MEASUREMENT AND COMPARISION OF BRACKET TRANSFER ACCURACY OF FIVE INDIRECT BONDING TECHNIQUES AN IN VITRO STUDY

A Dissertation submitted
in partial fulfilment of the requirements
for the degree of

MASTER OF DENTAL SURGERY

BRANCH V

ORTHODONTICS & DENTOFACIAL ORTHOPEDICS

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CERTIFICATE

This is to certify that DR S.SUGANYA, Post graduate student (2014-2017) in the Department of Orthodontics and Dentofacial Orthopedics, Adhiparasakthi Dental College and Hospital, Melmaruvathur – 603319, has done this dissertation titled **"MEASUREMENT AND COMPARISION OF BRACKET TRANSFER ACCURACY OF FIVE INDIRECT BONDING TECHNIQUES – AN IN VITRO STUDY"** under our direct guidance and supervision in partial fulfillment of the regulations laid down by The Tamilnadu Dr .M.G.R Medical University, Chennai – 600032 for MDS; (Branch V) Department of Orthodontics& dentofacial Orthopedics Degree Examination.

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DECLARATION

TITLE OF THE DISSERTATION	"Measurement and comparision of bracket transfer accuracy of five indirect bonding techniques" -An in vitro study
PLACE OF THE STUDY	Adhiparasakthi Dental College and Hospital, Melmaruvathur – 603319
DURATION OF THE COURSE	3 years
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ABSTRACT

AIM:

To measure and compare bracket transfer accuracy of five indirect bonding (IDB) techniques.

MATERIALS AND METHODS:

Five groups were studied. In each group 10 working models and 10 study models are taken.

Group I – PolyVinyl Siloxane (PVS – Putty)

Group II – Single Vacuum Form (Single-VF)

Group III – Clear Polyvinyl Siloxane (PVS -Clear)

Group IV - Double Vacuum Form - Double VF

Group V – Polyvinyl Siloxane (Clear) Vacuum form (PVS-VF)

Brackets were bonded on 50 identical stone working models (10 per technique) . IDB trays were fabricated to transfer brackets to another 50 identical stone study models (10 per technique). The MesioDistal (M-D: x-axis), OcclusoGingival (O-G: y-axis), and BuccoLingual (B-L: z-axis) positions of each bracket are measured using the Photographic and Caliper measurements.

RESULTS:

When the techniques were compared, bracket transfer accuracy was similar for PVS-VF, PVS-Clear, and PVS putty, whereas Double-VF showed significantly less accuracy in the O-G direction. Single VF was less accurate in all three directions (M-D, O-G & B-L).

CONCLUSION:

Based on the findings of the present study, overall differences in bracket position were relatively small. Silicone-based trays had consistently high accuracy in transferring brackets, whereas methods that exclusively used vacuum-formed trays were less consistent.

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LIST OF ABBREVIATIONS

B-L	:	Bucco-Lingual
DVF	:	Double Vacuum Form
IDB	:	Indirect Bonding Technique
M-D	:	Mesio-Distal
O-G	:	Occluso-Gingival
PVS-VF	:	Poly Vinyl Siloxane-Vacuum Form
PVS	:	Poly Vinyl Siloxane
PETG	:	Polyethylene Terephthalate Glycol
SVF	:	Single Vacuum Form

INTRODUCTION

Edward Hartley Angle[1], introduced the concept of fixed orthodontic appliance therapy with bands cemented on all teeth. In those early days, brackets were welded to gold or stainless steel bands. Before treatment, the orthodontist had to create enough space around each tooth to accommodate the bands, and then those spaces had to be closed at the end of treatment, when bands were removed. Buonocore[2] (1955) introduced Acid Etching technique, the basis for the adhesion of brackets to enamel with phosphoric acid. He demonstrated increased adhesion produced by acid pre treatment of enamel. In 1965 with advent of Epoxy resin bonding, Newman[3] began to apply these findings to direct bonding of orthodontic attachments.

Bonding brackets on tooth surface revolutionized orthodontics, making the clinical results easier and more reliable. It solved some of the difficulties encountered in orthodontic banding such as professional skills, patient discomfort resulting from separators and banding. The transition from banded attachments to direct bonded attachments has significantly improved orthodontists ability to attain accurate bracket positioning. With chemically cured bonding resins, working time was fairly limited, and this presented an additional challenge in trying to bond posterior teeth.[1]

The introduction of light cure resin allowed increased working time and significant positioning of brackets before the light is cured. Direct bonding has its own limitations like increased chair side time, bracket positioning errors and difficulty in bonding the posteriors because of decreased visibility. These limitations caused most clinicians to use direct bonding of brackets on anterior tooth and premolars and largely to avoid direct bonding on molars.[3]

In 1972, Silverman and Cohen[4] devised a method of delivering full arch brackets onto the dentition on one time. The operator obtained a stone model of the patient's dentition and then treated labial surface of the model with liquid foil separating medium. Metal or plastic brackets were bonded with caramel candy.

In 1979, Dr Royce Thomas[5] developed an innovative indirect bonding technique called "Custom base". This laboratory technique attaches brackets to a stone model with composite adhesive. This technique established the foundation for contemporary indirect bonding technique.

The advantages of indirect bonding includes accurate bracket placement, less chair side time, patient comfort, hygienic, avoiding fitting bands on posterior teeth, eliminating the need of separators. Both direct and indirect methods of orthodontic bracket placement can produce accurate and favourable results. The only way to assess the accuracy of finished cases includes the chosen bonding technique to measure the outcomes and then fine tune treatment procedures.[3]

At present lot of biomaterials are available for making indirect bonding trays. Most commonly indirect bonding trays are fabricated with vacuum formed thermoplastics, silicone impression materials, or a combination of both.

The purpose of this current study was to measure and compare bracket transfer accuracy of five Indirect bonding techniques. The five indirect bonding techniques includes

Polyvinylsiloxane – PVS putty, Single vaccum form – Single VF, Double vaccum form – Double VF, Polyvinylsiloxane vaccum form PVS-VF, Clear Polyvinylsiloxane – Clear PVS .

AIM AND OBJECTIVES

AIMS:

To measure and compare the bracket transfer accuracy between the five indirect bonding techniques.

OBJECTIVE:

- To measure bracket transfer accuracy in five different indirect bonding techniques.
- To compare the bracket transfer accuracy among the five indirect bonding techniques.
- To identify and establish the best IDB technique among the five groups.

REVIEW OF LITERATURE

Michael J. Aguirre et al (1982)[6] evaluated the bond strength of bracket placement comparing direct bonding to indirect bonding technique and concluded that maxillary canine showed better bond strength in indirect bonding when compared to premolars and incisors in vertical bracket placement.

Nasib Balut et al (1992)[7] determined the accuracy of bracket placement with the direct bonded technique. Fifty sets of models served as the population of the study. Photographs of the models were measured to determine vertical and angular discrepancies. A mean of 0.34mm for the vertical discrepancies and a mean of 5.54 degree angular discrepancies are found in orthodontic bracket placement. With proper wire bending or rebonding bracket positions, an excellent result can be achieved.

Koo BC et al (1999)[8] compared the accuracy of bracket placement between direct and indirect bonding techniques and concluded that indirect bonding had better bracket placement in bracket heightand no significant difference was found between direct and indirect bonding technique regarding the angulation and mesiodistal position.

Rainer R et al (1999)[9] evaluated the influence of vertical bracket displacement on 1^{st}, 2^{nd}, and 3^{rd} order corrections on plaster models including all teeth from central incisors to first molars of 28 young patients. The facial contours were evaluated at the mesial, central and distal aspect of the bracket and concluded that intraindividual variation in tooth morphology is larger than the variation between the different types of preadjusted appliances.

Arndt Klocke et al (2003)[10] evaluated bond strength for a cyanoacrylate adhesive in combination with an indirect bonding technique. Eighty bovine permanent mandibular incisors were randomly divided into four groups of 20 each. The study concluded that bond strength for an indirect bonding technique using the cyanoacrylate adhesive was found to be lower than Thomas technique using a composite adhesive.

Arndt Klocke et al (2003)[11] evaluated in vitro investigation of indirect bonding with a hydrophilic primer. Moisture contamination after application of hydrophilic primer resulted in significantly lower bond strength compared with bond strength for uncontaminated enamel.

Arndt Klocke et al (2004)[12] evaluated the influence of Custom base composite age on bond strength in indirect bonding. One hundred and fifty bovine mandibular incisors were divided into ten groups of 15 specimens each. The study confirmed the risk for bond failure at clinically relevant lower levels of stress with custom composite base aged for 100 days compared to aging of custom base composite for up to 30 days which did not affect the shear bond strength.

Pablo Echarri (2004)[13] describes indirect bonding has a number of advantages over direct bonding, including greater accuracy of bracket positioning and the ability to customize bracket prescriptions according to individual case requirements.

Fabio Ciuffolo et al (2005)[14] describes a new method of preparing trays for indirect bracket bonding. Computer aided technology is used to design the individualized trays, which are then produced with a rapid prototyping procedure.

