LINEAR DIMENSIONAL CHANGES IN ACRYLISED MAXILLARY AND MANDIBULAR COMPLETE DENTURES WITH DIFFERENT ARCH FORMS USING TWO INVESTMENT MATERIALS -A COMPARATIVE IN VITRO STUDY

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ABSTRACT

Aim:-To investigate linear dimensional changes before and after curing procedure using two investment materials using dental plaster type II (kalabhai) and type III dental stone (kalabhai) for maxillary and mandibular complete dentures with three different arch forms.

Material and Methods:A Comparative in vitro Study conducted in the Department of Prosthodontics in jaipur dental college, Jaipur (Rajasthan) using conventional poly methyl methacrylate denture base resin without any addition of reinforced fibers.Three pairs of Edentuolous cast of three different arch forms – U (GROUP 1) , V(Group 2), Square (Group 3) for maxilla and mandible were taken (Total 30 pairs) , did the waxup of the teeth onto the arches using a silicone matrix and marking and measuring three reference points to compare the pre - acrylisation and post- acrylisation values for the samples, also compared these results with two different investment material marked as Investment A (Dental Plaster type II) and Investment B (Type III Dental Stone).

Results-: Paired 't' Test was done to compare mean values within each group. Student 't' Test was done to compare changes between different arch forms. Using Investment A for maxilla and mandible in U ,V and Square arch had no statistical significance.Using investment B for maxilla and mandible in U, V and Square arch showed statistically significant values.Choice of investment material A or B; has little statistical significance when compared with each other. Arch from has statistically insignificant value if proper processing steps are followed.(P>0.05)

Conclusion: Upon comparison of the arches with each other it was found that investment procedure matters more and all possible steps should be taken to control the errors that arise due to the various steps that are involved in the processing of the complete dentures rather than one factor of kind of investment material used.If care is taken in the processing of the dentures and all correct steps are followed, the errors can be greatly reduced.

Keywords : Linear dimensional changes, Arch forms, Investment materials,poly methyl methacrylate denture base resin

INTRODUCTION

For the normal continuity of life, replacement of missing teeth by artificial substitutes like denture hold importance. Parts of denture include denture base and denture teeth.[1] Denture base acts as an intermediary between teeth and the jaw, and has to transfer all or part of masticatory forces to the adjacent tissues. It must be realized that dentures are artificial substitutes & have limitations.[2]

With the progressing civilization, moreover, advancement in the field of biological, chemical and physical sciences, there has been a slow but steady increase in both the quantity and quality of material used for dental prosthesis.[3] There has been continued refinement of material available for dental practice. The materials should be biologically compatible, readily available, reasonably inexpensive and simple to manipulate with a readily controlled technical procedure, to develop a prosthesis that is functionally effective and pleasing in appearance.[4,5]

In the past few years, acrylic resin monomer and polymers have also been modified to improve not only physical and mechanical properties, but also the dimensional shrinkage and working properties that facilitate laboratory techniques of denture fabrication.

However, later research and investigations revealed that, regardless of the curing technique or type of acrylic resin selected, the processing deformation that is apparent when the cured dentures are removed from the cast is universally recognized as major disadvantage of this material.Upon polymerizing, these poly methyl methacrylate resins exhibit a 0.2% to 0.5% linear polymerization shrinkage.[6] A similar degree of linear expansion should occur because of water sorption.[7]This shrinkage is unfortunately associated with its polymeric and polymerization process, which is must for its hardening process. Further, heat curing process also imparts shrinkage because of cooling of polymer from its curing temperature to room temperature. Therefore, it would appear that these two opposing processes would balance each other and would result in an accurately fitting base. However, clinical experience and research findings indicate that this does not occur. Linear shrinkage is actually greater than linear expansion. The expansion of dentures after storage in water at room temperature for one week failed to compensate for the initial processing shrinkage.

