COMPARISION OF DIRECT BONDING TECHNIQUE VERSUS INDIRECT BONDING TECHNIQUE ON BOND FAILURE RATE USING LIGHT CURE ADHESIVE- AN INVIVO STUDY

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CERTIFICATE

This is to certify that this dissertation titled **" COMPARISION OF DIRECT BONDING TECHNIQUE VERSUS INDIRECT BONDING TECHNIQUE ON BOND FAILURE RATE USING LIGHT CURE ADHESIVE - AN INVIVO STUDY "** is a bonafide research of work done by **Dr. K. SURESH** Under my guidance during his postgraduate study period between 2010-2013.

This dissertation is submitted to **THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY,** in partial fulfillment for the degree of Master of Dental Surgery in Branch V- Orthodontics.

It has not been submitted (partially or fully) for the award of any other degree or diploma.

Dr. R.K. VIJAYAKUMAR, MDS.,
Guide, Professor and Head
Department of orthodontics,
Sri Ramakrishna Dental college
And Hospital,
Coimbatore.

Dr. V. PRABHAKAR, MDS.,
Principal,
Sri Ramakrishna dental college and Hospital,
Coimbatore.

Date:

Place: Coimbatore

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COMPARISION OF DIRECT BONDING TECHNIQUE VERSUS INDIRECT BONDING TECHNIQUE ON BOND FAILURE RATE USING LIGHT CURE ADHESIVE - AN INVIVO STUDY.

ABSTRACT:

INTRODUCTION: Bonding of orthodontic attachments may be accomplished by either direct bonding technique or indirect bonding technique. The aim of this study was to compare and evaluate the bond failure rate between both the techniques using light cure adhesive.

MATERIALS AND METHODS: A total of thirty patients were assigned to alternating group in a split-mouth design. In group A, the maxillary right & mandibular left quadrants were bonded using direct bonding technique whereas the contralateral quatrants were bonded using indirect bonding technique . In group B, the sides bonded were opposite to those in group A. Modified Thomas indirect bonding technique of using 2mm soft clear vacuum formed thermoplastic sheet and light cured adhesive was used in this study. Observational period of 6 months till leveling & alignment was followed & all loose brackets were recorded according to the group & the bonding technique.

RESULTS: Failure rate of brackets bonded with direct bonding technique were 10.5% whereas for indirect bonding technique were 8.8% with no statistically significant difference($p>0.05$).

CONCLUSION: Both the direct as well as the indirect bonding technique using light cured adhesive had enough bond survival rate with no significant difference and either of the technique can be followed clinically depends on the operators interest.

KEY WORDS: Direct bonding technique, Modified Thomas technique, Indirect bonding technique, Clinical trial, Light cure adhesive

INTRODUCTION

Bonding systems and materials have undergone continued improvement over time when **Buonocore (1955)** introduced a method of etching enamel to enhance retention of acrylic restoration, and later **Bowen (1979)** developed a restorative material commonly referred to as composite (BIS-GMA). The chemically cured composites (self cure) were the first systems developed for orthodontic bracket bonding. More recently, the curing methods have been improved, with the most recent method being the light curing of the resins[29].

The advent of direct bonding of orthodontic attachments to the etched enamel surface, first described by **Newman(1965)** was a major advance in orthodontic treatment. Historically, bonding agents have been categorized into seven generations based on the manner in which they treat the smear layer. In those, the fifth generation bonding system of using first a 37% phosphoric acid etchant applied to the tooth surface and then the bonding agent applied followed by the adhesive resin is more reliable in providing optimal bond strength and is currently used by most practitioners for orthodontic bonding.

The indirect bonding method was introduced in 1972 by **Elliot silverman and Morton Cohen[20,22]** to produce a more accurate and efficient bracket placement system .This system involve two stage process of bracket placement in the laboratory on a plaster model and transfer of these attachments to the patient mouth by means of a tray, where they are bonded to the etched enamel[48]. By placing the brackets on stone model before placement in the mouth, Orthodontist can visualize the tooth in 3 dimensions, allowing the brackets to be more precisely positioned on the tooth; this might decrease the need to reposition brackets later in the treatment[27].

Silverman and Cohen reported that the advantages of indirect bonding technique were

(1) Reduced chairside time for the patient[20,21,22].

(2) Reduced stress for the operator[20,21,22].

(3) Reduced trauma and discomfort to the patient[20,21,22,51].

(4) Increased accuracy of bracket placement[13,44].

Over the years this technique has been refined and variations described as new technique or material have become available[6,24,34,33,68,74]. The technique originated with the bracket being placed on the plaster model with sugar candy (**Silverman et al[22] .,)** which was later removed and a composite bonding agent placed at the time of bonding[22]. This led to the excess flash and clean up and evolved to the use of custom bases, whereby the brackets are attached to the model with either a chemical, light or thermal activated composite. Later **Royce G.Thomas[74] (1979)** used a filled resin to form the custom base, which became the foundation for contemporary indirect bonding.

The transfer tray used for indirect bonding technique should be rigid enough to hold the bracket in place and should have elasticity for easy removal of tray from the mouth. The first transfer tray (**Silverman et al[22] .,)** used was a plastic wafer in a Vanguard unit. Later putty impression material was used which had difficulty during tray removal. **Myrberg and Warner[54]**(1982); **Milne** et al[51](1989); **Read and o'Brien[68]** (1990) methods of using vacuum formed thermoplastic sheet which is transparent and inexpensive method became popular among most practitioners.

Later a molten polymer of ethylene vinyl acetate using hot glue gun was described by **Larry W.White [37](2001)** was also an inexpensive method with rigidity and dimensional stability. Regardless of modification, the goal of indirect bonding is to deliver accurate bracket placement with minimal chair time and sufficient bond strength.

The final step in indirect bonding is attaching the brackets to the teeth via an adhesive system. Over the years many adhesive material have been used for indirect bonding most of which were the same material used for direct bonding. Chemical cured two paste adhesives, has the disadvantage of limited working time as the setting reaction starts as soon as the mixing begins. To overcome this disadvantage, light cure adhesive (Transbond XT,3M Unitek, Monrovia, Ca,USA) was developed with sufficient working time as its starts setting only when exposed to the curing light.

No previous studies to our knowledge evaluated the clinical bond failure rates using both direct and indirect bonding technique using the same light cure adhesive (Transbond XT, 3M unitek, Monrovia,USA) using a split mouth technique.

The purpose of this study is to compare and evaluate the clinical bond failure rates between direct and indirect bonding techniques using light cure adhesive (Transbond XT,3M Unitek,Monrovia,USA) using split mouth technique.

Elliott Silverman, Morton Cohen, Anthony A.Gianelly et al .,[22](1972) First to report a procedure for indirect bonding. The adhesive used was a mixture of bisphenol A and glycidyl methacrylate and methyl methacrylate monomer. The brackets were positioned on the cast which was placed in a Vanguard unit and a plastic wafer with hand pressure for tray adaptation. The labial and buccal surfaces of the teeth were prepared with 50% phosphoric acid and the sealant was painted over the treated enamel surfaces. The NuvaSeal gun, with its ultraviolet light waves was then passed over the painted sealant for 30 seconds. Small amount of cement or adhesive was placed on each bracket base and inserted into the mouth and held firm for 5 minutes to ensure setting of the bonding cement. Silverman and Cohen reported that the advantage of indirect bonding were (1) reduced chair time for bonding, (2) reduced stress for the operator and (3) patient comfort.

Elliott Silverman and Morton Cohen[20] (1975) reported a major improvement in the indirect bonding technique. New bonding adhesive was used "Nuva Tack", which allow the bracket to stick to the teeth until activated by the light (Nuva lite). This allowed for absolute pinpoint accurate bracket placement upon all teeth in the arch simultaneously and automatically. Thus ultraviolet lamp capable of polymerizing half of an entire arch in 90 seconds, since the lamp was shaped in the configuration of half a dental arch. The Nuva Tach reaches its greatest strength in 24 hours after setting.

Elliott Silverman and Morton Cohen[21] (1976) described a new indirect bonding method that required only 20 minutes for full strap up. They introduced a new bonding agent "Auto-Tach" which was a thermoset and self polymerized rapidly in the warm environment of the

oral cavity. After etching and drying the teeth to be bonded, Auto tach, which was a two-paste system, mixed on a cold slab and applied to the bracket bases on the transfer tray. Since the setting time for Auto tach was limited, time should not be wasted after the two pastes are mixed to insert the tray into the mouth. The authors say 20 minutes is all that is required for a full strap-up.

Kambiz Moin and Leon Dogon[52] (1977) introduced a method for indirect bonding of orthodontic attachments. A small drop of sticky wax was placed on the facial surfaces of all crowns. The brackets held in cotton plier were warmed over Bunsen burner and positioned on the dental cast at the desired level and angulation where they were retained by the wax. Impression was made using polyether impression material and molded over buccal and occlusal surfaces of posterior teeth and the labial and incisal edges of the anteriors. But not covered more than 2 to 3mm of the lingual aspect of the incisors. After setting, the impression was carefully separated from the cast but the bracket remain in situ.

Each bracket was removed from cast with warmed cotton plier and immediately placed on a paper towel to absorb the melted wax. The brackets were then inserted carefully into their respective imprints in the impression. For sealing the etched enamel, the low viscosity resin "Concise Enamel Bond" was used by mixing equal amount of catalyst and universal liquids. For bonding the brackets to the treated enamel, the two paste composite was used.

Zachrisson and Brobakken[93] (1978) Conducted a study to compare direct and indirect bonding with different bracket types (mesh backed versus perforated bracket pads) and adhesives (small filler particles versus large, coarse filler particles). 42 patients with split

mouth design was studied about 6 months for plague accumulation, gingival tissue reaction and bond failure. They conclude that (1) Adhesive with small filler particles were more hygienic than adhesives with large,coarse filler particles and about equally strong, (2) Mesh backed brackets were cleaner and bond better than brackets with perforated bases, (3) Direct bonding was likely to be more hygienic with stronger bonds than indirect bonding.

The failure rate of brackets were low particularly for the direct bonded attachments. With direct bonded brackets 6 out of 243 and with indirect bonded brackets 28 out of 201 came loose in the course of the test period.

Michael D.Simmons[47] (1978) developed a method for indirect bonding wherein, the bracket were placed on the cast using caramel candy(sugar daddy), which was softened at 50°c in a small oven, or incubator or dry heat and preloaded into a centrix syringe. The dental cast was marked for bracket placement and a small amount of candy was squeezed onto each tooth to be bonded. The brackets were positioned using cotton plier. An impression was made with bracket in position, using am impression material such as Bondosil optisil or citricon(polysiloxane material). Over the set impression, hot water was run over for easy removal of the tray with the brackets. The bonding adhesive then applied to the cleaned bracket bases and seated in the mouth. The advantage of caramel candy was its solubility in hot water and allows impression removed with all the brackets embedded in position within impression.

Royce G. Thomas[74] (1979) introduced a new technique that involved the formation of a custom base on the brackets. The technique involved application of concise or Dyna bond,

which were chemically cured resins on the brackets to secure them on to the study cast in their desired position. When set, a transfer tray was fabricated with a thermoformed tray material. Later applied concise or Dyna bond sealant; Universal resin part (A) on the teeth. The custom bases on the transfer tray were painted with liquid sealant catalyst resin part (B). The tray was then held in the mouth for 1 1/2 mins. The author says this technique can provide a simple no rush atmosphere as no polymerization can occur till the two liquid sealants (A) and (B) come in contact with each other. Another advantage was that the unpredictable nature of the previously used glue or tape material during bonding of brackets on the cast is eliminated.

Farhad Moshiri and Michael D.Hayward[24] (1979) developed a method with improved laboratory procedure for indirect bonding. The dental cast was marked for proper height and angulation. A laboratory adhesive which came from manufacturer preloaded syringe was placed in small amount at the bases of each bracket and positioned on the model. Sufficient adhesive strength developed after 30 minutes. If a faster set was desired, the model were placed under a heat lamp for 2-3 minutes.

A transfer tray was made using a clear Bioplast material of 2mm thick in a Biostar machine. The tray was easily removed under warm running water, any residual adhesive was also easily removed with warm water. Auto-Tach adhesive was loaded on the cleaned bracket bases and the tray was seated in the mouth.

Robert P.Scholz[70] (1983) In his article, he reported that the patient selection for indirect bonding was extremely important. Patient exhibit short clinical crown height, severe rotation

or poor oral hygiene were not suited for indirect bonding. Also, if extraction were included in the treatment plan, it was essential to place the bracket before the teeth were removed. Otherwise, drifting of the teeth around the extracted site will preclude proper seating of the tray. Even placement of separator at the time of indirect bonding impression can result in enough tooth movement to cause a problem during tray seating. Separator can be placed at the time of bracket delivery and then extraction can be complete. One week aftet bonding the patient can return to have any teeth banded as required.

Aguirre, King and Waldron[44] (1982) assessed accuracy of bracket placement and clinical failure rate comparing indirect and direct bonding techniques. The indirect bonding procedure employed was the Thomas technique. 11 patients were included in the study. Two measurements were made from photographs of the teeth including vertical and angular measurements. Maxillary and mandibular arches were divided into hemi arches and one technique was used on each arch as decided by the flip of a clip. The direct technique was done with the help of visual inspection and the indirect technique involved ideally placing the brackets on the cast. A camera with a jig attached having a rectangular wire at its end was used where the rectangular wire engaged the bracket for the photograph. A vertical reference line was marked along the midline marker of the bracket and a horizontal plane on rectangular wire. A vertical measurement linear was made along the vertical plane and the measurement lay between the points at which the horizontal plane intersected the vertical plane and the incisal and cuspal margin of the dental unit in question. The angular measurement was made on the angle formed in the mesioocclusal margin where the vertical and horizontal planes intersected. Results showed no statistically significant difference in

vertical placement. Angular brackets placement showed statistically significant difference in the canine with indirect being more accurate. The bracket failures recorded 3 months after bonding showed 4.55 for indirect and 5.3% for direct.

