EVALUATION AND COMPARISON OF SHEAR BOND STRENGTH OF BONDED AND REBONDED CERAMIC BRACKETS

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By

Dr. Astha Baul

Under the guidance of

DR. TRIPTI TIKKU

Professor

Department of Orthodontics and Dentofacial Orthopaedics

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

(Faculty of Babu Banarasi Das University)

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"EVALUATION AND COMPARISON OF SHEAR BOND STRENGTH OF BONDED AND REBONDED CERAMIC BRACKETS"** is a bonafide and genuine research work carried out by me under the guidance of ***Dr. Tripti Tikku***, Head of Department, Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Date: 05/07/2021

Place: Lucknow

Dr. Astha Baul

Astha Baul

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"EVALUATION AND COMPARISON OF SHEAR BOND STRENGTH OF BONDED AND REBONDED CERAMIC BRACKETS"** is a bonafide work done by **Dr. Astha Baul**, under my direct supervision and guidance in partial fulfilment of the requirement for the degree of MDS in Orthodontics and Dentofacial Orthopaedics.

Tripti Tikku

Date: 05/07/2021

Dr. Tripti Tikku
Head of Department
Department of Orthodontics &
Dentofacial Orthopaedics
BBDCODS, BBDU
Lucknow

ENDORSEMENT BY THE HOD / HEAD OF THE INSTITUTION

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(Mrs.) Tripti Tikku
H. O. D.,
Deptt. of Orthodontics

Dr. Tripti Tikku
Professor & Head
Department of Orthodontics &
Dentofacial Orthopaedics
BBDCODS, BBDU
Lucknow

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

Dr. B. RAJKUMAR
Principal
Professor & Head
Department of Conservative
Dentistry & Endodontics
BBDCODS, BBDU
Lucknow

It is a matter of great pride and pleasure for any academician to take up any research work that would have even a fraction of positive contribution towards the betterment and advancement in the thoughts and concepts in the chosen era of research. And when this humble effort of the researcher becomes an integral part of the objective to pursue post-graduation qualification, it becomes a matter of intellectual delight and satisfaction for all who are genuinely concerned and have contributed directly or indirectly towards the enrichment of this academic pursuit.

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I seek apology for any shortcoming that might have crept into this study, inadvertently, despite of my sincere efforts to avoid them. I earnestly request for suggestions and comments from all regardging this thesis.

- Astha Baul

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INTRODUCTION: The purpose of this study was to evaluate the shear bond strengths of newly bonded ceramic brackets and compare it with SBS rebonded ceramic brackets using universal testing machine. These brackets were rebonded after recycling the bracket bases by sandblasting.

MATERIALS AND METHOD: The sample consisted of 50 extracted human premolar teeth, which were randomly divided into two groups of 25 each.Group I included teeth where new Symetri Clear (Ormco) brackets were bonded. Group II included teeth where Symetri Clear brackets were bonded then debonded using special debonding pliers and rebonded after sandblasting of the bracket base. The enamel surface was cleaned of remaining adhesive by low-speed tungsten carbide burs followed by finishing with super-snap discs and finally polishing with pumice slurry with rubber cup.SBS was measured for both the groups using universal testing machine. ARI was calculated after the SBS test for Group I, after debonding with special pliers in Group II and again after the SBS test in group II.

RESULTS: The results of the study indicated that the mean SBS of Group I (9.95±3.32) was higher than the mean SBS of Group II (8.32±2.74) with no significant statistical difference between the groups. No significant statistical difference was seen in the distribution of ARI scores among the study groups.

CONCLUSION: Rebonded brackets had comparable and clinically acceptable bond strengths similar to the newly bonded ones, hence, these ceramic brackets can be recycled after accidental or intentional bond failure and rebonded.

The desire to amalgamate acceptable esthetics for the patients as well as maintaining optimum technical performance for the Orthodontist has always been the driving force behind the constantly evolving technique of fixed Orthodontics. With the introduction of acid-etch technique by Buonocore[1,2] in 1955, the horizons of “band-less” Orthodontics expanded. He used 85% orthophosphoric acid for 30 seconds to produce micromechanical bonding between the tooth surface and the attachments. Subsequently, Newman[3] also proposed bonding between orthodontic bracket and the enamel surface in 1965 after treating the enamel with phosphoric acid. This approach had several advantages: enhanced potential for plaque removal by the patient[4,5,6], reduced soft tissue irritation and hyperplastic gingivitis, elimination of the need for separation[4,5], absence of post treatment band spaces, facilitation of application of attachments to partially erupted teeth, reduced danger of decalcification with loose bands[5,7], easier detection and treatment of caries and much more esthetic appearance for the patient. Thus, by late 1970s, direct bonding of brackets became a routine procedure in Orthodontics.

There are three types of brackets available based on their composition. They are metal brackets, polycarbonate brackets and ceramic brackets. Although the metal brackets provided good results in terms treatment, the patients still desired for superior esthetics. So, during the early 1970s, plastic brackets were marketed as the esthetic alternative to metal brackets. However, these polycarbonate brackets quickly lost favor because of discoloration and slot distortion caused by water absorption[8,9,10,11]. This led manufacturers to modify the plastic brackets by reinforcing the slots with metal and ceramic fillers[12,13]. Despite these alterations, the clinical problems like distortion and discoloration persisted. In 1980s, brackets made up of monocrystalline and polycrystalline alumina came into the field of Orthodontics[6,8]. They were introduced as an esthetic appliance, which unlike plastic brackets, could withstand most orthodontic forces and resist staining and were chemically inert to oral fluids. However, inability to form chemical bonds with resin adhesives, low fracture toughness and increased frictional resistance between metal arch wires and ceramic brackets were major disadvantages associated with ceramic brackets[8]. Presently, metal and ceramic brackets are the ones most commonly used in daily Orthodontic practice.

The bonding of attachments in fixed orthodontic treatment comes with its own set of challenges, as it is imperative for the clinician to maintain an effective bond between brackets and enamel surface[14,15]. It is must for these bonded attachments to remain in place until the end of the treatment, however, they should also detach easily at the end of treatment without damaging the enamel surface. The bond between the bracket base and the enamel surface should be strong enough to resist the shear forces and tensions during mastication[16]. However, during orthodontic treatment, unplanned debonding of orthodontic brackets is a common occurrence[17]. It is an unpleasant event both for clinician and the patient as along with inconvenience caused, it results in increased number of appointments leading to increased treatment time and greater treatment costs [18]. Bond failure at bonding interface between enamel and bracket has been reported to be around 17.6%[19]. Bracket failure occurs mainly because of two reasons. Firstly, due to inadequate bond strength which can be due to poor quality of brackets and bonding material or a poor bonding technique used by the operator. Secondly, due to inappropriate force applied by the patient on the bracket during mastication. Sometimes, bracket dislodgement can also occur accidentally while playing contact sports or if the patient gets injured in the facial area. Sometimes, intentional bracket removal and rebonding is also necessary by the operator to establish correct bracket position so as to correct the positional and angulation errors that help in achieving optimum orthodontic mechanics[20]. However, in both the situations, bracket needs to be rebonded while maintaining clinically acceptable shear bond strength (SBS). The most important consideration while rebonding recycled brackets is to properly remove the adhesives from the bracket base without distorting the bracket or changing the bracket slot dimensions and also remove the adhesive from the enamel so that a clinically acceptable SBS can be achieved. Reynolds[9] proposed that the brackets having shear bond strength of 5-7 Mpa were clinically accepted. However, Mizrahi and Smith[21] found that bond strength in the range of 2.8-10 Mpa is sufficient for clinical purposes. The microscopic destruction of bracket base, bracket base design, adhesive remnants on the base and also the method of bracket removal influenced the SBS of recycled brackets hence assessment of SBS of such recycled bracket is must. Matasa[22] stated that a bracket could be recycled upto five times.

Thus, based on the above discussion, the rebonding of brackets will require an Orthodontist to follow three main steps failing which it will be impossible to achieve adequate bond strength of the recycled bracket. They are: availability of the debonded brackets in one piece, proper enamel conditioning before rebonding and recycling the bracket following the standard methods.

Accidental debonding of brackets is not in operator's hands but intentional debonding of brackets is a very technique sensitive process since the operator has to debond the brackets without damaging them as well as protect the enamel from fracture. The various debonding methods are: using debonding pliers, ultrasonic debonding, electrothermal debonding and laser debonding [23-32]. The debonding pliers apply force at the bracket-adhesive interface on both sides of the bracket [33]. Applying load to the two sides simultaneously with the pliers increases the chances of creating a crack in the brittle adhesive. This method transmits one-third less force to the enamel thereby reducing its risk of fracture damage. The ultrasonic technique uses specially designed tips applied at the bracket-adhesive interface to erode the adhesive layer between enamel surface and bracket base. However, the major disadvantages associated with this method are that it is a time consuming procedure and cause significant wear of the expensive ultrasonic tips as well as may cause enamel scars. Electro-thermal debonding instruments are heating devices that are placed in contact with the bracket. The instrument transfers heat through the bracket, softening the adhesive and allowing the bond failure between the bracket base and the adhesive resin. Although this method is a quick and an effective way to debond a bracket, yet the major disadvantage of this technique is that additional armamentarium is required and is also expensive. Recently, debonding is being done using C02 and YAG lasers [25-35]. The lasers to debond a brackets use the same principle as the electro-thermal debonder i.e heat generation to soften the adhesive. On one hand it is a precise and a time saving procedure but on the other it is an expensive technique as well as there are chances of pulpal damage due the heat generation.

Protection of enamel while debonding and subsequent removal of adhesive from the tooth surface is also an important consideration prior to rebonding. Damage to enamel can be attributed to enamel fractures caused by forcibly removing brackets, mechanical removal of remaining composite with rotary instruments or cleaning with abrasives before etching. The search for an efficient and safe method of adhesive resin removal after debonding has resulted in the introduction of a wide array of instruments and procedures. These include manual removal with the use of a scaler [26], tungsten-carbide burs (TCB) with low- or high- speed hand pieces [28,36], Super snap discs [37],and special composite finishing systems with zirconia paste or slurry.In addition, air- powder abrasive systems have been suggested for removing residual adhesives [38]. Though using a TCB with high speed seems to be a very efficient way to clean the surface and the least time consuming, it was the most hazardous procedure to the enamel causing enamel scars. On the other hand, TCB with low speed have been found to cause lesser enamel damage when used for initial cleanup of enamel. Furthermore, the different polishing and abrasion systems techniques like zirconia paste and slurry produce significant loss of enamel. Abrasive procedures also call for the need of rubber dam and protective mask/eye-wear, which is an impractical aspect of this technique. These methods may also have adverse effects on the pulpal tissues if not dissipated with an appropriate coolant. Recently, novel approaches involving carbon dioxide–laser application have been promising. Development of Er:YAG laser and Er, Cr:YSGG enabled for the removal of composite from the tooth surface completely with no destructive side effects, however, they are expensive. Since TCB at low speed for initial adhesive removal from enamel along with Sof-lex discs with pumice slurry for final polishing seemed to have least damaging effects on enamel and also an economical option, it was decided to use these for the study for adhesive removal from enamel after debonding.

The final step in rebonding procedure is the recycling of the bracket base. Recycling process depends on the material of the bracket used. Metal brackets can be recycled by two methods- indirectly by industrial recycling or directly by recycling in the Orthodontic clinic[39]. Among the methods used in industrial recycling, the most commonly used method was to burn the bond agent followed by electrolytic polishing to eliminate the remaining oxide, or using chemical agents to dissolve the bond agent in combination with high-frequency vibration and electro-chemical polishing[40-42]. Various researchers have observed a reduction in shear bond strength (SBS) after industrial bracket recycling of 6%–20%[43], reaching 35% [41]for finer mesh-type brackets. Other studies have reported some metal loss in parts of the bracket and a reduction in the diameter of the mesh wires among commercially recycled brackets, whether reconditioned using heat or chemicals[41,43,44]. Nevertheless, these changes did not seem to affect bond strength.

The other option is recycling metal brackets in the clinic. The clinicians have used various in-office techniques like direct burning, micro sandblasting or both. Though thermal method of recycling brackets is a relatively simple and time saving method but the bond strength of such recycled brackets had been found be much lesser than the newer brackets, thereby leading to multiple bonding failures as seen in studies conducted by Basudan and Emran[45] and by Quick et al[46].

Nowadays, sandblasting with aluminium oxide for metallic brackets base is used most widely. Sandblasting technique uses a high-speed stream of aluminum oxide particles driven by compressed air to remove undesired oxides, contaminants, increase surface roughness as well as increase surface area of the bracket base [47,48]. The recommended aluminum oxide particle is the use of 50 μm. Sonnis [49] in his study observed that when brackets are recycled via sandblasting, the mechanical retention improved.Diedrich and Dickmeiss[50] found air abraded bracket bases increased bond strengths 34% over untreated bracket bases. Bishara conducted a study where sandblasted recycled brackets had comparable shear bond strength like new brackets. Quick et al[46] compared shear bond strength of recycled brackets treated with sandblasting, ultrasonically treated and untreated groups and their results indicated that the sandblasted group had the maximum strength. In these studies it was seen that the SBS of recycled brackets after sandblasting was much above that recommended by Reynolds[9], which is around 7 Mpa. The SBS of new brackets ranged from 7.8-9.15 Mpa while the SBS of recycled bracket by sandblasting ranged from 7.23-8.77 Mpa. Thus, it was concluded that sandblasting was the best method for recycling of metal brackets.

Nowadays, esthetics is preferred not only in our day-to-day life but also in the field of Orthodontics. Manufacturers introduced ceramic brackets to eliminate the problem of unaesthetic appearance of stainless steel brackets without the disadvantages of plastic brackets. All currently available ceramic brackets are mainly composed of aluminium oxide. However, because of their distinct differences during fabrication, there are mainly two types of ceramic brackets i.e. polycrystalline ceramic brackets and monocrystalline ceramic brackets[51,52]. The manufacturing process plays a very important role in the clinical performance of the ceramic brackets. The production of polycrystalline brackets is less complicated, and thus these brackets are more readily available at present. The most apparent difference between polycrystalline and single crystal brackets is in their optical clarity. Single crystal brackets are noticeably clearer than polycrystalline brackets and hence are translucent. Fortunately, both single crystal and polycrystalline brackets resist staining and discoloration. Ceramic brackets can also be categorized based on their retention method. They can be mechanically retentive, chemically retentive or a combination of both. Mechanical retention is achieved through indentations and/or undercuts in the bracket base[53,54]. Debonding is much easier with a mechanical interlock because bond strengths are apparently marginal. Chemical bonding is a technique in which glass is added to the aluminum oxide base and treated with a silane coupling agent[54]. The silane bonds with the glass and has a free end of its molecules that reacts with any of the acrylic bonding materials[3]. It produces exceptional bond strengths, but these can possibly exceed the brittle fracture resistance of the thinner areas of a ceramic bracket[55,56]. Thus, it can be safely said that mechanical retention in ceramic brackets are more desirable. In ceramic brackets, the stresses of debonding can also be shifted from the bracket-adhesive interface to the adhesive- enamel interface. A rigid, brittle ceramic bracket bonded to rigid, brittle enamel has little ability to absorb stresses. A sudden impact loading is more likely to cause failure in the more brittle ceramic and enamel than in the polymeric bonding material. Since the ceramic brackets have a tendency to fracture while debonding, so the chances of recycling them are much less. Recycling ceramic brackets is possible only if the bracket is undistorted or its tie wings had not fractured during accidental or intentional bond failure. Having discussed the shortcomings associated with ceramic brackets, debonding ceramic brackets in one piece and then recycling them to achieve adequate clinical bond strength is an extremely challenging task. To overcome these disadvantages, newer ceramic brackets -Clarity (3M, Unitek) and Symetri Clear (Ormco, Orange, Calif) have been introduced which did not fracture while debonding making availability of intact ceramic bracket a possibility. These brackets were made of polycrystalline alumina and were mechanically retentive. Both these brackets came with special debonding pliers so that the brackets detaches from the enamel in one piece and thus saving the clinician's time

Different methods had been suggested to recycle ceramic bracket base and the techniques are quite similar to those of the metal brackets as discussed before i.e. direct heating of bracket base[57,13], use of sandblasting[39], use of lasers [19] and application of silane [24]. It has been noted that ceramic brackets can maintain their dimensions during direct torching as concluded by Lwezy and Mukhtar[58] in their study. When ceramic brackets were heated, they showed high resistance and maintained their slot form and dimensions after recycling provided ceramic brackets did not fracture during accidental debonding. Compared to new brackets, it has been reported that values of SBS of rebonded brackets were similar after sandblasting. Recently, lasers have been used for bracket recycling. Lasers like Er:YAG, Nd:YAG, Er, Cr:YSGG and CO2 are used for removal of adhesive remnants. However, lasers are expensive. Application of silane after removal of adhesive from the bracket base improved rebonding strength significantly. The clinically debonded bracket with intact tie wings were used for recycling by Lew et al[59] and found that silanisation of base was an convenient method of recycling ceramic brackets. Gaffey et al[60] found the SBS of recycled ceramic brackets bonded to bovine teeth and then debonded by electrothermal debonding technique after treating with heat, silane and hydrofluoric acid was within clinically acceptable limits in comparison to new brackets. A study was conducted by Tikku et al[62], in which electrothermal debracketing technique appeared to be a better procedure than conventional method as it debonded the brackets without damage to the enamel or distortion to the bracket. However, this method is exoensive. Amongst these various methods, sandblasting of bracket base and application of silane coating proved efficacious in improving the SBS of recycled brackets. Hence, it was decided in this study to sandblast the debonded bracket base before rebonding them.

A study by Chung et al[61] on Clarity brackets showed that the SBS of new brackets have the highest mean bond strength when compared with rebonded brackets. Also, the bond strength of sandblasted rebonded brackets with sealant applied on bases were just close to clinically acceptable limits but was lesser than the newer brackets. However, this SBS was achieved when debonding of bracket was done from the bracket bonded to un-etched enamel surface and thus the true clinical situation was not simulated in their study.

Symetri Clear bracket is reportedly designed to address the challenges that often come with a ceramic system—bracket breakage, wire notching, and difficulties while de-bonding. However, information regarding the bond strength of both new and recycled Symetri Clear brackets is still lacking in literature. Manufacturers have claimed that Symetri Clear bracket debonds in one piece without fracturing and required minimal forces when their special de-bonding pliers were used. Hence it was decided to evaluate the SBS of both new and recycled ceramic bracket in the present study.

There are five possible sites at which bond fractures can occur during debonding of brackets. They are: within the tooth enamel, at the enamel-adhesive interface, within the adhesive, at the adhesive-bracket interface or within the bracket[63]. The bond failures for metal brackets occur mostly at the adhesive-bracket interface[51] whereas ceramic brackets showed greater incidence of bond failure at the enamel-adhesive interface thus increasing the risk of enamel damage. An adhesive remnant index (ARI) developed by Artun and Bergland[64] was also used in the present study to evaluate the amount of adhesive that remained on the tooth surface after debonding of bracket base. Thus, the aim of the present study was to evaluate and compare the SBS of newly bonded Symetri Clear brackets to that of recycled Symetri Clear brackets using Universal testing machine Instron.

1. To evaluate the shear bond strength of Symetri Clear ceramic brackets bonded for the first time on etched enamel surface using a universal testing machine.

2. To evaluate the shear bond strength of rebonded Symetri Clear ceramic brackets (whose bases are sandblasted) and the remaining adhesive was removed from the enamel.

3. To compare the SBS of bonded and rebonded Symetri Clear ceramic brackets.

4. To assess the Adhesive Remnant Index (ARI) on the tooth surface after debonding freshly bonded Symetri Clear brackets using universal testing machine in Group I, after debonding freshly bonded brackets using special debonding pliers in Group II and after debonding of these rebonded brackets with universal testing machine with the help of magnifying glass under 10X magnification.

1. **Buonocore MG (1954)[1]:**The aim of this study was to find a simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. Two methods were used for treating the enamel surfaces. The first method involved the use of a 50% dilution of commercial phosphomolybdate reagent containing sodium tungstate (Folin-Wu) in conjunction with 10% oxalate acid solution. In the second method, 85% phosphoric acid solution was used.A qualitative comparison of adhesion was obtained by periodically testing the resistance to removal by thumbnail pressure of acrylic drops placed on treated and untreated enamel and dentin surfaces of extracted teeth that had been stored in water prior to and after affixing of the acrylic resin. Positive evidence of increased adhesion was obtained on the treated surfaces. Because the laboratory results were encouraging, it was decided to test the effect of surface treatments intra-orally. It was concluded from the results that phosphoric acid and a phosphomolybdate- oxalic acid treatment could be employed to alter enamel surfaces chemically. The phosphoric acid treatment seems to give better results and is simpler to use.

2. **Newman SM, Dressler KB, and Grenadier MR (1984)[3]:** conducted a study to test the ability to bond orthodontic brackets to porcelain and a heat-cured composite resin using normal direct-bonding technique. In addition, they used silane to theoretically enhance the bond to porcelain and the glass component of the composite. A normal acid-etch procedure to enamel served as a comparison. Bonding equivalent to the enamel acid-etch procedure was achieved with the heat-cured composite, whether silane was used or not. It was concluded that silane enhanced the bond to porcelain, but the bond might not be adequate for clinical effectiveness.

3. **Årtun J and Bergland S (1984)[64]**: performed two clinical experiments to test the hypothesis which states that different ion solutions containing sulfate induce crystal growth and might be a better alternative than conventional acid etching for enamel pretreatment in bracket bonding, combining optimal bond strength with easy and quick debonding. The first experiment dealt with the debonding procedure. Following conditioning with dilute sulfuric acid which contained sodium sulfate on one side and etching with 37% phosphoric acid

on the other, brackets were bonded on the maxillary and mandibular incisors of twenty dental nurse students. Debracketing and a subsequent cleanup procedure were performed after 2 days. The mode of loosening was mainly between the enamel surface and adhesive on the crystal-growth-conditioned teeth and between the bracket mesh and adhesive on the teeth etched with phosphoric acid. In the second experiment, which dealt with the clinical bond strength, 250 brackets were bonded in forty patients. One side served as a control and was conventionally acid etched. On the experimental side conditioning was done with solution A in thirty patients. In ten patients, 10% phosphoric acid was added to the dilute sulfuric acid used. Failure rates and modes of failure were recorded for a 6-month period. It was concluded that the failure rates were significantly higher after enamel conditioning with solution A than after conditioning with solution B ($P < 0.001$) and after conditioning with solution B than after phosphoric acid etching ($P < 0.05$). Subsequent to solution A conditioning, nearly all the brackets came loose during the first 2 weeks. When solution B was used, the failures occurred at a later point of time.

