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DEPENDABILITY OF A DIGITAL INDIRECT BONDING APPROACH USING E-MODELS AND TWO TRANSFER TRAYS

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Abstract

Introduction: *Orthodontics have been affected by digital technology, including diagnostic tools, treatment planning, appliance production, and 3D printing. To enable bracket arrangement more precisely and effectively, various CAD applications were available. Numerous research that examined the effectiveness and precision of the digital indirect bonding approach discovered that it is, overall, an effective solution. However, there was little investigation on the literatures regarding the external reliability of digital indirect bonding systems.* ***Aim of the study:*** *to assess digitally the amount of variation in bracket locations that occurred during their transfer using an indirect bonding tray within the patient's mouth, as well as the exterior accuracy of the measurements.*

Materials and methods: Ten patients—four men and six women—with ages ranging from 15.9 to 23.4 years (mean 19.647 years, SD 2.232) had their upper arches' PVS impressions taken, which were then scanned using a lab scanner to create STL files for use in digital models. 100 digital indirect bonds By placing brackets on digital models utilising Ortho Analyzer (3Shape) software, American Orthodontic minimaster braces were applied to the upper arch. After that, a double transfer tray will be built, loaded with braces, and printed in 3D to bond within the patient's mouth. Following that, the CEREC omnicam scanned the bonded brackets. The patient's mouth's bracket position deviations were measured using the Geomagic Control X software.

Results: From (-173.1131.65 µm) to (200.2132.86 µm), the total length of the linear measurements. These aberrations, which corresponded to the top right first premolars and upper left canines, respectively, were occlusogingival and in-out in nature. Overall angular readings ranged from 0.51 to 1.94 with a tolerance of 0.03 degrees. These deviations indicated the upper right canines and upper left central incisors, respectively, and were associated to the mesiodistal tip.

Discussion: The present study's overall angular differences varied from 0.51° to 1.94° and its overall linear differences ranged from 0.1731 mm to 0.2002 mm; these values coincided with those found in the literature, demonstrating the technique's dependability. **Conclusion:** The position of brackets on digital models can be accurately replicated by indirect bonding using a dual transfer tray.

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INTRODUCTION

Currently, the accuracy of bracket bonding is a key and difficult component to achieve successful and efficient orthodontic treatment outcomes. [1]. Therefore, even a small movement during bracket placement could cause all of the prescription data for the brackets to be translated incorrectly into the tooth structure. [2,3].

In order to achieve more exact and precise bracket insertion, the indirect bonding process has been devised. [4]. Indirect bonding has been researched over time to strengthen the bonding of fixed orthodontic equipment. [5]. The costs of taking and pouring the impression materials, the additional laboratory step, the requirement for trained laboratory staff, and the challenge of obtaining a suitable material to glue brackets over the cast were just a few of the many justifications provided by orthodontists for not using the indirect method, though. [6]. On the other hand, the lab method has been crucial in removing the effects of saliva, mental and physical stress brought on by extended patient chair time, and a compromised work area as a result of patients' tongues, lips, and cheeks. [7,8]. Additionally, it was fascinating that digital indirect bracket bonding eliminated most of the problems of traditional indirect bonding.

Zachrisson and Brobakken discovered that the following benefits made indirect bonding technique superior to direct bonding: (1) the bracket's base was situated nearer the tooth's structure., (2) superfluous adhesives around the bracket base are easily removed, and (3) The composite adhesives were widened to completely cover the bracket's contact surface. [9]. According to some writers, indirect bonding has additional benefits including less frequently needing compensatory wire bending and more patient satisfaction. [5,10,11]. Yildirimand and sanglam-Aydinatay discovered that both bonding strategies worked well. Indirect bonding, however, produced superior outcomes with aperfectly flat marginal ridges. [12].

As is well known, digital technology has permeated all aspects of orthodontics, including diagnostic tools, treatment planning, appliance production, and 3D printing. Botsford et al 2011 claimed that intraoral scanning-based virtual 3D occlusal records bite registration had clinically sufficient precision when gathering contact size and location. [13]. Additionally, advances in digital technology have made it possible to combine tomographic scan data with digital models to visualize dental roots in scanned casts and enable accurate bracket positioning. [14]. Virtual setup, printing of 3D models, and digital transfer trays for indirect bonding were all made possible by digital workflow using intraoral scanners and CAD-CAM software. [15,16,17]. There were numerous CAD applications that make bracket placement more effectively and precisely. Numerous studies have assessed the effectiveness and precision of the digital indirect bonding approach and determined that it is a generally effective strategy, including 3 shape, Maestero, Orthoselect, exceedortho, Sprintray, etc. [18,19]. However, there was little published research on the external validity of digital indirect bonding methods..

Materials and Methods

Ten patients were included in the study, with ages ranging from 15.9 to 23.4 years old (mean 19.647 years, SD 2.232), four male and six female patients. The study's inclusion criteria were as follows:

- **All permanent teeth have fully erupted.**
- **No congenital or developmental dental problems.**
- **No past extractions.**
- **No fillings or cavities on the face.Exclusion criteria was as follows**
- **Patients with medical or psychological restrictions were not included.**
- **Patients with severe gum disease or uncontrolled periodontal disease were not accepted.**
- **Poor dental health.**
- **Severe crowding of the labial segment.**

All eligible patients, together with their parents or legal guardians, had been informed of the study's purpose and given the opportunity to provide their informed permission. The following diagnostic records were completed for each of them once the chosen sample was resolved.:

- **Detailed history of dental and medical issues.**
- **Extensive clinical evaluation.**
- **Alginate imprints for the upper and lower dental arches were used to create study casts. Additionally, a plastic stock tray was used to take a Polyvinyl Siloxane (PVS) impression utilising a putty wash, two-step procedure, and a polyethylene spacer for the upper arch only. [20]. prior to above step by at least 30 min, comprehensive dental prophylaxis was conducted.**

The PVS imprint was immediately rinsed under running water until all organic components were fully dissolved. After that, it will be soaked in sodium hypochlorite (5.25%) diluted1:10, daily mixture for 10 minutes [21,22].

