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RESEARCH ARTICLE

A COMPARATIVE EVALUATION OF DIMENSIONAL ACCURACY OF POLYVINYL SILOXANE AND VINYL POLYETHER SILICONE USING TWO IMPRESSION TECHNIQUES ON PORCELAIN LAMINATE VENEER TOOTH PREPARATION À AN INVITRO STUDY

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Abstract

The aim of this invitro study was to comparitively evaluate dimensional accuracy of PVS and VPES impression materials using 2 impression techniques on porcelain laminate veneer tooth preparation. A standard porcelain laminate veneer with four microscopic dimples of 1 mm dimension on a right maxillary central incisor was prepared on a typhodont and it was casted to obtain a standard stainless-steel die. Total 60 samples were made which was divided into 6 groups(based on the impression material and type of tray used). All the impressions were poured using type IV gypsum and dimensions were microscopically determined using toolmakers measuring microscope. Data was analysed using Independent t-test and One-way Anova test followed by Post hoc Tukey's test. The level of significance was set at 0.05 at 95% confidence interval. The anterior dual arch metal trays produced more accurate results among trays and in materials, VPES showed more accurate results.

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Introduction:-

To achieve an accurately fitting casting, precision must be maintained from the impression to the casting procedure. The impression material is used in the first phase, and any inaccuracy is carried through to the finished casting.¹ Impression materials are used to register or reproduce the form and relations of the teeth and the surrounding oral tissues. One such group of materials arethenonaqueous elastomeric impression materials, or elastomers, which were developed as an alternative to natural rubber during World War II. Today, two of the most popular elastomers used in dental practice are the polyethers and addition-reaction silicones, or vinyl polysiloxanes.²

The dual-arch impression is a closed-mouth impression technique that became popular in the late 1980s.The advantages of this technique are time and material saving, patient comfort, ease of use and reduced chair time, expense, effort and error as it requires fewer steps. It also reduces patient discomfort and gagging and several articles have elaborated on the technique as first reported by Wilson and Werrin and others.^{3,4,5}Dual-arch quadrant impression trays are often used to make simultaneous impressions of a prepared tooth and the opposing teeth.⁶ The dual-arch impressions can be made with either plastic or metal trays, where there is little evidence about the accuracy of these trays.⁸

Ceramic veneers were introduced to dentistry during late 1920s and 1930s which have become apopular, well accepted, and perceptive dental procedure. Different tooth preparation designs for ceramic veneers are described in the literature. Clyde and Gilmour¹⁰ and Huiet al¹¹ described the feathered incisal edge tooth preparation, the incisal

0.5 to 1.0 mm bevel preparation, the intraenamel or "window" tooth preparation in which 1 mm of incisal edge is preserved, and the overlapped incisal edge tooth preparation.

Vinyl polysiloxane (VPS) and polyether (PE) impression materials are commonly used to obtain final impressions in restorative dentistry. In 2009, a vinyl polyether silicone product (VPES) was commercially introduced which is available in a variety of consistencies and setting times. EXA'lence is composed of a combination of VPS and PE and is promoted as a hydrophilic material that presumably maintains the stability of the parent products.¹⁶ While data regarding the accuracy, dimensional stability, and surface detail reproduction of impression materials is readily available in the dental literature, little information is available on the properties of VPES.¹⁷ So the objective of this study was to evaluate dimensional accuracy of Vinyl polyether silicone and polyvinyl siloxane and comparing dimensional accuracy of Vinyl polyether silicone and polyvinyl silicone using two impression techniques: Conventional technique and Dual arch technique.

Materials and Method:-

Sample size and materials used:

The invitro study comprised of 60 samples which were divided into 6 groups based on impression trays and impression materials used. The impression trays include full arch conventional trays (Jabbar Company No.4), anterior dual arch plastic (Dual Tray, Dispodent, India) and metal (Anterior quad tray X2, Quad tray xtreme, USA) trays and the impression materials used were Polyvinyl siloxane (AquasilUltra, Dentsplysirona, India) and Vinyl polyether silicone (GC Europe N.V, Belgium) impression materials. The six groups were (GROUP A -Impression made using PVS with the help of conventional arch technique, GROUP B -Impression made using VPES with the help of conventional arch technique, GROUP C - Impression made using PVS with the help of dual arch technique using metal trays, GROUP D - Impression made using VPES with the help of dual arch technique using metal trays, GROUP E -Impression made using PVS with the help of dual arch technique using plastic tray, GROUP F - Impression made using VPES with the help of dual arch technique using plastic trays) used.

Preparation Of Die Model:

A standard type 2 porcelain laminate veneer preparation (butt joint preparation—2 mm incisal reduction without palatal chamfer)¹⁰⁻¹³ was made on a right maxillary central incisor of a typhodont. Four microscopic dimples of 1 mm dimension, two on the cervical region and two on the incisal region were made on the labial surface of the preparation. Four reference points were made on the labial surface for cast measurement on incisal edge, finishline and both the proximal line angles. Buccolingual dimensions were measured from point prepared on the incisal edge to the point prepared on the finish line and mesiodistal dimensions were measured with the help of two points prepared on the proximal surfaces of the preparation (Figure 1). The wax pattern of prepared central incisor was invested and casted to obtain the standard stainless-steel die (Figure 2). The die was then attached in the position of maxillary right central incisor on the typhodont model (Figure 3). The dimensions of the standard die between the centres of the reference points were microscopically determined with the help of toolmakers measuring microscope (Figure 4). Sufficient clearance around the preparation was provided for the adequate thickness of the impression material.