Gwinnett, Knoll and Wolff[28] (1986) conducted a study to determine the shear strength of brackets bonded to anterior and posterior teeth. The result obtained was the posterior teeth had lower shear strength(115.7 kg/cm^2) when compare to anteriors (164.3 kg/cm^2). A nonuniformity of the resin thickness beneath the bracket on the posteriors weaken the bond strength. Greater polymerization shrinkage in thicker areas of resin and differences in the coefficient of thermal expansion/contraction set up stresses within the resins. This might also account for some of the bond failure that were observed for posterior teeth at small force application. Greater masticatory forces produced in the posterior region also causes more failure at this region.

Andrew L.Sonis[5] (1988) compared light cured adhesive with an autopolymerizing resins for bond failure in direct bonding technique. Seventeen patients using split mouth design were bonded using both the adhesives and evaluated the bond failure for 22 months. The result showed was twelve brackets failed with the failure rate of 7.7% in autopolymerized group and seven brackets failed with the failure rate of 4.5% in the light cured adhesive group. All bracket failures involved premolars except one lower lateral incisor in the autopolymerized group and one lower central incisor in the light cured group. Also bracket placement and flash removal were found to be much easier with light cured composite than autopolymerizing system where failure to remove excess material predisposes the patient to decalcification and periodontal problems.

Alan P.Kinch, Helen Taylor, Rosie Warlter et al .,[2] (1988) conducted a study to compare the bond failure when 15 seconds or 60 seconds acid etch times were used for direct bonding. A sample of ninety patients using split mouth technique were divided into two groups and were etched for 15 seconds and 60 seconds. Each quadrant was etched from most posterior tooth forward and rinsed in the same order, thus ensuring that each tooth was etched for a similar period of time. The brackets were loaded with two paste adhesive and placed firmly on the tooth, and was monitored for bond failure about 6 months. The result obtained was, in total 1174 bonds placed; 123 were first time failed; 27 were second time failed and 8 were third time failed. The bond with 15 seconds showed a favourable survival rate than in those with 60 seconds etch. They conclude that Bond failure related to tooth position within the arch; anteriors showed lower failure rate than posteriors; first time bonds were more favourable survival rate than second or third time.

Richard A.Hocevar and Howard F.Vincent[69] (1988) did a study to compare bond strength and failure location for brackets bonded with indirect bonding procedure described by Thomas versus conventional direct bonding. They conclude that the comparison of bond strength between direct and indirect bonded attachments showed no significant difference between the groups. On visual inspection, voids could be detected in 65% of the indirect samples; unfilled voids yielded a significant decrease in bond strength. Sealed voids with liquid resins produced bond strength comparable to direct bonds and void free indirect bonds. Although 72% of the indirect bonding failed predominately at the enamel resin interface, no

significant decrease in bond strength resulted, also facilitate the easy clean up after debonding.

Milne, Andreasen and Jacobsen[51] (1989) conducted a study to compare tensile and shear bond strength obtained from the Thomas indirect bonding technique with direct bonding. 48 incisors and 48 premolars were extracted and used to attach the brackets. Half of the sample teeth were bonded with a highly filled bis GMA adhesive by a direct placement method. The remaining teeth were bonded with the same adhesive by Thomas indirect method. Tensile and shear bond strength determination showed no statistically significant differences between either of the two bracket application methods for incisor and premolars. The selection of one bonding method over another may therefore be determined by the accuracy of the bracket positioning and the convenience in handling the material.

M.J.F.Read and K.D.O'Brien[68] (1990) carried out a clinical trial to evaluate the clinical performance of a visible light cured adhesive when used in an indirect bonding technique. The brackets were attached to the stone model with the visible light cured bonding material. Any excess material around the bracket was carefully removed. When all the brackets had been placed, the material was cured with the visible light source. The light was directed down the long axis of each tooth so that the center of the beam was directed at the composite material between the bracket and the model. Complete polymerization could then be confirmed by touching the material with a sharp probe at the farthest point away from the light source.

A vacuum-formed transfer tray, made from a 2mm thick soft, clear plastic sheet was then molded over the brackets. The models was soaked in water for 15 minutes before removal of the tray. The tray was then trimmed to a horseshoe shape so that the border extended only to the gingival margin; this prevented any moisture on the gingival from running under the close-fitting tray through capillary action.

The teeth were thoroughly cleaned with pumice, the enamel surface were etched with 37% phosphoric acid for 60 minutes, and the composite on the bracket bases was cleaned and lightly abraded with a green alpine stone. The dried etched enamel and the composite on bracket base were then painted with unfilled resin. The tray was placed in the mouth and firmly seated. The adhesive under each bracket was then exposed, through clear plastic tray, to the visible light source for 10 seconds. The tray was peeled from the palatal or lingual side and as the adhesive material was fully polymerized, an archwire could be immediately engaged in the brackets.

The result obtained was, out of 407 brackets that were placed, 29 failed; and all failure occurred during the first 12 months of treatment. The overall failure rate was 6.5% and the failure rates for upper and lower arches were 6.4% and 6.7% respectively. For anterior and posterior teeth in the upper arch, the failure rate were 6.6% and 6.1%. Those for the lower arch were 7.5% and 5.4% respectively. They concluded that no significant difference were detected between the failure rates for both the arches. Similarly, no significant difference were detected between the anterior and posterior failure rates.

Stephen J.Reicceld, Robert A.Ritucci and Anthony A.Gianelly[79] (1990) developed a method for indirect bonding that eliminated the need for a transfer tray. The brackets used

had come with preformed height gauges, which was reinforced with a small amount of sticky wax. A small piece of soft wax was placed over the cusp tips which embed the height gauge until the bracket bases contact the labial surfaces of the teeth with no space exist between the bracket bases and the labial surfaces. A cold cure acrylic splint was made that covered the occlusal rests of the gauge and transfer the brackets from the model to the mouth. The splint was released by cutting the plastic gauge occlusal to the each bracket with a ligature cutter and the remaining portions of the height gauge was removed from the bracket slot. This technique generally takes only 15 to 20 minutes. It was a simple and accurate method for bonding brackets indirectly without a transfer tray.

Bradburn and N.Pender[14] (1992) examined the methods of improving the bond strength of the light activated composite. The brackets were bonded to the appropriate bracket site either with precured bracket bases or brackets with regular bonding procedure. The result showed was the brackets bonded with precured bases or with intermediate resins yield higher bond strength than the brackets bonded with the regular material.

Jing-Yi Shiau, Stephen T.Rasmussen, Phelps et al .,[32] (1993) examined the bond strength of aged composite found in bracket placed by an indirect technique. Four groups of teeth;(1) direct bonding with metal bracket,(2) indirect bonding with metal bracket,(3) direct bonding with ceramic bracket and (4) indirect bonding with ceramic brackets were done using modified Thomas indirect technique. All specimens were free of marginal defects after bonding to etched enamel as determined with a stereomicroscope. The bond strength of brackets placed by direct and indirect technique were similar. Fracture occurred primarily at

the bracket-composite interface regardless of type of brackets(metal or ceramic) or methods of bracket attachment (indirect or direct). They conclude that an aged composite surface upto 7 days produced in the modified Thomas indirect technique, was not likely to compromise the bond strength of brackets attached by this technique.

John H.Hickham[34] (1993) described a system of indirect bonding procedure, in which the bracket bases were thoroughly covered with a filled light cured restorative materials and cured for several minutes. The transfer tray used was a dual tray which consist of a soft 1mm vacuum form Bioplast sheet overlayered bt a hard 2mm Biocryl sheet in a Biostar machine. The teeth were pumiced and etched using 37% phosphoric acid for 30 seconds and dried. The sealant was applied to coat the etched enamel and the two pate composite was mixed and applied to the bracket custom bases. The tray was seated in the mouth and made bite on a cotton roll on each side to stabilize the dual tray for five minutes. Advantage of dual tray was to prevent any distortion of the soft tray that may compromise the fit of the brackets.

Ronald B.Cooper and Nile A.Sorenson[72] (1993) conducted a study to evaluate Adhesive Precoated Brackets(APC) for modified Thomas indirect bonding technique. APC brackets were bonded on 61 patients using metal and ceramic bracket types. Brackets were positioned on the cast and were light cured for 20 seconds, then a vacuum form acrylic former of 2mm clear soft Bioplast and a 1.5mm clear hard Biocryl sheet was used to form transfer tray. The custom bases were cleaned using liquid acrylic monomer or acetone. The teeth and the custom bases were coated with APC primer and the trays were seated in the mouth and cured for 10 seconds. They found 15 brackets failed during the bonding procedure and with

the failure rate of 1.4%. APC have number of advanteges including consistency and accuracy of positioning, ease of placement and reduction of chairtime. They can be bonded indirectly as well as directly.

Hugo R.Armas Galindo, Lionel Sadowsky, Christos Vlachos et a .,[29] (1998) conducted a study to evaluate and compare the rate of bond failure between the visible light cured bonding material and chemically cured bonding material. 32 consecutive patients were bonded following contralateral split mouth bonding pattern to eliminate any bias that might have been introduced from the clinician being right handed. The chemically cured composite required 5 minutes to set with 60% curing and final set of the adhesive occurred approximately 24 hours after the initial set. The light cured composite when exposed to the visible blue light at 420 to 450 nm had polymerized within 30 seconds. The result of the study had failure rate of 11.3% for light cured material and a failure rate of 12% for chemical cured composite. It was also noted that there was tendency for the posterior segment to show a higher failure rate. They conclude that both the visible cured bonding material and chemically cured bonding material were found to be clinically acceptable. There was no statistically significant difference in the failure rates when comparing the two systems but there was a significant more failures in the posterior segment than in the anterior segments.

Anoop Sondhi[6] (1999) reported a new method for effective and efficient Indirect bonding of orthodontic brackets wherein a custom base was developed with Transbond XT light cured adhesive. The transfer trays were fabricated using Biostar unit to vacuu-form a 1mm thick layer of Bioplast overlayered with a 1mm thick layer of Biocryl.The trays were cleaned in an

ultrasonic cleaner with a dishwashing detergent for 5 minutes and in water only for additional 5 minutes. They were then rinsed and dried thoroughly.

Once the teeth were etched and made ready for bonding, small amount of the Indirect bonding Resin A and Resin B liquid should be poured into the wells. Resin A can be painted onto the tooth surface with a brush and Resin B can be painted on the resin pads in the indirect bonding trays. Trays were positioned and hold for minimum of 30 seconds and allowed 2 more minutes of cure time before removing the tray.

Bon Chan Koo, Chun-His Chung and Robert L.Vanarsdall[13] (1999) conducted an in vitro study to evaluate the accuracy of bracket placement for direct and indirect bonding techniques. Nineteen sets of model divided into 3 groups: (1) one set for ideal bracket placement, (2) 9 sets for light cure direct bonding, (3) 9 sets for therma cure indirect bonding. All the brackets were placed on the long axis and the vertical height from the center of bracket to the cusp tip were 3.5mm for incisors, 4mm for canine, and 3.5mm for premolars according to Swain. The accuracy in placement was checked for bracket height, mesiodistal position and angulation. The results conclude that both direct and indirect technique failed to execute ideal bracket placement, whereas indirect bonding yielded better result in bracket height and mesiodistal positioning than the direct technique.

M**attew Gaworski, martin Weinstein Alan J.borislow et al[43] ., (1999)** did a study to determine the bond failure rate and decalcification between light cured glass ionomer and the light cured composite resins. They conclude that the 77.1% teeth bonded with glass ionomer and 75% teeth bonded with composite resin exhibit decalcification and was no significant

difference. But the glass ionomer failure rate was 24.8% and was higher than composite resin failure rate of 7.4%.

Larry White[38] (1999) Demonstrated a new method of indirect bonding using a more rigid matrix material for transferring the brackets from the model to the patient. The brackets were positioned on the model using Tacky glue, a water soluble adhesive and were sprayed with a silicone spray as a lubricant which make easy removal of matrix after complete polymerization. The molten matrix was formed by glue gun which covered the occlusal and lingual surfaces and part of facial surface of the teeth and the bracket. The matrix was submerged in warm water for 30 minutes to dissolve the Tacky glue and the matrix with the bracket was separated from the cast. The teeth were etched with 37% phosphoric acid , rinsed and dried. Excel A and B unfilled resins were mixed and painted over the teeth. Excel A and B filled composite resins were mixed and applied over the bracket mesh and was placed in the mouth. Hold the tray and allow the resin to cure. The tray matrix was removed using a small scaler. The hot glue technique has its advantage for using light cured composites, since the clear matrix allows light to penetrate completely.

Jay Collins[31] (2000) presented a new ultra viscous, water soluable and tenacious bonding adhesive, JC Endirect for his JC Endirect technique. The labial and buccal surfaces to be bracketed were paint with a fluorescent yellow marking pen, this eliminates the need for a separating medium while providing a visual aid to improve the accuracy of bracket placement. The long axis of the crown was scribed with a fine–line pencil, also scribe

horizontal reference lines at the appropriate bracket heights and the accuracy were inspected under the ultraviolet black light.

JC Endirect adhesive was placed on the bracket base and the brackets were positioned agaist the appropriate tooth on the working cast. The adhesives were allowed for bench cure for 20 minutes. Vacuum-formed 1mm soft plastic mouthguard sheet over bracketed cast, and soaked it for 15 minutes in a bowl of warm water to dissolve the adhesive. Tray was trimmed to the cervical margin of the teeth and sectioned depending on whether a one, two or three-piece transfer tray was needed. Vacuum-formed an 0.040" rigid clear plastic sheet over bracketed soft transfer tray and was trimmed.