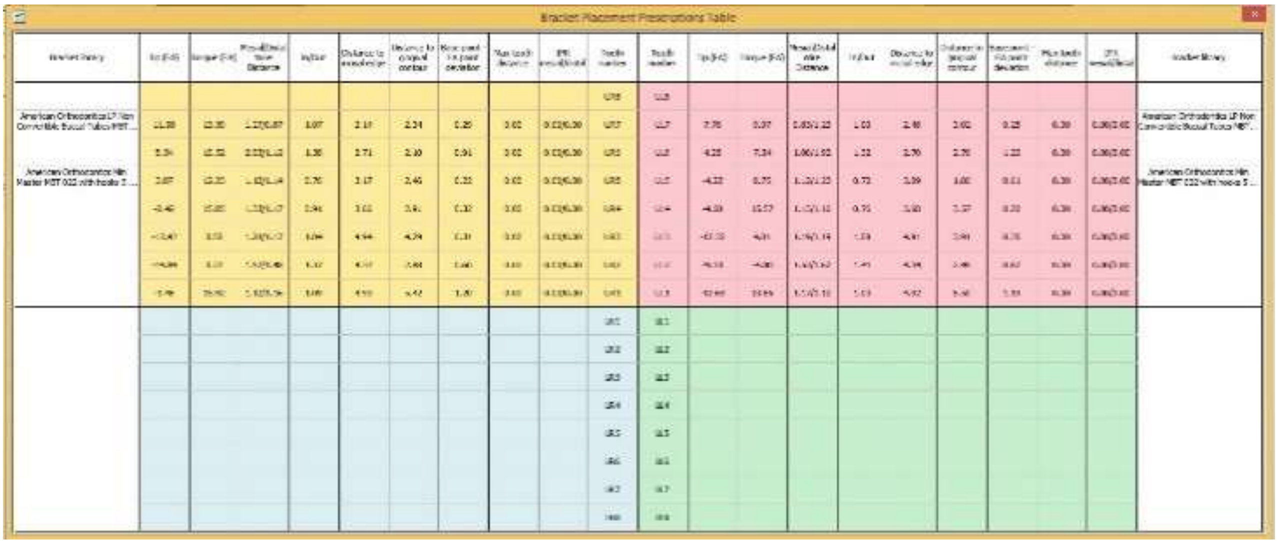
- **Photographs taken intra- and extra-oral.**
- **Radiographic Exam (Before and After Maxillary Posterior Segment Intrusion):**
- **Panorama radiographs**
- **Radiographs with lateral cephalometry.**

After cleaning the PVS impression for the upper arch, virtual data collecting began. Ten upper PVS impressions were optically 3D scanned with Desktop Scanner Activity 885 (Fig.1) (smart optics Sensortechnik GmbH Lise-Meitner-AIIee 10 44801Bochum-Germany). The STL format files are then (Standard Tessellation Language) were exported to CAD programme called OrthoAnalyzer CAD software (Indirect bonding studio,3Shape, Copenhagen, Denmark). After that, each virtual model underwent segmentation on the digital side. The process of virtual model separation using the ortho analyzer software included identifying contact points. (Fig. 2), All teeth differ in their long axis orientation and gum line. Additionally, to establish the virtual alignment procedure, select the arch wire arc from the ortho Analyzer library and set it on the dental midline plane on the occlusal view of the upper virtual model in the most symmetrical manner feasible. (Fig. 3). The first stage in bracket installation would involve selecting the type of bracket, slot, and prescription from the library. The bracket type, slot, and prescriptions in this trial were American Orthodontic minimaster braces, slot 0.022”and Roth prescriptions. After selecting the braces, the software automatically positioned the brackets at the location where each tooth's maximal cervical-occlusal and mesiodistal bulges intersected. However, this bracket placement location may not always be able to achieve the desired levelling and alignment.Ortho Analyzer software based on the location of the bracket through the selected virtual arc, would predict the final position of each tooth. (Fig. 4), It is possible to move each bracket in relation to the anticipated ultimate position. [23]. Additionally, it is simple to adjust the bracket angulation order. Unless the brackets can be inserted without touch over the virtual teeth, and this gap was afterwards filled with a composite resin pad, the torque and in-out order can be modified minimally with limited amplitude. The result of bracket placement by Ortho Analyzer software is denoted by (P1) in this study. The virtual master model with minimaster braces was ready (Fig. 5) and might be imported into the CAM software by exporting an STL file to Wanhao D7 Digital Light Processing (DLP) resin 3D printer to begin physically prototyping of the build plate with braces (Fig. 6).

Fig 1. The used scanner Activity 885.

Fig 2. Setting up of mesiodistal dimensions.

Fig. 3 setting the desired arch form from program library.



