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Evaluation of the Effect of Addition of Aluminium Oxide on Adaptation of Heat Cure Denture Base Resin

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Abstract
Background :
The success of the removable complete denture depends upon its retention, stability, and support. The retention of the complete denture is directly related to the adaptation of the base. Improvement on mechanical properties of denture base were achieved by metal oxides, metal wire or fiber .It improves the impact strength and fatigue resistance, it may affect denture adaptation and dimensional stability. This study is conducted to evaluate effect of aluminium oxide on adaptation of heat cure denture base resin.
Material and Methods:
It is an in-vitro study in which the study group will comprise of cast- denture base sets (20 specimens, 10 for each control and experimental groups). In experimental group, aluminium oxide 15 wt % is added to PMMA. Three points will be marked on the cast on transverse line at 10 mm from the posterior border of the cast specimens and three points will be marked on the cast on midline. All denture bases placed on their respective master cast for each group will be scanned by CBCT. Measurements will be made, first one made immediately after deflasking of all the samples. Second measurement will be done after incubation in distilled water at room temperature for 14 days for all the samples.
Result*: Reduction of denture base adaptation (measured at 5 point A, B,C,D and E) occurred in experimental group when compared to control group.*
Conclusion*: The denture bases with aluminium oxide has less adaptation.*
Keyword: *Acrylic denture base, master cast,aluminium oxide fillers, denture base adaptation*

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I. Introduction

One of the most widely used materials in prosthetic dentistry is Polymethyl methacrylate (PMMA). Since its introduction to dentistry, it has been successfully used for denture bases because of its ease of processing, low cost, light weight, and color-matching ability[1, 2]. However, acrylic resin denture base materials have poor strength[3, 4]. Many attempts have been made to enhance the strength of acrylic denture bases including the addition of metal wires and cast metal plates[5-7.]

Mechanical reinforcement of acrylics has also been attempted through the inclusion of fibers and metal inserts[5, 8].Although the inclusion of the fibers produced encouraging results, this method has various problems including tissue irritation, increased production time, difficulties in handling, the need for precise orientation,and placement or bonding of the fibers within the resin[1, 9, 10]. In the case of metal inserts, failure due to stress concentration around the embedded inserts has beenreported. It has been reported that untreated aluminum oxide (Al_2O_3) powder develops physical properties of high impact acrylic resin[11-13]. Many aspects of Prosthodontic treatment; be that clinical or laboratory based, may impact on overall patient satisfaction and the clinical success of treatment. This study will focus on denture base materials, in particular the resin based polymethymethacrylate (PMMA) materials. These materials are the most widely used non-metallic denture base materials[14,15]

II. Aim And Objective Of The Study

This study is done for evaluation of effect of aluminium oxide on adaptation of heat cure denture base resin.

III. Material And Method

The present in vitro study was conducted in Department of Prosthodontics and Crown and Bridge,Hazaribag College of Dental Sciences,Hazaribag,Jharkhand to evaluate the effect of aluminium oxide on heat cure denture base resin.

The investigation was carried out in the following manner:

- Selection of Material
- Armamentarium and equipment
- Methodology

MATERIAL

The following materials were used in the study.

- Dental stone (BNSTONE)
- Dental plaster (BNPLAST)
- Heat activated poly methyl meth acrylate resin powder and liquid (DPI)
- Aluminium oxide particles (50 Micron 15wt%)
- Sandpaper (120 grit and 600 grit, Million international)
- Modeling wax (Pyrax)
- Distilled water (Spritzer)
- Cold mould seal (DPI)
- Pumice (cooksongold)
- Polishing cake

ARMAMENTARIUM

The following materials were used in the study.

- Cone Beam Computed Tomograpy machine -Used for measurement of gap in between cast and sample
- Electronic balance-used for measurement of weight of polymethyl methacrylate powder and aluminium oxide powder
- Micromotor (Marathon)-used for trimming of samples
- Straight hand piece (Marathon)-used for finishing of samples
- Beaker -Used for storage of distill water and samples
- Rubber bowl-Used for mixing the dental stone and plaster of paris for pouring cast and for flasking
- Spatula-Used for mixing of dental stone and plaster of paris
- Clamp and flask-used for flasking and curing of samples
- Acryliser-Used for curing of samples
- Ceramic cup-Used for mixing of conventional heat cure powder and liquid
- Brush-Used for application of separating media

IV. Methodology:

20 dental stone edentulous cast was made in dental moulds. 2 modelling wax sheets of 1 mm thickness was adapted to each cast. Flasking was done. Then dewaxing, packing and curing was done in conventional manner (figure 1).