The dentures remained dimensionally stable even after storage in water for eight months. However, polymerization shrinkage of the resin and distortion of the denture base due to thermal stress is virtually unavoidable during the processing of dentures, though it is doubtful they will be noticed by the patient.[8]

In 1937, Dr.Walter Wright, introduced Poly methyl methacrylate, as denture base material, which became the major polymer to be used for many years.[9]The processing warpage and base distortion that occour when polymerized dentures are removed form the cast are considered the major disadvantage of acrylic resins.[10,11]

The quality of a complete denture is affected by several processing variables that may cause base distortion and consequent alteration of tooth position.[12,13]. These variables start from the time of waxup of trial dentures, the investing procedure and the investment material used, method of resin introduction and flask closure, temperatures used to activate polymerization are known to cause changes in the processed dentures.[14,15]

In efforts to overcome these undesirable processing effects, various flasking and polymerization techniques and materials have been studied indicated that the use of artificial stone as an investing medium can significantly reduce tooth movement.[16,17]Differences in denture base thickness of different arch forms have also been found to lead to variation in tooth movement.[18] Flask closure method and post-pressing time were reported to be important factors affecting tooth displacement.[19]

Very less literature was available with different arch forms influencing tooth movement & with different investing material.Therefore this study was conducted to assess the dimensional variation in plain heat cure denture base acrylic resin, compare movement of teeth during the processing of simulated complete maxillary and mandibular dentures of three different arch forms (U,V and Square) using two different investing materials (dental plaster Type II (kalabhai) and Type III dental stone (kalabhai) and the compression moulding technique, using conventional poly methyl methacrylate denture base resin without any addition of reinforced fibers.

MATERIAL AND METHODS

Study design:- comparative study design.

Study duration:-2 years (January 2015-December 2016)

Study done-Department of Prosthodontics ,crown & bridge , Jaipur Dental College,Jaipur (Rajasthan) India

Sample size:.Three pairs of Edentuolous cast of three different arch forms – U (GROUP 1) , V(Group 2), Square (Group 3) for maxilla and mandible were taken (Total 30 pairs)

Materials: Following materials were used in the fabrication of maxillary and mandibular dentures,as well as standardized method for waxing an arch of teeth to the base.

Type III dental stone (Kalabhai, India), Type II dental plaster (Kalabhai, India),Edentulous silicone moulds for class I (Nissin),II and III (Biostarmould),Modelling wax (Y- dent, India) ,Heat Cure Acrylic resin (DPI, India) ,Hanau flask ,Dental clamp ,Mean value articulator (Jabbar& company India),Digital vernier caliper(Aerospace) ,Digital weighing scale ,Measuring cup ,Black marker (Luxor) ,Mackintosh sheet ,Waxup instruments (API, India) ,Acrylic teeth set (Caredent,size –medium, shade no.23) ,Lab micromotor (Marathon)

,Trimming burs (Shofu) ,Medium round carbide bur(SS.white no. 8) ,Petroleum jelly (Vasaline) ,Silicone duplication material (murtisil 1010) ,OPG film ,Porcelain Tile ,Sticky wax(Surana, India) ,Stapler ,Kidney tray ,Burner ,Vibrator (Wipmix), Rubber bowl and spatula ,Acryliser (Apex) ,Hydraulic press ,Acrylic mixing cup ,Pattern measuring gauge (API, India) ,Could mould seal (DPI, India) ,Faber castell brush no.9 ,Cellophane sheet (DPI, India) ,Match Stick ,Tap water ,Water storage Box

Procedure-

1. **Stone cast fabrication and standard models -**Ideal edentulous maxillary and mandibular moulds for Square (Nissin), U & V (Biostarmould) arch were taken and type III dental stone (Kalabhai India) and 10 U-shape, 10 V-shape and 10 Square shape maxillary and mandibular stone cast were made .