The JC Endirect technique met several advantages (1) precise bracket position that was verified under the black light. (2) its viscosity prevent bracket drift (3) adequate strength

Chun-His Chung and Annalisa Piatti[18] (2000) conducted a study to evaluate the bond failure between fluoride releasing and non fluoride releasing composite resins. The release of fluoride incorporated in the composite resin is probably due to two different mechanisms. First, fluoride diffuses into the oral cavity through material dissolution (NaF), which may have the effect of weakening the structure of the composite resin and thus decreasing its bond strength. Second, fluoride may leach out of the material by ion exchange with other anions in the oral environment. A total of 370 brackets, 186 (77 maxillary and 109 mandibular) were bonded with the fluoride-releasing Phase II, and 184 brackets (75 maxillary and 109 mandibular) were bonded with the non-fluoride-releasing Phase II. The result showed was only two failures (one for each composite) occurred within one month. Four more (two for each adhesive) were found between one and three months. Ten bond failures (six with the

fluoride-releasing Phase II and four with the non-fluoride-releasing Phase II) occurred between three and six months after bonding. Statistical analysis showed no significant difference in the bond failure rates between the fluoride-releasing and non-fluoridereleasing groups. More failures were noted in the mandibular arch than in the maxillary arch, but there was no significant difference between the two composites. There were more premolar bond failures than incisor or canine bond failures in both groups, with no significant differences among the failure locations.

Alastair Gardner and Ross Hobson[3] (2001) conducted a study and compared the enamel etch patterns achieved on the orthodontic bonding area of extracted mandibular premolars treated with 37% phosphoric acid and 2.5% nitric acid applied for 15,30 or 60 seconds. They concluded that phosphoric acid at 37% concentration was more significantly increased the amount of better quality etch than nitric acid at 2.5% for all 3 application times.

The quantity of good-quality etch produced by phosphoric acid at 37% was time specific, with 15 seconds being significantly less effective than 30 or 60 seconds. However, 60 seconds was not significantly better than 30 seconds. These finding supports the use of 37% phosphoric acid and indicate an optimum application time of 30 seconds.

Larry White[37] (2001) Developed a new improved method for indirect bonding, where the use of prompt L-Pop, a self etching adhesive; Quick cure composite and a Power Slot curing light tip can greatly expedite light cured indirect bonding. As the etching progress, the pH of the phosphoric ester rises due to neutralization of the acidic monomers and this stops the demineralization. Addition to the mechanical attachment, a chemical bond occurs between

the calcium hydroxyl apatite and the phosphoric esters of Prompt L-Pop. Brackets were positioned on the model using Tacky Glue cement and the transfer tray was fabricated using hot glue material. The bracket bases were microetched and dried. Prompt l-Pop ingredients were mixed and rubbed over the enamel for a few seconds and the teeth were dried and glue matrices were positioned in both arches. The curing light with power Slot tip was quickly passed over the teeth in both arches to initiate polymerization, 5 seconds per tooth. They conclude that the light cured indirect bonding with conventional curing tip required 20 minutes to bond the maxillary and mandibular arches, but the Power Slot tip required only seven minutes for complete bonding of both the arches and save a 65% clinician time.

Ulf Adolfsson, Erik Larsson and Bjork Ogaard[83] (2002) conducted a study to investigate the factors that contribute to bond failure of brackets bonded with no-mix adhesive system. The total percentage of bond failure during treatment was 9.4%. There was a statistically significant difference between the bond failures in the maxillary and mandibular arch. The highest failure rates among the mandibular teeth, with the left second premolars. Fewer loose brackets were registered in patients with initial crowding. Development of white spot lesions during treatment was significantly associated with high frequency of bond failure and also complexity of appliance design was associated with high bond failure rates.

Peter G.Miles[64] (2002) Described the use of flowable light cure adhesive in Indirect bonding technique. Adhesive Precoated brackets were used to position the brackets on the model, forming light cured custom bases which was lightly microetched and cleaned by painting a small amount of acrylic monomer about 10 minutes prior to bonding and then thoroughly

dried. Only a small amount of Filtex Flow applied to moisten the surface of each base. The transfer tray used was a clear vacuum formed thermoplastic sheet which contain a soft inner tray and a hard outer tray to allow light for curing the bases.

Gia K.Yi, William J.Dunn and Louis J.Taloumis[27] (2003) compared the shear bond strength of orthodontic brackets bonded to teeth with either an indirect bonding technique or a direct bonding technique. In one group, the APC premolar brackets were placed on the stone model and cured in a Triad light curing oven and the bonding tray was fabricated with a Reprosil light- viscosity was and heavy-bodied polyvinylsiloxane impression material. The specimens were etched with 34% phosphoric acid and dried, part A of the rapid set indirect bonding bonding resin was painted on the teeth and part B on the custom base pads. In group B, teeth were etched and light cure adhesive primer was applied and cured. Premolar APC brackets were placed on each tooth and light cured for 40 seconds.

Each bonded bracket was tested for shear bond strength 72 hours after bonding. They concluded that the mean shear bond strength for indirect bonding and direct group were 11.2 MPa and 10.9 MPa respectively, both exceeding the minimum shear bond strength range of 5.9 to 7.8 MPa. There was no significant difference between the two technique whether they were bonded with direct or indirect technique.

Arndt klocke, Dr med dent, Jianmin Shi et al .,[9] (2003) conducted a study to evaluate bond strength for a custom base indirect bonding technique using a hydrophilic primer on moisture contaminated tooth surfaces. Stainless steel brackets were bonded using light cured custom base composite adhesive, a chemically cured sealant, and the hydrophilic primer.

Five groups of 20 teeth each were formed according to the time of contamination; A, control group with no contamination had the mean bond strength of 15.07 MPa; B, contamination with saliva before application of the primer had mean bond strength of 14.91 MPa; C, Contamination with water before application of the primer had mean bond strength of 16.12 MPa; D, contamination with saliva before and after application of the primer had mean bond strength of 11.92 MPa; and E, contamination with water before and after application of the primer had the mean bond strength of 9.85 MPA. Results concluded that the custom base indirect bonding technique with the hydrophilic primer was not significantly different in groups without contamination and with water or saliva contamination before application of the primer, but the contamination after primer application resulted in an increased risk of bond failure at clinically relevant levels of stress.

Arndt Klocke, Dr med dent, Jianmin Shi et al .,[11] (2003) conducted a study to evaluate bond strength for a cyanoacrylate adhesive with composite adhesive. The result was that the cyanoacrylate adhesive yield lower bond strength and there was an increased risk of bond failure at the clinically relevant levels of stress for indirect bonding with the cyanoacrylate adhesive.

William Layman and Tatsuki Koyama[88] (2004) did a study on 12 patients for comparing bond failure between brackets directly bonded using conventional halogen and LED light curing units. The teeth were prepared with Transbond self-Etching primer and direct bonded with transbond adhesive. Upper and lower right quadrants were bonded using halogen light

and left quadrants were bonded using LED. They conclude that, over a three month period the halogen had a failure of 4.8% and LED had 1.9% of bond failure and the difference was not statistically significant.

Rajagopal, venkatesan, Gnanashanmugam et al[67] (2004) Explained a method for indirect bonding wherein the brackets were placed on the adhesive tape spreaded over the glass plate with the adhesive facing up. Tape around the brackets were cutted and a drop of cyanoacrylate glue was applied to the non-adhesive side of each tape, then was fixed to the working model. Vacuum formed transfer tray of 2mm thickness soft sheet was made which on removal leave the bracket base, with adhesive free mesh. Tray was positioned using resin based luting agents and cured.

Arndt klocke, Dr Med dent,Drazen Tadic et al.,[8] (2004) conducted a study to evaluate the influence of custom base composite age on bond strength in indirect bonding. Stainless steel brackets were bonded to the teeth using Thomas indirect technique using two different custom base composite-sealant combination, (1) chemically cured composite and sealant,(2) light cured composite and chemically cured sealant. The composite custom bases were preaged for 24 hours and for 7, 15, 30, and 100 days. The results indicate that aging of composite custom bases for up to 30 days does not cause reduction in shear bond strength. However, storage of the custom base for a longer time interval of 100 days before polymerization of the sealant had a detrimental effect on shear bond strength with both the composites.

Pablo Echarri and Tae-Weon Kim[62] (2004) Introduced double transfer tray for indirect bonding. Triad light cured acrylic was used to make single unit transfer tray. Then a silicone tray is fabricated to cover all the single unit trays and transfer to the mouth. After bonding, the silicone tray was removed first and the single tooth tray can then be removed one by one without dislodging any of the brackets. The single unit can be used for precise rebonding at any time during treatment, without distortion.

Bruno Manzo, Giuseppe Liistro and Hugo De Clerck[16] (2004) conducted a study to evaluate the bond failure between the conventional halogen and the plasma arc. 608 brackets bonded using both the technique using split mouth design and were evaluated for 12 months. Twelve bond failures were reported with each technique with the overall failure rate of 3.9% with higher bracket failure rate in the posteriors and hence there was no significant difference in survival rate between the two bonding methods.

Maria Francesca sfondrini, Vittoria cacciafesta, Andrea Scribante et al .,[41](2004) did a study to evaluate the clinical performance of orthodontic stainless steel brackets bonded with a composite resin and cured with either a conventional halogen for 20 seconds or a plasma arc light for 5 seconds. The degree of polymerization is directly related to the amount of total energy that the resin absorbs. Total light energy is related to the intensity of the light and to the duration of exposure. 42 randomly selected patients with split mouth design were examined and total of 717 were cured with conventional halogen and 717 were cured with plasma arc. The result showed that 39 bond failures(5.4%) occurred with conventional and

31 failures(4.3%) in plasma arc light. Thus the failure rate with conventional halogen light was not significantly different from that of cured with plasma arc.

Vetea G.Miklus, Jean-Paul Alibert and Shane N. White[84] (2005) presented a safe, fast, and easy method for cutting the silicone or polyvinyl siloxane trays that are used in most indirect bonding techniques. Brackets were positioned on the working model and a length of ligature wire was twisted around the acrylic ring to make the cutting system. A light body silicone tray material was applied over the brackets and position the cutting wire directly above the occlusal edges of the brackets before the silicone sets. Then heavy body silicone material overlayered the light body and the cutting wire during which using the acrylic ring, tail of the cutting wire was brought around the anterior, and secured within the heavy body material in the incisor region.

Once the tray was safely removed with the bracket intact, enamel surfaces were prepared and the tray was positioned in the mouth with the adhesive. After polymerization was complete, the oral commissures were retracted and tray was supported at the posteriors, then engage the acrylic ring and pull the wire forward. The wire cutted the silicone along the occlusal surfaces of the brackets, separating the tray into occlusolingual and the bucccal portion. The occlusolingual portion piece was removed and the remaining buccal piece was peeled away safely, minimizing the force transmitted to the newly bonded brackets.

Ari Y.Krug and Scott Conley[7] (2005) did a study to compare bond strength using an indirect bonding technique with different light sources. Brackets were bonded with Transbond XT adhesive to form custom base and transfer tray of 0.5mm soft vacuum –

formed and a 1mm hard Biocryl sheet was used. The custom bracket bads were cleaned with rubbing alcohol. Orthosolo primer and Transbond XT adhesive placed on the custom base and were cured intraorally using halogen light or LED or Plasma arc light. The result showed were halogen unit showed failure rate of 0.3 per patient, LED unit failed at the rate of 0.33 per patient and the Plasma arc failed at the rate of 0.27 per patient. Thus there was no significant difference among the three units with regards to bond.

Peter G.Miles and Robert J.Weyant[63] (2005) Compared the clinical bond failure rate of chemically cured resin and flowable light cured resin using indirect bonding technique in split mouth design. The transfer tray used for indirect bonding was a 1.5mm clear vacuum formed mouthguard material overlayered by a second 1.5mm vacuum formed clear splint material. The custom bases were microetched with 110 µm aluminium oxide particles and painted with methyl methacrylate monomer. The flowable composite was applied to the custom bases and chemically cured composite on the contralateral side of the tray was applied, then the tray seated in position. The result obtained after 6 months of observation showed 36 brackets bonded with chemically cured came loose with the failure rate of 2.9% and 30 brackets bonded with light cured came loose with the failure rate of 2.4% . The failure rates were low for both adhesives with no significant difference.

Christiana Gioka, Christoph Bourauel, Anastasia Hiskia et al.,[17] (2005) conducted a study to estimate the degree of cure and monomer leaching of a light cured and a chemically cured adhesive and their cytotoxic effects. Two monomers mainly used in orthodontics are Bisphenol A diglycidyl dimethacrylate(Bis-GMA) and triethylene glygol

dimethacrylate(TEGDMA). It was found that the degree of cure of adhesive modulates the physical and mechanical properties of the material, particularly solubility and degradation. In this study, a standardized volume of adhesive was applied to the bracket bases and were pressed firmly over a cellulose film to facilitate detachment of the bracket for assessment by infrared spectroscopy. The results showed was no difference between the 2 adhesives with respect to their degree cure and the amount of TEGDMA; no Bis GMA was detected in the eluent. Hence both the material had similar amount of monomer leaching and no difference in the degree of cure and both had no cytotoxic effects too.

Julio Pedra and Jose Augusto Mendes Miguel[35] (2005) investigated the invivo bond failure rates of brackets bonded with composite resin after the use of either a conventional etchant and Transbond Moisture Insensitive Primer or Transbond Plus Self etching primer alone. The results obtained was, among 15 patients, only 9 bond failure were noted in 6 months follow up- 3(2.54%) with conventional acid etch and the hydrophilic primer, and 6 (5.08%) with the self etching primer. There was no significant difference in bond failure between the two primers.

Scott M.Peterson, James L.Drummond, Carla A Evans et al[76] (2006) conducted a study to compare bond strength using halogen, Plasma arc and LED curing units. A total of 180 freshly extracted permanent incisors were etched and bonded using Transbond XT light cure adhesive. The result was found that the halogen light demonstrated significantly lower bond strength than the plasma arc or the LED units, which were not significantly different from each other.

Yinzhong Duan, Xuepeng Chen, Junjie Wu[92] (2006) did a study to compare the bond failure rate on fluorotic teeth using different enamel preparation. In Group A enamel surfaces were cleaned with non fluoridated pumice, in Group B surfaces were cleaned and polished by removing 01-0.2mm of enamel with a carbide drill, in Group C thesurface are cleaned, polished and a tooth coloured 0.2-0.3mm layer of Transbond plus self etching primer was affixed. The results after 12 weeks were bond failure rate of 74% for Group A, 25.9% for Group B and 1.7% for Group C and had a significant difference between the three groups.