Acrylic resin material was mixed and manipulated according to manufacturer's instructions. 10 specimens of resins was assigned to the experimental group by addition of fillers i.e. 15wt% Al_2O_3 by weight. Once the polymerization cycle completed, the flask was allowed to slow cooling in a water bath at room temperature before deflasking. The acrylic specimens was finished and polished. (figure 2)

V. Denture Base Adaptation Testing:

The cast- denture base sets (20 specimens, 10 for each control and experimental groups) were taken. Three points were marked on the cast on transverse line at 10 mm ahead the posterior border of the cast specimens (deepest point of the left vestibule, left ridge crest and midline point which is marked according to the line bisecting the incisive papilla and extending posterior on the cast) as (A, B and C)respectively and three points in the in the sagittal section (C, D, E where C is the common point in both sagittal and horizontal section, D is the crest of the ridge in sagittal section and E is the depth of the vestibule in sagittal section) . The gap between the cast and the denture base margin at these five points were measured with the use of CBCT. Two measurements were made, first one made immediately after deflasking of all the samples. Second measurement will be done after incubation in distilled water at 37°C for 14 days for all the samples.

To observe the overall gap formation of the denture base, all denture bases placed on their respective master cast for each group were scanned by CBCT. The frontally-sectioned images of the denture-cast set and

sagittal images obtained at the palatal midline were taken from the CBCT data (figure 3,4). The collected data were subjected to statistical analysis.