2. **Occlusal rims and cast marking -**Prior to making the occlusal rims the casts were marked for(Midline ,Crest of ridge ,Slope of mandible ,Retromolar pad and its divisions ,Canine line ,Canine papilla canine line (CPC) ,Incisive papilla ,Maxillary tuberosity(figure1).A uniform denture base was made with 2mm modelling wax which was then acrylized with heat cure acrylic resin (DPI).The height of the occlusal wax rim in maxilla was 22mm anteriorly at the canine line and 20 mm at the second molar area,in the mandible anteriorly it was 15 mm[35] in the midline and upto 2/3rd of retromolar pad posteriorly.(figure 2)

The maxillary and mandibular cast were articulated on the non adjustable articulator (Jabbar& Company India) with the following anterior over jet :-

Class I -The overjet was kept at 1-2 mm .

 Class II-The overjet was kept at 4-6 mm.

Class III-The over jet was kept at edge to edge bite .
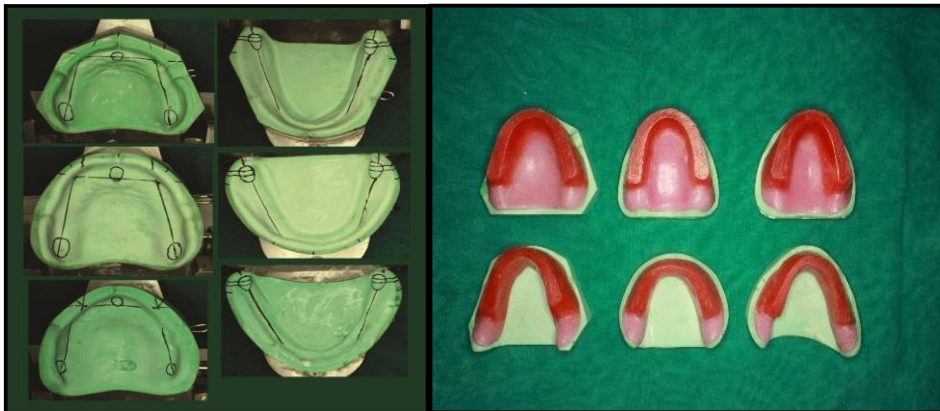
Figure 1: Cast marking   Figure 2: Occlusal rims

3. **Teeth arrangement** -Routine teeth arrangement was done using Caredent, size – medium, shade no.23 with all the three arches with minor variations for each respective arch type.(figure 3,4)

ClassI – 5-7 mm space between canine and first premolar kept

ClassII-second premolar is missed in maxilla and mandible, 5-7mm space kept between canine and premolar.[38]

ClassIII- occlusally the central incisor is angled outward.

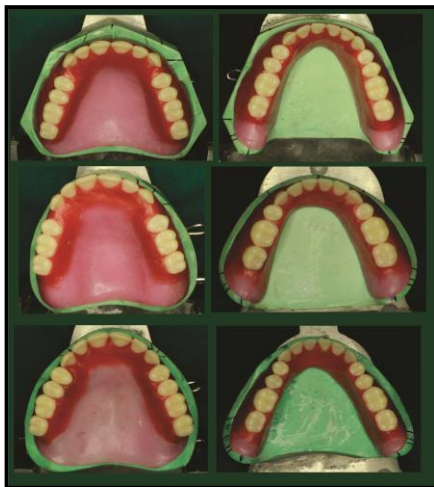**Figure 3: Teeth Arrangement**

Figure 4-Square,U ,V Arches

4. Siliconemould for duplication of arrangements:

After finishing the teeth arrangement, a silicone matrix was made by using Murtisil 1010 and pouring the duplication material onto the trial dentures after enclosing it with OPG film on a tile .

5. Duplication of complete waxed denture (with teeth):

With the same mould of the teeth (Caredent, size – medium, shade no.23) the denture wax up were duplicated by melting and poring wax into the mould that held the acrylic resin teeth and inverting stone cast in correct relationships to each other (fig 13). 60 denture wax ups (10 U-shape complete denture,10 for V- shape, and 10 for Square arch shape maxillary and mandibular dentures). (figure 5)

Each group processed into acrylic resin denture using two different investment materials as follows:

Group 1: U -arch shape conventional, standardized complete denture.