4. **Gwinnett A.J (1988)[26]:** This study aimed to measure and compare the shear bond strengths of metal, ceramic brackets and ceramic-filled plastic brackets. For this study, 5 groups (A-E) were taken consisting of 10 caries-free incisor teeth. Five types of brackets assigned to these groups were Ormesh (Metal), Microlok (Metal), Allure (Ceramic), Mirage (Plastic/ceramic-filled),Transcend (Ceramic). Each tooth was first embedded in stone blocks with its labial surface exposed and parallel with the face of the block. Each tooth was then etched with 37% phosphoric acid gel for 60 seconds and then rinsed for another 30 seconds. Brackets were then bonded with Concise orthodontic bonding systems. Shear bond strength was measured for each group with an Instron machine at a crosshead speed of 5mm per minute. The data obtained was then statistically analyzed with One-way analysis of variance and the Scheffe test. The tests showed that the differences among the means were not statistically significant at the 95% confidence level. An examination of the failure site showed that the metal brackets (groups A and B) failed consistently

at the resin/bracket base interface as did the ceramic brackets in group C. The ceramic-filled plastic brackets (group D) failed at different sites within the group. Ceramic brackets comprising group E consistently failed in a combination of resin/enamel interface, and resin and resin/bracket base interface with the bulk of resin remaining on the bracket base. These findings suggested that although ceramic brackets are esthetically superior, they should combine the advantages of strength, durability and retention of the metal brackets.

5. **Odegaard J, Segner D (1988)[65]:** This study aimed to compare the Shear bond strength of metal brackets with a new ceramic bracket. For this, one hundred twenty bovine teeth were bonded with two types of metal brackets and a new ceramic bracket for comparison. The metal brackets used were an integral metal bracket with grooves-Dynalock and a metal mesh bracket –Minimesh. A T-piece made of polycrystalline aluminum oxide with a prepared bonding surface was used as a ceramic bracket. Its bonding surface was manufactured exactly as that of the Transcend. Two different adhesives were used, a so-called no-mix(Unite) and a paste/paste adhesive(Dynabond II). The teeth were mounted in a circular ring with cold-cure acrylic; the labial surfaces were kept parallel to the acrylic surfaces. After bonding of the teeth the samples were subjected to a shear strength test in a Zwick testing machine. Means and standard deviations were determined for shear bond strength. A two-way analysis of variance was used in addition to a one-way analysis of variance combined with the Student-Newman-Keuls test to as- certain differences within the adhesives. To find differences between adhesives, a t test was used. The results showed that the shear bond strength of the ceramic bracket was found to be superior for both adhesives. Bond failure with the ceramic bracket occurred predominantly in the enamel/adhesive interface; the failure site for the metal bracket was mainly in the bracket/adhesive interface. It is concluded that the bond strength between the ceramic bracket and the adhesive in shear mode is stronger than that between the adhesive and the enamel.

6. **Viazis A.D, Cavanaugh G, Bevis R.R (1990)[66]:**The purpose of this study was to examine the bond strengths of 4 ceramic brackets- *Transcend* (chemical bond, polycrystalline), *Allure* (mechanical, polycrystalline), *Starfire* (chemical, monocrystalline), *Gem* (mechanical, monocrystalline) and a metal SS bracket ; to examine the potential enamel damage after debonding of ceramic brackets under shear stress; and finally to compare the adhesive properties of light cured (*Transbond*) and chemically cured (*Concise*) adhesive resin by testing resistance of bond. For this study 80 human extracted premolars were taken. Group 1 (n=50) consisted of brackets bonded with light-cured *Transbond*. 50 teeth in this group were divided into 5 subgroups of 10 teeth i.e. 10 teeth for each bracket type. Group 2(n=30) consisted of brackets bonded with chemically cured *Concise*. 30 teeth in this group were divided into 3 equal sub-groups with 10 teeth for SS bracket and rest for 2 types (*Transcend, Allure*) ceramic brackets. The entire sample was then tested on a universal testing machine to measure the shear bond strength. It was inferred that the shear bond strength of chemically bonded ceramic bracket was significantly higher than the mechanically retentive ceramic or metal brackets. Mechanically bonded brackets primarily failed within the adhesive itself whereas the chemically bonded brackets failed at the adhesive-bracket interface. Monocrystalline ceramic bracket was more brittle than the polycrystalline brackets.

7. **Britton J.C, Mcinnes P, Weinberg R, Ledoux W.R, Retief D.H (1990)[8]:** This study was done to evaluate the *in-vitro* shear bond strength of 4 ceramic brackets and one stainless steel bracket with two different acid- etching times on enamel. Eighty human extracted central incisors were taken.4 ceramic bracket types taken were: *starfire* (mechanical retention and silane treated), *allure* (mechanical retention and silane treated), *transcend* (silane treated), *and quasar* (mechanical retention and silane treated) and the SS bracket taken was: *Mini-diamond* (mechanical retention). Each group consisting of n=16,brackets were bonded to the teeth and in each group 8 were acid etched for 15 seconds and 8 for 60 seconds. After etching, a low-viscosity bonding agent was applied and the brackets were boned to the etched enamel. The entire sample was

tested in an Instron machine to measure the shear bond strength. It was concluded that predictability and high bond strength, along with other factors, are important in the clinical selection of bracket system. When either predictability or bond strength was considered independently, several bracket systems, coupled with a particular etch time had either high predictability or high bond strength. The highest predictability and the highest bond strengths were both found with allure bracket system.

8. **Lew K.K.K, Chew C.L, Lee K.W (1991)[59]:**This study was conducted to compare the *in–vitro* shear bond strengths of new and recycled ceramic brackets (Transcend by Unitek corporation)and to assess the bond failures under scanning electron microscope. A sample of 20 extracted human maxillary premolars were taken and divided into 2 equal groups (n=10). Group 1 was the control group which consisted of new chemically retentive Transcend ceramic brackets and group 2 consisted of recycled transcend ceramic brackets. Recycling was done by burning off the residue composite from the debonded brackets till it was cherry red and then after cooling they were re-silanized with a thin layer of porcelain primer. The shear bond strength of the entire sample was then tested on a universal testing machine. It was inferred that the shear bond strength of new brackets (259.7 ±88.2N) was higher than recycled brackets (187.2 ±60.8N). However the bond strength of recycled ceramic brackets appeared to be clinically adequate. Scanning electron micrograph examination of failure sites showed enamel fracture in one sample where the bond strength was extremely high.

9. **Forsberg C.M, Hagberg C (1991)[55]:** This study was conducted to compare the shear/peel bond strength of two different types of ceramic brackets-*Transcend* (silane with chemical retention) and *Transcend 2000*(mechanical retention) and also compare it with a SS bracket(Ormesh, Ormco); and to study the site of failure during debonding with the help of scanning electron microscope. The study used a sample size of 51 extracted human premolars, which was equally divided into 3 groups (n=17) for each bracket type used. The shear bond strength was then measured for each group in a universal testing apparatus. It was then concluded that the bond strength

of chemically retentive ceramic bracket exhibited significantly higher bond strength than the mechanically retentive ceramic bracket. Both the ceramic brackets showed higher bond strengths than the metal bracket. The mechanically retentive ceramic bracket and the metal bracket showed similar sites of bond failure whereas the chemically retentive ceramic bracket showed bond failure at enamel-bracket interface.

10. **Harris A.M.P, Joseph V.P, Rossouw P.E (1992)[67]:** The objective of this study was to determine to the shear peel bond strengths (SPBS) of various debonded orthodontic bracket, SPBS of rebonded esthetic brackets with and without use of silane and to examine the fracture sites. The sample consisted of 75 non-carious human premolar teeth. The sample was then equally divided into 5 groups according to the bracket bonded. Brackets used were – metal bracket (Ormco), *silkon* brackets, *Transcend 2000*, debonded *Transcend 2000* brackets (thoroughly washed after debonding and rebonded), and *Transcend 2000* (silanized and rebonded). The teeth were etched with 37% ortho-phosphoric acid for 60 seconds, washed, dried and bonded with two-paste Ortho-Concise resin. Sealant was applied before bonding. SPBS of the entire sample was tested in an Instron machine. It was concluded that SPBS for metal bracket was highest however; the SPBS for other brackets i.e *Silkon*, *Transcend 2000* and debonded *Transcend 2000* showed clinically acceptable bond strengths. Silanized debonded *Transcend 2000* brackets showed unacceptable SPBS thus clinically not recommended. Fracture sites of metal and *Transcend 2000* was primarily on the resin-bracket interface, whereas *Silkon* brackets showed fracture at the resin-enamel interface.

11. **Bishara SE, Fehr DE (1993)[33]:**The purpose of this study was to compare the debonding strengths of different ceramic brackets, enamel conditioners and adhesives. For this experiment 240 human teeth samples were taken. Four different types of brackets were used in the study-the Transcend ceramic bracket 2000 series (Uni. lek/3M. Monrovia, Calif.), the Contour ceramic bracket (Class One Orthodontics, Lubbock, Texas), the Allure IV ceramic bracket (CAC International, Inc.. Central blip, N.Y.) and the Sturm ceramic bracket ("A" Company/Johnson & Johnson. San Diego, Calif.). Three different

bonding systems were used on the basis of the fillers used. They wereQuasar Debonding Adhesive (Rocky Mountain Orthodontics, Denver. Colo.), Endur (Ormco Corporation. Glendora. Calif.) and Phase II (Reliance Orthodontic Products, Inc. Ithasca,III). Two enamel conditioners were taken- (I) The conventional enamel acid etching technique that uses a 33% phosphoric acid solution in liquid form and crystal growth enamel conditioning that uses a poly-acrylic acid solution -CRYSTAL-LOK (Orthon Dental Inc., Victoria, British Columbia. Canada). 120 samples were divided into 2 groups of 60 each. The teeth were then places in 12 categories according to the bracket type and bonding system used. The brackets were debonded using a debonding plier mounted on a universal testing machine and the SBS of the samples were evaluated. It was concluded thatthe debonding strength values for the different bracket, adhesive, and enamel conditioner combinations ranged between a low of 40 kg/cm^2 and a high of 194 kg/cm^2 .A number of bracket, adhesive, and conditioner combinations are considered to have clinically adequate bonding.The use of polyacrylic crystal growth enamel conditioner resulted in significantly less adhesive being left on the tooth as compared with the phosphoric acid enamel conditioner.

12. **Gaffey P.G, Major P.W, Glover K, Grace M, Koehler J.R (1994)[60]:** The purpose of this study was to investigate the amount of bonding resin remaining on the mono-crystalline ceramic bracket (starfire) following electro-thermal debonding and to measure the shear bond strength of these rebonded ceramic brackets under different treatment conditions. A sample of 237 bovine incisors were taken out of which 100 debonded ceramic bracket bases were investigated for remaining resin and classified with an adaptation of adhesive remnant index (ARI) and then evenly distributed to 4 experimental groups with sample size of 25 in each group. Group 1 was treated with silane coupling agent, group 2 comprised of heat plus silane coupling agent, group 3 consisted of hydrofluoric acid plus silane coupling agent, and group 4 consisted of heat plus HF plus silane coupling agent. A control group (n=25) was taken which consisted of non-bonded mono- crystalline ceramic brackets. The brackets were then bonded to 125 fresh bovine incisor teeth. Shear bond

strength of each sample was then tested on universal testing machine. It was concluded that 79% of the brackets were resin free. Bond strength of control group (non –treatment group) was highest (16.9Mpa). Group 1 had greater bond strength (12.7Mpa) than Group 2 (9.1Mpa). It was further concluded that HF acid significantly decreased the bond strength below 2 Mpa.

13. **Bordeaux J.M, Moore R.N, Bagby M.D (1994)[51]:** The purpose of this study was to compare shear and tensile bond strengths and fracture sites of four second-generation ceramic brackets: Allure IV (A) (GAC International, Inc., Central Islip, N.Y.), Ceramaflex (C) (TP Orthodontics, Inc., LaPorte, Ind.), Intrigue (I) (Lancer Orthodontics, Carlsbad, Calif.), Transcend 2000 (T) (Unitek Corp., Monrovia, Calif.), and a foil-mesh base stainless steel bracket, DynaBond II (D) (Unitek Corp., Monrovia, Calif.). Twenty brackets of each type were bonded to 100 mandibular bovine incisor teeth with Concise bonding adhesive. The samples were thermocycled for 24 hours and the brackets were debonded with an Instron universal testing machine. A modified Transcend debonding instrument was used for tensile debonding, whereas a chisel was used for shear debonding. An analysis of variance was performed with a 0.05 level of confidence. Fracture sites examined with a light microscope showed no enamel damage with any of the ceramic brackets. Intrigue was the only bracket to fracture and had 30% bracket fracture in the tensile mode and 20% bracket fracture in the shear mode. From the data in this study, it may be concluded that (1) the ceramic brackets tested did not cause enamel damage during debonding, (2) the bracket base designs, which allow for increased adhesive thickness, decrease bond strengths, (3) the plastic wafer bases attached to ceramic brackets have adhesive-bracket base fracture sites and decreased bond strengths, (4) the wing design on ceramic brackets is a factor in bracket failure when a tensile load is applied, and (5) the tensile force is more favorable than the shear force in removing ceramic brackets.

14. **Hong YH, Lew KKK(1995)[36]:** The aim of this study was to quantitively and qualitatively assess the enamel surface following five composite removal methods after bracket debonding. So, for this study, Orthodontic brackets were bonded on 50 premolar teeth extracted for orthodontic purpose. After

debonding with a standardized technique, the teeth were randomly divided into five equal groups(n=10). Samples in each group were subjected to different finishing procedures: Group A-Ormco band removing plier. Group B-Komet slow speed tungsten carbide bur. Group C-High speed ultrafine diamond bur. Group D-Jet high speed tungsten carbide bur. Group E-High speed white stone finishing bur. The composite remnants which then remained on the enamel surface were graded using the Composite Remnant Index (CRI) The enamel surfaces were then examined in a Scanning Electron Miscrocope at x 203 magnification. It was concluded through the results that the Jet high speed tungsten carbide bur gave the best surface smoothness in the surface roughness assessment, but was fourth in the composite remnant assessment. The ultrafine diamond bur on the other hand was most efficient in the removal of composite remnants, but produced the roughest finished enamel surface. A combination of three methods; namely, the Jet high speed tungsten carbide bur, the Komet slow speed tungsten carbide bur and the Ormco band removing plier may prove ideal in the effective removal of composite remnants following debonding.

15. **Blight SJ, Lynch E (1995)[68]:**The purpose of this study was compare the SBS and the site of failure of ceramic brackets bonded to etched enamel. 80 human extracted premolar teeth were taken and divided into four groups of 20 each based on the different bonding techniques. On these teeth, a polycrystalline ceramic bracket Transcend series 2000 (Viatek Corp., Monrovia, Ca, USA) were bonded. In Group1 37% phosphoric acid and a light-cured composite resin Marathon was used during bonding. In group 2, 2.5% nitric acid Tenure Conditioner and Marathon was used. Group 3 used Tenure Conditioner and a resin modified glass ionomer cement Geristore and Group 4 was bonded with Tenure Conditioner and light-cured Zionomer (a resin modified glass ionomer cement). All the specimens were subjected to bond strength testing using tensile testing machine DB 30. The site of bond failure was observed using a stereomicroscope. Through the results it was concluded that 1. There were no significant differences in bond strength or prevalence of enamel fracture between ceramic orthodontic brackets bonded to 2.5 per cent nitric acid etched

enamel, and 37 per cent phosphoric acid-etched enamel, when using composite resin as a bonding material. Significantly less composite resin remained on the enamel surface to be removed following bracket removal when 2.5 per cent nitric acid etching was used. The use of Geristore or Light-cured Zionomer for bonding ceramic brackets to 2.5 per cent nitric acid etched enamel gave rise to a significantly lower bond strength compared to ceramic brackets bonded with composite resin.

16. **Olsen M.E, Bishara S.E, Jacobson J.R (1996)[6]:** This study aimed to evaluate the shear bond strength of 2 different ceramic bracket base designs and to study the site of bond failure. The ceramic brackets used were- *Ceramaflex* and *Transcend 6000.*For this study 40 human extracted premolars were taken and divided into 2 equal groups (n=20) for each type of bracket. The shear bond strength was then measured on an Instron machine. After debonding, the teeth and the brackets were examined using a 10X magnification. Also Adhesive Remnant Index (ARI) was assessed. It was inferred that the Ceramaflex brackets have significantly lower bond strengths than Transcend 6000. However, the bond failure location of Ceramaflex bracket was more favorable i.e. occurring in the bracket-polycarbonate base.

17. **Sonis AL(1996)[49]:**showed the comparable shear bond strengths between new brackets and failed brackets that were subsequently air abraded. The bond strengths observed were consistent with other studies that used a light-cured bonding system. Sixty non-carious human mandibular premolars were used and were randomly assigned to either the control group *(n* = 30) or experimental group *(n*= 30).The control group was bracketed with new untreated GAC microarch mandibular premolar brackets (GAC International, Inc., Central Islip, N.Y.), while the experimental group was bracketed with previously used brackets of the same design and manufacturer. These brackets are stainless steel with a machine-cut slot and welded mesh base. The experimental brackets were obtained from patients who had experienced a bracket bonding failure during the course of their therapy. These brackets had been bonded with a light-cured orthodontic bonding system, Rely-a-bond (Reliance, Inc., Itasca, Ill.). The bracket base area was 9.9 mm^2. They found

that the use of air abrasion alone, probably increased the mechanical retention by increasing surface area of the foil-mesh, which resulted in comparable bond strengths with new brackets. Thus, they concluded that the bond strengths of previously failed bonded metal brackets subjected to air abrasion were not significantly different from bond strengths of new brackets. Air abrasion removes residual bonding material from the failed bracket base and results in a roughened and irregular surface of the mesh. This probably results in increased mechanical retention of the previously failed bracket.

18. **Martina R, Laino A, Cacciafesta V, Cantiello P (1997)[69]:** This study was conducted to investigate the recycling effects on ceramic brackets with respect to dimension, weight and shear bond strength for this study 90 premolar ceramic brackets (Transcend 2000, Unitek Corp., Monrovia, CA, USA) were bonded to 90 human premolar teeth. All the samples were tested for SBS using a Universal Testing Machine. The SBS 20 out of 90 samples were randomly selected and recorded in order to make comparisons of groups with the same number of brackets. After debonding the 90 samples were dived into 3 groups of 30 each. These groups were recycled for one, five and ten cycles. The results showed that the recycled brackets showed adequate bond strength for clinical use. The weight and dimensional changes were determined using scanning electron microscope.The results suggest that changes in weight, in buccal and base slot widths, in slot depth and in the total bracket base area are of little clinical relevance in recycled versus new brackets. Also, the brackets showed bond failures mostly at the bracket/adhesive interface, without causing enamel damage.

19. **Sinha PK, Nanda RS (1997)[70]:** the purpose of this study was to compare the effect of three different bonding and debonding techniques on debonding two types of ceramic orthodontic brackets using different modes of bonding. 180 bovine teeth were taken and equally divided into 2 groups. Group 1 consisted of monocrystalline ceramic brackets that were chemically bonded and group 2 consisted of polycrystalline ceramic brackets that were mechanically retentive. These brackets were bonded with the direct and two different indirect bonding methods: the conventional indirect method (modified Thomas) and the indirect

technique that used a thermally cured resin. Each bonding group was further divided into three groups of 10, based on the type of debonding technique used, i.e., lift off, delamination, and twisting. The variables evaluated were bracket failure and remnant adhesive on debonding. The data were subjected to an analysis of variance to determine existence of significant differences, followed by multiple comparisons of means. Bracket failure or fracture was significantly affected, based on the bonding technique and the debonding technique for the monocrystalline and the polycrystalline ceramic brackets. The delamination debonding technique combined with the thermal-cured indirect bonding technique was shown to be a safe combination for debonding both types of ceramic brackets. Therefore, it was seen that both bonding and debonding techniques significantly affect bracket failure or fracture and remnant adhesive of ceramic orthodontic brackets during the debonding procedure.

20. **Bishara SE, VonWald L, Laffoon JF, Warren JJ (2000)**:[71]evaluated the effect of repeated bonding on the shear bond strength of orthodontic brackets. They collected fifteen freshly extracted human molars and stored in a solution of 0.1% (wt/vol) thymol. The teeth were cleaned, polished, and etched with a 37% phosphoric acid gel. The brackets were bonded with the adhesive and light cured for 20 seconds. The teeth were sequentially bonded and debonded 3 times with the same composite orthodontic adhesive. At each time, all 15 teeth were debonded within half hour after bonding to simulate the clinical condition at which a newly bonded bracket is attached to the arch wire. They concluded that in general, the highest values for shear bond strength were obtained after the initial bonding. Rebonded teeth have significantly lower and inconsistent shear bond strength; ie, bond strength may further decrease or increase after the second debonding, and the changes in bond strength may be related to the changes in the morphologic characteristics of the etched enamel surface.

21. **Basudan AM, Al-Emran SE (2001)[45]**: The objective of this study was to compare the effect of five in-office bracket reconditioning methods on: (i) bracket slot width and interwing gap measurements; (ii) the appearance of the

bracket bases under scanning electron microscope (SEM), and; (iii) shear/peel bond strength (SPBS). It was an ex- vitro study in which they collected one hundred and twenty-five brackets which were initially bonded and were divided into five experimental groups and reconditioning by the following methods: (i) adhesive grinding using green stone (Gp II); (ii) sandblasting (Gp III); (iii) direct flaming (Gp IV); (iv) using the BigJane machine (Gp V), and; (v) application of Buchman method (Gp VI). It was observed that there was distortion of the brackets. Scanning electron microscopy of three representative specimens from each group was performed. The remaining brackets were rebounded and then shear/peel forces to failure were measured (SPBS). They observed no clinical significant increase in the bracket measurements of Group VI. However, there was a significant reduction (28%) in the SPBS of Group II. They also observed, under the SEM, the wire mesh structure was maintained; however, the amount of adhesive remnants greatly varied among the groups.

