ORIGINAL RESEARCH

Comparison of Bracket Failure Rate between Two Different Materials Used to Fabricate Transfer Trays for Indirect Orthodontic Bonding

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Abstract

Background: Various techniques have been advocated for over half a century for the fabrication of transfer trays for indirect orthodontic bonding. Authors have aimed to provide better light curing and accuracy of bracket positioning to avoid bracket failure and get the best possible results. Aim: This study is aimed to compare bracket failure rate when transfer trays were fabricated with a glue gun material and polylactic acid (PLA) filament for an indirect bonding procedure.

Materials and methods: Customized transfer trays were fabricated using a glue gun material and PLA filament, and an indirect bonding procedure was performed. Bracket failure was assessed at regular intervals with adhesive remnant index (ARI) scoring, and reasons for bracket failure were assessed.

Results: Kolmogorov–Smirnov test was employed to test the normality of data. A Chi-square test was performed for the quantitative variables. Results showed higher bracket failure in the PLA transfer tray groups and in the mandibular arch, especially in the posterior region. Adhesive remnant index scores of 2 followed by 3 were prevalent, and the most common reason for bracket failure was an excessive force during PLA transfer tray retrieval followed by masticatory forces.

Conclusions: Both the transfer tray methods are effective for an indirect bonding procedure. Polylactic acid transfer trays showed more bracket failure as compared to glue gun transfer trays, especially in the mandibular posterior region due to excessive force applied during tray retrieval.

Clinical significance: This study aims to provide valuable information regarding the efficiency of various in-house methods of fabricating customized transfer trays and their effect on bracket failure rates.

Keywords: Bracket failure, Glue gun material, Indirect bonding, PLA filament, 3D printing pen, Transfer tray.

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Background

The process of aligning and creating a harmonious, esthetic smile involves the orthodontic treatment, which is carried out with the help of orthodontic brackets. These brackets can be bonded directly or indirectly on the teeth of the patient willing to undergo orthodontic treatment. The process of positioning the brackets on the working models followed by the fabrication of the transfer tray in the laboratory is termed indirect bonding.[1]

Various authors have proposed different materials used to fabricate the transfer trays. Moin and Dugon[2] used polyether material, while Thomas[3] used a thermoplastic sheet adapted over the working model using a vacuum former. A transparent material was used to fabricate transfer trays by Read and O'Brien[4] and Read and Pearson[5] so that light-cure resin could be used instead of self-cure resin, and Hickman[6] in 1993 developed a "dual-tray" transfer system for a chemically cured composite. Moskowitz et al.[7] used Reprosil vinyl polysiloxane impression material, while Kasrovi et al.[8] in 1997 used opaque transfer trays and provided direct access and visualization to the brackets. White[9] used hot glue to make the matrix around the brackets, and Vashi and Vashi[10] used a thermoplastic impression compound along with thermoplastic glue to increase the rigidity of transfer trays. Bhardwaj et al.[11] used a soft transfer tray made up of a vacuum-formed thermoplastic material, while Madhusudhan et al.[12] prepared gelatin jigs over brackets for additional retention and transfer trays were fabricated using a 2-mm thick Bioplast. Aileni et al.[13] used glue gun material to form customized trays, and Kulkarni et al.[14] used PLA filament to add rigidity to customized transfer trays.

Bracket failure leads to an increase in the orthodontic treatment duration and inferior results, and it is a setback in the treatment procedure. Indirect bonding helps in finer bracket positioning as the study model can be viewed from different directions when deciding their placement on a particular set of teeth, which further aids in better treatment results.[14]

The configuration of the transfer tray plays a vital role in the efficient curing of the composite by allowing sufficient light to penetrate to obtain an optimum bond strength. Glue gun and our technique of transfer tray fabrication using PLA filament were easy

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to fabricate and economical and aided in optimal light curing of the adhesive resin.[13,14]

When the literature was appraised, we could not find any literature for comparison in the aforementioned pretext. Hence, an attempt was made to compare the bracket failure rate between transfer trays made using a glue stick and PLA filament used for indirect orthodontic bonding of brackets.

