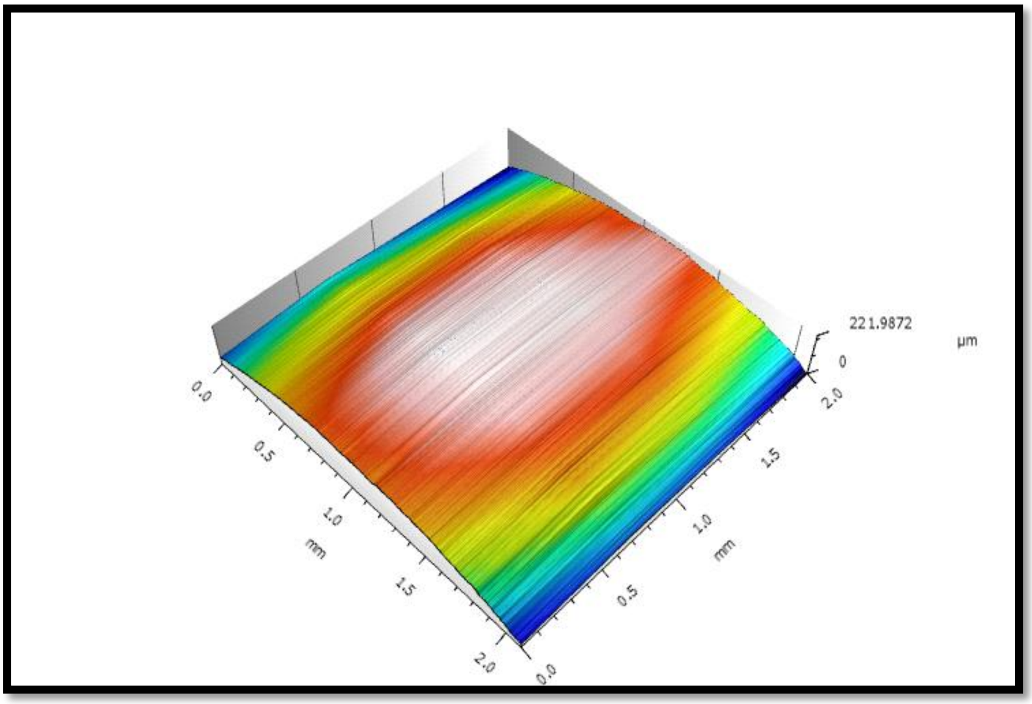
6b:PROFILOMETRY MACHINE MEASURING THE SURFACE EXTENT CHANGES.



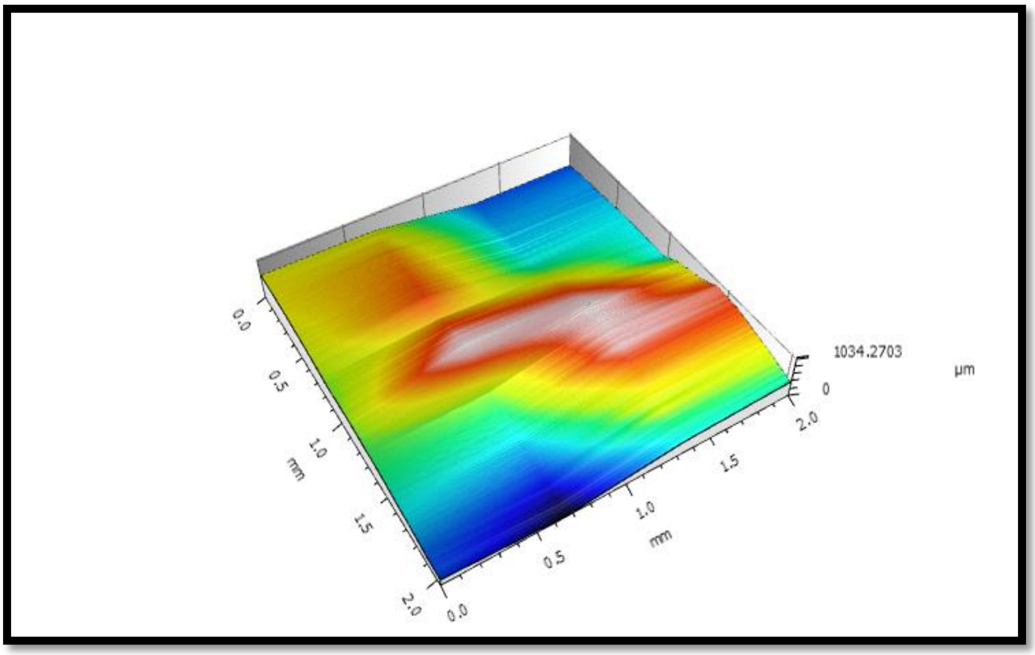
6c : SURFACE CHANGES OF GROUP 1 - LABIAL UPPER PREMOLAR BRACKET ENAMEL SURFACE AFTER DEBONDING



6d : SURFACE CHANGES OF GROUP 2- LABIAL LOWER PREMOLAR BRACKET ENAMEL SURFACE AFTER DEBONDING



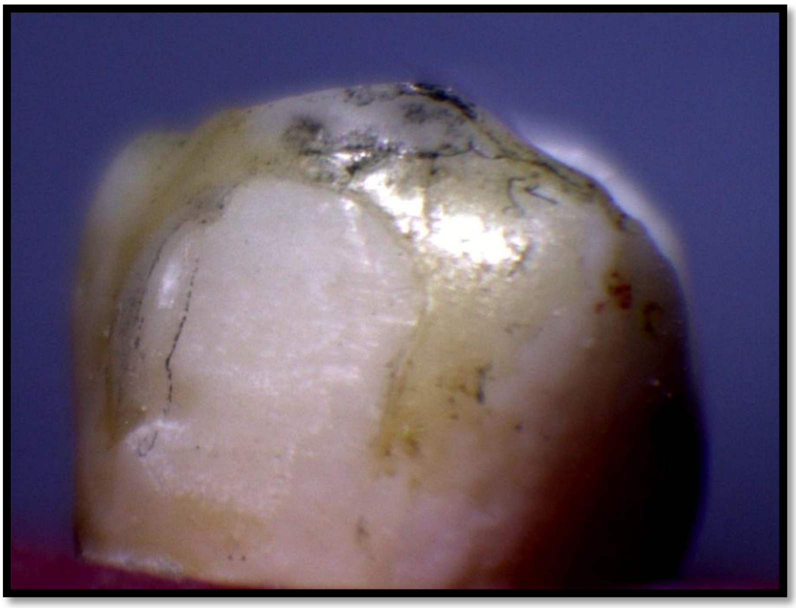
6E : SURFACE CHANGES OF GROUP 3 - LINGUAL UPPER PREMOLAR BRACKET ENAMEL SURFACE AFTER DEBONDING



6f : SURFACE CHANGES OF GROUP 4- LINGUAL LOWER PREMOLAR BRACKET ENAMEL SURFACE AFTER DEBONDING

COLOUR PLATE 7:

7a : STEROMICROSCOPE



7b : LABIAL UPPER PREMOLAR ADHESIVE REMNANT SCORE - MICROSCOPIC PICTURE

7c : LABIAL LOWER PREMOLAR ADHESIVE REMNANT SCORE - MICROSCOPIC PICTURE

7d : LINGUAL UPPER PREMOLAR ADHESIVE REMNANT SCORE - MICROSCOPIC PICTURE

7e : LINGUAL LOWER PREMOLAR ADHESIVE REMNANT SCORE - MICROSCOPIC PICTURE

RESULT

Forty extracted premolars were included in this study comprising of 20 maxillary premolars and 20 mandibular premolars, which were divided into 4 groups. Group I-Maxillary Labial Premolars. Group II- Mandibular Labial Premolars. Group III-Maxillary Lingual Premolars. Group IV-Mandibular Lingual Premolars. All are bonded using stainless steel brackets(labial and lingual). All the samples were taken for shear bond strength analysis and surface profilometry to analyze for the extent of enamel damage.

The values of shear bond strength and surface changes of enamel for all samples are measured individually and tabulated.

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks test results reveal that the variables do not follow Normal distribution. Therefore, to analyze the data non-parametric method is applied. To compare values between groups (main and sub) Mann Whitney test is applied. To analyze the data SPSS (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY: IBM Corp. Released 2017) is used. Significance level is fixed as 5% ($\alpha = 0.05$).

The results obtained after statistical evaluation are presented in tables 1-18 and graphically represented in graphs 1 - 5.

The values of shear bond strength, Sa (average mean surface extent of enamel wear) and Sz (depth of enamel wear) were analyzed to calculate their mean and standard deviation.

TABLE 16: Represents mean shear bond strength of labial brackets and lingual brackets.

In this table, we have the comparison of shear bond strength between

1. Labial brackets versus Lingual brackets
2. Labial upper brackets versus Labial lower brackets
3. Lingual upper brackets versus Lingual lower brackets
4. Labial upper brackets versus Lingual upper brackets
5. Labial lower brackets versus Lingual lower brackets

SHEAR BOND STRENGTH (SBS) OF LABIAL BRACKETS VERSUS LINGUAL BRACKETS:

Table 1 represents the mean shear bond strength value of labial brackets is 1.55mpa(±1.146) and lingual brackets are 2.80mpa(±1.542). The p-value is 0.010 which reveals that it is statistically significant. The shear bond strength value of lingual brackets is higher compared to labial brackets.

SHEAR BOND STRENGTH(SBS) OF LABIAL UPPER BRACKETS VERSUS LABIAL LOWER BRACKETS:

Table 2 represents the mean value of labial upper brackets is 2.20mpa(±1.135) and labial lower brackets are 0.90mpa(±0.738). The p-value is 0.010 which reveals that it is statistically significant. SBS value of labial upper brackets is higher compared to labial lower brackets.

SHEAR BOND STRENGTH(SBS) OF LINGUAL UPPER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

Table 3 represents the mean value of lingual upper brackets is 1.80mpa (±0.789) and lingual lower brackets are 3.80mpa (±1.476). The p-value is 0.004 which reveals that it is statistically significant. SBS value of lingual lower brackets is higher compared to lingual upper brackets.