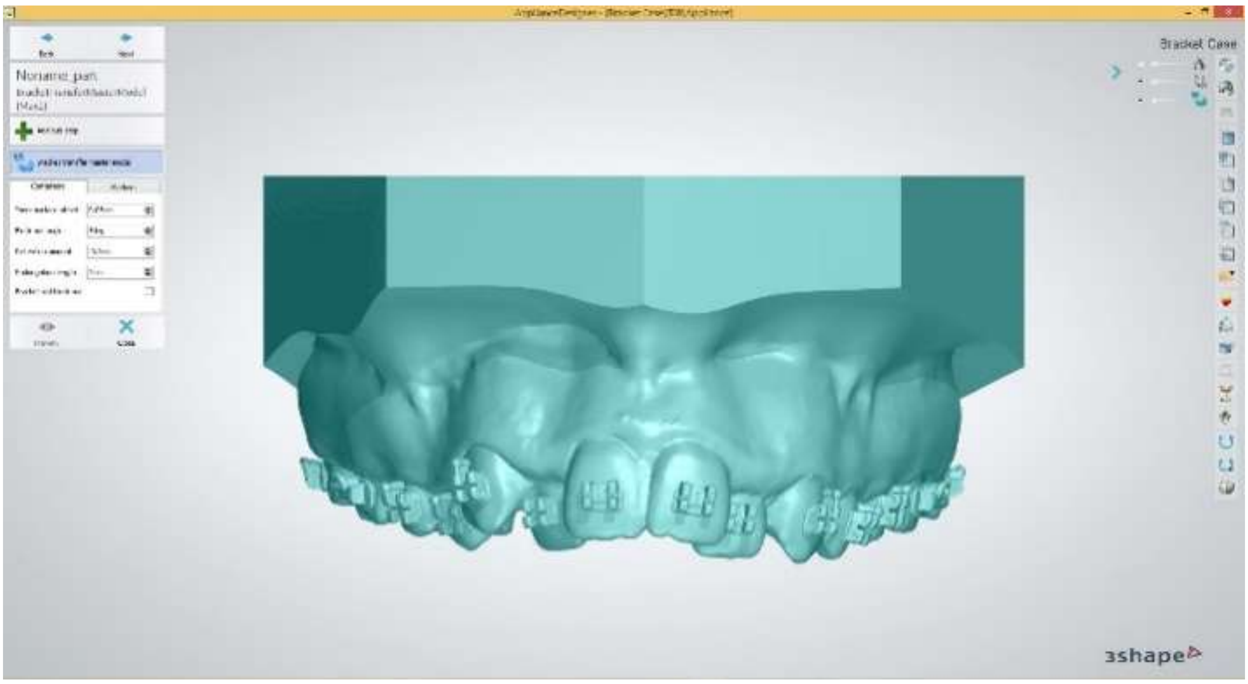


Fig. 4 Chart for American orthodontic minimastert bracket position found by Ortho Analyzer software.
Fig. 5 virtual master model with settled braces in final positiion.

Fig. 6 The printed master model with American orthodontic brackets.

All upper physical master models with AO minimaster braces were used to create the transfer tray was put through the following process.:

1- Using a vacuum former machine (Easy Vac2, Vacuum former, Korea), thermoform soft sheet a 1 mm thick (Gasket bleaching 040, 3A Medes, Korea) was pressed on the master model. Then, Scissors were used to trim the surplus sheet surrounding the figure. Next, a thin layer of silicon spray is applied. (Liqui Moly Silikonspray, Irvine, CA, USA) was used as a divider above the soft tray. (24). Further, a thermoform rigid sheet a 1.5 mm thick (Gasket splint 060, 3A Medes, Korea) was vacuumed on the the first sheet. a Both trays were cut 2 mm above the cervical edge of the teeth on the buccal and palatal sides using a double-sided diamond disc.

2- Separating the rigid transfer tray from the face and palatal sides of the tray and trimming it with carborundum stone up to the top of the bracket hooks.

3- separating the soft transfer tray and trimming it with scissors from both the buccal and palatal sides of the tray, up to the cervical edge of the teeth.

4- Next, the hard and soft trays were positioned one on top of the other.

5- Lastly, stock AO minimaster braces were carefully loaded to their corresponding negative duplicate on the soft transfer tray's inner buccal side.

The loaded double transfer tray was prepared as a result. In the recent past, a double transfer tray was used during the traditional indirect bonding technique. The hard tray was initially removed after light curing. To ensure that the light cure had successfully reached all the braces, a second light cure cycle was performed over a soft tray. Furthermore, the soft tray was taken out, and any damaged brackets were excluded from the study. The results of the indirect bonding tray's bracket location are indicated by (P2) in this study. Patients with indirect bond upper braces underwent intraoral scanning by CEREC Omnicam scanner (Sirona Dentsply Global HQ, Charlotte, NC, USA). The extracted STL file from this scan will now be transferred to be digitally compared.

Comparison of P1 and P2 were done by 3D metrology software called Geomagic® Control X™ (Artec 3D Technology, 20 rue des Peupliers, L-2328, Luxembourg). When comparing the scanned image's details to the original bracket details, it was discovered that various imperfections had arisen in the brackets' wings, slots, and bases. (Fig.7). So, actual 3D CAD From an American orthodontic manufacturer, bracket models were ordered. By using Omnicam, these models were overlaid on top of the scanned brackets intraoral scanner via Geomagic® Control X™ software to replace actual scanned brackets to have at the end brackets with sharp and definite margins and edges (Fig.8). Positional alterations that took place in the brackets from P1(brackets position in 3Shape software) to P2 (brackets position in the patient's mouth) because of indirect bonding, bracket tray transfers were digitally evaluated. by Geomagic® Control X™ software. Therefore, Geomagic® Control X™ Software was able to produce centroid points, which denote the geometric shape's centre. To enable us to detect any errors caused by indirect bracket positioning, the geometric centroid point for the captured brackets by the Omnicam scanner and the bracket prototype from the 3Shape software programme were crucial. (Fig. 9 and 10). These deviations were angular and linear deviations. The linear deviations were mesiodistal, occlusocervical, and in-out deviations (Fig. 11). There were a difficulty to calculate the angular deviations of the brackets. However, Geomagic® Control X™ This issue was resolved by software, which created cubes over the bracket wings to measure these variances. (Fig. 12). Angular deviations were inclination (Torque), angulaion (Mesiodistal tip) and rotation deviation (Fig. 15). These data were collated and statistically examined after the angular and linear deviations data collection.

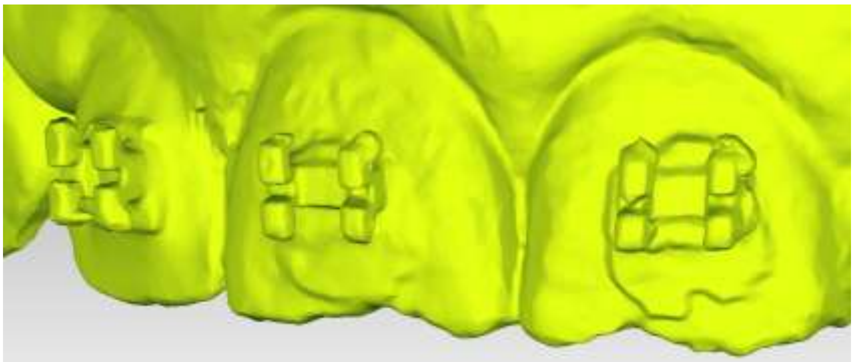


Fig. 7: The sacnned braces with Omnicam intraoral Scanner.