Jacob Daub et al (2006)[15] evaluated the shear bond strength of one direct and two indirect bonding methods after thermocycling. The study shows that tooth indirectly bonded and light cured had a lower bond survival rate as compared to others after thermocycling.

John T. Kalange(2007)[16] evaluated a highly accurate method for Precision based full arch indirect bonding in which vertical and horizontal reference lines are placed on working models for bracket placement. The use of this technique offers quality care and efficiency of treatment. It is quick, accurate and reliable and ensures idealized anterior gingival margin contour and overall excellence in facial esthetics.

Duncan W. Higgins (2007)[17] evaluated the indirect bonding with light-cured adhesive and a hybrid tray transfer. The technique described in this article serves to simplify tray fabrication by combining clear vinyl polysiloxane with thin thermoplastic outer tray. The resulting tray is easier to trim and less bulky.

Nir Shpack et al (2007)[18] evaluated bracket placement in lingual vs labial systems and direct vs indirect bonding. Forty pretreatment dental casts of 20 subjects were selected. The study concluded that indirect bonding was more accurate than direct bonding for all teeth in both labial and lingual orthodontics.

Bjorn U. Zachrisson (2007)[19] evaluated direct bonding in orthodontic treatment and retention a post treatment evaluation. The study concluded that carefully performed bonding techniques may be of value, on anterior tooth, premolars and second molars, while first molars were better banded.

David Armstrong et al (2007)[20] evaluated a comparision of accuracy in bracket positioning between two techniques – localizing the centre of the clinical crown and measuring the distance from incisal edge. The study concluded that placement of brackets in positions appears to be more accurate in vertical dimensions for both upper and lower anterior teeth.

B. Wendl (2008)[21] determined Indirect bonding – a new transfer method. The study concludes that Aptus bonding device was found to provide accurate transfer method for indirect bonding of brackets. The bond strength tested in vitro is sufficient for orthodontic purposes and comparable with direct bonding.

Mark Joiner (2010)[22] determined In-house precision bracket placement with the indirect bonding technique.The study concluded that advantage of indirect bonding relative to direct bonding are numerous which outweigh the perceived disadvantage of increased laboratory time and technique sensitivity.

S.Madhusudhan (2010)[23] determined a newly simplified indirect bonding technique. The study concluded that technique is simple accurate and cost effective indirect bonding procedure.

Mauricio et al (2011)[24] described the indirect bonding procedure with thermal glue transfer tray and brackets with positioning jigs for precise bracket position and concluded that the technique is simple, accurate, reliable and inexpensive.

Domenico et al (2012)[25] evaluated the effectiveness of an indirect bonding technique in reducing plaque accumulation around the braces. The study concluded the plaque accumulation around different bracket margins did not differ significantly.

Lylian et al (2014)[26] determined the influence of two adhesion boosters on shear bond strength and on the bond failure location of indirectly bonded brackets. Sixty bovine incisors were selected and divided into three groups. The study concluded that the use of Assure adhesion booster increased both the shear bond strength of indirectly bonded brackets and the amount of adhesive that remained on the enamel after bracket debonding.

Katiyar R et al (2014)[27] evaluated a simplified indirect bonding technique. The advantage of this technique over existing techniques are easy removal of of excess resin flash, better curing accessibility and easy removal of transfer tray. Reduced chair side time, simple and cost-effective method for indirect bonding.

Qamaruddin I et al (2014)[28] evaluated indirect bonding with hot glue gun method. The study concluded that this is the most convenient and economical method for indirect bracket bonding. Although technique sensitive it does not require any additional training for lab technicians and assistants.

P Premanand et al (2014)[29] compared the efficacy between direct and indirect bonding methods. Twenty patients were chosen with selection criteria being, no visible cracks on enamel, normal tooth morphology and non extraction treatment plan. The study concluded that the indirect bonding technique is definitely a better option and could provide efficient bracket placement in significantly less chair side time which overweighs the cost involved in the laboratory procedure.

Sudhir Sharma et al (2014)[30] evaluated a comparision of shear bond strength of orthodontic brackets bonded with four different orthodontic adhesives. The study concluded that highest shear bond strength was observed in Transbond XT followed by XenoV withXeno Ortho, Rely-a-Bond and lowest in Transbond plus.

Fahad F. Alsulaimani (2014)[31] determined the effect of lactic acid etching on bonding effectiveness of orthodontic bracket after water storage. The study concluded that six months of water storage significantly reduced the shear bond strength regardless of the etchant used.

Lincoln Issamu Nojima et al (2015)[32] describes Indirect bonding technique ensures precise bracket position. Simplicity, accuracy and reproducibility of this technique lead to its efficiency in orthodontic bonding providing the advantages related to indirect bonding.

M Swetha et al (2015)[33] compared Indirect versus direct bonding – A shear bond strength comparision: An in vitro study. The study concluded that Bond strength obtained with Thomas indirect bonding technique was comparable with direct bonding technique. The journal of contemporary dental science.

Breuning KH (2015)[34] Bonding metal brackets on tooth surfaces. The study signifies that bonding forces should not be too low to prevent bracket failure. Bracket failure is due to increased time and cost.

Ana E. et al (2014)[35] measured and compared bracket transfer accuracy of five indirect bonding techniques. The techniques include double polyvinyl siloxane (double-PVS), double vacuum-form (double-VF), polyvinyl siloxane vacuum-form (PVS-VF), polyvinylsiloxane putty (PVS-putty), and single vacuum-form (single-VF.)Brackets were bonded on 25 identical stone working models. Indirect bonding trays were fabricated over working models (n = 5 per technique) to transfer brackets to another 25 identical stone patient models and concluded that silicone based trays had consistently high accuracy in transferring brackets than vaccum formed trays.

Thorsten Grunheid (2016)[36] et al elicited the magnitude, directional bias and frequency of bracket positioning errors caused by transfer of brackets from a dental cast to the patient’s dentition using cone beam computed tomography and 3-D positioning data. The study concluded that indirect bonding using PVS trays transfers the planned bracket position from dental cast to patient’s dentition with high positional accuracy.

MATERIALS AND METHODS

PREPARATION OF STUDY MODELS

Silicone molds of the master model were fabricated. From the molds, 100 identical orthodontic stone models (Orthokal) were fabricated; 50 served as working models to which the brackets were bonded. Each tooth had two reference notches: one on the facial and another on the lingual side. [35] IDB trays were fabricated (n=10 per technique) to transfer the brackets to another 50 identical patient models.

Indirect Bonding Techniques

The working models were coated twice with separating agent (Cold mould seal, DPI ,India) and dried for 8 hours. Brackets were bonded along the long axis of the crown and the vertical height (from the centre of the bracket to the occlusal tip of the crown) was 5mm for central incisors, 4mm for lateral incisors, 5mm for canine, 4mm for premolars and 3mm for molars. A Boon's gauge was used to assess the position of the bracket.[12] Reference notches were blocked out with light-curing resin to prevent tray material locking. Ten trays per technique were then fabricated over their corresponding working models which includes, Poly Vinyl Siloxane Putty (PVS-putty), Single Vacuum Form (Single-VF),Clear Polyvinyl Siloxane (PVS-Clear) , Double Vacuum-Form (Double-VF), Polyvinyl Siloxane Vacuum-form (PVS-VF)

All trays were fabricated following the manufacturer's guideline. In general, all trays extended from the facial over to the occlusal and at least half of the lingual surfaces.[35]

Working model-tray assemblies were soaked in water for 1 hour to dissolve the separating agent. After removal, trays with brackets were cleaned using a detergent solution in an ultrasonic cleaner as described by Sondhi.[3] A two-part (A-B) chemically cured bonding adhesive (Sondhi Rapid-Set Indirect Bonding Adhesive, 3M Unitek, St Paul, Minn) was used during IDB. Part A was applied to the patient model teeth and part B to the custom composite pads on brackets.

Each tray was seated uniformly and held in place, with firm pressure applied parallel to the occlusal plane. After 2.5 minutes, the bonding adhesive was set and the trays were carefully removed from the lingual to the buccal.

Table 1: Tray Descriptions for Indirect Bonding Techniques

Technique name		Tray Material	
Descriptive Name	**Proprietary Name**	**Single/Inner**	**Outer**
GROUP I - PVS-putty	AD-SIL	Very high viscosity polyvinyl siloxane putty, buccolingual thickness: 3–6 mm	-
GROUP II - Single-VF (single-vacuum form)	SCHEU	Clear vacuum-formed 1.5-mm-thick EVA sheet (Bioplast, Great Lakes Orthodontics)	-
GROUP III - Clear PVS	MEMOSIL 2	Clear soft silicone, buccolingual thickness: 1–1.5 mm	Clear polyvinyl siloxane, buccolingual thickness: 3–6 mm
GROUP IV - Double-VF (double-vacuum form)	LEONE, SCHEU	Clear vacuum-formed 1.5-mm-thick ethyl vinyl acetate (EVA) sheet (Bioplast, Great Lakes Orthodontics, Tonawanda, N.Y.)	Clear vacuum-formed 0.75-mm clear polyethylene terephthalate glycol (PETG) sheet (Biocryl, Great Lakes Orthodontics)
GROUP V - PVS-VF (PVS-vacuum form)	AD-SIL, SCHEU	Light-body polyvinyl siloxane, buccolingual thickness: 2–3 mm	Clear vacuum-formed 0.75-mm-thick co-polyester sheet.

