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EVALUATION OF DIFFERENT TECHNIQUES TO ENHANCE DENTURE BASE ADAPTATION IN POSTERIOR PALATAL SEAL REGION- AN IN VITRO STUDY

Dr. Vivek V. Nair	MDS Associate Professor Department of Prosthodontics Government Dental College, Alappuzha, PIN-688005, Kerala.
Dr Prasanth. V	MDS Assistant Professor in Prosthodontics, Government Dental College, Thiruvananthapuram.
Dr. K .N .Velayudhan Nair	MDS Retired Professor and Head, Department of Prosthodontics Government Dental College, Thiruvananthapuram.
Dr.Sheela Virginia Rodrigues	MDS Professor in Prosthodontics Government Dental College, Alappuzha.
Dr.K.R.Vijayanand	BDS Lecturer in Prosthodontics Government Dental College, Alappuzha

ABSTRACT

Me SH words: *Dental acrylic resin, maxillary complete dentures, denture processing, curing shrinkage, acrylic resin-fiber reinforcement, posterior palatal seal.*

Purpose

The study investigated the efficacy of three different laboratory techniques viz,

a. Posterior palatal strap
b. Polyaramid fiber reinforcement, and
c. Glass fiber reinforcement, in decreasing the posterior palatal shrinkage of denture bases that occur during processing.

Materials and methods

Forty identical maxillary edentulous casts were made from high strength dental stone using a standard flexible rubber mold. An undersized wax occlusal rim was made which was duplicated in heat cure acrylic resin to be used as a standard jig throughout the study to regulate the volume of resin. Forty casts were divided into 4 groups; Group I – Control, Group II- posterior palatal strap , Group III- Kevlar 49 fiber reinforcement, and Group IV- Glass fiber reinforcement. The casts for posterior palatal strap were altered by addition of box at the base of the cast which served as a mechanical lock. In case of Kevlar fiber and Glass fiber reinforcement, pre-pregs were incorporated in the base during the packing stage. Twenty-four hours after polymerization the bases on their casts were sectioned at the posterior border at pre-designated points and evaluated for degree of adaptation using a high resolution microscope.

Results and Conclusion

Statistical analysis was performed using analysis of variance followed by 95% confidence interval test. The maximum gap was noted in mid palatine region (0.132mm) followed by maxillary tuberosity region (0.005mm) in control group. There was no measurable gap between the cast and denture base in any of the three different laboratory techniques compared. The study concluded that the fiber reinforcement technique was simply the best and most efficient when compared with the other techniques.

KEYWORDS :

INTRODUCTION

Among the various polymers, polymethyl methacrylate (PMMA) introduced since 1937 coupled with compression moulding technique remains the denture base material of choice. The chief reasons cited for the lack of adaptation of the denture base in the palatal and post palatal seal region of maxillary dentures are the volumetric shrinkage of resin and the lesser thickness and bulk of the denture base at the above area. Shrinkage of denture base material is observed as a pulling away from the cast in the posterior mid-palatine area. As shrinkage occurs and volume decreases the material is pulled from this area of lesser bulk to the ridges having greater bulk.

The objectives of this study are:

1. To comparatively evaluate the efficacy of three different laboratory techniques viz;
   (a) Posterior palatal strap
   (b) Polyaramid fiber reinforcement, and
   (c) Glass fiber reinforcement at the palatal and posterior palatal seal region in controlling the curing shrinkage of PMMA at that area.
2. To determine the site that undergoes maximum curing shrinkage in the palatal and posterior palatal seal region

MATERIALS AND METHODS

Forty identical maxillary edentulous casts were made from high strength dental stone (Type V stone- DENFLO- HX) using a standard flexible rubber mold. A record base in shellac base plate was fabricated on one of the casts and an undersized wax occlusal rim was made on it taking care to eliminate all undercuts. The occlusal rim was made undersized in order to approximate the quantity of the denture base resin that is normally present in a processed denture. The dimensions of the occlusal rim that was fabricated are presented in Table I.