22. **Chung C.H, Friedman S.D, Mante F.K (2002)[61]:** The objective of this study was to evaluate the bond strength of rebonded mechanically retentive ceramic brackets (Clarity) under different treatments of bracket base.120 extracted human premolars were taken. 20 new and 100 sandblasted rebounded ceramic brackets were then bonded to these teeth with composite resin. The entire sample was then divided into 6 groups on the basis of the treatment received on bracket bases. Group 1 consisted of new brackets, group 2 consisted ofrebonded/sandblasted brackets, group 3 comprised of rebonded/sandblasted/sealant, group 4 was rebonded/sandblasted/Hydrofluoric acid group 5 consisted of rebonded/sandblasted/HF/sealant and group 6 comprised of rebonded sandblasted/silane. Shear bond strength of each sample was then measured universal testing machine. It was concluded that shear bond strength of new ceramic brackets are highest when compared to rebonded brackets. Sandblasted/rebonded/sealant (group3) have highest bond strength among rebonded brackets. Silane treatment of bracket base does not significantly increase the bond strength of rebonded brackets and HF acid on sandblasted rebonded brackets significantly lowers the bond strength.

23. **Quick AN, Harris AMP, Joseph VP (2005)[46]**:investigated to determine a simple, effective method for reconditioning stainless steel orthodontic attachments in the orthodontic office as it is important to find a rapid office method of treating recently debonded brackets to produce clinically acceptable bond strengths with minimal changes in the physical properties of the brackets. 100 new brackets were bonded to premolar teeth, then debonded and the bond strength recorded as a control for the reconditioning process. The debonded brackets were divided into six groups and each group reconditioned using different techniques, attachments in four groups were flamed and then either (1) sandblasted, (2) ultrasonically cleaned, (3) ultrasonically cleaned followed by silane treatment, (4) rebonded without further treatment. Of the two remaining groups, one was sandblasted, while the brackets in the other were roughened with a greenstone. The brackets were rebonded to the premolar teeth after the enamel surfaces had been re-prepared, and their bond strengths measured. They concluded that sandblasting was the most effective way in removing composite without a significant change in bond strength compared with new attachments. However, silane application did not improve the bond strength values of flamed and ultrasonically cleaned brackets. They also found that the attachments that had only been flamed had the lowest bond strength, followed by those that had been roughened with a greenstonece as a result of the presence of adhesive remnants.

24. **Liu J.K, Chung C.H, Chang C.Y,Shieh D.B (2005)[72]:** This study was aimed to evaluate the shear bond strength of collapsible mono-crystalline bracket-*Inspire* and compare it with another collapsible ceramic bracket-*Clarity* and a metal bracket-*Tomy*; to assess the modes of failure of the 3 brackets; and also to examine tooth surfaces after debonding. All the 3 brackets were mechanically retentive.100 extracted human premolars were taken out of which 60 premolars were taken and divided into 6 subgroups according to different combinations of brackets and adhesive. Adhesives taken were- (1) *Enlight* (Ormco) fluoride releasing light cure adhesive, (2) *Transbond XT* (non-fluoridated). Then, each sample was tested on a universal testing machine to measure the shear bond strength. The remaining 40 teeth

were also divided into groups and bonded with different ceramic brackets and adhesive combinations and debonded via debonding pliers. After debonding, the tooth surfaces were examined under scanning electron microscope and adhesive remnant scores (ARI) were recorded. It was concluded that there was no significant statistical differences between bond strengths of different combinations of bracket and adhesives. The mode of failure after debonding either by testing machine or by pliers was predominantly at the bracket/adhesive interface in all groups. It was also found that even though the bond strength and mode of failure of *Inspire* and *Clarity* were similar yet the bracket fracture after debonding was higher with the former.

25. **Eminkahyagil N, Arman A, Cetlinsahin A, Karabulut E (2006)[24]:** This study was conducted to evaluate the the effect of different resin-removal methods on shear bond strength (SBS) of rebonded brackets, condition of the enamel surface, time spent to remove resin remnants, and the location of the bond failure. For this study 80 premolar and all were bonded with metal brackets(Ormco series 2000 Sybron Dental, Orange, Calif). From total samples, 50 were divided into 5 equal groups. In Group 1, the brackets were debonded by pliers (GAC International, Inc, Bohemia, NY) and the remaining adhesive was removed by low speed tungsten-carbide bur. In Group 2, the adhesives were removed by high speed tungsten-carbide bur after evaluating the ARI. In Group 3, sof-lex discs were used to remove the adhesives. In Group 4, the remaining resin was removed by micro-etcher and Group 5 was the control group in which the SBS at first debonding was evaluated by universal testing machine. In all the above groupd ARI was evaluated. The remaining 30 out of 80 samples were randomly dividd into five groups (n=6) and in the first four groups, the same methods of resin removal was done. The fifth group acted as control and received no treatment. SEM was evaluated in all these enamel surfaces for changes in enamel surface after various methods of resin removal. Re- bonded teeth had a greater SBS than the initial bonding, except in group 4. Sof-lex discs were the most time-consuming procedures and left much adhesive remnant. The high-speed

TCB was found to be the most hazardous to the enamel. The scarring of enamel after the debonding is inevitable but can be reduced.

26. **Tavares S.W, Consani S, Nouer D.F, Magnani M.B.B.A, Martins L.M (2006)[16]:** The purpose of this study was to evaluate the *in-vitro* shear bond strengths of new and recycled orthodontic brackets- S2C-03Z and also to assess the sites of bond failure using scanning electron microscope. The study had a sample size of 50 extracted human premolars. They were then randomly assigned into 5 equal groups (n=10). Group1-newly bonded brackets as control group. Group 2- debonded brackets were rebonded after sandblasting the bracket base with aluminum oxide. Group 3- debonded brackets were rebonded after silicon carbide grinding at low speed. Group 4- debonded brackets rebonded after specialized recycling in a contractor company. Group 5- debonded brackets were detached and new brackets were bonded to the enamel surface. The entire sample was then tested for shear bond strength in a universal testing apparatus. Also the bracket bases were observed under SEM. It was seen that there was no statistically significant difference between group 1, 2 and 5. Groups 3 and 4 exhibited lowest shear bond strength when compared to control group. Thus it was concluded that the brackets recycled by sandblasting was efficient and clinically acceptable. Also, failures of sandblasted/rebonded brackets predominantly occurred in bracket-adhesive interface.

27. **Habibi M, Hosseinzadeh T, Hooshmand T (2007)**[73]: The aim of this study was to compare the debonding strengths of 1 metal and 2 types of ceramic orthodontic brackets with different retention mechanisms bonded to enamel and to determine the risk of enamel damage after debonding. In this in-vitro study, 36 maxillary premolars were divided into 3 groups. Three types of orthodontic brackets (metal, ceramic with chemical retention, and ceramic with mechanical retention) were bonded to the teeth with a luting resin composite. The brackets were debonded with sharp-edged debonding pliers in a universal testing machine. Enamel cracks were evaluated with a stereomicroscope. The ARI was also evaluated on th enamel. It was seen through experiments that the mean bond strength for the metal brackets was

significantly higher than that of the 2 ceramic brackets and there was no significant difference between the mean bond strengths for the 2 ceramic brackets. There was no statistically significant difference in the number (*P*= .871) or length (*P* =.188) of enamel cracks among the 3 groups. There were significant differences in the adhesive remnant index scores between metal and chemically retained ceramic brackets (*P*= .007), and between chemically and mechanically retained ceramic brackets (*P*= .002).

28. **Torgulu S.M, Yaylali S (2008)[54]:** The purpose of this study was to determine the shear force strength on rebonded mechanically retentive premolar ceramic brackets Inspire (Ormco, Orange, Calif). 60 human premolar teeth were taken and the samples were divided into 4 groups (n=15). According to the method of treatment of the debonded bracket base. Group 1 was the control group. Group 2 the debonded bracket base was treated by sandblasting with 50Um aluminum oxide particles. In Group 3, the brackets bases were treated with sandblasting and silane and silica coating with 30Um silicon oxide was used in Group 4. All the samples were then tested for SBS using Universal Testing Machine. It was concluded that Sandblasting +silane and silica coating+silane applications on debonded ceramic bracket base can produce bond strengths comparable with new brackets.

29. **Kitahara-Céia FM, Mucha JN, Marques dos Santos PA(2008)[74]:** this study was conducted with the aimto assess the enamel damage after removal of ceramic brackets. So, for this study, 45 human extracted premolars teeth were randomly assigned to be bonded with one of the following: ceramic brackets with mechanical retention (Clarity, 3M Unitek); ceramic brackets with epoxy-base mechanical retention (InVu, TP Orthodontics); and ceramic brackets with chemical (silane) retention (Fascination 2, Dentaurum). Each tooth was evaluated under 60x magnification before bonding and after debonding. All brackets were debonded according to the manufacturer's instructions. After debonding, a single trained observer evaluated the pictures of the enamel surfaces for cracks or enamel fractures. It was seen that the brackets that used chemical retention had a significantly higher percentage of cracks and/or fractures. For the other two bracket types, removal was either

by squeezing over the mesio-distal sides of the metal arch-wire slot for the mechanical retention brackets and using a wire cutting pliers over the adhesive bracket interface in the epoxy- base mechanical retention brackets. The Adhesive Remnant Index (ARI) scores indicated that the least adhesive remained on the enamel in the case of the chemical retention brackets.

30. **Chen-Sheng Chen; Ming-Lun Hsu; Kin-Di Chang; Shou-Hsin Kuang; Ping-Ting Chen; Yih-Wen Gung (2008)[75]:** This study was conducted to determine the location and size of enamel fracture (EF) when debonding a bracket. For this study, thirty human premolar specimens with intact enamel surfaces were collected, and 30 stainless-steel edge-wise orthodontic premolar brackets (Tomy International Inc., Tokyo, Japan) bonded to the sample teeth. The specimens were randomly divided into three groups of 10 each. Specimens in one group were brought to failure under the tension mode, specimens in the second group were brought to failure under the shear mode, and specimens in the third group were brought to failure un- der the torsion mode. After debonding, the enamel surface was analysed by SEM. To analyze stress distribution, an FEM comprising three materials—enamel, adhesive, and bracket—was constructed with the use of ANSYS 7.0 software. The results showed that the The EF usually was located in the area where the force was exerted during various loading modes. The tensile, shear, and torsion debonding modes produce EF sizes and incidences with no significant differences. Findings on FEM matched the mechanical testing and SEM results.

31. **Faltermeier A, Behrb M (2009)[76]:** The aim of this study was to compare the effects of different types of bracket base reconditioning that is by silicoating system, sandblasting, and the effect of a silane-coupling agent after sandblasting. 80 extracted third molars were taken. The samples were divided into 4 groups of 20 teeth each. Group 1 consisted of 20 Ormesh brackets (Ormco, Glendora, Calif) that were sandblasted on the base with 120 Um aluminium oxide. In Group 2, brackets were treated with a silane-coupling agent (Espe Sil, 3M Espe) after sandblasting the bracket base. In Group 3, brackets were sandblasted with 110 Um of aluminium oxide (Rocatec Pre, 3M

Espe). Then, a tribochemical coating was added by using Rocatec Plus (3M Espe) with a pressure of 2.8 bar for 13 seconds. A silane-coupling agent (Espe Sil, 3M Espe) was applied. Group 4 acted as the control group which included 20 new and untreated foil-mesh brackets. The samples were then tested for SBS using a universal testing machine. It was concluded thatsandblasting and tribochemical treatment of brackets improved the shear bond strength of stainless steel brackets whereas Combined sandblasting and silane-coupling treatment offered no benefit of increased in-vitro strength.

32. **AL-Lwezy O.H, AL-Mukhtar A.M, Salih S.S (2010)[58]:** The aim of this study was to evaluate the strength of rebonded ceramic brackets after recycling by burning technique. For this study, samples were divided into two groups, control and test group. The brackets in the test group bonded, de-bonded and then recycled using burning technique, then both control and test group brackets are bonded to the buccal surface of premolar teeth and tested for shear bond strength. It was seen that although there was complete removal of the resin under the bracket base, the SBS decreased significantly after recycling the brackets as compared to the fresh ones.

33. **Pakshir HR, Najafi HZ, Hajipour S(2011)[77]:**This*in vitro* study investigated the effect of two enamel surface treatments on the bond strength of metallic brackets in the rebonding process. For this experiment Fifty freshly extracted human premolars were taken. Dyna-Lock premolar brackets (3M Unitek, Monrovia, California, USA) were bonded to these sample teeth by Transbond Xt adhesive. Then the brackets were debonded with Lift-off debonding pliers (3M Unitek). After debonding, visible residual adhesive on the tooth surfaces was removed with a carbide bur at slow speed. The samples were then divided into two equal groups of 25 teeth each. In one group, the teeth were etched with 37% phosphoric acid and new brackets were rebonded as in the first step, with Transbond XT. In the second group, the teeth were sandblasted with micro-etcher (Micro-Etcher ERC II, Danville Engineering, San Ramon, California, USA), using 50 m aluminium

oxide particles. All the samples in both groups were then subjected to SBS testing using a universal testing machine. After the testing, the teeth were examined for remaining adhesive on the enamel surface by ARI (Artun and Bergland). The results showed that the mean SBS in both groups did not differ significantly ($P = 0.081$). Most bond failures occurred with ARI scores of 2 and 3, and the difference between the two groups was statistically significant ($P < 0.001$). Enamel surface preparation with sandblasting prior to acid etching did not significantly improve SBS in bracket rebonding and left more residual adhesive remnants on the enamel surface.

34. **Ishida K, Endo T, Shinkai K, Katoh Y (2011)[78]:** This study was conducted to examine the bond strength of the recycled brackets after the removal of adhesive with Er; Cr:YSGG. For this experiment, 76 brackets were bonded and then debonded. Then the brackets were equally divided into 4 groups on the basis of method of removal of adhesive. Group 1 consisted of untreated bracket bases. Group 2,3 and 4 consisted of brackets treated by Er; Cr:YSGG, sandblaster and combination of sandblaster/Er; Cr:YSGG respectively. The recycled brackets were then bonded on new premolars.The shear bond strength was measured and after debonding failure modes were evaluated after each debonding. The results showed that the rebond strength was significantly lower in group 1 and other groups whereas, there was no significant difference among other groups. It was also seen that the SBS of initially bonded brackets was significantly higher than the mean rebond strength in group 1 but there was no significant difference between the two in other three groups.

35. **Bahnasi FI, Abd-Rahman ANA, Abu-Hassan MI (2013)[79]**: In this study180 new stainless steel upper premolar brackets were taken out of which 100 brackets were divided into five groups of 20-teeth each. Four methods of recycling orthodontic brackets were used in each of the first four groups while the last one (group V) was used as the control. Groups (I-V) were subjected to shear force within half an hour until the brackets debond. SBS was measured and the method showing the highest SBS was selected. A New group (VI) was

recycled twice with the selected method. Six subgroups (1-6) were established; the primer was applied for three sub-groups, and the composite was applied for all brackets. Brackets were subjected to the same shear force, and SBS was measured for all sub-groups. They observed a significant difference between the mean SBS of the sandblasting method and the means of SBS of each of the other three methods. However, no significant difference between the mean SBS of the new bracket and the mean SBS of recycled bracket using sandblasting was seen. Brackets with primer showed slightly higher SBS compared to those of brackets without bonding agent. Thus they concluded to decrease cost, sandblasted recycled orthodontic brackets can be used as an alternative to new brackets. It was recommended to apply a bonding agent on the bracket base to provide greater bond strength.

36. **Yassaei S, Aghili H, Payeh K, Goldani moghadam M (2013)[19]:** The objective of this study was to compare the shear bond strength of rebonded brackets with four methods of adhesive removal. For this study, 80 human premolar extracted teeth were taken and divided into 4 experimental groups. Metal brackets were bonded and later debonded from the teeth and the resin was removed from the teeth using Er: YAG laser, sandblasting, direct heating and CO2 laser respectively. After the teeth surfaces were cleaned using carbide bur, recycled brackets were rebonded. SBS of the rebonded brackets were determined using Dartec testing machine. ARI was also determined after debonding using a stereomicroscope at 10X magnification The results showed that group 3 ans 4 had significantly lower bond strengths than the other groups.

37. **Reddy YG, Sharma R, Singh A, Agarwal V,Agarwal V et al (2013)[80]:** the aim of this study was to compare the Shear Bond Strengths of ceramic brackets and metal brackets for which 40 extracted, human maxillary first premolars were selected and they were equally bonded with ceramic brackets (Transcend series 6000) and metal brackets (Mini Dynalock Straight wire brackets). Each specimen was held in a mounting jig of Instron universal

machine and the debonding tests were performed. The results showed that the mean SBS was significantly higher for the ceramic group (20.68 ± 3.89 MPa) as compared to that of the metal bracket group (12.15 ± 1.32 MPa). Therefore it was concluded that the ceramic brackets (Transcend 6000 series) were aesthetically superior and they provided a greater bond strength as compared to the metallic brackets.

38. **Devjee N, Deshmukh SV, Jethe S, Naik CR (2015)[81]:** The aim of the study was tocompare the shear bond strength of brackets after being recycled with erbium-doped yttrium aluminum garnet (ER:YAG) laser, sandblasting and the thermal method. The study has a sample size of 126 extracted premolars. Premolar metal brackets and premolar ceramic brackets, without the metal slot was bonded to these teeth. 84 teeth were subdivided into three groups (28 each) for each method of recycling. These groups were further subdivided into two groups of 14 teeth each for the types of brackets used. A universal testing machine was used to find shear bond strengths after rebonding of brackets, as well as establishing a control group reading, during the first debonding. Prior to the initial bonding the bracket was also viewed under an environmental scanning electron. After the brackets were debonded and their shear bond strengths recorded they were recycled by the ER:YAG laser at a wavelength of 2.94Um, sandblasted with a particle size of 50 Um, and thermo recycled. Their meshwork once again viewed under the environmental scanning electron microscope (ESEM) to examine the condition of the meshwork and amount of adhesive removed from the bracket base. While comparing all three methods it was found that the ER:YAG laser was the method of choice for recycling ceramic brackets but for stainless steel brackets the most effective method is the sandblasting method. On ESEM evaluation, it was seen that the thermal method damaged the ceramic brackets while removing the least amount of composite from both the stainless steel as well as ceramic bracket base. The sandblasted group showed a roughened bracket base for stainless steel brackets with sufficient removal of the adhesive, whereas the ceramic bracket bases were damaged by the alumina particles.

39. **Guarita MK, Moresca AHK, Losso EM, Moro A, MorescaRC et**

al(2015)[82]: The aim of this study was to evaluate the shear bond strength of rebonded ceramic brackets after subjecting the bracket base to different treatments. For this study, 75 premolars were selected.Ceramic brackets (sapphire brackets, MBT .022, Perfect SB Clear Bracket; Hubit Co. Ltd., Seoul, South Korea) were bonded to the buccal enamel surface of the teeth with Transbond XT but without application of phosphoric acid. The brackets were then debonded using specific ceramic bracket removal pliers (Orthometric, Marilia, SP, Brazil), following the manufacturer's instructions. The teeth were then randomly assigned into 5 groups (n=15) according to the type of surface treatment employed for the bracket base. In Group I, no treatment, first bonding (control); in group II, sandblasting with aluminum oxide (50 μm); in Group III, sandblasting with aluminum oxide (50 μm) followed by silane application; in Group IV, sandblasting with silica dioxide particles (30 μm) (silicatization) followed by silane application; in Group V, silicatization performed in the laboratory (Rocatec system), which consisted in sandblasting with aluminum oxide (110 μm, Rocatec-Pre powder), sandblasting with silicic-acid-modified aluminum oxide particles (110 μm, Rocatec-Plus powder) and silane application. After surface treatment of brackets, the brackets were rebonded again and subjected to SBS testing using a universal testing machine. The adhesive remnant index (ARI) was then evaluated for all samples. The results showed that there was a statistically significant difference was observed only between Rocatec and the other groups. The Rocatec group showed the lowest SBS values. The highest SBS values were observed for group I, without any significant difference from the values for groups II, III and IV.

40. **Yousef ME, Ismail HA, Marzouk ES, ShelibMA(2015)[13]:** The aim of this study was to compare the effect of three recycling methods – Tribochemical silica coating combined with silane, conventional sandblasting combined with silane, and heat application combined with silane – on the shear bond strength of rebonded ceramic bracket compared to newly bonded brackets. For this study 60 Mechanically retentive ceramic brackets (Inspire ICE) were bonded to 60 extracted human premolar teeth. The samples were divided randomly in

to four groups to be bonded to the ceramic brackets: Control group (new brackets without silane application), recycled brackets using 50µm aluminum oxide particles + silane, recycled bracket using 30µm silica coated aluminum oxide particles + silane and lastly recycled brackets using heat + silane. All the samples were then subjected to shear bond strength testing. It was seen through the results that the highest bond strength was found in the heat + silane group and the new control brackets (19.5 and 19.2 MPa, respectively) followed by the silica coated aluminum oxide + silane (11.8 MPa). Recycling using 50 µm aluminum oxide + silane resulted in significantly low bond strength (1.5 MPa).

41. **Shetty V, Shekatkar Y, Kumbhat N, Gautam G, Karbelkar S, Vandekar M (2015)[83]:** The aim was to evaluate and compare the shear bond strength of brackets recycled with sandblasting and silicoating. For this study, ninety extracted human premolars were bonded with 0.022" SS brackets (American Orthodontics, Sheboygan USA) and later debonded. The debonded brackets were divided into three groups of 30 each. Group I: Sandblasting with 50- m aluminum oxide (control group) Group II: Sandblasting with 50- m aluminum oxide followed by metal primer application Group III: Silicoating with 30- m Cojet sand followed by silane application and rebonded with Transbond XT. The sandblasted brackets and silicoated brackets were viewed under the scanning electron microscope, immediately after surface conditioning before rebonding. The shear bond strength with each group was tested. The results showed that sandblasting created more irregularities and deeper erosions while silica coating created superficial irregularities and shallow erosions.

42. **Montero M, Vicente A,Alfonso-Herna ́ndez N, Jime ́nez-Lo ́pezM, Bravo-Gonza ́lez L.A (2015)[39]:** This study was done to evaluate the shear bond strength of recycled brackets using sandblasting and industrial methods. For this experiment, eighty brackets were bonded and debonded sequentially three times. After the first debonding, brackets were divided into

four groups: group 1- sandblasting with aluminum oxide particles of 25 m, group 2- 50 m aluminum oxide particles, and group 3- 110 m, and group 4- industrial recycling. Bond strength and ARI were evaluated for each successive debond. Results showed that there were no significant differences between the four groups following the first recycle. After the second recycle, bond strength was significantly greater for the industrially recycled group than the other groups. The bond strength of sandblasted brackets decreased with the increase of particle size and with each recycle; for the industrially recycled group, no significant differences were detected between the three sequences. Thus, it was concluded that the industrial recycling obtained better results than sandblasting after three successive debondings.