SHEAR BOND STRENGTH(SBS) OF LABIAL UPPER BRACKETS VERSUS LINGUAL UPPER BRACKETS:

Table 4 represents the mean value of labial upper brackets is 2.20mpa (±1.135) and lingual upper brackets are 1.80mpa (±0.789). The p-value is 0.298 which reveals that it is statistically insignificant. SBS value of labial upper brackets is higher compared to lingual upper brackets.

SHEAR BOND STRENGTH(SBS) OF LABIAL LOWER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

Table 5 represents the mean value of labial lower brackets is 0.90mpa (±0.738) and lingual lower brackets are 3.80mpa (±1.476). The p-value is 0.001 which reveals that it is statistically significant. SBS value of lingual lower brackets is higher compared to labial lower brackets.

Figure 6 c, d, e, f represents the profilometry images of enamel surfaces after debonding in which greenish-yellow area represents the extent of enamel wear(Sa) and the red area represents the depth of enamel wear(Sz).

TABLE 17: To compare the Sa values between Groups

In this table, we have the comparison of surface changes between

1. Labial brackets versus Lingual brackets
2. Labial upper brackets versus Labial lower brackets
3. Lingual upper brackets versus Lingual lower brackets
4. Labial upper brackets versus Lingual upper brackets
5. Labial lower brackets versus Lingual lower brackets

Sa VALUES OF LABIAL BRACKETS VERSUS LINGUAL BRACKETS

Table 6 represents the mean value of labial brackets is 39.12 (±14.204)and lingual brackets are 72.67(±55.631). There is a statistically significant difference in Sa value between Labial brackets and lingual brackets (p-value is 0.006).

Sa VALUES OF LABIAL UPPER BRACKETS VERSUS LABIAL LOWER BRACKETS

Table 7 represents the mean value of labial upper brackets is 44.09(±10.538) and labial lower brackets are 34.14(±16.121). There is a statistically significant difference in Sa value between Labial upper brackets and labial lower brackets (p-value is 0.013).

Sa VALUES OF LINGUAL UPPER BRACKETS VERSUS LINGUAL LOWER BRACKETS

Table 8 represents the mean value of lingual upper brackets is 59.36(±56.506)and lingual lower brackets are 85.99(±54.285). There is a statistically significant difference in Sa value between Lingual upper brackets and lingual lower brackets (p-value is 0.034).

Sa VALUES OF LABIAL UPPER BRACKETS VERSUS LINGUAL UPPER BRACKETS

Table 9 represents the mean value of labial upper brackets is 44.09(±10.538) and lingual upper brackets are 59.36(±56.506). The p-value is 0.496 which reveals that it is statistically insignificant.

Sa VALUES OF LABIAL LOWER BRACKETS VERSUS LINGUAL LOWER BRACKETS

Table 10 represents the mean value of labial lower brackets is 34.14(±16.121) and lingual lower brackets are 85.99(±54.285). There is a statistically significant difference in Sa value between Labial lower brackets and lingual lower brackets (p-value is 0.001).

TABLE 18: To compare the Sz values between Groups

In this table, we have the comparison of surface changes between

1. Labial brackets versus Lingual brackets
2. Labial upper brackets versus Labial lower brackets
3. Lingual upper brackets versus Lingual lower brackets
4. Labial upper brackets versus Lingual upper brackets
5. Labial lower brackets versus Lingual lower brackets

LABIAL BRACKETS VERSUS LINGUAL BRACKETS

Table 11 represents the mean value of labial brackets is 190.02 (±95.060)and lingual brackets are 407.68(±311.157). The p-value is 0.001 which reveals that it is statistically significant.

LABIAL UPPER BRACKETS VERSUS LABIAL LOWER BRACKETS

Table 12 represents the mean value of labial upper brackets is 230.49 (±58.655)and labial lower brackets are 149.55(±109.532). The p-value is 0.041 which reveals that it was statistically significant.

LINGUAL UPPER BRACKETS VERSUS LINGUAL LOWER BRACKETS

Table 13 represents the mean value of lingual upper brackets is 359.73(±371.675) and lingual lower brackets are 455.62(±247.274). The p-value is 0.023 which reveals that it is statistically significant.

LABIAL UPPER BRACKETS VERSUS LINGUAL UPPER BRACKETS

Table 14 represents the mean value of labial upper brackets is 230.49(±58.655) and lingual upper brackets are 359.73(±371.675). The p-value is 0.450 which reveals that it is statistically insignificant.

LABIAL LOWER BRACKETS VERSUS LINGUAL LOWER BRACKETS

Table 15 represents the mean value of labial lower brackets is 149.55(±109.532) and lingual lower brackets are 455.62(±247.274). The p-value is 0.001 which reveals that it is statistically significant.

TABLE 19: shows adhesive remnant index score:

The adhesive remnant index of all the samples in both groups were tabulated (table 19) according to the scoring criteria developed by Artun and Bergland . There were no adhesive left out on the tooth (score 0- adhesive failure at tooth-resin interface) in some of the samples between these groups and few samples had less than half the amount of adhesive left (score 1-cohesive failure within the resin) on the tooth. These specimens underwent adhesive failure at tooth-resin interface than cohesive failure. Some of the samples in both the group had scores 2 and 3, which shows that the bond strength between the resin bracket interface was stronger in both total etch and self-etch group compared to tooth-resin interface. There is statistically significant difference between the labial and lingual groups with regard to adhesive remnant score - p value is 0.002. There is statistically significant difference between the upper and lower groups also - p value is 0.044.

TABLES

Mann-Whitney test to compare of SBS values between Groups:

TABLE 1:COMPARISON OF SHEAR BOND STRENGTH OF LABIAL BRACKETS VERSUS LINGUAL BRACKETS:

Ranks

	GROUP	N	Mean Rank	Sum of Ranks	p-VALUE
SBS	LABIAL	20	15.85	317.00	.010*
	LINGUAL	20	25.15	503.00	
	Total	40			

TABLE 2: COMPARISON OF SHEAR BOND STRENGTH OF LABIAL UPPER BRACKETS VERSUS LABIAL LOWER BRACKETS:

	GROUP	N	Mean Rank	Sum of Ranks	p-VALUE
SBS	LABIAL UPPER	10	13.80	138.00	.010*
	LABIAL LOWER	10	7.20	72.00	
	Total	20			

TABLE 3: COMPARISON OF SHEAR BOND STRENGTH OF LINGUAL UPPER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

	GROUP	N	Mean Rank	Sum of Ranks	p-VALUE
SBS	LINGUAL UPPER	10	6.85	68.50	.004*
	LINGUAL LOWER	10	14.15	141.50	
	Total	20			

TABLE 4: COMPARISON OF SHEAR BOND STRENGTH OF LABIAL UPPER BRACKETS VERSUS LINGUAL UPPER BRACKETS:

	GROUP	N	Mean Rank	Sum of Ranks	p-VALUE
SBS	LABIAL UPPER	10	11.75	117.50	.298
	LINGUAL UPPER	10	9.25	92.50	
	Total	20			

TABLE 5: COMPARISON OF SHEAR BOND STRENGTH OF LABIAL LOWER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

	GROUP	N	Mean Rank	Sum of Ranks	p-VALUE
SBS	LABIAL LOWER	10	6.05	60.50	.001*
	LINGUAL LOWER	10	14.95	149.50	
	Total	20			

Mann-Whitney test to compare of Sa values between Groups

TABLE 6: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL BRACKETS VERSUS LINGUAL BRACKETS:

	Labial	Lingual
N	20	20
Mean	39.12	72.67
Std. Dev	14.204	55.631
Median	36.34	55.89
1st Quartile	29.24	38.52
3rd Quartile	43.94	72.49
	p-value (Labial vs Lingual)	0.006

TABLE 7: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL UPPER BRACKETS VERSUS LABIAL LOWER BRACKETS:

	LABIAL UPPER	LABIAL LOWER
N	10	10
Mean	44.09	34.14
Std. Dev	10.538	16.121
Median	42.93	30.26
1st Quartile	36.89	26.79
3rd Quartile	48.45	34.29
	p-value	0.013

TABLE 8: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LINGUAL UPPER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

	LINGUAL UPPER	**LINGUAL LOWER**
N	10	10
Mean	59.36	85.99
Std. Dev	56.506	54.285
Median	38.52	59.46
1st Quartile	33.80	54.71
3rd Quartile	59.18	90.95
	p-value	0.034

TABLE 9: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL UPPER BRACKETS VERSUS LINGUAL UPPER BRACKETS:

	LABIAL UPPER	**LINGUAL UPPER**
N	10	10
Mean	44.09	59.36
Std. Dev	10.538	56.506
Median	42.93	38.52
1st Quartile	36.89	33.80
3rd Quartile	48.45	59.18
	p-value	0.496

TABLE 10: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL LOWER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

	LABIAL LOWER	**LINGUAL LOWER**
N	10	10
Mean	34.14	85.99
Std. Dev	16.121	54.285
Median	30.26	59.46
1st Quartile	26.79	54.71
3rd Quartile	34.29	90.95
	p-value	0.001

Mann-Whitney test to compare of Sz values between Groups

TABLE 11: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL BRACKETS VERSUS LINGUAL BRACKETS:

	Labial	**Lingual**
N	20	20
Mean	190.02	407.68
Std. Dev	95.060	311.157
Median	180.74	314.38
1st Quartile	138.50	222.35
3rd Quartile	237.03	449.47
	p-value (Labial vs Lingual)	<0.001

TABLE 12: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL UPPER BRACKETS VERSUS LABIAL LOWER BRACKETS:

	LABIAL UPPER	**LABIAL LOWER**
N	10	10
Mean	230.49	149.55
Std. Dev	58.655	109.532
Median	218.07	144.97
1st Quartile	180.41	58.39
3rd Quartile	281.82	181.07
	p-value	0.041

TABLE 13: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LINGUAL UPPER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

