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Orthodontic Bracket Holders and Techniques: A Review

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Abstract **Background:** The correct positioning of brackets in the orthodontic field is a crucial step in orthodontic treatment. Various methods, including both direct and indirect approaches, are currently employed to achieve precise bracket placements. Each method has its own set of advantages and disadvantages in terms of accuracy and treatment duration. This study introduces a review of the previous researchers work in the field of different bracket placements techniques. **Results:** In comparison with direct bonding (16 mins and 47 secs), computer-aided indirect bonding required much less time in the clinical chair to bond half of a mouth (12 mins and 52 secs). Nevertheless, the overall bonding time (28 mins and 14 secs) for indirect bonding turned out to be longer than for direct bonding in a case when the time that is needed for digital bracket placement was taken into account. The direct bonding approach did not result in immediate debonding, while the indirect bonding approach resulted in the loss of 14 brackets (5.1%). Computer-aided indirect bonding has been shown to be more costly compared to the direct bonding after a cost-minimization analysis. **Conclusions:** Many papers are reviewed in bracket placement methods showing a strong need for a newly mechanism that has the feature of semi-automatic operations, that facilitates the time for treatment and in the same time reduce the cost and complexity of the treatment.

Key Words orthodontics, brackets, direct bonding, indirect bonding, semi-automatic, orthodontic mechanism

1. Introduction

Former researchers have done many scientific work in the field of orthodontics, regarding many aspects, like the bonding technique starting from the direct and indirect techniques, then moving to the aspect of the adhesive materials and fluids. Adhesive materials play a pivotal role in the field of orthodontics, providing a reliable means to attach orthodontic appliances to teeth surfaces. One widely used adhesive in orthodontics is the light-cured composite resin, characterized by its biocompatibility and ability to bond with enamel effectively. This material, which usually contains a blend of the inorganic fillers and resin monomers, is polymerized in the case of exposure to curing light, which forms an aesthetic and durable bond. One of the key references in orthodontic adhesives realm is the work that has been proposed by Brantley and Eliades, entitled as "Orthodontic Materials: Scientific and Clinical Aspects." This study had explored the scientific concepts that underly different orthodontic materials, which include adhesives, offering important information about their characteristics, compositions, and clinical applications. Adhesive materials had facilitated the attachment of the brackets as well as other orthodontic appliances in addition to contributing to increasing the efficiency of the treatment through minimizing the demineralization of the enamel as well as increasing patient comfort. With the continuous evolvement of the orthodontics, the ongoing researches and development of the adhesive materials are still highly important for the advancement of the results of treatment as well as patient satisfaction. The method of indirect bonding in the area of orthodontics emerged as one of the accurate and sophisticated methods for placing the orthodontic brackets on the teeth, offering advantages related to efficiency, accuracy, and patient comfort. This approach includes the creation of customized transfer tray precisely positioning the brackets on teeth before the adhesive application. One of key advantages related to the indirect bonding is that it is capable of addressing individual patient variations in the morphology of the teeth, leading to the minimization of bracket misplacement risks.

This process usually starts with fabricating patient-specific transfer tray based upon digital models that have been obtained from the traditional impressions or the intra-oral scans. The orthodontic brackets are after that accurately placed on tray, taking under consideration the unique anatomical features of every tooth. From the scientific point of view, researches like the one that had been proposed by Wiechmann et al., titled as the "Indirect bonding technique and transfer tray fabrication with 3-D printed model," had explored the efficacy of 3-D printing in creating precise transfer trays for the indirect bonding. This study had looked into technological advancements contributing to indirect bonding process precision and efficiency. The method of indirect bonding had resulted in enhancing the orthodontic brackets' placement accuracy, while reducing chairside time throughout the process of bonding. Through streamlining the process and reducing the need for manual adjustments of the brackets, this method plays a role in the improvement of the results of treatment and the increase of patient satisfaction. This technique represents one of the fundamental aspects of modern orthodontics, which had resulted in the facilitation of the precise orthodontic bracket attachment onto the surfaces of teeth directly. This approach involves applying adhesive to the teeth directly, followed by bracket placement on adhesive-coated surfaces. The method of direct bonding is utilized commonly as a result of its effectiveness, simplicity, and ability to accomplish precise placement of the bracket. A study that had been carried out by Zachrisson et al., with the title "Improving the Bond between Metal and Enamel" had explored the advancements in the adhesive materials and methods that are related to the direct bonding. This study investigates bond strength and durability of different adhesive systems, which had contributed important information about the enhancement of direct bonding method effectiveness. This technique relies upon meticulous tooth surface preparation by the etching, cleaning, and application of a bonding agent prior to attaching the brackets. The process of etching creates micro-mechanical retention on the surface of enamel, ensuring strong bond between the tooth and the adhesive. Once the brackets are positioned, a curing light lead to the activation of adhesive, securing the brackets in its place firmly. One direct bonding benefits is its capability of addressing individual tooth features, providing a customized method to the bracket placement. This method also minimizes any needs for auxiliary devices such as the transfer trays, decreasing the chairside time and increasing the overall efficiency of treatment.