Group 2: V -arch shape conventional, standardized complete denture.

Group 3: Square -arch shape conventional, standardized complete denture

All the three groups have further subdivisions based on type of investment materials used:

Subdivision A - processing of complete denture using dental plaster type II (kalabhaiindia).

Subdivision B - processing of complete denture using type III dental stone (kalabhaiindia).

Figure 5: Duplication of complete waxed denture

6.Methods of measurement of linear dimensional changes: Pre - Acrylisation measurements -In this study, digital vernier caliper (Aerospace) as the measurement tool of dimensional accuracy was used. We attempted to evaluate and compare the linear changes of teeth before acrylisation.

Linear dimensional changes in the unprepared denture base:Reference points were marked with medium round carbide bur (SS. WHITE no.8) on disto - buccal cusps of molars and mesio – incisal angle of right central incisors of both maxilla and mandible.Measurements were made between these points –MI,1M,MM.

The reading between these points were made for each of the dentures. The measurements were taken at this stage, first after the wax-up and carving of complete denture and the values thus recorded were tabulated and subjected for statistical evaluation to get the results. This was done for investment A and investment B. After which the sample was acrylized as follows.(Figure 6)
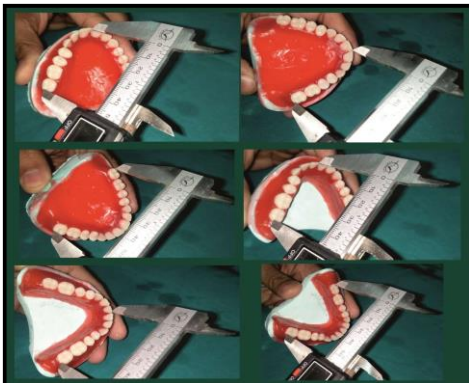
Figure 6: Measurements pre acrylisation

7.Flask preparation and wax elimination:-The cast with the record base was flasked in the lower part of a Hanu brass flask with plaster. A separating medium(DPI) was applied to the investment and allowed to dry, and then the upper part of the flask was assembled and filled with plaster with singleFor evaluating the Linear dimensional changes in the unprepared denture base, Measurements were made between the same points –MI,1M,MM (Figure 7)

Figure 7:flask Preparation and Wax elimination

The reading between these points were made for each of the acrylised dentures The measurements were taken at this stages, after curing , after immersion in water for 24 hours i.e of processed dentures.[44]The values thus recorded were tabulated and subjected for statistical evaluation to get the results. This was done for investment A (fig 19) and investment B (Figure 8).
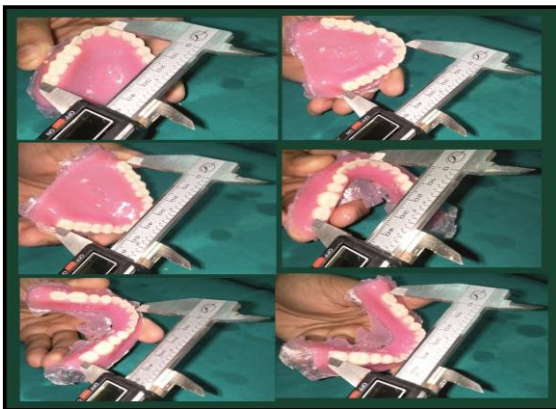
Figure 8: Recording of values for Investment A and B

RESULTS

Data were subjected to statistical analysis using SPSS (IBM® SPSS (software package used for statistical analysis)® Statistics 20 Student Version (manufactured in august 2011)) Software (Version 20). Paired 't' TEST was done to compare mean values within each group. Student 't' TEST was done to compare changes between different arch forms.