This occlusal rim was duplicated into heat cure acrylic resin and was used as a standard jig throughout the study to regulate the volume of resin. Lines were scribed on the occlusal and polished areas of the jig (Figure1) to delineate and determine the areas for sectioning and measurement. Forty casts were divided into 4 groups containing ten casts in each and the groups were designated as groups I, II, III and IV. In each group one particular laboratory technique to decrease the posterior palatal shrinkage was employed. The casts were numbered. The cast numbers and the techniques which were employed are shown in table II.

Preparation of Group I specimens

The acrylic jig was placed on the cast and its periphery was sealed to the cast by flowing molten modeling wax. The assembly was flasked and dewaxed. The flask halves were separated and the jig was removed from the cast. All traces of wax were eliminated using boiling water. The mold surface was pointed with separating medium (cold mould seal). The mold was then packed with acrylic resin and compression molded with two trial closures. After 30 minutes that clamped flask was placed in an acrylizer (confident company) and cured at 74°C for 2 hours followed by 100°C for 1 hour. The flask was then allowed to cool to room temperature in the acrylizer. The flaks halves were opened taking care to retain the base on the cast. The base with its cast was washed in filtered slurry water and stored in a closed box. Altogether 10 bases were thus processed.

Preparation of Group II specimens

The acrylic jig was placed on the cast which was modified as follows. On the posterior surface of

the base of the cast, a box was prepared with a flat fissure bur, extending from the posterior

palatal seal region (Fig). The box had a width of 17.5 mm, a length of 8 mm and a depth of

2mm. An undercut was made towards the cast to serve as a mechanical lock at the basal aspect of

the box. The box was filled with modeling wax and sealed to the posterior border of the jig as

introduced by Robert G. Vig. The rest of the processing was similar to that employed in Group I

and the procedure was repeated for all the 10 casts of this group. (Figure 2).

Preparation of group III specimens

In this group, pre-pregs of polyaramid fiber (Kevlar 49, Dupont, Switzerland) were incorporated in the base during the packing stage. This was necessitated due to the following reasons (a) to promptly complete the procedure of incorporating the fibers accurately in the designated location within the limited time available for trial closure, and (b) to prevent the probable displacement of placed fibers from its desired location during trial closures. Pre-pregs were made by adapting two bunches of fibers extending from the buccal aspect of one tuberosity to the other along the posterior palatal seal region of a cast and by encircling the fibers with self cure resin. After allowing the self cure resin to get cured for 60 minutes the pre-pregs were removed from the cast and the excess fibers were trimmed off using sharp scissors. The molds were prepared as in Group I. A thin strip of wax the thickness of which was limited to half the thickness of the acrylic jig was adapted over the posterior palatal region extending from one tuberosity to the other. Acrylic was then packed. After trial closure the flask was opened, the wax spacer is removed and the pre-preg was positioned in its place (Figure 3). Acrylic was added over the pre-preg sandwitching the latter between the two layers of acrylic and the mold was closed. Curing was done as in the previous groups. Altogether 10 fiber reinforced bases were thus processed (Figure 4).

Preparation of group IV specimens

In this group, pre-pregs of Glass fiber (V.S.S.C, Trivandrum, India) were incorporated in the base during the packing stage. Pre-pregs were made by adapting two bunches of fibers extending from the posterior palatal seal region of a cast and by enriching the fibers with self cure resin. After allowing the self cured resin to get cured, for 60 minutes, the pre-pregs were removed from the cast and the excess fibers were trimmed off using sharp scissors. The pre-pregs were incorporated as described in group III curing was done as in the previous groups. Altogether 10 fiber reinforced bases were thus processed .

