

Comparison of accuracy of bracket placement between direct and indirect bonding techniques –An in-vivo study

Priyanka Agarwal¹, Rohit Kulshrestha^{2,*}

¹Senior Lecturer, Dept. of Orthodontics & Dentofacial Orthopaedics, Haldia Institute of Dental Sciences & Research, Haldia,

²Consulting Orthodontist, Private Practitioner, Mumbai

***Corresponding Author:**

Email: kulrohit@gmail.com

Abstract

Aim: The aim of this study was to compare the accuracy of bracket placement between direct and a new indirect bonding technique.

Material and Methods: 25 patients requiring upper and lower pre-adjusted edgewise appliances were taken for the study and subjected to a split mouth system of allocation of bracket bonding. The labial aspect of the dentition of each patient were divided into upper and lower segment drawing 50 samples from 25 patients. In each segment, half of the quadrant was bonded with direct bonding technique and the other half of the quadrant was bonded by the new technique of indirect bonding randomly. Bracket placement accuracy was measured in 3 ways, inciso-gingival, mesio-distal and angular measurement.

Results: Central Incisor Group: The inciso-gingival and mesio-distal parameter showed a minor statistical significance ($p < 0.005$) whereas the variation in the group of Angular measurements was comparatively higher ($p < 0.002$). Lateral Incisor Group: The inciso-gingival and mesio-distal parameter showed a minor statistical significance ($p < 0.005$) whereas the variation in the group of Angular measurements was comparatively higher ($p < 0.001$). Canine Group: The inciso-gingival and mesio-distal parameter showed a minor statistical significance ($p < 0.005$) and ($p < 0.004$) respectively whereas the variation in the group of Angular measurements was comparatively higher ($p < 0.001$). Overall, in all three groups, though there was a statistical difference, it was very minor (fraction of millimetre), however comparatively large error was found in angular measurements

Conclusion: Indirect bonding is more accurate than direct bonding in following aspects: vertical, horizontal and in angulation. The magnitudes of the findings are of clinical relevance.

Keywords: Indirect bonding, Bracket placement, Transfer tray

Introduction

Orthodontists have always made a mark for themselves in the arena of smile corrections but so far they were only skill oriented but now they are also slowly changing to perfection with skill and advances in materials and techniques. "The best results in the present and in future will be achieved by those Orthodontists who are best at accurate bracket positioning" as quoted by TM Graber. There is a large increase in the use of the straight wire or pre-adjusted appliance (PEA) in Orthodontics and practitioners are switching their focus from accurate wire bending to accurate bracket positioning.⁽¹⁾ The main aim of modern orthodontics is to create the finest occlusal relationship within the framework of acceptable facial aesthetics and stability, which requires positioning the crown of each individual tooth in its appropriate position for optimum function and appearance with the advent of pre-adjusted appliance.⁽²⁾ Great emphasis is being laid on accurate bracket positioning for the efficient application of biomechanics and for utilizing the full potential of PEA appliance. The advent of pre-adjusted appliances has increased the importance of accurate bracket placement.⁽³⁾ Originally Angle had taught that the best position of the band was where it fits better mechanically. Then, if possible the bracket should be placed at the centre of the labial surface of the tooth.

Rickets advocated the use of marginal ridges as guidelines for band and bracket vertical positioning.⁽⁴⁾

Improvements in bracket design were made incorporating tip, torque, rotations and the differences in bases thickness beginning with Angle in 1928 and more recently with Andrews in 1970 who introduced the straight wire concept in pre-adjusted orthodontic appliance.⁽⁵⁾ It has been widely recognised for many years that accurate bracket positioning is of critical importance in the efficient application of biomechanics and in realising the full potential of pre-adjusted edgewise appliance. Andrews used facial axis of clinical crown (FACC) as a guideline and believed that its middle point is reliable location to use in straight wire appliance (SWA). Mc Laughlin and Bennett proposed a table to determine vertical height of bracket. The most commonly used gauge for measuring vertical height are Height bracket positioning gauge (HBPG) and Boons gauge (BG).⁽⁵⁾