	LINGUAL UPPER	**LINGUAL LOWER**
N	10	10
Mean	359.73	455.62
Std. Dev	371.675	247.274
Median	226.70	347.82
1st Quartile	192.66	314.48
3rd Quartile	297.82	470.59
	p-value	0.023

TABLE 14: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL UPPER BRACKETS VERSUS LINGUAL UPPER BRACKETS:

	LABIAL UPPER	**LINGUAL UPPER**
N	10	10
Mean	230.49	359.73
Std. Dev	58.655	371.675
Median	218.07	226.70
1st Quartile	180.41	192.66
3rd Quartile	281.82	297.82
	p-value	0.450

TABLE 15: COMPARISON OF SURFACE CHANGES IN ENAMEL AFTER DEBONDING LABIAL LOWER BRACKETS VERSUS LINGUAL LOWER BRACKETS:

	LABIAL LOWER	**LINGUAL LOWER**
N	10	10
Mean	149.55	455.62
Std. Dev	109.532	247.274
Median	144.97	347.82
1st Quartile	58.39	314.48
3rd Quartile	181.07	470.59
	p-value	0.001

TABLE NO 16 : MANN-WHITNEY TEST TO COMPARE OF SBS VALUES BETWEEN GROUPS:

Descriptive Statistics

GROUP	N	Minimum	Maximum	Mean	Std. Deviation	Median
LABIAL SBS	20	0	4	1.55	1.146	1.000
LINGUAL SBS	20	0	6	2.80	1.542	2.000

Descriptive Statistics

GROUP	N	Minimum	Maximum	Mean	Std. Deviation	Median
LABIAL UPPER SBS	10	0	4	2.20	1.135	2.000
LABIAL LOWER SBS	10	0	2	.90	.738	1.000
LINGUAL UPPER SBS	10	0	3	1.80	.789	2.000
LINGUAL LOWER SBS	10	1	6	3.80	1.476	4.000

TABLE NO 17 : MANN-WHITNEY TEST TO COMPARE OF SA VALUES BETWEEN GROUPS

Main Group	Variable		Sub Group			p-value (Upper vs Lower)
			Total	Upper	Lower	
Total	Sa value	N		20	20	
		Mean		51.73	60.07	0.841
		Std. Dev		40.328	47.183	
		Median		41.43	52.42	
		1st Quartile		35.67	30.26	
		3rd Quartile		52.24	62.03	
Labial	Sa value	N	20	10	10	0.013
		Mean	39.12	44.09	34.14	
		Std. Dev	14.204	10.538	16.121	
		Median	36.34	42.93	30.26	
		1st Quartile	29.24	36.89	26.79	
		3rd Quartile	43.94	48.45	34.29	
Lingual	Sa value	N	20	10	10	0.034
		Mean	72.67	59.36	85.99	
		Std. Dev	55.631	56.506	54.285	
		Median	55.89	38.52	59.46	
		1st Quartile	38.52	33.80	54.71	
		3rd Quartile	72.49	59.18	90.95	
p-value (Labial vs Lingual)			0.006	0.496	0.001	

TABLE NO 18 : MANN-WHITNEY TEST TO COMPARE OF SZ VALUES BETWEEN GROUPS

Main Group	Variable		Sub Group			p-value (Upper vs Lower)
			Total	**Upper**	**Lower**	
Total	Sz value	N		20	20	
		Mean		295.11	302.59	0.820
		Std. Dev		267.322	243.513	
		Median		224.09	278.65	
		1st Quartile		191.89	144.97	
		3rd Quartile		289.03	374.29	
Labial	Sz value	N	20	10	10	0.041
		Mean	190.02	230.49	149.55	
		Std. Dev	95.060	58.655	109.532	
		Median	180.74	218.07	144.97	
		1st Quartile	138.50	180.41	58.39	
		3rd Quartile	237.03	281.82	181.07	
Lingual	Sz value	N	20	10	10	0.023
		Mean	407.68	359.73	455.62	
		Std. Dev	311.157	371.675	247.274	
		Median	314.38	226.70	347.82	
		1st Quartile	222.35	192.66	314.48	
		3rd Quartile	449.47	297.82	470.59	
p-value (Labial vs Lingual)			<0.001	0.450	0.001	

TABLE NO 19 : ADHESIVE REMNANT INDEX SCORE CHI SQUARE TEST WAS USED TO CHECK FOR DIFFERENCE BETWEEN THE GROUPS FOR REMNANT SCORE.

LABIAL AND LINGUAL

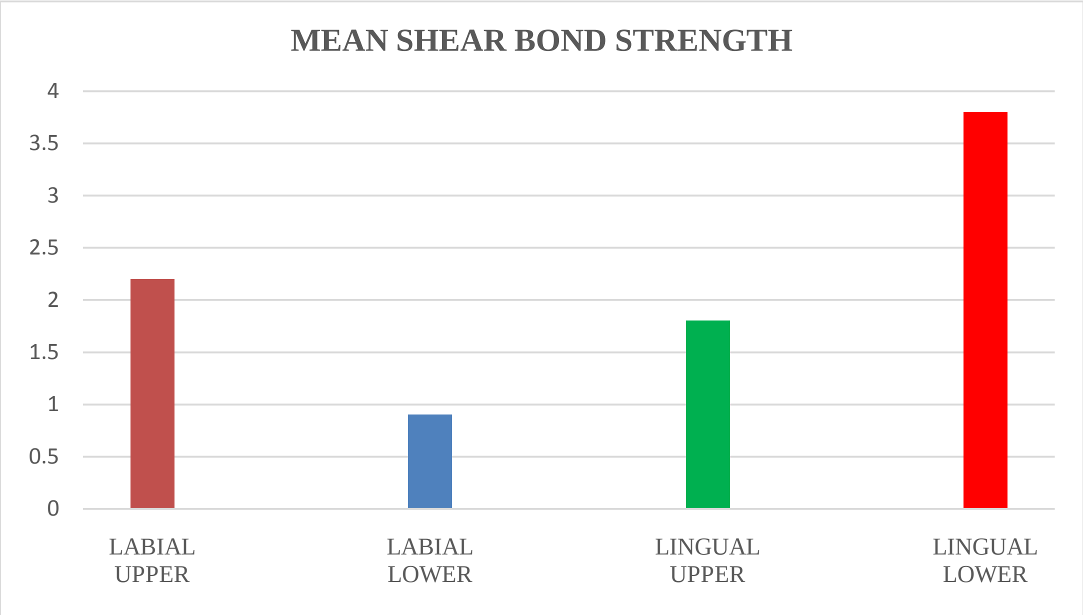
		ADHESIVE REMNANT SCORE				Total	p-VALUE
		.00	1.00	2.00	3.00		
GROUP	LABIAL	0	0	10	10	20	.002
	LINGUAL	4	7	4	5	20	
Total		4	7	14	15	40	

UPPER AND LOWER

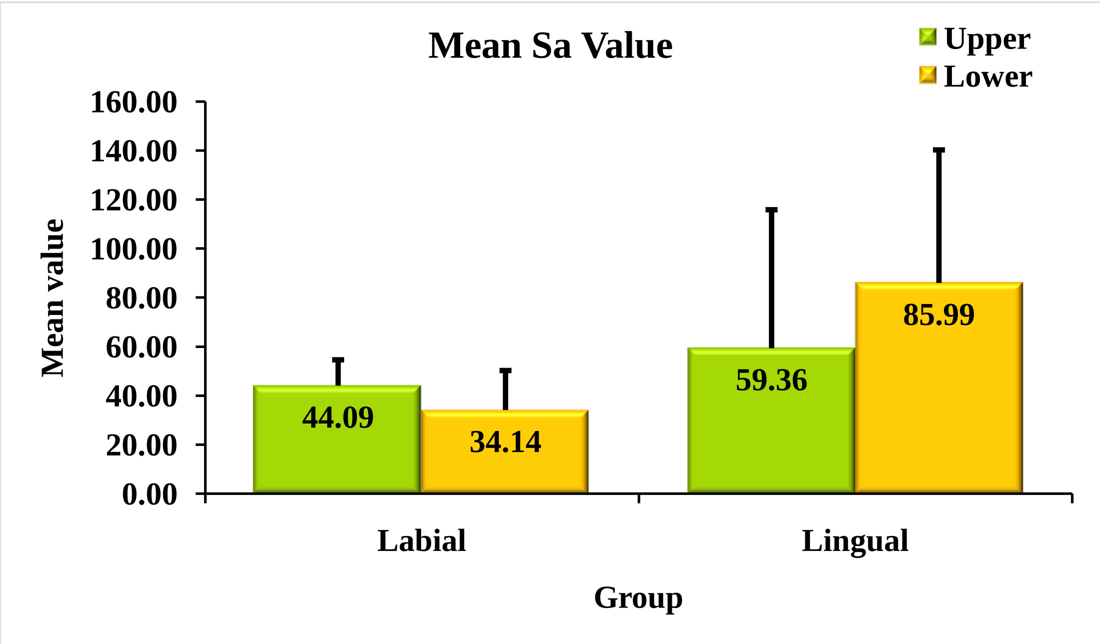
		ADHESIVE REMNANT SCORE				Total	p-VALUE
		.00	1.00	2.00	3.00		
GROUP	LABIAL UPPER	0	0	4	6	10	.044
	LABIAL LOWER	0	0	6	4	10	
	LINGUAL UPPER	2	3	3	2	10	
	LINGUAL LOWER	2	4	1	3	10	
Total		4	7	14	15	40	

