Original Article

3D printed indirect bonding trays: transfer accuracy of bar vs shell design in a prospective, randomized clinical trial

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ABSTRACT

Objectives: To compare the transfer accuracy of two different indirect bonding (IDB) trays.

Materials and Methods: Digital IDB was performed on a total of 30 patients using one of two designs: shell and bar trays, with 15 patients in each group. Trays were designed with the Appliance Designer software (3Shape A/S, Copenhagen, Denmark). Angular (torque, tip, angulation) and linear (mesiodistal, buccolingual, occlusogingival) differences were compared between the bonded intraoral scans taken immediately after IDB and the virtually bracketed model prepared in Ortho Analyzer software (3Shape A/S) using open source GOM inspect software (GOM GmbH, Braunschweig, Germany).

Results: There were no significant differences found between the bar and shell groups. Within the groups, significant tip differences were found between the incisors, canines, and premolars in both groups ($P = .0001$). Additionally, a statistically significant torque difference was found in the canines and incisors in the shell group. The percentage of values that deviated from the clinical acceptance limit was relatively higher in the bar group.

Conclusions: Although there was no statistical difference between groups, the shell tray showed better results according to clinical acceptability limits. This study is important as it is the first clinical study to compare directly printed transfer trays with different designs. (*Angle Orthod*. 2024;94:648–656.)

KEY WORDS: Indirect bonding; 3D-printed digital transfer tray; Bonding accuracy

INTRODUCTION

The indirect bonding (IDB) method assists in more accurate bracket positioning and provides easier overcorrection than the direct bonding (DB) method.[1] Additionally, it has been shown to shorten the total treatment time by 5 months compared with DB.[2] Depending on the material, tray design, and amount of adhesive used, positional differences might be seen.[3]

IDB can be accomplished with two methods: conventional and digital. In the digital method, after determining the location of the brackets on the virtual three-dimensional (3D) bracket transfer model, the tray might be produced in three ways. In the first, brackets are placed on the 3D-printed dental resin model containing a marker that guides the intended bracket positions, and IDB trays are manually fabricated with materials such as nontransparent polyvinyl siloxane (PVS), transparent PVS, hot glue guns, and thermoforming (vacuum-formed) plastic materials.[4] In the second method, dental resin models printed with virtual brackets and IDB trays are manually fabricated with these materials. In the third method, after virtual bracket placement, the IDB tray may be designed as a shell or bar via software and directly 3D printed.[5] The design, fabrication process, and materials of IDB trays are important factors that affect their fit and the positional accuracy of brackets. The third method is recommended for its lower frequency of bracket positioning errors and ease of fabrication compared to the first method.[6]

Shell and bar trays differ in design and thickness. It was hypothesized that these differences might affect tray resiliency, flexibility and, consequently, transfer accuracy. This study aimed to compare the transfer accuracy of two different, directly printed 3D transfer trays in a prospective clinical setting.

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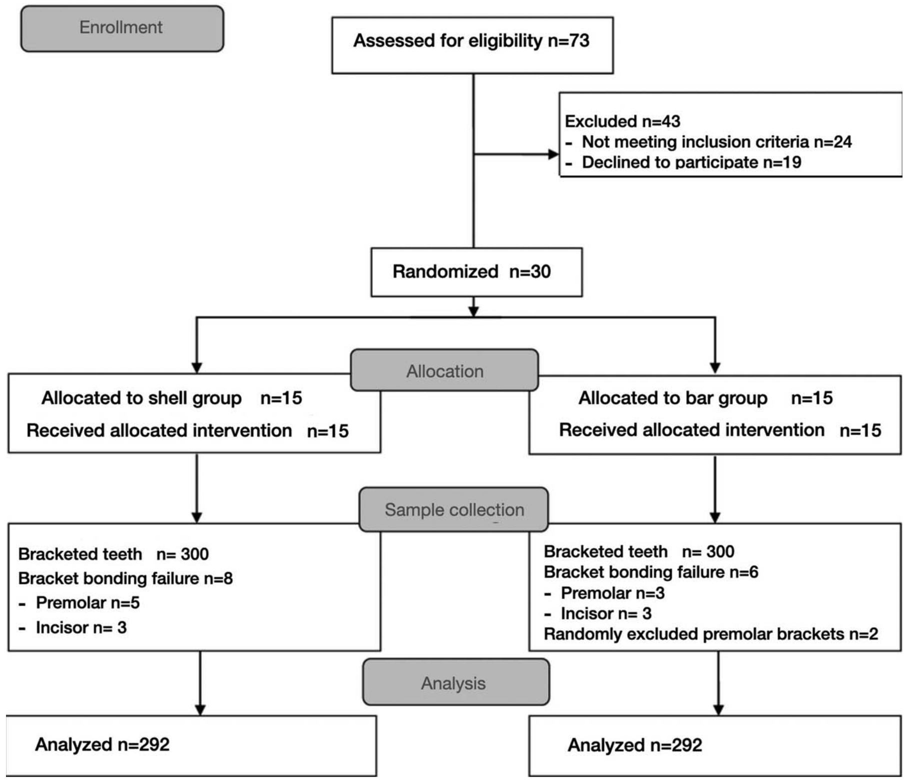