2. Materials and Methods

The exploration of pertinent articles in the peer-reviewed publications has been carried out by comprehensive searches on recent studies, which have been supplemented by the utilization of the Google Scholar search engine. The inclusion criteria encompassed articles published exclusively in the English language within the timeframe spanning from 1982 to 2023. In instances where recent literature on a specific subject was limited, older articles were incorporated either as foundational references, providing historical and background information on the discussed materials, or to elucidate the consistency observed between more recent and earlier test results. To ensure comprehensiveness, the reference lists of the identified studies were meticulously examined, thereby minimizing the potential oversight of any relevant research. This rigorous search methodology was employed to guarantee the thorough acquisition of scholarly articles and to establish a robust foundation for the synthesis of information in the scientific paper.

A. Literature Review

Many researchers were reviewed in this paper regarding in different aspects, these aspects are:

B. Indirect Bonding

In this aspect of indirect bonding, in [1]an extensive explanation of indirect bonding technique using an adhesive that cures with visible light is provided. The benefits include the simplicity and speed with which many brackets can be applied at predetermined points. The approach's focus is on the binding between adhesive material and bracket base, with the goal of strengthening it. Another notable advantage of this method is the simple removal of both brackets and post-treatment materials. This method moves the weaker bond to tooth-to-material interface, which has important ramifications, particularly when removing brackets. When debonding, certain methods leave a significant amount of material on enamel surface and cause less to stick to the bracket. In cases of substantially loaded composites, the extraction regarding such composite material might present difficulties for the patient as well as the operator, lengthening the time required for cleanup and raising the possibility of potential enamel damage.

In the case of indirectly bonded brackets, a majority of the composite material typically stays connected to the bracket base. On the other hand, in the case when deboned, directly bonded brackets leave most of the composite on the tooth surface and only a little amount on the bracket base. The indirect bonding technique often leaves the majority of the material on bracket base, with the remaining material on the tooth consisting of a small, readily detachable unfilled resin circle around the edges. By doing so, a considerable block of material could be extracted without using tungsten carbide burs, manual tools, or rotary instruments, which cuts down on the amount of time needed to clean the enamel surface. This presents a notable advantage, as the risk of damaging the bracket base is lower, allowing for potential recycling of more brackets. The failure rates of bonds formed through the indirect technique are comparable to those achieved with the material for direct bonding, highlighting the overall effectiveness of this method.

On the other hand, in [2] a specialized resin has been developed for the indirect bonding technique, addressing previous issues associated with indirect bonding systems. Using resins intended for direct bonding was partly blamed for these difficulties. The article describes a methodical approach to constructing bonding trays and provides a step-by-step guide for indirect bonding.

Acknowledging the necessity for the bonding materials that have been designed expressly for the indirect bonding in healthcare environments, 3M Unitek and others have collaborated to build a unique resin. This material is prepared with many goals in mind. The viscosity of the filled resin was improved through adding a fine particle fumed silica filler (about 5%) for ensuring that it can tolerate minor defects in the fit of a custom base against the enamel as well as custom base that is made from light-cured adhesive. This modification is important because bracket drift may result from an unfilled resin since it is less viscous. Moreover, the resin has 30-second quick set time that cuts down on the amount of time needed for securing the bonding tray greatly. The resin completes its curing process in a mere two minutes, making the bonding tray removal rather quick. The fact that this resin is specifically made for indirect bonding and is unsuitable for direct bonding should not be overlooked is significant.

After multiple clinical studies, it was determined that a quick, easy, and straightforward way to prepare a custom resin base, especially with APC brackets, is by employing a light-cured resin. Individual brackets don't need being sorted or having resin applied to base prior to being placed on the model, which reduces contamination and lab time. Transbond XT is suggested as the best material to prepare resin bases when APC brackets are not used. In order to create the custom base for indirect bonding method, the practitioner currently utilizes the new indirect resin in conjunction with the APC brackets or Transbond XT adhesive applied in the lab. Using such indirect bondingadhesive in the treatment of over 500 patients has consistently showed an effective bonding procedure, with sporadic bond failures often attributed to contamination or poor method. Resolution in these cases is simple: just section the bonding tray, re-apply adhesive, and reposition brackets. Tests on the resin's bond strength have validated its efficacy; the results show that it is as strong as other resins that are frequently used in indirect bonding. Notably, this resin's improved clinical efficacy is attributed to its increased binding strength at the 5-minute mark.