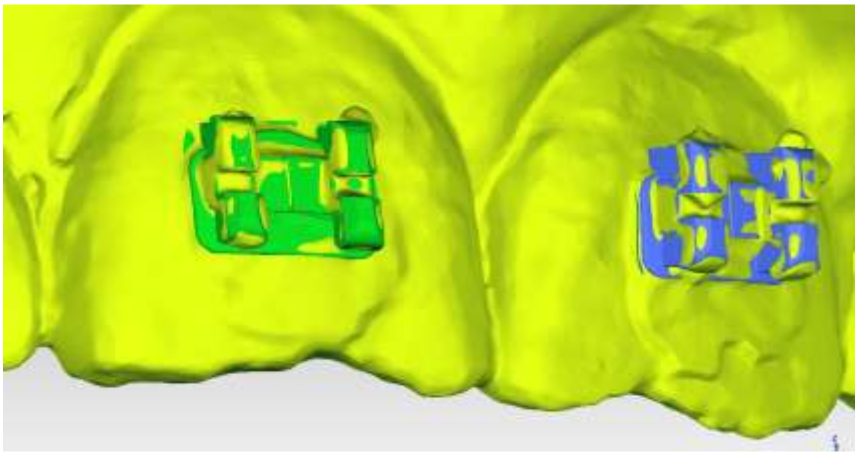


Fig.8: Superimposetion of original braces model over the scanned braces.

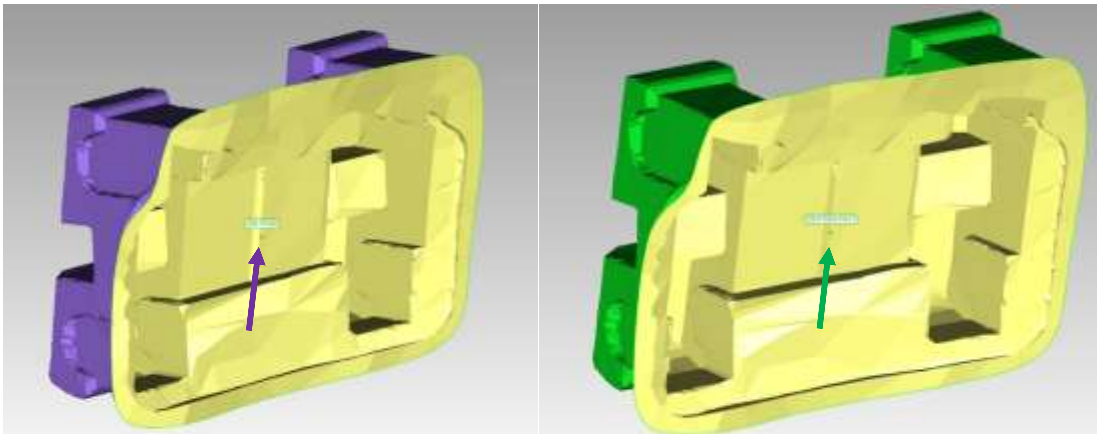


Fig. 9: A) Showing the geometric centroid of AO Minimaster bracket by 3 Shape software library.

B) Showing the geometric centroid of the scanned AO Minimaster braces by Omnicam scanner.

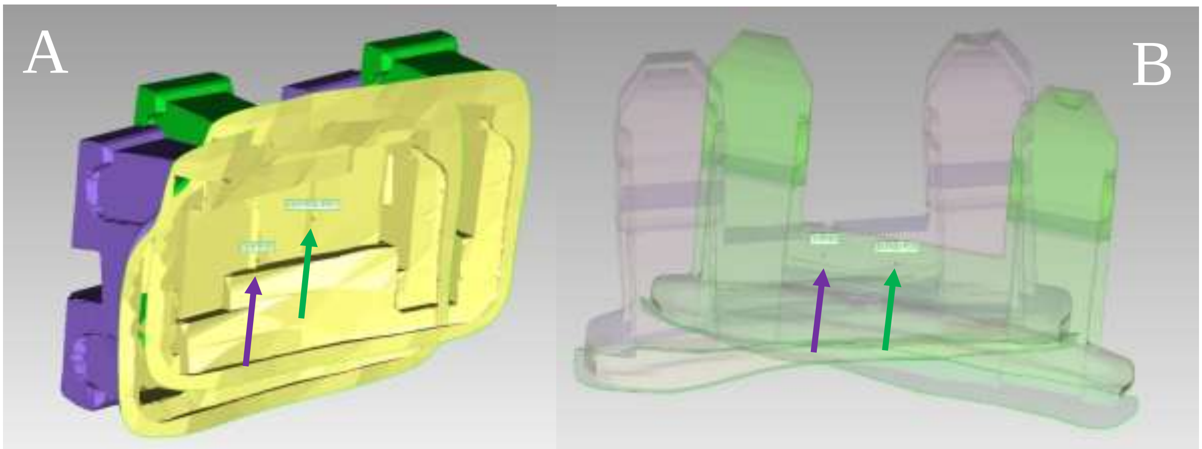
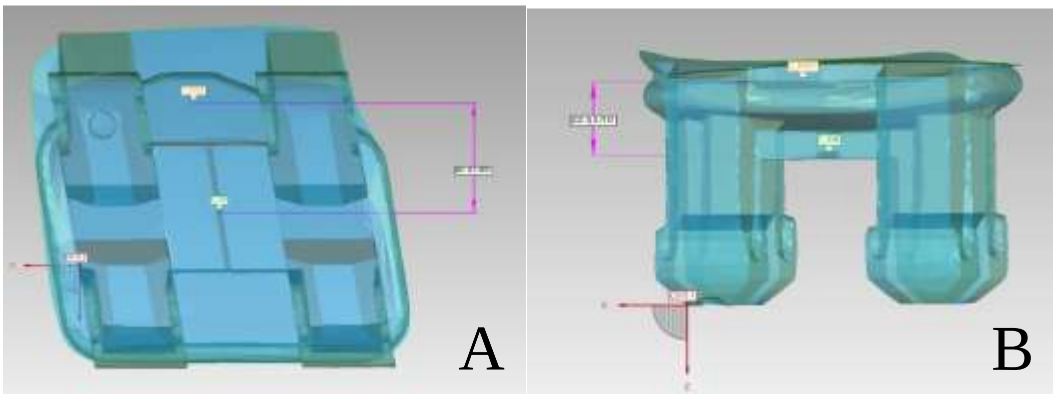


Fig.10: Demonstrating the amount of discrepancy between the geometric centroid points in solid CAD model (A) and frame of CAD model (B).