Figure 1. Collection and allocation of the sample.

MATERIALS AND METHODS

Sample Selection and Tray Fabrication

This study was approved by the Ethical Committee of Istanbul Medeniyet University Goztepe Research and Education Hospital (approval date and number: 2022/0671) and was conducted following the Declaration of Helsinki (The Code of Ethics of World Medical Association, 2013). The study complied with the CONSORT guideline protocol. Trial registration: NCT, NCT06167278. Registered: 01 December 2023. https://clinicaltrials.gov/study/NCT06167278

Patients presenting to the Orthodontic Department were included in the study according to the inclusion criteria of being aged 17–30 years, with complete permanent dentition, mild to moderate (3–6 mm) crowding, and good oral hygiene and periodontal health. The exclusion criteria were patients needing treatment with extraction or with tooth shape anomaly, deficiency, fractures, crowns, or abrasion. Informed written consent was obtained from each patient.

This prospective, randomized clinical trial used a parallel-group design with a 1:1 allocation ratio, involving 30 patients randomly assigned to either the shell or bar tray group. The allocation was done using the random number generator on https://www.random.org. Each group comprised 15 patients, and the trays were designed accordingly. A total of 600 brackets (300 per group) were bonded to incisors, canines, and premolars in both groups by an experienced operator (MNE). After tray removal, bond failure occurred in 14 brackets: eight in the shell group (five premolars, three incisors) and six in the bar group (three premolars, three incisors). The excluded brackets were balanced by randomly excluding two premolars from the bar group. The analysis was conducted on 292 samples in each group (117 samples in each group; 117 incisors, 60 canines, 115 premolars; Figure 1).

For tray fabrication, 3Shape OrthoAnalyzer software (3Shape A/S, Copenhagen, Denmark) was used to determine the virtual bracket positions. Mini Twin Brackets RMO (Rocky Mountain Orthodontics OrthoAmerica Holdings, CO, USA) with 0.22-inch slots were selected from the virtual bracket library and placed on the initial STL model. The virtually bracketed STL models were then imported to ApplianceDesigner software (3Shape A/S), and digital transfer trays were designed, paying attention to undercuts by MNE, with experience in tray design using Appliance Designer software (3Shape A/S; Figure 2a–b). Production of 3D-printed trays was carried out in horizontal orientation with a Formlabs3D printer (Formlabs Form 3B Plus, Somerville, MA, USA) using a transparent flexible biocompatible Class I resin material FLIBCL01 (Formlabs IBT) with a build layer thickness of