GRAPHS

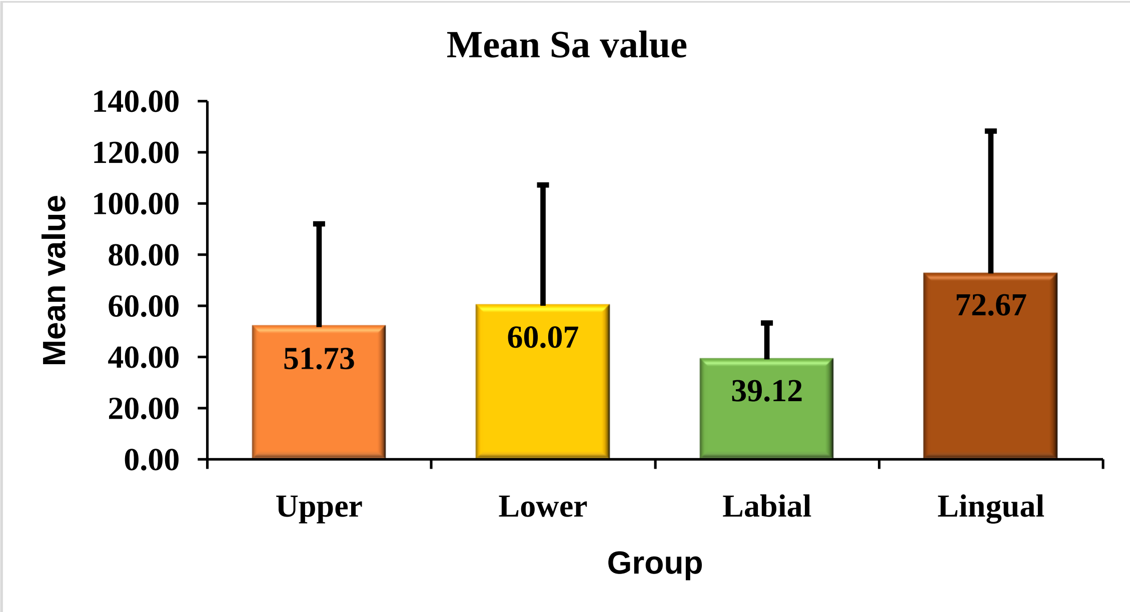
GRAPH 1: SHOWS THE MEAN SHEAR BOND STRENGTH BETWEEN LABIAL AND LINGUAL MAXILLARY AND MANDIBLE BRACKETS.



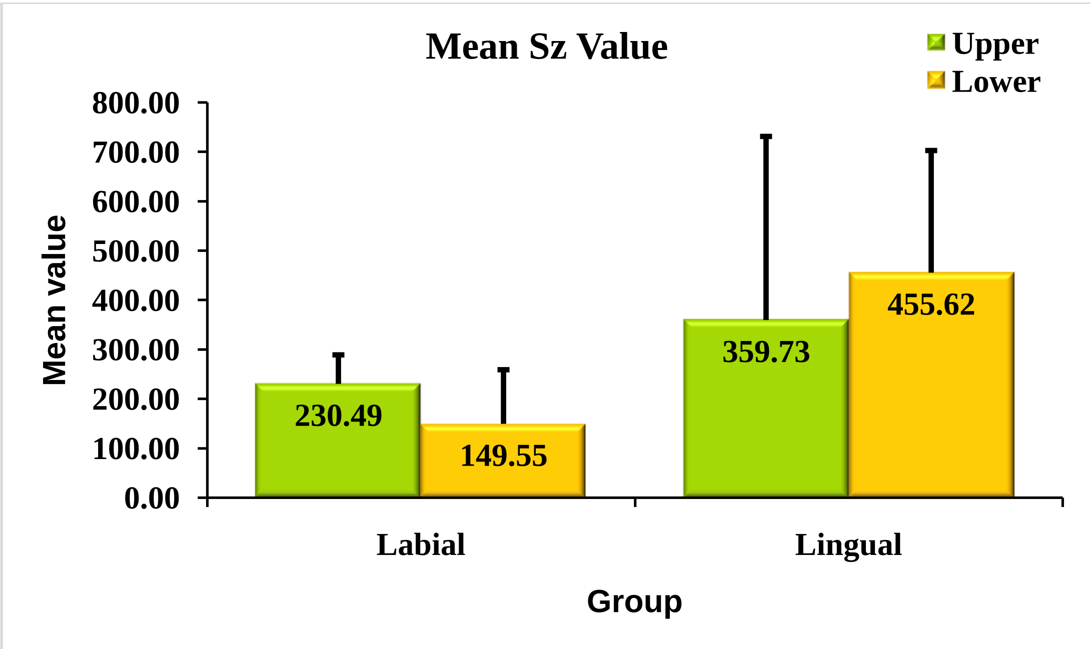
GRAPH 2: SHOWS THE MEAN SURFACE CHANGES Sa VALUE OF LABIAL AND LINGUAL MAXILLARY AND MANDIBLE BRACKETS.



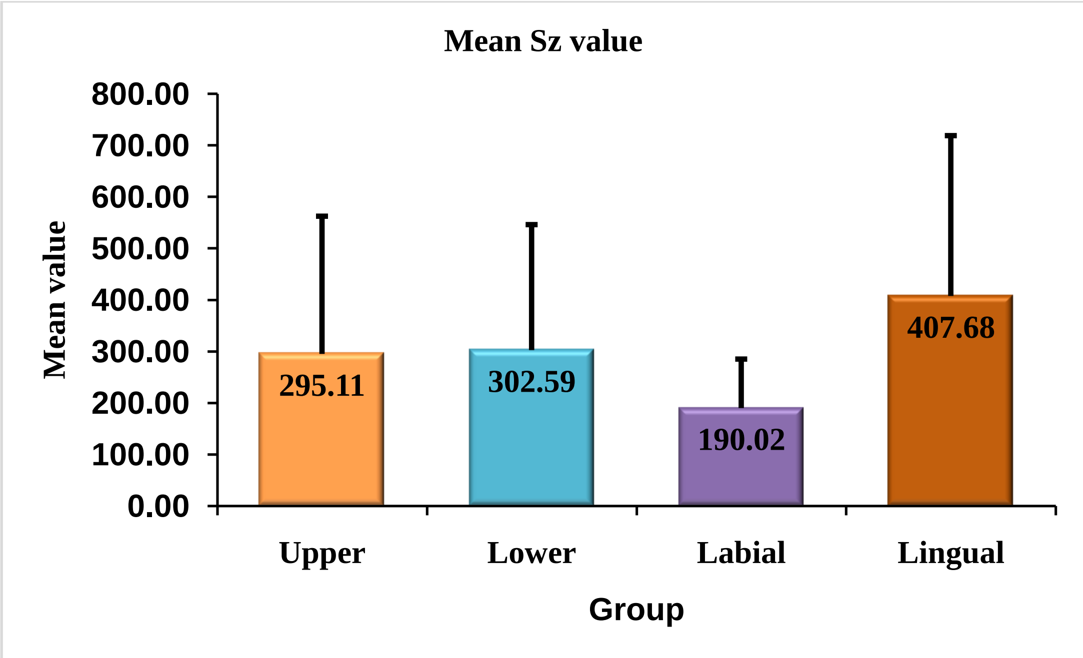
GRAPH 3: SHOWS THE INDIVIDUAL SURFACE CHANGES Sa VALUE BETWEEN LABIAL AND LINGUAL MAXILLARY AND MANDIBLE BRACKETS.



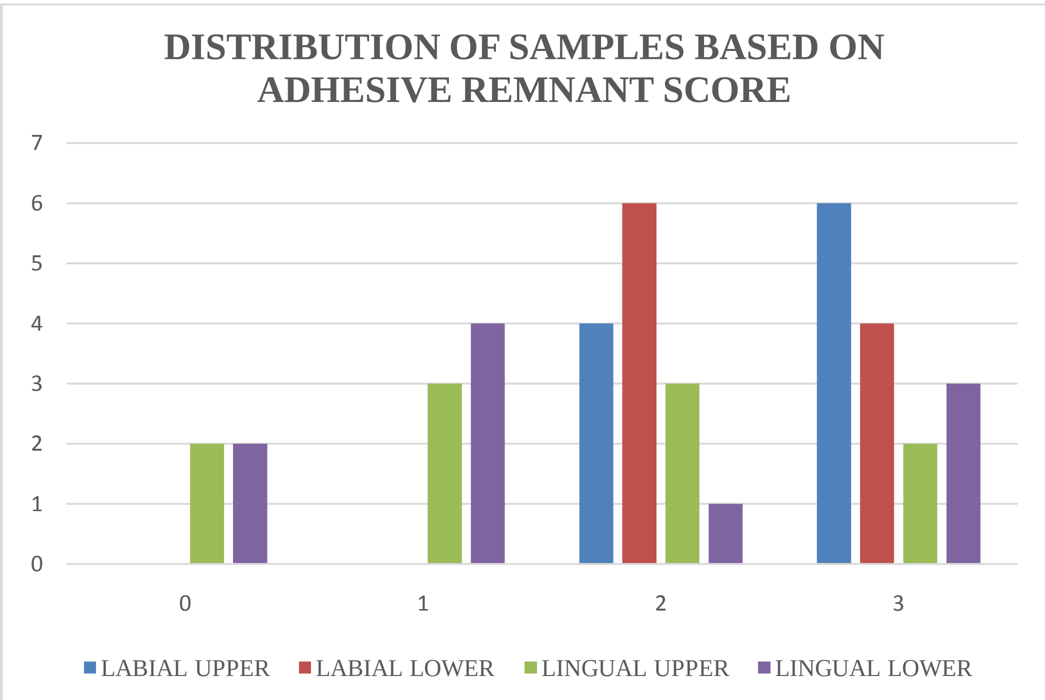
GRAPH 4: SHOWS THE MEAN SURFACE CHANGES Sz VALUE OF LABIAL AND LINGUAL MAXILLARY AND MANDIBLE BRACKETS



GRAPH 5: SHOWS THE INDIVIDUAL SURFACE CHANGES Sz VALUE BETWEEN LABIAL AND LINGUAL MAXILLARY AND MANDIBLE BRACKETS.



GRAPH 6: SHOWS THE ADHESIVE REMNANT INDEX SCORE BETWEEN LABIAL AND LINGUAL MAXILLARY AND MANDIBLE BRACKETS.