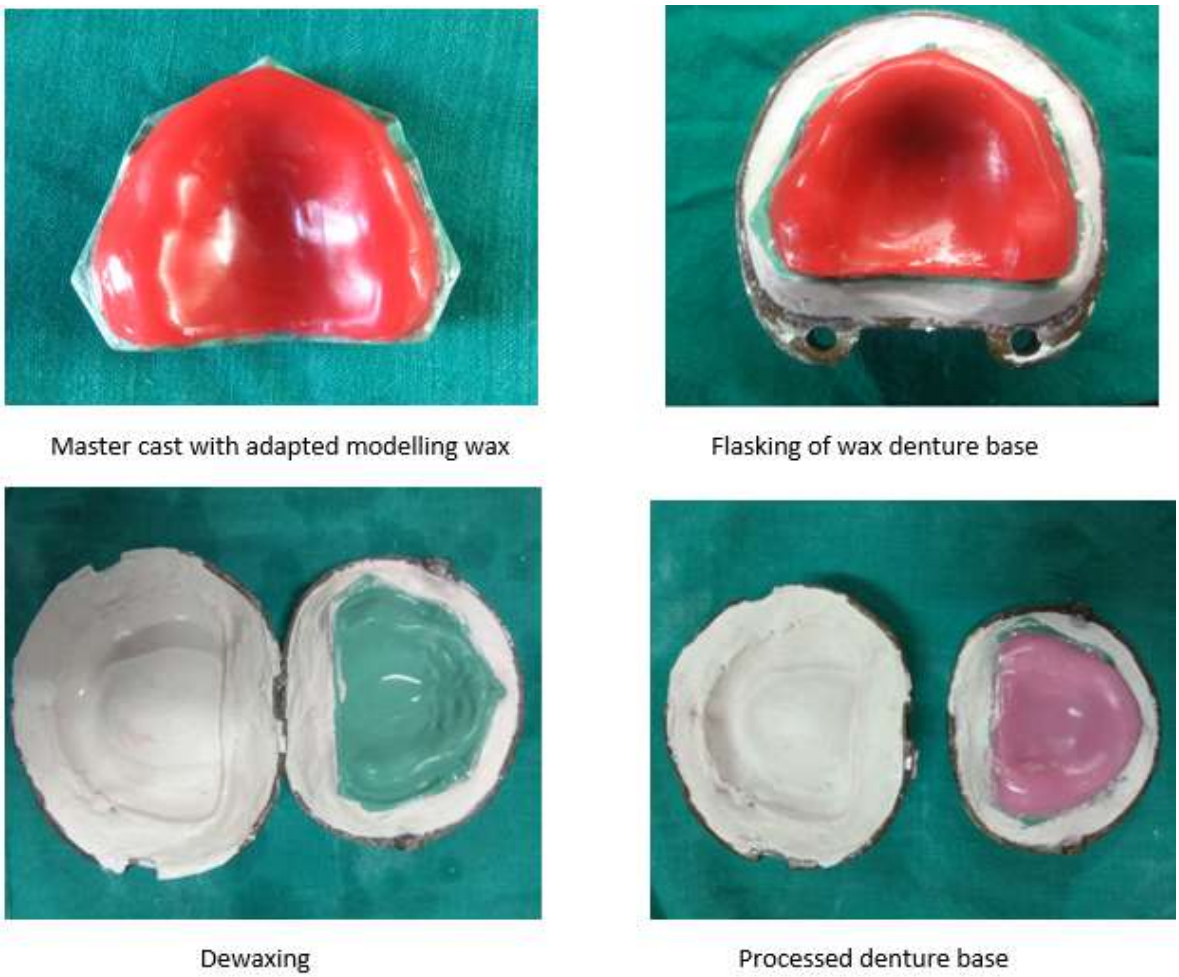


Figure. 1 Processing of denture base

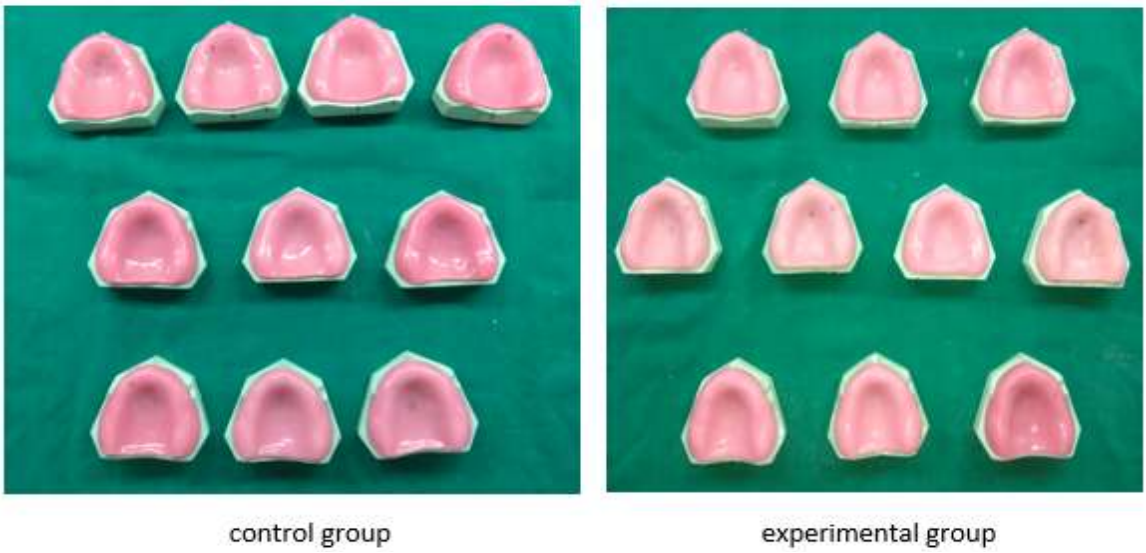


Figure 2. Finished and Polished denture base

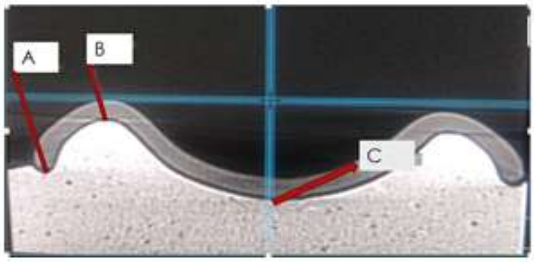


Figure 3. Transverse section

Point A - deepest point of left vestibule,

Point B - left ridge crest,

Point C- midline point

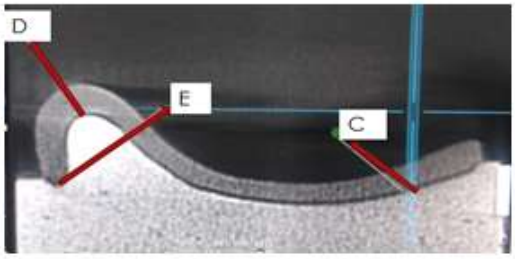


Figure 4. Saggital section

Point D - crest height

Point E – deepest point of vestibule

VI. Statistical Analysis

Statistical analysis was performed on all the data collected for dimensional testing. Quantitative analysis was performed to check for statistical differences between the linear dimension measurements. An Independent t-test and dependent t-test was subsequently used to compare conventional pressure packed and injection moulded sample groups. A significance level of $p<0.05$ was set.

For internal adaptation testing of conventional pressure packed control and experimental sample groups, means and standard deviations were calculated. The difference between the means of the two groups and standard deviation was then calculated.

Level of significance: p is the level of significance

$p> 0.05$	Not significant
$p< 0.05$	Significant
$p< 0.01$	Highly significant
$p< 0.001$	Very highly significant

VII. Result

The dimensional inaccuracy of poly methylmethacrylate is one of the well recognised problems associated with the material. Inaccuracies may exist in the material owing to its polymerisation shrinkage and high co-efficient of thermal expansion. The addition of metal fillers has been added to heat cure acrylic resin to improve strength. This study investigated the adaptation of denture base on addition of aluminium oxide fillers to heat cure denture base resin.