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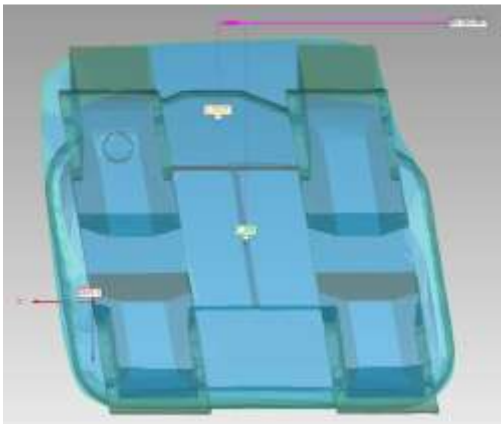


Fig. 11: showing the linear deviations,

A) Occlusocervical discrepancy.

B) In-Out discrepancy.

C) Mesiodistal discrepancy.

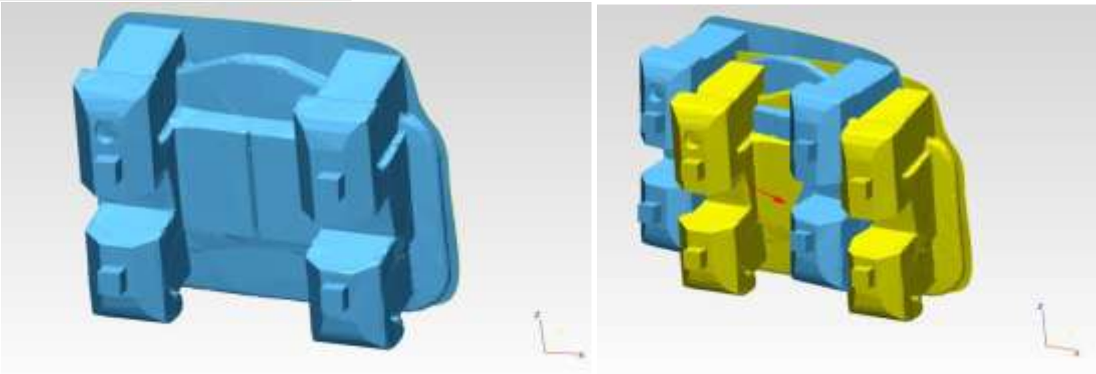


Fig. 12 Representing the cubes added on the wings of the braces via Geomagic® Control XTM software.

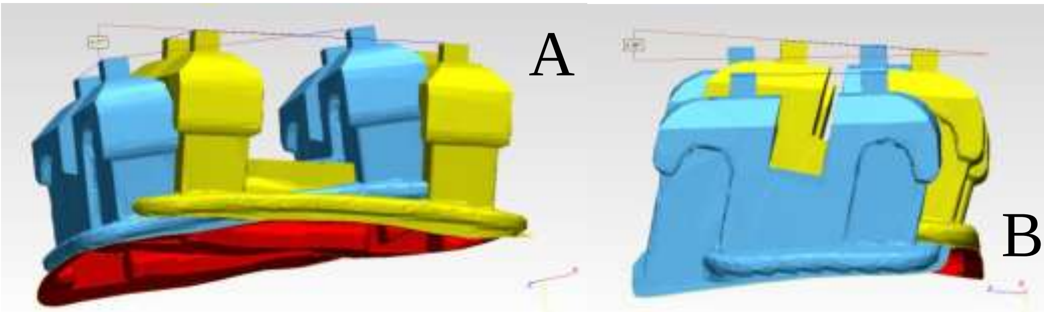
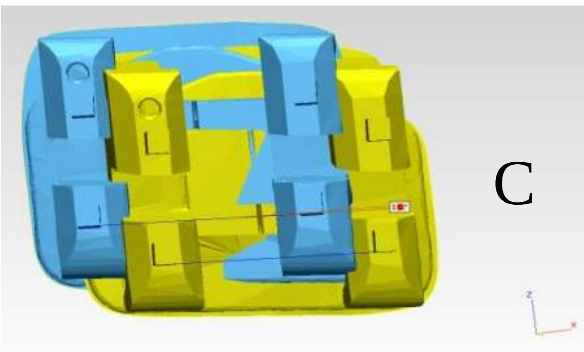


Fig.15 Showing the angular discrepancy:

A) rotation discrepancy.

B) Inclination (Torque) discrepancy.

C) Angulation (Mesiodistal tip) discrepancy.



RESULTS

This study was conducted to assess the accuracy of the measurements as well as the amount of bracket position difference that occurred during their transfer by indirect bonding tray inside the patient's mouth. Ten patients participated in this trial. However, because 10 brackets were bonded for each patient, it required moving over 100 brackets inside the patient's mouth.The collected data from Geometric® Control X™ was statistically analyzed using SPSS (Statistical Packages for Social Sciences) statistical program to obtain:

- **Descriptive statistics**:
  - Mean (x).
  - Standard deviation (S.D).

For the variations in bracket placements in angular and linear measurements, means and standard deviations were obtained and tabulated (Tables 1 &2). P2 was used to record any deviations in the three planes from P1 (Zero position). In order to be clear,there were negative (-ve) and positive signs (+ve) related to all types of linear measurements. The negative indications of the mesiodistal linear deviations indicated that the brackets had been pushed horizontally in the distal direction. The negative signals of ooclusogingival linear deviations indicated that the brackets had been displaced vertically in gingival direction. As a result, the negative signals of In-Out linear deviations indicated that the brackets were pushed in toward the tooth structure's facial surface.

Linear Measurements: (Graph 1)

Overall linear measurements were ranging from (-173.1±131.65 µm) to (200.2±132.86 µm). These deviations were related to occlusogingival and in-out directions and denoted to upper right first premolars and upper left canines respectively.