C. Bracket Positioning

Orthodontists strive for precise bracket placement for achieving optimal occlusion when it comes to bracket positioning [3]. Errors in bracket positioning might occur during the first appliance placement process, in spite of the type of bonding technique used. Throughout treatment, clinicians rectify such errors, making any necessary corrections or adjusting the archwire to make up for misaligned brackets. Clinicians should evaluate bracket positioning as soon as possible using radiography and clinical assessments, and they should correct any problems during a separate reset appointment. A five-step procedure for identifying and fixing bracket positioning issues is described in this article. Step 1; Initial Bracket Positioning. Make sure the bracket base is in line with the contour of the tooth's surface. If required, enhance or flatten the bracket base's concavity to fit particular teeth. The smooth flow of adhesive throughout installation depends on an optimal base shape. Incomplete bracket seating, on the other hand, might cause undesirable rotations even with an optimal base contour. Step2; Primary Expression of Bracket Position and Prescription Completely realize the prescription and orientation of the bracket after initial placement by carefully leveling and aligning. Before the reset evaluation, make sure a full-sized wire is fully seated in every bracket slot. The bracket prescription and position might just be partially reflected by using a smaller wire. Choose a wire that fits properly, and give it four to eight weeks to take on the shape and positioning of bracket. Step 3; Rest Evaluation. The reset assessment, which usually takes place within the first six months of active therapy, consists of a clinical examination and a root-paralleling radiography series. Step 4; Reset Appointment. Plan the reset session to provide enough time for de-bonding, bracket preparation, rebonding, tooth preparation, and re-banding, as determined by the reset evaluation. Make sure you give this appointment at least an hour. Step5; Secondary Expression and Finishing. Utilizing the guidelines provided in step 2, manifest the new bracket positions following the reset appointment. It usually takes six to eight weeks to realize secondary expression. After secondary expression, make sure root alignment is attained by introducing an adjustable wire for the finishing process. Apply the selected finishing techniques to wrap up the treatment.

D. The effect of Temperature

The research conducted examined how temperature affected the mechanical behavior regarding archwires. The purpose of the study presented in [4] is to examine and contrast the properties of conventionally utilized initial archwires as well as heat-activated initial archwires at various temperature degrees. To do this, load/deflection graphs will be made, and 3 parameters that characterize discharge plateau period will be evaluated. We procured 48 archwires from seven different manufacturers, whose cross-sectional sizes ranged between 0.010 inches and 0.016 inches. Three equivalent samples of every type of archwire underwent a modified 3-point wire-bending test at 55°C and 5°C, which replicated the temperature range in which an inserted archwire would come into contact with hot or cold drinks throughout a meal. Every resulting load/deflection curve's plateau portion has been located, and the average value of each one of the parameters for every wire type has been computed. At 55°C, every tested wire showed persistent strain. In the case when tested at both 55°C and 5°C, significant statistical differences have been found for the three parameters analyzed for almost all of the wires. At a temperature of 55°C, the loads were greater than at 5oC. Heat-activated archwires were found to exhibit differences from the typical ones, including shorter plateaus at 5oC, longer plateaus at 55oC, and lighter mean forces at those two temperature degrees. At both temperatures, the mean force increased proportionately with increasing diameter. Whether heat-activated or not, all of the nickel-titanium wires showed significant temperature-related variations in force and behavior. Permanent strain was the outcome of elevated temperatures, whereas residual strain that was noted at lower temperatures might be regained as the temperature

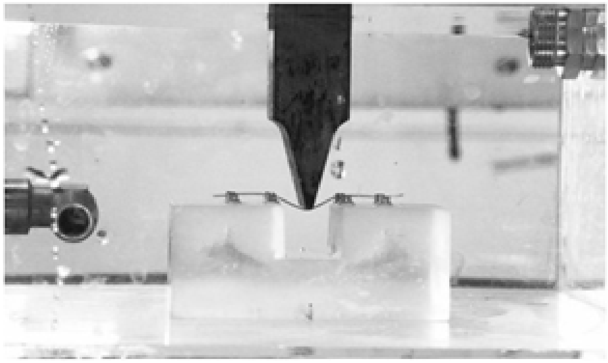

Figure 1: Deflection, with 1-mm blade, of mounted archwire, kept in a water bath [9]

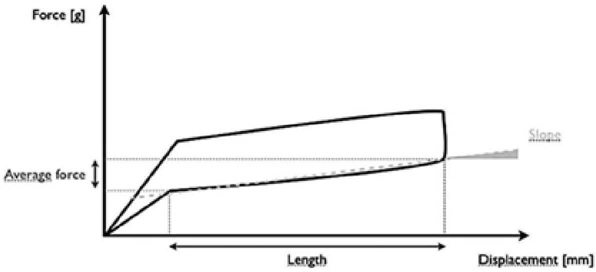

Figure 2: Isolation of discharge plateau and 3 parameters taken under consideration, which are: mean force, length, and slopebath [9]

rose. Figure 1 illustrates the mounting process, while Figure 2 shows the isolation of discharge plateau, taking into account 3 parameters, which: mean force, slope, and length.