The advent of pre-adjusted appliances has increased the importance of direct bonding. However there are some inherent short comings with the direct bonding technique, including poor visualization of posterior teeth, greater possibility of moisture contamination, and increased doctor chair side time. To reach these goals in 1972, Silverman and Cohen introduced the indirect bonding technique to place brackets on teeth more accurately and efficiently in the

clinic.^(6,7) In indirect bonding the brackets are first placed accurately on the patients cast. They are transferred to the patient's mouth by a custom made transfer tray. This helps in accurate bracket positioning.⁽⁸⁾ Zachrisson defined indirect bonding as a "technique in which the brackets are attached to the teeth on the patient's models, transferred to the mouth with some sort of tray into which the brackets become incorporated, and then bonded simultaneously."⁽⁹⁾ Direct bonding of brackets is still the most popular method of attaching brackets to teeth but indirect bonding is increasing in popularity. In 1990, 7.8% of practitioners used indirect bonding where as by 2008 the number had increased to 13.2 %.⁽¹⁰⁾ Compared to direct bracket placement methods, indirect bracket placement method is more accurate because of the ability to see the bracket position from many different angles and also it helps in reducing the chair side time of the patient and the operator.⁽¹¹⁾ Recent studies have shown that there has been no difference in bracket positioning accuracy by both the techniques.⁽¹²⁻¹⁴⁾ To fill this lacuna this study was done to compare the accuracy of bracket placement between direct versus a new indirect bonding technique.

1. Vertical bracket position (occluso-lingual)
2. Mesio-distal bracket position (horizontal)
3. Angulation of bracket

Materials and Method

This prospective study was conducted on the patients seeking orthodontic treatment in the Department of Orthodontics, Guru Nanak Institute of Dental Sciences and Research, Kolkata. Consent was taken from all the patients involved in the study. Inclusion criteria consisted of

- Patient's with all permanent teeth up to 2nd molars..
 - Patient's with alignment of teeth enough to permit ideal bracket placement.
 - No previous orthodontic treatment
 - No systematic diseases
- Exclusion criteria -
- Subjects with attrition, fractured/restored incisal edges or cusp-tips.
 - Apparent tooth size discrepancy.
 - Where observation of the mesio-distal and angular position of the brackets is obscured by crowding.
 - Patients with retained deciduous teeth.

Twenty five patients requiring upper and lower pre-adjusted edgewise appliances satisfying the inclusion criteria were selected for the study. Each patient was subjected to a split mouth system of allocation of bracket bonding. The labial aspect of the dentition of each patient were divided into upper and lower segment drawing 50 samples from 25 patients. In each segment, half of the quadrant was bonded with direct bonding technique and the other half of the

quadrant was bonded by the new technique of indirect bonding randomly. The split mouth technique was used because each patient could act as their own control, which in turn allowed a reduction in total sample size without adversely affecting validity. Direct bonding technique was done by standard bonding protocols. The new indirect bonding technique is described as follows, alginate impressions were obtained by using impression trays and casts were poured using dental Orthokal.

The vertical facial axis of the clinical crowns were marked with 0.3 mm marking pencil on the working model by measuring the mesio-distal width of each tooth with the help of digital caliper (classic digimatic caliper). The inciso-gingival length was measured with digital caliper and these measurements were rounded up as whole number nearer to it (mm), in order to match with the recommended MBT bracket positioning chart. Markings were done with the help of Height bracket positioning gauge and 0.3mm marking pencil. 3M Unitek MBT brackets were placed using bracket holder on the markings made on the working cast with the help of starch (paste of rice). The separating medium (cold mould seal) was applied on the cast; transfer tray was prepared by flowing molten glue from the glue gun and covered the brackets only partly under occlusal wings. The tray was removed with braces attached to it once the glue was set and the same is kept in water in order to remove the residues of starch attached to the bracket mesh (Fig. 1).