Adjusting the articulator:

Typhodont models were mounted in maximum intercuspation on a semi adjustable articulator using acrylic blocks. A tray positioning jig was attached to the articulator so that the position of the impression tray was constant and reproducible between the trials (Figure 5 and 6).

Impression making:

The impressions of typhodont teeth were made using polyvinyl siloxane and vinyl polyether silicone impression materials using conventional impression technique and dual arch impression technique according to the groups mentioned above with the help of metal trays and plastic trays (Figures 7, 8 and 9). A total of 60 impressions were made, 10 for each technique. Before taking any impression tray adhesive (GC America Inc, Chicago, IL.) was applied. For all the impressions, two-step technique was used with a polyethylene spacer. A polyethylene spacer (0.3 mm) supplied by the manufacturer was placed over the master model, putty was kneaded and placed on the tray and the tray was placed on the master model and allowed to set for 10 minutes. Then the spacer was removed and light body was syringed on to the tooth surface and the set putty. The set putty was then placed over the master model and allowed to set for 12 minutes (Figures 10 and 11).

Preparation of the Mater Cast:

Once the impressions were made, they were stored at room temperature for 60 minutes before being poured. All the impressions were rinsed in tap water for 10 seconds and air dried. Distilled (23ml) water was dispensed into the jar of a vacuum mixer and 100 gm of improved dental stone (type IV, Pearlstone) was weighed in an electronic measuring balance and was sifted gradually into the distilled water and allowed to soak for 30 seconds. Later the stone was mechanically mixed under vacuum in a vacuum mixer for 30 seconds. Small increments of stone mix were placed in the impression, and then placed on the vibrator. Using a blunt probe, the stone mix was directed into prepared Porcelain laminate veneer tooth impression to avoid air entrapments and void formation. After pouring the casts, the impression trays were suspended in a tray holder for 60 minutes for the gypsum to set. For the dual arch impressions, one side of the impression (maxilla) was poured. All casts were allowed to set for 24 hours at room temperature before removal from the impressions.

Measuring Procedure:

Once all the casts were obtained, they were labeled as per group and subjected to measurements in Toolmakers Measuring Microscope (Mitutoyo, Japan) (Figure 4). It can be used to measure up to 1/100th of a mm. The microscope was calibrated and adjusted to receive the samples. The die specimens were placed on the measuring table of the microscope and measurements on X and Y axis were done by turning the micrometer heads (Figures 12 and 13). Mesiodistal and incisogingival distances were measured between the center of the reference points.

Statistical analysis:

The data was collected, coded and fed in SPSS (version 23) for statistical analysis. The descriptive analysis included mean and standard deviation. Inferential statistics included Independent t test and one-way ANOVA followed by post hoc Tukey's test. The level of significance was set at 0.05 at 95% confidence interval.

Results:-

The mesiodistal and incisogingival distances between the reference points in the master die and in the casts obtained from all the six groups were tabulated. The average of the two mesiodistal distances measured between the center of the reference points in the master die was measured to be 2.365 mm. The average of the two incisogingival distances measured between the center of the reference points in the master die was measured to be 7.18 mm. The six groups were compared to these values.

Comparison of mean dimensional accuracy of conventional, metal and plastic trays used to assess the incisogingival and mesiodistal dimensions of VPES and PVS materials was conducted using the one-way ANOVA test respectively (Table 1 and Table 2, Graph 1 and Graph 2) followed by post hoc tuckey test (Table 3). Comparison of mean difference of increase and mean % increase of VPES and PVS at incisogingival and mesiodistal dimensions of conventional, metal and plastic trays was conducted using independent t test respectively (Table 4 and Table 5, Graph 3 and Graph 4).

It was observed that, when the mean difference in increase and mean % increase of dimensional accuracy of VPES and PVS of conventional trays at incisogingival dimensions were compared, there was a stastically significant difference noted ($p < 0.05$), where PVS showed more accurate results compared to VPES (Table 4 and Table 5). Intergroup comparison between conventional trays and metal trays and using PVS material in incisogingival dimensions showed statistically significant results ($p < 0.05$) in which metal trays showed more accurate results. Intergroup comparison between metal trays and plastic trays using PVS material in incisogingival dimensions showed statistically significant results ($p < 0.05$) in which metal trays showed more accurate results (Table 3).