E. Computer Aided Bonding

Regarding [5], for comparing bracket bonding times between computer-aided direct and indirect approaches, a randomized controlled trial has been started. In addition, the research sought to evaluate immediate bracket debondings and carry out a cost-minimization analysis. Individuals have been divided into 2 groups at random with the use of a split-mouth design. Group 1 experienced direct bonding in one quadrant and indirect bonding in the lower left and upper right. Group 2 proceeded in the opposite manner. The secondary outcome concentrated on immediate bracket debondings, the primary outcome had examined the difference in bonding time. The amount of time that has been spent on indirect bonding was tracked throughout the clinical bonding process as well as the placement of digital brackets. Statistical tests such as Friedman's ANOVA and Chi-square have been employed for analysis, and the assessment was conducted in a blinded manner. An analysis of cost minimization has been carried out. Following exclusions, a total of 37 individuals were randomized, with 15 placed in Group 1 and 12 in Group 2. In comparison to direct bonding (16mins 47secs), computer-aided indirect bonding (12 mins 52 secs) required a significantly lower clinical chair time to bond half of a mouth ($P < 0.001$). Nevertheless, the overall bonding time (28 mins 14 secs) for indirect bonding has been greater than that of direct bonding ($P < 0.001$) when the time for the installation of the digital bracket was taken into account. With the direct bonding approach, there has not been any instant debonding; however, with the indirect bonding approach, 14 brackets have been lost (5.1%) ($P = 0.0001$). Computer-aided indirect bonding has been found to be more costly when compared to the direct bonding by means of a cost-minimization analysis. Conclusion: Compared to direct bonding, the total bonding time, such as digital bracket installation, has been longer with computer-aided indirect bonding; however, clinical chair time has been much shorter. With computer-aided indirect bonding, immediate debondings were much higher. Consequently, it turned out that computer-aided indirect bonding has been more costly when compared to the direct bonding in these circumstances. Separate projected appliances in an indirect bonding tray are shown in Figure 3.

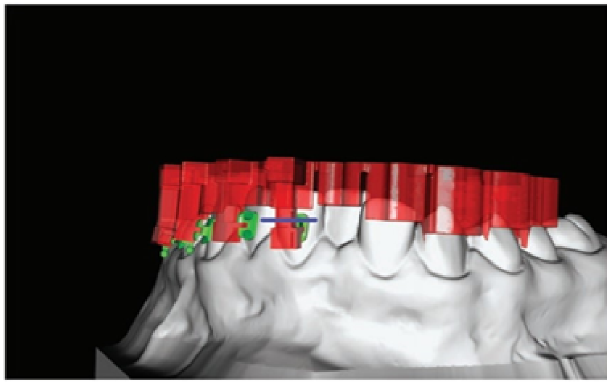

Figure 3: Individually projected appliances (IPA) indirect bonding tray from the DDP-Ortho (v1.6_2917, Czestochowa, Poland). Please note that the jigs don't cover brackets, allowing the operator to easily remove the excess of the composite prior to the light-curing. The blue line indicates the place where jigs have been sectioned with carbide bur prior to the removal [8]

This clinical investigation, which includes control and randomization, is the first attempt to assess the bonding times, bracket failures that occur right away, and cost-effectiveness of CAD/CAM indirect bonding vs traditional direct bonding of the brackets in a context of available data. Compared to conventional direct bonding, the research showed a significant decrease in clinical chair time with CAD/CAM indirect bonding. When put to comparison with the direct bonding method, CAD/CAM indirect bonding chair time was, on average, four minutes shorter per half mouth. In particular, direct bonding took 16 mins and 47 secs for the same area, but indirect bonding took an average of 12 mins and 52 secs for half a mouth. Those results are consistent with previous studies; Aguirre et al., for instance, found that indirect bonding took 24 mins and 30 secs, while direct bonding of an entire mouth took 42 mins and 18 secs [6]. An average chair time of 13 mins and 8 secs [7] for indirect bonding of the entire mouth. This could be clinically significant, particularly in a busy orthodontic practice, since it could save up to 8 minutes each patient, or one-third of the bonding time for a full arch when utilizing CAD/CAM. Orthodontists might be able to see more patients each day as a result of this time savings. Furthermore, in situations where bonding may be done by dental assistants, assigning indirect bonding to several patients each day can save a significant amount of time and provide orthodontists greater flexibility in how they spend their time without sacrificing the accuracy of bracket positioning.

F. Bracket Bond Failures

[8], in this prospective randomized controlled trial, which was carried out at two centers, a single clinician fitted brackets to 33 consecutive patients with varying malocclusions who were between the ages of 12 and 15. The procedures were started between April 2002 and March 2003, and the participants have been chosen from waiting lists at Good Hope Hospital, Sutton Coldfield, and Birmingham Dental Hospital. Consent was given by all possible participants, who included individuals in need of orthodontic treatment with complete lower and upper edgewise appliances that had already been modified. The teeth that were going to be bonded had to be free of any indications of cavities, substantial restorations, fluorosis, hypoplasia, or anomalies in the morphology of the crown that would affect the bonding of the bracket. The number of the teeth that are needed in order to demonstrate statistically significant differences between indirect and direct bond failures has been utilized in order to calculate the sample size. With the use of data from two previous studies with a comparable design, this calculation which used the nQueryH software estimated the probability of bracket failure in indirectly and directly bound groups to be 0.107 and 0.033, respectively. A 2-group continuity-corrected chi-square test with an odds ratio of 3.511, at a significance level of $P<0.05$ and a power of 90% suggested a sample size of 271 teeth in each group, even though the final analysis has been based upon quadrants within individuals due to the limited data meeting all criteria for comparison.