Sectioning and measurement

The cast with the resin base was sanctioned with a hack-saw blade transversely along the line AC. The posterior piece was discarded. The sectioned assembly was cleaned in filtered slurry water and compressed air was flown to remove any fragments of dental stone or acrylic. The cast was dried and the gap between the denture base and cast was measured using an optical microscope (Latitex latimet television micrometer) using a magnification of 20X. The measurements were made at three different points corresponding to the marks A, B and C. Marks A and C were at hamular notches and B at the midpalatine raphae.

A second transverse section was made along with the line DF which was 10mm anterior to the line AC. After debriding this area, the gap was again measured at the points D,E and F (Figure 5).

Methods of statistical analysis

The data collected were entered into a master sheet and fed into a computer for statistical analysis. The statistical constants like Mean and standard deviation were computed for drawing inference about the data. The hypothesis formulated were tested statistically by using F test by constructing Analysis of Variance (ANOVA) table. In the case of equality of means the hypotheses was tested with the help of student 't' test. In order to predict the possible interval in which the gap may lies, 95% confidence interval has been computed. For all statistical analysis the computer software package SPSS has been used.

RESULTS

It was observed that the maximum gap is noted in site B(0.132mm) followed by site C (Mean=0.0121) and site D(Mean=0.0016) in that order. The least gap was observed in site A(Mean=0.0007), (Table III, Graph I). The ANOVA test revealed that the difference noted in mean gap between various sites was statistically significant ($F=14.94$; D.F=5,54; $p<0.0001$) (Table IV). Therefore it was proved beyond doubt that maximum gap occurred in sites B and C. It was observed that in site B the 95% confidence interval may be 0.044 to 0.094 and in site C it was estimated as 0.0063 to 0.031 (Table V). In the present study, the gap between cast and denture base according to site was computed in the case of Posterior palatal strap (Table VI), Kevlar fiber reinforcement(Table VII), and Glass fiber reinforcement(Table VIII). In all the three different methods, hardly none of the observations showed any gap and invariably the difference turned out to be zero.

DISCUSSION

Polymethyl methacrylate has become very popular with the profession because of its biocompatibility profile and easier manipulation techniques. The denture base resins which undergoes polymerization is subjected to volumetric shrinkage of 21% which can make a denture clinically unacceptable because of the dimensional inaccuracies[19,20,21]. Hence a mixture of methylmethacrylate polymer and monomer in a ratio of 3:1 by volume is used for moulding purposes and this mixture manifests a shrinkage of only 7%. While processing dentures, shrinkage of this rate is not observed because of the restrictive nature of the mold and due to the soft nature of the resin above the glass transition temperature. On cooling, when the resin crosses the glass transition temperature it becomes glassy and rigid. The shrinkage that occurs after this stage in the resin is independent of the shrinkage of the mold. Shrinkage observed in the resin is directly proportional to the volume of the resin. The design of maxillary complete denture is dictated by the volume of denture base resin which is more towards the ridges than compared to the mid-palatal region[1,3,4,7,12,13]. The shrinkage finally results in stretching the resin towards the ridges causing a gap in the mid-palatal region which is evidently manifested in the posterior palatal seal region[4,5,12]. **Anusavice**[2] has observed a processing dimensional change of 0.1-0.2mm in the second molar region.

Considering the importance of posterior palatal seal in providing adequate retention, many attempts have been made to control shrinkage of acrylic resin in this area. The rationale of these attempts was to mechanically lock the resin with the cast. For this purpose, the denture base was extended in the form of a strap to engage the lock made in the base of the cast. The technique was developed by **Vig R.G** [11,14] to decrease the anterior migration of denture teeth in processing and to improve the adaptation of maxillary denture base. This method required additional laboratory modification of the denture which at times can be considered as arbitrary and time consuming.

Reinforcing the palatal termination area of the denture is attempted and tested in this study as a simple and effective method in controlling the shrinkage. Glass, carbon and polyaramid fibers were used in the past to strengthen acrylic resin. Fiber reinforcement as an efficient method of improving palatal seal has been reported very scarcely. The acrylic-aramid composite technique was developed by **Chandrasekharan Nair K et al**[5] to reinforce fixed partial dentures. Generally long pleats of fibers were used in the reinforcement. Short length fibers were also attempted in some of the reported experiments. The quantity of fibers by weight should be limited to 5%.