Intergroup comparison between conventional trays with metal trays and plastic trays using VPES material in incisogingival dimensions showed statistically highly significant results ($p < 0.05$) in which metal trays showed more accurate results followed by plastic trays. Intergroup comparison between conventional trays with metal trays using VPES material in mesiodistal dimensions showed statistically significant results ($p < 0.05$) in which metal trays showed more accurate results. Intergroup comparison between metal trays and plastic trays using VPES material in mesiodistal dimensions showed statistically significant results ($p < 0.05$) in which metal trays showed more accurate results (Table 3). In metal trays, at incisogingival dimensions, when the mean difference in increase and mean % increase of dimensional accuracy of VPES and PVS was compared, there was a stastically significant difference noted ($p < 0.05$), where VPES showed more accurate results compared to PVS. In metal trays, at mesiodistal dimensions, when the mean difference in increase and mean % increase of dimensional accuracy of VPES and PVS

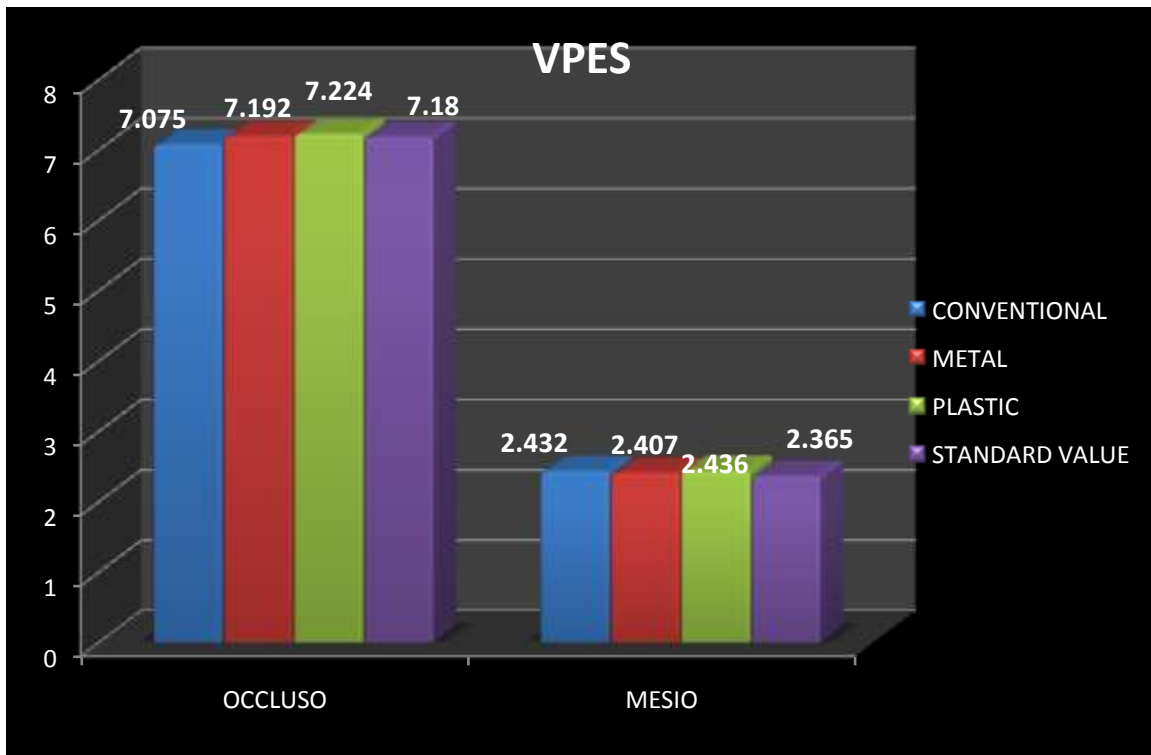
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In plastic trays, at incisogingival dimensions, when the mean difference in increase and mean % increase of dimensional accuracy of VPES and PVS was compared, there was a stastically highly significant difference noted ($p < 0.05$), where VPES showed more accurate results compared to PVS (Table 4 and Table 5).

When mean dimensional accuracy between two dimensions of each tray and standard value was compared it was found that mesiodistal dimensions of casts made using VPES and VPS impression materials with conventional, metal and plastic trays and incisogingival dimensions of cast made using VPES impression material with metal and plastic trays were larger compared to the standard value. It was also found that incisogingival dimensions of casts made using VPS with conventional, dual arch metal and dual arch plastic trays and VPES impression material with conventional trays were smaller compared to the standard value (Table 1 and Table 2).

Table 1:- Comparison of dimensional accuracy between Conventional, metal and plastic trays using VPES at incisogingival and mesio-distal dimensions.