Brandon James Linn, David W.Berzins, Virendra B.Dhuru et al.,[15] (2006) conducted a study to evaluate and compare the shear bond strength and site of bond failure for brackets bonded to teeth , using a direct bonding technique and two indirect bonding technique (1) light cured adhesive and chemically cured primer, (2) light cured adhesive and light cured primer. They conclude that direct bonding with light cured adhesive and primer, indirect bonding using light cured adhesive and chemical cured primer, and light cured adhesive and primer , all produced clinically acceptable in vitro bond strength of 16.27 MPa, 13,83MPa and 14.76Mpa respectively. Also all the three groups tested provided over a 90% survival rate at normal masticatory an orthodontic force levels.

Jacob Daub, David W.Berzins, Brandon James Linn[30] (2006) did a study to evaluate the shear bond strength of direct and indirect bonded brackets after thermocycling. Sixty human premolars were extracted and divided into three groups: one light cured direct bonding, another two with indirect bonding of chemically cured and light cured. The brackets were bonded and were sectioned 2-3mm below the cementoenamel junction and crowns were

mounted in acrylic cylinders with the bracket exposed. After 24 hours the samples were thermocycled between 5°C and 55°C for complete 500 cycles in distilled water of each bath at 30 seconds. The result showed was, no significant difference in shear bond strength found between teeth bonded directly and indirectly after thermocycling. The thermocycling process resulted in a significant decrease in shear bond strength.

Michael D.Signorelli, Elizabeth Kao, Peter W.Ngan et al .,[46](2006) did a study to evaluate the in-vitro shear bond strength and in-vivo bond survival rate of orthodontic brackets bonded with either a halogen or a plasma arc light. The study concludes that no significant difference was found in shear bond strength and also in failure rate between both the groups. This indicate that the plasma arc light with 6 seconds curing time can produce similar bond strength and bracket failure rates as the halogen that requires a longer curing time.

Arturo Fortini, Fabio Giuntoli and Lorenzo Franchi[12] (2007) Described a modified indirect bonding technique where brackets were positioned on the model using light cure composite and a thin layer of medium viscosity silicone impression material applied to the bracket to block undercuts. Transfer tray fabricated using glue gun cover the facial surfaces and parts of the lingual and occlusal surfaces of the teeth. Tray was fitted to the patient with a flowable composite resin to each bracket and cured. Holding warm water for 2 minutes softens the glue and facilitate removal of the transfer tray.

Nir Shpack, Silvia Geron, Ioannis Floris et al .,[59] (2007) conducted a study to examine the accuracy of bracket placement in labial and lingual system in both direct and indirect

bonding. The objective of the study were to compare torque error(TqE) and rotation deviation(RotD) between labial and lingual bracket systems for both direct and indirect technique. 20 orthodontic subjects pretreatment models were randomly divided into four groups according to the location and the technique: labial direct, labial indirect, lingual direct and lingual indirect. Transbond XT was used for both direct and indirect bonding. Lingual Bracket Jig System(LBJ) was used in both lingual groups. The TqE was the angle between occlusal plane and the long axis of each bracket slot. TqE was measured with a torque angle gauge constructed of a geometric triangle and a plumb line emerging from the vertex of the protractor. The RotD were measured with an optic toolmaker's microscope. The study concluded that the indirect bonding technique was significantly more accurate than the direct technique for all teeth in both labial and lingual technique and was valid for both TqE and RotD.

S.Thomas Deahl, Norman Salome,John P.Hatch et al .,[81](2007) did a study to compare direct and indirect bonding technique for bond failure rate and the treatment time in 1386 patients collected from 11 orthodontic office. The proportion of failed bonds per patient was calculated and the result obtained was 1.17% for direct bonding and 1.21% for indirect bonding. The bond failure rate for each tooth between the direct and indirect found no significant difference. The total visit per patient did not differ between the two technique, which had the mean visits of 22 and 750 days of treatment duration for direct and 22.2 visits and 745 days for indirect technique. They conclude that there was no significant difference in failure rate, number of appointments,and total treatment duration between the two technique.

David Mirabella, Refaele Spena, Giovanni Scognamiglio (2008) conducted a study to determine the failure rate of orthodontic brackets bonded with conventional halogen versus Light emitting diode. 65 patients with split mouth design was used in two groups. The composite was polymerized using blue conventional halogen light for 20 seconds and the remaining quadrants were polymerized using LED for 10 seconds. Over a period of 6 months 3.2% brackets failed in conventional halogen group and 2.6% brackets failed in LED group. There was no statistically significant difference in the bond failure rate between the two light sources .

Michael C.Alpern, Carolyn Primus and Ada Hinda Alpern[4] (2009) described a new indirect,single tray bonding system which uses two adhesive to construct a custom base for each bracket. The AccuBond tray material has high elasticity enables the tray to conform tightly to the shape of the dental model, and its flexibility allows easy intraoral removal. The thinness of the material facilitates light curing and at the same time it does not warp after forming, nor does it distort after being removed from the dental cast. Two coats of AccuBond primer applied to the custom base and to the teeth and light cured. And a small amount of AccuBond indirect adhesive placed on each custom base just before tray insertion and light cured.The study concluded that the AccuBond system had substantially reduced immediate failures compared with direct bonding.

Akhter Husain, Tariq Ansari, Rohan Mascarenhas et al.,[1] (2009) explained an Indirect bonding technique uses a modified acrylic platform in which the putty was placed only on

the labial and buccal surfaces, providing easier access for light-curing. Two acrylic or metal strips bent at 90° angle attached to the buccal side of the putty transfer tray which on squeezed together, flare out the transfer tray, allowing placement of the brackets at right angles to the tooth surface thus preventing the scraping of the adhesive coated bracket along the long axis of the tooth during occlusogingival insertion which resulting in uneven distribution of adhesive compared with the perpendicular placement of bracket.

Felipe de Assis Ribeiro Carvalho, Almeida, Cevidanes et al.,[25] (2010) compared the residual monomer in composites beneath brackets bonded to enamel using a light-emitting diode or a halogen unit and the residual monomer in the central to the peripheral areas of the composite. The result was that the LED leaves less residual monomer than the halogen but not statistically significant; there was no difference between the centrals and peripheral regions and no interaction between light type and region.

Mark Joiner[42] (2010) described a modification of Kalange's technique of bracket placement for indirect bonding that improved the accuracy and repeatability. Kalange technique of bracket placement on models requires drawing a line on each posterior tooth to connect the mesial and distal marginal ridges. A second parallel line was drawn approximately 2mm gingival to the marginal ridge line; this is the slot line, where the vertical center of the bracket slot should be placed. This modification require 2 bow compass and 3 mechanical pencils. The compass was adjusted with the aid of a millimeter ruler so that the tip of the lead in the pencil is approximately 2 mm longer than the long axis of the compass. Accurate bracket placement begins with drawing the long axis of each crown. A point source

of light shining on the side of the teeth illuminates developmental lobes or grooves on the labial surface and will help you locate the long axis . To construct the slot line, place the steel stylus of compass 1 on the marginal ridge of a posterior tooth, with the long axis of the compass parallel to the long axis of the crown, and then rotate the compass slightly to make a pencil mark on the buccal surface . Place these dots on the mesial and distal aspects of each posterior tooth. Connecting the two dots on each tooth with the pencil established the slot line.

Nabeel F.Talic[55] (2011) did a split-mouth randomized clinical trial to determine the effect of fluoridated paste compared with plain pumice on the clinical bond failure rate of precoated brackets with self etching primer. Bracket failure was followed over 6 months. The overall failure rate was 8%. The failure rate of the brackets were 4.8% on pumice-treated teeth and 11.2% on fluoridated paste-treated teeth. They conclude that the preparation of the enamel surface with fluoridated paste before bonding was not recommended and the use of plain pumice was recommended.

Fabio Ciuffolo, Nicola Tenisci and Luca pollutri[23] (2012) described a modified technique for Indirect bonding performed in 3 stages, in which, brackets were placed on the model using light cure composite adhesive. The tray for transferring was fabricated by a thin translucent soft silicone and overlayered by thermo-form 1mm thick rigid tray, which was removed, cleaned and dried fully. Final stage was preparing the tooth by etching with 37% phosphoric acid for 30 seconds and apply a thin layer of primer on the teeth and then apply the self-curing components A and B(Sondhi Rapid set;3M Unitek) on the teeth and the

bracket bases respectively. Trays were seated firmly maintain the 2 vectors for a minute and an additional 3 minute, to complete the self curing process.

MATERIALS AND METHODS

The various materials used in this study are described below:

MATERIALS:

1.Brackets (figure 2) :

Direct bonding stainless steel preadjusted fully programmed edgewise MBT 0.022 slot brackets with metallic foil mesh backing were used on all patients.

2.Adhesive (figure 3 and 4) :

Transbond XT light cure adhesive paste (3M Unitek)

Transbond XT light cure adhesive primer(3M Unitek)

3.Light cure unit (figure 5) :

Conventional Halogen light curing unit- 3M Unitek curing unit.

4.Transfer tray material (figure 8):

Vacuum formed soft clear thermoplastic sheet of 2mm thickness.

5.Biostar machine (figure 7) :

Scheu company

6.Other materials and arnamentarium used were:

- Mouth mirror, Probe, Bracket holder, Tweezer, MBT bracket positioning gauge, Marking pencil, Scissor, BP blade.

- Cold mould seal (DPI)
- Applicator tips.
- Compressed air/water facility with a 3-way syringe
- Acrylic monomer(Methyl methacrylate)
- Micro motor hand piece with polishing cups and slurry of pumice
- 37% orthophosphoric acid
- Suction unit

METHODOLOGY

Thirty patients who came for orthodontic treatment to our department of orthodontics, requiring fixed orthodontic appliance therapy were included in the study. All patients participated were informed about the study and were made to sign an informed consent form.

PILOT STUDY:

A pilot study was under taken to determine the feasibility of bonding the brackets on the models using Transbond XT (3M Unitek) light cured adhesive and the fabrication of transfer tray using soft clear vacuum formed thermoplastic sheet of 2mm thickness for transferring the bonded brackets to the patient mouth with adequate rigidity and elasticity. The outcome of the pilot study confirmed thermoplastic sheet of 2mm was an ideal transfer tray material.

SELECTION CRITERIA:

Inclusion criteria:

- Full permanent dentition without any missing teeth
- Age of the sample : 14 yrs to 30 yrs
- Good oral hygiene

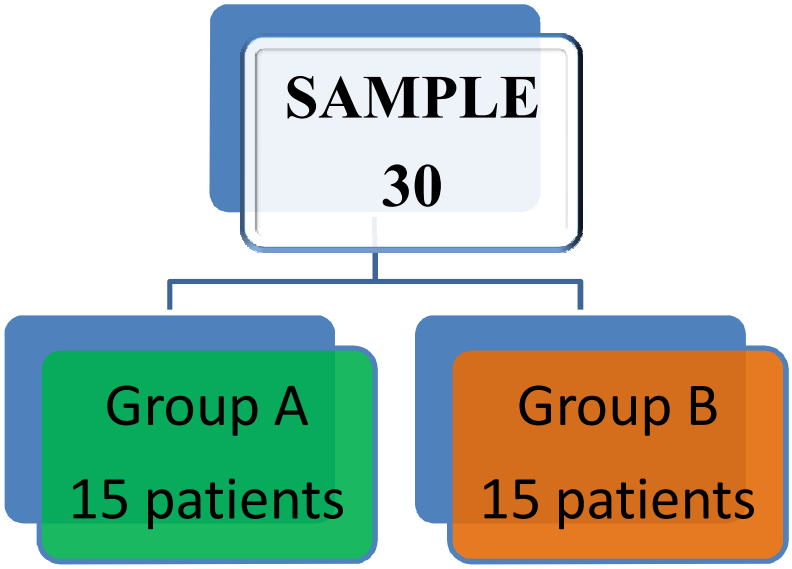
Exclusion criteria:

- Severe deep bite cases
- Teeth with crowns, bridges, veneers, restoration or enamel hypoplasia[70]
- Severely rotated and blocked out teeth[70]
- Partially erupted teeth

DIVISION OF SAMPLES:

Thirty patients were randomly divided into two groups: Group A & Group B.

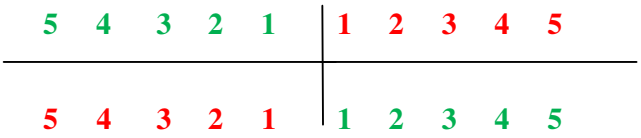
The randomization was done using a software (Graphpad.com / quickcals). A split-mouth design was used. For each patient both the sides contain both the groups so that they were distributed equally for all the patients.



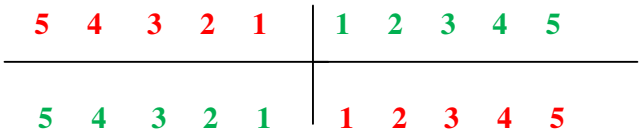
SPLIT MOUTH DESIGN:

- Group A consisted of fifteen patients with maxillary right and mandibular left quadrants bonded using direct bonding technique whereas contralateral sides were bonded using indirect bonding technique.
- Group B consisted of fifteen patients with maxillary left and mandibular right quadrants bonded using direct bonding technique whereas contralateral sides were bonded using indirect bonding technique.

GROUP A:



GROUP B:



-Direct bonding technique

-Indirect bonding technique

A total of 518 teeth were bonded using split mouth technique to rule out any bias in the study; out of which 256 teeth were bonded using direct bonding technique (3M Unitek) and 262 teeth were bonded using indirect bonding technique(3M Unitek & Vacuum formed clear soft thermoplastic tray of 2mm thickness)

Transfer tray fabrication for indirect bonding procedure:

A customized method of indirect bonding was followed for all patients, using thermoplastic sheet of 2mm thickness.

Accurate alginate impressions of both arches were made and the models were poured without voids or air bubbles.

When the models were absolutely dried, the long axis of the teeth were marked and MBT bracket positioning gauge was used to mark the vertical height for individual

teeth (figure 9). A thin coat of separating medium (cold mould seal) was diluted with water (1:3 ratio) applied evenly all over the model and allowed to dry for 24 hours[7,8,10].