The prepared transfer tray was placed in patient's mouth and checked for any error. Then after removal of the tray, proper isolation was done by using cotton rolls and tweezers. Etchant was applied on the labial tooth surface in the quadrant selected for indirect method. Etchant was washed with water after 20 seconds and the tooth surface was dried, primer was applied on all the dried teeth followed by application of composite on the bracket embedded in the transfer tray, the tray was then seated in the patients mouth and curing was done for 40 seconds using light cure unit.



Fig. 1: Fabrication of transfer tray

Measurement Technique: After direct and indirect bonding on the patient, the rubber base impression was obtained and the cast was poured using Orthokal. Photographs of each tooth were taken (Canine to Canine) in the patient's mouth by focusing on the centre of each tooth using Nikon DSLR camera.

Vertical Bracket Positioning: The errors in vertical bracket positioning were measured for direct and indirect bonding technique by using digital caliper (Fig. 2). The measurements were calculated from incisal edge of the tooth to the centre of the bracket on the cast as well as in the patients mouth (for greater accuracy) and compared with the recommended chart used for bonding of above two techniques.



Fig. 2: Measurement of bracket positioning by using Digital Caliper

Mesio Distal Bracket Position: The vertical facial axis of each tooth was drawn using digital caliper and the line was drawn from the centre of the each bracket. The mesio distal bracket positioning values were obtained by measuring the distance between the two lines i.e. vertical facial axis line of tooth and the line drawn from the centre of the bracket with the help of digital caliper.

Angulation of Bracket: Photographs which were taken of each tooth in the patient's mouth by focusing on centre of the tooth were used for the measurement of angulations of brackets by using Surface Protractor software (Windows 10, Drawboard 5.0 app) (Fig. 3).



Fig. 3: Measurement of angulations of brackets by using Surface Protractor software

Statistical Analysis: For statistical analysis data were entered into a Microsoft excel spreadsheet and then analysed by SPSS 10.0.1 and GraphPad Prism version 5. Data has been summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables. The median and the inter-quartile range have been stated for numerical variables that are not normally distributed. Student's independent sample's t-test was applied to compare normally distributed numerical variables between groups, Unpaired proportions were compared by ANOVA, a Parametric Test for Inequality of Population Means, as appropriate.

Results

All the parameters (Vertical, Horizontal and Angular) showed a minor significant variation in vertical and horizontal errors (in fraction of millimetre) and comparatively more errors in angulations. Intra-group variation for each group was as follows, Central Incisor Group: The inciso-gingival and mesio-distal parameter showed a minor statistical significance ($p < 0.005$) whereas the variation in the group of Angular measurements was comparatively higher ($p < 0.002$) (Table 1). Lateral Incisor Group: The inciso-gingival and mesio-distal parameter showed a minor statistical significance ($p < 0.005$) whereas the variation in the group of Angular measurements was comparatively higher ($p < 0.001$) (Table 2). Canine Group: The inciso-gingival and mesio-distal parameter showed a minor statistical significance ($p < 0.005$) and ($p < 0.004$) respectively whereas the variation in the group of Angular measurements was comparatively higher ($p < 0.001$) (Table 3). Overall, in all three groups, though there was a statistical difference, it was very minor (fraction of millimetre), however comparatively large error was found in angular measurements.

Table 1: Comparison of inciso-gingival, mesio-distal and angular measurement of direct and Indirect Central incisor group

Vertical	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	.5268	.1315	0.3000	0.9000	0.5100	5.4774	<0.0001
Indirect	.2568	.2085	0.0700	1.1000	0.2000		

Horizontal	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	.5648	.1624	0.1200	0.8900	0.5600	7.1558	<0.0001
Indirect	.2084	.1888	0.0600	0.7000	0.1500		

Angular	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	1.4636	.4354	0.3400	2.6400	1.4200	7.9354	<0.0001
Indirect	.5772	.3498	0.2800	1.7000	0.4500		

Table 2: Comparison of inciso-gingival, mesio-distal and angular measurement of direct and Indirect Lateral incisor group