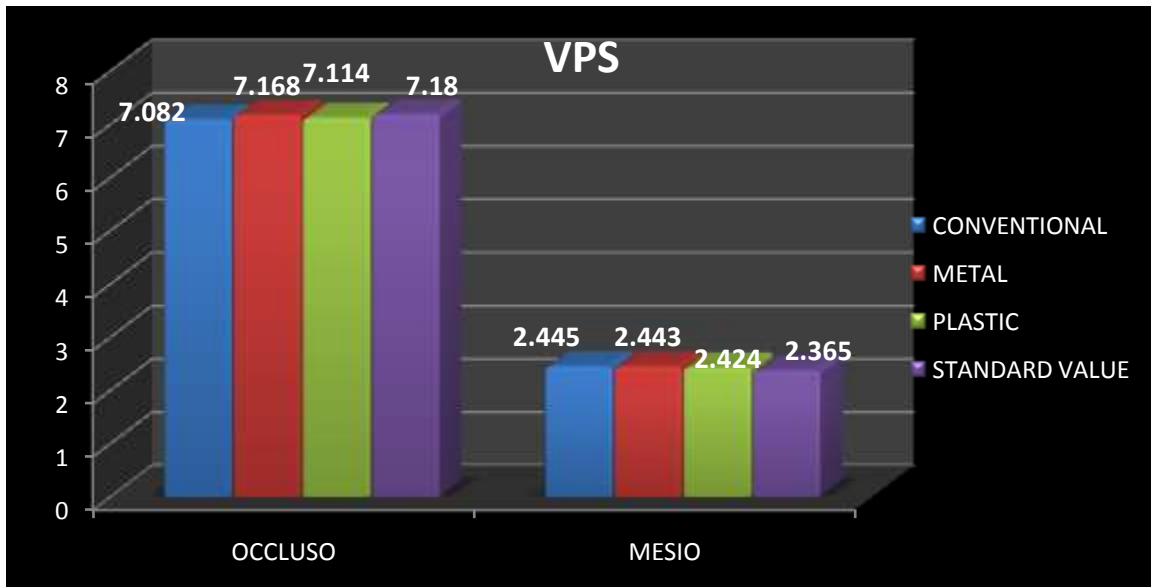
		Mean	Standard deviation	F	Significance
Incisogingival	Conventional	7.0750	.04035	12.033	0.000 (H.S)
	Metal	7.1920	.08162		
	Plastic	7.2240	.08396		
Mesio distal	Conventional	2.4320	.03259	0.889	0.042 (S)
	Metal	2.4070	.01889		
	Plastic	2.4360	.08316		



Graph 1:- Comparison of dimensional accuracy between Conventional, metal and plastic trays with standard value using VPES at incisogingival and mesiodistal dimensions.

Table 2:- Comparison of dimensional accuracy between Conventional, metal and plastic trays using VPS at incisogingival and mesiodistal dimensions.

		Mean	Standard deviation	F	Significance
incisogingival	Conventional	7.0820	.07084	1.922	0.016(S)
	Metal	7.1680	.10654		
	Plastic	7.1140	.11452		
Mesiodistal	Conventional	2.4450	.04089	0.819	0.045(S)
	Metal	2.4430	.02983		
	Plastic	2.4240	.04858		



Graph 2:- Comparison of dimensional accuracy between Conventional, metal and plastic trays with standard value using VPS at incisogingival and mesio-distal dimensions.

Table 3:- Intergroup comparison of dimensional accuracy between Conventional, metal and plastic trays using vpes and VPS at incisogingival and mesio-distal dimensions.

VPES			Mean difference	Standard error	Significance	95% Confidence interval	
Incisogingival	conventional	Metal	-.11700	.03198	.003 (H.S)	-.1963	-.0377
		plastic	-.14900	.03198	.000(H.S)	-.2283	-.0697
	Metal	plastic	-.03200	.03198	.583(N.S)	-.1113	.0473
Mesiodistal	conventional	Metal	.02500	.02357	.046(S)	-.0334	.0834
		Plastic	-0.004	0.02357	0.984(N.S)	0.0624	0.0544
	Metal	Plastic	.02900	.02357	.044(S)	-.0294	.0874
PVS							
Incisogingival	Conventional	Metal	0.086	0.04434	0.014(S)	0.1959	0.0239
		Plastic	-.03200	.04434	.753(N.S)	-.1419	.0779
	Metal	Plastic	-.05400	.04434	.045(S)	-.1639	.0559
Mesiodistal	Conventional	Metal	.00200	.01811	.993(N.S)	-.0429	.0469
		Plastic	.02100	.01811	.048(S)	-.0239	.0659
	Metal	Plastic	.01900	.01811	.035(S)	-.0259	.0639

Table 4:- Comparison of difference between mean dimensional accuracy and standard value of different dimensions of each tray.

Mean difference increase	Mean	Standard	T	Significance
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				deviation		
Conventional	Incisogingival	VPES	-.1050	.04035	0.272	0.012(S)
		PVS	-.0980	.07084		
	Mesiodistal	VPES	.0630	.03466	0.708	0.488(N.S)
		PVS	.0750	.04089		
Metal	Incisogingival	VPES	.0120	.08162	1.754	0.018 (S)
		PVS	-.0660	.11452		
	Mesiodistal	VPES	.0420	.01889	-3.224	0.005(H.S)
		PVS	.0780	.02983		
Plastic	Incisogingival	VPES	.0440	.08396	4.088	0.001(H.S)
		PVS	-.0980	.07084		
	Mesiodistal	VPES	.0710	.08316	0.394	0.062 (N.S)
		PVS	.0590	.04858		



Graph 3: Comparison of difference between mean dimensional accuracy and standard value of each tray in Incisogingival dimension

Mesiodistal dimension:

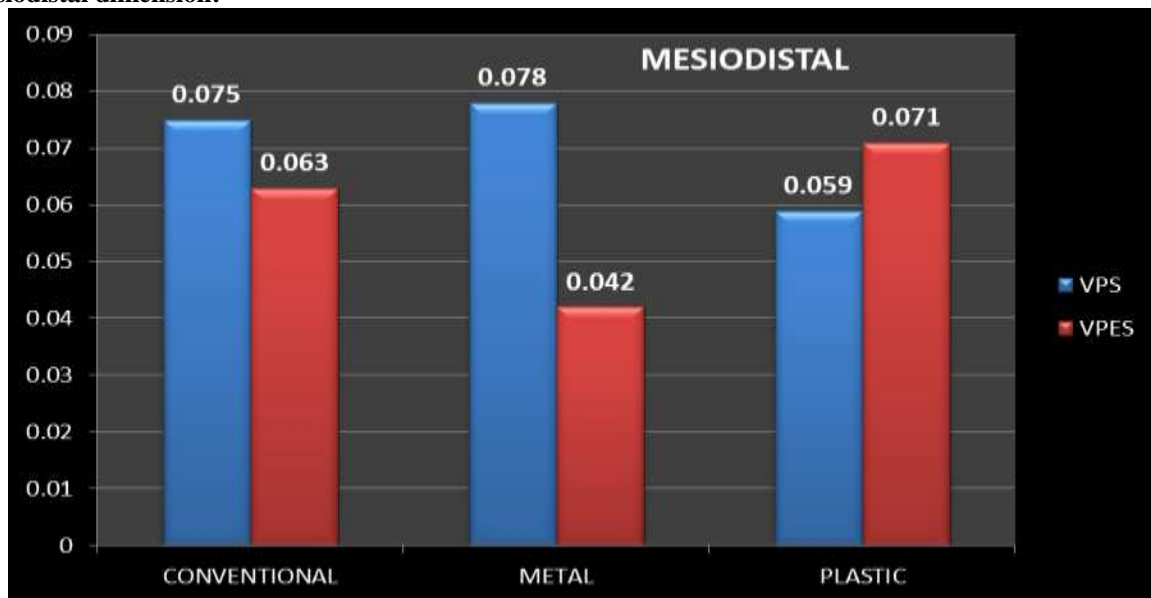
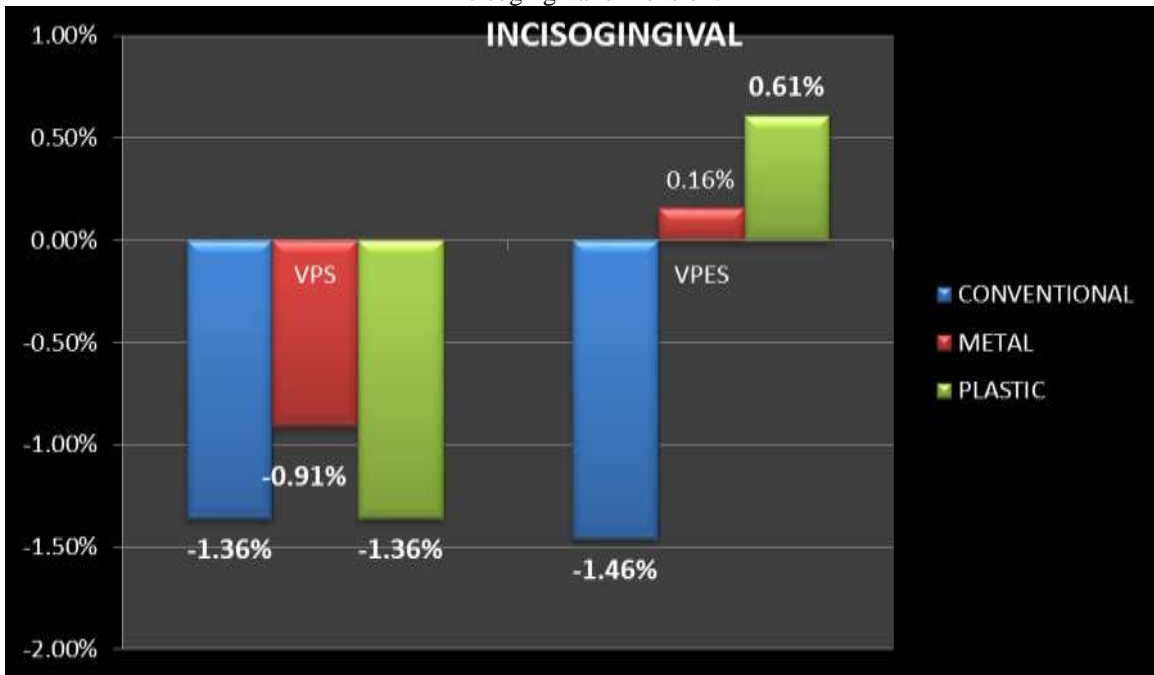
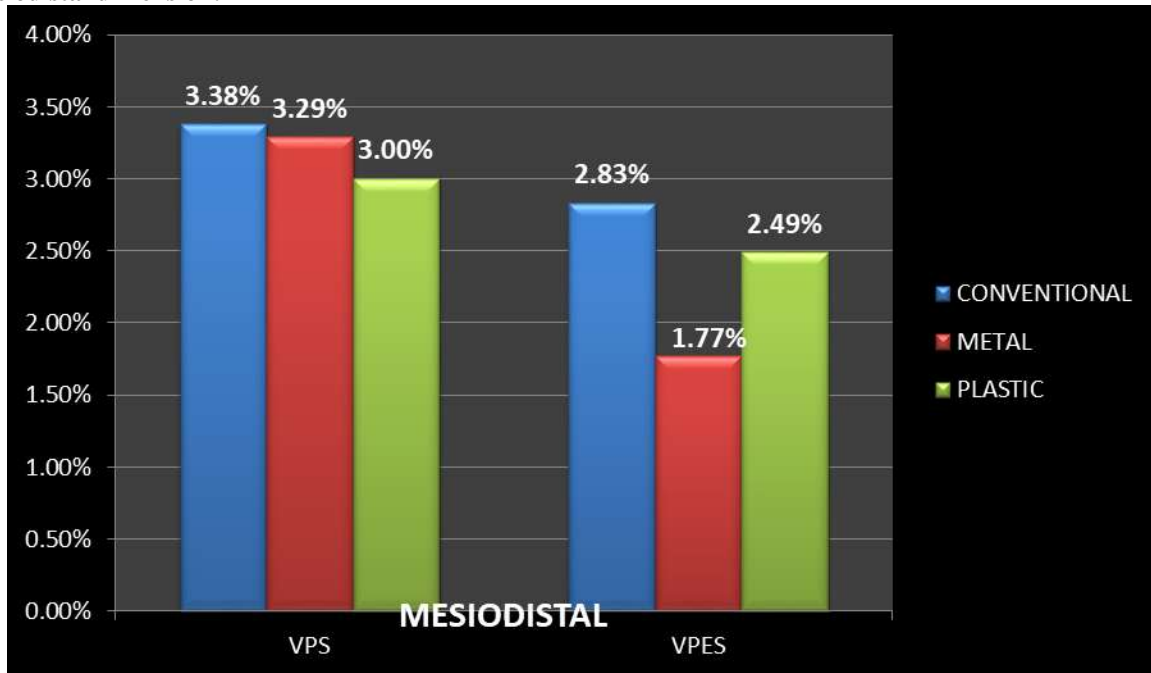