Mesiodistal (X-Axis) The minimum mesiodistal (MD) linear deviations on the right and left sides belonged to upper right canines and left lateral incisors, respectively, and the quantity of deviations were as follows: (-73.6±67.12 µm, -148.8±86.09 µm) respectively. Furthermore, the upper right central incisors and left second premolars had the highest MD deviations on both sides, and the number of deviations was high. (26±248.10, 184.8±151.77µm) sequentially. The mesial deviations for right side were ranging from (0.6±130.95 µm) to (26±248.10 µm) and corresponding to the upper right second premolars and central incisors. While the mesial deviations on the left side ranged from (43.3±42.89 µm) to (184.4±151.77 µm) and corresponding to the upper left first and second premolars. The distal deviations for the right side ranged from (-6.8±219.27 µm) to (-73.6±67.12 µm) and corresponding to the upper right lateral incisors and canines. Whereas this distal deviations on the left side ranged from (-26.6±20.69 µm) to (-148.8±86.09 µm) and corresponding progressively to the upper left canines and lateral incisors.

Occlusogingival (Y-Axis) deviations for all brackets were ranging as follows; the minimum Occlusogingival (Y-Axis) The linear deviations on the right and left sides belonged to upper right first premolars and left canines, respectively, and the quantity of deviations was (-173.1±131.65 µm, -166±81.02 µm) respectively. In addition, the maximum Occlusogingival (Y-Axis) The variations on the right and left sides belonged to the upper right lateral incisors and the left first premolars, respectively, and the total number of deviations was (169.6±114.43, 162.2±116.20 µm) sequentially. The occlusal deviations for right side ranged from (94±96.72 µm) to (169.6±114.43µm) and for the upper right central incisors and lateral incisors respectively. While the occlusal deviations for left sides ranged from (30.2±26.56 µm) to (162.2±116.20 µm) and for the upper left central incisors and first premolars respectively. The deviations gingivally for right side ranged from (-165.1±41.36 µm) to (-173.1±131.65 µm) and for the upper right first and second premolars respectively. While the deviations gingivally for left sides ranged from (-7.4±109.06 µm) to (-166±81.02 µm) and for the upper left second premolars and canines respectively.

In-Out deviations(Z-Axis) for brackets ranged as follows; the minimum in-out (Z-Axis) linear deviations on right and left sides for the upper right and left second premolars and the amount of deviations were (-79.8±5.18 µm, -160.2±9.53 µm) respectively. In addition, the maximum in-out (Z-Axis) The variations on the right and left sides belonged to upper right first premolars and left canines, respectively, and the total number of deviations was (-9.5±29.53, 200.2±132.86 µm) sequentially. The deviations for right side ranged between (-9.5±29.53µm) to (-79.8±5.18 µm) and for the upper right first and second premolars respectively. While the in deviations for left sides ranged between (-103±2.40 µm) to (-160.2±9.53 µm) and belonging to the upper left central incisors and second premolars sequentially. There were no out deviations related to right side. While the out deviations for left sides ranged between (74.4±3.98 µm) to (200.2±132.86 µm) and for the upper left lateral incisors and canines respectively.

Angular Measurements: (Graph 2)

Overall angular measurements ranged between (0.51±0.03 degree) to (1.94±0.03 degree). These aberrations were related to the mesiodistal tip and designated higher right canines and upper left central incisors.

Mesiodistal (MD) the tip deviations for all brackets were as follows; the upper right and left central incisors had the smallest buccolingual tip angular deviations, and the amount of deviations were as follows. (0.51±0.03,0.79±0.02 degree) respectively. Furthermore, the upper right first premolar and left central incisors showed the biggest MD tip variations, as well as the greatest number of deviations.. (1.80±0.5, 1.94±0.03 degree) respectively.

Buccolingual (torque) deviations for all brackets were ranging as follows; the minimum buccolingual tip angular deviations were belonging to upper right and left central incisors and the amount of deviations were (0.69±0.54, 0.62±0.03 degree) respectively. In addition, the maximum BG deviations were belonging to upper right lateral incisors and left canines and the amount of deviations were (1.45±0.11, 1.84±0.97 degree) sequentially.

Mesiodistal (MD) The rotation deviations for all brackets ranged as follows: the upper right central incisors and left second premolars had the smallest mesiodistal rotation angular deviations, and the quantity of deviations was (0.62±0.49, 0.77±0.61 degree) respectively. Furthermore, the largest MD deviations belonged to the upper right lateral incisors and the left central incisors, and the number of deviations were (1.60±0.80, 1.73±0.8 degree) sequentially.

Internal Reliability (internal consistency reliability):