Fig 1: FIVE GROUPS OF IDB TECHNIQUE

WORKING AND PATIENT MODELS

GROUP I – PVS PUTTY

SINGLE VF

GROUP III – CLEAR PVS

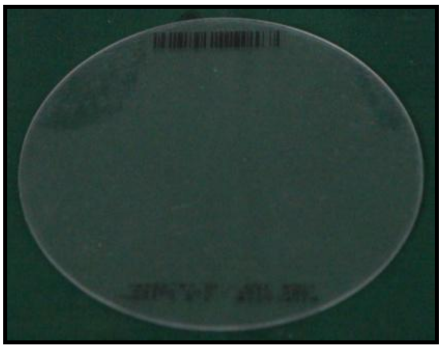
DOUBLE VF

PVS - VF

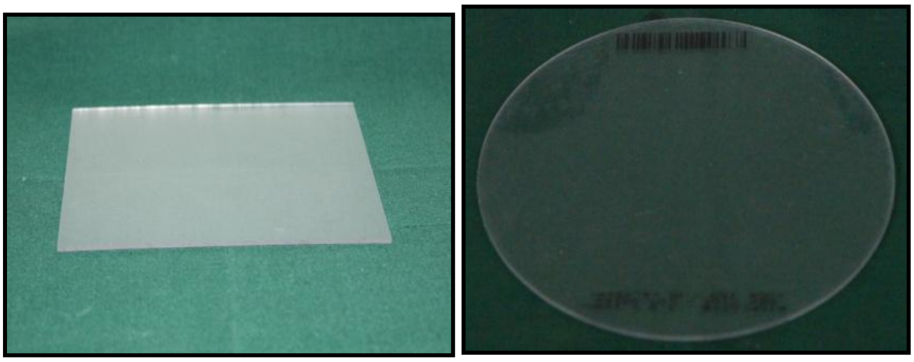
Fig 2: ARMAMENTARIUM

MATERIALS

PVS PUTTY **SINGLE VF**



DOUBLE VF



CLEAR – PVS

PVS-VF

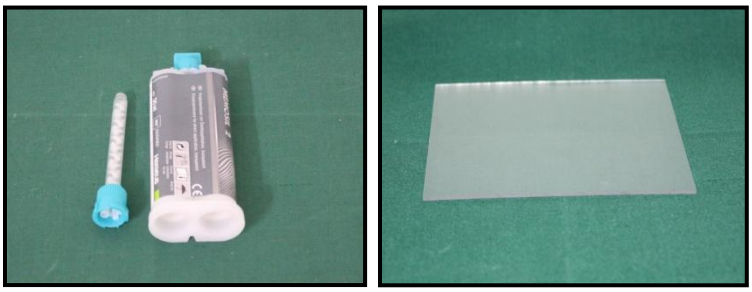


Fig 3

WORKING MODEL

PATIENT MODEL

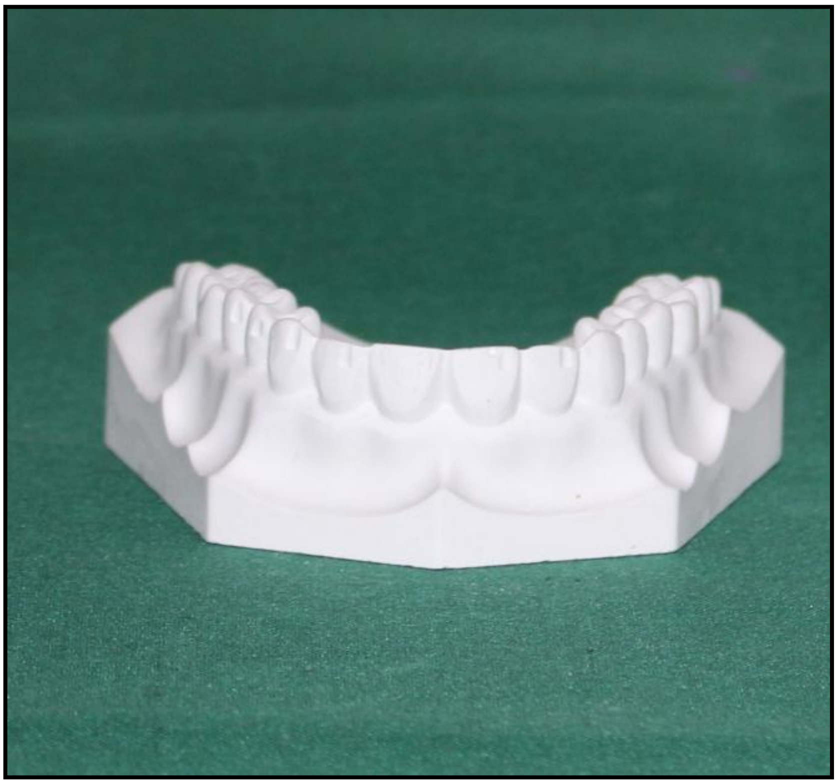


Fig 4: BONDING ADHESIVE KIT