Transbond XT (3M Unitek) light cure adhesive was evenly spread over the bracket mesh and placed onto the dental model with respect to the long axis and vertical height markings(figure 10). The excess flash was removed and each bracket was cured for 20 seconds each side (occlusal and gingival) to form the custom base[4,6,12,23,62,68] (figure 11).

Transfer trays were constructed using soft clear thermoplastic sheet of 2mm thickness in a biostar machine[24,54,68](figure 12). The formed tray was then dipped in warm water for 30 minutes allowing the separating medium to dissolve, which facilitate easy removal of tray from the model without any distortion.

The transfer trays for all patients were extended 2mm below the gingival margin on buccal and lingual/ palatal side. The bracket hook areas be trimmed/ cut off the bonding tray to permit easy removal[6].

The transfer trays were then gently rinsed with running tap water to remove the separating medium and allowed to dry for 30 minutes. Each of custom base was cleaned by applying methyl methacrylate monomer [48,49,64,72] about 10 minutes prior to bonding and then thoroughly dried.

Indirect bonding with Transbond XT light cure adhesive (3M Unitek):

The arches were subjected to pumice prophylaxis with a polishing cup and the pumice paste(figure 13). All the teeth to be bonded were etched with 37% orthophosphoric acid gel for the duration of 30 seconds(figure 14) and rinsed thoroughly(figure 15). In each quadrants, the teeth were etched from the most posterior

tooth forward and rinsed in the same order, these ensure each tooth was etched for a similar period of time[2]. The teeth were dried with oil and moisture free source of compressed air. The bonding arches were properly isolated using a suction unit and maintained dry till the end of the bonding procedure.

A thin coat of light cure primer (Transbond XT – 3M Unitek) was applied onto the each of tooth surface and to the custom base. The tray then seated and held firmly in place with a gentle and uniform pressure applied over occlusal and the buccal surfaces of the teeth to be bonded (figure 16).

Each bracket was cured using a conventional halogen curing unit for 20 seconds on each side (occlusal and gingival). The tray was then removed after two minutes from palatal/lingual side to the buccal side. Extreme care was taken not to debond the brackets during tray removal(figure 17).

After tray removal, all the interproximal contacts were checked using a dental floss to ensure that all contacts were open.

Direct bonding using Transbond XT light cure adhesive(3M Unitek)

All the teeth to be bonded were pumiced and etched with 37% orthophosphoric acid gel for the duration of 30 seconds and rinsed thoroughly. The teeth were dried with oil and moisture free source of compressed air. The bonding arches were properly isolated using a suction unit and maintained dry till the end of the bonding procedure.

The long axis of the teeth was marked and MBT bracket positioning gauge was used to mark the vertical height for individual teeth which was symmetry to the opposite side of the same arch.

A thin coat of Transbond XT light cure primer (3M Unitek) was applied to each tooth to be bonded and the bracket mesh were loaded with Transbond XT light cure adhesive paste(3M Unitek). The brackets were placed onto the tooth with respect to the long axis and the vertical height markings (figure 18).

The excess flash was removed and each bracket was cured for 20 seconds on each side (occlusal and gingival). After bracket bonding, the initial archwires were placed on the same day. Bracket failures were recorded every three weeks for a period of six months.

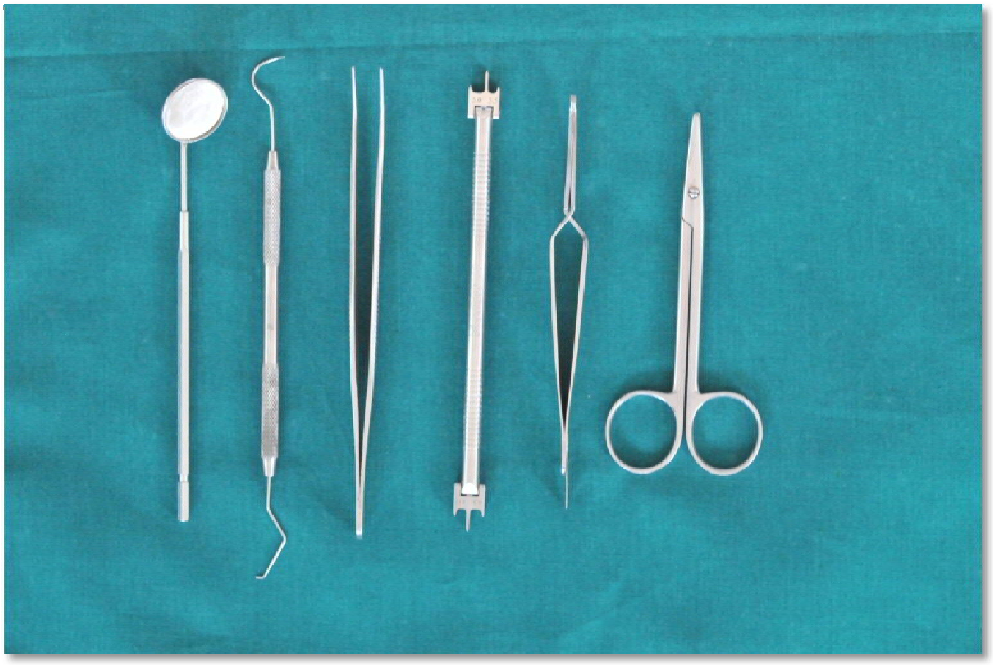


FIGURE 1 : Mouth mirror, Probe, Tweezer, MBT gauge,

Bracket holder, Scissor.

FIGURE 2 : Stainless steel MBT 0.022 slot brackets

FIGURE 3 : Transbond XT light cure adhesive paste (3M unitek)

FIGURE 4: Transbond XT light cure adhesive primer (3M unitek)

FIGURE 5: 3M Unitek light cure unit (Conventional halogen)

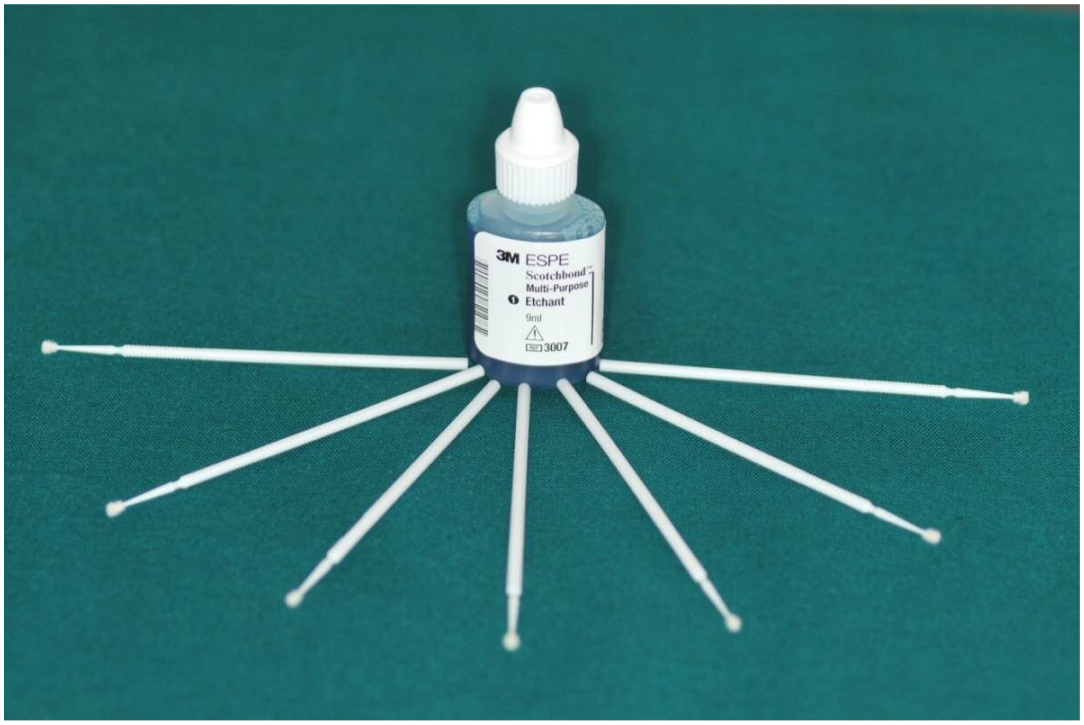


FIGURE 6: 3M ESPE Etchant (37% phosphoric acid)

FIGURE 7 : Biostar machine

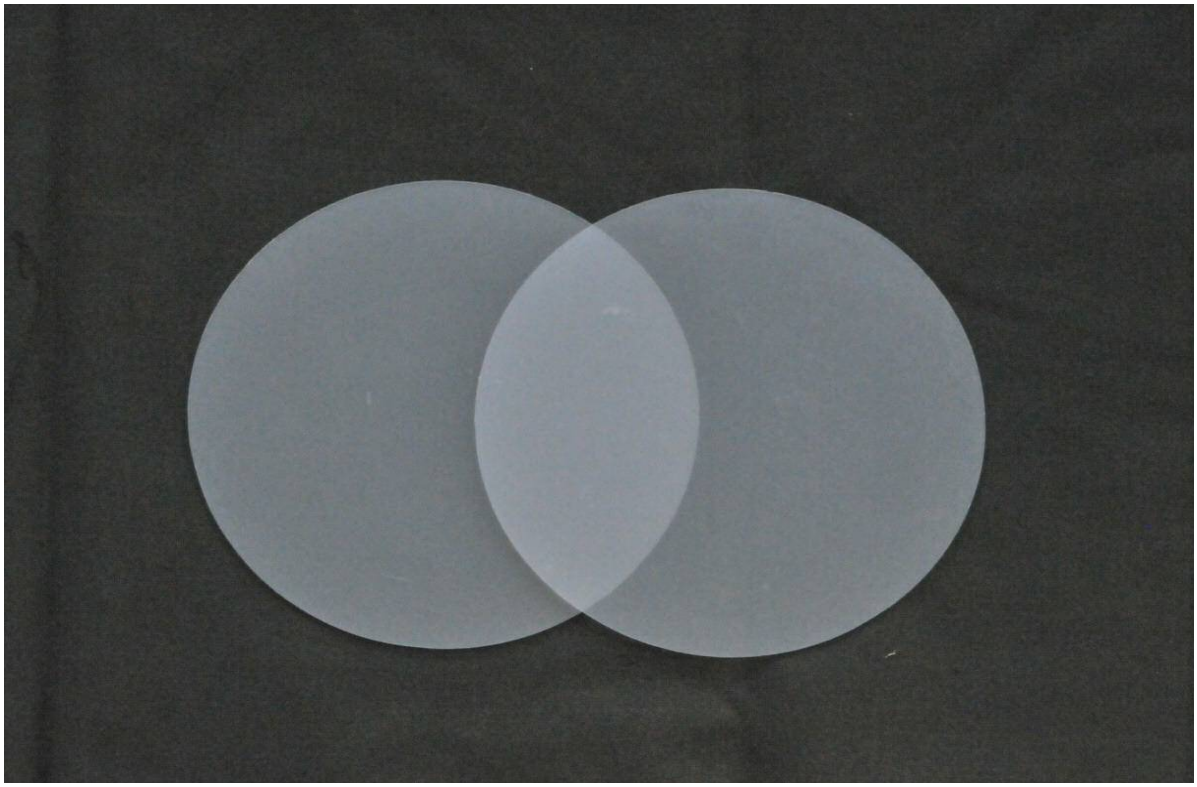


FIGURE 8: Vacuum formed soft clear thermoplastic tray material (2.0mm)

z 

FIGURE 9: Horizontal and vertical lines marking on the model

FIGURE 10: Brackets placed over the markings using light cure adhesive (3M Unitek)