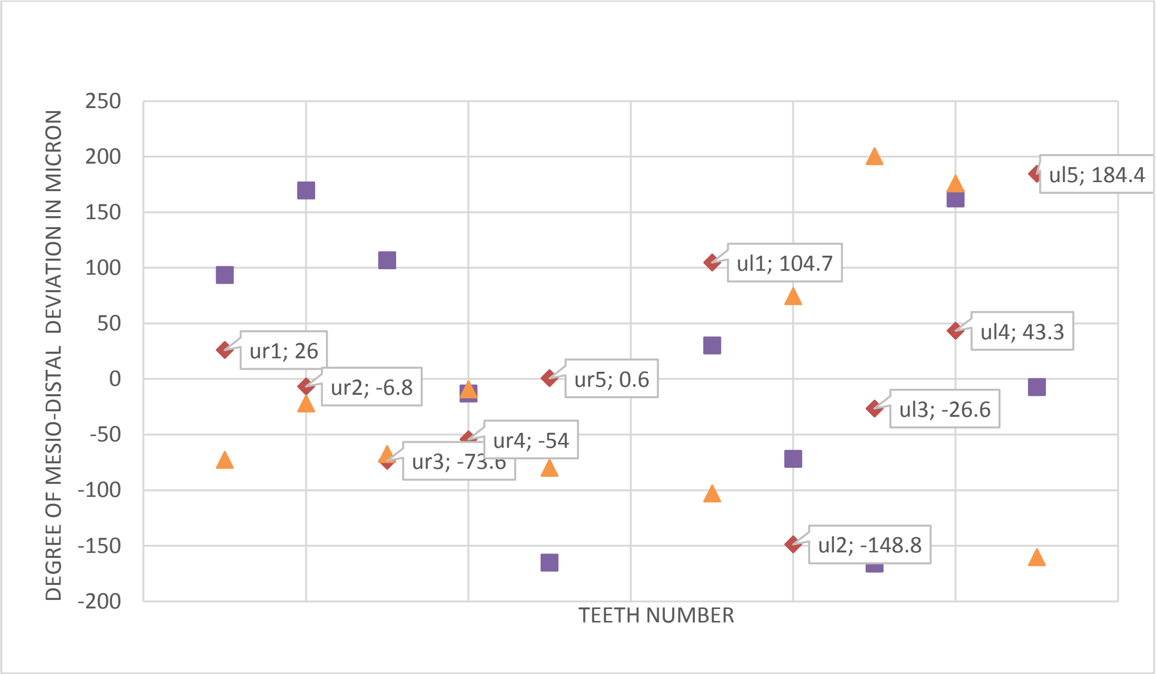
To ensure the stability and internal reliability of the measurements of the research, the researcher used the alpha coefficient of Cronbach, where the researcher applied it to a sample of (10) individuals, and the alpha coefficient reached (0.85), which is a statistically significant coefficient, which indicates stability of the measurements of the sample.

External Reliability (Test-retest reliability): (Table 3)

To calculate the stability and reliability of the measurements of the research, the researcher used the method of test retest (Intra-observer error), where the researcher applied it to a sample of (10) individuals and then re-application on the same sample with an interval of ten days, and the correlation coefficients between the first and second applications were calculated to find the stability of the measurements of the research.

Table (1) shows means and standard deviation of the linear bracket's movements in microns.

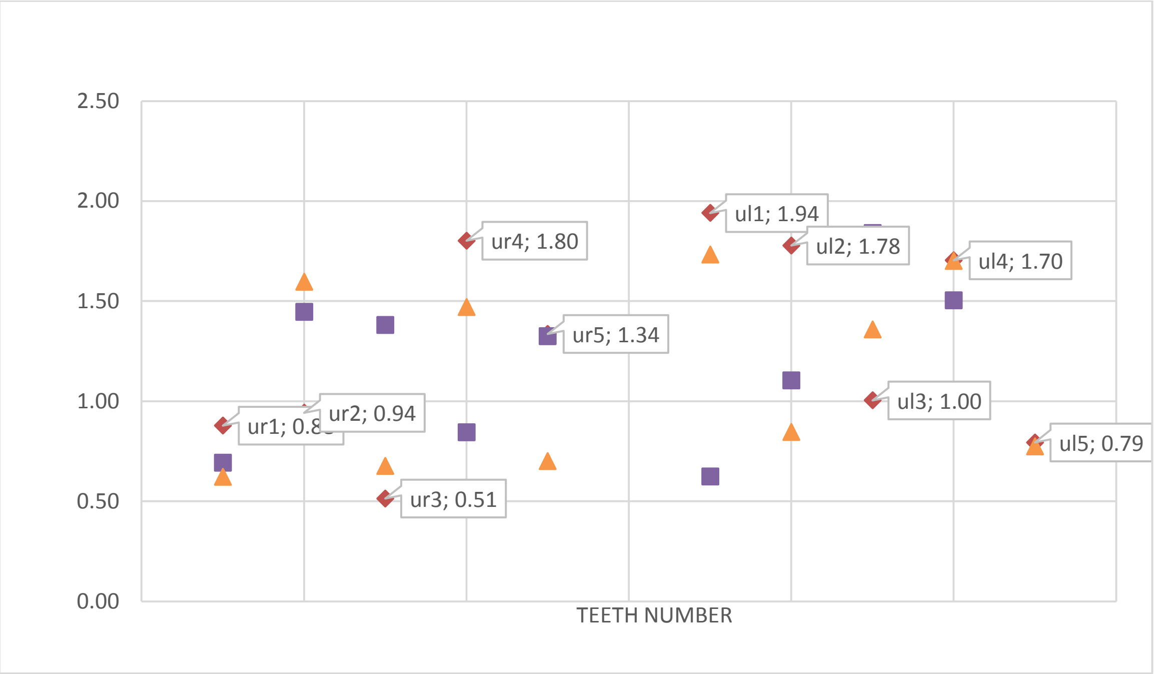
	linear movement (mesial+, occlusal+& out+)		
Mean±SD	X-axis(M-D)	Y-Axis (Occ-Ging)	Z-Axis(In-Out)
UR1	26±248.10	94±96.72	-73±55.17
UR2	-6.8±210.27	169.6±114.43	-22±108.98
UR3	-73.6±67.12	106.6±6.60	-67.6±44.89
UR4	-54±67.12	-173.1±131.65	-9.5±29.53
UR5	0.6±103.9	-165.1±41.36	-79.8±5.18
UL1	104. 7±11.06	30.2±26.56	-103±2.40
UL2	-148.8±86.09	-71.9±118.80	74.4±3.98
UL3	-26.6±20.69	-166±81.02	200.2±132.86
UL4	43.3±42.89	162.2±116.20	175.8±99.71
UL5	184.4±151.77	-7.4±109.06	-160.2±9.53



Green triangles represnt z axis (in-out) linear mensuration, orange squares represnt y axis (occluso- gingival) linear mensuration, and orange rhomboids represnt x axis (mesio-distal linear mensuration).

Table (2) shows means and standard deviation of the angular brace's deviations in degrees.

	Angular movement		
Mean±SD	Tip	Torque	Rotation
UR1	0.88±0.67	0.69±0.54	0.62±0.49
UR2	0.94±0.03	1.45±0.11	1.60±0.80
UR3	0.51±0.03	1.38±0.56	0.68±0.03
UR4	1.80±0.5	0.84±0.45	1.47±0.50
UR5	1.34±0.78	1.32±0.91	0.70±0.05
UL1	1.94±0.03	0.62±0.03	1.73±0.8
UL2	1.78±0.71	1.10±0.93	0.85±0.03
UL3	1.00±0.68	1.84±0.97	1.36±0.93
UL4	1.70±0.95	1.50±1.11	1.70±0.06
UL5	0.79±0.02	1.65±0.71	0.77±0.61



Orange triangles represent rotation, blue squares represent torque degrees and red rhomboids shows tip degrees.