Comparison of control and experiment groups at immediate after deflasking and 14 days after processing time points in each point i.e. A, B, C, D, E by independent t test was done in table 3. At each point the value is significant i.e.there was significant changes in adaptation at all the reference points.

Comparison of Immediately after deflasking and 14 days after processing time points in each point in control group by dependent t test was done in table 4.By this test in control group, the values at all the reference points were found significant.

Samples	A		B		C		D		E	
	immediate	After 14 days	immediate	After 14 days	immediate	After 14 days	immediate	After 14 days	immediate	After 14 days
1	0.57	0.64	0.39	0.44	0.67	0.76	0.38	0.43	0.87	0.92
2	0.57	0.65	0.38	0.43	0.38	0.60	0.19	0.23	0.39	O.43
3	0.44	0.55	0.29	0.30	0.63	0.76	0.41	0.34	0.36	0.82
4	0.39	0.45	0.34	0.45	0.59	0.64	0.39	0.45	0.57	0.64
5	0.54	0.62	0.43	0.62	0.76	0.82	0.31	0.45	0.32	0.40
6	0.44	0.57	0.44	0.59	0.44	0.59	0.34	0.41	0.44	0.54
7	0.45	0.50	0.39	0.49	0.73	0.82	0.33	0.45	0.38	0.60
8	0.47	0.54	0.38	0.45	0.59	0.67	0.32	0.35	0.46	0.49
9	0.38	0.41	0.43	0.46	0.68	0.73	0.38	0.46	0.51	0.59
10	0.53	0.57	0.58	0.62	0.79	0.88	0.43	0.48	0.75	0.83

Table1:CONTROL GROUP (IMMEDIATELY AFTER DEFLASKING AND 14 DAYS AFTER PROCESSING –In Mm)

Samples	A		B		C		D		E	
	immediate	After 14 days	immediate	After 14 days	immediate	After 14 days	immediate	After 14 days	immediate	After 14 days
11	0.79	0.85	0.65	0.71	0.51	0.77	0.53	0.66	0.72	0.80
12	0.89	0.91	0.86	0.87	0.96	1.06	0.89	0.97	0.66	0.79
13	0.87	0.95	0.87	0.97	1.13	1.13	0.74	0.80	0.80	0.88
14	0.98	1.39	0.85	0.95	1.14	1.18	0.60	0.81	0.84	1.10
15	0.87	0.99	0.78	0.86	0.86	0.95	0.53	0.86	0.75	0.97
16	0.95	1.03	0.95	1.05	1.12	1.12	0.53	0.69	0.70	0.83
17	0.67	0.75	0.57	0.66	0.72	0.76	0.41	0.43	0.62	0.65
18	0.55	0.63	0.55	0.64	0.63	0.74	0.43	0.52	0.79	0.84
19	0.58	0.65	0.55	0.60	0.61	0.70	0.52	0.60	0.65	0.72
20	0.61	0.70	0.44	0.61	0.52	0.69	0.44	0.55	0.43	0.53