Table 1-.Comparison b/w Pre & Post processing means of Maxilla for Investment A

		Maxilla Pre Pro		Maxilla Post Pro		
		Mean	SD	Mean	SD	P-Value b/w Pre & Post
"U"ARCH	MI	43.60	0.33	43.37	0.26	0.1223
	IM	46.45	0.16	48.53	4.45	0.3458
	MM	53.14	0.52	52.92	0.43	0.3835
"V" ARCH	MI	47.52	0.31	47.19	0.27	0.0038
	IM	48.94	0.36	48.74	0.08	0.2889

	MM	58.62	0.24	58.33	0.29	0.0135
"SQUARE" ARCH	MI	49.15	0.33	48.92	0.19	0.1490
	IM	51.87	3.53	50.34	0.30	0.3908
	MM	56.83	0.38	56.54	0.56	0.4521

Table 2-Comparison between Maxillary "U","V" & "SQUARE" arch

		Maxilla Pre Pro				
		Mean	SD	P-Value b/w U & V Arch	P-Value b/w U & Square Arch	P-Value b/w V & Square Arch
"U"ARCH	MI	43.37	0.26			
	IM	48.53	4.45			
	MM	52.92	0.43			
"V" ARCH	MI	47.19	0.27	0.0000		
	IM	48.74	0.08	0.9178		
	MM	58.33	0.29	0.0000		
"SQUARE" ARCH	MI	48.92	0.19		0.0000	0.0000
	IM	50.34	0.30		0.3914	**0.0000**
	MM	56.54	0.56		0.0000	0.0002

Table 3-Comparison b/w Pre & Post processing means of Mandible for Investment A

		Maxilla Pre Pro		Maxilla Post Pro		
		Mean	SD	Mean	SD	P-Value b/w Pre & Post
"U"ARCH	MI	41.82	3.65	41.29	3.00	0.8241
	IM	41.09	0.57	40.79	0.42	0.0481
	MM	50.38	0.24	48.76	2.77	0.2324
"V" ARCH	MI	46.10	0.26	45.96	0.12	0.2620
	IM	48.36	0.25	48.10	0.22	0.1380
	MM	55.45	0.35	54.91	0.58	0.0368
"SQUARE" ARCH	MI	45.28	0.71	45.20	0.68	0.5543
	IM	46.72	0.57	46.88	0.72	0.3510
	MM	53.39	0.56	53.15	0.41	0.2905

Table 4-Comparison b/w Different Arches in Mandible Post processing for Investment A

		Maxilla Pre Pro				
		Mean	SD	P-Value b/w U & V Arch	P-Value b/w U & Square Arch	P-Value b/w V & Square Arch
"U"ARCH	MI	41.29	3.00			
	IM	40.79	0.42			
	MM	48.76	2.77			
"V" ARCH	MI	45.96	0.12	0.0084		
	IM	48.10	0.22	0.0000		

	MM	54.91	0.58	0.0012		
"SQUARE" ARCH	MI	45.20	0.68		0.0218	0.0397
	IM	46.88	0.72		0.0000	0.0066
	MM	53.15	0.41		0.0079	0.0005

Table 5-Comparison b/w Pre & Post processing means of Maxilla for Investment B

		Maxilla Pre Pro		Maxilla Post Pro		P-Value b/w Pre & Post
		Mean	SD	Mean	SD	
"U"ARCH	MI	43.76	0.13	43.63	0.28	0.1736
	IM	46.55	0.21	46.37	0.19	0.0694
	MM	53.23	0.24	52.76	0.34	0.0048
"V" ARCH	MI	47.87	0.25	47.66	0.22	0.0156
	IM	49.04	0.30	48.75	0.20	0.0180
	MM	59.03	0.24	58.47	0.17	0.0018
"SQUARE" ARCH	MI	49.24	0.18	48.98	0.16	0.0106
	IM	50.28	0.21	49.96	0.08	0.0163
	MM	57.18	0.22	56.81	0.20	0.0088

Table 6-Comparison b/w Different Arches in Maxilla Post processing for Investment B