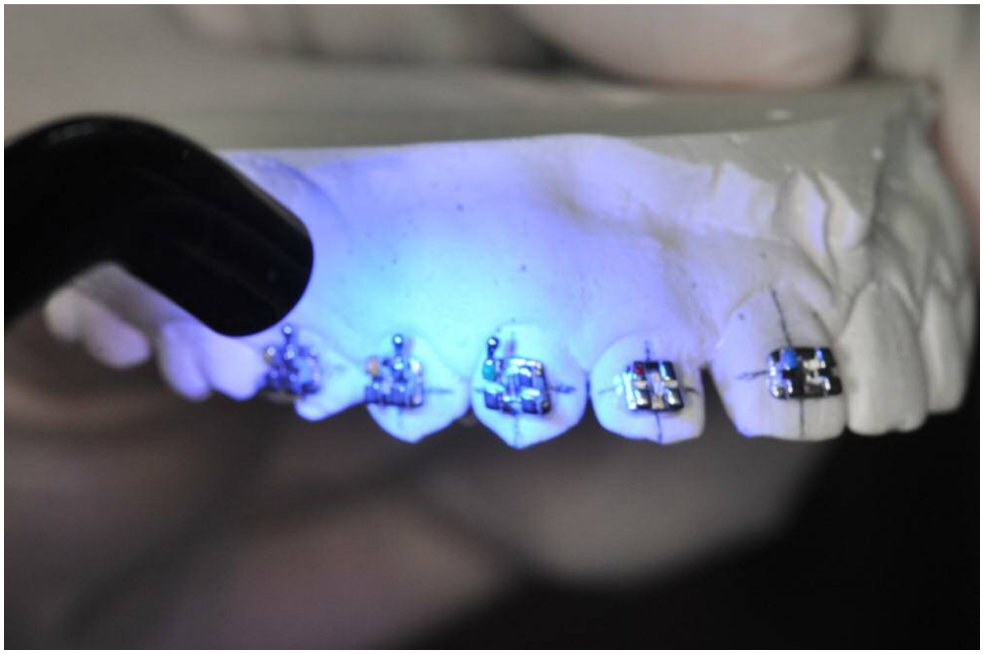


FIGURE 11: Light curing of adhesive to form custom base

FIGURE 12: Transfer tray fabrication using thermoplastic sheet of 2mm thickness

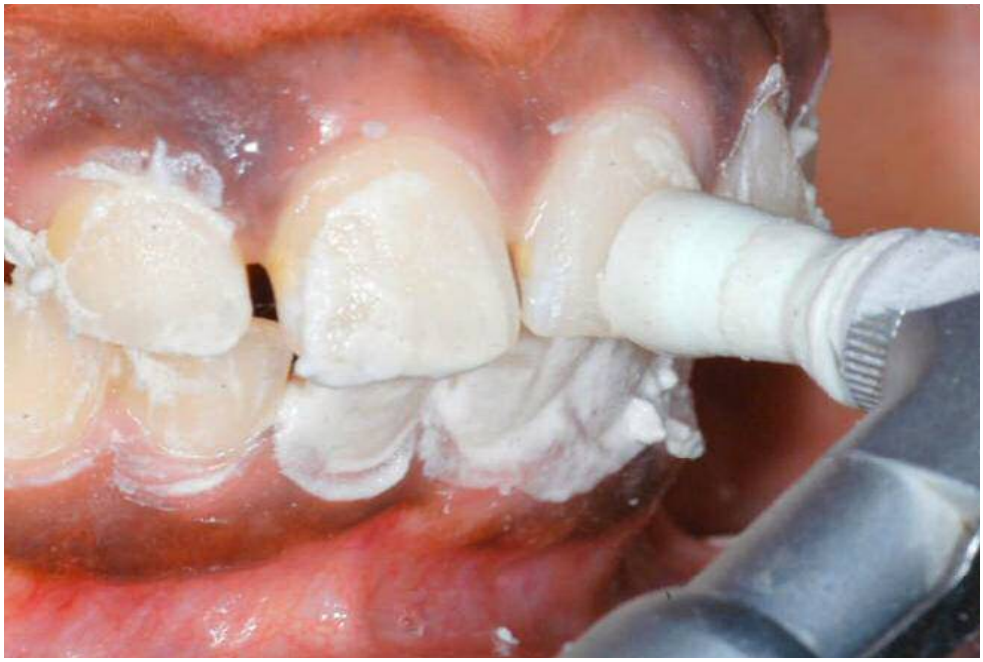


FIGURE 13: Pumice prophylaxis

FIGURE 14: 37% phosphoric acid etching for 30 seconds

FIGURE 15: Etched enamel

FIGURE 16: Thermoformed Transfer tray placed in the patient mouth

FIGURE 17: After tray removal

FIGURE 18: Completion of direct bonding in the remaning quadrants

RESULTS

A total of 30 patients were included in this study (18 females, 12 males, mean age 21.73 years, range 15 -28 years). A total of 518 brackets,out of which 256 were placed using direct bondingtechnique and 262 were placed using indirect bonding technique.

Parameters assessed for bond failure are

1.Overall bond failure rate between direct & indirect bonding

2. Bond Failure rate of anterior brackets between direct & indirect

3.Bond Failure rate of posterior brackets between direct & indirect

4.Bond Failure rate of individual tooth .

Since the data were paired from contra-lateral quadrants from each patients and the distribution was not normal, statistical analysis involved the use of the Z-test. A **Z-test** is any statistical test for which the distribution of the test statistic under the null hypothesis can be approximated by a normal distribution. Because of the central limit theorem, many test statistics are approximately normally distributed for large samples.

For comparing two groups results (failure or success outcomes), the Z proportion test was used. P values were calculated using standard normal probability distribution functions and used to reject or accept the hypothesis of equality in proportions of two independent groups.

Null Hypothesis: There is no significant difference between direct and indirect bonding technique in term's of bond failure.

Overall failure rate:

A total of 50 brackets were debonded from both groups(9.6% failure rate) over observation period of 6 months . Of the brackets placed with direct bonding technique, 27 brackets debonded (10.5% failure rate), whereas 23 brackets debonded (8.8% failure rate) when using indirect bonding technique (Table 1).

The **Z-Score** was 0.681 and the **p-value** was 0.4965. Since p value was greater than 0.05, **the null hypothesis was accepted**. The result was that there was no statistically significant($p > 0.05$) difference between direct and indirect bonding technique in-terms of bond failure rate. The proportion of failed brackets for direct bonding is 0.105. The proportion for indirect bonding is 0.088 and both proportions were equal.

Bond failure rate for anteriors & posterior brackets:

In the **anterior teeth**, 19 brackets failed (10.8% failure rate) with direct bonding technique and 11 brackets failed (6.2% failure rate) with indirect bonding technique. In the **posterior teeth,** 8 brackets failed (9.8% failure rate) with direct bonding technique and 12 brackets failed (14.4% failure rate) with indirect bonding technique(Table 2).

Anterior:

The **Z-Score** was 1.592. The **p-value** was 0.11184. Since p value was greater than 0.05, **the null hypothesis was accepted**. The result was not significant at < 0.05. The proportion of failed brackets for direct bonding is 0.109 .The proportion for indirect bonding is 0.061 and both proportions were equal.

Posterior:

The **Z-Score** was -0.896. The **p-value** was 0.36812. Since p value was greater than 0.05, **the null hypothesis was accepted**. The result was not significant at < 0.05. The proportion of failed brackets for direct bonding is 0.099. The proportion for indirect bonding is 0.145 and both proportions were equal.

Failure rate for individual tooth:

Individual tooth failure rate showed, in direct bonding technique mandibular centrals had highest failure rate of 20 % followed by maxillary canine of 16.6% , whereas in indirect bonding technique, mandibular 2nd premolars had highest failure rate of 18.8% followed by mandibular 1st premolar & maxillary 2nd premolar of 16.6% respectively.(Table 3)

Since p value was greater than 0.05 for all the individual tooth, the null hypothesis was accepted. The result was not significant at < 0.05.

TABLE 1

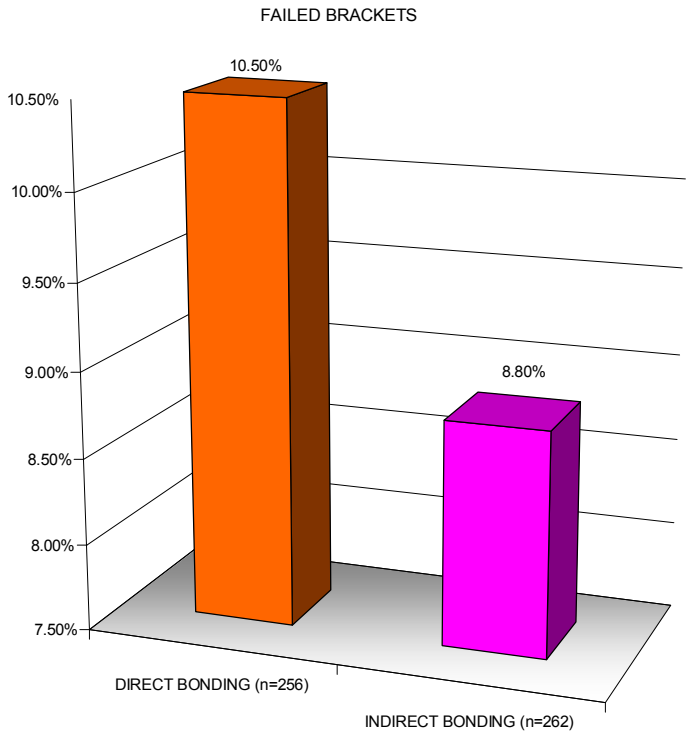
TECHNIQUE	BRACKETS(n)	FAILED BRACKETS	FAILURE (%)	Z-TEST
DIRECT BONDING	256	27	10.5%	**Z-score= 0.681**
INDIRECT BONDING	262	23	8.8%	**P = 0.4965(>0.05)**
OVERALL	518	50	9.6%	

TABLE 2

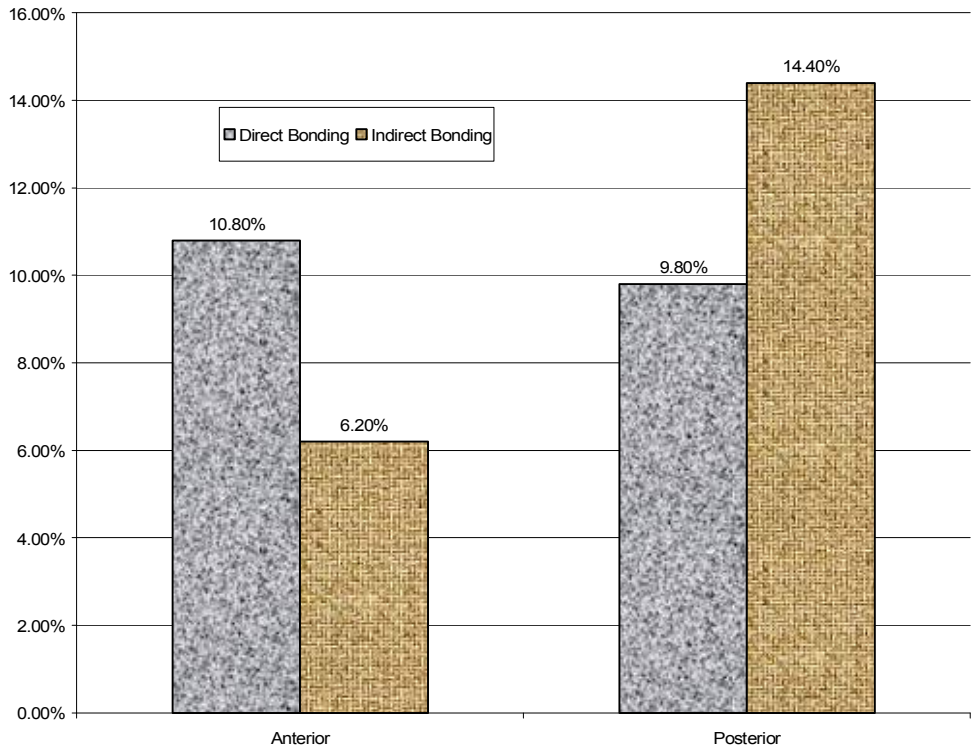
	DIRECT BONDING		INDIRECT BONDING	
	ANTERIOR	**POSTERIOR**	**ANTERIOR**	**POSTERIOR**
BONDED (n)	175	81	179	83
FAILED BRACKETS	19	8	11	12
PERCENTAGE (%)	10.8 %	9.8 %	6.2%	14.4%

TABLE 3

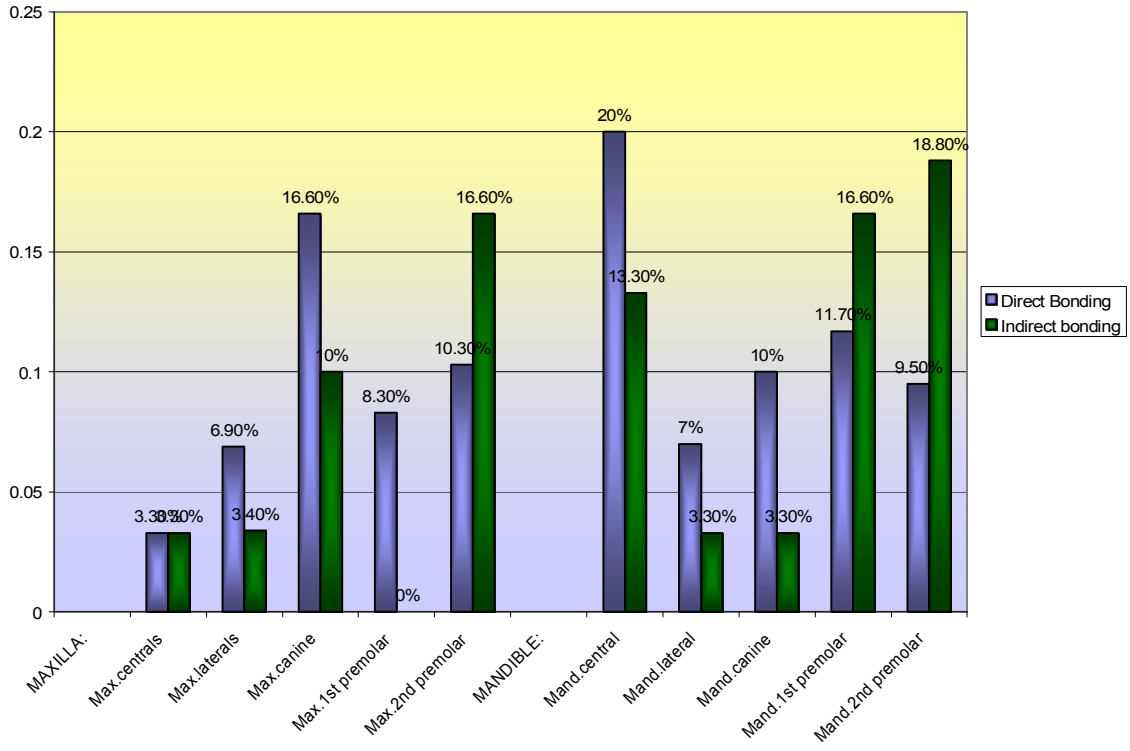
	DIRECT BONDING			INDIRECT BONDING			
	BONDED	FAILED	(%)	BONDED	FAILED	(%)	SIGNIFICANCE
MAXILLA:							
Max.centrals	**30**	**1**	**3.3%**	**30**	**1**	**3.3%**	**Z-Score= 0 p-value= 1**
Max.laterals	**29**	**2**	**6.9%**	**29**	**1**	**3.4%**	**Z-Score=0.593 p-value=0.5552**
Max.canine	**30**	**5**	**16.6%**	**30**	**3**	**10%**	**Z-score=0.76 p-value=0.4472**
Max.1st premolar	**12**	**1**	**8.3%**	**13**	**0**	**0%**	**Z-score=1.062 p-value=0.2891**
Max.2nd premolar	**29**	**3**	**10.3%**	**30**	**5**	**16.6%**	**Z-score=0.709 p-value=0.4777**
MANDIBLE:							
Mand.central	**30**	**6**	**20%**	**30**	**4**	**13.3%**	**Z-score=0.693 p-value=0.4902**
Mand.lateral	**28**	**2**	**7%**	**30**	**1**	**3.3%**	**Z-score=0.655 p-value=0.5157**
Mand.canine	**30**	**3**	**10%**	**30**	**1**	**3.3%**	**Z-score=1.035 p-value=0.2983**
Mand.1st premolar	**17**	**2**	**11.7%**	**18**	**3**	**16.6%**	**Z-score=0.414 p-value=0.6818**
Mand.2nd premolar	**21**	**2**	**9.5%**	**22**	**4**	**18.8%**	**Z-score=0.819 p-value=0.4122**



Graph 1



Graph 2


0.25
0.2
0.15
0.1
0.05
0
20%
18.80%
16.60%
16.60%
16.60%
13.30%
11.70%
10%
10.30%
10%
9.50%
8.30%
7%
6.90%
3.40%
3.30%
3.30%
Direct Bonding
Indirect bonding
MAXILLA:
Max.centrals
Max.laterals
Max.canine
Max.1st premolar
Max.2nd premolar
MANDIBLE:
Mand.central
Mand.lateral
Mand.canine
Mand.1st premolar
Mand.2nd premolar

Graph 3

DISCUSSION

Bonding of orthodontic attachments may be accomplished either through direct bonding method or indirect bonding methods[51]. The advent of direct bonding and the light-cured resins like Transbond XT light cure adhesive improved the working time available, permitting significant latitude in bracket positioning before curing[6]. Direct bonding is far more common than indirect bonding. However, achieving an accurate and consistent bracket position on the posterior teeth continues a problem because of poor access. A significantly superior, efficient and effective indirect bonding procedures has been developed which has greater accuracy in bracket placement also reduced the chair time for the operator and the patient[6,13,24].