Table 2:EXPERIMENTAL GROUP (IMMEDIATELY AFTER DEFLASKING AND 14 DAYS AFTER PROCESSING-in mm

Table 3: Comparison of control and experiment groups at immediate after deflasking and 14 days after processing time points in each point i.e. A, B, C, D, E by independent t test

Points	Time points	Control group		Experiment group		t-value	P-value
		Mean	Std.Dev.	Mean	Std.Dev.		
Point A	Immediately after deflasking	0.48	0.07	0.78	0.16	-5.3852	<0.001, S
	14 days after processing	0.55	0.08	0.89	0.23	-4.3994	<0.001, S
	Difference	0.07	0.03	0.11	0.11	-1.0367	0.3136
Point B	Immediately after deflasking	0.41	0.08	0.71	0.18	-4.9899	<0.001, S
	14 days after processing	0.49	0.10	0.79	0.17	-4.9874	<0.001, S
	Difference	0.08	0.06	0.09	0.04	-0.2245	0.8249
Point C	Immediately after deflasking	0.63	0.13	0.82	0.26	-2.1334	<0.05, S
	14 days after processing	0.73	0.10	0.91	0.20	-2.6125	<0.05, S
	Difference	0.10	0.05	0.09	0.08	0.3642	0.7199
Point D	Immediately after deflasking	0.35	0.07	0.56	0.15	-4.1191	<0.001, S
	14 days after processing	0.41	0.08	0.69	0.17	-4.8224	<0.001, S
	Difference	0.06	0.06	0.13	0.09	-2.0999	<0.05, S

Point E	Immediately after deflasking	0.51	0.18	0.70	0.12	-2.8240	<0.05, S
	14 days after processing	0.63	0.18	0.81	0.16	-2.4534	<0.05, S
	Difference	0.12	0.13	0.12	0.07	0.1269	0.9005

Graph 1: Show comparison of control and experiment groups at immediate after deflasking and 14 days after processing time points in each point i.e. A, B, C, D, E