Vertical	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	.5332	.1237	0.3900	0.9000	0.5100	5.6073	<0.0001
Indirect	.2620	.2078	0.0700	1.1000	0.2100		

Horizontal	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	.5828	.1334	0.4000	0.8900	0.5100	8.0955	<0.0001
Indirect	.2088	.1886	0.0600	0.7000	0.2100		

Angular	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	1.4900	.3810	1.0000	2.6400	1.4200	9.5773	<0.0001
Indirect	.5388	.3185	0.2800	1.7000	0.4300		

Table 3: Comparison of inciso-gingival, mesio-distal and angular measurement of direct and Indirect Canine group

Vertical	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	.5332	.1237	0.3900	0.9000	0.5100	5.6073	<0.0001
Indirect	.2620	.2078	0.0700	1.1000	0.2100		

Horizontal	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	.5828	.1334	0.4000	0.8900	0.5700	8.0955	<0.0001
Indirect	.2088	.1886	0.0600	0.7000	0.1500		

Angular	Mean	SD	Minimum	Maximum	Median	t-test	p-value
Direct	2.4900	.3810	1.0000	2.6400	1.4200	0.4418	0.0002
Indirect	1.2416	.4973	0.2800	3.0000	0.4500		

Discussion

Evolution of pre- adjusted appliances increased the importance of accurate bracket placement. The outcome and efficiency of orthodontic care are influenced by numerous variables including errors in bracket placement, manufactures tolerance, operator acuity and fatigue and ability to accurately monitor treatment. According to Anoop Sondhi (1999),⁽¹⁴⁾ the advent of direct bonding improved the clinician’s ability to position the brackets more accurately than when using bands. We conducted this study from canine to canine in upper and lower arch because according to T.M.

Hodge⁽³⁾ (2004) aesthetic consequences of incorrect bracket positioning are more serious on anterior teeth than elsewhere in the mouth and also due to extraction of 1st or 2nd premolars in most of the cases hamper the accuracy of indirect bonding with the technique we have used in this study. As the study is done in the patients seeking orthodontic treatment in GNIDSR, Kolkata, according to academic protocol 1st molars are banded. Thus we chose to conduct study on canine to canine.

This study was conducted by single operator, direct and indirect bonding is done in alternate quadrants in

the study samples to reduce the bias in the results achieved. Armestong et al.⁽³⁷⁾ concluded that accurate direct bonding of orthodontic brackets to teeth does not appear to be related to clinical experience or specialist training. Here in the study we have used Height Bracket Positioning Gauge to measure the vertical height of the tooth to place the bracket. Armestong et al.⁽³⁷⁾ in another study, compared accuracy of bracket positioning, localizing the centre of the clinical crown and measuring the distance from the incisal edge. They reported that bracket bonding guided by measuring the distance from incisal edge may result in improved placement for anterior teeth. Mohammadi et al.⁽⁷⁾ compared the accuracy of bracket placement with Height Bracket Positioning Gauge (HBPG) and Boone Gauge and concluded that the use of HBPG gauge results in less vertical error and better accuracy in bracket positioning in comparison to Boone Gauge. Thus, recommended HBPG gauge.

For this study we have considered McLaughlin and Bennett proposed table to determine vertical heights of brackets. According to Mohammadi et al.⁽⁷⁾ at first the length of clinical crowns which are completely erupted is measured. Then, a row of McLaughlin and Bennett proposed table which has the closest numbers to the obtained measures is selected and brackets are placed in the proper position by means of gauge. In this method, in addition to the use of clinical crown centre, a gauge is used to increase vertical precision. In this study we used starch (paste of rice) to attach bracket to the working model in indirect bonding. According to Anoop Sondhi,⁽¹³⁾ initially they used candy to position the bracket on the teeth, and chemically cured resins to bond the brackets to the teeth. This generally resulted in excessive flash, and clean up was a significant problem. In addition, the laboratory time was excessively high. Different glues have been tried over the years, but only with moderate success. Heat cured resins subsequently entered the market, but several clinicians have experienced problem with bracket floating while heating the resin.