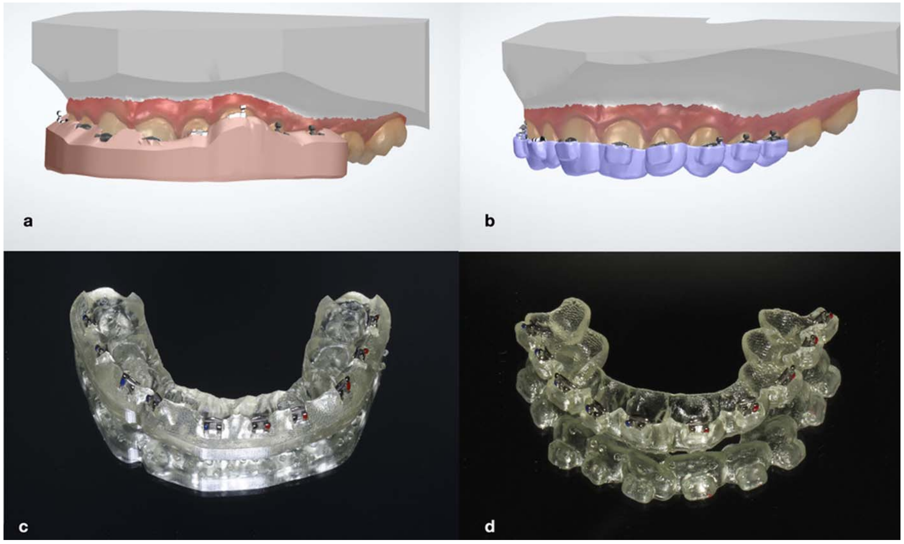

Figure 2. Virtual tray design: Bar-design (a), Shell-design (b). Placement of Mini Twin Brackets RMO Bar-design (c), Shell-design (d).

100 microns. The resin material had ≥5 MPa tensile strength, >25% elongation, >16 MPa Young modulus, and <90 Shore A hardness. Both designs of the 3D-printed transfer trays had closed coverage, with a 1.5-mm vertical slot overlap, as in the study by Sabbagh et al.[7]

Clinical Application

Mini Twin Brackets (RMO, Rocky Mountain Orthodontics OrthoAmerica Holdings,) were placed into the trays (Figure 2c–d). Transbond XT light-curing adhesive (3M Unitek) was applied to the bracket mesh bases. After brush-polishing, teeth were etched with 37% phosphoric acid for 20 seconds, rinsed, and dried. A 3M Transbond primer (3M Unitek) was applied, followed by LED curing. Trays were seated with passive pressure, and LED curing was performed with VALO (Ultradent Products, South Jordan, UT, USA) for 2 × 3 seconds in high power mode (1400 mW/cm^2). After tray removal, the excess composite was cleaned, and intraoral scanning was repeated with brackets for the actual STL models by a right-handed operator (MNE).

Data Evaluation

Initially (T0) and after IDB (T1), intraoral scanning records were taken via the 3Shape device (3Shape TRIOS) on the same day. All outcome assessments were made blindly by GK.

Nominal (with virtual brackets) and actual (scan after IDB) STL models were imported to GOM Inspect open-source software 2018 (GOM GmbH, Braunschweig, Germany). The order of process follows:

- Superimposition of the models was performed by the iterative closest point algorithm of this software. The first superimposition of STL models was conducted with the prealignment tool.
- After initial superimposition, local best-fit was performed for each tooth (through lingual or palatal and occlusal surfaces) to increase the quality of registration, as described by Faus-Matoses et al.[8] and Yoo et al.[6]
- Eight landmarks were determined from the base of the brackets (most incisal and gingival middle points on the axis of the bracket, most mesial and distal middle points on the slot of the bracket, and inner corners in the cross-section of the tie-wings and bracket base; Figure 3a).
- Planes were determined for each tooth between the most mesial, distal, and incisal or occlusal points.
- Local coordinate systems were established for each bracket in the GOM Inspect program. Points were marked on three perpendicular surfaces representing the x, y, and z directions. This involved marking the disto-occlusal or incisal wing of each bracket, with the origin of the coordinate system determined at the inner corner of the relevant wing (Figure 3b).
- The linear measurements between eight corresponding points in nominal and actual data were calculated using the coordinate system as a reference. To enhance reliability and minimize error margins, the calculations were averaged across eight measurements. Additionally, angular deviations were assessed relative to the coordinate system using planes (Figure 3c).
- Linear measurements: mesiodistal/direction x, occlusogingival/direction y, buccolingual/direction z.
- Angular measurements: torque (yz), tip (xy), rotation (xz).
- In the x axis, + value is distal, − value is mesial; in the y axis, + value is gingival, − value is occlusal; in the z axis, + value is lingual, − value is palatal. For angles,