		Maxilla Pre Pro		P-Value b/w U & V Arch	P-Value b/w U & Square Arch	P-Value b/w V & Square Arch
		Mean	SD			
"U"ARCH	MI	43.63	0.28			
	IM	46.37	0.19			
	MM	52.76	0.34			
"V" ARCH	MI	47.66	0.22	0.0000		
	IM	48.75	0.20	0.0000		
	MM	58.47	0.17	0.0000		
"SQUARE" ARCH	MI	48.98	0.16		0.0000	0.0000
	IM	49.96	0.08		0.0000	0.0000
	MM	56.81	0.20		0.0000	0.0000

Table 7-Comparison b/w Pre & Post processing means of Mandible for investment B

		Maxilla Pre Pro		Maxilla Post Pro		P-Value b/w Pre & Post
		Mean	SD	Mean	SD	
"U"ARCH	MI	40.35	0.25	40.11	0.17	0.0024
	IM	41.34	0.18	41.27	0.19	0.1991
	MM	50.55	0.27	51.88	3.52	0.4662
"V" ARCH	MI	45.87	0.54	45.55	0.47	0.0041
	IM	48.25	0.60	47.90	0.57	0.0010
	MM	55.27	0.35	54.79	0.26	0.0053
"SQUARE"	MI	45.95	0.26	45.70	0.20	0.0622

ARCH						
	IM	47.13	0.28	47.05	0.18	0.5395
	MM	53.22	0.30	52.83	0.30	0.0293

Table 8-Comparison b/w Different Arches in Mandible Post processing for investment B

		Maxilla Pre Pro		P-Value b/w U & V Arch	P-Value b/w U & Square Arch	P-Value b/w V & Square Arch
		Mean	SD			
"U"ARCH	MI	40.11	0.17			
	IM	41.27	0.19			
	MM	51.88	3.52			
"V" ARCH	MI	45.55	0.47	0.0000		
	IM	47.90	0.57	0.0000		
	MM	54.79	0.26	0.1023		
"SQUARE" ARCH	MI	45.70	0.20		**0.0000**	0.5277
	IM	47.05	0.18		**0.0000**	**0.0132**
	MM	52.83	0.30		0.5646	**0.0000**

Table 9-Comparison arch values of Maxilla Post Process b/w investment A & investment B

S. NO.		Maxilla Pre Pro INVESTMENT -A		Maxilla Pre Pro INVESTMENT -B		P Value
		Mean	SD	Mean	SD	
"U"ARCH	MI	43.37	0.26	43.63	0.28	0.1721
	IM	48.53	4.45	46.37	0.19	0.3091
	MM	52.92	0.43	52.76	0.34	0.5412
"V" ARCH	MI	47.19	0.27	47.66	0.22	0.0166
	IM	48.74	0.08	48.75	0.20	0.9353
	MM	58.33	0.29	58.47	0.17	0.3546
"SQUARE" ARCH	MI	48.92	0.19	48.98	0.16	0.5783
	IM	50.34	0.30	49.96	0.08	0.0263
	MM	56.54	0.56	56.81	0.20	0.3408

Table 10-Comparison arch values of Mandible Post Process b/w Investment A& Investment B

		Maxilla Pre Pro INVESTMENT -A		Maxilla Pre Pro INVESTMENT -B		P Value
		Mean	SD	Mean	SD	
"U"ARCH	MI	41.294	3.002812	40.112	0.167242	0.4051
	IM	40.79	0.42	41.27	0.19	0.0504
	MM	48.76	2.77	51.88	3.52	0.1577
"V" ARCH	MI	45.96	0.12	45.55	0.47	0.0916
	IM	48.10	0.22	47.90	0.57	0.4897
	MM	54.91	0.58	54.79	0.26	0.6883
"SQUARE"	MI	45.20	0.68	45.70	0.20	0.1570

ARCH						
	IM	46.88	0.72	47.05	0.18	0.6119
	MM	53.15	0.41	52.83	0.30	0.1998

DISCUSSION

Table 1 showsComparison b/w Pre & Post processing means of Maxilla for Investment A that there was a significant difference between the pre-processing and post-processing (P) values of "V" shaped arch, the analysis showed the changes were highly significant and significant."U" and Square arch showed non-significant findings.These results are consistent with the study done by done by Alaa'aM.Salloum[20] on effect of investing materials on tooth movement during flasking procedure for complete denture construction, gave similar values with our study. This can be attributed to the use of same investment material and procedure and also post acrylisation care was the same as in this study.