DISCUSSION

Every orthodontist and orthodontic patient prefer the best treatment in a shorter duration of time but orthodontic treatment time can be greatly influenced by the frequency of debonding occurring during treatment that can lead to lack of progress in the treatment and some cases even relapse. Therefore bond strength between the bracket and enamel has become an important issue in clinical practice.

The direct bonding of orthodontic brackets has revolutionized and improved the efficiency of the clinical practice. This procedure due to its simplicity and reduced time was immediately and widely accepted by all the orthodontists [37]. Since then, there has been a significant improvement in this method. Etching tooth surfaces with phosphoric acid to the bond acrylic resin to tooth enamel was introduced in 1955 by Buonocore [39]. This procedure was not widely accepted until the late 1970s. Acid etching differentially dissolves enamel crystals in the prism structure; this results in a roughened surface amenable to micromechanical retention. Acid-etching creates a porous enamel surface layer that ranges in depth from 5 to 50 m. Shear bond strengths generally range from 20 to 25 mpa when the resin-based composite is bonded to enamel etched with 37% phosphoric acid. Numerous studies were conducted to improve the bond strength by varying the acid etching technique, adhesive material, and bracket base design.

Initially, studies were done to increase the bond strength by altering the etching time and acid concentrations. The results of these studies show that there was significant enamel loss occurring, which made the enamel surface more susceptible to decalcification [38]. Thus, to conserve the tooth structure, the focus was shifted in developing a stronger adhesive and a better bracket base design to increase the bond strength.

As the nature of forces of orthodontic brackets is subjected to a complex of shear, tensile and torsion, the purpose of our in-vitro study was to evaluate the shear bond strength of labial and lingual brackets and to assess the surface changes of enamel. One of the main factors for bond failure is the application of force and strength of bonding material.

Shear bond strength (SBS) is the main factor, concerned with the evolution of bonding materials. The sufficient bracket bond strength is essential for orthodontic treatment, which means that bonded brackets have to withstand the forces of occlusion during the treatment, mastication, and archwire stress while allowing for biomechanical control. The bracket bond must resist these multiple forces in the complex oral environment, within the moisture and the rapid temperature and pH changes. The poor bond strength and repeated bond failures result in increased treatment time and cost for the orthodontist and the patient. Hence in this study shear bond strength of the bonding material is analyzed with two brackets systems in two different areas of the tooth. In vitro studies provide us with valuable information about the amount of controlled force lead to a bond failure and which protocol could give the clinically desired bond strength, and to guide clinicians about the condition of enamel after debonding.

The Clinical incidence of orthodontic bracket bond failure is higher for posterior teeth. Various reasons have been postulated as causes for this difference including (1) the existence of greater masticatory forces in the posterior region of the mouth, (2) the different etching patterns produced on different teeth by acid conditioning, and (3) the increased difficulty in maintaining a dry field posteriorly. Bond strength determines the amount of force delivered and also affects the treatment duration. Shear bond strength depends on various factors including the adhesive properties of the bonding materials, the attachment at the different interphases such as the tooth to composite interphase and the composite to bracket interphase, as well as the polymerization of the composite bonding material. The bonding procedure involves etching, primer solution, and adhesive application followed by composite application. Different generations of adhesives were developed to improve the bond strength and to reduce the duration. There is a search for methods to improve the bond strength to enhance the treatment outcome. Hence in this study, the shear bond strength of stainless steel labial and lingual brackets bonded to premolars was evaluated and the surface changes on enamel were assessed.

The present study was carried to evaluate the difference in shear bond strength between labial and lingual stainless steel brackets using enlight composite resin (ormco) with regular bonding procedure. In this study, all the procedures were done by the same individual under the same environment. 37% phosphoric acid etching was done in all the samples. The bonding agent applied was the same in all samples and cured. Pinhead Composite resin was taken and cured in all samples. In our study, we have used ormco company bonding agent and composite resin. Stainless steel brackets were bonded to both labial and lingual tooth surfaces. Several studies were done to study the influence of bracket base design. It was found that as the retentive surface area of the bracket base was reduced for an esthetic purpose, the base design and the surface morphology greatly influenced the bond strength. Several manufacturers came up with different bracket base designs and claimed to be superior to the others. Originally, metal brackets were fabricated with perforated backings that had 12 to 16 holes per bracket and the bonding resin would seep through these perforations and secure the bracket. The problem with this type of bracket was the decreased bond strength due to less number of retentive grooves to hold the adhesive. Common base design, which most orthodontists prefer to use is the mesh base bracket that has a mesh welded to the base to provide better mechanical interlocking of the resin to the bracket. These brackets are manufactured by using bracket dies, the fine meshes are then pressed under heat to the foil having various thicknesses. Regarding the bracket system used the labial and lingual bracket system used in our study is ORMCO labial stainless steel and ORMCO STB lingual stainless steel brackets. The7th generation brackets are manufactured by the casting process and STB manufactured milling process and which were customized by composite as an intermediary medium for customization done by TARG which is by the study conducted by Wang et al [40]. They concluded that the size and design of a bracket base can affect the bond strength which was also by the studies conducted by Maccoll et al[41]. There are not many studies in the literature which compared the lingual brackets with labial brackets. Hence in our study, we evaluated the SBS of the labial and lingual bracket.

WITH REGARDS TO LABIAL BRACES:

- Labial braces are much less expensive than lingual braces
- Labial braces require visits every 8-12 weeks as opposed to every 6-8 weeks for lingual braces

- The treatment time for labial braces is usually about 3-5 months shorter than for lingual braces
- Labial braces are mechanically superior in most cases, and often result in a more excellent final result
- Labial braces are more visible

WITH REGARDS TO LINGUAL BRACES:

- They are less visible
- There is a lower risk of visible decalcification caused by poor oral hygiene
- It is easier for the orthodontist to evaluate the aesthetics of the smile
- We often have to put clear buttons on the outside of some upper teeth. The elastics that are worn on these buttons are visible
- Sometimes the upper lingual braces have to be removed and replaced with labial braces in the last 3-6 months of treatment for the best result (no extra charge).

ADHESIVE AND BOND STRENGTH:

The scientific literature has thoroughly documented the importance of adhesion between brackets and enamel surfaces. Sorel et al investigated the dependency of adhesive forces on the type of bracket base, determining the effect on the adhesive failure area and enamel behavior after debonding. Bishara et al[5] conducted research aimed at explaining the relevance of bracket base mesh type in determining the entity of the forces that the adhesive system can produce. The experimental research carried out in the present study focused on the evaluation of the adhesive performance of lingual brackets as opposed to labial brackets since a comparison between labial and lingual appliance would be of great interest.

Bond strength of orthodontic brackets has been studied extensively, with a wide range of data and publications available. The ideal orthodontic bond should ensure that the bracket remains attached to the tooth surface for the duration of treatment, withstanding the application of forces to achieve tooth movement and functional forces and at the end of treatment, the attachment should be easily removed without damage to the tooth surface. Considerable research has been undertaken to examine the *in vitro* shear bond strengths of different orthodontic brackets when bonded to extracted teeth. There are advantages and disadvantages to such testing and its relevance to clinical practice is questionable. In vitro shear bond strength testing does not exactly replicate the clinical situation; however, it does indicate potential or anticipated bond strengths in vivo. In reality, potential loading would be complex with the following acting as stresses on the enamel - adhesive and adhesive - bracket interfaces:

- Multi-directional loading during function e.g. eating
- Stress introduced by the application of orthodontic force e.g. following ligation of an archwire.

Bonding is the mechanical locking of an adhesive to the irregularities in the enamel surface of the tooth and mechanical locks formed in the base of the orthodontic attachment. Surface bonding depends upon tooth surface and its preparation, the technique of bonding and bonding material. There are different types of resins available for orthodontic bonding – Acrylic resin and Diacrylate resins. Depending upon the curing types it is divided as Self cure composite and light cure composites. With the advent of newer techniques, new bonding materials and bonding techniques have also emerged. In spite of this bonding, failures have been reported during orthodontic treatment which is multifactorial. One of the main factors for bond failure is the application of force and strength of bonding material. There are different types of forces like tensile, compressive, shear. Hence in this study shear bond strength of the bonding material is analyzed with two brackets systems in two different areas of the tooth.

Our literature review revealed that both material- and teeth-related factors influenced the shear bond strength of orthodontic brackets. However, this cannot be considered as a comprehensive review because it has not included all the material-related, teeth-related and other miscellaneous factors that may have a direct or indirect influence on the SBS of orthodontic brackets. Within its limitations, using the conventional acid-etch technique, ceramic brackets and bonding to non-fluorotic teeth were reported to have a positive influence on the SBS of orthodontic brackets, but higher shear bond strength found on using ceramic brackets can be dangerous for the enamel. More research is required to develop our understanding of the role of these factors in influencing the shear bond strength of orthodontic brackets.

This was an in vitro study, care should be taken in the interpretation of the results, which may differ from those results obtained in the oral environment.

The shear bond strength is evaluated using the Instron universal testing machine. In a review of the literature, we found many reports of tests of in-vitro bond strengths in orthodontics. Laboratory studies were designed to evaluate bond strengths and provide guidance for the selection of bracket adhesive systems. In a review of 66 articles, Fox et al [42] showed that 58 studies were conducted with testing machines. The problem arises with the precise relationship of the bracket and its link with the testing machine, which might be not reliable. This indicates the importance of mounting the specimen on a universal joint to minimize variation in the direction of the debonding force. The values are recorded -

Compressive load at Break (Standard) (N). This study tested for bond strength between labial stainless steel and lingual stainless steel brackets where one type of bonding system is used by the same operator.