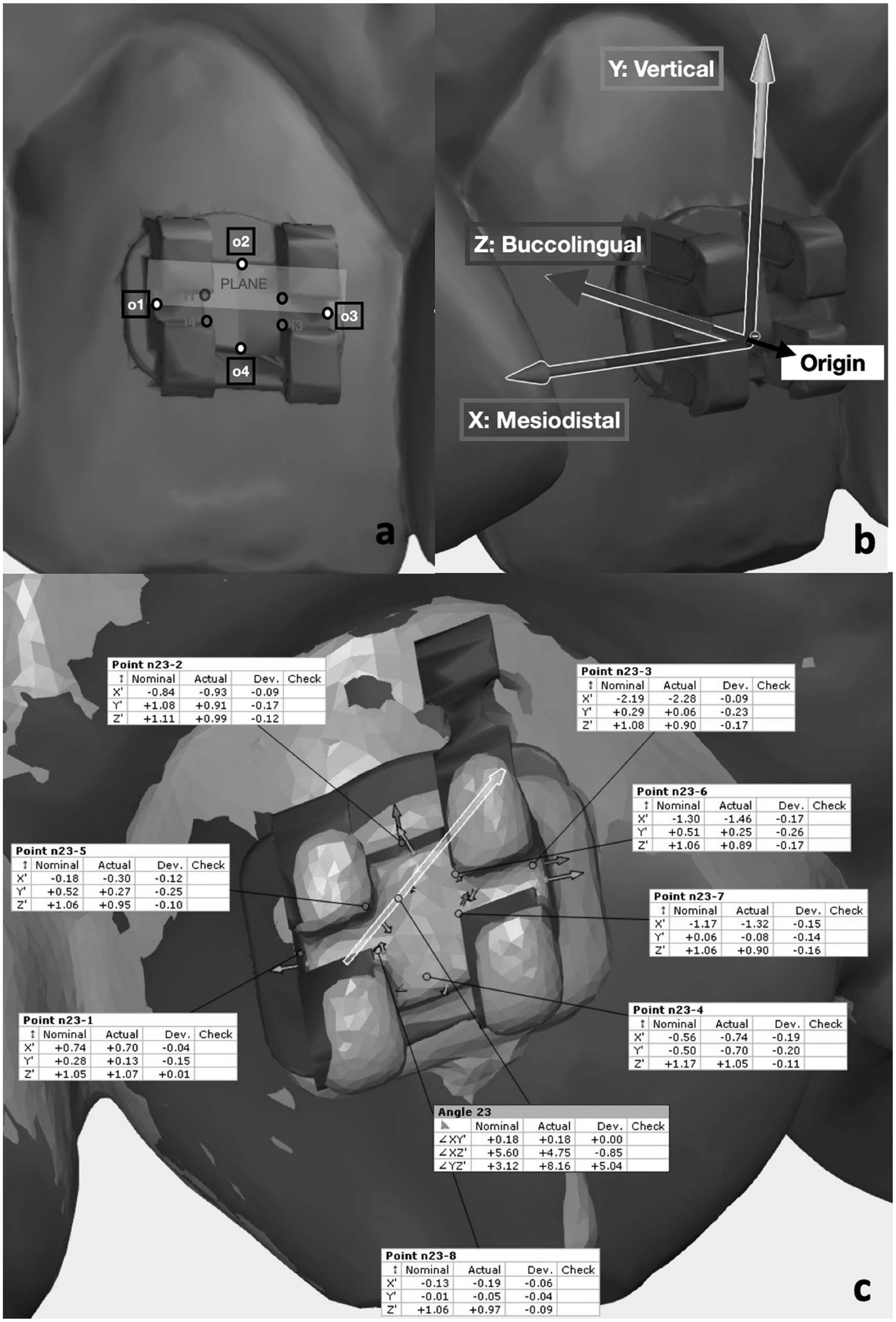

Figure 3. Measurements: Determined landmarks (o1, o2, o3, o4: most mesial, gingival, distal, incisal/occlusal middle points; i1, i2, i3, i4: inner corners in cross-section of tie-wings and bracket base) from the bracket base and plane (a); Local coordinate systems were constructed from disto-occlusal wings of brackets and originated from inner and outer corners of related wings (b); Superimposition of actual and nominal models and calculation of deviation between points and planes (c).