Table 2 showsthe comparison between Maxillary "U",",V" & "SQUARE" archand found that the difference in values does not depend on the investment material in relation to the arch form.Lechnerwho reported that investing material does not influence linear distance as long as teeth are kept in position by virtue of existence of mesio - distal contacts.[21]

Table 3 shows theComparison b/w Pre & Post processing means of Mandible for Investment A and found all findings non-significant. Though the nonsignificant findings can be attributed to the use of plaster as investment material as it has less setting expansion than dental stone ,there by not able to compensate for polymerisation shrinkage leading to more tooth movement.[22]

Table 4 shows Comparison between Different Arches in Mandible Post processing for investment A and obtained highly significant results. As per the findings of the comparison of P values of the mandibular arches it can be concluded that the difference in values does not depend on the investment material in relation to the arch form.

Table 5 shows Comparison between Pre & Post processing means of Maxilla for investment B .Highly significant results were found. Our results were similar to a research report by Myung –Joo Kim[23] submitted to dental department of prosthodontics, graduate school, seoul national university .He measured different denture bases for maxillary arch for dimensional changes by making markings on central incisor and second molars similar to this study and measured the marks with laser scanner and concluded that conventional acrylic resin showed significant dimensional change with 91% confidence interval for the mean, which is similar to this study having 99% confidence of mean for MI and IM, even though the packing and curing cycles for between our study and his study are different.[24]

Table 6 showsComparison b/w Different Arches in Maxilla Post processing for investment B.As per the findings of the comparison of P values of the maxillary arches it can be concluded that the difference in values does not depend on the investment material in relation to the arch form.

Table 7 showsthe Comparison between Pre & Post processing means of Mandible for investment B and found out inconsistent values for MI, IM, MM. A two pour technique with brush on method was used for flasking of investment B which can be a reason for shift of teeth as the heat from setting investment material (second pour) can be sufficient to move the

teeth.[23] Rapid flask closure at the time of flasking can cause the teeth to move and can also be the reason for the inconsistent values.[25]

Table 8 shows Comparison between Different Arches in Mandible Post processing for investment B . As per the findings of the comparison of P values of the mandibular arches it can be concluded that the difference in values does not depend on the investment material in relation to the arch form.

Table 9 shows Comparison of Post acrylisation P values between Investment A & B forMaxilla.Non significant values were found.It can be concluded that Upon comparing the P values for investment A and investment B statistically there is not much evidence stating which investment material is better, these findings are dissimilar to the study done by Alaa'a M Salloum[26] in which he compared dental plaster with dental stone as investment material and concluded that dental stone has better ability to control the errors pertaining to the shift of teeth during the processing of complete dentures.

Table 10 shows the Comparison of Postacrylisation P values between Investment A & B for mandible and found Non significant values..It can be concluded that Upon comparing the P values for investment A and investment B statistically there is not much evidence stating which investment material is better,

CONCLUSION

1. Using Investment A for maxilla and mandible in U ,V and Square arch had no statistical significance.
2. Using investment B for maxilla and mandible in U, V and Square arch showed statistically significant values.
3. Choice of investment material A or B; has little statistical significance when compared with each other.
4. Arch from has statistically insignificant value if proper processing steps are followed.
5. Upon comparison of the arches with each other it was found that investment procedure matters more and all possible steps should be taken to control the errors that arise due to the various steps that are involved in the processing of the complete dentures rather than one factor of kind of investment material used.
6. If care is taken in the processing of the dentures and all correct steps are followed, the errors can be greatly reduced.

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CONFLICTS OF INTEREST
There were no conflicts of interest.

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