Materials and Methods

A split-mouth design was applied by dividing each half of the maxillary and mandibular arches into the right and left sides with the help of the Microsoft Excel randomization tool. In that chart, 1 denoted the glue gun method and 2 indicated the PLA method. The type and side of allocation of methods were written on blank paper and sealed in an opaque envelope. The participant selected the sealed envelope randomly. The transfer tray was fabricated as per the technique allocated in the sealed envelope. Ethical approval was obtained from Sumandeep Vidhyapeeth Institutional Ethics Committee (SVIEC/ON/Dent/RP/21004).

G Power Software was used to estimate the sample size of the study. The significance level was fixed at 5%, and a p-value of ≤0.05 was considered statistically significant with an effect size of 0.60, an alpha error of 0.05, and a power of 0.80. A sample estimate of 27 was obtained. Considering a dropout ratio of 20%, a total of 35 patients were included.

Selection Criteria: 35 patients having full permanent dentition, no history of orthodontic treatment, mild-to-moderate crowding, sound buccal enamel surface, and no history of chemical treatment of tooth surfaces within the age range of 18–35 years and who agreed to provide informed consent were included. Participants having congenital syndromes, developmental anomalies and craniofacial abnormalities, obvious facial asymmetry, prosthetic replacement in the region of second premolar to the contralateral premolar in both upper and lower arches, and those with orthognathic surgery as part of their treatment were excluded from the study.

The two types of transfer trays were fabricated according to the techniques advocated by Aileni et al.[13] (Fig. 1A) over one half and Kulkarni et al.[14] (Fig. 1B) over the other half over the working models as per the allocation derived from randomization and retrieved (Fig. 2).

The bonding procedure was carried out, and the teeth were etched with 37% orthophosphoric acid for 30 seconds, rinsed thoroughly with water to ensure complete removal of the etchant, air-dried, and primed using a light-cure adhesive primer (Transbond XT Light Cure Adhesive Primer; 3M Unitek). Composite was applied to the bracket base and placed in the mouth (Figs 3A and B), and flash was removed using a probe (Figs 3C and D). The composite was light-cured for 30 seconds per tooth with an LED curing light. The distance between the exit window and adhesive was kept minimum for optimum polymerization of the adhesive resin. The tray was then retrieved from the oral cavity (Figs 3E and F). Figure 4 depicts completely bonded teeth.

Bracket failure was recorded at standardized appointment intervals of 4 weeks till the completion of treatment, and the participants were asked for the reason for bracket failure. During the treatment, a first-time bracket failure was recorded for each bracket, and subsequent bracket failures were not recorded. In addition, the participants were instructed to call and visit the doctor immediately in case any bracket gets debonded. The ARI score was utilized to categorize the failure mode.[15]

Statistical Analysis

The data collected were entered in Microsoft Excel and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS, IBM version 20.0). Kolmogorov–Smirnov test was employed to test the normality of data. A Chi-square test was performed for the quantitative variables to determine the significance.