This is aggravated by the fact that the model must be heated to 350° for approximately one and half hour to cure the resin (Thermacure, Reliance Orthodontic Products). Further, ceramic brackets could not be exposed to such heat and had to be placed separately after the metal brackets had been heat cured, a cumbersome procedure. Current techniques for bonding tray placement use chemically cured sealants or bonding resins. Thus we tried this new technique of attaching bracket to the working model with the starch. We have used glue gun with glue to prepare a transfer tray for indirect bonding procedure. M.R. Balasubramaniam et al, according to him, the development of transfer trays for indirect bonding made the use of light cured adhesives possible. The most commonly used materials for making indirect bonding trays are either silicon impression material or vacuum

formed resin. A major disadvantage of the transparent transfer trays was that it required vacuum forming equipment's like the Biostar, Droformat, Drosoft etc. These equipments were expensive and the orthodontist needed to have a good laboratory support. Larry white introduced a cost effective indirect bonding technique using a hot glue gun for making transparent transfer trays. The hot glue matrix offered a simple, reliable and inexpensive method for transferring brackets onto the teeth accurately.⁽³⁸⁾ Although there appears to be no difference in shear bond strength between brackets that are bonded directly or indirectly, there does seem to be a difference of opinion as to the level of accuracy that can be achieved with each. For angular measurements we have used photographic method and then photos were selected in a surface protractor software to measure the angulations errors. According to Lahcen et al(2011),⁽²³⁾ the photographic assessment is a reliable way to study the position of the bracket, provided the same protocol and the same parameters are followed. In our study comparison between the two techniques of bracket placement on Central incisor, Lateral incisor and Canine showed that the Indirect Bonding is more accurate than direct bonding in all three parameters (Table 1, 2 & 3) i.e. vertical, mesio-distal and angular.

T.M. Hodge et al(2004),⁽³⁾ their results indicate that the main advantage of indirect bonding is that it reduces the envelope of error of bracket position in each of three directions examined. For example, the vertical error range for direct bonding is 1.81mm, compared with only 0.27 mm for the indirect placement. Methodological differences make it difficult to compare the present results with those of other studies. For example Aguirre et al. and Balut et al. did not consider mesio-distal errors, although clinically such errors can cause rotational irregularities. Furthermore, it can be difficult to assess mesio-distal errors, particularly where teeth overlap, but Koo et al. felt able to do so by sectioning model teeth with a saw in an ex vivo study.

It was also interesting that they found that errors in angular placement of brackets were small and less than those either in the vertical and mesio-distal dimension. This suggests either that the various bracket design features that aid alignment are particularly effective or that the operator in the study was most accurate in this respect when placing brackets and this contrasts with previous findings, which have shown that clinicians could consistently locate the vertical facial axis of teeth, but that they were less accurate at estimating tooth angulations. Furthermore, Andrews found that operators were poor at judging angular measurements.

There has been disagreement in the literature regarding the accuracy of indirect bonding when compared to the standard direct technique. The present study shows significant statistical difference between direct and indirect bonding, proving indirect bonding is more accurate than direct bonding in all three parameters. Though the errors are in fraction of a

millimetre in vertical and mesio-distal and angulations errors are by one degree. Bohn Chan Koo⁽¹²⁾ conducted an in vitro study comparing the accuracy of bracket placement between direct and indirect technique. For this, 19 sets of models of the same occlusion were divided into two groups, one for direct bonding (9 models), the second for indirect bonding (9 models). A model has been set aside for ideal bonding. The bonding was done by nine experienced orthodontists. Comparing the accuracy bonding on the basis of three measurements: vertical, angular, and mesio-distal using enlarged photographs of each tooth.

Conclusion

There was difference between mean bracket placement errors for direct and indirect methods.

- Indirect bonding is more accurate than direct bonding in following aspects: vertical, horizontal and in angulation.
- The magnitudes of the findings are of clinical relevance.

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