- The results of this study showed that the mean shear bond strength value of labial brackets is 1.55(±1.146) and lingual brackets are 2.80 (±1.542). The p-value is 0.010 which reveals that it is statistically significant.SBS value of lingual brackets is higher compared to labial brackets. It could be assumed that the morphological dissimilarities between the lingual and buccal surfaces have affected the bond strength of brackets. The labial surface of the lower first premolar is inclined so lingually that the tip of the buccal cusp lies almost above the center of the cervical cross-section of the tooth. The lingual surface is slightly narrower. The lingual surface is lower than the labial surface.
- The mean value of labial upper brackets is 2.20(±1.135) and labial lower brackets are 0.90(±0.738). The p-value is 0.010 which reveals that it is statistically significant. The shear bond strength value of labial upper brackets is higher compared to labial lower brackets.
- The mean value of lingual upper brackets is 1.80(±0.789) and lingual lower brackets are 3.80(±1.476). The p-value is 0.004 which reveals that it is statistically significant. SBS value of

lingual lower brackets is higher compared to lingual upper brackets.

- The mean value of labial upper brackets is 2.20(±1.135) and lingual upper brackets are 1.80(±0.789). The p-value is 0.298 which reveals that it is statistically insignificant. SBS value of labial upper brackets is higher compared to lingual upper brackets.
- The mean value of labial lower brackets is 0.90(±0.738) and lingual lower brackets are 3.80(±1.476). The p-value is 0.001 which reveals that it is statistically significant. SBS value of lingual lower brackets is higher compared to labial lower brackets.

The result obtained in our study is statistically insignificant but clinically significant due to the smaller sample size. The mean average bond strength required for labial brackets is 1.55mpa and lingual brackets are 2.80mpa. The results suggest that bonding with lingual brackets is advantageous in terms of decreased incidence of debonding and enamel damage resulting in better treatment outcomes. Moreover, the shear bond strength of lingual brackets on lower premolars was higher compared to that of upper premolars suggesting its capacity to withstand more masticatory forces.

The statistical analysis of the shear bond showed that there was no statistical difference between labial and lingual brackets.

Hence lingual brackets can be preferred over labial brackets for esthetic reasons. The increase of bonding strength of brackets can lead to a decrease in the percentage of bracket debonding. this, in turn, has the advantage of saving time and preserving healthy enamel surface. however, excessive bond strength high values are undesirable because of the increased debonding forces needed, resulting in possible damage in enamel.

A study showed that to have a satisfying treatment outcome bond strength of 5.9-7.8 mpa is required in vitro. Another study showed that up to 17 mpa are recommended values of bond strength whereas higher values are considered too high for orthodontic use and could result in enamel fracture during debonding [8] . However other studies reported that increased number of enamel fracture associated with bond strength exceeding 13.5 mpa. In the present study, the SBS of the brackets ranged between 1.55 mpa and 2.80 mpa which is lower than what is reported in the aforementioned studies.

We used the SBS test that has acceptable accuracy and reproducibility using a crosshead speed of 1mm/min .however, crosshead speeds of 0.1-10 mm/min have been used for SBS testing but these values do not correspond to values in the clinical oral environment because the speed of mastication is in the range of 81-100 mm/s or 4860-6000mmm/min with a frequency of 1.03-1.2 Hz.

The direction of application of the debonding force in this study was standardized as the previous study reported that shear bond strength measurements were significantly influenced by the direction of the debonding force.

The bond strengths recorded in this study ranged from 1.55 to 2.80 mpa compared with 18 to 25 mpa reported in previous studies. These differences may be attributed to variations in types of tested samples (human or animal teeth, plastic cylinder, or a combination of these), types of teeth (incisor, canine, premolar, or molar; young or old permanent teeth, deciduous teeth, or a combination of these) other possible factors are the type and size of bracket base, contour of tooth surface, etching times, concentrations of etchant, pretreated condition (humidity, temperature, and duration of water bathing), rebonding of tooth surface, recycling of bracket, types of resin or testing speed of the Instron.

Pickett et al [6] modified an intraoral debonding device to determine the actual bond strength in vivo. Their study provided actual in-vivo bond strength values when compared with other studies that relied on in-vitro results to assess bond strengths required for clinical success. In our study, the brackets were debonded under in vitro condition and the results indicated that in vivo debonding forces were significantly lower than those measured in vitro.

Since the contours on the lingual and buccal surfaces of premolars are different, they may affect the result of bond strength. Hence the premolars of the lingual bonding group were selected for careful adaptation of the buccal bracket base to the lingual surface with Howe pliers before bonding [2]. From the result of the present test, the bond strength on lingual surfaces is the same as that on the buccal surfaces. The bonding techniques currently accepted for lingual surfaces were the same as those for the buccal surfaces. This is despite an earlier study by Chumak et a1[12] with adapted brackets that found the bond strength on the lingual surface of maxillary or mandibular premolars was statistically greater than that on the buccal surface.

Reynold [8] in his study has suggested 5.9 to 7.8mpa as the optimal bond strength required for bonding of brackets to the enamel. The results showed that the laser-etched base bracket had more than optimal bond strength required for successful bonding. This increase in the bond strength of the laser-etched base bracket may be due to the increased surface area available due to the absence of welding tags and mesh wires that reduced the surface area for adhesive adhesion.

Wei Nan Wang [40] stated that relative bond strengths were 7.2 MPa and 7.0 MPa for the lingual and buccal surfaces, respectively. The bond strength on the lingual surface was not statistically different from that on the buccal surface. These differences may be attributed to variations in types of tested samples (human or animal teeth, plastic cylinder, or a combination of these), types of teeth (incisor, canine, premolar, or molar; young or old permanent teeth, deciduous teeth, or a combination of these) other possible factors are the type and size of bracket base, contour of tooth surface, etching times, concentrations of etchant, pretreated condition (humidity, temperature, and duration of water bathing), rebonding of tooth surface, recycling of bracket, types of resin or testing speed of the Instron.

When compared with these above studies the result in our study showed the mean shear bond strength of the labial stainless steel bracket is 1.55 mpa and that of lingual stainless steel bracket is 2.80mpa.

ADHESIVE REMNANT INDEX SCORE:

Lesser ARI scores are clinically advantageous, as the least adhesive remnant found on the substrate base, make clean-up of the tooth surfaces easier and faster. Higher ARI scores indicate breakage at adhesive-bracket interface, leaving much of remnants and thus requiring a lot of clean-up of the tooth surfaces. In this study there is statistically significant difference between the labial and lingual groups with regard to adhesive remnant score - p value is 0.002 because of the tooth morphology. There is statistically significant difference between the upper and lower groups also - p value is 0.044.

SURFACE CHANGES ON ENAMEL:

This current study identified surface changes of enamel after debonding and roughness measurements from the center of debonded enamel samples were calibrated using profilometric study. The amount of enamel wear after debonding was assessed.

Surface changes of enamel can be assessed using various methods like Stereomicroscope, Transmission Electron Microscope, and Scanning Electron Microscope. All these will not be interpreted as three dimensional. So, the exact amount of enamel damage cannot be assessed. So far, no study has been done to evaluate the surface roughness with profilometry. So, in this study Profilometry is used to evaluate the surface roughness of the enamel in a 3dimensional image. Profilometry is a technique used to extract topographical data from a surface. This can be a single point, a line scan or even a full three-dimensional scan. The purpose of profilometry is to get surface morphology, step heights and surface roughness. This can be done using a physical probe or by using light.

Morphological changes in the topography of dental surfaces, especially if related to enamel loss and roughness, are of considerable clinical importance. Optical profilometry can provide accurate qualitative and quantitative nanoscale data during repeated measurements of the same tooth area, irrespective of whether the surface is flat, curved, stepped, rough, or smooth. The stability and repeatability of this assessment technique enable a more comprehensive understanding of the effects of orthodontic bonding on teeth. The results confirmed the precision of the noncontact 3D optical profilometric method in evaluating changes on enamel surfaces after bracket debonding. This high-precision instrument enables accurate nondestructive qualitative and quantitative measurements to be made of dental hard tissues and is, therefore, a valuable tool for use in dentistry applications.

Optical profilometers scan surfaces with optical probes that send light interference signals back to the profilometer detector via an optical fiber. Fiber-based probes can be physically located hundreds of meters away from the detector enclosure, without signal degradation. The additional advantages of using fiber-based optical profilometers are flexibility, long profile acquisition, ruggedness. With the small diameter of certain probes, surfaces can be scanned even inside hard-to-reach spaces, such as narrow crevices or small-diameter tubes. Because these probes generally acquire one point at a time and high sample speeds, acquisition of long (continuous) surface profiles is possible. Scanning can take place in hostile environments, including very hot or cryogenic temperatures, or radioactive chambers, while the detector is located at a distance, in a human-safe environment. Fiber-based probes are easily installed in-process, such as above moving webs or mounted onto a variety of positioning systems[30].

Surfaces that have higher and lower step height deviations have higher Sa roughness values and therefore classed as rougher. Previous erosion studies have shown that polished enamel becomes rougher after erosion. It could be suggested that this is due to polished enamel having less textural features at baseline than unpolished enamel. The result of our study is obtained as :

- The mean value of labial brackets is 39.12 (±14.204)and lingual brackets are 72.67(±55.631). There is a statistically significant difference in Sa value between Labial brackets and lingual brackets (p-value is 0.006).
- **T**he mean value of labial upper brackets is 44.09 (±10.538) and labial lower brackets are 34.14(±16.121). There is a statistically significant difference in Sa value between Labial upper brackets and labial lower brackets (p-value is 0.013).
- The mean value of lingual upper brackets is 59.36 (±56.506)and lingual lower brackets are 85.99(±54.285). There is a statistically significant difference in Sa value between Lingual upper brackets and lingual lower brackets (p-value is 0.034).

- The mean value of labial upper brackets is 44.09 (±10.538) and lingual upper brackets are 59.36(±56.506). The p-value is 0.496 which reveals that it is statistically insignificant.
- The mean value of labial lower brackets is 34.14 (±16.121) and lingual lower brackets are 85.99(±54.285). There is a statistically significant difference in Sa value between Labial lower brackets and lingual lower brackets (p-value is 0.001).
- The mean value of labial brackets is 190.02 (±95.060)and lingual brackets are 407.68(±311.157). The p-value is 0.001 which reveals that it is statistically significant.
- The mean value of labial upper brackets is 230.49 (±58.655)and labial lower brackets are 149.55(±109.532). The p-value is 0.041 which reveals that it was statistically significant.
- The mean value of lingual upper brackets is 359.73 (±371.675) and lingual lower brackets are 455.62(±247.274). The p-value is 0.023 which reveals that it is statistically significant.
- The mean value of labial upper brackets is 230.49(±58.655) and lingual upper brackets are 359.73(±371.675). The p-value is 0.450 which reveals that it is statistically insignificant.