In addition to being a highly technique- sensitive procedure, indirect bonding has two significant disadvantages. Firstly, the occlusogingival insertion of a transfer tray causes the adhesive coated brackets to scrape along the long axis of each tooth, resulting in more uneven distribution of adhesive compared with perpendicular placement of direct bonding. Secondly, when opaque transfer trays were used, the putty covering the palatal surfaces prevent light curing from the palatal or occlusal side[1].

In this study, both the direct and the indirect bonding technique were used for all 30 patients using the split mouth design [2,5,16,18,29,46] to eliminate the bias between the right and left side and also between upper and lower as well, using light cured adhesive. Also to eliminate the bias that may be introduced from the clinician being right-handed [29]. The split mouth technique can equate any variability between the right and left quadrants. Force of

mastication and hygiene effectiveness can vary from the left side to the right side , and these variables could affect bracket failure[2,46].

Visible light–activated bonding systems seems to be an improved over autopolymerizing resins because of their "on-command" curing, which allows more accurate bracket placement, and their unlimited working time. With autopolymerizing systems, it is difficult to remove flash once curing has begun and failure to remove excess material predispose the patient to decalcification and periodontal problems[5]. **Andrew L.Sonis[5] (1988)** reported 4.5% bond failure rate with light cure adhesive and 7.7% bond failure rate with autopolymerizing system with no significant difference. **Hugo R.Armas Galindo et al.,[29](1998)** reported that the failure rate of light cured composite was 11.3% and that of chemical cured was 12% with no significant difference.

The conventional halogen curing unit was used in this study as supported by **Ari Y.Krug et al.,[7](2005)** where by concluding that orthodontic brackets can be bonded with either conventional halogen light or high speed curing units (LED, Plasma arc) without compromising clinical bond strength and bond survival rate. **Nikolaos S.Koupis et al.,[57](2008)** suggested that failure rate of 3.3% with halogen curing compared with 5% in LED with no significant difference. **Bruno Manzo et al.,[16] (2004)** reported that there was no significant difference in bond survival rate between the plasma arc and the conventional halogen curing unit.

The transfer tray used for indirect bonding was a single 2mm soft clear vacuum formed thermoplastic sheet[24.54,67,68]. Light intensity is inversely proportional to the square of the distance from the light source. The dual trays used in previous studies[7,19,23,31,34,64] for

indirect bonding not only increase the distance between the light and bracket, but may act as a filter to reduce the light intensity[7]. If a light cured adhesive is used with a tray technique, the tray has to be transparent enough to allow light transmission[45].

Arndt Klocke et al.,[10](2003) in his study, he conclude that the original Thomas indirect bonding technique and the modified Thomas technique of indirect bonding using polysiloxane tray material result similar bond strength and the survival rate. **Kalange[33] (2007)** described a method of indirect bonding using a opaque silicone transfer tray and chemical cure sealant where light cure cannot be used since the opaque transfer tray limit the light to penetrate for curing.

Alastair Gardner et al.,[3](2001) found that the 37% phosphoric acid with the application time of 30 seconds was optimum than 2.5% nitric acid for any application time. **Alan P.Kinch et al.,[2](1988)** suggested that a 37% phosphoric acid at 15-seconds etch time be adequate for routine clinical use.

This study suggests that the indirect bonding protocol using a light cured adhesive and primer can provide similar bond failure rate even less **(8.8 %)** as direct bonding(**10.5%**) using similar adhesive, with statistically no significant difference($p>0.05$). Bond failure rate below 10% are generally considered to be clinically acceptable as suggest by **Julio Pedra et al[35] (2005).** This is similar to the result obtained by **Michael J.Aquirre et al.,[44](1982)** where the failure rate for indirect bonding was 4.5% and for direct bonding was 5.3% . **Thiyagarajah et al.,[80] (2006)** did a similar study and reported that bond failure rate of 2.2% for indirect bonding technique and 2.9% for direct bonding technique with no significant difference. This also correlate with the previous study done by **Brandon James Linn et**

al(2006), where he compared the direct and two indirect bonding methods for the bond strength and the bond survival rate and conclude that the light cured indirect bonding provides similar bond strength and survival rate as direct bonding method than the chemical cured indirect bonding methods [15].

Failure rate of visible light cured adhesive using direct bonding technique was 10.5% in this study and was similar to the study by **Hugo R.Armas Galindo et al [29](1998)** where he obtained about 11.3% failure rate using direct light cured bonding system.The failure rate of brackets gives no indication of the time of failure. Therefore, the time distribution of the bond failure rate was uniform throughout the study.

Gia K.Yi, et al [27] suggest that the indirect bonding of APC brackets using light cure adhesive provide similar bond strength to that the direct bonding of APC brackets and conclude that there was no difference between the two technique whether they were bonded with the direct or indirect technique.

In this study, we also found that anteriors bonded indirectly has less bond failure rate(6.2%) than the anteriors (10.8%) bonded directly. The difference was not statistically significant in our study. But this increase in bond failure for direct bonding technique may be due to the amount of anterior discrepancy like crowding and rotation in the anteriors at the start of the treatment[57]. Also as suggested by **Alan P.Kinch et al.,[2] (1988)** bond failure was related to tooth position within the arch.

Bond failure for posteriors suggest that the indirect bonding technique has more bond failure rate (14.4%) than the direct bonding technique (9.8%). The difference was not statistically significant. The reason for increase in the bond failure rate in posteriors for indirect bonding technique was suggested to be the bracket debonding during the transfer tray removal as the tray removal was difficult in posteriors and also because of the capillary pressure built between the transfer tray and the teeth, the seepage of saliva below the tray increased the salivary contamination of the etched tooth surface before light curing of the brackets.

Knoll et al [28] (1986) conclude that the weak link in the posterior teeth was caused by bracket design and variation in resin thickness beneath the brackets [14,28] and also greater masticatory forces ranged above 30 Kg in the posterior when compared to 13 to 15 Kg in the anterior. **McKay(1988)** has investigated the effect of adhesive thickness on the bond strength and concluded that increasing the thickness of adhesive upto 0.5mm had no significant effect on the bond strength [14]

Individual tooth bond failure rate showed, in direct bonding of brackets, mandibular centrals had highest failure rate of 20% and this greater loss from centrals may reflect the former's more prominent position in relation to trauma and also was attributable to occlusal forces, particularly where the overbite is increased. This was similar to the study by **Alan P.Kinch[2](1988)** where he reported that the bond failure in the lower anterior was due to occlusal force and trauma. Whereas in indirect bonding of brackets the mandibular second premolar showed higher bond failure rate of 18.8% followed by mandibular first premolars and maxillary second premolar with bond failure rate of 16.6% and this greater loss from

posteriors in indirect bonding technique may be attributed to the fact that often these teeth were partially erupted when bonded so that it was more difficult to prevent contamination of the etched surface by gingival fluid seepage as suggested by **Zachrisson[93] (1997).** In addition the larger amount of aprismatic enamel on premolars as suggested by **Lovius and associates[2](1987)** and increased labial curvature on premolars may affect the quality of the micromechanical bond on the premolar teeth[2,14,16,50].

In this bond failure study, debonding of brackets were observed during transfer tray removal as the operator error, brackets failed also due to occlusal interferences because of masticatory load in the posterior brackets and during tooth brushing as heard from the patient. Further studies has to be to be done to rule out these etiological factors to reduce the bond failure rate and obtaining better results with both the technique.

SUMMARY AND CONCLUSION

An in-vivo study was carried out in 30 patients using split mouth design to evaluate the bond failure rate between direct bonding technique and an indirect bonding using modified Thomas technique for a period of 6 months. All the patients were selected under inclusion criteria for standardization. Light cure adhesive(Transbond XT- 3M Unitek) was used for both the technique. The transfer tray for indirect bonding used was 2mm thick soft clear vacuum formed thermoplastic sheet, which allow the use of light cure adhesive. The light cured custom bases were formed for indirect bonding brackets and were cleaned using methyl methacylate monomer. Over six months period, the bond failure rate for direct bonding technique was 10.5% whereas for indirect bonding technique was 8.8%. The statistical analysis between direct and indirect bonding technique showed no significant difference($p>0.05$) between the two technique as observed in other studies. Thus this modified Thomas indirect bonding technique using Transbond XT(3M Unitek) light cure adhesive and 2mm soft thermoplastic transfer tray was simple, easy to use, economic, more précised bracket position with reduced clinical chair time without compromising the bond survival and accuracy. Additionally, indirect bonding technique required additional set of model for the laboratory procedure and more time consuming for tray fabrication than the direct bonding technique which require less time and cost effective.

Hence by concluding this study, both the direct as well as the indirect bonding technique using light cured adhesive had enough bond survival rate with no significant difference and either of the technique can be followed clinically depends on the operators interest.

BIBLIOGRAPHY

1. **Akhter Husain, Tariq Ansari, Rohan mascaenhas, Sandeep Shetty.** A New Approach toIndirect Bonding. J Clin Orthd 2009;43:652-654.

2.**Alan P. Kinc, Helen Taylor, Rosie Warltier, Richard G. Oliver, and Robert G. Newcombe**. A clinical trial comparing the failure rates of directly bonded brackets using etch times of 15 or 60 seconds. Am J Orthod 1988; 94:476-483.

3**. Alastair gardner, Morth, Ross Hobson.** Variation in acid –etch patterns with different acids and etch times. Am J Orthod 2001;120:1: 64-67.

4. **Alpern MC, Primus C, Alpern AH.** The AccuBond system for indirect orthodontic bonding. J Clin Orthod. 2009; 43: 572-576.

5. **Andrew L.Sonis.** Comparison of light cured system with an auto polymerizing system. J Clin Orthod 1988 ; 22: 730-732.

6. **Anoop Sondhi.** Efficient and effective indirect bonding. Am J Orthod 1999;115: 352-359.

7. **Ariy Krug, R.Scott Conley**. Shear Bond Strengths Using an Indirect Technique with Different Light Sources.J Clin Orthod 2005;39:485-487.

8. **Arndt Klocke , Drazen Tadic , Farhad Vaziri, and Bärbel Kahl-Nieke** . Custom Base Preaging in Indirect Bonding. Angle Orthod 2004;74;106-111.

9. **Arndt Klocke , Jianmin Shi , Bärbel Kahl-Nieke, and Ulrich Bismayer**. In Vitro Evaluation of a Moisture-Active Adhesive for Indirect Bonding . Angle Orthod 2003;6;697-701.

10. **Arndt Klocke, shi, Kahl -Nieke B.** Bond strength with custom base indirect bonding techniques. Angle Orthod 2004;4:176-180 .

11. **Arndt Klocke, shi, Kahl -Nieke B, Ulrich B.** In vitro investigation of indirect bonding with a hydrophobic primer. Angle Orthod 2003; 73:445-450.

12**. Arturo fortini, Fabio Giuntoli, Lorenzo Franchi.** A Simplified Indirect bonding technique. J Clinical Orthod 2007 ;41:11: 680-683.

13. **Bon Chan Koo, Chun-Hsi Chung, Robert L. Vanarsdall**. Comparison of the accuracy of bracket placement between direct and indirect bonding techniques. Am J Orthod 1999;116;3;346-351

14**. G. Bradburn and N. Pender.** An in Vitro study of bond strength of 2 light cured composites used in the direct bonding of orthodontic brackets. Am J Orthod 1992;102: 418-426.

15**. Brandon James Linn.** A comparison of bond strength between direct & indirect bonding methods. Angle Orthod 2006;76:289–294

16**. Bruno Manzo, Giuseppe Liistro, Hugo De Clerck**. Clinical trial comparing plasma arc and conventional halogen curing lights for orthodontic bonding. Am J Orhtod 2004; 125;2;30-35

17. **Christiana Gioka, Christoph Bourauel, Anastasia Hiskia, Dimitris Kletsas, Theodore Eliades, and George Eliades, Bonn, Germany, and Athens and Thessaloniki, Greece**. Light-cured or chemically cured orthodontic adhesive resins? A selection based on the degree of cure, monomer leaching, and cytotoxicity . Am J Orthod 2005;127;4;413

18. **Chun-His-Chung, Annalisa Piatti.** Clinical Comparison of the Bond Failure Rates Between Fluoride- Releasing and Non-Fluoride-Releasing Composite Resins. J Clin Orthod 2000; 34:7:409-412.

19. **Echarri P, Kim T.** Double transfer trays for indirect bonding. J Clin Orthod,2004; 1:8-13.