Fig 5: VACUUM FORM MACHINE

Fig 6: JIG WITH POSITIONING BLOCKS FOR PHOTOGRAPHIC MEASUREMENTS

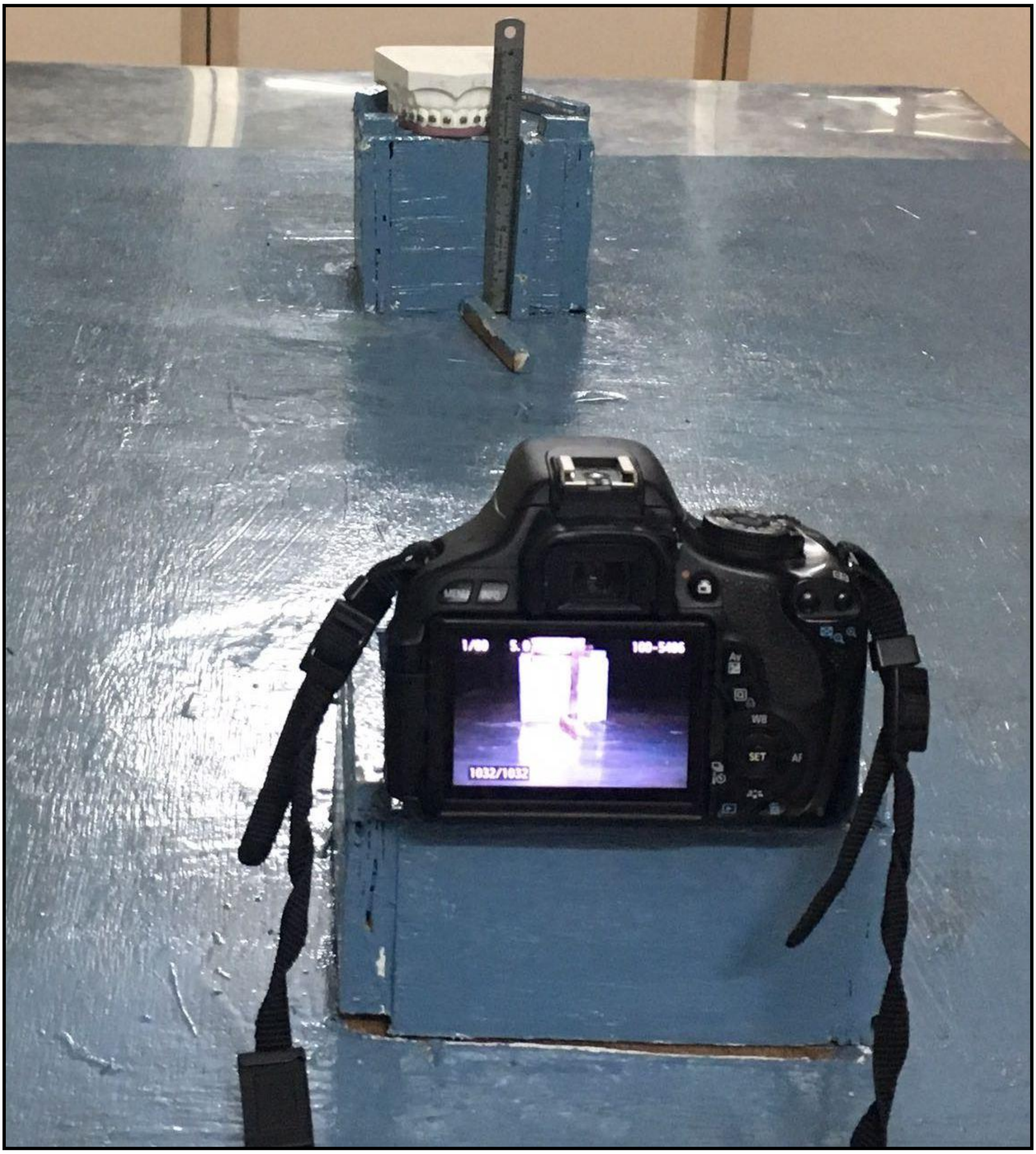


Fig 7: VERNIER CALIPER MEASUREMENTS

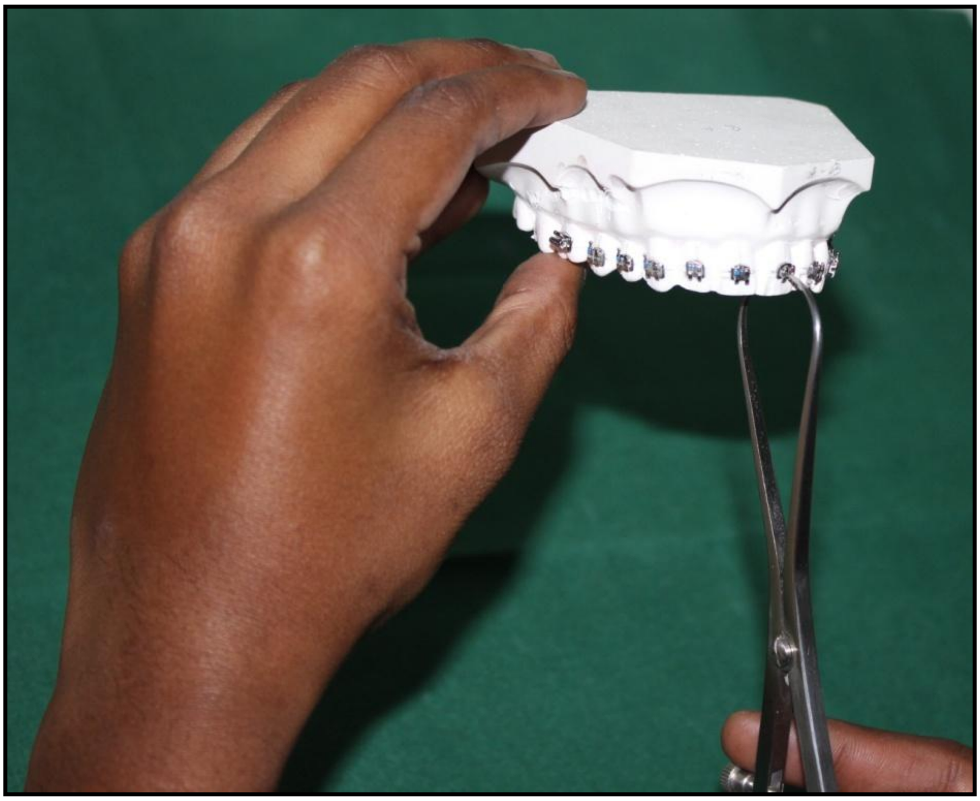


Fig 8: GRID LINE MEASUREMENTS

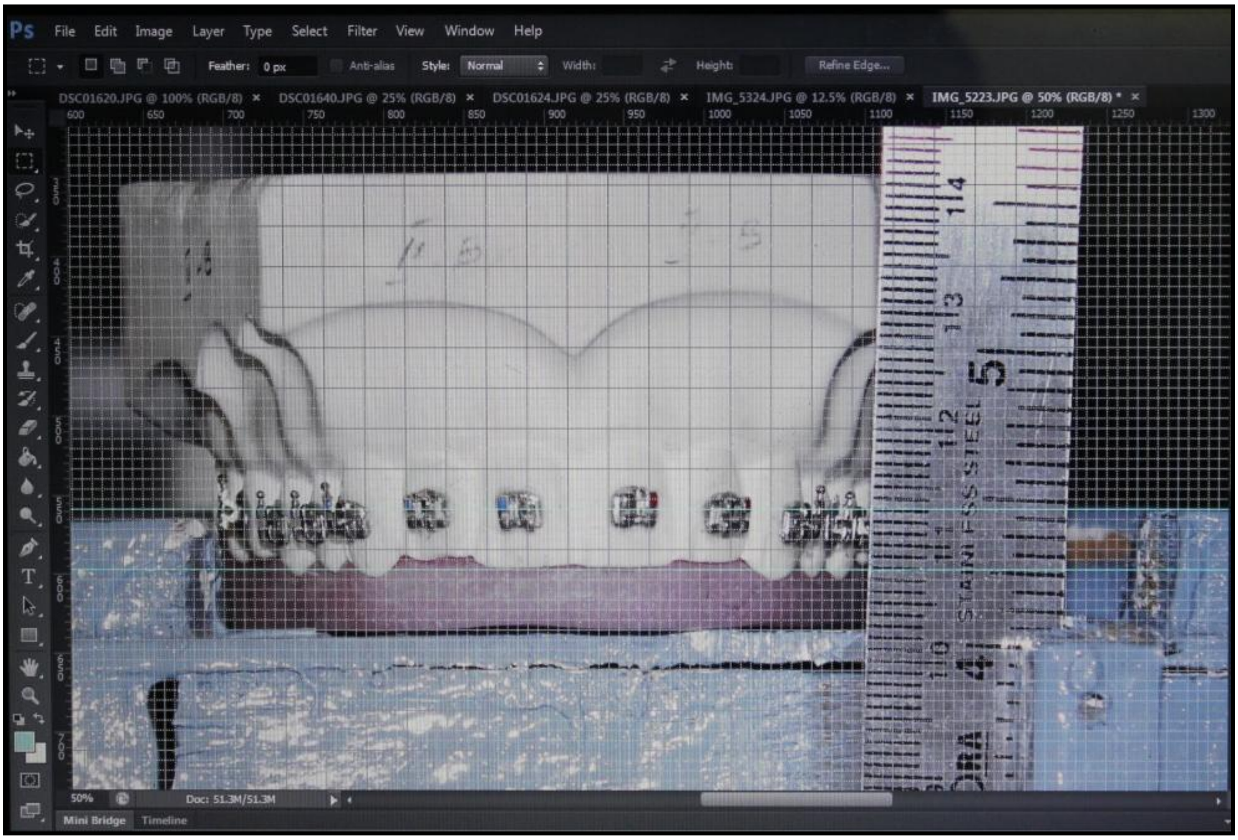


Fig 9: PVS PUTTY

BRACKETS BONDED ON WORKING MODEL

IDB TRAY

BRACKET TRANSFERRED TO PATIENT MODEL

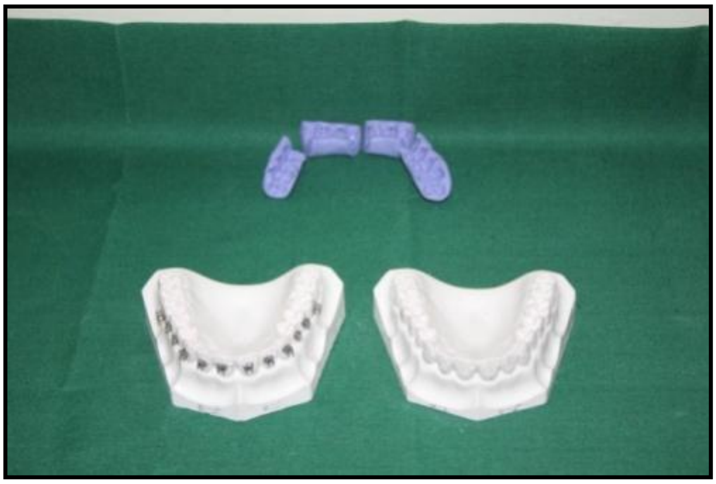
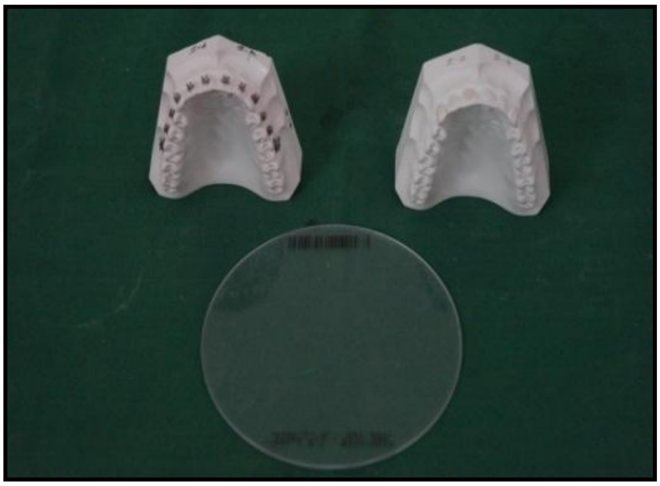