Table 5:- Comparison of difference between % increase of dimensional accuracy and standard value of different dimensions of each tray

% increase			Mean	Standard deviation	T	Significance
Conventional	Incisogingival	VPES	-1.4610	.56361	0.264	0.013(S)
		PVS	-1.3660	.98682		
	Mesiodistal	VPES	2.8330	1.37949	0.787	0.442(N.S)
		PVS	3.3830	1.72687		
Metal	Incisogingival	VPES	.1671	1.13680	1.754	0.018(S)
		PVS	-.9192	1.59503		
	Mesiodistal	VPES	1.7759	.79855	-3.224	0.005(H.S)
		PVS	3.2981	1.26143		
Plastic	Incisogingival	VPES	.6128	1.16933	4.088	0.001(H.S)
		PVS	-1.3649	.98658		
	Mesiodistal	VPES	3.0021	3.51627	0.394	0.062(N.S)
		PVS	2.4947	2.05412		

Graph 4:- Comparison of difference between % increase of dimensional accuracy and standard value of each tray in Incisogingival dimension.



Mesiodistal dimension:**Discussion:-**

Distortion of impression is an inherent problem during the indirect fabrication of a dental restoration. The choice of impression material and technique are the major factors that affect the accuracy of the final restoration. The addition silicone impression materials are considered to be very accurate as they are dimensionally stable for an extended period of time. Complete arch custom tray impression with addition silicone impression materials is considered as an accepted clinical standard.

The Dual-arch impression technique represents a significant advance in fixed prosthodontics and has many advantages over conventional impression techniques in the fabrication of certain fixed prosthesis. Lane DA²⁹ in 2003 stated that the double-arch technique was faster, more comfortable, better tasting, and preferred by 80% of the patients. The dual arch impression technique as described by Wilson and Werrin³ is convenient as it makes the maxillary and mandibular impressions and the interocclusal record in one procedure thereby saving time and material. Additional reasons for utilization of dual-arch impression technique also have been suggested. First, the dual arch impression technique allows the impression to be made in closed mouth position. This position provides two benefits: 1) The mandibular flexure that occurs after 28% of maximum opening was eliminated, and 2) teeth are placed near maximum intercuspation.^{41,42,43} The technique can also reduce patient discomfort and gagging. The major advantage of this technique is that it can reduce errors and the need for occlusal adjustment which result from:

1. Inaccuracies produced by the flexion of the mandible during the wide opening required for conventional impression techniques
2. Errors that may occur during articulation of casts either with or without interocclusal records
3. Discrepancies in opposing casts which are made from irreversible hydrocolloid⁴¹

During the making of dual arch impression, the teeth should be in Maximal Intercuspal Position (MIP). Cayouette MJ et al.⁴² mentioned that the teeth can shift when the dentition assumes maximum intercuspation. In 1997, Parker et al.⁴⁷ found that dual arch impression technique produced mounted casts with significantly more accurate maximum intercuspation than mounted casts made of full- arch impressions. Arora M et al.³⁹ stated that maxillary and mandibular master models can be mounted in maximum intercuspation position on a semi adjustable articulator (Hanau wide Vue series). Kaplowitz GJ²⁴ suggested that the dentist must carefully evaluate the patient before choosing the dual arch impression procedure and must select an appropriately sized impression tray that fits the arch and does not impinge on any anatomic structures that may produce a deflection of the tray wall.