20. **Elliot Silverman and Morten Cohen.** A report on major improvement in the indirect bonding technique. J Clin Orthod 1975 ;9: 270-276.

21. **Elliot Silverman and Morten Cohen**. The twenty minute full strap up. J Clin Orthod 1976 ;10: 764-768.

22. **Elliot Silverman , Cohen M , Gianelly A , Dietz V S .** A universal direct bonding system for both metal and plastic brackets . Am J Orthod 1972; 62 : 236 – 244

23. **Fabio Ciuffolo,,Nicola Tenisci,and Luca Pollutri.** Modified bonding technique for a standardized and effective indirect bonding procedure. Am J Orthod 2011;141:504-509

24. **Farhad Moshiri,Michael D. Hayward.** Improved Laboratory Procedure For Indirect Bonding. J Clin Orthod 1979; 13:7:472-473.

25. **Felipe de Assis Ribeiro Carvalho, Rhita C. Almeida, Marco Antonio Almeida, Lucia H.S. Cevidanes,and Marcia C. Amorim M. Leite** .Efficiency of light-emitting diode and halogen units in reducing residual monomers.Am J Orthod 2010;138:617- 622

26. **K.H. Fried and G.V. Newman** .Indirect Bonding With a No-Mix Adhesive .J Clin Orthod 1983; 17:6:414-417.

27**. Gia K Yi, William J Dunn, Louis J Taloumis.** Shear bond strength comparison between direct and indirect bonded orthodontic brackets- Am J Orthod 2003;124;5;577-581

28**. Gwinnet, Wolff and Knoll**. Shear strength of brackets bonded to anterior and posterior teeth. Am J Orthod 1986 ;89: 476-479

29**. Hugo. R. Armas, Lionel Sadowsky, Christos Vlachos, Alex Jacobson and Dennis Wallace.** An in vivo comparison between a visible light cured bonding system and a chemically cured bonding system. Am J Orthod 1998 ; 113: 271-276.

30**. Jacob Daub, Berzins DW, Linn BJ, Bradley TG.** Bond strength between direct & indirect bonded brackets after thermocycling. Angle Orthod. 2006 ;76:2:295-300.

31. **Jay Collins.** A Precise and Predictable Laboratory Procedure for Indirect Bonding . J Clinic Orthod. 2000 ;34:12:702-706.

32.**Jing Yi - Shian, Stephen Rassmussen.** Bond strength of age composites found in brackets placed by an indirect technique. Angle Orthod 1993; 3: 213 -220

33. **John T. Kalange.** Prescription-based precision full arch indirect bonding. Semin Orthod 2007;13: 19-42.

34. **John. H. Hickam.** Predictable indirect bonding. J Clin Orthod 1993; 27: 215- 217.

35**. Julio Pedra E Cal-Neto, Jose Augusto Mendes Miguel**. In Vivo Evaluation of Bond Failure Rates with Hydrophilic and Self-Etching Primer Systems. J Clin Orthod 2005; 39:701

36. **Larry James Evans, Charles Peters, Craig Flickinger, Louis Taloumis, William Dunn** A comparison of shear bond strengths of orthodontic brackets using various light sources, light guides, and cure times. Am J Orthod 2002;121;5;510-515

37**. Larry. W. White,** An Expedited Indirect Bonding Technique. J.Clin Orthod 2001;35:1:36-41.

38. **Larry. W. White.** New and improved indirect bonding technique . J Clin Orthod 1999. 33:17-23

39**. L. R. Legler, H. Retief,E. L. Bradley. R. Denys, and P. L. Sadowsky, Birmingham, Ala.** Effects of phosphoric acid concentration and etch duration on the shear bond strength of an orthodontic bonding resin to enamel-An in vitro study. Am J Orthod 1989 ;96:6:485-492.

40**. Leonard Gorelick, Arnold M. Geiger, and A. John Gwinnett Stony Brook and New York, N. Y-** Implications of the failure rates of bonded brackets and eyelets: A clinical study. Am J Orthod 1984 ;86:5:403-406.

41. **Maria Francesca Sfondrini, Vittorio Cacciafesta, Andrea Scribante, Catherine Klersy** Plasma arc versus halogen light curing of orthodontic brackets: a 12-month clinical study of bond failures. Am J Orthod 2004;125;3;342-347

42. **Mark Joiner.** In house precision bracket placement with the indirect bonding technique. Am J Orthod 2010; 137:6:850-854.

43. **Matthew Gaworski, Martin Weinstein, Alan J. Borislow, Leonard E. Braitman** Decalcification and bond failure: A comparison of a glass ionomer and a compositeresin bonding system in vivo- Am J Orthod 1999;116;5:518-521

44.**Michael Aguirre, Gregory King and Joseph Waldron.** Assessment of bracket placement and bond strength when comparing direct bonding to indirect bonding techniques. Am J Orthod 1982 ; 82: 269-276.

45**.Michael J.F.Read, Andrew I.Pearson.** A Method for Light-Cured Indirect Bonding. J Clin Orthod 1998;32:8: 502-504.

46**. Michael D. Signorelli, Elizabeth Kao, Peter W. Ngan, Marcia A. Gladwin.** Comparison of bond strength between orthodontic brackets bonded with halogen and plasma arc curing lights: An in-vitro and in-vivo study-Am J Orthod 2006;129; 2:277-282

47**. Michael D.Simmons**. Improved Laboratory Procedure For Indirect Bonding Of Attachments. J Clin Orthod 1978;12:4:300.

48**.Miles Pg,Weyant Rj.** A clinical comparison of two chemically cured adhesives used for indirect bonding. J Ortho 2003 30:331-336.

49**. Miles PG.** Indirect bonding with a flowable light-cured adhesive. J Clin Orthod 2002; 11:646-647.

50**. D.T. Millett , A. Hallgren , D. Cattanach, R. McFadzea, J. Pattison, M. Robertson and J. Love .** A 5-year clinical review of bond failure with a light-cured resin adhesive.

Angle Orthod 1998;4:351-356.

51**. Milne, Andreasen and Jacobsen.** Bond strength companson, simplified indirect techniques vs. direct placement of brackets. Am J Orthod 1989 ; 86: 8-15.

52. **Moin and Dogon.** Indirect bonding of orthodontic attachments. Am J Orthod 1977; 72: 261-275.

53**. Mona E. McAlarney, DEngSc, and Peter Brenn .**A modified direct technique versus conventional direct placement of brackets: In vitro bond strength comparison. Am J Orthod 1993 ; 104:6:575-583.

54. **Myrberge and Warner.** Indirect bonding technique. J Clin Orthod 1982;16:269 -272.

55. **Nabeel F. Talic.** Effect of fluoridated paste on the failure rate of precoated brackets bonded with self-etching primer: A prospective split-mouth study. Am J Orthod 2011;140:527-530

56**. Nadja.K.S.Hildebrand, Raboud, Heo, Nelson and Paul major.** Argon laser Vs Conventional visible light cured orthodontic bracket bonding. Am J Orthod 2007;131:530-536.

57**. Nikolaos S. Koupis, Theodore Eliades, and Athanasios E. Athanasiou.** Clinical Evaluation of Bracket Bonding Using Two Different Polymerization Sources. Angle Orthod 2008;78;5: 922-925

58. **Nikolaos Pandis, Argyro Polychronopoulou, Theodore Eliades.** Failure rate of self ligating and edgewise brackets bonded with conventional acid etching and a self ething primer- an invivo study. Angle Orthod 2006;76:119-122.

59. **Nir Shpack, Silvia Geron, Ioannis Floris, Moshe Davidovitch, Tamar Brosh, and Alexander Dan Vardimon** .Bracket Placement in Lingual vs Labial Systems and Direct vs Indirect Bonding. Angle Orthod 2007;77;3:509-517

60**. K. D. O'Brien, M. J. F. Read, R. J. Sandison, and C. T. Roberts, and Aberdeen.** A visible light-activated direct-bonding material: An in vivo comparative study-Am J Orthod 1989 ;95:4:348-351.

61. **Omur Polat DDS, Ali Ihya Karaman DDS, MS, PhD, and Tamer Buyukyilmaz DDS, MS-**In Vitro Evaluation of Shear Bond Strengths and In Vivo Analysis of Bond Survival of Indirect-Bonding Resins. Angle Orthod 2004;74;3:405-409.

62**. Paul.M.Kasrovi, Sherin Timmins and Ansheng Shen.** A New approach to indirect bonding using light cure composite. Am J Orthod 1997;111:652-656.

63. **Peter G. Miles and Robert J. Weyant**. A Comparison of Two Indirect Bonding Adhesives. Angle Orthod 2005 75 ;6:1019-1023.

64. **Peter G. Miles.** Indirect Bonding with a Flowable Light-Cured Adhesive .J Clin Orthod 2002; 36:646 - 647.

65. **Philip T. Dickinson, D.D.S., M.S., and John M. Powers, Ph.D. Ann Arbor, Mich.** Evaluation of fourteen direct-bonding orthodontic bases .Am J Ortho 1980;78:6:630-639.

66. **Phu T Le, Martin Weinstein, Alan J Borislow, Leonard E Braitman**. Bond failure and decalcification: a comparison of a cyanoacrylate and a composite resin bonding system in vivo. Am J Orthod 2003;123; 6:624-627.

67.**Rajagopal, Venkatesan, Gnanashanmughan, Harish Babu.**.A New Indirect Bonding Technique. J Clin Orthod 2004;38:600-602

68**. M. J. F. Read, and K. D. O'Brien.** A clinical trial of an indirect bonding technique with a visible light-cured adhesive.Am J Orthod 1990; 98:3:259-262.

69. **Richard A. Hocevar, , and Howard F. Vincent, Gainesville. Fla** Indirect versus direct bonding: Bond strength and failure location . Am J Ortho 1988; 94:5:367-371.

70**. Robert. P. Scholz.** Indirect bonding revisited. J Clin Orthod 1983 ; 17: 529-536.

71**. Rognvald A. Linklater, Peter H. Gordon-** Bond failure patterns in vivo. Am J Orthod 2003; 123; 5:534-539

72. **Ronald. B. Cooper and Nile. A.** Sorenson. Indirect bonding with adhesives precoated brackets. J Clin Orthod 1993 ; 27: 163-167

73. **Ross S. Hobson, John F. McCabe, Andrew J. Rugg-Gunn.** The relationship between acid-etch patterns and bond survival in vivo. Am J Orthod 2002;121;5:502-509

74. **Royce G. Thomas.** Indirect Bonding / Simplicity in Action . J Clin Orthod 1979; 13:2:93-102

75. **Samir E. Bishara, Marc E. Olsen,, Paul Damon, and Jane R. Jakobsen.** Evaluation of a new light-cured orthodontic bonding adhesive . Am J Orthod 1998 ;114:80-87.

76. **Scott M.Peterson, James L.Drummond, Carla A.Evans, Ellen A. Begole.** Comparison of Bond Strengths Using Different Curing Lights. J Clin Orthod 2006;40:309-313

77.**Sidney Brand, Servoss, Joseph Wolfson .** Practical methods of Bonding Direct and Indirect . J Clin Orthod 1975;9:10:610-635.

78. **Steven J. Lindauer, Henry Browning, Bhavna Shroff, , Frank Marshall, Ralph H. B.Anderson, and Peter C. Moon, Richmond**- Effect of pumice prophylaxis on the bond strength of orthodontic brackets . Am J Orthod 1997 ;111:599-605.

79. **Stephen J. Reichheld, Robert A.Ritucci, Anthony A.Gianelly -**An Indirect Bonding Technique. J Clin Orthod 1990;24:1:21-24.

80. **S. Thiyagarajah, D. J. Spary, W. P. Rock.** A clinical comparison of bracket bond failures in association with direct and indirect bonding . J. Orthod 2006; 33;3: 198-204.

81**. S. Thomas Deahl, Norman Salome, John P. Hatch, and John D. Rugh**. Practice-based comparison of direct and indirect bonding. Am J Orthod 2007;132:738-42.

82**. L. M. Trimpeneers and L. R. Dermaut.** A clinical trial comparing the failure rate of 2 orthodontic bonding systems. Am J Orthod 1996 ; 110: 547-550

83.**Ulf Adolfsson, Erik Larsson, Björn Ögaard** - Bond failure of a no-mix adhesive during orthodontic treatment - Am J Orthod 2002;122;3:277-281

84. **Vetea G. Miklus, Jean-Paul Alibert, Shane N.White.** A Cutting-Wire System for Removal of Indirect Bonding Trays. J Clin Orthod 2005;39:706-709.

85. **Wei Nan Weng, Chiang Meng.** A study of bond strength between light cured and self cured resins. Am J Orthod 1992 ; 101: 350

86. **Wei Nan Wang, and Tz Chau Lu**. Bond strength with various etching times on young permanent teeth . Am J Orthod 1991 ;100: 72-79.

87.**Wei Nan Wang, Ching Lin Yeh, Ber duen Fang.** Effects of H_3PO_4 concentration on bond strength. Angle Orthod 1994;64:377-382.

88. **William Layman, Tatsuki Koyam**. A Clinical Comparison of LED and Halogen Curing Units. J Clin Orthod 2004;38;385-387

89. **Wolfgang Carstensen .** Clinical effects of reduction of acid concentration on direct bonding of brackets.Angle Orthod 1993;3:221-224

90.**Wolfgang Carstensen, Schleswig .** Clinical results after direct bonding of brackets using shorter etching times . Am J Orthod 1986 ;89:70-72.

91.**Yasser Lotfy Abdelnaby and Essam Al-Wakeel.** Effects of early orthodontic force on shear bond strength of orthodontic brackets bonded with different adhesive system. Am J Orthod 2010;138:208-214.

92.**Yinzhong Duan, Xuepeng Chen, Junjie Wu.** Clinical Comparison of Bond Failures Using Different Enamel Preparations of Severely Fluorotic Teeth. J Clin Orthod 2006;40:152-154.

93**. Zachrisson and Brobakken.** Clinical comparison of direct vs. indirect bonding with different bracket types and adhesives. Am J Orthod 1978; 74: 62-78.