At the record collection time, subjects who have met the criteria of inclusion have been enrolled and given sequential numbers. The participant flow through each study stage is illustrated by a CONSORT diagram (Figure 4). With the use of randomization table, one of 2 split-mouth designs was randomly allocated (Figure 5).

For every tooth, the suitable pre-adjusted edgewise bracket (MBTTM Versatile z Bracket System) has been chosen. At the base of every bracket, a little quantity of 3 M Unitek laboratory adhesive has been placed. After that, every bracket has been fitted over its corresponding tooth, and before moving on to the next stage, the adhesive has been left to dry for at least 1 hr.

Drufolen WTM transparent tray material, with a thickness

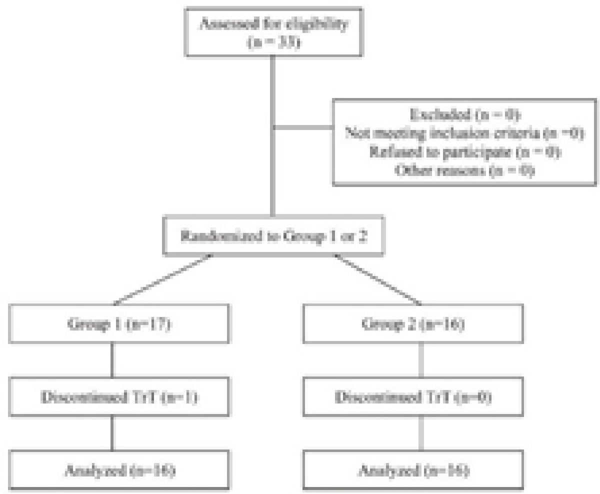

Figure 4: A CONSORT diagram depicting the flow of the participants through every trial stage [11]

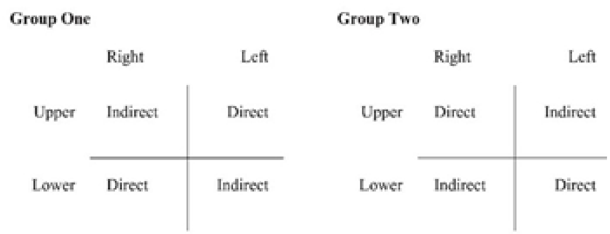

Figure 5: Random allocation into one of two split-mouth designs [11]

of 0.45 mm, was used to produce trays. The material's transparency made it possible to employ light curing, which improved control over the working time. A circular blank has been placed on top of the brackets and a dry model. The blank has been heated before being carefully fitted to the model with the use of a vacuum forming device (DrufomatTM; Figure 6) and negative pressure created. After it had cooled, Drufolen was cut with a hot tool and the brackets inside of it was taken out of the model. For the purpose of facilitating removal from mouth, the tray has been finally cut close to gingival edges of the teeth. Two vertical slits have then been made from the tray's edge to each bracket's mesial as well as distal gingival wings (Figure 7).

G. Time Length

Regarding the time length, [9], the purpose of this work was to compare how long laboratory (IBB) as well as clinical steps (DBB and IBB) took for indirect bracket bonding (IBB) and direct bracket bonding (DBB) procedures. Furthermore, following a 24-week follow-up, the prevalence of loose brackets has been evaluated. For this study, 17 individuals in need of orthodontic treatment were chosen, 7 males and 10 women, with an average age of 21. 304 brackets in all (153 IBB and 151 DBB) were used. The same type of bracket and

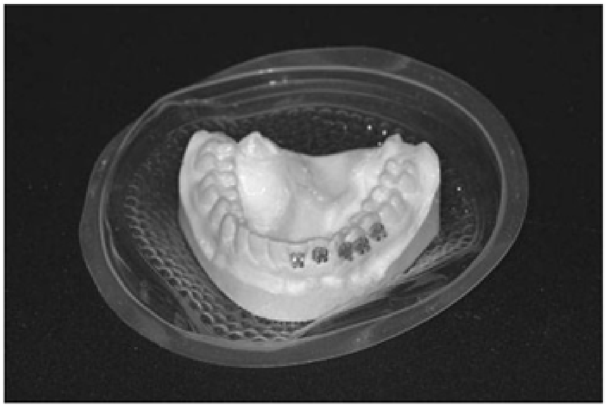

Figure 6: A tray blank adapted to a model [11]

Figure 7: A completed tray [11]