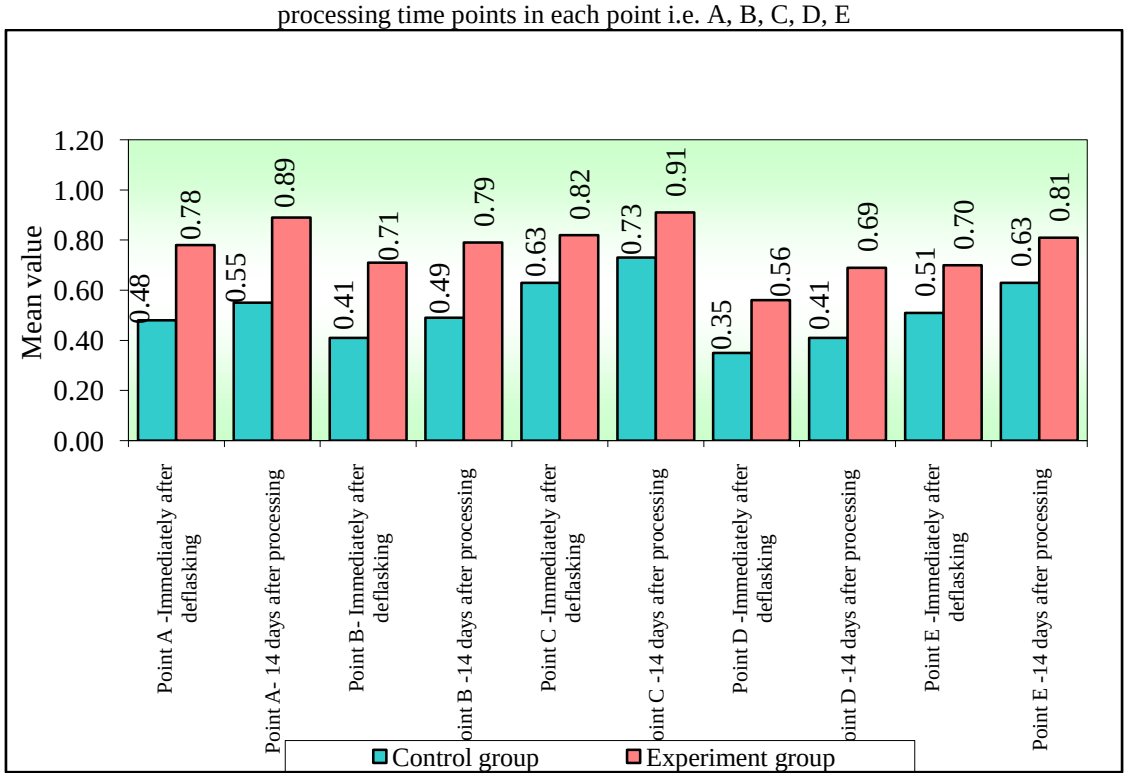
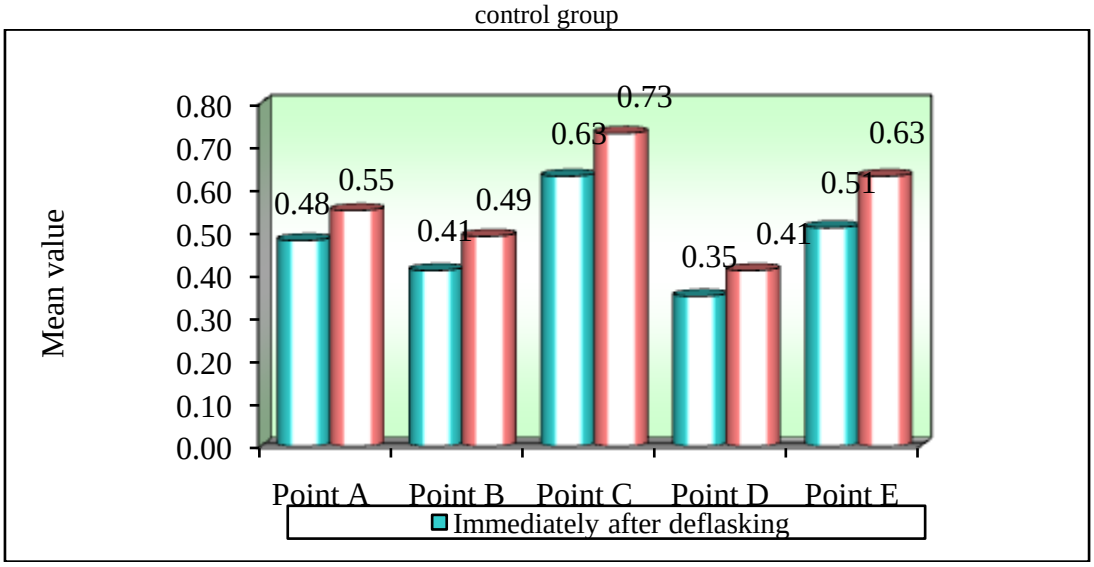


Table 4: Comparison of immediately after deflasking and 14 days after processing time points in each point in control group by dependent t test

Points	Time points	Mean	SD	Mean Diff.	SD Diff.	Pared t	p-value
Point A	Immediately after deflasking	0.48	0.07				
	14 days after processing	0.55	0.08	-0.07	0.03	-7.4705	<0.001, S
Point B	Immediately after deflasking	0.41	0.08				
	14 days after processing	0.49	0.10	-0.08	0.06	-4.4414	<0.01, S
Point C	Immediately after deflasking	0.63	0.13				
	14 days after processing	0.73	0.10	-0.10	0.05	-6.0491	<0.001, S
Point D	Immediately after deflasking	0.35	0.07				
	14 days after processing	0.41	0.08	-0.06	0.06	-3.1858	<0.05, S
Point E	Immediately after deflasking	0.51	0.18				
	14 days after processing	0.63	0.18	-0.12	0.13	-2.9377	<0.05, S

Graph 2: Comparison ofimmediately after deflasking and 14 days after processing time points in each point in control group



VIII. Discussion

It is widely accepted thatthe successful function of a complete denture is dependent upon its accuracy of fit [16]. Dimensional inaccuracies, as a result of polymerisation shrinkage, have been demonstrated to cause clinical instability of the resulting denture base against the denture bearing tissues[17]. This may in turn lead to pain during function as a result of uneven loading of the denture base. Denture base adaptation depends upon a number of factors, both clinical and laboratory, as well as the dimensional accuracy of the material from which it is made[18].