- The mean value of labial lower brackets is 149.55(±109.532) and lingual lower brackets are 455.62(±247.274). The p-value is 0.001 which reveals that it is statistically significant.

Our results suggest that there has been a structural breakdown at a profile level and the roughness changes we have identified are occurring within these areas of tissue loss. A recent study by Hara et al investigated the use of surface texture parameters to differentiate between different wear patterns using polished and unpolished enamel and dentine samples. The authors were unable to differentiate between sound and worn lesions by measuring Sa roughness of unpolished enamel[31]. However, there were differences compared to the methods used in our study. They immersed samples in acid four times a day for 2 minutes without agitation. As well as a reduced immersion time compared to our study, agitation can also affect erosive wear. Agitation increases fluid dynamics which facilitates more tissue loss. Hara et al also immersed their samples in a remineralizing solution. Furthermore, the filtering used in the analysis for Sa roughness in the study by Hara et al was not specified and may have influenced the outcome.

A computerized graphic image of enamel surfaces revealed that normal enamel surface (CS group) showed short and repetitive spiky peaks; while debonded enamel surface showed irregular peaks. the Sa value describes the surface profile extent above the mean line and the Sz value, the maximum depth of profile, These results agree with previous studies that indicated that the amounts of enamel loss are proportional to the Sa and Sz values. In this study, the greatest average enamel loss represented a minimal loss of enamel structure and was less than found in previous studies that have reported enamel losses of between 2.9 and 56 µm[33]. Moreover, most of the techniques used previously only allow a limited number of measurements of the tooth surface to be made, so that the results could be influenced by wider alterations on the tooth surface caused by the rotary instruments used to remove remnants of adhesive.

In conclusion, this study shows that the shear bond strength for lingual stainless steel brackets is higher than labial stainless steel brackets and between groups, the labial upper stainless steel brackets have more shear bond strength than labial lower stainless steel brackets. Lingual lower stainless steel brackets have more shear bond strength than lingual upper stainless steel brackets. The surface changes show that the lingual stainless steel brackets show more damage to the enamel. Labial upper stainless steel brackets have more damage to enamel than the labial lower stainless steel brackets and lingual lower stainless steel brackets show more damage to the enamel than the lingual upper stainless steel brackets.

SUMMARY

This in vitro study was conducted at the Department Of Orthodontics And Dentofacial Orthopedics, Madha Dental College And Hospital Kundrathur, "To compare the shear bond strength of bonded stainless steel labial and lingual brackets was evaluated and the surface changes in enamel was assessed using profilometry".

40 extracted premolar teeth were selected for this study. These teeth were divided into 4 groups as 10 in each group. Group A- Labial maxillary premolar brackets; Group B-Labial mandibular premolar brackets; Group C- Lingual maxillary premolar brackets; Group D- Lingual mandibular premolar brackets. Freshly extracted teeth were cleaned to remove blood or any tissue debris and stored in distilled water solution till the time of bonding procedure. Teeth were then mounted on self-cured, color-coded acrylic blocks of dimensions 35 x 7 x 7mm. The acrylic blocks are color-coded to differentiate between the groups.

The enamel was etched with 37% phosphoric acid gel for 30 seconds, rinsed under running water for 20 seconds, and then dried and moisture-free compressed air for 20 seconds .ORMCO primer was applied to the etched surface and the bracket base as well with the help of an applicator brush. ORMCO adhesive material was next applied to the bracket base directly from the syringe. The adhesive/bracket was cured using an LED (Light-emitting diode) curing unit. The above procedure was done for all samples in

Group-I to Group-IV by the same individual under the same environment.

EVALUATION OF BOND STRENGTH

Debonding was carried out with a universal testing machine (INSTRON, 8874).The samples were then stressed at a crosshead speed of 1mm per minute in a gingival incisal direction, and the maximum force at bond failure was recorded.

EVALUATION OF ADHESIVE REMNANT INDEX:

The samples after evaluation of bond strength, it is subjected to evaluate the remnant index using stereomicroscope.

EVALUATION OF THE SAMPLE FOR PROFILOMETRY ANALYSIS:

The samples were then loaded on to optical profilometry to assess the surface roughness. With this, a 3-dimensional image is captured to identify the surface roughness in terms of extent (Sa) and depth (Sz) of enamel wear.

The following statistical analysis was done to evaluate the results using the software "statistical package for social sciences" SPSS (IBM SPSS Statistics for Windows, Version 25.0, and Armonk, NY: IBM Corp. Released 2017). The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests were done.

CONCLUSION

There was significant difference in shear bond strength between labial and lingual brackets surface. Lingual brackets showed increased shear bond strength when compared to labial brackets. The Adhesive remnant index reported that the failure zone was between the bracket adhesive interfaces.

The surface changes of enamel were also more in lingual brackets when compared to labial brackets, which is also statistically significant. It could be assumed that the morphological dissimilarities between the lingual and labial surfaces have affected the bond strength of brackets.

This study opens a new avenue to explore the possibility of using the various material based labial brackets in lingual side and vice versa and its effect on enamel. Further extensive clinical study is needed to evaluate the performance of the changes in pulp temperature in both anterior and posterior teeth.

BIBILIOGRAPHY

1. **M. Knoll et al .** Shear strength of brackets and posterior teeth bonded to anterior - Am. J. *Orthod. June* 1986 Volume 89 Number 6.
2. **Wei Nan Wang et al.** Comparison of bond strength between buccal surfaces on young premolars - American Journal of Orthodontics and Dentofacial Orthopedics September 1993, Volume 104, No. 3.
3. **Samir E. Bishara et al.** Effect of a self-etch primer/adhesive on the shear bond strength of orthodontic brackets - American Journal of Orthodontics and Dentofacial Orthopedics June 2001 , Volume 119, Number 6
4. **Olivier Sorel et al .** Comparison of bond strength between simple foil mesh and laser structured base retention brackets - American Journal of Orthodontics and Dentofacial Orthopedics September 2002, Volume 122, Number 3.
5. **Bishara SE et al** . Comparison of Shear Bond Strength of Two Self-etch Primer/Adhesive Systems The Angle Orthodontist: January 2006, Vol. 76, No. 1, pp. 123-126.
6. **Jason C. Dorminey et al .** Shear bond strength of orthodontic brackets bonded with a modified 1-step etchant-and primer technique- American Journal of Orthodontics and Dentofacial Orthopedics October 2003, Volume 124, Number 4.
7. **Arndt Klocke, et al.** Bond strength with custom base indirect bonding techniques. Angle Orthod. 2003 Apr;73(2):176-80.

8. **Helen S. I. Grubisa et al.** An evaluation and comparison of orthodontic bracket bond strengths achieved with self etching primer- American Journal of Orthodontics and Dentofacial Orthopedics August 2004, Volume 126, Number 2.

9. **M Dolores Campoy et al.** Effect of saliva contamination on the shear bond strength of orthodontic brackets bonded with a self-etching primer. The Angle Orthodontist 75(5):865-9 · October 2005.

10. **Neslihan Eminkahyagil et al**. Comparison of the shear bond strength of 2 self-etch primer/adhesive systems. Am J Orthod Dentofacial Orthop. 2004 Mar;125(3):348-50

11. **Raed Ajlouni et al**. The use of new self-etching primer/adhesive effects on shear bond strength of orthodontic metal brackets bonded to surface.

12. **Julio Pedra e Cal - Neto et al.** Evaluation of a New Self-etching Primer on Bracket Bond Strength In Vitro. Angle Orthodontist, Vol 76, No 3, 2006.

13. **Manar K.A. Hajrassie et al.** In-vivo and in-vitro comparison of bond strengths of orthodontic brackets bonded to enamel and debonded at various times- American Journal of Orthodontics and Dentofacial Orthopedics Volume 131, Number 3 March 2007.

14. **Nir Shpack et at.** Bracket Placement in Lingual vs. Labial Systems and Direct vs Indirect Bonding- Angle Orthodontist, Vol 77, No 3, 2007.

15. **Tancan Uysal et al.** Evaluation of shear bond strength of metallic and ceramic brackets bonded to enamel prepared with self-etching primer- European Journal of Orthodontics 32 (2010) 214–218.

16. **Elham S. J. Abu Alhaija et al.** Factors affecting the shear bond strength of metal and ceramic brackets bonded to different ceramic surfaces. European Journal of Orthodontics, Volume 32, Issue 3, June 2010, Pages 274–280.

17. **Yasser Lotfy Abdelnaby et al.** Effect of early orthodontic force on shear bond strength of orthodontic brackets bonded with different adhesive systems- American Journal of Orthodontics and Dentofacial Orthopedics Volume 138, Number 2 August 2010.

18. **Mohammed Al-Saleh et al.** Bond strength of orthodontic brackets with new self-adhesive resin cements- American Journal of Orthodontics and Dentofacial Orthopedics Volume 137, Number 4 April 2010.

19. **Rondell Blakey and James Mah et al .** Effects of surface conditioning on the shear bond strength of orthodontic brackets bonded to temporary polycarbonate crowns. American Journal of Orthodontics and Dentofacial Orthopedics July 2010 Volume 138,Issue 1,Pages 72 -78.

20. **Valiollah Arash et al.** Shear bond strength of ceramic and metallic orthodontic brackets bonded with self-etching primer

and conventional bonding adhesives- Electronic Physician January 2017, Volume: 9, Issue: 1, Pages: 3584-3591.