43. **Sohrabi A, Jafari S, Kimyai S, RikhtehgaranS(2016)[84]**:This study was conducted with the purpose of evaluating the possibility of using Er, Cr:YSGG laser to eliminate the remaining composite materials from the base of ceramic brackets and to compare the bond strength of rebonded brackets with the new ones. 62 human premolars were taken for this study. These sample teeth were then divided into 2 groups of n=31. In Group 1, ceramic brackets (Fascination II; Dentaurum) were bonded to teeth with Transbond XT. Then, the shear bond strength was tested using Hounsfield test equipment. The debonded brackets bases were then irradiated with Er, Cr:YSGG laser (Biolase Europe GmbH) using the parame- ters of 3.5 W, 65% air, and 55% water until visible remnants of bonding material were eliminated from the bases. After removing the composite, these brackets were rebonded on 31 fresh teeth (group II) using the same procedure and were again tested for SBS. In both stages, tooth surfaces were inspected under a stereomicroscope and failure patterns were graded according to ARI. It was seen that the mean shear bond strength of both the groups were statistically insignificant. Thus, it was concluded that Er, Cr:YSGG laser was effective in removing the remnants of bonding material from the base of ceramic brackets without any interference with the ceramic base itself and was a clinically acceptable method for recycling ceramic brackets.

44. **Ansari MY, Agarwal DK, Gupta A, Bhattacharya P, Ansar J et. al. (2016)[85]:** The purpose of this study was to evaluate and compare the effect of base designs of different ceramic brackets on shear bond strength and to determine the fracture site after debonding. A sample comprising of 50 extracted maxillary premolars was collected from the patients. Five groups of 10 each were taken out of which four groups of ceramic brackets and one group of metal brackets with different base designs were used. Adhesive precoated base of Clarity Advanced (APC Flash-free) (Unitek/3M, Monrovia, California), microcrystalline base of Clarity Advanced (Unitek/3M, Monrovia, California), polymer mesh base of InVu (TP Orthodontics, Inc., La Porte, IN, United States), patented bead ball base of Inspire Ice (Ormco, Glendora, California), and a mechanical mesh base of Gemini Metal bracket (Unitek/3M, Monrovia, California). Ten brackets of each type were bonded to 50 maxillary premolars with Transbond XT (Unitek/3M). Samples were stored in distilled water at room temperature for 24 hours and subsequently tested for shear bond strength with a universal testing machine at a cross head speed of 1mm/minute with the help of a chisel. The debonded interface was recorded and analyzed to determine the predominant bond failure site under an optical microscope (Stereomicroscope) at 10X magnification. One-way analysis of variance (ANOVA) was used to compare SBS. Tukey's significant differences tests were used for post-hoc comparisons. The Adhesive Remnant Index (ARI) scores were compared by chi-square test. The results showed that the mean SBS of microcrystalline base (27.26±1.73), was the highest followed by bead ball base (23.45±5.09), adhesive precoated base (20.13±5.20), polymer mesh base (17.54±1.91), and mechanical mesh base (17.50±2.41) the least. Comparing the frequency (%) of ARI Score among the groups, chi-square test showed significantly different ARI scores among the groups ($\chi^2 = 34.07$, $p<0.001$). Thus it was concluded thatdifferent base designs of metal and ceramic brackets influence SBS to enamel and all were clinically acceptable.

45. **Kachoei M, Mohammadi A, MoghaddamM.E,RikhtegaranS, Pourghaznein M,Shirazi S (2016)[14]:**The purpose of this study was to compare the multiple rebond shear bond strength of debonded brackets after

preparation with sandblasting and CO2. For this study, brackets were bonded on 30 human and bovine maxillary central incisors. Brackets were debonded and the shear bond strength was measured using universal testing machine. The debonded brackets were then randomly divided into 2 groups of 15 each based on the surface preparation and the composite residue removal technique. In group 1, the adhesive was removed by sandblasting with 50um aluminum oxide particles and rebonding was done on new un-bonded teeth. In group 2, the composite resin was removed using CO2 laser having a wavelength of 10600nm and rebonded again. Both the groups were then subjected to shear bond strength testing. All the samples in each sub-group were again bonded for the third and fourth time using the protocol of that group and each bonding procedure was carried out on new teeth. SBS was measured each time. ARI was also recorded after each debonding. It was seen that there were significant differences in SBS values between pre-cycling, first, second and third recycling with laser. The SBS in sandblasting group decreased in first and second recycling and increased in third recycling procedure. It was concluded that SBS of brackets after recycling with laser and sandblasting showed no significant differences. However, repeated recycling of brackets with sandblasting showed more favorable results as compared to lasers.

46. **Mirhashemi A.H, Hosseini M.H, Chiniforoush N, Soudi A, Moradi M (2018)[15]:** This study aimed to determine the shear bond strength of rebonded ceramic brackets by using four different methods of adhesive removal. The removal of adhesive was done by using Er: YAG laser, Er;Cr: YSGG laser, sandblasting and direct flame. For this study, 50 human premolar teeth were taken and were divided into 5 groups of 10 each. Brackets in the 4 groups were debonded and the remaining adhesive was removed by the above-mentioned methods. After removing the adhesive, the recycled brackets were bonded again. The 5th group was the control group in which new ceramic brackets were bonded. All the groups were then subjected to shear bond strength testing by using universal testing machine. ARI was also visualized under 10x microscope. Obtained data were then analyzed by using one-way

ANOVA and Tukey's test. The results showed that there was no significant difference among the five groups. However, the highest SBS was noted in control group followed by Er:YAG group and lowest SBS was seen in direct heating group. ARI scores indicated that most of the adhesive remained on enamel surface.

47. **Salama F, Alrejaye H, Aldosari MA, Almosa N(2018)[48]:** Carried out a study to evaluate and compare the shear bond strength (SBS) of new and rebonded orthodontic brackets bonded enamel surfaces using two orthodontic adhesives: Transbond XT (resin-modified glass-ionomer) and GC Fuji Ortho (resin-composite). 40 premolars were randomly allocated into four groups (n=10). Orthodontic premolar brackets (Ortho Classic - Roth. 022, Ortho Classic Inc., McMinnville, OR, USA) were bonded to the enamel surface using both the adhesives. Then the brackets were debonded using debonding plier, ETM, Bracket Removing Plier #803-0104 (Ormco Corporation, Orange, CA, USA). Sandblasting was performed for the de-bonded brackets using sandblaster and rebounded to the ckean enamel surface. The rebonded brackets were then again evaluated for SBS. Also after each debonding, the remaining resin on enamel was scored for ARI. It was seen that the bond strength of debonded sandblasted stainless-steel brackets was higher than new brackets. Resin-composite and RMGI orthodontic adhesives used in this study exhibited sufficient SBS values for bonding brackets to sound and cleaned enamel and comparable to each other.

48. Ahmed ZA, Al-Khatieeb MM (2020)[86]: The aim of this study was to evaluate and compare the effects of different recycling methods on shear bond strength and morphological changes of deboned ceramic brackets. A total of eighty-four extracted human upper first premolars were used in this study. Forty-eight Damon® ClearTM self-ligating ceramic brackets with a mechanical retentive base were divided into two groups; the first group contained twelve new ceramic brackets (the control group), while the second group contained thirty-six new brackets which were bonded to unetched and slightly wet buccal tooth surface to allow an easy debonding of these brackets by tweezer, these debonded brackets then divided into three experimental (recycled) groups (12 per group): Recycled by sandblasting, irradiation by an Er, Cr: YAG laser and irradiation by CO_2 laser. After recycling, the 36 recycled brackets plus the twelve new brackets (the control) were bonded to the forty-eight premolar teeth again following standardized bonding procedure. The shear bond strength of all specimens was determined with a universal testing machine at a crosshead speed of 1 mm/min until bond failure occurred. The adhesive remnant index (ARI) was calculated under a stereomicroscope at X10 magnification. From the statistics, it was concluded that all reconditioning methods would result in clinically acceptable shear bond strength, except CO_2 laser method. The Er,Cr:YSGG recycling method can effectively remove the adhesive from the bases of ceramic brackets without damaging them; thus, this method may be preferred over other recycling methods.

49. **Joshi D, Singh K, Raghav P, Reddy M (2017)[87]:**A sample of 75 maxillary first premolar extracted teeth were divided into 3 equal groups of 25 each. Group 1: Control group in which initial bonding followed by debonding was done with no surface treatment. In In Group 2, enamel surface reconditioning was done with diamond bur using a high-speed handpiece and in Group 3 enamel surface reconditioning was done with air abrasion (50 µm aluminum oxide particles). The brackets in Group 2 and 3 were removed by pliers and rebounded after sandblasting the bracket base to remove the resin. Rebonding was done again following the same method as earlier. The SBS of all the groups were then evaluated using a universal testing machine. Enamel surface topography was also evaluated using scanning electron microscope. Results showed that shear bond strength was highest in the air abrasion group (7.68 ± 0.99 megapascal [MPa]) diamond bur group (6.7 ± 1.3 MPa). Also it was concluded through SEM investigations that rougher surface achieved higher shear bond strength.

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Lucknow in collaboration with Central Institute of plastic Engineering and Technology (CIPET), Ranchi,with an aim to evaluate and compare the shear bond strength (SBS) of bonded and rebonded ceramic brackets.

MATERIALS

1. COLLECTION OF SAMPLE (TEETH):

In this *in-vitro* study, a minimum total sample size of 50 i.e 25 in each group was found to be sufficient when assuming an alpha of 0.05, power of 95 %.The sample consisted of 50 human premolar teeth extracted from the patientsundergoing fixed orthodontic treatment. The teeth were obtained from Department of
Oral and Maxillofacial Surgery, Babu Banarasi Das College of Dental Sciences,
Lucknow and also from various dental institutions and clinics where extractions had been done for Orthodontic purpose. Informed consent was taken from all the subjects for using their teeth for the study. The teeth were thoroughly cleaned for any soft tissue debris or blood afterextraction and then stored in saline at room temperature for maximum of 3 months until they were subjected to SBS testing.

Eligibility criteria:

Inclusion criteria:

1. All premolar teeth should have intact enamel, without the presence of hypoplastic areas, caries, fractures or cracks visible to the naked eye.
2. No history of trauma or any structural alteration caused by mechanical procedure during extraction.
3. The teeth should have not been subjected to any chemical agent, eg. Hydrogen peroxide or any other bleaching agent
4. No previous history of bonding on the tooth surface.

Exclusion criteria:

1. Premolars of patients who have previously undergone orthodontic treatment.
2. Patients who had history of restoration or cosmetic dental treatment.

ALLOCATION OF GROUPS:

The study was carried out in 2 steps:

a) First step involved the bonding of Symetri Clear brackets on all the 50 premolar teeth.
b) Next step included debonding of the 25 out of the 50 Symetri Clear brackets with specialized debonding pliers and rebonding them.

Based on these steps, 2 groups of the study were made:

- **GROUP I:** consisted of 25 premolar teeth on which new Symetri clear brackets were bonded and then SBS was measured using a Universal testing machine Tineus Olsen.
- **GROUP II:** consisted of 25 premolar teeth on which rebonding was done after debonding the freshly bonded Symetri Clear brackets. The SBS of these rebonded brackets were then evaluated using a Universal testing machine Tineus Olsen.

1. MATERIALS FOR FABRICATION OF MOULD FOR MOUNTING OF TEETH (Fig 1):

- Alginate impression material (algitex)
- Plastic cylindrical pipe of 0.5 inch diameter
- Cold cure acrylic resin (pyrax)–white and pink
- Diamond disk- for grooving the cement- enamel junction of the tooth.
- saline- for storage of mounted teeth.

2. MATERIALSFOR BONDING (Fig 2):

- Etchant- DPI etchant gel (White, India, 37% phosphoric acid), was used for etching.

- Light cure unit-The light cure composite material was cured using RTA Mini S LED cure unit.The specification are shown in Table 1:

TABLE 1:SPECIFICATION OF THE LIGHT CURE UNIT

CODE	LIGHT CURING UNIT TYPE	LIGHT INTENSITY (mW/cm^2)	WAVELENGTH RANGE (nm)
RTA Mini S	LED	1000	420-480

- Brackets - a total of 50 premolar ceramic brackets of symetri clear (ormco corporation, orange, calif) with mesh base surface area, bracket base area of 12.2 mm^2 and a slot configuration of 0.022” x 0.028″ were used.

- Adhesive - Light curable orthodontic material Transbond XT adhesive (3M Unitek Corporation, Monrovia, Calif) supplied as a single paste contained in a syringe was used.

- Primer - Transbond XT Primer used prior to application of adhesive.

- Applicator tips

- Bracket holding tweezer

- Gloves

- Marker- for marking purposes

- 3 way air syringe

- Straight probe- for removing excess of adhesive

FIGURE 1: MATERIALS USED FOR FABRICATION OF MOULD

(A) ALGINATE; (B) COLD CURE ACRYLIC RESIN; (C) DIAMOND DISK

(D)PLASTIC CYLINDRICAL PIPE

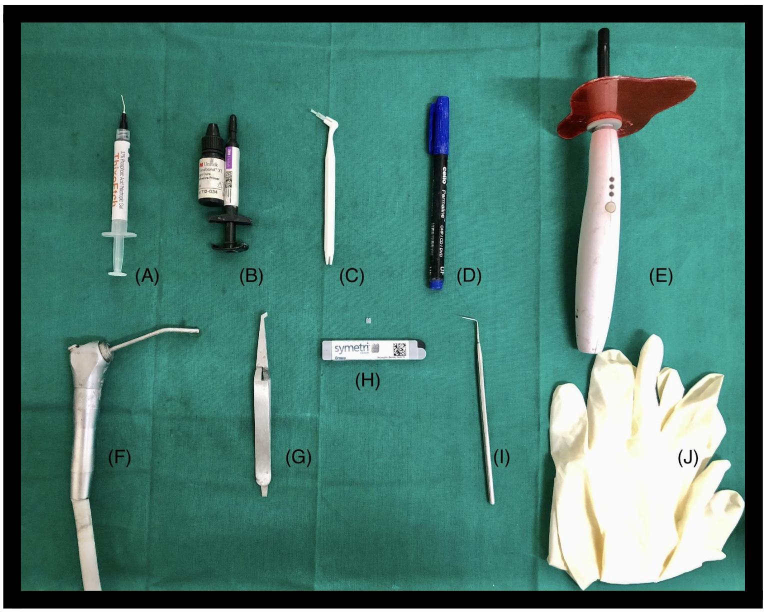


FIGURE 2: MATERIALS USED IN BONDING

(A) ETCHANT; (B) TRANSBOND XT PRIMER AND ADHESIVE; (C) APPLICATOR; (D) MARKER (E) LIGHT CURE UNIT; (F) THREE-WAY SYRINGE (G) BRACKET HOLDING PLIERS (H) SYMETRI CLEAR CERAMIC BRACKETS (I) STRAIGHT PROBE (J) GLOVES

3. **<u>MATERIALS USED FOR DEBONDING (Fig 3)</u>:**

Specialized debonding pliers for the bracket removalprovided by the manufacturer.

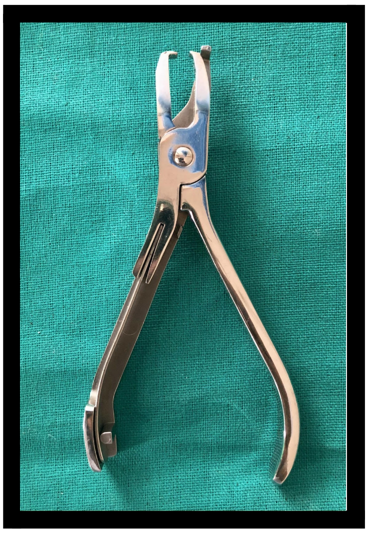


FIGURE 3: SPECIALIZED DEBONDING PLIERS

4. **<u>MATERIALS USED FOR EVALUATING API (Fig 4):</u>**

Magnifying glass of 10x magnification

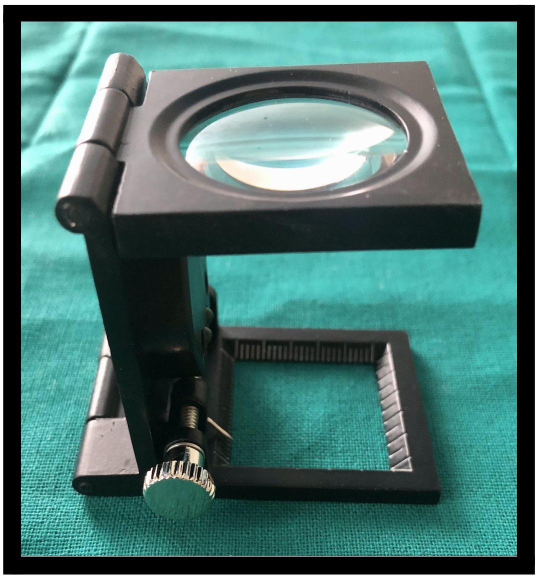


FIGURE 4: MAGNIFYING GLASS (10X)

5. MATERIALS USED FOR ENAMEL CLEANING (Fig 5):

- Initial cleanup: Tungsten carbide bur
- Final cleanup: Super-snap discs(Shofu)- fine and ultrafine
- Polishing: pumice with rubber cup
- Air-rotor
- Micromotor and with handpiece

6. MATERIALS USED FOR SURFACE TREATMENT OF BRACKET BASES BEFORE REBONDING (Fig 6):

- Sandblaster-Microblaster (Microjata standard, bio-art).
- Aluminum oxide–50 micron aluminum oxide particles (Microjata standard, bio-art).
- Protective eye shield and mouth masks

FIGURE 5: MATERIALS USED FOR ENAMEL CLEANUP
(A) MICROMOTOR; (B)HANDPIECE; (C) RUBBER CUP; (D) TUNGSTEN CARBIDE BUR;
(E) AIRROTOR; (F)SUPER-SNAP DISCS

FIGURE 6: MATERIALS USED FOR SURFACE TREATMENT OF BRACKET BASES
(A) MICROBLASTER WITH ALUMINUM OXIDE; (B)EYE SHIELD; (C) MOUTH MASK

7. MATERIALS USED FOR REBONDING:

Same as that used for bonding of brackets.

8. FOR MEASURING SHEAR BOND STRENGTH (Fig 7):

The Universal testing machine was used to measure the SBS was at Central Institute of Plastics Engineering and Technology, CIPET, Ranchi. The specifications of the machine are shown in Table 2.

TABLE 2: SPECIFICATIONS OF THE MACHINE

Universal Testing Machine	Model	Working Range	Cross Head Speed	Accuracy	Purpose
Tineus Olsen	25 ST	Max 25KN	0.001 mm/min	0.01 N	Mechanical properties

FIGURE 7: UNIVERSAL TESTING MACHINE (TINEUS OLSEN)

METHODOLOGY:

1. STEPS TO BE FOLLWED FORMOUNTING OF TEETH:

- First the moulds were made by inserting the plastic cylindrical pipe (0.5 inch diameter, 25 cm in height) in the alginate impression material and allowed to set.
- After setting of the alginate, the pipe was taken out thus creating a cylindrical mould.
- The moulds were then filled with cold cure acrylic resin and the extracted premolar teeth that were grooved at cement-enamel junction using water-cooled diamond disc were mounted vertically in these moulds with acrylic resin. The resin was poured to the level of grooved CEJ.
- Clear acrylic resin was used for sample of teeth to be used in group I and pink acrylic was used for sample of teeth to be used in group II(Fig 8).
- All specimens were positioned in moulds so that the buccal, lingual and proximal surfaces were perpendicular to the base of the mounting moulds (Fig 9 and 10).
- Then the auto-polymerizing polymethyl methyl-acrylate was allowed to set for 45 minutes.
- These mounted teeth were stored in saline to keep them moist so that desiccation did not affect the enamel surface.

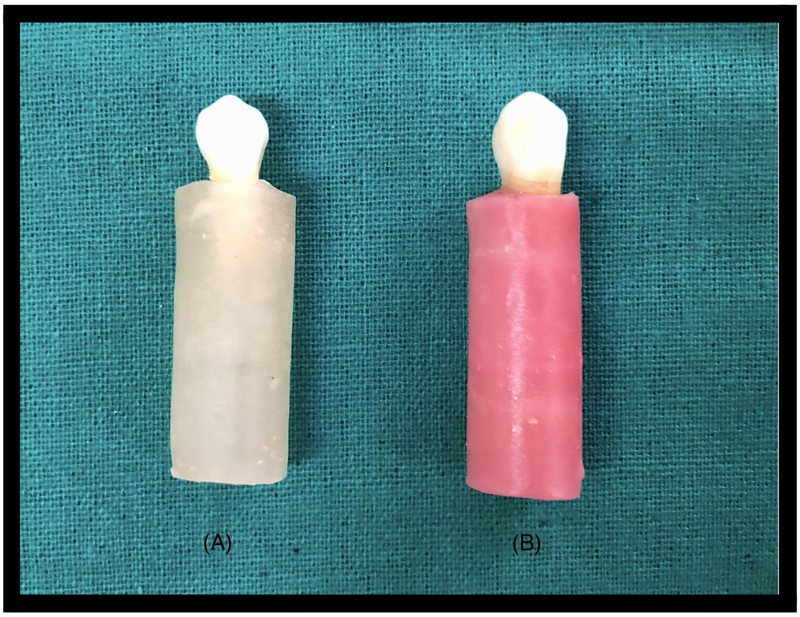


FIGURE 8: MOUNTED SAMPLE TOOTH:

GROUP I (CLEAR) GROUP II (PINK)

FIGURE 9: ALL MOUNTED SAMPLESOF GROUP I

FIGURE 10: ALL MOUNTED SAMPLE OF GROUP II

2. METHOD OF BONDING FOR GROUP – I AND GROUP -II

- Enamel surface was cleaned and polished with pumice using rubber cup in a slow speed hand piece and then washed with abundant water spray for 15seconds.
- Teeth were then dried with compressed oil free air spray for 5seconds.
- Pencil marks were made horizontally on mid of the premolar crown and vertically along the long axis of the tooth(Fig 11B and fig 12B).