The increase in dimensions observed may also be the result of water sorption. Water sorption wasshown to decrease with an increase in filler content (Cal et al., 2000)[19]. The present study was conducted to evaluate and compare the effect of addition aluminium oxide filler to PMMA on denture base adaptation of heat cured acrylic denture base. The gap between denture base and cast was measured at 5 point (A, B, C,D,E)in two time to evaluate denture base adaptation, where it mostly depend on polymerization shrinkage and water sorption of PMMA. So, in first measurement made immediately after deflasking showed a significant increase of gap in experimental group when compared to control Group at point A, B,C,D,E. This increase explained may be due to addition of microparticle lead to increase in thermal conductivity of acrylic resin[20,21]and degree of polymerization effected considerably by heat dissipation and thermal conductivity ,lead to contraction of denture base due to further polymerization shrinkage that occur due to exposure to high temperature with reduction in the spaces between the chain of the polymer this result in agreement with Ogawaand Hasegawa[22]. In second time after incubation 14 day showed in a significant increase of gap in experimental group when compared to control group at point A, and non-significant increase of gap in experimental group at point B and C. This result may be due to that the addition of microparticles to PMMA may decreased in water sorption when compared with unmodified PMMA[21], So decrease expansion of acrylic denture base which considered antagonist effect to polymerization shrinkage that occur in experimental group more than control group as discussed previously[23]. The CBCT images of denture base-cast sets did show this tendency of gap formation in medial-lateral and anterior-posterior areas (figure 3,4). These findings are also predictable with the results reported by Consaniet al.[24], who compared the posterior border gap of the denture base-cast sets sectioned transversally at each area of the canine, molar and posterior ends. Moreover, the magnitude of the posterior border gap generally increased medially along the palatal vault reaching a maximum at the midline of the palate[25,26].

IX. Summary

As per different studies, concluded that the introduction of fillers produces significant increase in value of impact strength, transverse strength, surface hardness, surface roughness at 15wt % filler particle.

In the present study, the gap between denture base and cast was measured at 5 points (A, B, C, D, E) in two time to evaluate denture base adaptation, where it mostly depend on polymerization shrinkage and water sorption of PMMA.In first measurement made immediately after deflasking, showed a significant increased gap in experimental group when compared to control group at all reference points.

This increase may be due to increase in thermal conductivity of acrylic resin, and degree of polymerization effected considerably by heat dissipation. It lead to contraction of denture base with reduction in

the spaces between the chain of the polymer. In second time after incubation 14 day showed a significant increase of gap in experimental group when compared to control group at all points. This result may be due to decreased in water sorption when compared with unmodified PMMA.

X. Conclusion

From the results obtained, the conventionally processed have better adaptation than filler added PMMA materials for use as denture base materials.

In terms of base-plate adaptation at five reference points, present between denture impression surface and master cast for both aluminium oxide filler added and plain PMMA samples, gap were small. Such magnitudes of dimensional inaccuracy, as demonstrated herein, are unlikely to impact upon the clinical success of the denture base.

Polymerisation shrinkage of PMMA type denture base materials is, however, a well recognised problem. There is a desire to overcome this shrinkage via the development of changes in processing methods and modified or new materials.

The study undertaken within this study have demonstrated plain PMMA have better adaptation as compared to aluminium oxide filler added PMMA resin and to be superior in terms of dimensional accuracy . However, as the differences observed were very small, and the sample size also relatively small, it is debatable whether they would actually be of significance clinically.

In both the control and experimental group, we find significant changes on addition of aluminium oxide at all the reference points. But since it is an in-vitro study we need to check whether it affects the retention, stability and support in patients mouth or not .So further there is need of an in-vivo study for the same.

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