21. **HR. Fattahi et al.** Comparison of Shear Bond Strength of Orthodontic Brackets Bonded with Core Max II and Transbond XT in Fluorosed Teeth and Evaluation of Enamel Damage after Debonding- The Journal of Islamic Dental Association of IRAN (JIDA) Spring 2014 ;26, (1).
22. **Luca Lombardo et al.** Frictional resistance exerted by different lingual and labial brackets: an in vitro study- Lombardo et al. Progress in Orthodontics 2013, 14:37.
23. **Mateus Rodrigues-Tonetto et al.** Bond strength and adhesive remnant index of experimental brackets bonded with self-adhesive resin cement- Rev. Clin. Periodoncia Implantol. Rehabil. Oral Vol. 10(2); 115-117, 2017.
24. **Blerim Mehmeti et al.** Shear Bond Strength of Orthodontic Brackets Bonded to Zirconium Crowns. Acta Stomatol Croat. 2017 Jun; 51(2): 99–105.
25. **Sudhir Sharma et al.** A comparison of shear bond strength of orthodontic brackets bonded with four different orthodontic adhesives. J Orthod Sci. 2014 Apr-Jun; 3(2): 29–33.
26. **Dennis Pham et al.** Comparative evaluation of orthodontic bracket base shapes on shear bond strength and adhesive remnant index: An in vitro study

27. **Sunil Kumar M et al .** Comparative Biomechanics of Labial versus Lingual Fixed Appliances - Journal of Dental & Oro-facial Research Vol 13 Issue 02 Aug 2017.

28. **Ahmad Alobeid et al.** Comparison of the efficacy of tooth alignment among lingual and labial brackets: an *in vitro* study- European Journal of Orthodontics, 2018, 1–6, 2018.

29. **Artun and Bergland (1984)** Reliability of the Adhesive Remnant Index Score System with Different Magnifications. The Angle Orthodontist: July 2009, Vol. 79, No. 4, pp. 773-776.

30. **X.Z. Zhang et al.** Optical Profilometric Study of Changes in Surface Roughness of Enamel during in vitro Demineralization- Caries Res 2000;34:164–174.

31. **C. Ganss et al.** A comparative pro®lometric in vitro study of the susceptibility of polished and natural human enamel and dentine surfaces to erosive demineralization- Archives of Oral Biology 45 (2000) 897±902.

32. **Hyun-Suk Cha et al.** Evaluation of Wear Resistance of Dental Resin Composites with a 3D Profilometer- Received 2 December 2003; revised 28 April 2003; accepted 3 May 2004.

33. **Seong-Sik Kim et al.** Enamel surface evaluation after removal of orthodontic composite remnants by intraoral sandblasting: A 3-dimensional surface profilometry study- American Journal of Orthodontics and Dentofacial Orthopedics July 2007.

34. **E.B. Las Casas et al.** Enamel wear and surface roughness characterization using 3D profilometry- E.B. Las Casas et al. / Tribology International 41 (2008) 1232–1236.

35. **Fabiano G. Ferreira et al.** Qualitative and quantitative evaluation of human dental enamel after bracket debonding : a noncontact three-dimensional optical profilometry analysis- Clin Oral Invest - DOI 10.1007/s00784-013-1159-0.

36. **Francesca Mullan et al.** Measurement of surface roughness changes of unpolished and polished enamel following erosion - org/10.1371/journal.pone.0182406 August 3, 2017.

37. **Dickinson P.T. and powers** J.M :Evaluation of fourteen direct -bonding orthodontic bases. Am J Orthod Dentofacial Orthop 1980:78;630-639.

38. **K.J Nordenvall, M.Brannstrom ,and O.Malmgren:** Etching of deciduous teeth and young and old permanent teeth. Am J Orthod Dentofacial Orthop; Jul ;1980;78 10: 99-108.

39. **Buonocore M.G.:** A simple method of increasing adhesion of acrylic filling materials to enamel surface. J. Dental Research, 1955; 34: 849-53.

40. **Wei Nan Wang** : Bond strength of various bracket base design - American Journal of Orthodontics and Dentofacial Orthopedics Volume 125, Number 1-January 2004.

41. **G. A. MacColl**; The relationship between bond strength and orthodontic bracket base surface area with conventional and microetched foil-mesh bases - American Journal of

Orthodontics and Dentofacial Orthopedics Volume 113, No. 3-March 1998.

42. **Fox et al** -Shear Bond Strength Comparison between Two Orthodontic Adhesives and Self-Ligating and Conventional Brackets -Angle Orthodontist, Vol 77, No 4, 2007.

43. **Leon V. Siomka and Powers** : In Vitro bond strength of treated direct -bonding metal bases. Am J Orthod Dentofacial Orthop 1985 aug;88(2) :133-136.

44. **R. Blakey and J. Mah.** Effects of surface conditioning on the shear bond strength of orthodontic brackets bonded to temporary polycarbonate crowns. AJO & DO.2010;138 :72–8.

45. **Surbhi Kakar, Mirudula Goswami, Anoop kinase.** Dentin bonding agents I; complete classification –A Review.WJD.2011;2(4):367-70.

46. **Elham S. J. Abu Alhaija, Issam A. Abu AlReesh and Ahed M. S. AlWahadni.** Factors affecting the shear bond strength of metal and ceramic brackets bonded to different ceramic surfaces.EJO. 2010;32: 274–0.

47. **I. R. Reynolds**. A Review of Direct Orthodontic Bonding.1975: 3: 171-8.

48. **A.John Gwinnett.** A comparison of shear bond strengths of metal and ceramic brackets. AJ O & D O.1988;93:346-8.

ANNEXURE

ANNEXURE I

MADHA DENTAL COLLEGE & HOSPITAL,

Kundrathur - Chennai-600069

Ref No : MDCH/IEC/2018/07 DATE : 02 / 03 / 2018

(Sub :IEC review of the research proposals)

Title of the work : COMPARISON OF SHEAR BOND STRENGTH AND SURFACE CHANGES WITH LABIAL AND LINGUAL BRACKETS - IN VITRO STUDY

Principal investigator: Dr. A. SARANYA, 1st YEAR MDS

Department: Department of Orthodontics and Dentofacial orthopedics, Madha Dental College & Hospital, Chennai-600069

The request for approval from the Institutional Ethical Committee (IEC) considered at the Institutional Ethics Committee meeting held on the 02 / 03 / 2018 at Madha Dental College and the documents related to the study referred above were discussed and reported to us through your letter dated 26/2/18 have been reviewed. The decision of the members of the committee, the secretary and the Chairperson IEC of Madha Dental College is here under:

Advised To Proceed With the Study

The principal investigators and their team are advised to adhere to the guidelines given below:

1. You should get detailed informed consent from the patients/participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the institution or the government.
3. You should inform the IEC in case of any change of study procedure, site and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s).
6. You should complete the work within the specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/Professor.
11. The investigator and guide should each declared that no plagiarism is involved, in this whole study and enclose the undertaking in dissertation/thesis.

Secretary 02/03/18
Prof.Dr.M.C. Sainath MDS,
PRINCIPAL
MADHA DENTAL COLLEGE & HOSPITAL
Kundrathur, Chennai 600 069.

Chairman
Prof.Dr.Gajendran,M.D.,
DEAN
MADHA MEDICAL COLLEGE & RI

ANNEXURE II

ए आर एस टी पी एस

(सेंट्रल इंस्टिट्यूट ऑफ प्लास्टिक इंजीनियरिंग एंड टेक्नालॉजी की आर. एंड डी. इकाई)

रसायन एवं पेट्रोरसायन विभाग, रसायन एवं उर्वरक मंत्रालय, भारत सरकार

टी वी के इन्डस्ट्रीयल एस्टेट, गिण्डी, चेन्नै – 600 032.

ADVANCED RESEARCH SCHOOL FOR TECHNOLOGY & PRODUCT SIMULATION

(Central Institute of Plastics Engineering & Technology)

Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Govt. of India

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07.08.2019

TO WHOM IT MAY CONCERN

This is to certify that **Dr. Saranya. A**, Post graduate student of Department of Orthodontics and Dentofacial Orthopedics, Madha Dental College and Hospital, Kundrathur, Chennai has carried out the Shear bond test in INSTRON 8874 machine and Surface roughness measurement in Taylor & Hobson machine was done at the division of CIPET: SARP-ARSTPS (R&D), Chennai for her thesis entitled **"Shear bond strength and surface changes in labial and lingual brackets – In-Vitro Study".**

This is for your information

Thanking you

With regards

Dr. R. Joseph Bensingh
Sr. Scientist & In-charge
CIPET: SARP-ARSTPS
Guindy, Chennai-32

सिपेट एस ए आर पी ए आर एस टी पी एस
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चेन्नै - 600 032

मुख्यालय : सिपेट, गिण्डी, चेन्नै - 600 032. **Head Office :** CIPET, Guindy, Chennai - 600 032.

केन्द्र : अहमदाबाद, अमृतसर, औरंगाबाद, अगरतला, बद्दी, बालासोर, बेंगलुरु, भोपाल, भुवनेश्वर, चन्द्रपुर, चेन्नै, गुरुग्राम, गुवाहाटी, ग्वालियर, हैदराबाद हाजीपुर, हल्दिया, इम्फाल, जयपुर, कोच्चि, लखनऊ, मदुरै, मुरथल, मैसूरु, रायपुर, राँची, वलसाड एवं विजयवाड़ा

Centres : Ahmedabad, Amritsar, Aurangabad, Agartala, Baddi, Balasore, Bengaluru, Bhopal, Bhubaneswar, Chandrapur, Chennai, Gurugram, Guwahati, Gwalior, Hyderabad, Hajipur, Haldia, Imphal, Jaipur, Kochi, Lucknow, Madurai, Murthal, Mysuru, Raipur, Ranchi, Valsad & Vijayawada

ANNEXURE III

URKUND

Urkund Analysis Result

Analysed Document:	combined.docx (D61994826)
Submitted:	1/8/2020 6:28:00 AM
Submitted By:	saranyadoc21@gmail.com
Significance:	2 %

Sources included in the report:

11.DISCUSSION NEW.docx (D60899252)
Moina Thesis - Orthodontics.pdf (D46341578)
12.SUMMARY.docx (D60899253)

Instances where selected sources appear:

4