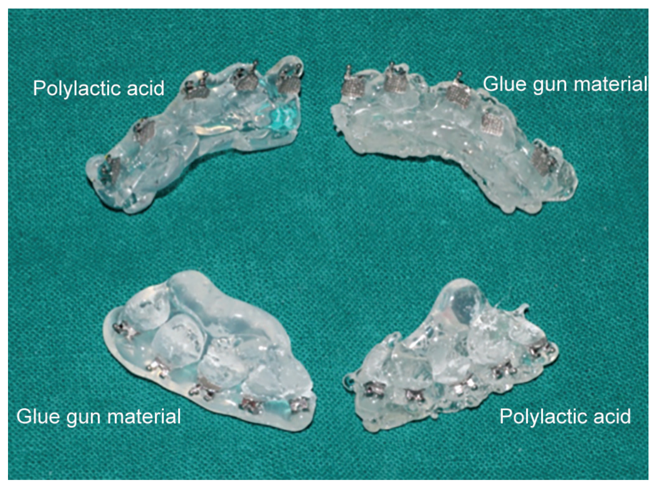
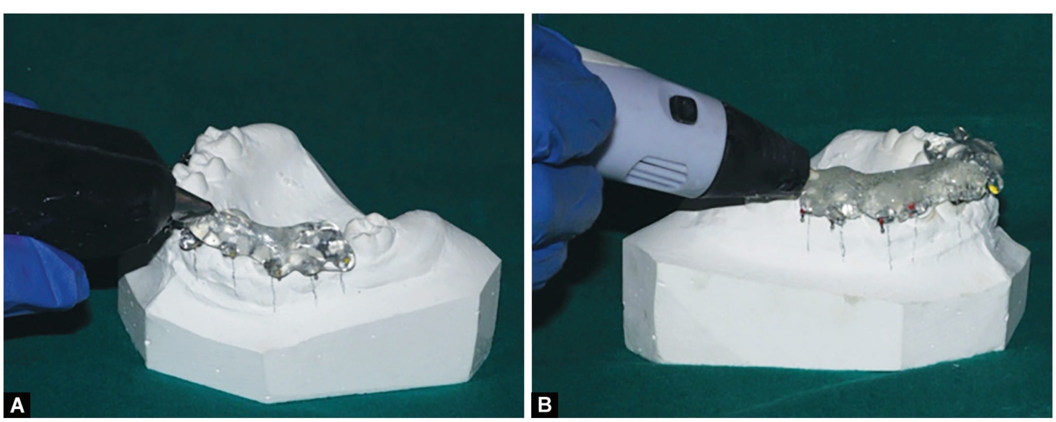
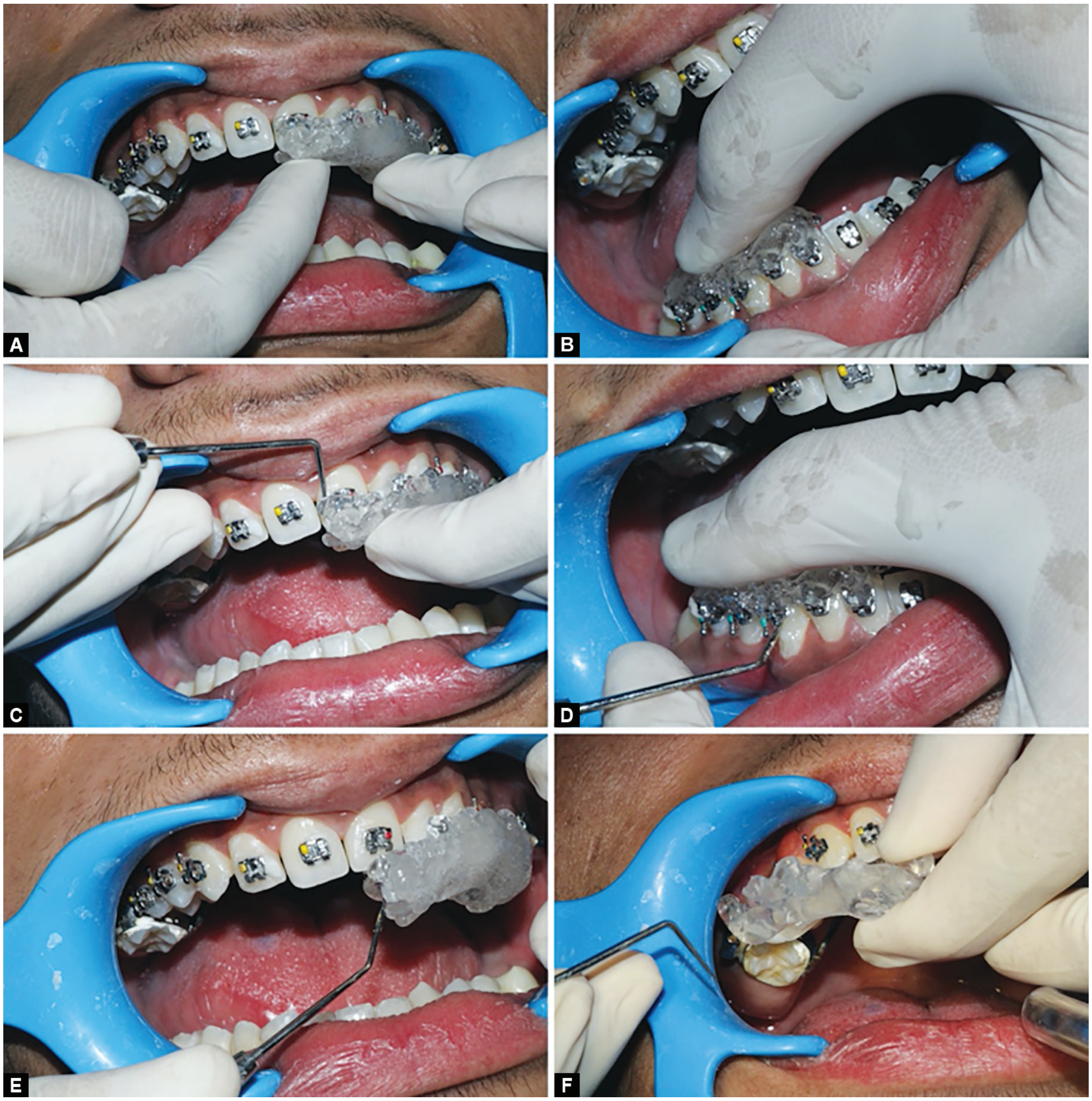