Fig 10: SINGLE - VF

BRACKETS BONDED ON WORKING MODEL

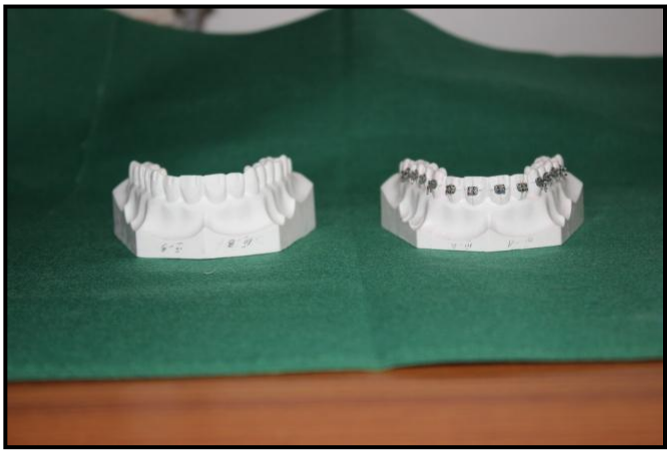


IDB TRAY

BRACKET TRANSFERRED TO PATIENT MODEL

Fig 11: PVS CLEAR – MEMOSIL

BRACKETS BONDED ON WORKING MODEL

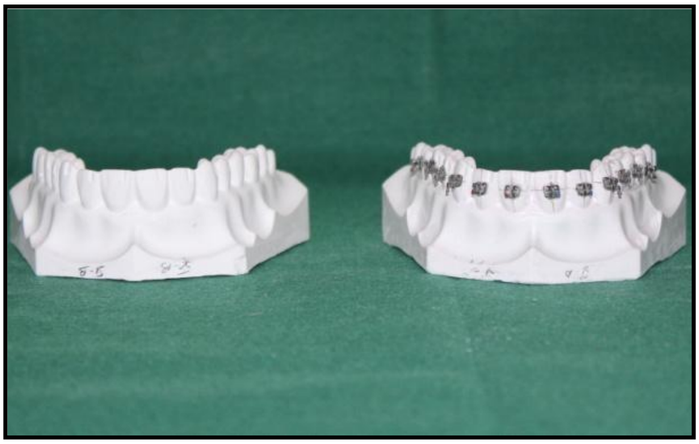


IDB TRAY

BRACKET TRANSFERRED TO PATIENT MODEL

Fig 12 : Double VF

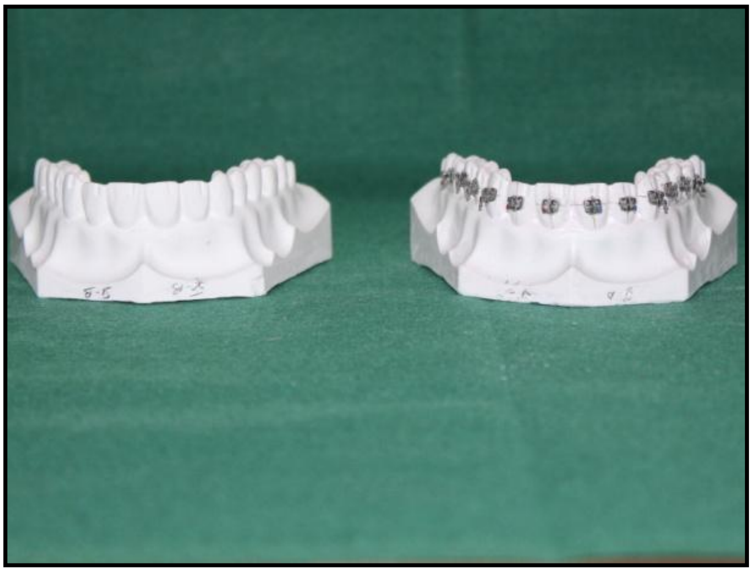
BRACKETS BONDED ON WORKING MODEL



IDB TRAY

BRACKET TRANSFERRED TO PATIENT MODEL

Fig 13: PVS – VF



Photographic Measurements: Mesiodistal and Occluso gingival

Bonded teeth on both working and patient models were photographed individually using a Canon EOS 600D camera with EFS 18-55mm Macrolens set on manual with an F-stop of 40 at 1:500 of a second.JPEG images (300 to 300 dpi) were imported into Adobe Photoshop Elements 10 (Adobe Systems Inc, San Jose, Calif) and magnified 8.5 times. For each bracket, mesiodistal (M-D) (X-axis) and occlusogingival(O-G) (Y-axis) measurements were made as follows,

- A software-constructed grid was calibrated so that the distance between the gridlines equaled 1.00 mm.
- The image was rotated so that the horizontal and vertical lines outlining the corner of the facial reference notch closest to the bracket paralleled the gridlines.
- The origin of the grid was made coincident with the intersection of the lines outlining the corner of the reference notch.
- Two points (A, B) were selected to coincide with the intersection of the inside of the mesial and distal tie wings with the occlusal edge of the scribe line base, except for the molars, where the inner occlusal corners of the tie wings were used.
- For each point, x- and y-coordinate values were recorded to the nearest 0.01 mm.
- Point coordinates were recorded three times consecutively on the same image and then averaged.[35]

Caliper Measurements: Buccolingual

Manual caliper were used to measure buccolingual (B-L) (Z-axis) bracket positions as follows:

- Two points (C, D) were selected at the gingival and occlusal ends of the bracket scribe line, except for molars, where the points were located at the intersection of the gingival and occlusal scribe lines with the bracket base.
- One tip of a manual caliper was placed at the depth of the lingual reference notch, and the other tip was aligned with each of the points.
- Measurements were recorded to the nearest 0.01 mm.
- Measurements were repeated three times consecutively and averaged.[35]

RESULTS

Statistical Analysis

To assess the accuracy of each technique, bracket coordinate value differences for each tooth between working and patient model pairs ($n = 10$) were analyzed using paired t-tests. For technique comparisons, analyses were conducted for all teeth grouped, anterior teeth, posterior teeth of the arch using analysis of variance followed by Tukey post hoc comparisons. Significance was set to $P < .05$.

PAIRED t-tests

GROUP I - PVS PUTTY

VARIABLES	BEFORE			AFTER			t - Test	P - Value	RESULT
	N	MEAN	±SE		MEAN	±SE			
MD-1A	10	2.64	0.0178		2.59	0.0315	1.77	0.1114	NS
MD-1B	10	2.16	0.0083		2.13	0.0285	1.08	0.3092	NS
OG-1A	10	4.17	0.0285		4.04	0.0657	2.99	0.0152	*
OG-1B	10	4.10	0.0329		3.98	0.0655	2.70	0.0245	*
BL-1A	10	6.94	0.0178		6.72	0.0817	2.68	0.0252	*
BL-1B	10	6.35	0.0140		6.17	0.0858	2.18	0.0572	NS

GROUP II - SINGLE - VF

VARIABLES	BEFORE			AFTER			t - Test	P - Value	RESULT
	N	MEAN	±SE		MEAN	±SE			
MD-1A	10	2.62	0.0255		2.40	0.0643	3.47	0.0070	**
MD-1B	10	2.18	0.0290		2.00	0.0541	3.28	0.0095	**
OG-1A	10	4.25	0.0370		3.69	0.0992	6.40	0.0001	**
OG-1B	10	4.22	0.0340		3.67	0.0978	6.40	0.0001	**
BL-1A	10	6.90	0.0243		6.32	0.1734	3.51	0.0066	**
BL-1B	10	6.43	0.0242		5.90	0.1524	3.43	0.0075	**

GROUP III - CLEAR - PVS

VARIABLES	BEFORE			AFTER			t - Test	P - Value	RESULT
	N	MEAN	±SE		MEAN	±SE			
MD-1A	10	2.63	0.0184		2.63	0.0136	0.00	1.0000	NS
MD-1B	10	2.16	0.0231		2.17	0.0215	1.00	0.3434	NS
OG-1A	10	4.25	0.0294		4.21	0.0252	3.00	0.0150	*
OG-1B	10	4.17	0.0329		4.13	0.0285	3.00	0.0150	*
BL-1A	10	6.74	0.0271		6.73	0.0306	1.00	0.3434	NS
BL-1B	10	6.24	0.0256		6.23	0.0265	1.00	0.3434	NS

GROUP IV - DOUBLE - VF

VARIABLES	BEFORE			AFTER			t - Test	P - Value	RESULT
	N	MEAN	±SE		MEAN	±SE			
MD-1A	10	2.63	0.0186		2.56	0.0352	1.56	0.1527	NS
MD-1B	10	2.16	0.0150		2.13	0.0311	1.18	0.2695	NS
OG-1A	10	4.20	0.0241		4.01	0.0624	2.96	0.0161	*
OG-1B	10	4.14	0.0299		3.96	0.0724	2.85	0.0191	*
BL-1A	10	6.84	0.0262		6.72	0.0788	1.82	0.1018	NS
BL-1B	10	6.25	0.0288		6.14	0.0606	1.86	0.0962	NS

GROUP V - PVS - VF

VARIABLES	BEFORE			AFTER			t - Test	P - Value	RESULT
	N	MEAN	±SE		MEAN	±SE			
MD-1A	10	2.68	0.0150		2.64	0.0127	1.50	0.1679	NS
MD-1B	10	2.18	0.0167		2.18	0.0111	0.00	1.0000	NS
OG-1A	10	4.10	0.0188		4.08	0.0158	1.86	0.0957	NS
OG-1B	10	4.08	0.0215		4.06	0.0178	1.96	0.0811	NS
BL-1A	10	6.73	0.0178		6.73	0.0178	1.00	0.3434	NS
BL-1B	10	6.11	0.0206		6.11	0.0208	1.00	0.3434	NS