Table 1. Prevalence of Clinically Unacceptable Transfer Errors and Distribution of Clinically Unacceptable Transfer Errors, in Each Direction[a]

Tooth type	Tray type	n	Mesiodistal (x) %	Buccolingual (z) %	Vertical (y) %	Torque (yz) %	Tip (xy) %	Rotation (xz) %	Mesial %
Incisor	Shell	117	0	41.66	15.83	55	20	45	0
	Bar	117	0.83	10.83	28.33	52.5	20.83	50	100
Canine	Shell	60	0	6.66	6.66	41.66	0	43.33	0
	Bar	60	0	10	15	51.66	1.66	61.66	0
Premolar	Shell	115	1.66	11.66	7.5	44.16	5.83	37.5	50
	Bar	115	0	17.5	13.33	55.83	7.5	50.83	0
Total	Shell	292	0.67	7.82	10.88	48.9	9.88	42.5	50
	Bar	292	0.33	13.37	19.66	53.84	11.70	52.84	100

[a] BCT: indicates buccal crown torque; DRT, distal root tip; LCT, lingual crown torque; m-b, mesiobuccal; m-l, mesiolingual; MRT, mesial root tip; n, sample size.

xy+ is distal root tip, xy− is mesial root tip; yz+ is lingual crown torque, yz− is buccal crown torque; xz+ is mesiolingual rotation, xz− is mesiobuccal rotation.

The percentage of clinically unacceptable values was calculated according to the clinical acceptability limits of 0.5 mm and 2°, consistent with the American Board of Orthodontics (ABO) Orthodontic Grading System.[9]

Statistical Analysis

Power analysis for independent samples *t*-test was performed using G*Power version 3.1 (Heinrich-Heine-University Düsseldorf, Germany). The calculation indicated that a minimum sample of n = 286 each was required for shell and bar groups for a power of 91% to detect a small effect size (0.25) at a significance level of 0.05.

Percentages were found by calculating the ratio of values exceeding ABO criteria to all values. The directions were also determined according to the minuses and pluses.

For each transfer method, normally and non-normally distributed data were determined with Shapiro-Wilks test. Intragroup comparison of tooth groups (incisors, canines, premolars) was performed with analysis of variance (parametric) followed by post-hoc Tukey honestly significant difference and independent-samples Kruskal-Wallis (nonparametric) tests. For the intergroup comparison, Mann-Whitney *U*-test (nonparametric) and independent samples *t*-test (parametric) were conducted to clarify significant differences of transfer errors between the two groups (shell and bar). Mean calculations were made using the absolute values of each deviation to eliminate the possibility that the sum of the positive and negative differences would negate each other. Statistical analyses were performed using Statistical Package for Social Sciences version 25.0 software (SPSS Inc, Chicago, IL, USA).

Intraclass correlation coefficients (ICC) were used to assess the reliability and reproducibility of the measurement methods. Sixty brackets randomly selected from each group, and all measurements, including the matching process, were repeated by GK within 2 weeks. A *P* value of less than .05 was considered statistically significant.

RESULTS

The intraclass correlation coefficients for the bar and shell groups ranged from 0.989 to 1.000 and 0.981 to 1.000, respectively, showing a high level of intra-examiner reliability.

Most of the clinically unacceptable deviations were seen in torque (bar: 53.84%; shell: 48.9%) and rotation (bar: 52.84%; shell: 42.5%) measurements. The linear measurements showed the least clinically unacceptable deviations in mesiodistal direction for both groups (bar: 0.33%; shell: 0.67%). The greatest deviations in linear measurements were observed vertically for the bar group (19.66%) and buccolingually for the shell group (13.37%). Among the angular measurements, the deviation was lowest in the tip angle (bar: 11.70%; shell: 9.88%; Table 1).

Vertical clinically unacceptable deviations were predominantly observed in the gingival direction for the shell group (65.63%), and in the occlusal direction for the bar group (64.41%). All buccolingual deviations were in the buccal direction (100%). Mesiodistal, torque, rotation, and tip deviations showed similar directional distributions (Table 1).

No significant differences were found between the bar and shell groups (Table 2). Within the shell group, significant differences were observed for torque between canines (mean: 1.954 ± 0.710) and incisors (mean: 2.605 ± 0.678; *P* = .034), and for tip between canines (mean: 0.346 ± 0.178) and incisors (mean: 1.208 ± 0.336; *P* = 0) and between premolars (mean: 0.572 ± 0.312) and incisors (*P* = 0). In the bar group, significant tip deviations were seen between canines (mean: 0.498 ± 0.778) and premolars (mean: 0.701 ± 0.413; *P* = .014), between canines and incisors (mean: 1.262 ± 0.466;