Fig. 2: Transfer trays after retrieval from cast



Figs 1A and B: Tray fabrication: (A) Glue gun material; (B) PLA filament



Figs 3A to F: Clinical procedures: (A and B) Tray placement; (C and D) Flash removal; (E and F) Tray retrieval from the oral cavity

Fig. 4: Bonded teeth

Results and Observation

The present study was carried out to evaluate and compare the bracket failure rate between transfer trays fabricated with glue sticks and PLA filament for indirect orthodontic bonding. The results are based on an analysis of 35 patients evaluating and comparing the bracket failure rate.

A significant proportion of the study participants were females (57.1%). The mean age of the male and female participants was 20.80 ± 3.34 and 20.70 ± 2.79 years, respectively.

Table 1 depicts the bracket failure rates in maxillary and mandibular arches. A higher bracket failure was seen in the PLA method in both maxillary (21) and mandibular (49) arches with maximum failures in the mandibular arch (49) when the PLA method was employed for transfer tray fabrication.

The evaluation of bracket failure by tooth types bracket failure in maxillary and mandibular arches is represented in Table 2. A comparative evaluation revealed minimal failures in the central

Table 1: Bracket failure rates in maxillary and mandibular arches

		Maxillary arch		*Mandibular arch*	
Study group	*Total (n)*	*Failures (n)*	*Failure rate*	*Failures (n)*	*Failure rate*
Glue gun method	175	16	9.14%	31	17.71%
PLA method	175	21	12%	49	28%
Overall	350	37	10.57%	80	22.85%

Table 2: Evaluation of bracket failure by tooth types in maxillary and mandibular arches

	Maxillary arch		*Mandibular arch*	
Tooth type	*Glue gun method*	*PLA method*	*Glue gun method*	*PLA method*
Central incisor	1	1	5	10
Lateral incisor	1	1	3	5
Canine	1	1	1	2
First premolar	6	8	10	13
Second premolar	7	10	12	19
p value	0.033*		0.088	

Table 3: Comparative evaluation of reasons for bracket failure among the two groups

Reason for bracket failure	*Glue gun method*	*PLA method*	*p value*
While eating/chewing/biting	20	22	
While brushing	10	9	
Excessive force applied during tray retrieval	8	26	
Lack of isolation during a bonding procedure	9	13	0.046*
Total	47	70	

Table 4: Adhesive remnant index scores among the two groups

ARI score	*Glue gun method n (%)*	*PLA method n (%)*	*p value*
0	10 (21.27%)	9 (12.85%)	
1	11 (23.40%)	7 (10%)	
2	14 (29.78%)	33 (47.14%)	
3	12 (25.53%)	21 (30%)	0.034*
Overall	47 (100%)	70 (100%)	

incisor (1), lateral incisor (1), and canine (1) by the glue gun and PLA method in the maxillary arch and canine by glue gun method in the mandibular arch. Maximum failure was reported in the second premolar followed by the first premolar by both glue gun and PLA method in the maxillary and mandibular arches. The highest failure was observed with the lower second premolar (19) in the PLA group.

As observed in Table 3, a comparative evaluation of the reasons for bracket failure among the two groups revealed a significant difference between the two groups (p-value = 0.046), with the PLA method showing the maximum number of bracket failures (70). Excessive force applied during tray retrieval caused the maximum number of bracket failures in the PLA group (22). Eating/chewing/biting were the reasons for bracket failure reported in a majority of proportion in both the groups combined.