- 37% orthophosphoric acid was applied to the center of the clinical crown around intersection of marks made on the buccal surface of each tooth and left for 15sec (fig 11C and 12C).
- The teeth were then thoroughly rinsed with distilled water for 20seconds.
- The conditioned enamel surface was then dried for 5seconds with the compressed air until the buccal surface of the etched teeth had frosty appearance.
- The primer was applied to the etched surfaces of the teeth and then cured for 10 seconds.
- Primer was applied to the bracket base followed by small layer of Transbond XT before placing the ceramic brackets on the demarcated etched enamel surface.
- Bracket was placed at the center of the clinical crown with long axis of bracket perpendicular to the long axis of the crown. This was done to ensure that the bracket would later receive a shear force at 90^{o} to the wider dimension of the slot (Fig 11E and 12D).
- The bracket was seated on the tooth surface with gentle pressure to squeeze out surplus resin, which was removed with a straight probe.
- The bracket adhesive interface was cured for 20 secondseach on mesial and distal side of bracket with light curing units(Fig 11F and 12 E).. These bonded teeth were then stored in saline until they were subjected to SBS testing (Fig 13).

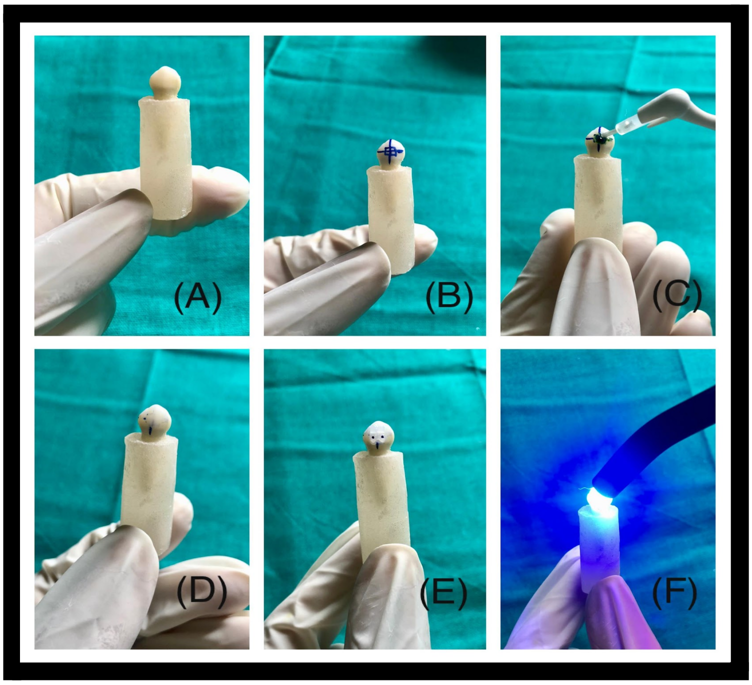


FIGURE 11: METHOD OF BONDING FOR GROUP I
(A) CLEANED BUCCAL SURFACE OF PREMOLAR TEETH; (B) AREA MARKED FOR APPLICATION OF ETCHANT; (C) APPLICATION OF ETCHANT; (D) FROSTY WHITE APPEARANCE AFTER ETCHING; (E) PLACEMENT OF BRACKET; (F) CURING OF THE ADHESIVE WITH LIGHT CURE GUN.

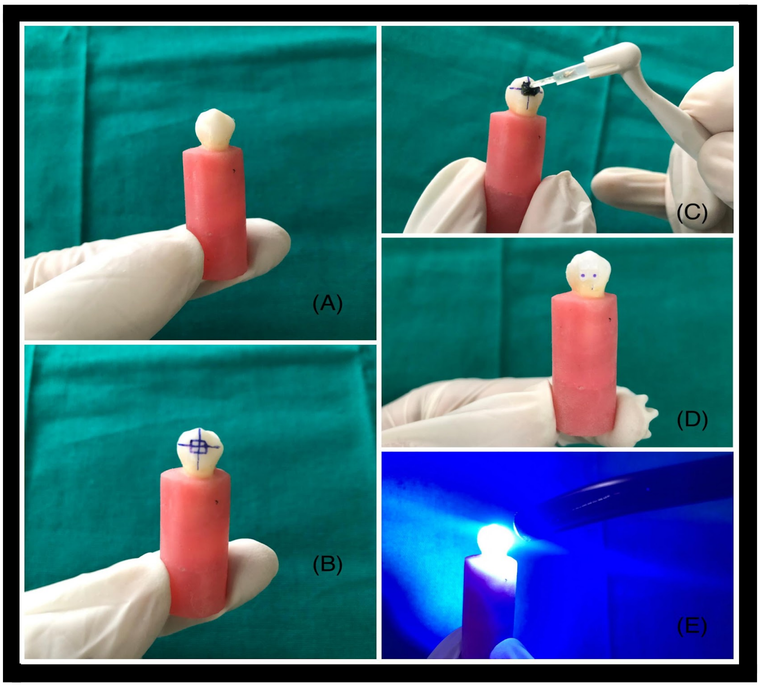


FIGURE 12: METHOD OF BONDING FOR GROUP II

(A) CLEANED BUCCAL SURFACE OF PREMOLAR TEETH; (B) AREA MARKED FOR APPLICATION OF ETCHANT; (C) APPLICATION OF ETCHANT; (D) PLACEMENT OF BRACKET; (E) CURING OF THE ADHESIVE WITH LIGHT CURE GUN.

FIGURE 13: GROUP I AND II SAMPLES AFTER BONDING

3. METHOD OF DEBONDING GROUP II (Fig 14):

- The brackets in Group II were now debonded using the specialized debonding pliers provided by the manufacturer.
- Gentle pressure was given to debond the brackets.
- Special care was taken as not to fracture or damage the brackets in any way.
- After debonding with the pliers, ARI was visualized on the tooth surface with a magnifying glass of 10X magnification as discussed later.

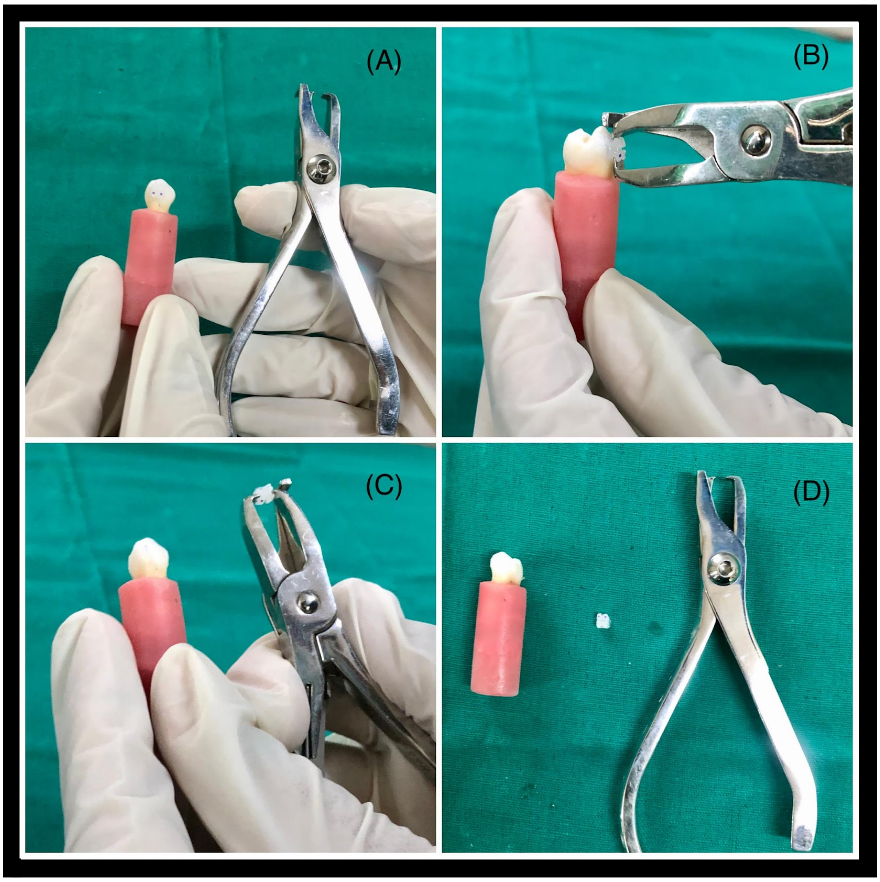


FIGURE 14: METHOD OF DEBONDING FOR GROUP II
(A)DEBONDING PLIERS AND THE SAMPLE OF GROUP II; (B) DEBONDING THE

BRACKET BY GENTLE PRESSURE ON THE PLIERS (C,D) DEBONDED INTACT BRACKET WITHOUT FRACTURE OF TIE WINGS

4. METHOD OF TREATMENT OF DEBONDED SYMETRI CLEAR BRACKET BASE(Fig 15):

Sandblasting was done for the bracket base using 50-micron aluminium oxide particles for 40 seconds in circular motion by a sandblaster held at 2 to 4 mm of distance and this now served as a recycled ceramic bracket.Precaution was taken during air abrasion for protection of eyes and to avoid unwanted inhalation of aluminum oxide particles during the procedure by using eye shield and mouth mask.

5. METHOD FOR TOOTH SURFACE CLEANUP FOR REBONDING IN GROUP II (Fig 16):

Initial enamel cleaning for removal of adhesive remaining on the tooth surface after debonding was done using a tungsten carbide at low speed. Final enamel cleanup was done using a composite finishing bur followed by sof-lex discs. Polishing was done with pumice using rubber cupslow speed hand piece and then washed with abundant water spray for 15seconds.

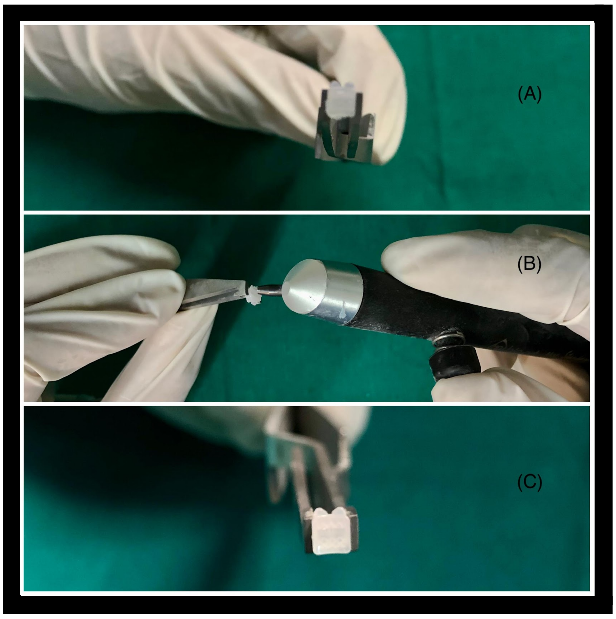


FIGURE 15: METHOD OF TREATMENT OF DEBONDED BRACKET BASE
(A) DEBONDED BRACKET WITH ADHESIVE REMAINING ON THE BASE;
(B)SANDBLASTING OF THE BASES OF DEBONDED BRACKETS;
(C) NO ADHESIVE REMAINING ON BRACKET BASES AFTER SANDBLASTING

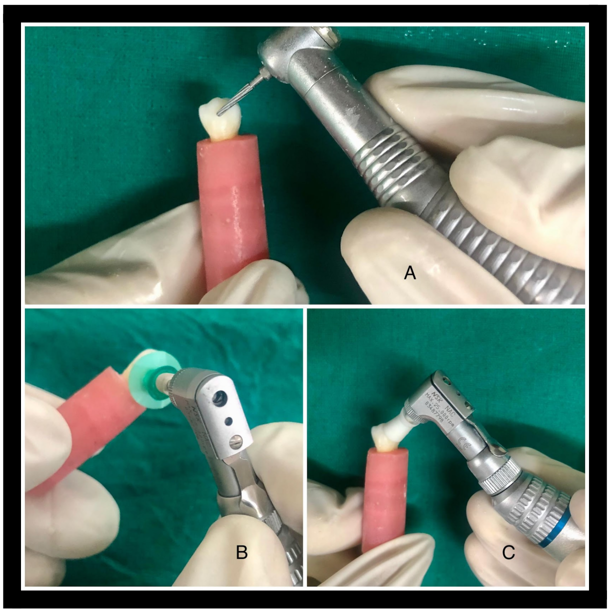


FIGURE 16: METHOD OF CLEANING ENAMEL SURFACE

(A)INITIAL CLEANING BY TUNGSTEN CARBIDE BUR (B)FINISHING WITH SUPER-SNAP DISC (C) FINAL POLISHING BY RUBBER CUP AND PUMICE SLURRY.

6. METHOD OF REBONDING FOR GROUP – II

- Same procedures were followed for bonding as discussed earlier.
- These rebonded teeth were then stored in saline until they were subjected to SBS testing.

7. SHEAR BOND STRENGTH TESTING (Fig 17):

- All the specimens of Group I and Group II were subjected to Shear Bond Strength (SBS) testing using universal testing machine Instron. A customized mounting jig positioned on the compression plates of the machine was used to hold the tooth and an occluso-gingval force was applied to the bracket, producing a shear force at the bracket-tooth interface. The shear force was applied using a chisel – edge plunger, mounted in the movable crosshead of the testing machine. The plunger was positioned such that the leading edge aimed at the bracket-tooth interface before being brought into contact with it at a crosshead speed of 0.5mm/min. The force was increased till the brackets were debonded and this was recorded in Newton (N) by a computer, which was electronically connected with the testing machine. Force was converted into megapascal (MPa= N/mm^2) by dividing the measured force values (N) by the mean surface area of the brackets (mm^2). SBS calculated in MPa for all the samples was recorded.

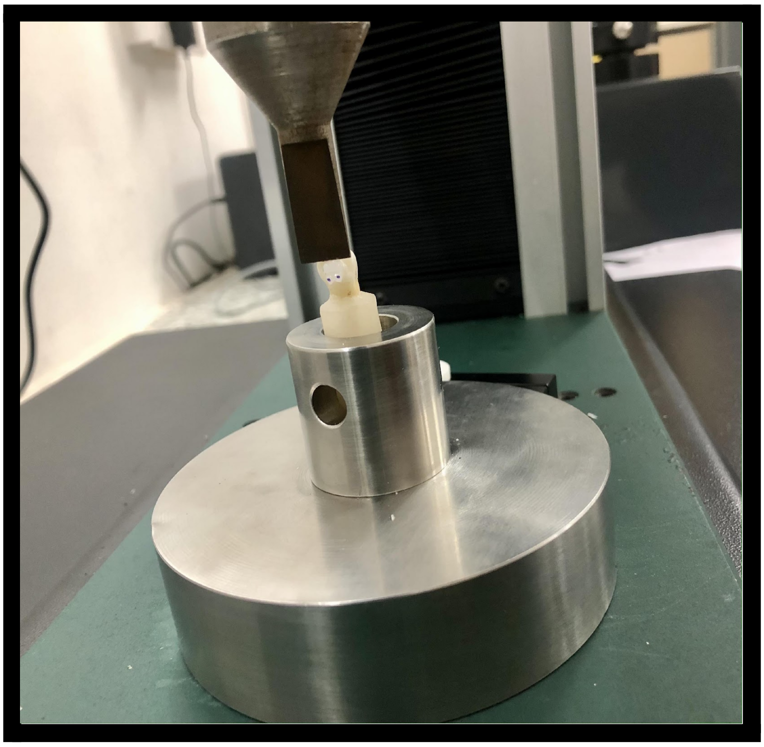


FIGURE 17 : SHEAR BOND STRENGTH TESTING POSITION CHISEL EDGE AT THE BRACKET-TOOTH INTERFACE. DEBONDING OF BRACKET IN GROUP I

8. ADHESIVE REMNANT INDEX:

- After debonding, ARI was visualized in group I and II and scored according to the index given by Artun and Bergland(Table 3)

TABLE 3: ADHESIVE REMNANT INDEX

ARI SCORES	CRITERIA
0	No adhesive left on the tooth
1	Less than half of the adhesive left on the tooth
2	More than half of the adhesive left on the tooth
3	All adhesive left on the tooth

- The brackets of Group I were visualized for adhesive remaining on the tooth surface with a magnifying glass.

- In Group II, ARI was evaluated twice. First after debonding with the special debonding pliers. Second, after the rebonded brackets were debonded with Universal testing machine.

STATISTICAL TOOLS EMPLOYED

A. The Arithmetic Mean

The most widely used measure of central tendency is arithmetic mean, usually referred to simply as the mean, calculated as

$$X = \frac{\sum_{i=1}^{n} \bar{X}_i}{n}$$

B. The Standard Deviation

The standard deviation (SD) is the positive square root of the variance, and calculated as

$$SD = \sqrt{\frac{\sum X_i^2 - \frac{(\sum X_i)^2}{n}}{n-1}}$$

where, n= no. of observations

and also denoted by subtracting minimum value from maximum value as below

C. Tests of significance

Test of significance are used to estimate the probability that the relationship observed in the data occurred purely by chance was there a relationship between the variables. They are used to test the hypothesis proposed at the start of the study.

In this study Parametric tests were used

a) The data was normally distributed

b) The data was obtained from the sample which is randomly selected

c) The data was quantitative data

I. t TEST.

T tests are based on the t distribution which is a symmetrical, bell-shaped curve like the normal distribution, but having different area and probability properties.

T distribution is a family of curves which are differentiated by their degrees of freedom.

With increasing sample sizes, the t distribution assumes the shape of the normal distribution. 2 A sample size of 100 is often chosen as the cut-off point for deciding when to apply For t or z.

TYPES OF t TESTS INDICATIONS.

a) Paired T Test

The paired t test is used to decide whether the differences between variables measured on the same or similarly matched individual are on average zero. As the data are matched there must be an equal number of observations in each sample.

Assumption. The paired t-test assumes that the differences in scores between pairs are approximately normally distributed, although the two sets of data under scrutiny do not need to be normally distributed.

b) Unpaired or two-sample t test (equal variance assumed)

The unpaired t test is used for comparing two independent groups of observations when no suitable pairing of the observations is possible.The samples do not need to be of equal sizes.

Assumptions. The test requires the populations to be normally distributed with equal variance, though the test is relatively robust to deviations from these assumptions. Unpaired t test or two-sample t test (unequal variance)

When the variances of the two groups differ and transformation does not produce equal variance, the calculation of the t test becomes more complex. Instead of using the pooled variance, estimates of the individual population variances are used

Formula:

$$t = \frac{M_x - M_y}{\sqrt{\frac{S_x^2}{n_x} + \frac{S_y^2}{n_y}}}$$

M =mean

n = number of scores per group

$$S^2 = \frac{\sum (x - M)^2}{n - 1}$$

x = individual scores

M = mean

n= number of scores in group

- Define the problem
- State null hypthesis(H_0) & alternate hypothesis(H_1)
- Find t value, Find (X_1 - X_2)
- Calculate SE of difference between two means

$$SE = \sigma\sqrt{1/n_1+1/n_2} \text{ or}$$

$$t = (X_1 - X_2) / SE$$

- Calculate degree of freedom = $n_1 + n_2 - 2$
- Fix the level of significance (0.05)
- Compare calculated value with table value at corresponding degrees of freedom and significance level
- If observed t value is greater than theoritical t value, t is significant, reject null hypothesis and accept alternate hypothesis

II. ANALYSIS OF VARIANCE

Analysis of variance (ANOVA) is used when we compare more than two groups simultaneously. The purpose of one-way ANOVA is to find out whether data from several groups have a common mean. That is, to determine whether the groups are actually different in the measured characteristic. One way ANOVA is a simple special case of the linear model. For more than two independent groups, simple parametric ANOVA is used when variables under consideration follows Continuous exercise group distribution and groups variances are homogeneous otherwise non parametric alternative Kruskal-Wallis (H) ANOVA by ranks is used. The one way ANOVA form of the model is

$Y_{ij} = \alpha_{.j} + \varepsilon_{ij}$

where:

- Y_{ij} is a matrix of observations in which each column represents a different group.
- $\alpha_{.j}$ is a matrix whose columns are the group means (the "dot j" notation means that α applies to all rows of the j^{th} column i.e. the value α_{ij} is the same for all i).
- ε_{ij} is a matrix of random disturbances.

The model posits that the columns of Y are a constant plus a random disturbance. We want to know if the constants are all the same.

Assumptions are:

a) Response variable must be normally distributed (or approximately normally distributed).
b) Samples are independent.
c) •Variances of populations are equal.
d) The sample is a simple random sample (SRS).

Two-way anova is used when we have one measurement variable and two nominal variables, and each value of one nominal variable is found in combination with each value of the other nominal variable. It tests three null hypotheses: that the means of the measurement variable are equal for different values of the first nominal variable; that the means are equal for different values of the second nominal variable; and that there is no interaction (the effects of one nominal variable don't depend on the value of the other nominal variable). When we have a quantitative continuous outcome and two categorical explanatoryvariables, we may consider two kinds of relationship between two categorical variables,In this relationship we can distinguish effect of one factor from that of the other factor. This type of model is called a **main effect model** or **no interaction** model.

Tukey Multiple Comparison Test

After performing ANOVA, Tukey HSD (honestly significant difference) post hoc test is generally used to calculate differences between group means as where,

$$q = \frac{X_1 - X_2}{SE}$$

$$SE = \sqrt{\frac{S^2}{2} \quad \frac{1}{n_1} + \frac{1}{n_2}}$$

S^2 is the error mean square from the analysis of variance and n_1 and n_2 are number of data in group 1 and 2 respectively.

Statistical significance

Level of significance "p" is level of significance signifies as below:

$p>0.05$	Not significant (ns)
$p\leq 0.05$	significant (*)

MEASUREMENT OF RELIABILITY

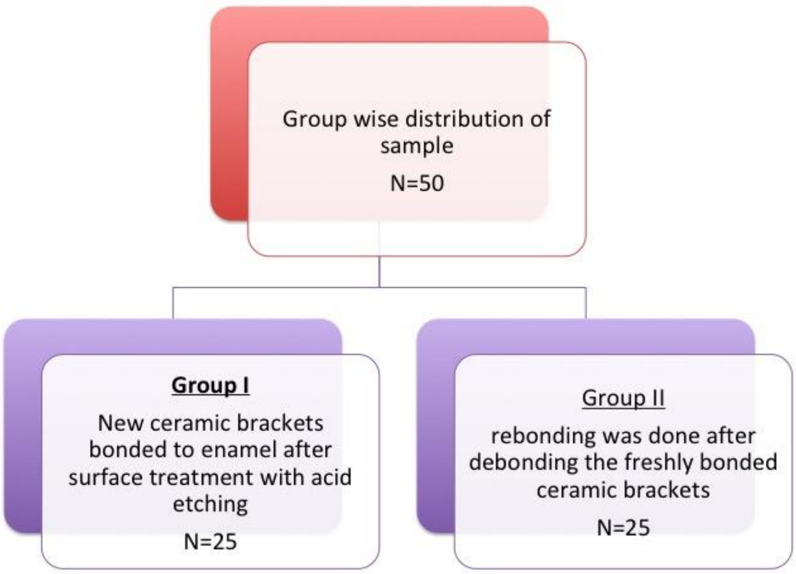
No differences were seen in the two set of observations taken at different time intervals as p >0.05.Thus SBS obtained in the study were reliable.