Table 1. Extended

Distal %	Buccal %	Lingual %	Occlusal %	Gingival %	BCT %	LCT %	MRT %	DRT %	m-b %	m-l %
0	100	0	31.57	68.43	50	50	56	44	53.7	49.3
0	100	0	70.59	29.41	50.8	49.2	64	36	50	50
0	100	0	50	50	52	48	0	0	61.57	38.46
0	100	0	11.11	88.89	48.39	51.61	0	100	54.05	45.95
50	100	0	33.33	66.67	52.83	47.17	58	42	44.45	55.55
0	100	0	37.5	62.5	55.23	44.77	44.45	55.55	40.99	59.01
50	100	0	34.37	65.63	51.38	48.62	56.25	43.75	52	48
0	100	0	64.41	35.59	52.18	47.82	55.88	44.12	47.46	52.54

$P = 0$), and between premolars and incisors ($P = .018$; Table 3).

DISCUSSION

Various in vitro[6,10,11] and in vivo[12] studies have generally evaluated 3D-printed trays alone or compared them with PVS and thermoforming trays. Only one in vitro study compared the transfer accuracy of different digital 3D-printed trays with each other.[13] However, this is the first in vivo study comparing different digital 3D-printed trays.

No significant differences were found between the groups (bar and shell) in any direction (Table 2). However, depending on ABO-OGS,[9] when the mean values in Table 2 were analyzed, linear deviations were

Table 2. Intergroup Comparison of Shell and Bar Trays

Tooth Type	Tray Type	Mean ± SD	min max	P	Mean ± SD	min max	P	Mean ± SD	min max	P
LINEAR		Mesiodistal (x) (mm)			Buccolingual (z) (mm)			Vertical (y) (mm)		
Incisor	Shell	0.076 ± 0.025	0.048 0.137	.144[b]	0.305 ± 0.190	0.078 0.379	.548[b]	0.257 ± 0.089	0.123 0.403	.909[b]
	Bar	0.089 ± 0.046	0.038 0.201		0.204 ± 0.081	0.116 0.891		0.335 ± 0.120	0.106 0.619	
Canine	Shell	0.085 ± 0.037	0.033 0.152	.135[b]	0.249 ± 0.093	0.096 0.447	.775[a]	0.207 ± 0.118	0.071 0.508	.250[b]
	Bar	0.103 ± 0.063	0.026 0.224		0.310 ± 0.226	0.149 1.045		0.244 ± 0.125	0.110 0.461	
Premolar	Shell	0.118 ± 0.096	0.057 0.442	.870[a]	0.265 ± 0.151	0.069 0.624	.958[b]	0.220 ± 0.072	0.111 0.344	.549[b]
	Bar	0.096 ± 0.036	0.041 0.175		0.320 ± 0.135	0.097 0.529		0.291 ± 0.183	0.093 0.746	
Total	Shell	0.095 ± 0.043	0.064 0.242	.902[a]	0.232 ± 0.063	0.078 0.443	.089[a]	0.235 ± 0.097	0.153 0.324	.948[b]
	Bar	0.095 ± 0.035	0.042 0.042		0.298 ± 0.115	0.158 0.726		0.311 ± 0.154	0.133 0.574	
ANGULAR		Torque (yz) (°)			Tip (xy) (°)			Rotation (xz) (°)		
Incisor	Shell	2.605 ± 0.678	1.613 4.298	.621[b]	1.208 ± 0.336	0.834 1.899	.256[b]	2.129 ± 0.573	1.460 3.391	.909[b]
	Bar	2.445 ± 0.973	1.090 5.295		1.262 ± 0.466	0.461 2.086		2.185 ± 0.469	1.493 2.918	
Canine	Shell	1.954 ± 0.710	0.965 3.248	.775[b]	0.346 ± 0.178	0.100 0.725	.653[a]	1.956 ± 0.708	0.908 3.398	.250[b]
	Bar	2.354 ± 0.902	1.053 4.835		0.498 ± 0.778	0.073 3.273		2.521 ± 0.916	0.745 3.730	
Premolar	Shell	2.181 ± 0.667	1.110 3.408	.358[b]	0.572 ± 0.312	0.184 1.356	.412[a]	2.041 ± 0.590	1.074 3.286	.549[b]
	Bar	2.156 ± 0.539	0.918 2.848		0.701 ± 0.413	0.325 1.966		2.202 ± 0.554	0.861 2.985	
Total	Shell	2.295 ± 0.594	1.576 3.681	.980[b]	0.777 ± 0.225	0.455 1.390	.304[b]	2.050 ± 0.529	1.474 3.150	.948[b]
	Bar	2.313 ± 0.663	1.200 3.795		0.883 ± 0.302	0.429 1.433		2.260 ± 0.523	1.189 2.931	

[a] Mann-Whitney *U*-test. [b] Independent sample *t*-test. Statistical significance: $P < .05$.