Table 4 shows the evaluation of the ARI scores among the two groups. A comparative evaluation revealed a significant difference (p-value = 0.034) between the two groups. A more substantial proportion of score 2 (47.14%), followed by score 3 (30%), was seen in the PLA method.

Discussion

Indirect bonding techniques were developed to improve the bracket placement accuracy, reduce chairside time, and avoid bracket failures, thus decreasing the treatment duration. However, these systems have not consistently demonstrated such results.[9,16,17] Despite the advantages of indirect bonding, difficulty in isolation of posterior teeth and problems with composite flash and inadequate bond strength have reduced its clinical popularity.[18]

The critical components in the indirect bonding technique comprise positioning the brackets precisely on the working model with a suitable interface that aids in the adherence of the brackets to the working model. The configuration of the transfer tray also plays a vital role in transferring the registered position of the brackets on the working model to the oral cavity. The type of adhesive and the amount of light permitted through the transfer tray for efficient curing of resin affects the bond strength outcome in the oral cavity.[18]

There are various products available like bracket-positioning devices, newer adhesives, and advanced light-cured systems, but the challenge remains in choosing the best and superior technique.[19] Continuous efforts are being made to make the indirect bonding superior and efficient from the previous debacles it suffered during the previous years.

There has been a multitude of materials used for the construction of transfer trays, with their advantages and disadvantages as mentioned in Table 5, and the extent of this has been left only to the

Table 5: Advantages and disadvantages of various indirect bonding transfer tray techniques

Sl. No.	*Author*	*Materials used to fabricate trays*	*Advantages*	*Disadvantages*
1	Moin and Dugon[2]	Polyether material	Sufficient time for bracket placement	Costly and additional material
2	Thomas[3]	Thermoplastic sheet adapted over the working model using a vacuum former	Good adaptation, minimal flash, and easy cleanup	Suitable only for chemical curing
3	Read and O'Brien[4] and Read and Pearson[5]	Transparent material was used to fabricate transfer trays	Facilitated the use of light-cured adhesives	Difficult flash removal
4	Hickman[6]	"Dual-tray" transfer system with chemically cured composite	High accuracy	More inventory, additional cost, less working time
5	Moskowitz et al.[7]	Reprosil vinyl polysiloxane impression material along with clear thermoplastic material	Flexible, yet accurate trays	Additional cost and it is opaque, no light penetration
6	Kasrovi et al.[8]	Opaque transfer trays and provided direct access and visualization to the brackets	Easy flash removal and direct light curing	Technique-sensitive
7	White[9]	Hot glue to make the matrix around the brackets	Dual nature, expressed through flexibility, ease of removal of trays	Accuracy is questionable
8	Vashi and Vashi[10]	Thermoplastic impression compound along with thermoplastic glue to increase the rigidity of transfer trays	Accurate bracket positioning	Opaque, no light penetration
9	Bhardwaj et al.[11]	Soft transfer tray made up of vacuum-formed thermoplastic material	Ease of usage	Compromised accuracy due to the flexibility of the tray
10	Madhusudhan et al.[12]	Prepared gelatin jigs over brackets for additional retention, and transfer trays were fabricated using 2-mm thick Bioplast	Increased working time due to the use of a light-cure adhesive	Additional laboratory procedures and increased material cost
11	Aileni et al.[13]	Thermal glue gun technique	Flexibility of tray helped in easy tray retrieval	Compromised accuracy due to the flexibility of the tray
12	Kulkarni et al.[14]	PLA method	Rigidity of tray provided accuracy and ease of flash removal	Difficulty in tray removal caused debonding of brackets

imagination. The tray materials used in this study, after reviewing the literature, were PLA[14] and thermal glue gun material.[13]

While devising new techniques, various authors tried to include characteristics like good adaptation to bracket and tissues for accuracy, transparency of trays to facilitate light curing, and flexibility to ensure easy retrieval of the trays. However, there were certain common disadvantages, including requiring additional material and inventory, a higher cost, the opaqueness of the trays, and difficulty in flash removal. Considering these advantages and disadvantages, a flexible and rigid transfer tray technique was chosen for comparison.