bonding material were given to the two groups. Wilcoxon non-parametric test has been used in order to statistically analyze data at the 5% significance level. When taking into account the total time, it was shown that the IBB method required more time compared to the DBB ($p < 0.001$). But if we just consider the clinical stage, IBB took less time compared to DBB ($p < 0.001$). Between the clinical process for DBB and the laboratory bracket positioning for IBB, there has been no statistically significant difference ($p = 0.910$) in the time of the two sessions. Moreover, there was no difference in the two groups' occurrence of loose brackets. Using the same bonding procedure as on the model, a slightly fluid hot melt adhesive has been applied to every bracket and vestibular surface of each tooth to construct the transferring tray (see Figure 8a and b). In order to generate a harder and less flexible tray, more adhesive was applied to incisal and occlusal surfaces of teeth after bonding tooth number 21 to number 25 and tooth number 31 to number 35. Additionally, TL3, or the time spent on upper and lower transferring trays, has been measured and recorded for the fabrication of transferring trays. The casts were hydrated for a minute to remove the silicone adhesive (also known as hot melt glue) after it had set. The IBB approach's laboratory stage was then finished when the brackets have been moved by utilizing transferring trays. The overall laboratory time (TLt - total laboratory time for maxilla and mandible) was calculated as follows: TLt = TL1 + TL2 + TL3. This included the time that has been spent on bracket bonding and the construction/cleaning of transferring trays. The upper and lower left side underwent the IBB approach, whereas the right side has been assigned to DBB (refer to Figure 8c). The process was timed in accordance with the manufacturer's recommendations after prophylaxis (with pumice and a rubber tip) and enamel etching with 37% phosphoric acid (RMO). This was because the initial step took about the same amount of time for both methods. For bonding, Mono Lock 2 (RMO®), a self-curing resin (paste + liquid – No Mix), was selected. For the purpose of maintaining the physical and chemical characteristics of adhesive system, etched teeth and transferring trays have been dried during IBB. The enamel was then treated with the bonding material's liquid activator, and the brackets were inserted into the transferring tray. The bracket mesh position at the patient's hemiarch was then covered with resin (paste). The Wilcoxon test revealed a significant difference ($p < 0.001$) between the groups when comparing the total time that has been spent on the two jaws for DBB (TCDt) and IBB (TLt+TCIt). This suggests that DBB was less time-consuming than IBB (Table 1). But in the case when the clinical step was the only thing considered, there has also been a statistically significant difference ($p < 0.001$) in the time required, with IBB (TCIt) taking less time than DBB (TCDt) (Table 2). The time spent on the laboratory bracket positioning (TPBt = TL1+TL2) and the clinical step with IBB (TCIt) compared with the clinical time with DBB (TCDt) did not differ significantly ($p = 0.910$) (Table 3). Following bracket bonding in the two jaws utilizing the IBB and DBB techniques, all patients underwent a 24-week follow-up to look for any potential loose brackets. Three hundred and fifty brackets were placed in all; fifty-one were placed using DBB technique (in the maxilla and mandible, for example), and fifty-three were placed using the IBB method (in the maxilla and mandible, for example). Ultimately, 18 brackets were removed, or 5.92% of the total (Table 4). With 4 detachments in the upper arch (1 for the DBB and 3 for the IBB) and 14 occurrences in the lower arch (6 for the DBB and 8 for the IBB), the maxilla had fewer loose brackets (22.22%) than mandible (77.78%).

H. CAD/CAM Intervention

[10], the first straight-wire appliance has been developed more than 40 years ago with the goal of improving the effectiveness and consistency of orthodontic treatment. Customized orthodontic appliances have recently been produced with using computer-aided design and computer-aided manufacture (CAD/CAM) technologies. Compared with indirectly and directly bonded stock orthodontic brackets, the purpose of this research has been to evaluate clinical efficacy and efficiency of CAD/CAM customized orthodontic appliances. Three treatment groups participated in this retrospective study: patients in group 1 underwent direct

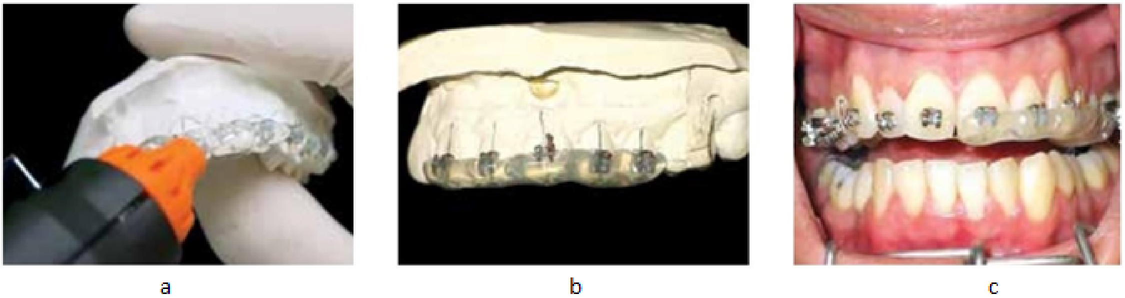

Figure 8: (from left to right) a- Fabrication of transferring tray, b-Transferring trays with ideal thickness and dimension, c– Example of brackets that have been bonded with the use of the DBB and IBB techniques in maxilla [5]

Time	n	Mean±SD	Minimum	Maximum	Median
IBB (TLt+TClt)	17	1167,20±239,39	961	1913	1092,00
DBB (TCDt)	17	892,73±116,21	646	1057	914,00
Time in second					

Table 1: Total time spent with IBB (TLt+TCIt) and DBB (TCDt), in both arches. Time in seconds [5]

Time	n	Mean±SD	Minimum	Maximum	Median
IBB (TClt)	17	380,13±47,59	315	489	376,00
DBB (TCDt)	17	892,73±116,21	646	1057	914,00
Time in second					