Table (3) Correlation coefficients between the first and second applications of the research measurements (n = 10):

Measurements		*P* value
linear movement (mesial+, occlusal+& out+)	X-axis(M-D)	0.99**
	Y-Axis (Occ-Ging)	0.99**
	Z-Axis(In-Out)	0.99**
Angular movement	Tip	0.99**
	Torque	0.98**
	Rotation	0.98**

DISCUSSION

In 1970, Lawrence Frederick Andrews the three-order straight wire appliance method was invented by him. (25). As a result, correct bracket positioning has become a vital process for achieving an efficient treatment result. (26). Incorrectly positioned brackets may result in unwanted tooth movement, longer treatment time, and ineffective treatment outcomes. Due to the importance of second molar bonding, individuals in this study were beyond the age of 15 to ensure that the second permanent teeth erupted. Dr. Keim stated in 2007 that there are no excuses for overlooking second molars in orthodontic treatment planning. (27). The tubes of the first and second permanent molars were bonded. However, they were excluded from the current investigation due to recurrent debonding during transfer tray removal. The PVS impressions were acquired in this study using a two-step procedure to be more accurate and stable. According to Levartovsky et al. (2013) and others, the two-step PVS impression approach was more accurate than the one-step impression technique. (28,29). Aalai et al and Other authors stated that the PVS impression could last up to a week. (30,31). We have been in the COVID-19 pandemic era for the last two years, thus using protective personal equipment, washing the taken impression materials under running water, and cleaning them with sodium hypochlorite have been essential actions in dentistry. (32,33,34). So, In this investigation, the imprint trays were disinfected by soaking them in a 1:10 solution of sodium hypochlorite for ten minutes. (35). The PVS impression materials were then scanned using a bench scanner, which was supported by the Keul study, which stated that the data collected from the impression scans with high accuracy impression obtained by laboratory scanner were more reliable than the cast scans obtained by the same scanning technique ((36). In comparison to the traditional indirect bonding process, virtual indirect bonding reduced laboratory time and promoted a sensitive improvement in bracket location. (37). Durate et al and Camadrella te al used Orthoanalyzer to simulate indirect bonding, which was utilised in our study (38,39). Several researchers also found a considerable reduction in total treatment duration when compared to typical direct and indirect bonding approaches. (40). Different authors advocated using a double transfer tray in this study to allow the physician to transfer bracket locations to the patient's teeth fast and effectively, and to withdraw the transfer tray after bonding while dislodging brackets. (41,42).

An important aspect of the virtual indirect bonding approach is the inspection of the virtual occlusal set up generated from the digital 3D model according to the orthodontist's prescription. Once the virtual occlusal set-up is finalised and accepted, the computer-aided indirect bonding technique transfers the information to the virtual 3D cast and produces dual trays for bracket transmission to the patient. As a result, one of the key advantages of indirect bonding would be realised: consistent and exact bracket placement. (43). According to Armstrong et al., only adjustments of 0.25 mm for incisor bracket placement and 0.5 mm for other teeth should be considered clinically meaningful. (44). The model grading system of the American Board of Orthodontics indicated that variations of.0.5 mm in tooth contact and levelling would lead to undesirable evaluation. (45). Differences of 0.13 mm in multiple directions between neighbouring brackets should be considered clinically significant according toCastilla et al (46). When Koo et al. looked at indirect bonding, they discovered horizontal variances of 0.18 mm and vertical differences of 0.31 mm (47). The overall linear differences in this study varied from 0.1731 mm to 0.2002 mm, which was similar to previous investigations and confirmed the reproducibility of the approach. According to Larson et al., angulation deviations of less than 2° could be considered clinically accaeptable. (18). After indirect bonding, Koo et al. discovered mean differences of 2.43° between brackets (47).)The overall angular deviations in the current investigation varied from 0.51° to 1.94°, which corresponded with those found in the literature, validating the technique's repeatability. Kim et al. assessed the accuracy of a digital indirect bonding method by comparing the discrepancies between desired digital bracket placements and actual bracket positions following indirect bonding of five maxillary arch models. [(48)]. The latest study supported the findings of Kim et al, who found no clinically meaningful differences in bracket location. In Kim's study, the angulation mean differences were 1.538 and 1.528. One reason for the reported discrepancies in bracket locations could be discrepancies in the positioning and fit of the prototype transfer trays on the models by each orthodontist. An incorrect fit of the tray could result in an occlusal displacement. Furthermore, poor fitting of each bracket in its correct slot in the tray may result in errors, decreasing the technique's accuracy. [(24,47,48,49).]

The digital indirect bonding technology has various advantages, including the possibility of less archwire bending, fewer appointments to adjust bracket sites, and the opportunity to display the patient the 3D treatment strategy on a computer screen. [(50,51)]. Furthermore, employing 3D-printed transfer trays for computerized indirect bonding keeps the bracket base adhesive-free prior to bonding. This advantage lowers the risk of clinical bonding breakdown as well as the chance of excessive adhesive. [(52)].

The correlation coefficients between the first and later applications of the research measurements ranged from (0.98 to 0.99), indicating that the research measurements are highly reliable. This study was an early evaluation of the precision of dual tray fit of the digital indirect bonding approach. As a result, more clinical studies are required to evaluate the reproducibility of bracket positioning with a wide range of malocclusions, as well as the effect of the practice situation on the technique's accuracy.

CONCLUSION

1- **1- An intraoral scanner is a fantastic instrument for correctly scanning intraoral features. However, scanning the braces inside the patient's mouth with an intraoral cam was inaccurate due to foggy borders and edges.**

2- **Indirect bonding with a double transfer tray can accurately recreate bracket position on digital models.**

Conflicts of Interest

The authors state that they do not have any conflicts of interest.

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Ethics Approval

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