Sample	Reading 1	Reading 2	Mean diff
1	9.336	9.302	.03
2	9.713	9.790	-.08
3	9.891	8.962	.93
4	9.109	9.110	.00
5	9.536	9.542	-.01
6	8.726	8.701	.03
7	8.803	8.816	-.01
8	9.619	9.621	.00
9	8.414	8.451	-.04
10	9.278	9.301	-.02
Mean ±SD	9.24±0.47	9.15±0.43	
p value	0.403		

The present study was undertaken in the Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Lucknow in collaboration with Central Institute of plastic Engineering and Technology (CIPET), Ranchi. The purpose of the study was to evaluate and compare the shear bond strength of bonded and rebonded ceramic brackets.

The study comprised a total of 50 samples of extracted premolar teeth which were equally divided into two groups of 25 teeth each. For Group I, new Symetri clear brackets were bonded and then SBS was measured using a Universal testing machine Instron. InGroup II, rebonding was done after debonding the freshly bonded Symetri Clear brackets. The SBS of these rebonded brackets were then evaluated using a Universal testing machine. Table 4 shows the distribution of samples.

TABLE 4: SHOWING DISTRIBUTION OF SAMPLES



The force was measured in Newton as the chisel moving at a cross-head speed of 0.001 mm/min debonded the bracket. This was divided by the bracket surface area (BSA) which was 12.24 mm^2 for Symetri Clear brackets to obtain stress in Mpa.

Stress (Mpa) = force (N)

BSA (mm^2)

Where, P= pressure (N/mm 2)

F= force applied by the piston (N)

a= surface area of the bracket mesh base (10.50mm 2)

The Shear Bond Strength thus obtained was in N/mm 2 which was converted to MPa as:

1N/mm 2 = 1Mpa

TABLE 5: DESCRIPTIVE STATISTICS FOR GROUP I AND GROUP II

GROUP	N	MEAN SHEAR BOND STRENGTH (Mpa)	STANDARD MEAN ERROR	MINIMUM VALUE (Mpa)	MAXIMUM VALUE (Mpa)	95% CI FOR MEAN	
						Lower Bound	Upper Bound
Group I	25	9.95±3.32	.65201	5.41	16.37	8.58	11.32
Group II	25	8.32±2.74	.56062	3.63	13.32	9.45	7.19

TABLE 6: COMPARISON OF THE MEAN DIFFRENCE OF SBS BETWEEN GROUP I AND GROUP II

Mean Difference of Shear Bond Strength of two groups Mean + S.D. (MPa)	*p*Value	*t*Value
1.16±0.58	0.067	1.877

Table 5 and shows the descriptive statistics for Group I and Group II. Group I has a higher mean SBS of 9.95±3.32 Mpa than that of Group II which has a mean SBS of 8.32±2.74 Mpa. No significant statistical difference was seen in the mean shear bond strength of two study groups when compared using t test as p>0.05 (table 6).

Group I had maximum and minimum SBS value of 5.41 and 16.37 Mpa respectively whereas, Group II had a maximum and minimum SBS value of 3.63 and 13.32 respectively.

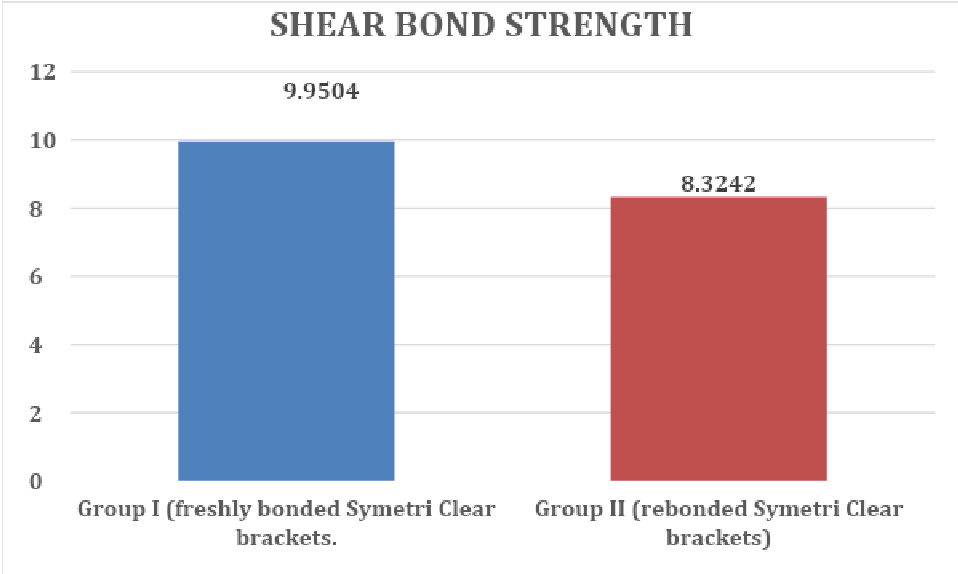
p> 0.05 Not significant

p< 0.05 Significant

p< 0.01 Highly significant

p< 0.001 Very highly significant.

GRAPH 1: BAR DIAGRAM SHOWING THE MEAN SBS OF BOTH THE GROUPS.



GRAPH 2: BOX PLOT SHOWING MAXIMUM AND MINIMUM MEAN SBS VALUES FOR GROUP I AND GROUP II

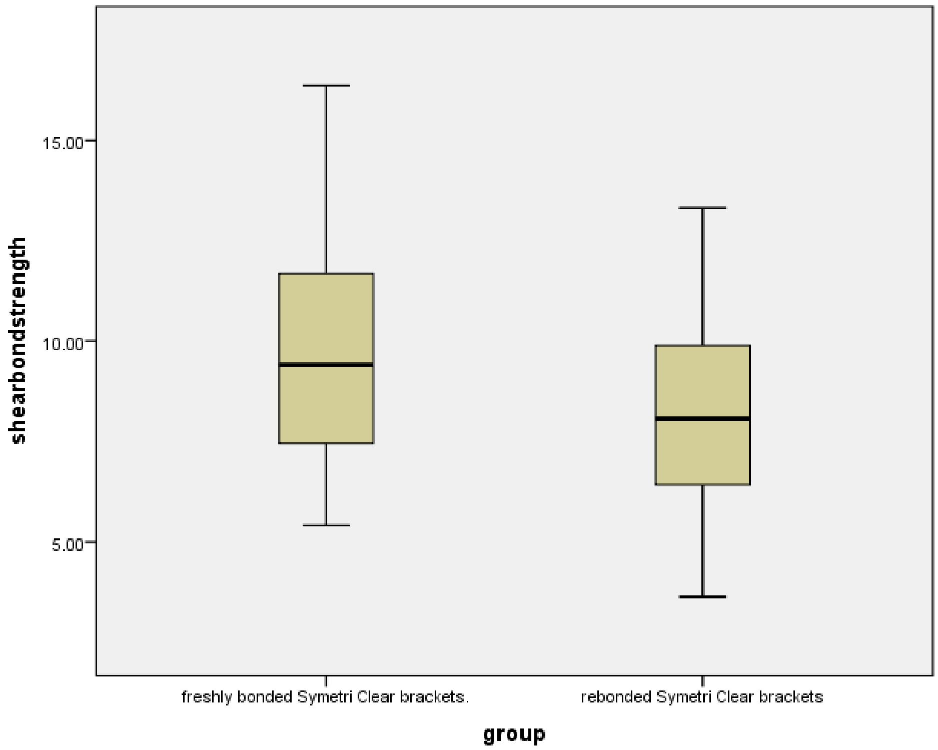


TABLE 7:PERCENTAGE DISTRIBUTION OF ARI SCORES AMONGST THE SAMPLES OF GROUP I AND GROUP II(after debonding with pliers and rebonded brackets debonded with UTM)

SCORES	0	1	2	3
GROUP I	12%	64%	24%	0%
GROUP II (after debonding with pliers)	4%	60%	24%	0%
GROUP II (rebonded brackets after debonding with UTM)	4%	72%	20%	0%

Table 7 depicts the percentage distribution of ARI scores amongst Group I and both the subgroups in Groups in II. 24% of the samples in Group 1 and Group II (after debonding with pliers) had an ARI score of 2 whereas only 20% of the samples in Group II (rebonded brackets debonded with UTM) had a score of 2. None of the samples had a score of 3.

Maximum samples in all the groups had an ARI score of 1- 64% samples Group I , 60% in Group II(after debonding with pliers) and 72% in Group II (rebonded brackets debonded with UTM). 12% in Group 1, and 4% both subgroups in Group II had an ARI score of 0.

The groups are now evaluated statistically with the help of a chi square test

to assess if they are statistically significant or not.

TABLE 8 - COMPARATIVE EVALUATION OF FREQUENCY

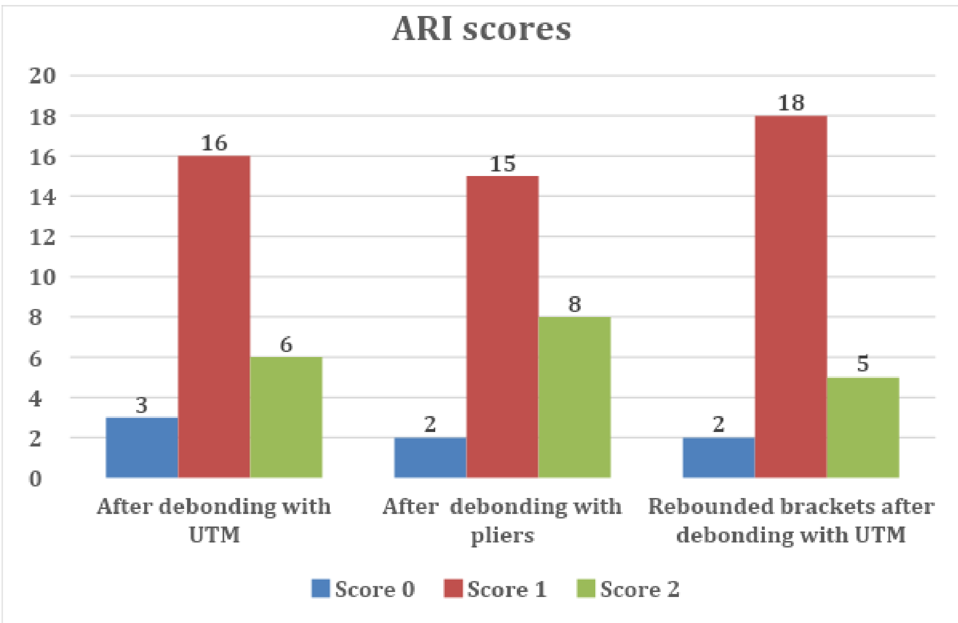
DISTRIBUTION OF ARI SCORE BETWEEN GROUP I AND II(a) and II(b) USINGCHI SQUARE TEST

ARI	0	1	2	3	*p*Value
GROUP I	3	16	6	0	
GROUP II (a)	2	15	8	0	**0.860**
GROUP II (b)	2	18	5	0	

On analysing the above Table 8, no significant statistical difference was seen in the distribution of ARI scores among three study groups when compared using Chi square test as $p>0.05$.

Graph 3 showing the bar diagram for mean ARI scores

GRAPH 3: THE BAR DIAGRAM SHOWING THE MEAN ARI SCORES



Orthodontics has come a long way since the past century and is still a continuously evolving field. Patient esthetics and comfort, maintenance of adequate bond strength and ease of operation for the clinician are the primary reasons for the various innovative developments in Orthodontics. The acid-etch technique by Bunocore[1,2] in 1955 made it possible to directly bond the attachments to the tooth. Direct bonding significantly reduced various disadvantages of banding the tooth.

The success of any fixed Orthodontic treatment depends on adequate bond strength between the brackets and enamel surface[14,15]. The nature of enamel surface, the conditioning and bonding procedure, proper isolation, the quality of adhesive and the bracket material and the design of the bracket base are the factors that influence bond strength[78]. A compromise in any of the above factors will lead to bonding failure and hence treatment failure. Eminkahyagil et al.[24] reported that one out of every five bonded brackets came loose during orthodontic treatment. The bond strength in Orthodontics has to be optimum. It should be able to withstand the masticatory as well as orthodontic forces throughout the treatment and should be just enough so that if there is an intentional debonding planned by the clinician to correct the positional and angulation errors, it can be easily done without damaging the bracket or the enamel. When intentional or accidental debonding happens, it is the call of the Orthodontist whether to rebond the same bracket after recycling it or to bond a new one[39]. The main consideration of the clinician while rebonding the same bracket would be to ensure that the shear bond strength is at least within a range of 5-7 Mpa as proposed by Reynolds[9].

Recycling a debonded bracket is a more economically viable option[79]. The main purpose of the recycling process is to remove adhesives from the bracket base without damaging it or changing the bracket slot dimensions[83]. However, there are several factors that have to be taken into consideration prior to recycling to maintain adequate bond strength[69]. It includes the type of the bracket, method of removal of adhesive from bracket base and enamel, enamel conditioning prior to rebonding[19].

Metal brackets can be recycled in two ways: industrially or Chair-side. In industrial recycling most commonly used method is to burn the bond agent followed by electrolytic polishing to eliminate the remaining oxide, or using chemical agents to dissolve the bond agent in combination with high-frequency vibration and electrochemical polishing. Various in-office recycling techniques are direct burning, micro sandblasting or both. In recent years lasers are being used increasingly to recycle metal brackets. However, metal brackets still did not satisfy the esthetic demands of the patients. This led to the evolution of esthetic alternatives like polycarbonate/plastic brackets and ceramic brackets. Amongst these, ceramic brackets have shown promise as a better esthetic alternative to both polycarbonate and plastic brackets and hence used widely in Orthodontics[65,67,68].

All currently available ceramic brackets are composed of aluminium oxide[73]. However, because of their distinct differences during fabrication, there are two types of ceramic brackets, namely, polycrystalline alumina and mono-crystalline alumina.

Monocrystalline brackets are machined from extrusions of synthetic sapphire. Polycrystalline alumina brackets, on the other hand, are made by injection moulding submicron-sized particles of alumina suspended in a resin, sintering them to fuse the alumina and finally machining the bracket as necessary to produce the finished article[57].

Ceramic brackets are bonded to tooth surfaces via three different mechanisms: mechanical bonding, chemical bonding or a combination of both[85]. However, debonding brackets with chemical retention was difficult resulting in fracture of bracket[70]. If intentional debonding was needed, use of the same bracket was challenging as the tie wings might fracture during debonding. The advancements in this field had led to the development of ceramic brackets by different manufacturers that will debond in one piece and can be reused. Clarity plus brackets were introduced first with the same intention. Another type of ceramic bracket has been developed by Ormco, which is a polycrystalline alumina, mechanically retentive bracket named Symetri Clear. It tackles one of the most challenging aspects associated with ceramic brackets that is it debonds in one piece without any distortion of bracket or fracture of its tie wings. It is achieved by a special debonding plier provided by the manufacturer, which gently squeezes out the bracket without any damage to the bracket or the enamel surface.

A study by Chung et al[61]on Clarity Plus brackets showed that the SBS of rebonded brackets was just close to clinically acceptable limits but was lesser than the newer brackets. However, there are no studies done to evaluate the bond strengths of Symetri Clear ceramic brackets. The present study was conducted with the aim of evaluating and comparing the shear bond strength of newly bonded Symetri Clear brackets to that of recycled Symetri Clear brackets using Universal testing machine.

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics of BabuBanarasi Das College of Dental Sciences, Lucknow in collaboration with Central Institute of Plastic Engineering and Technology (CIPET), Ranchi.

For this study, 50 premolar teeth were divided into two equal groups of 25 each. New Symetri Clear brackets were bonded in both the groups. In Group II, the freshly bonded ceramic brackets were then debonded using a specialized debonding plier provided by the manufacturer. After debonding, brackets bases in Group II were cleaned of adhesives by sandblasting it with 50Um aluminum oxide particles. The enamel surface was cleaned of remaining adhesive with tungsten carbide bur at low speed, then finishing with super-snap dics and finally polishing with rubber cup with pumice slurry. The recycled Symetri Clear brackets were then rebonded on the cleaned enamel surface.

The shear bond strength of Group I and II were then measured using Universal testing machine- Tineus Olsen. The debonded brackets of Group Iwere preserved and scored according to Adhesive Remnant Index. For Group II, ARI was scored twice-once after debonding with the specialized pliers and second after debonding with Universal Testing Machine. Data obtained for SBS and ARI was tabulated and analyzed statistically.

The results of the present study indicated that there was no statistical difference between the shear bond strength values in both the groups. However, on comparison of mean shear bond strength between Group I and Group II,Group I had higher SBS of 9.95±3.32 Mpa than that of Group II which has a mean SBS of 8.32±2.74 Mpa.The mean values of SBS of both the groups of the present study were however above the clinically acceptable limits of SBS as had been suggested by Reynolds as 5-7 MPa. Another important finding of the study was that all the Symetri Clear brackets of Group II debonded in one piece with intact tie wings using specialized debonding pliers as recommended by the manufacturer.

This is a novel study as none of the previous studies have evaluated the bond strengths of newly as well recycled Symetri clear ceramic brackets. Hence, the results of the present study were compared to various studies conducted to evaluate the SBS of freshly bonded ceramic brackets (Reddy et al, Gwinnet et al, Brittton et al, Viazis et al, Forsberg et al).

In a study conducted by **Reddy YG et al**[80]**,** a comparison was made between the bond strengths of ceramic to metal brackets. The study had a sample size of 40 human extracted premolar teeth, which was divided into two equal groups of 20 each. Ceramic brackets (Transcend series 6000) were bonded to Group I and metal brackets (Mini Dynalock Straight wire brackets) were bonded to the second group and the SBS testing was done. The mean SBS was significantly higher for the ceramic group (20.68 ± 3.89 MPa) as compared to that of the metal bracket group (12.15 ± 1.32 MPa). The values for ceramic group was much higher than that obtained in our study for Group I. This could probably be due to the increased micromechanical retention at the base of the ceramic brackets or difference in bracket surface area (BSA) of the brackets used in the study.

Gwinnett AJ[26]did a similar study in which he evaluated and compared the shear bond strength of ceramic brackets to metal brackets. 50 human extracted incisors were established into 5 groups (n=10) and to each group different bracket systems were bonded – Ormesh (metal), Microlok (metal), Allure (ceramic), Transcend (ceramic) and Mirage (plastic/ceramic filled). Higher SBS was observed in ceramic bracket than metal bracket. The average bond strength of ceramic brackets Allure and Transcend were 18.3 ±6.7 Mpa and18.8±5.4 Mpa respectively which was higher than that of plastic/ceramic filled Mirage(15.7±3.0 Mpa), Ormesh and Microlok metal brackets (12.1 ±4.6 , 12.9 ±4.6 respectively). Allure comprised of combination of mechanical slots and silane treatment at their bracket bases and this could be the reason of the enhanced bond strength. Transcend on the other hand had an adhesion promoting treatment at the bracket base which contributed to the high SBS values. This could be the treason for higher SBS values in their study than freshly bonded Symetri Clear brackets of our study.

Britton JC et al[8] conducted a studyin which sample of 80 extracted human incisors were taken which was divided into 5 equal groups (n=16). Five types of orthodontic brackets systems were bonded on the teeth- ceramic (Starfire, Allure, Transcend, Quasar) and stainless steel (in the control group) after etching for 15 and 60 seconds. The SBS was then measured with a universal testing machine. The results indicated that the stainless steel brackets in the control group had highest range of SBS (16.0-31.2 Mpa) followed by Allure (15.0-24.9 Mpa) > Transcend (14.6-24.3Mpa) > Quasar (12.0-27.2 Mpa) > Starfire (7.4-18.7 Mpa). In all the groups 15 second acid etching produced higher bond strengths than 30 second acid-etching.

Viazis AD[66] did a similar study in which he compared the bond strength of different ceramic brackets. The brackets were divided into two groups, one bonded with a new light-cured orthodontic adhesive (Transbond) and the other with a conventional chemically cured system (Concise). Ceramic brackets used were Transcend (polycrystallin, chemically retentive), Allure (polycrystalline, mechanically retentive), Starfire (monocrystalline, chemically retentive) and Gem (monocrystalline, mechanically retentive). The results indicated that the average of the shear bond strengths of chemically retentive ceramic brackets i.e Transcend (39.25 Kg) and Starfire (16.9 kg) was higher than the mechanically retentive ceramic brackets Allure (28.8 kg) and Gem(9.87 kg). This was because ceramicbracket with a chemical bond allows a much greater distribution of stress over the whole adhesive interfacewithout the presence of any localized stress areas.

Therefore the shear bond must be much greater to cause debonding and pure adhesive failure, in contrast to brittle failure with mechanical bonds. Also, there was no statistically significant difference between the mean shear bond strength of the new light-cured orthodontic adhesive tested and the conventional chemically cured system even though the average SBS of chemically cured resin was higher than the light-cured adhesive. They did not calculate the SBS by diving force by BSA as done in most of the studies.

In a different study by **Forsberg CM**[55]**,** comparisons were made in the bond strengths of ceramic brackets having chemical and mechanical retention. Ceramic brackets used were Transcend, which were chemically retentive, and Transcend 2000, which had a mechanical retention. Both were compared with a metal bracket (Ormco Foil-Mesh). The ceramic bracket with chemical retention exhibited significantly *(P* < 0·05) higher bond strength (22.3±7 Mpa) than the corresponding bracket with textured base (17.8±5.7 Mpa). In comparison with the metal brackets (8.4±1.9 Mpa), significantly (P<0.001) higher bond strengths were obtained with both types of ceramic brackets. The results thus obtained was due to the presence of a strong bond between the conditioned enamel and adhesive in chemically retentive brackets and the removal of the bracket seems to be associated with an increased risk for damage to tooth structures.