P > 0.05 – NS – Not Significant

P < 0.05 - * - Significant

P < 0.01 - ** - Highly Significant

MD – Mesiodistal – X-axis

OG – Occlusogingival – Y-axis

BL – Buccolingual – Z - axis

ANALYSIS OF VARIANCE

		N	Mean	Std. Deviation	Std. Error	F-value	P-value
B-MD-1A	PVSP	10	2.6417	.05625	.01779	1.352	0.266
	SVF	10	2.6167	.08051	.02546		
	MEMO	10	2.6333	.05827	.01843		
	DVF	10	2.6250	.05893	.01863		
	PVSVF	10	2.6750	.04730	.01496		
	Total	50	2.6383	.06211	.00878		
A-MD-1A	PVSP	10	2.5917	.09977	.03155	7.166	0.000
	SVF	10	2.4000	.20337	.06431		
	MEMO	10	2.6333	.04303	.01361		
	DVF	10	2.5583	.11146	.03525		
	PVSVF	10	2.6417	.04025	.01273		
	Total	50	2.5650	.14215	.02010		
B-MD-1B	PVSP	10	2.1583	.02635	.00833	0.357	0.838
	SVF	10	2.1750	.09171	.02900		
	MEMO	10	2.1583	.07297	.02307		
	DVF	10	2.1583	.04730	.01496		
	PVSVF	10	2.1833	.05270	.01667		
	Total	50	2.1667	.06070	.00858		
A-MD1B	PVSP	10	2.1250	.09001	.02846	4.874	0.002
	SVF	10	2.0000	.17123	.05415		
	MEMO	10	2.1667	.06804	.02152		
	DVF	10	2.1250	.09821	.03106		
	PVSVF	10	2.1833	.03514	.01111		
	Total	50	2.1200	.11804	.01669		
B-OG1A	PVSP	10	4.1667	.09001	.02846	4.989	0.002
	SVF	10	4.2458	.11695	.03698		
	MEMO	10	4.2542	.09307	.02943		
	DVF	10	4.1958	.07620	.02410		
	PVSVF	10	4.1000	.05958	.01884		

A-OG1A	PVSP	10	4.0420	.20787	.06574	9.775
	SVF	10	3.6917	.31378	.09923	
	MEMO	10	4.2125	.07966	.02519	
	DVF	10	4.0083	.19720	.06236	
	PVSVF	10	4.0792	.04988	.01577	
	Total	50	4.0067	.25497	.03606	
B-OG1B	PVSP	10	4.0958	.10403	.03290	0.331
	SVF	10	4.2208	.10767	.03405	
	MEMO	10	4.1667	.10393	.03287	
	DVF	10	4.1417	.09461	.02992	
	PVSVF	10	4.0833	.06804	.02152	
	Total	50	4.1417	.10548	.01492	
A-OG1B	PVSP	10	3.9833	.20713	.06550	7.629
	SVF	10	3.6667	.30932	.09782	
	MEMO	10	4.1250	.09001	.02846	
	DVF	10	3.9583	.22906	.07244	
	PVSVF	10	4.0583	.05625	.01779	
	Total	50	3.9583	.24972	.03532	
B-BL1C	PVSP	10	6.9417	.05625	.01779	16.854
	SVF	10	6.8958	.07670	.02426	
	MEMO	10	6.7375	.08573	.02711	
	DVF	10	6.8417	.08287	.02621	
	PVSVF	10	6.7292	.05642	.01784	
	Total	50	6.8292	.11016	.01558	
A-BL1C	PVSP	10	6.7208	.25839	.08171	3.661
	SVF	10	6.3208	.54823	.17337	
	MEMO	10	6.7292	.09672	.03059	
	DVF	10	6.7167	.24907	.07876	
	PVSVF	10	6.7250	.05625	.01779	
	Total	50	6.6425	.32799	.04638	

B-BL-1D	PVSP	10	6.3458	.04414	.01396	27.071	0.000
	SVF	10	6.4333	.07658	.02422		
	MEMO	10	6.2375	.08110	.02565		
	DVF	10	6.2542	.09097	.02877		
	PVSVF	10	6.1125	.06529	.02065		
	Total	50	6.2767	.12980	.01836		
A-BL-1D	PVSP	10	6.1667	.27146	.08584	2.207	0.083
	SVF	10	5.9000	.48201	.15242		
	MEMO	10	6.2292	.08391	.02653		
	DVF	10	6.1417	.19165	.06060		
	PVSVF	10	6.1083	.06573	.02079		
	Total	50	6.1092	.27892	.03945		