Table 2: Total time spent with IBB (TLt+TCIt) and DBB (TCDt) in both arches, for clinical steps [5]

Time	n	Mean±SD	Minimum	Maximum	Median
IBB(TPBt+TClt)	17	885,87±149,31	720	1296	842,00
DBB(TCDt)	17	892,73±116,21	646	1057	914,00
Time in second					

Table 3: Total time spent for laboratorial and clinical steps with IBB (TPBt+TCIt) and DBB (TCDt). Time in seconds [5]

		Months						
Technique	tooth	1	2	3	4	5	6	Detachment
IBB	25							0
	24					1		1
	23					1		1
	22							0
	21			1				1
DBB	11							0
	12					1		1
	13							0
	14							0
	15							0
IBB	35	1						1
	34	1						1
	33	2						2
	32	1						1
	31	2	1					3
DBB	41				1			1
	42			1				1
	43	2						2
	44							0
	45				1		1	2
Detach		9	1	2	2	3	1	18

Table 4: Distribution of the total number of loose brackets in maxilla and mandible regarding time and teeth. Time in seconds [5]

	n	Median age(y)	Females(n)	Males(n)
Group 1	31	13.58	15	16
Group 2	33	13.92	17	16
Group 3	32	13.42	17	15
The Kruskal-Wallis test showed no significant difference between the groups(P=0.251)				

Table 5: Sample demographic data

	0% (min)	25%	50%	75%	100%(max)	Mean	SD	P value
ABO DI								0.56
Group 1	2	12	15	19	44	16.0	9.1	
Group 2	4	12	14	19	40	15.9	8.1	
Group 3	5	13	17	20	33	16.8	6.5	
ABO CRE								0.13
Group 1	15	21.5	28	34.5	47	28.5	8.5	
Group 2	18	26	34	37	52	32.3	7.8	
Group 3	17	26.5	34	39	49	32.2	9.3	
Treatment time(mo)								<0.00 1
Group 1	12	19	22	25	33	21.9	5.0	
Group 2	9	15	18	19	30	16.9	4.1	
Group 3	8	11	13	17	21	13.8	3.4	
Treatment appointmen ts(n)								0.02
Group 1	10	14	16	19	28	16.5	4.0	
Group 2	9	12	14	18	25	14.9	3.7	
Group 3	8	11	13	17	23	14.1	3.9	
Statistical significance was set at P <0.05 ABO DI, American Board of Orthodontics Discrepancy Index ABO CRE , American Board of Orthodontics Cast –Radiograph Evaluation								

Table 6: ABO discrepancy index and treatment outcomes

comparisons	Observed difference	Critical difference	difference
Group 1-2	12.21	16.93	Not significant
Group 1-3	19.74	16.93	Significant
Group 2-3	7.53	16.93	Not significant
Statistical differences for number of appointments between the groups. The level for critical difference was set at 16.93			

Table 7: Multiple comparisons test of treatment appointments

comparisons	Observed difference	Critical difference	difference
Group 1-2	21.53	16.93	Significant
Group 1-3	40.15	16.93	Significant
Group 2-3	8.62	16.93	Significant
Statistical differences for appointments intervals between the groups. The level for critical difference was set at 16.93			

Table 8: Multiple comparisons test of appointment intervals

bonding with self-ligating appliances, patients in group 2 underwent indirect bonding with self-ligating appliances, and patients in group3 underwent indirect bonding with CAD/CAM self-ligating appliances. For every individual, thorough pretreatment and posttreatment documentation was obtained. Pretreatment records have been evaluated with the use of American Board of Orthodontics (ABO) Discrepancy Index, and posttreatment results have been examined with ABO Cast-Radiograph Evaluation. Every step of the data gathering and analysis was done by one evaluator. Between the three groups, there have not been any statistically significant differences in ABO Cast-Radiograph Evaluation or ABO Discrepancy Index. CAD/CAM group experienced the shortest treatment time of 13.80 $\pm$ 3.40 months, while the directly bonded group had a period of 21.9 $\pm$ 5.0 months and the indirectly bonded group had a duration of 16.9 $\pm$ 4.1 months. Nonetheless, there was a large variation in treatment durations. Also, in comparison to the directly bonded group, CAD/CAM group needed significantly fewer treatment appointments. The Univ. of North Carolina at Chapel Hill's institutional review board gave its approval for this retrospective study. Patients treated by a private orthodontist from Mar. 2008 to Aug. 2013 were included in the study. For comprehensive patients during this time, the practitioner used 3 different protocols of bonding that did not overlap: group1 was bonded directly with self-ligating appliances (Damon Q; Ormco, Orange, Calif.); group2 was bonded indirectly with self-ligating appliances (Damon Q; Ormco) from 2010 to 2011; and group3 was bonded indirectly with CAD/CAM self-ligating appliances (Insignia SL; Ormco) from 2011 to 2013. Within such three groups, patients were sequentially treated and were selected according to predetermined standards. Pre- and post-treatment digital casts, post-treatment panoramic radiographs, pre-treatment cephalometric radiographs, using complete maxillary as well as mandibular fixed appliances, and treatment involving only intraoral, inter-arch or intra-arch mechanics were among the inclusion criteria. Functional appliances, extractions, growth modification, temporary skeletal anchorate, impacted teeth (save for 3rd molars), and orthognathic surgery were all considered exclusion criteria. Incomplete pre- or post-treatment data as well as those needing post-orthodontic restorative care were also disqualified.