Since ceramics are brittle materials, the chances of bracket fracture while debonding are high. Therefore, the method of intented debonding of ceramic brackets and recycling ceramic brackets has been challenging for the Orthodontist. Various methods have been proposed for the surface treatment of ceramic brackets at their bases, such asheat application, hydrofluoric acid application, silane application, sandblasting with aluminum oxide, and silica coating + silane (silicatization).Lasers are increasing being used in recent times for resin removal from bracket base. Irrespective of the method of recycling, the clinician has to make sure that the rebonding strength is within the clinically acceptable limits of 5-7 Mpa. No literature is available till now which evaluates SBS of recycled Symetri Clear ceramic brackets. Therefore, the results of the present study were compared to other studies conducted to evaluate the rebond strength of recycled brackets (Chung et al, Guarita et al,Gaffey et al, Yousef ME et al, Lew KKK et al , Lwezy ey al, Sohrabi et al, Devjee et al).

Chung et al[61]conducted a study where the SBS of rebonded mechanically retentive Clarity (3M Unitek) ceramic brackets was evaluated. After the first debonding, the brackets were recycled by various methods like sandblasting, sandblasting + sealant, sandblasting + hydrofluoric acid, sandblasting + HF + sealant and sandblasting + silane. The SBS was compared to newly bonded brackets. The results showed that the new brackets group had the highest mean strength (15.66 ±7.05 MPa), followed by the rebonded/sandblasted/sealant group (7.65 ±5.62 MPa), the rebonded/sandblasted/silane group (5.94 ±5.33 MPa), the rebonded/sandblasted group (2.97±2.29 MPa), the rebonded/sandblasted/HF group (1.22±1.66 MPa), and the rebonded/sandblasted/HF/sealant group (0.82±1.16 MPa). The rebonded/sandblasted/sealant group did not show statistically significant difference. with the new brackets group in bond strength (*P* >.05). The highest bond strength of sandblasted+sealant group amongst different methods of rebonding was probably because sandblasting the base of the debonded brackets not only removed the remaining adhesive; it also roughened the ceramic surface to allow enhanced bonding. Additional sealant applied on the sandblasted ceramic bracket base could flow and fill the microetched surface increasing the bond strength. SBS of rebonded Symetri Clear bracket was 8.32 Mpa where only sandblasting was done was higher than rebonded/sandblasted/sealant group of the above study.

In a very similar study, **Guarita et al**[82] evaluated the SBS of rebonded ceramic brackets after subjecting the bracket base to different treatments: sandblasting with aluminum oxide; sandblasting + silane; silica coating + silane and silicatization performed in a laboratory (Rocatec system). The SBS values of new brackets were then compared with the rebonded brackets. The highest SBS values were observed for new brackets but there was no significant difference with the other rebonded brackets except for the Rocatec group which showed lowest bond strength values. From this result it can be concluded that except Rocatec, other methods of recycling were effective in removing the remaining adhesive from the bracket base and expose it again for rebonding. Thus, sandblasting was found to be an effective yet simple method for recycling.

There was another study by **Gaffey et al**[60]in which the shear bond strength of repositioned Starfire (A-Company) ceramic brackets were evaluated. The brackets were first debonded electrothermally and then they were recycled by various procedures like silane coupling agent, heat + silane coupling agent, hydrofluoric acid + silane coupling agent, heat+ HF + silane coupling agent. The results showed that the SBS values were greater for new brackets (16.9±4 Mpa) and lowest for HF + silane (1.6±2 Mpa). This is probably because the silane coupling agent chemically mediates the adhesion between the ceramic base and adhesive resin. A silica layer placed on the bracket by the manufacturer helps to facilitate the silanation. However, HF acid removes this silica layer resulting in poor bond strength. The bond strengths of other recycling methods were statistically comparable to that of new brackets.

In similar study done by **Yousef et al**[13], rebond strength of 3 recycling methods were evaluated and compared with new brackets. Mechanically retentive Inspire ICE ceramic brackets were recycled bytribochemical silica coating + silane, conventional sandblasting combined + silane, and heat application + silane.The highest bond strength was found in the heat + silane group and the new control brackets (19.5 and 19.2 MPa, respectively) followed by the silica coated aluminum oxide + silane (11.8 MPa.Recycling using 50 μm aluminum oxide + silane resulted in significantly low bond strength (1.5 MPa). High bond strength of heat+silane group could be due to the bracket base maintaining its irregularities which facilitated in the better bond strength as opposed to other methods in which created a smooth surface of the bracket base resulting in lower bond strengths.

In another study by **Lew KKK et al**[59], a comparison was made between the SBS of new and recycled ceramic brackets. Transcend (3M Unitek) was used for this study which were chemically retentive brackets. The debonded brackets were recycled by burning off the residual composite material and then the bracket bases were resilanized with Ormco Porcelain Primer. The bond strengths of all the bonded and rebonded were evaluated and compared. They found that the mean shear bond strengths of the new and recycled ceramic brackets were 259.7 ±88.2 N and 187.2±60.8 N, respectively. Although the bond strength of recycled ceramic brackets was significantly lower ($P<0.01$), they appeared to be clinically adequate. The results are in contrast to the present study where there was non-significant difference between freshly bonded and rebonded Symetri Clear ceramic brackets. This could be due to difference in recycling method and the bracket surface area.

There was another similar study conducted by **AL- Lwezy et al**[58], in which the brackets were recycled by burning technique. Fascination II (Dentarum) ceramic brackets were bonded and then debonded by “Bachmann” Needle holder. The brackets were then torched till a cherry red appearance was seen and then these recycled brackets were rebonded. After testing both the new and the rebonded for SBS, the results showed that though there was complete removal of the adhesive from recycled bracket base, shear bond strength in recycled brackets (2.3±1.7 Mpa) was significantly lower than the new ones (7.3±3.4 Mpa) making this method of recycling ceramic bracket unfit for clinical use. This was probably because the rapid thermal change will cause cracks and separation of the composite resin from the bracket base and this partly removes the irregularities provided by the zirconium layer at the base of the bracket which is applied by the manufacturer to increase bond strength by providing mechanical retention with the composite resin. Another reason for lowered bond strength may be due the partial removal of the silane layer at the bracket base, which is a material applied by the manufacturer to add chemical bond to the mechanical retention. The results are in contrast to our study where sandblasting resulted in non-significant difference in the SBS of new and rebonded ceramic brackets.

Adhesive removal by lasers to remove the adhesive from the bracket bases was recently being explored. One such study is by **Sohrabi et al**[85], where Er, Cr: YSGG laser was used to recycle the bracket bases. The debonded Fascination II brackets bases were irradiated with Er, Cr: YSGG laser (Biolase Europe GmbH) using the parameters of 3.5 W, 65% air, and 55% water until visible remnants of bonding material were eliminated from the bases. The brackets were then rebonded and and were SBS values thus obtained were compared with that of bonded brackets. The results showed that the mean shear bond strength of the bond and rebond groups was 12.29 ±5.46 Mpa and 10.58± 5.16 MPa, respectively. There were no significant differences between the two groups (p = 0.21). The lasers helps in fusion, evaporation, and elimination of composite materials from the bracket base making Er, Cr:YSGG laser an effective method for recycling ceramic brackets base without any interference with the ceramic base itself.

A similar study was conducted by **Devjee et al**[81], in which the SBS of of three recycling methods were compared- erbium-doped yttrium aluminum garnet (ER:YAG) laser, sandblasting and the thermal method. The study was done in both metal and ceramic brackets. After initial bonding, brackets were debonded with a universal testing machine and were subjected to various recycling procedures. The recycled brackets were then rebonded and tested for bond strength. The results showed that for the stainless steel brackets, the sandblasting method was superior to the ER:YAG laser, as the recycled brackets showed a higher shear bond strength(7.14 ±0.78 Mpa). For ceramic brackets the ER:YAG laser recycled group had the highest recycled shear bond strength(7.15 ±3.24 Mpa).the higher bond strength of metal brackets with sandblasting could be due to roughening of the bracket base with sufficient removal of the adhesive, whereas in ceramic bracket bases were damaged by the alumina particles. The bond strength with laser was higher in ceramic brackets since lasers were effective in completely removing the resin residue without any damage to the brackets. On evaluation of the above-mentioned studies, it could be seen that sandblasting of bracket bases definitely improved SBS. However, sandblasting of enamel surface had controversial finding. Hence it can be suggested that sandblasting of bracket bases improved SBS of recycled bracket making it comparable to new brackets.

Apart from recycling brackets, effective removal of residual resin from the enamel surface is necessary to obtain good rebond strength. There are various methods that have been used for efficient and safe reconditioning of enamel surface. These include manual removal with the use of a scaler or a band-removing plier, sandblasting,various shapes of tungsten-carbide burs (TCB) with low- or high- speed hand pieces,Super snap discs,and special composite finishing systems with zirconia paste or slurry pumice as well as ultrasonic applications.Also, novel approaches involving carbon dioxide–laser application have been promising,whereas the Nd:YAG laser has demonstrated potent structural degradation of the composite, suggesting that it could be used as an adjunct to the removal of residual resin. Studies related to effective ways of resin removal from enamel were given by Eminkahyagil et al[24],Pakshir HR[77], Joshi D et al[87] and Hong YH et al[36].

The objective of study conducted by**Eminkahyagil et al**[24] was to determine the effect the effect of various resin-removal methods on shear bond strength (SBS) of rebonded brackets. After debonding the initial bonding, the enamel surface was cleaned of remaining adhesive by four diifrent methods: low-speed tungsten-carbide bur (TCB), high-speed TCB, Sof-Lex finishing disks and microetcher. After the brackets were rebonded, SBS testing was done and the values were compared with the initial bond strength. Rebonded teeth had a greater SBS than the initial bonding, except in microetcher group. TCB at low speed was found to be most effective and safe method in enamel cleanup. High spped TCB caused irreversible enamel damage and the sof-lex discs was an effective but was time consuming method. Microetching for enamel was not advisable sine it cause irreversible loss of enamel by removal of both organic and inorganic components of the enamel matrix.

In another study by **Pakshir et al**[77], effect of enamel surface treatment on the bond strength of metallic brackets was assessed. In this experiment, after removing the bulk of remaining adhesives by TCB at low speed (25000 rpm), the enamel surface was cleaned by two methods post debonding- acid etching by 37% phosphoric acid and sandblasting with microetcher. The brackets were rebonded and the SBS was evaluated and compared with the bind strength of new brackets. Mean SBS in both groups did not differ significantly ($P = 0.081$). Micro-etching and acid-etching had a higher bond strength than only acid-etching. This is probably because air abrasion and etching caused the roughening effect enamel surface. However, this method left more residual adhesive remnants on the enamel surface.

In a similar study, **Joshi et al**[87] has discussed about different composite removal techniques from the enamel surface during rebonding of metal brackets. After debonding of initial bonding, reconditioning of the tooth surface was performed by two methods: diamond bur with a high-speed hand-piece andsandblasting with 50 μm aluminum oxide particles. The results showed that the SBS was highest in the control group of new brackets (9.06±0.95 Mpa). Shear bond strength was highest in the air abrasion group (7.68 ± 0.99 MPa) and lowest in diamond bur group (6.7 ± 1.3 MPa). It was probably because of more surface roughness achieved by air brasion than diamond bur; which facilitated in achieving higher SBS values.

Hong YH[36]**,** compared the SBS of rebonded brackets using five different methods of resin removal from the debonded enamel surface. These include: Ormco band removing plier, Komet slow speed tungsten carbide bur, High speed ultrafine diamond bur, Jet high speed tungsten carbide bur and High speed white stone finishing bur. After the new brackets were debonded with debracketing pliers, the composite remnants on the enamel surface were evaluated using The Composite Remnant Index (CRI). Subsequent to this, the enamel surface was examined in a Scanning Electron Miscrocope at x 203 magnification. The photomicrographs were then graded using the Surface Roughness Index (SRI). The results showed that there was no absolute method for composite removal. The Jet high speed tungsten carbide bur gave the best surface smoothness in the surface roughness assessment, but was fourth in the composite remnant assessment. The ultrafine diamond bur on the other hand was most efficient in the removal of composite remnants, but produced the roughest finished enamel surface. A combination of three methods; namely, the Jet high speed tungsten carbide bur, the Komet slow speed tungsten carbide bur and the Ormco band removing plier may prove ideal in the effective removal of composite remnants following debonding.

On evaluation of above-mentioned studies, it could be seen that proper cleanup, finishing and polishing of enamel surface helps in achieving clinically accepatable SBS of new and rebonded brackets. Similar to the results of above mentioned studies, it could be seen that tungsten carbide bur at low speed, followed by polishing by super-snap discs, and final polishing by pumice and water help in improving SBS of recycled brackets making it comparable to new brackets in the present study as well.

The residual resin on the enamel surface after debonding was also assessed and scored according to that of ARI Index as proposed by Artun and Bergland[64]. This index helps to determine the site of bond failure and which is an important factor while debonding. The bond failure should ideally be at the bracket-resin interface, however, bond failure within the adhesive is also clinically acceptable. On visualizing the ARI scores in our study it was seen that maximum samples were in Grade 1 in Group I (64%)and in Group II ;after debonding with pliers 60% and after debonding with UTM was 72%. This showed that maximum debonding occurred within the adhesive,which is clinically acceptable for any adhesive to be used forOrthodontic bonding procedures. Score 2 was seen in 24% samples in both Group I(after debonding with UTM) and in Group II after debonding with pliers and debonding with UTM was around 20%. A score 2 is said to be ideal since the bond failure occurs at bracket-resin interface with minimum damage to the enamel. Very few samples had scored 0 in all the samples which was 12% for Group I and 4% for each debonding in Group II. None of the samples had an ARI score of 3. However there was no significant statistical difference among the groups in relation to ARI scores.

A few studies have measured the ARI scores with regards to ceramic brackets.A was study was conducted by **Ahmed ZA**[86], where he scored the ARI of rebonded ceramic brackets after different reconditioning procedures like sandblasting, Er,Cr:YAG laser and CO_2 laser. He found statistical difference among the groups with relation to ARI in sandblasted groups of enamel or bracket base and control groups where more adhesive remained on the enamel surfaces. No significant statistical difference was seen in control and Er,Cr:YSGG and CO_2 groups.

In a similar study by **Salama F**[48]**,** ARI was scored after the debonding rebonded brackets using two different types of orthodontic adhesives. No significant statistical difference was found between the two adhesive systems.

In another study by **Faltermeier A**[76]**,**ARI score was seen on the enamel surface after the debonding of the recycled brackets with different recycling procedures. eventhough there was no statistical difference among the groups, the general trend was that adhesives tend to remain on the bracket bases.

The results of various studies are variable in terms of ARI scores. However, bond failure was either in adhesive or at the bracket-resin interface in most of the studies. This was seen for most of our sample of Group I and Group II as well also making these brackets acceptable in clinical practice.

The main drawback of any in-vitro study is the inability to simulate complex oral environment of in-vivo studies like oral pH and temperature, saliva, occlusal and masticatory forces that might alter the mechanical properties of various materials and their performance in oral cavity.

Within the limitations of results of this study, it can be suggested that the SBS of new and rebonded brackets was acceptable and was above the clinically acceptable limits as suggested by Reynolds. Also all the Symetri Clear brackets were debonded in one piece with intact tie wings. ARI scores after debonding suggested that bond failure was at clinically acceptable sites (at the bracket-resin interface or within the adhesive) for both the groups. The main clinical implication of the study would be that these Symetri Clear brackets could be reused even after accidental or intentional bond failure, Accidental bond failure can occur due toinappropriate force applied by the patient on the bracket during mastication, improper isolation during bonding or as a consequence of poor bonding technique by the operator. Intentional debonding is needed at times by the operator to establish correct bracket position so as to correct the positional and angulation errors that help in achieving optimum orthodontic mechanics. Thus use of rebonded Symetri Clear ceramic bracket which debonded in one piece and had comparable bond strengths as new brackets will not only save the Orthodontist's chair-side time but also will prove a cost-effective option for both the patient and the clinician.

Future studies can be conducted on a larger sample to validate the results of our study and to see if Symetri Clear brackets always debonded in one piece without distortion. Also, further studies can be done comparing SBS of bonded and rebonded Symetri Clear ceramic brackets with other commercially available ceramic brackets.

Following conclusions were drawn from the present study which was conducted to evaluate the bond strength of freshly bonded Symetri Clear ceramic brackets and then comparing it with the SBS of recycled Symetri Clear brackets:-

1. New Symetri Clear brackets of Group I had higher shear bond strength when compared to rebonded Symetri Clear brackets of Group II though there was no significant statistical difference between them. This suggested that sandblasted and rebonded ceramic brackets of Group II had comparable bond strength to the new ceramic brackets of Group I.
2. Sandblasting done to recycle debonded ceramic brackets can produce clinically acceptable bond strengths as it effectively etches the ceramic thereby causing micro-etched surface and improving mechanical retention.
3. All the Symetri Clear brackets were debonded in one piece with intact tie wings using specialized debonding pliers as recommended by the manufacturer.
4. There was no significant difference seen in the distribution of ARI scores among three study groups when compared using Chi square test as$p>0.05$. Bond failure was within the adhesive for 64% of the samples Group I after debonding with UTM, 60% of the samples in Group II(after debonding with pliers) and 72% of the samples in group II after the rebonded brackets were debonded with UTM. Around 20-24% of the samples in all the groups had an ARI score of 2. Very few samples had an ARI score of 0 and non eof the sampled were given a score of 3.

The clinical implications of the study suggests that freshly bonded Symetri Clear brackets and rebonded Symetri Clear brackets have comparable SBS. Hence, it can be said that these brackets can be recycled during accidental or intentional bond failures and bonded again. As Symetri Clear brackets debonded in one piece without the fracture of the tie wings or any bracket distortion when the specialized pliers were used while debonding, making their use acceptable in clinical practice. However, further studies need to be done with larger sample size to see if Symetri Clear brackets debond in one piece without distortion.

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ANNEXURE I

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES (FACULTY OF BBD UNIVERSITY), LUCKNOW

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"Evaluation and Comparison of the Shear Bond Strength of Bonded and Rebonded Ceramic Brackets."** submitted by **Dr Astha Baul** Post graduate student from the **Department of Orthodontics & Dentofacial Orthopedics** as part of MDS Curriculum for the academic year 2018-2021 with the accompanying proforma was reviewed by the Institutional Research Committee present on **27th November 2018** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Vandana A Pant
Co-Chairperson

Prof. B. Rajkumar
Chairperson

ANNEXURE II

Babu Banarasi Das University
Babu Banarasi Das College of Dental Sciences,
BBD City, Faizabad Road, Lucknow – 226028 (INDIA)

Dr. Lakshmi Bala
Professor and Head Biochemistry and
Member-Secretary, Institutional Ethics Committee

Communication of the Decision of the VIIth Institutional Ethics Sub-Committee

IEC Code: 04 **BBDCODS/01/2019**

Title of the Project: Evaluation and Comparison of the Shear Bond Strength of Bonded and Rebonded Ceramic Brackets.

Principal Investigator: Dr. Astha Baul **Department:** Orthodontics & Dentofacial Orthopedics

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr. Astha Baul,

The Institutional Ethics Sub-Committee meeting comprising following four members was held on 10th January 2019.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow
2.	Dr. Amrit Tandan Member	Prof. & Head, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow
3.	Dr. Rana Pratap Maurya Member	Reader, Department of Orthodontics & Dentofacial Orthopedics, BBDCODS, Lucknow
4.	Dr. Sumalatha M.N. Member	Reader, Department of Oral Medicine & Radiology, BBDCODS, Lucknow

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.
The comments were communicated to PI thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala 22/01/19

(Dr. Lakshmi Bala)
Member Secretary
IEC

Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

(Dr. B. Rajkumar)
Principal
BBDCODS

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

ANNEXURE III

CIPET सिपेट
probe - perform - practice - Plastics

सिपेट : सेन्टर फॉर स्किलिंग एण्ड टेक्निकल सपोर्ट (सी एस टी एस)
रसायन एवं पेट्रोल विभाग, रसायन एवं उर्वरक मंत्रालय, भारत सरकार
हेहल, राँची - 834005 (झारखण्ड)

CIPET : CENTRE FOR SKILLING AND TECHNICAL SUPPORT (CSTS)
Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Govt. of India
Hehal, Ranchi - 834005 (Jharkhand)

मुख्यालय: गिण्डी, चेन्नै - 600 032 Head Office: Guindy, Chennai - 600 032

स्वच्छ भारत
एक कदम स्वच्छता की ओर

फ़ोन / Phone: (0651) 2511118 ई-मेल / E-mail: cipetranchi@gmail.com; ranchi@cipet.gov.in वेबसाइट / Website: www.cipet.gov.in

CIPET/RNC/Cons./AB/2021-22/329

Dated: 05.07.2021

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Dr. Astha Baul** has carried out Shear Bond Strength Test on Universal Testing Machine for her thesis **" Evaluation and comparison of Shear Bond Strength of bonded and rebonded ceramic brackets"** at CIPET.

Praveen B. S.

Authorized Signatory

सिपेट : सी एस टी एस, राँची
CIPET : C.S.T.S. Ranchi
Government of India

केन्द्रः अहमदाबाद, अमृतसर, औरंगाबाद, अगरतला, बद्दी, बालासोर, बैंगलुरु, भोपाल, भुबनेश्वर, चंद्रपुर, चेन्नै, गुरुग्राम, गुवाहाटी, ग्वालियर, हैदराबाद, हाजीपुर, हल्दिया, इम्फाल, जयपुर, कोच्ची, 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 IV

BabuBanarasi Das College of Dental Sciences
(A constituent institution of BabuBanarasi Das University)
BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Participant Information Document (PID)

1. **Study title**

   Evaluation and comparison of shear bond strength of bonded and rebondedceramic brackets.

2. **Invitation paragraph**

   You are being invited to take part in a research study, it is therefore important for you to understand why the study is being done and what it will involve. Please take time to read the following information carefully. Ask us for any clarifications or further information. Whether or not you wish to take part is your decision.

3. **What is the purpose of the study?**

   The purpose of this study is to evaluate and compare the shear bond strength of bonded and rebondednew type of ceramic brackets.

   4.Why have I been chosen?

   You have been chosen for this study as you are fulfilling the required criteria for this study.

5. **Do I have to take part?**

   Your participation in the research is entirely voluntary. If you do, you will be given this information sheet to keep and will be asked to sign a consent form. During the study you still are free to withdraw at any time and without giving a reason.

6. **What will happen to me if I take part?**

   You will have to give your consent to use your extracted teeth.

7. What do I have to do?

You do not have to change your regular lifestyles for the investigation of the study.

8. What is the procedure that is being tested?

The procedure will involve evaluating and comparing the shear bond strength of two different types of ceramic brackets.