Table 3. Intragroup Comparison of Tooth Groups for Shell and Bar Trays

Variables (Transfer errors)	Mean ± SD				Overall difference between tooth groups (*P* values)	Post hoc comparisons (*P* values)
	Incisors (I)	Canines (C)	Premolars (P)	Total		
Shell						
Mesiodistal (x) (mm)	0.076 ± 0.025	0.085 ± 0.037	0.118 ± 0.096	0.095 ± 0.043	.215[b]	
Buccolingual (y) (mm)	0.305 ± 0.190	0.249 ± 0.093	0.265 ± 0.151	0.232 ± 0.063	.319[a]	
Vertical (z) (mm)	0.257 ± 0.089	0.207 ± 0.118	0.220 ± 0.072	0.235 ± 0.097	.342[a]	
Torque (yz) (°)	2.605 ± 0.678	1.954 ± 0.710	2.181 ± 0.667	2.295 ± 0.594	.040*[a]	C/I: *P* = .034*
Tip (xy) (°)	1.208 ± 0.336	0.346 ± 0.178	0.572 ± 0.312	0.777 ± 0.225	.000*[b]	C/I; P/I: *P* = .000*
Rotation (xz) (°)	2.129 ± 0.573	1.956 ± 0.708	2.041 ± 0.590	2.050 ± 0.529	.754[a]	
Bar						
Mesiodistal (x) (mm)	0.089 ± 0.046	0.103 ± 0.063	0.096 ± 0.036	0.095 ± 0.035	.607[b]	
Buccolingual (y) (mm)	0.204 ± 0.081	0.310 ± 0.226	0.320 ± 0.135	0.298 ± 0.115	.483[b]	
Vertical (z) (mm)	0.335 ± 0.120	0.244 ± 0.125	0.291 ± 0.183	0.311 ± 0.154	.123[b]	
Torque (yz) (°)	2.445 ± 0.973	2.354 ± 0.902	2.156 ± 0.539	2.313 ± 0.663	.851[b]	
Tip (xy) (°)	1.262 ± 0.466	0.498 ± 0.778	0.701 ± 0.413	0.883 ± 0.302	.000*[b]	C/P: *P* = .014[b]; C/I: *P* = .000[b]; P/I: *P* = .018[b]
Rotation (xz) (°)	2.185 ± 0.469	2.521 ± 0.916	2.202 ± 0.554	2.260 ± 0.523	.317[a]	

[a] Analysis of variance (ANOVA); Tukey HSD post-hoc test $P < .05$ significant; [b] Kruskal-Wallis $P < .05$ significant.

found to be acceptable (below 0.5 mm) in both groups, whereas torque and rotation deviations were above the acceptance limit of 2°. Additionally, despite no statistical difference between groups, the prevalence of deviated values from clinical acceptance was higher in the bar group compared to the shell group (Table 1).

In an in vitro study comparing tooth groups after IDB with bar-like trays, 2.1% of values exceeded the clinical acceptance limits of linear measurements in the vertical direction, with 83.3% toward the occlusal direction; variations existed among tooth groups.[8] Mesiodistal and buccolingual deviations within 0.5 mm of tolerance were 100%, but differences were found among tooth groups. For angular measurements, incisors displayed greater torque (41.5%; mean: −1.747 ± 0.538) and tip (3.3%; mean: −0.796 ± 0.805) deviations than canines and premolars. The rotation deviation was greater in canines (1.038 ± 0.528°).[8]

Another study on PVS trays found all values within limits but noted differences in mesiodistal measurements between incisors (0.021 ± 0.016 mm) and premolars (0.040 ± 0.026 mm), and in tip measurements between canines (0.225 ± 0.199°) and premolars (0.568 ± 1.280°).[11] In the present study, no statistically significant linear deviation differences were observed between tooth groups. Torque difference was only observed between incisors and canines ($P = .040$) of the shell group. On the other hand, tip deviation was seen between all tooth groups of both the shell ($P = .0001$) and bar ($P = .0001$) trays (Table 3). Tip and torque deviation for the shell and bar trays were more frequently observed in incisors, similar to the findings of Faus-Matoses et al.[8]