Group1 had 31 patients, Group2 included 33 patients, and Group3 included 32 patients after eligible participants were subjected to inclusion and exclusion criteria. To reduce the possibility of learning curve effects from a novel treatment regimen, patients were sequentially selected for study inclusion from the middle range of every treatment group's patient list. The study participants' demographic data included their gender and age at the start of treatment. The number of treatment appointments (covering bonding, adjustments to the archwire, emergencies, and debonding) as well as the length of treatment in months, as well as pre- and post-treatment eModel digital casts (GeoDigm Corp., Falcon Height, Minn.) and initial and final clinical photographs and cephalometric and final panoramic radiographs, were among the treatment-related data. Except in situations when long wires coming out of molar tubes have been clipped, emergencies have been regarded as appointments if brackets have been modified or wires were replaced. Overbite, overjet, and crowding digital measures were validated, however occlusal contacts, buccolingual inclination, and marginal ridge were not. As a result, post-treatment digital models have been produced with the use of a three-dimensional printer (iPro8000; 3-D Systems, Rockhill, SC) after being converted from eModel's proprietary software file format to stereolithography file.

In order to blind the evaluator (M.W.B.) throughout data scoring and analyses, a research assistant randomly allocated codes to each individual and set of treatment data. eModel's software analysis program has been utilized in order to apply ABO Discrepancy Index to pretreatment digital casts by assessing first cephalometric radiographs. Each subject's orthodontic problems were ranked according to their relative severity using this index. To objectively measure the treatment outcome for each patient, final panoramic radiographs as well as stereolithography posttreatment models were evaluated with the use of ABO Cast-Radiograph Evaluation. The evaluator performed all of the measurements as well as case analyses prior to data collection, and he received training and calibration forABO Discrepancy Index and ABO Cast-Radiograph Evaluation procedures. In order to evaluate intraexaminer reliability, ten randomly chosen participants had a repeat administration of ABO Discrepancy Index and Cast-Radiograph Evaluation one week following the conclusion of data collection. ABO Discrepancy Index as well as ABO Cast-Radiograph Evaluation scores had intra-class correlation coefficient values of 0.95 and 0.91, respectively, indicating nearly perfect correlations and proving the lead investigator's dependability and consistency with the assessment methods. For groups 1, 2, and 3, the corresponding median ages at the start of treatment have been 13.58, 13.92, and 13.42 years (see Table (2.7)). The groups' median ages did not differ significantly from one another (P = 0.252). There were 16 males and 15 females in group 1, 17 females and 16 males in group2, and 15 males and 17 females in group 3. Table2.7 shows the composition of these groups. Table (2.8) shows that the ABO Discrepancy Index values for groups 1 and 2 were 16.0 $\pm$ 9.1, 15.9 $\pm$ 8.1, and 16.8 $\pm$ 6.5, respectively. P = 0.56 indicates that those differences have been not been statistically significant. In terms of efficacy, group 1's final ABO Cast-Radiograph Evaluation scores were 28.5 $\pm$ 8.5, group 2's scores were 32.30 $\pm$ 7.80, and group 3's scores have been 32.20 $\pm$ 9.30 Table (2.8). Between the 3 treatment groups, there was no statistically significant difference (P = 0.13). Moreover, no statistically significant variation has been observed between the groups in any of the 8 categories that make up ABO Cast-Radiograph Evaluation. Table 5 shows that there have been significant differences ($P < 0.05$) in the mean treatment times (months) between groups 1, 2, and 3. The differences were as follows: group 1, 21.90 $\pm$ 5; group2, 16.90 $\pm$ 4.10; and group 3, 13.80 $\pm$ 3.40. Table 6 shows that the groups' average treatment appointment counts were 16.5 $\pm$ 4.0, 14.9 $\pm$ 3.7, and 14.1 $\pm$ 3.9. There were no statistical differences between groups 1 and 2 or group 2 and group 3, but there has been a significant difference ($P < 0.05$) between groups 1 and 3. Table 7. Table 8 shows that the groups' appointment intervals varied as well (group 1, 1.10 months; group 2, 1.30 months; group 3, 1.40 months).

3. Conclusions

It was implied in this research and literature review that various aspects of the orthodontic field are affected by temperature and bonding time, that computer-aided design and manufacturing are used, that bracket positioning occurs, and that bonding method failures occur. Numerous reviews of articles in bracket placement strategies demonstrate the urgent need for a novel mechanism with semi-automatic operations that can shorten treatment times while also lowering costs and complexity.

Conflict of interest

The authors declare no conflict of interests. All authors read and approved final version of the paper.

Authors Contribution

All authors contributed equally in this paper.

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