9. What are the interventions for the study?

Teeth indicated for extraction during their fixed orthodontic treatment will be collected from the patients. Shear bond strength will then be testedon teeth.However you will not have anyside effect on your health. This will be done only once in the study.

10. What are the side effects of taking part?

There are no side effects on patients of this study.

11. What are the possible disadvantages and risks of taking part?

There are no risk or disadvantages of taking part in this study.

12. What are the possible benefits of taking part?

This study will help us to know that the strength of rebondedceramic brackets is within the clinically acceptable limits as the new brackets. This will help to reduce the extra charges on the patients as well as the clinicians in case of accidental or intentional bracket debonding.

13. What if new information becomes available?

If additional information becomes available during the course of the research you will be told about these and you are free to discuss it with your researcher, your researcher will tell you whether you want to continue in the study. If you decide to withdraw, your researcher will make arrangements for your withdrawal. If you decide to continue in the study, you may be asked to sign an updated consent form.

14. What happens when the research study stops?

If the study stops/finishes before the stipulated time, this will be explained to the patient/volunteer.

15. What if something goes wrong?

If any severe adverse event occurs, or something goes wrong during the study, the complaints will be handled by reporting to the institution (s), and Institutional ethical community.

16. Will my taking part in this study be kept confidential?

Yes it will be kept confidential.

17. What will happen to the results of the research study?

The results of the study will be used to assess the shear bond strength of bonded and rebondednew type of ceramic brackets. Your identity will be kept confidential in case of any report/publications.

18. Who is organizing the research?

This research study is organized by the academic institution (BBDCODS).

19. Will the results of the study be made available after study is over?

Yes.

20. Who has reviewed the study?

The study has been reviewed and approved by the Head of the Dept, and the IEC/IRC of the institution.

21. Contact for further information

Dr. Astha Baul
Department of Orthodontics and Dentofacial Orthopedics
BabuBanarasi College of Dental Sciences.
Lucknow-227105

Mob-8984627433

Dr.Tripti Tikku (HOD)
Department of Orthodontics and Dentofacial Orthopedics
BabuBanarasi College of Dental Sciences.
Lucknow-227105
Mob- 9554832799

Dr. Laxmi Bala,
Member Secretary,
BabuBanarasi College of Dental Sciences.
Lucknow
bbdcods.iec@gmail.com

Signature of PI…………………………………………………….

Name……………………………………………………………

Date ……………………………………………………………….

ANNEXURE V

बाबू बनारसी दास कॉलेज ऑफ डेंटल साइंसेज
(बाबू बनारसीदास विश्वविद्यालय का एक घटक संस्थान)
बीबीडी सिटी, फैजाबाद रोड, लखनऊ - 227105 (भारत)

प्रतिभागी सूचना दस्तावेज (पीआईडी)

1-अध्ययन शीर्षक

नयी तरह के सिरेमिक ब्रैकेट्स के पहली बार तथा दोबारा चिपकाने के बाद उसकी ना टूटने की क्षमता का मूल्याँकन एवं तुलना करना।

2- आमंत्रण अनुच्छे?

आपको एक शोध अध्ययन में भाग लेने के लिए आमंत्रित किया जा रहा है, इसलिए यह समझना आपके लिए महत्वपूर्ण है कि अध्ययन क्यों किया जा रहा है और इसमें क्या शामिल होगा।कृपया निम्नलिखित जानकारी को ध्यान से पढ़ने के लिए समय दें। किसी भी स्पष्टीकरण या आगे की जानकारी के लिए हम से पूछे। चाहे आप भाग लेना चाहते हैं या नहीं, आपका निर्णय है।

3-अध्ययन का उद्देश्य क्या है?

नयी तरह के सिरेमिक ब्रैकट्स के पहली बार तथा दो बारा चिपकाने के बाद उसकी ना टूटने की क्षमता का मूल्याँकन एवं तुलना।

4-मुझे क्यों चुना गया है?

इस अध्ययन के लिए आपको चुना गया है क्योंकि आप इस अध्ययन के लिए आवश्यक मानदंडों को पूरा कर रहे हैं।

5- क्या मुझे भाग लेना है?

शोध में आपकी भागीदारी पूरी तरह से स्वैच्छिक है। यदि आप करते हैं, तो आपको यह जानकारी पत्र दिया जाएगा और सहमति फॉर्म पर हस्ताक्षर करने के लिए कहा जाएगा। अध्ययन के दौरान आप अभी भी किसी भी समय बिना किसी कारण के वापस लेने के लिए स्वतंत्र हैं।

6- अगर मैं भाग लेता हूं तो मेरे साथ क्या होगा?

आपको इस अध्ययन में ऑर्थोडॉटिक उपचार के दौरान निकले गए दाँत देने होंगे।

7- मुझे क्या करना है?

अध्ययन की जांच के लिए आपको अपने नियमित जीवन शैली को बदलने की ज़रूरत नहीं है।

8- परीक्षण की जा रही प्रक्रिया क्या है?

इस अध्ययन में हम दो तरह की सिरेमिक ब्रैकेट्स पहली बार व दोबारा चिपकाने के बाद उसकी ना टूटने की क्षमता का मूल्याँकन करेंगे।

9- अध्ययन के लिए हस्तक्षेप क्या हैं?
न्यूनतम हस्तक्षेप किया जाएगा।

10- भाग लेने के दुष्प्रभाव हैं?
इस अध्ययन के कोई दुष्प्रभाव नहीं हैं।

11- भाग लेने के संभावित नुकसान और जोखिम क्या हैं?
इस अध्ययन में कोई जोखिम शामिल नहीं है।

12- भागलेनेकेसंभावितलाभक्याहैं?
इस अध्ययन में हमें एक नए सिरैमिक ब्रैकट की पहली बार एवं दूसरी बार चिपकाने के बाद उसकी ना टूटने की क्षमता के बारे में पता चलेगा। यदि परिणाम सही निकला तो इस सिरेमिक ब्रैकट का प्रयोग और भी अधिक की जा सकती है।

13- क्या होगा अगर नई जानकारी उपलब्ध हो जाए?
यदि शोध के दौरान अतिरिक्त जानकारी उपलब्ध हो जाती है तो आपको इनके बारे में बताया जाएगा और आप अपने शोधकर्ता के साथ चर्चा करने के लिए स्वतंत्र हैं, आपका शोधकर्ता आपको बताएगा कि आप अध्ययन में जारी रखना चाहते हैं या नहीं। यदि आप वापस लेने का निर्णय लेते हैं, तो आपका शोधकर्ता आपके वापसी के लिए व्यवस्था करेगा। यदि आप अध्ययन में जारी रखने का निर्णय लेते हैं, तो आपको एक अद्यतन सहमति फॉर्म पर हस्ताक्षर करने के लिए कहा जा सकता है।

14-शोध अध्ययन बंद होने पर क्या होता है?
यदि अध्ययन निर्धारित समय से पहले समाप्त/खत्म हो जाता है, तो यह रोगी/ स्वयं सेवक को समझा या जाएगा।
15-क्या होगा अगर कुछ गलत हो जाए?

यदि कोई गंभीर प्रतिकूल घटना होती है, या अध्ययन के दौरान कुछ गलत हो जाता है, तो शिकायतों को संस्था (ओं), और संस्थागत नैतिक समुदाय को रिपोर्ट करके संभाला जाएगा।

16-क्या इस अध्ययन में मेरा हिस्सा गोपनीय रखा जाएगा ?
हां इसे गोपनीय रखा जाएगा।

17-शोध अध्ययन के नतीजों का क्या होगा?
इस अध्ययन के परिणाम से नए सिरेमिक ब्रैकेट्स की ना टूटने वाली क्षमता का पता चलेगा।।किसी भी रिपोर्ट /प्रकाशन के मामले में आपकी पहचान गोपनीय रखी जाएगी।

18-शोध का आयोजन कौन कर रहा है?
यह शोध अध्ययन अकादमिक संस्थान द्वारा आयोजित किया जाता है। आपको शामिल किसी भी प्रक्रिया के लिए भुगतान नहीं करना है।

20-अध्ययन की समीक्षा किसने की है?
इस अध्ययन की समीक्षा विभाग के प्रमुख और संस्थान के आईईसी/ आई आर सी द्वारा की गई और अनुमोदित की गई है।

21- अधिक जानकारी के लिए संपर्क करें
डॉ. आस्था बौल
ऑर्थॉडॉटिक एंड डेंटोफेशियल ऑर्थपेडिक्स विभाग
बाबू बनारसी कॉलेज ऑफ डेंटल साइंसेज
लखनऊ- **227105**
8984627433

डॉ. तृप्ति टिक्कू
प्रोफेसर और हेड
ऑर्थॉडॉटिक्स एंड डेंटोफेशियल ऑर्थपेडिक्स विभाग
बाबू बनारसीकॉलेजऑफडेंटलसाइंसेज
लखनऊ- **227105**
9554832799

डॉ. लक्ष्मीबाला
सदस्यसचिव
बाबूबनारसीकॉलेजऑफडेंटलसाइंसेज
लखनऊ

bbdcods.iec@gmail.com

पीआईकाहस्ताक्षर ....

नाम ....

दिनांक....................................

ANNEXURE VI

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Consent Form (English)

Title of the Study ....Evaluation and comparison of shear bond strength of bonded and rebonded ceramic bracket.

Study Number........

Subject's Full Name..........

Date of Birth/Age ....

Address of the Subject.........................

Phone no. and e-mail address..................

Qualification ....

Occupation: Student / Self Employed / Service / Housewife/ Other (Please tick as appropriate)

Annual income of the Subject..................

Name and of the nominees(s) and his relation to the subject (For the purpose of

compensation in case of trial related death).

1. I confirm that I have read and understood the Participant Information Document dated ....for the above study and have had the opportunity to ask questions. **OR** I have been explained the nature of the study by the Investigator and had the opportunity to ask questions.
2. I understand that my participation in the study is voluntary and given with free will without any duress and that I am free to withdraw at any time, without giving any reason and without my medical care or legal rights being affected.
3. I understand that the sponsor of the project, others working on the Sponsor's behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. However, I understand that my Identity will not be revealed in any information released to third parties or published.
4. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).

5. I permit the use of stored sample (tooth/tissue/blood) for future research. **Yes [ ] No [ ]**

Not Applicable [ ]

6. I agree to participate in the above study. I have been explained about the complications and side effects, if any, and have fully understood them. I have also read and understood the participant/volunteer's Information document given to me.

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:……………..

Signatory's Name……………. Date ……….

Signature of the Investigator………………… Date……….

Study Investigator's Name........................... Date……….

Signature of the witness…………………… Date……….

Name of the witness………………………..

Received a signed copy of the PID and duly filled consent form
Signature/thumb impression of the subject or legally
Date……..

ANNEXURE VII

बाबू बनारसी दास कॉलेज ऑफ डेंटल साइंसेज
(बाबू बनारसी दास विश्वविद्यालय का एक घटक संस्थान)
बीबीडीसिटी, फैजाबाद रोड, लखनऊ - 227105 (भारत)
प्रतिभागी सूचना दस्तावेज (पी आई डी)

1-अध्ययन शीर्षक

नयी तरह के सिरेमिक ब्रैकेट्स के पहली बार तथा दोबारा चिपकाने के बाद उस की ना टूटने की क्षमता का मूल्याँकन एवं तुलना करना।

2- आमंत्रण अनुच्छे?

आपको एक शोध अध्ययन में भाग लेने के लिए आमंत्रित किया जा रहा है, इसलिए यह समझना आपके लिए महत्वपूर्ण है कि अध्ययन क्यों किया जा रहा है और इसमें क्या शामिल होगा। कृपया निम्नलिखित जानकारी को ध्यान से पढ़ने के लिए समय दें। किसी भी स्पष्टीकरण या आगे की जानकारी के लिए हमसे पूछे। चाहे आप भाग लेना चाहते हैं या नहीं, आपका निर्णय है।

3-अध्ययन का उद्देश्य क्या है?

नयी तरह के सिरेमिक ब्रैकट्स के पहली बार तथा दोबारा चिपकाने के बाद उसकी ना टूटने की क्षमता का मूल्याँकन एवं तुलना।

4-मुझे क्यों चुना गया है?

इस अध्ययन के लिए आपको चुना गया है क्यों कि आप इस अध्ययन के लिए आवश्यक मानदंडों को पूरा कर रहे हैं।

5- क्या मुझे भाग लेना है?

शोध में आपकी भागीदारी पूरी तरह से स्वैच्छिक है। यदि आप करते हैं, तो आपको यह जानकारी पत्र दिया जाएगा और सहमति फॉर्म पर हस्ताक्षर करने के लिए कहा जाएगा।

अध्ययन के दौरान आप अभी भी किसी भी समय बिना किसी कारण के वापस लेने के लिए स्वतंत्र हैं।

6- अगर मैं भाग लेता हूं तो मेरे साथ क्या होगा?

आपको इस अध्ययन में ऑर्थोडॉंटिक उपचार के दौरान निकले गए दाँत देने होंगे।

7- मुझे क्या करना है?

अध्ययन की जांच के लिए आपको अपने नियमित जीवन शैली को बदलने की ज़रूरत नहीं है।

8- परीक्षण की जा रही प्रक्रिया क्या है?

इस अध्ययन में हम दो तरह की सिरेमिक ब्रैकेट्स पहली बार व दोबारा चिपकाने के बाद उसकी ना टूटने की क्षमता का मूल्याँकन करेंगे।

9- अध्ययन के लिए हस्तक्षेप क्या हैं?

न्यूनतम हस्तक्षेप किया जाएगा।

10- भाग लेने के दुष्प्रभाव हैं?

इस अध्ययन के कोई दुष्प्रभाव नहीं हैं।

भाग लेने के संभावित नुकसान और जोखिम क्या हैं?

इस अध्ययन में कोई जोखिम शामिल नहीं है।

12- भाग लेने के संभावित लाभ क्या हैं?

इस अध्ययन में हमें एक नए सिरैमिक ब्रैकट की पहली बार एवं दूसरी बार चिपकाने के बाद उसकी ना टूटने की क्षमता के बारे में पता चलेगा। यदि परिणाम सही निकला तो इस सिरेमिक ब्रैकट का प्रयोग और भी अधिक की जा सकती है।

13- क्या होगा अगर नई जानकारी उपलब्ध हो जाए?

यदि शोध के दौरान अतिरिक्त जानकारी उपलब्ध हो जाती है तो आपको इनके बारे में बताया जाएगा और आप अपने शोधकर्ता के साथ चर्चा करने के लिए स्वतंत्र हैं, आपका शोधकर्ता आपको बताएगा कि आप अध्ययन में जारी रखना चाहते हैं या नहीं। यदि आप वापस लेने का

निर्णय लेते हैं, तो आपका शोधकर्ता आपके वापसी के लिए व्यवस्था करेगा। यदि आप अध्ययन में जारी रखने का निर्णय लेते हैं, तो आपको एक अद्यतन सहमति फॉर्म पर हस्ताक्षर करने के लिए कहा जा सकता है।

14- शोध अध्ययन बंद होने पर क्या होता है?

यदि अध्ययन निर्धारित समय से पहले समाप्त/खत्म हो जाता है, तो यह रोगी/ स्वयं सेवक को समझाया जाएगा।

15-क्या होगा अगर कुछ गलत हो जाए?

यदि कोई गंभीर प्रतिकूल घटना होती है, या अध्ययन के दौरान कुछ गलत हो जाता है, तो शिकायतों को संस्था(ओं), और संस्थागत नैतिक समुदाय को रिपोर्ट करके संभाला जाएगा।

16-क्या इस अध्ययन में मेरा हिस्सा गोपनीय रखा जाएगा?

हां इसे गोपनीय रखा जाएगा।

17-शोध अध्ययन के नतीजों का क्या होगा?

इस अध्ययन के परिणाम से नए सिरेमिक ब्रैकेट्स की ना टूटने वाली क्षमता का पता चलेगा।।**किसी भी रिपोर्ट/प्रकाशन के मामले में आपकी पहचान गोपनीय रखी जाएगी।**

18-शोध का आयोजन कौन कर रहा है?
यह शोध अध्ययन अकादमिक संस्थान द्वारा आयोजित किया जाता है। आपको शामिल किसी भी प्रक्रिया के लिए भुगतान नहीं करना है।
20-अध्ययन की समीक्षा किसने की है ?
इस अध्ययन की समीक्षा विभाग के प्रमुख और संस्थान के आईईसी/ आईआरसी द्वारा की गई और अनुमोदित की गई है।

21- अधिक जानकारी के लिए संपर्क करें

डॉ. आस्था बौल
ऑर्थों डॉंटिक एंड डेंटोफेशियलऑर्थपेडिक्सविभाग
बाबूबनारसीकॉलेजऑफडेंटलसाइंसेज
लखनऊ- **227105**
8984627433

डॉ. तृप्तिटिक्कू
प्रोफेसरऔरहेड
ऑर्थोंडॉंटिक्सएंडडेंटोफेशियलऑर्थपेडिक्सविभाग
बाबूबनारसीकॉलेजऑफडेंटलसाइंसेज
लखनऊ- **227105**
9554832799

डॉ. लक्ष्मीबाला
सदस्यसचिव
बाबूबनारसीकॉलेजऑफडेंटलसाइंसेज
लखनऊ
bbdcods.iec@gmail.com

पीआईकाहस्ताक्षर ....

नाम ....

दिनांक.....................................

ANNEXURE VIII

Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Child Assent Form

StudyTitle -: Evaluation and comparison of shear bond strength of bonded nad rebonded ceramic brackets.
StudyNumber____
Subject's Full Name ____
DateofBirth/Age____
Address____
____

I____, exercising my free power of choice, hereby give my consent for participation in the study entitled: "Quantitative analysis of enamel surface roughness using a colour changing adhesive for bonding – A Comparative Study" I have been informed, to my satisfaction, by the attending physician, about the purpose of the study and the nature of the procedure to be done. I am aware that my parents/guardians do not have to bear the expenses of the treatment if I suffer from any trial related injury, which has causal relationship with the said trial drug. I am also aware of right to opt out of the trial, at any time during the course of the trial, without having to give reasons for doing so

Signature of the study participant______________________
Date:_____________________
Nameofthe study participant______________________

Signature of the Witness ___________________________
Date________________________
Name of the Witness ____________________________

Signature of the attending Physician___________________
Date_______________________
Name of the attending Physician ______________________

ANNEXURE IX

Babu Banarasi Das College of Dental Sciences(BabuBanarasiDasUniversity)
BBDCity,FaizabadRoad,Lucknow–227105 (INDIA)

f'k'kq lgefr i=

eSa-- --------------------------esa Hkkx ysus ds fy, viuh lgefr iznku djrk gw¡A eq>s bl v/;;u ds gsrq vkSj mlesa dh tkus okyh izfØ;k ds ckjs esa fpfdRld }kjk crk fn;k x;k gSA eq>s irk gS fd v/;;u lEcU/kh fdlh gkfu ftldk v/;;u dh nkok ls lEcU/k gS mldk [kpZ esjs ekrk&firk vFkok vfHkokgd dks ugha ogka djuk gSA eq>s ;g Hkh irk gS fd eSa bl v/;;u ls fdlh le; fcuk dksbZ dkj.k crkjs ckgj gks ldrk gw¡A

v/;;u esa Hkkx ysus okys dk uke vkSj gLrk{kj

-----fnukad---

xokg ds gLrk{kj---fnukad---

xokg dk uke---

fpfdRld dk uke vkSj gLrk{kj---fnukad--------------------

ANNEXURE X

Sample No.	Group I Freshly bonded Symetri Clear Brackets (Mpa)	Sample no.	Group II Rebonded Symetri Clear Brackets (Mpa)
1	8.91	1	7.61
2	9.33	2	11.15
3	15.92	3	5.40
4	6.40	4	8.64
5	9.49	5	6.12
6	11.32	6	11.56
7	7.61	7	13.32
8	11.68	8	13.14
9	11.10	9	9.01
10	16.37	10	8.99
11	11.26	11	9.15
12	6.52	12	7.55
13	6.26	13	6.81
14	13.25	14	9.01
15	8.42	15	6.84
16	7.46	16	3.67
17	6.31	17	9.54
18	10.16	18	13.00
19	16.29	19	7.06
20	5.41	20	7.10
21	6.42	21	6.13
22	8.13	22	10.24
23	12.83	23	6.67
24	14.76	24	3.63
25	9.49	25	6.17
Mean ± SD	9.95±3.32	Mean ±SD	8.32±2.74

ANNEXURE XI

Curiginal

Document Information

Analyzed document	ABSTRACT thesis pdf.pdf (D110139398)
Submitted	7/5/2021 7:05:00 AM
Submitted by	Kamna srivastava
Submitter email	dramitn99@bbdu.ac.in
Similarity	7%
Analysis address	dramitn99.bbduni@analysis.urkund.com

Sources included in the report

W	URL: https://www.researchgate.net/publication/7238226_Effect_of_resin-removal_methods_on_enamel_and_shear_bond_strength_of_rebonded_brackets Fetched: 3/4/2020 3:21:24 PM	3
SA	**Complete LD.docx** Document Complete LD.docx (D65282200)	1
W	URL: https://www.researchgate.net/publication/11162345_Shear_bond_strength_of_rebonded_mechanically_retentive_ceramic_brackets Fetched: 8/31/2020 7:26:11 AM	9
SA	**29.1.17.docx** Document 29.1.17.docx (D35099379)	1
W	URL: https://worldwidescience.org/topicpages/c/ceramic%2Bbracket%2Bdebonding.html Fetched: 6/14/2021 9:12:39 PM	2
SA	**PLAG FILE.pdf** Document PLAG FILE.pdf (D60705491)	1
W	URL: https://www.researchgate.net/publication/272190401_Effect_of_Different_Surface_Treatments_for_Ceramic_Bracket_Base_on_Bond_Strength_of_Rebonded_Brackets Fetched: 4/24/2020 10:45:03 AM	2
SA	**thesis.docx** Document thesis.docx (D46694466)	1
W	URL: https://www.researchgate.net/publication/325440731_Enamel_Surface_Roughness_after_Debonding_A_Comparative_Study_using_Three_Different_Burs Fetched: 3/7/2020 1:06:24 PM	4
SA	**Complete LD.docx** Document Complete LD.docx (D95868940)	1
W	URL: https://www.researchgate.net/publication/11943263_Tensile_bond_strength_of_ceramic_orthodontic_brackets_bonded_to_ceramic_surfaces Fetched: 12/12/2019 9:52:50 AM	1

1/27