Faus-Matoses et al.[8] reported the linear transfer deviations for bar-like trays in the total sample as 0.10 ± 0.08 mm, 0.18 ± 0.14 mm, and 0.10 ± 0.07 mm for the mesiodistal, vertical, and buccolingual directions, respectively, and the angular transfer deviations for torque, tip, and rotation were 2.55 ± 1.98°, 2.01 ± 1.66°, and 2.47 ± 2.09°. These deviations were similar to those found in the bar group of the present study, except for the tip (0.883 ± 0.302°). This may be have been due to the difference in transfer pressure, the measurement methods, or the difference in the type of bracket used.

Clinically unacceptable buccolingual deviations of both trays were predominantly in the buccal direction, similar to the findings of Faus-Matoses.[8] The shell group had a higher prevalence of buccolingual deviations for incisors (41.66%), whereas the bar group showed a greater prevalence of overall differences (Table 1). Since the shell tray was more flexible than the bar tray, it might have stretched toward the buccal due to incisor inclinations. On the other hand, a lower prevalence of buccal movement in canines and premolars for the shell group may have resulted from flexibility of the tray, allowing gentle buccal pressure, and enhancing bracket–tooth adaptation by removing excess adhesive. Chaudary et al.[12] asserted that 3D-printed trays outperformed PVS in buccolingual accuracy due to the higher elasticity of PVS. Chaudary et al.[12] reports that elasticity was seen in the current study as a factor that might increase buccolingual adaptation. Additionally, the quantity of adhesive on the bracket base could contribute to buccal deviations.

The rate of clinically unacceptable total vertical deviation was 19.66% for the bar group (mean: 0.311 ± 0.154 mm); and 10.88% for the shell group (mean: 0.235 ± 0.097 mm). Although the deviation in the gingival direction within the total vertical deviation was greater in the shell group (65.63%), the occlusal deviation was greater in the bar group (64.41%). However, there was no statistically significant difference between the bar and shell groups.

Additionally, the deviation amount was below 0.5 mm of clinical acceptance.

In the study by Niu et al.[10] the vertical deviation was 0.19 ± 0.20 mm, with a prevalence of 3.7%, of which 79.6% were in the occlusal direction, similar to the bar group of this study. The bar-like 3D-printed tray of Faus-Matoses et al.,[8] equivalent to the bar design of the current study in terms of the bracket coverage amount, showed a vertical deviation of 3.6%, of which 54.3% was in the occlusal direction. According to these results, more occlusal deviations can be seen in rigid trays and more gingival deviations in elastic trays.

Niu et al.[10] reported the mesiodistal, buccolingual, torque, tip, and rotation deviations as 0.07 ± 0.06 mm, 0.13 ± 0.15 mm, 3.14 ± 2.91°, 2.25 ± 1.97°, and 1.22 ± 0.90°, respectively. Torque and tip deviations were higher than in the present study (Table 2). The reason for this may have been related to the coverage amount of the tray and its elasticity.

Transfer accuracy might be affected by the tray design (ie, flexibility, bracket coverage amount), fabrication process (ie, sensitivity of 3D printer, IDB resin type), and operator experience (ie, applied pressure during IDB, amount of composite resin placed on mesh base). In this study, all the variables except the tray design were standardized. The use of metal brackets may be one limitation of this kind of research due to reflection of light during intraoral scanning. For clinical purposes, ceramic brackets might be advantageous for preventing light reflection during intraoral scanning.[8,14]

CONCLUSIONS

- There was no significant difference in bonding accuracy between the two groups.
- The most common deviation prevalence was seen for rotation and torque.
- The least common deviations were found in the buccolingual and mesiodistal directions.
- The linear transfer accuracy was higher than the angular transfer accuracy. According to the mean table, only the torque and rotation deviations were above the ABO limits.
- The amount of tip deviation that differed between tooth groups was, in ascending order: canines, premolars, and incisors for the shell and bar groups.
- The teeth most affected by tip deviation were the incisors in both groups.
- In the group using shell trays, which were more flexible, torque deviation in the incisors was higher than in the canines.
- In clinical use, shell trays are suggested for ease of handling and removal and for showing lower ABO-OGS deviations.

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