P > 0.05 – NS – Not Significant

P < 0.05 - * - Significant

P < 0.01 - ** - Highly Significant

A – After tray transfer

B – Before tray transfer

MD – Mesiodistal – X-axis

OG – Occlusogingival – Y-axis

BL – Buccolingual – Z - axis

BAR CHART

Chart 1 : Mean Difference in M-D dimension – X axis – Point A

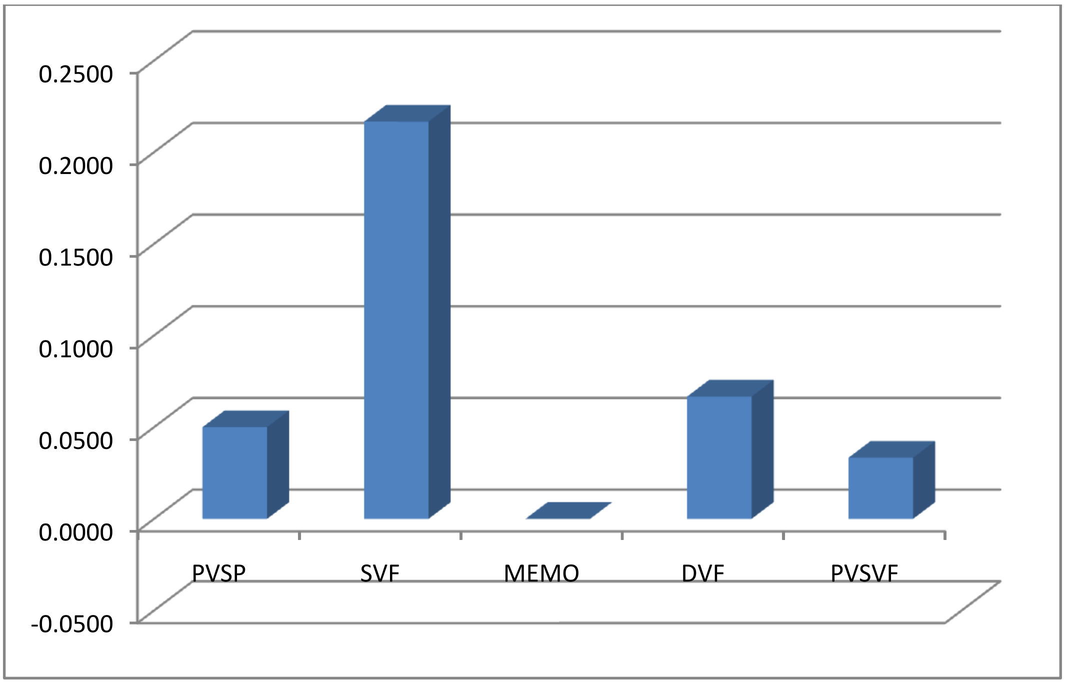


Chart 2 : Mean Difference in M-D dimension – X axis – Point B

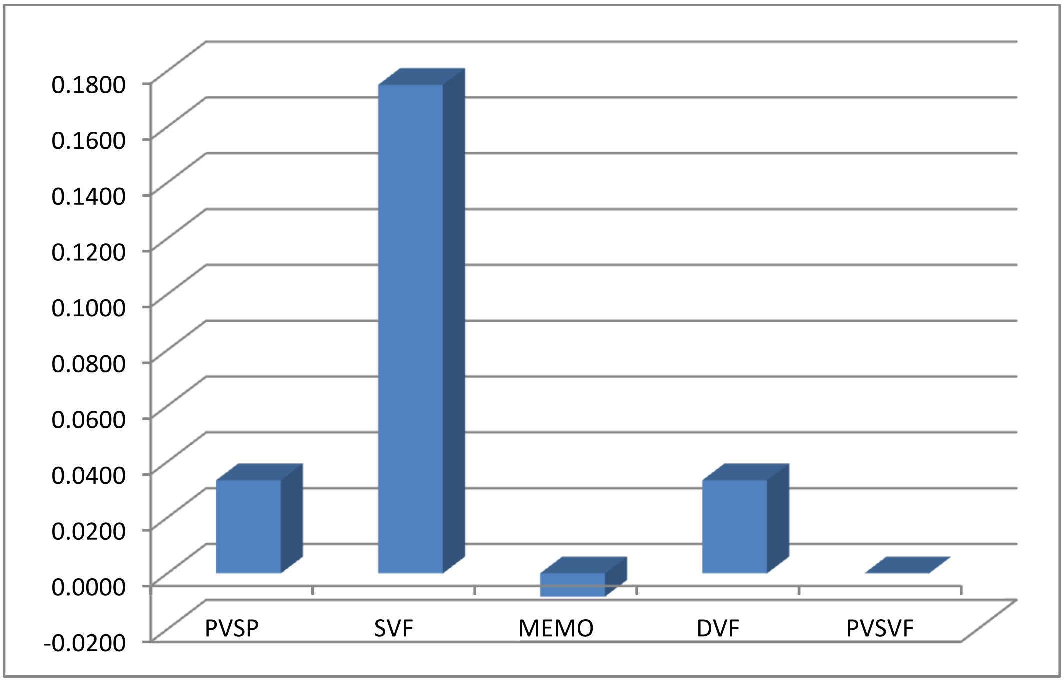


Chart 3 : Mean Difference in O-G dimension – Y-axis – Point A

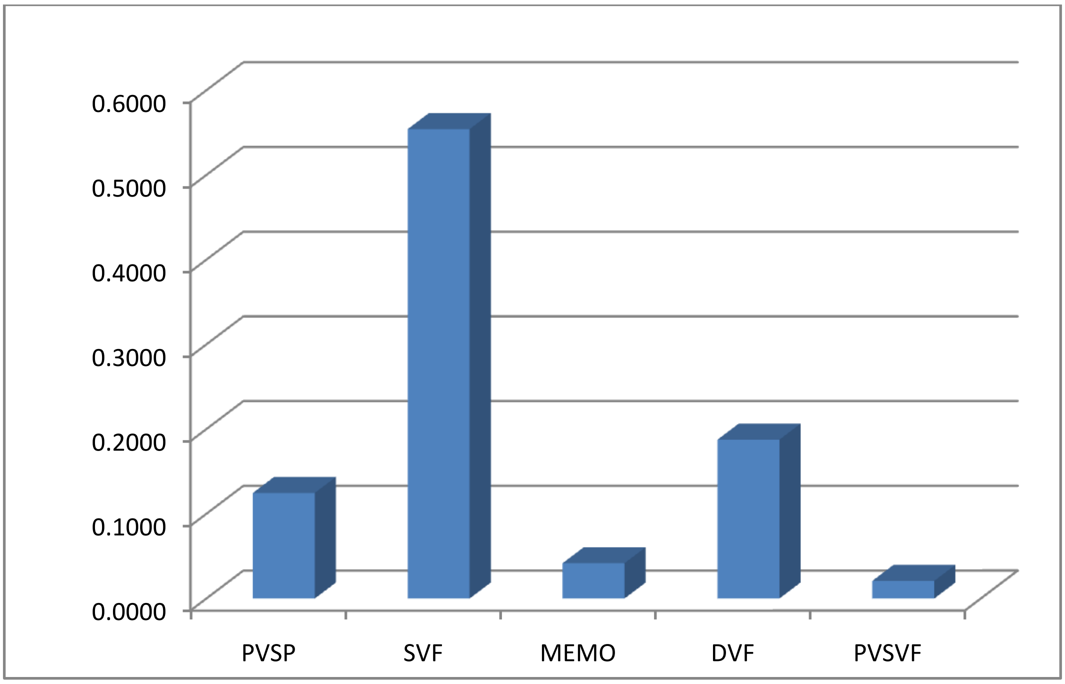


Chart 4 : Mean Difference in O-G dimension – Y-axis – Point B

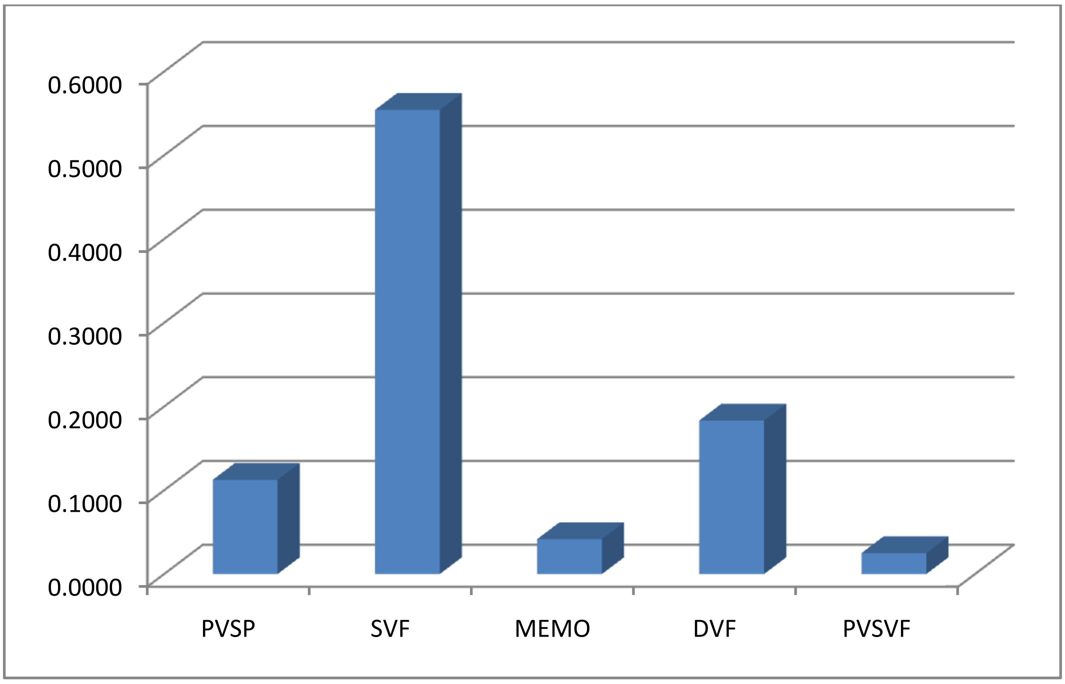


Chart 5 : Mean Difference in B-L dimension – Z-axis – Point A

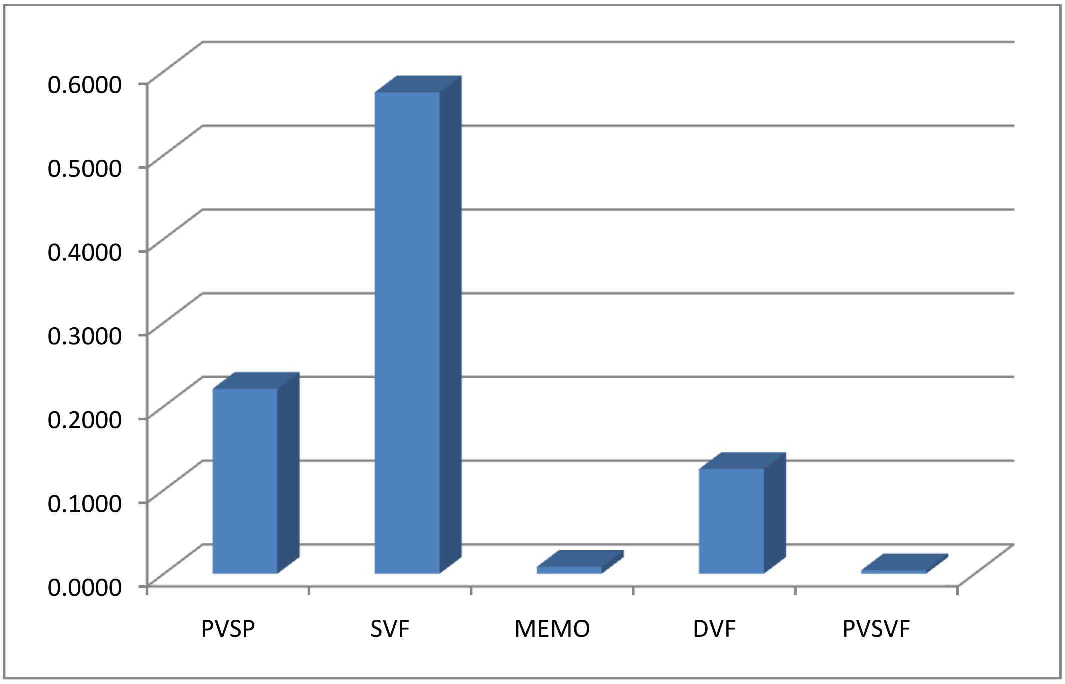
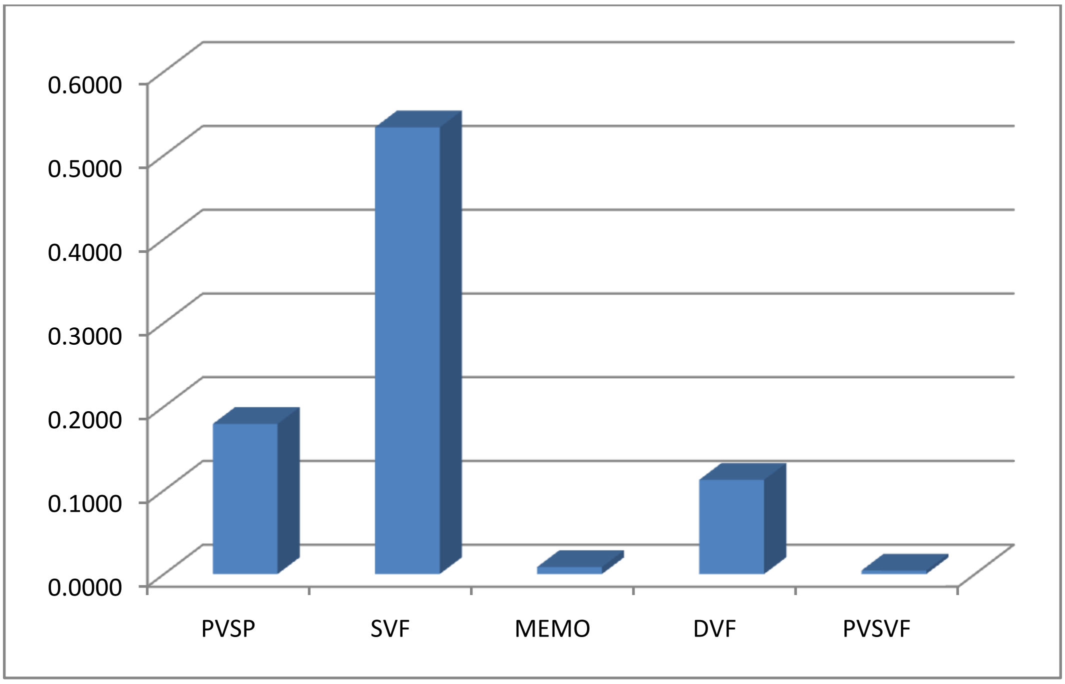