A newer type of elastomer named EXA'lence (GC America Alsip, IL, USA) is available as a vinyl polyether silicone impression material (VPES). The manufacturer datasheet shows that it consists of a combination of two different elastomers. The major component of this material combines vinyl dimethyl polysiloxane (10% to 50%), methyl hydrogen dimethyl polysiloxane (3% to 10%), and silicon dioxide (30% to 65%), as well as the smaller portion of 5%- 20% PE to enhance hydrophilicity in the presence of fluids.⁴² This phenomenon can be explained as the following: the mixture of high molecular weight of polyether chains form the backbone frames, and that the smaller PVS molecules attach to the PE backbone. The existence of functional groups of VSE can provide similar hydrophilic characteristics to PE. While data regarding the accuracy, dimensional stability and surface detail reproduction of VPS impression materials is readily available in the dental literature, little information is available on the properties of VPES. Because the main component of VPES is VPS, this in vitro study aimed at testing the dimensional accuracy of a VPES impression material in comparison to a VPS-based one.^{16,17,34,40}

The purpose of the present study was to evaluate and compare the dimensional accuracy of the working dies generated from anterior dual arch impression technique using plastic anterior dual arch trays and metal anterior dual arch trays to the working dies generated from conventional full arch metal tray impression technique. Polyvinyl siloxane impression materials (PVS) and Vinyl polyether silicone (VPES) have been used to make the impressions in this study.

Group A and Group B impressions were made using conventional metal full mouth trays, Group C and Group D impressions were made using anterior dual arch metal trays and Group E and Group F impressions were made using anterior dual arch plastic trays (Dual Tray, Dispodent Dental Products). Manufacturers have recommended that this tray can be used along with PVS impression materials or irreversible hydrocolloids. In Group A, C and E, impressions were taken using poly vinyl siloxane (PVS) impression material and in Group B, D and F impressions were taken using vinyl polyether silicone (VPES) impression material.

There was an increase in mesiodistal and incisogingival dimensions of the dies obtained from all the six groups except incisogingival dimensions of casts made using VPS material and VPES impression material with conventional trays which were smaller compared to the standard value. This was in agreement with previous studies conducted by **Breeding LC and Dixon DL**⁶ in which they concluded that the plastic trays produced tooth replicas that were larger than the tooth. In a study, done by **Davis and Schwartz**⁹, it was found that the dual arch trays were as accurate as the custom trays in every dimension measured and the variations were within 35 μm in all instances. **Lane et al.**²⁹ stated that no significant differences were found between complete arch technique and dual arch technique for accuracy of fit of the restoration. The margin is considered to be open only if there is a discrepancy of 50 μm or more. The marginal discrepancy less than this will not be detected even by a sharp explorer. The altered dimensions of the dies may be attributed to various factors. The polyvinyl siloxane impression material shrinks towards the center of mass during polymerization.⁴⁹ The use of a tray adhesive would redirect this shrinkage towards the walls of the tray.⁵⁰ Also there will be compensation of polymerization shrinkage by the die stone expansion. The measurements made on the stone casts are potentially affected not only by the impression material and the tray type but also by the expansion of the die stone used.

The significance of these results is that there appears to be little advantage to the use of the conventional complete arch impression technique over the dual arch impression technique while making an impression of an anterior porcelain laminate veneer tooth preparation. Conventional impression technique requires an additional impression of the opposing arch, additional cost in materials and more chairside time. And it did not show any clinically significant difference from the dual arch technique in any of the dimensions measured in this study. Hence the dual arch impression technique can be strongly recommended for making impressions of single anterior porcelain laminate veneer tooth preparations.

The dual arch metal trays produced more accurate casts when compared to dual arch plastic and conventional trays. This was in agreement with previous studies done by Arora M³⁹ et al in which they concluded that metal dual arch trays produce more accurate dies when compared to dies produced from plastic dual arch trays. The casts made using VPES showed more accuracy dimensionally when compared to casts made using PVS irrespective of the trays (Table 1 and Table 2).

The results of the study were limited to the specific type of trays and impression materials used. This study examined the variations only in mesiodistal and incisogingival dimensions of the die. These results cannot be

applied to clinical situations involving the fixed partial dentures or multiple prepared teeth, because variations in interabutment distances were not evaluated in this study.

Other limitations of the study include:

1. The effect of the lips, tongue, and cheeks in containing the impression material could not be simulated in this study.
2. The influence of the varied occlusal forces in the oral cavity could not be simulated in the study.

Conclusion:-

In fixed prosthodontics, dual arch impression trays are often used to make impressions of the prepared teeth and of the opposing arch simultaneously. The accuracy of the working dies prepared with this technique is of concern, because of lack of confinement of the impression material, variation in impression material thickness and flexibility of the dual arch impression trays. The present in-vitro study was conducted to evaluate and compare the dimensional accuracy of working dies prepared from dual arch impression technique, and from conventional impression technique and to evaluate dimensional accuracy of vinyl polyether silicone and poly vinyl siloxane following anterior porcelain laminate veneer tooth preparation. The dies were measured in mesio-distal and inciso-gingival dimensions using a Toolmakers Measuring Microscope.

Within the limitations of the study, the following conclusions were drawn:

Multiple group comparisons between all the six groups using oneway analysis of variance (ANOVA) revealed statistical significance indicating metal trays produced more accurate results followed by plastic trays.