The tray material used in the study was thermal glue gun material; it is flexible, economical, and transparent. The material's flexibility provides close adaptation on the tooth surface and offers good retention to hold the brackets. However, the thermal glue material[13] displayed some deformation of the tray during tray placement and removal that may affect the precision of bracket placement intraorally.

The other method of transfer tray preparation employed in this study was based on another clinical technique that utilized PLA filament.[14] The stiffness and dimensional stability of PLA material dismissed the limitation of tray distortion, as seen with the thermal glue material. A difficulty in tray retrieval after the indirect bonding procedure was observed, which led to an increased bond failure rate.

Both the transfer trays were not extended to cover the entire buccal surface but were extended only up to the bracket gingival wings (not under it) for ease of removal and maximum light curing. Care was taken to maintain the adequate thickness of the tray to provide desired dimensional stability of the transfer tray.

The indirect bonding procedure was carried out according to the authors' instructions.

Initially, bond failure rates for indirect bonding (13.9%) were higher when compared with direct bonding (2.5%).[20] However, with modifications and improvements to the techniques, the two systems now have similar bond strengths and failure rates.

Most clinical studies on bond failure with indirect bonding attributed the failure to the adhesive material without taking into consideration the effect of the transfer tray in the case of severe malocclusion.[4,21]

This study comprised 20 females and 15 males. There was no difference in the mean age of males and females in this study. It was a split-mouth study, which provided a similar oral environment for the brackets placed with both the transfer tray systems; hence, it eliminated the selection bias. The randomization procedure was carried out using the Microsoft Excel randomization tool, which is easy to operate and help in the equal distribution of the two transfer tray methods being compared.

The mandibular arch showed more bracket failure than the maxillary arch (Table 1). These results resemble the results of a study by Linklater and Gordon[22] and Khan et al.[23] They concluded that mandibular brackets show bond failure more often due to interferences from overlapping maxillary teeth, which cause bracket failure during biting and chewing. The PLA method showed more bracket failure in the maxillary and mandibular arches. However, the mandibular arch invariably showed more bracket failure.

Increased bracket failure was observed in the posterior teeth than those in the anterior teeth (Table 2) for both the arches. These results were similar to a comparative clinical trial by Mavropoulous et al.,[24] who concluded that bracket failure in the posterior region was three times higher than that in the anterior region. In the anterior region, lower incisors showed maximum bond failure among the anterior teeth of both the arches. This is primarily due to excessive overlapping of teeth and hindrances during biting.

The reasons for bracket failure were assessed; masticatory forces were the most common reasons observed for bracket failure for both methods. However, the PLA group had a significantly higher bracket failure than glue gun material during tray retrieval, especially posteriorly. The reasons for bracket failure when the glue gun method was used showed maximum failure due to chewing/eating/biting. This may be prevalent due to the trays not adapting closely to the teeth because of their flexibility. At the same time, the rigidity of PLA transfer trays caused difficulty in retrieving the trays from the brackets (Table 3).

Most of the bracket failures showed an ARI score of 2 followed by 3 for both the transfer tray systems. The observation of this study is in agreement with a study by Ahmed et al.,[25] who assessed the ARI for direct bonding procedure (Table 5).

Some limitations of this study included difficulty in removal of the PLA transfer tray, dimensional and positional instability of glue gun transfer tray, and difficulty in maintaining isolation during the indirect bonding procedure. Improvisation in the transfer tray design is needed to facilitate their easy removal. Modifications in the transfer tray may require a combination of the two materials, that display the characteristics of both, hard and soft materials. A further study will be required to assess its effectiveness in indirect bonding and improvisation for bonding in the posterior region.

Conclusions

Both glue material and PLA filament can be used for the fabrication of transfer trays for indirect bonding procedures. Both the transfer tray materials showed bracket failures, with maximum brackets showing an ARI score of 2 followed by 3. PLA method invariably showed more bracket failure during tray retrieval. Maximum bracket failure was observed for mandibular brackets, especially in the posterior region.

Clinical Significance

This study aims to provide valuable information regarding the efficiency of various in-house methods of fabricating customized transfer trays and their effect on bracket failure rate. This study shows that the indirect bonding procedure does not need to be an expensive laboratory procedure that is usually outsourced, and it can be performed easily at any place with minimal armamentarium.

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