Chart 6 : Mean Difference in B-L dimension – Z-axis – Point B



RESULTS

Method Error

The method error was 0.07 mm for photographic measurements and 0.01 mm for caliper measurements.

Debonded Brackets

Eleven of the 600 brackets that were transferred debonded during tray removal: two with PVS putty, eight with single VF, one with double VF.

Comparisons between Working and Patient Models

All techniques had at least one tooth with significant differences in bracket position. Single-VF had the most teeth (n=59) with significant differences, whereas PVS-VF had the fewest (n=4). The greatest number of significant differences occurred in the O-G dimension (n=47), followed by B-L (n=26) and M-D (n=11).

DISCUSSION

The goal of the study was to compare the bracket transfer accuracy of five different indirect bonding tray transfer material. Ideal maxillary model was taken for this study to minimize the variables related to arch form, tooth shape and crowding. Henceforth assessment is made in ideal maxillary arch and reference notches are made in distolabial line angle in the labial surface and lingually in middle third of the tooth for measurement purpose.

The transferred brackets were photographed and saved as JPEG images and imported to Adobe photoshop CS6 and measurements are taken in mesiodistal (M-D) and occlusogingival (O-G) direction. Five techniques were compared and bracket transfer accuracy was found between the five groups and it was found that single VF and double VF has less accuracy in transferring the brackets because of less thickness of tray material and increased elongation of ethyl vinyl acetate (EVA) sheets in anteriors

This study evaluated and compared five commonly used techniques that differed in transfer tray materials. To minimize the potential effects of variables such as dental arch form, tooth shapes, and crowding, a maxillary arch was used with well-aligned teeth to allow assessment in an ideal setting. Working models served as controls for their corresponding patient models, and reference notches provided reliable points for bracket position measurement, as evidenced by method errors #0.07 mm.

Each technique had at least one tooth with significant differences in bracket position; however, many differences were small, suggesting the need to set thresholds of clinical significance. Armstrong et al.[37] reported that changes of $\geq$ 0.25 mm for upper central and lower incisor brackets and $\geq$ 0.5 mm for remaining teeth would be clinically significant. For this study, a 0.13-mm discrepancy in any direction was deemed clinically significant, so if brackets on adjacent teeth were misplaced by 0.13 mm in opposite directions, tooth position discrepancies would be .0.25 mm. Single-VF and double-VF showed the greatest number of teeth with clinically significant differences, whereas PVS-VF had none.

Two measurement points were used per dimension to determine whether the bracket position changes were rotational or purely linear. Ten teeth (at least one per technique) had significant differences in only one of two points, indicating that bracket rotations had occurred. Significant differences in the B-L measurements on tooth no:21 (point C) and on tooth no:16 (point D) with single-VF likely relate to the large differences that were also present in the O-G direction, causing angulation changes in the B-L line of measurement when using calipers. This is inherent to the use of calipers and may be considered a weakness of the study.

When the techniques were compared for all teeth grouped bracket transfer accuracy was comparable for silicone-based techniques (Clear-PVS, PVS-VF, and PVS-putty). Both double-VF and single-VF were significantly less accurate than the others in the O-G direction, a result also evident for anterior but not for posterior teeth. For posterior teeth, O-G accuracy was significantly lower for single-VF versus double-PVS, and although potentially clinically significant, the mean change (0.15 mm) was considerably smaller than mean O-G changes for double-VF and single-VF with anterior teeth (0.29 mm and 0.33 mm, respectively). In the B-L direction, posterior teeth showed significantly lower accuracy for Clear-PVS versus PVS-VF and double-VF, but the small mean change (0.11 mm) is likely not clinically significant.

The poorer O-G accuracy for anterior teeth with double-VF and single-VF can be attributed to increased elongation of the ethyl vinyl acetate (EVA) sheets over the longer anterior crowns, resulting in relatively decreased anterior tray thickness. Ryokawa et al. found significant decreases in material thickness and elastic modulus (decreased rigidity) for EVA following vacuum-forming. Although double-VF has an outer polyethylene terephthalate glycol (PETG) tray, it is not fused with the inner EVA tray and is trimmed occlusal to the gingival bracket wings, away from all heights of contour, 12 and thus does not cover the entire O-G dimension of the brackets.

The use of hand pressure against the anterior part of the tray with double-VF and single-VF in an attempt to improve the tray's adaptation undoubtedly contributed to bracket position variability with these two techniques. Similarly, the poorer bracket transfer accuracy on the right vs left side, mostly involving single-VF and double-VF in the O-G direction, could be a result of the greater sensitivity of these techniques to differences in hand pressure.

The three techniques with the highest bracket transfer accuracy used polyvinyl siloxane (addition silicone) as the material in direct contact with both brackets and tooth surfaces. Additional silicone impression materials have been shown to have excellent dimensional stability, superior recovery from deformation (elastic recovery), and high rigidity. Additionally, all silicone trays were thicker buccolingually than nonsilicone trays, contributing to increased rigidity.

Low rigidity in an IDB tray may result not only in inaccurate bracket position transfer, but also in an increased number of bond failures due to poor adaptation. Bhatnagar et al.[38] evaluated bond failures for four IDB techniques and found the highest percentage of failures (50%) with a single-tray vacuum-formed technique that used 2-mm EVA sheets. Consistent with these results, this study showed bond failures only with methods that exclusively used vacuum-formed trays.

Based on results of this study, selection of Clear PVS, PVS-VF, and PVS-putty could be based on reference or criteria such as tray cost, fabrication time, and opacity. A limitation of this study is that it used an ideal dental arch model, rather than the typical clinical scenario of crowded and/or rotated teeth. Different results might be found in arches with irregular tooth alignment, as tray dimensions would vary, and different tray materials (eg, Biocryl) may respond differently to the divergent crown angulations. Future clinical studies evaluating the accuracy of IDB may provide insights into how tray material properties affect tray seating and therefore tray-tooth registration in vivo.

SUMMARY AND CONCLUSION

- All IDB techniques investigated had at least one tooth with statistically significant differences in bracket position, but the most clinically significant differences were found with the single-VF and double-VF techniques.

- Changes in bracket position were not purely linear; some were rotational.

- When the five techniques were compared, bracket transfer accuracy was comparable for the silicone-based techniques.

- When the techniques were compared, bracket transfer accuracy was similar for PVS-VF, PVS-Clear, and PVS putty, whereas Double-VF showed significantly less accuracy in the O-G direction. Single VF was less accurate in all three directions (M-D, O-G & B-L)

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This ethical committee has undergone the research protocol submitted by **DR. S. SUGANYA**, Post Graduate Student, Department of **ORTHODONTICS & DENTOFACIAL ORTHOPEDICS** under the title **Measurement and comparision of bracket transfer accuracy of five indirect bonding techniques –An in vitro study**. "Reference No: 2014-MD-BrV-VIJ-11**,** under the guidance of **DR.V.SUDHAKAR,_MDS**., for consideration of approval to proceed with the study.

This committee has discussed about the material being involved with the study, the qualification of the investigator, the present norms and recommendation from the Clinical Research scientific body and comes to a conclusion that this research protocol fulfils the specific requirements and the committee authorizes the proposal.

Date:

Member secretary