When VPES and PVS impression materials were compared using Independent t test, VPES material showed more accurate results in all dimensions using conventional, metal and plastic trays (except in incisogingival dimensions using conventional trays where PVS material showed more accurate results).

Figures:-



Figure 1:- Porcelain laminate veneer preparation with reference points made on right maxillary central incisor of a typhodont model.



Figure 2:- Casted maxillary central incisor preparation.



Figure 3:- Casted master die preparation reattached to the typodont.



Figure 4:- Toolmakers Measuring Microscope, (MITUTOYO, Japan) used for the measurement of dies.



Figure 5:- Positioning jig attached to the incisal pin portion of the Hanau Wide Veu articulator.



Figure 6:- Impression taken in Hanau Wide Veu articulator.



Figure 7:- Conventional full arch plastic, anterior plastic dual arch tray and anterior metal dual arch tray used for the study.



Figure 8:- VPES Impression material used for the study.



Figure 9:- PVS Impression material used for the study.

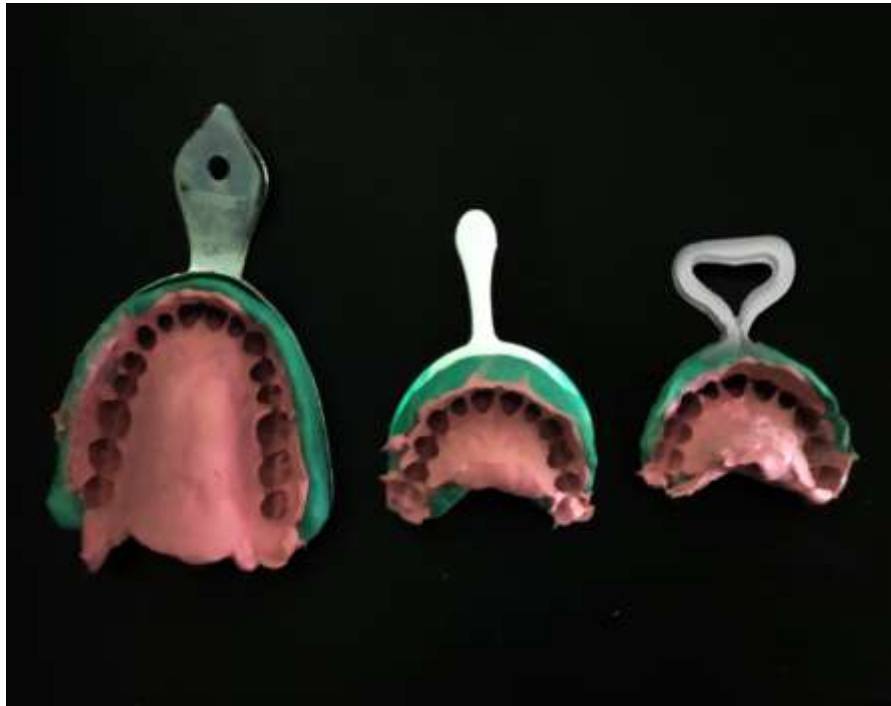


Figure 10:- Impression obtained using conventional, plastic and metal dual arch trays with VPES impression material.



Figure 11:- Impression obtained using conventional, plastic and metal dual arch trays with PVS impression material.



Figure 12:- Die prepared from the cast obtained.

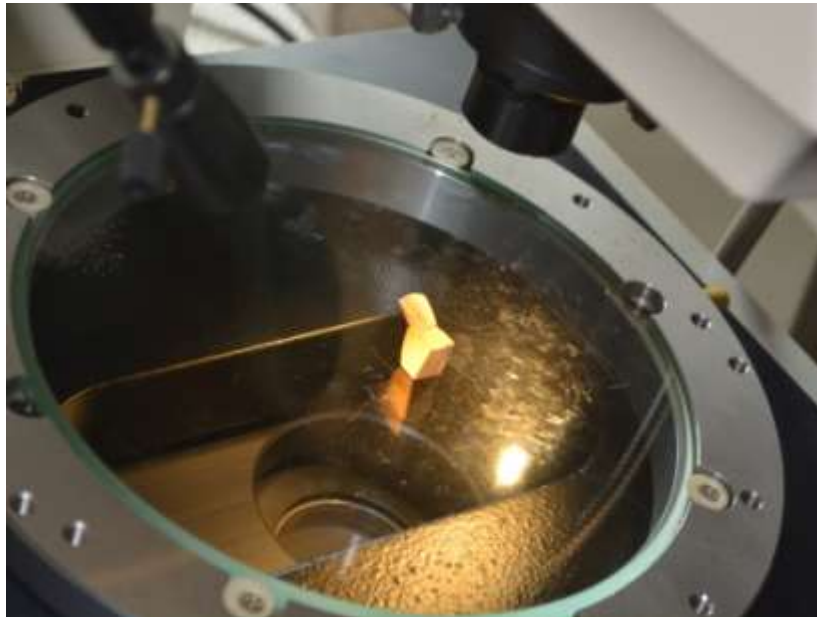


Figure 13:- Die placed on the measuring table of the Toolmakers Measuring Microscope.

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