The above circumstances have prompted to design the present study to control the deleterious effects of polymerization shrinkage affecting the dimensional accuracy of the posterior palatal seal region. It was aimed to compare different laboratory techniques namely Ristau post-dam and fiber reinforcement. Two different types of fibers were selected for the study:a) Polyaramid fiber (Kevlar 49) and b) Glass fiber (T 300).

In the present study, the gap between cast and the denture base according to the site was computed for control group, posterior palatal strap, Kevlar fiber reinforcement and Glass fiber reinforcement. In group I (Control) the measurement showed a gap that varied from 0.0007mm to 0.0688 mm along the line AC. The maximum gap was seen at the mid-palatine raphae (B). the gap progressively decreased from the mid-palatine raphae to the tuberosity area, where it was practically nil except in three specimens. The section along the line DF, 10 mm anterior to the line AC showed no gap except in two specimens suggesting that there is hardly any shrinkage resulting in distortion in this region. **John Jow**[11] in his experiment proved formation of gap between the denture base and the cast in the posterior palatal seal region in various types of post-dams. According to him the gap between the cast and denture base varies from 0.0152-0.0159 inches for control group, 0.00955- 0.01707 inches for post palatal strap and 0.01435-0.0234 inches for Ristau post-dam. **Chen JC et al**[4,15,16,17] measured the width of the misfit between the denture base and cast in the posterior palatal region and found that the gap varied from 0.23mm to 0.58mm with the thicker denture bases exhibiting wider gaps.

In group II (Posterior palatal strap)there was no gap in any of the areas along the lines AC and DF. This justifies that the locking of the resin into the multidirectional holes positioned along the posterior palatal seal area could effectively prevent the separation. The finding in the study contradicts that of **Jow J**[11]who found the prevention of shrinkage in the posterior palatal strap as insignificant. The present study conclusively found posterior palatal strap to be a positively effective method in controlling the dimensional changes in the posterior palatal seal region.

In groups III and IV (Fiber-reinforced) also there was absolutely no post palatal separation and no measurable gap noticed in any of the designated points along the line AC and DF. In this technique, the cast is not subjected to surface modification either in the form of scraping or drilling holes. Thus the posterior palatal seal area established functionally is preserved intact in the denture. This can be cited as a definite advantage of this technique. The improved strength of PMMA due to fiber reinforcement can be the key factor that has kept the resin tightly approximated to the cast. The possible mechanism for the equally excellent efficacy of the two fiber reinforcement methods to control shrinkage at post palatal areas could be due to the above factor. The highly improved flexural strength values of fiber reinforced acrylic support the above said observation.

LIMITATION OF STUDY

The problems encountered with the use of polyaramid fiber during trial packing may limit its routine application in denture base reinforcement. Lateral spreading of the fibers during packing of the acrylic resin results in a rough denture surface with extruded fibers that may cause mucosal irritation and discomfort to the patient. Uneven distribution and bunching of the polyaramid fibers in the resin matrix occurred frequently.

SUMMARY AND CONCLUSION

1. There was no measurable gap between the cast and the denture base in the cause of Posterior palatal strap, polyaramid fiber reinforcement and glass fiber reinforcement in any of the designated points. Polyaramid fiber (Kevlar 49) and Glass fiber (T300) reinforcement were equally efficient in controlling the shrinkage in the posterior palatal seal region.
2. Maximum shrinkage was observed at the mid post palatal seal region in the control group..
3. In the case of Posterior palatal strap technique, the final cast has to be modified arbitrarily before processing of dentures resulting in inaccuracy in the meticulously developed posterior palatal seal.

TABLES & GRAPH

TABLE I. DIMENSIONS OF OCCLUSAL RIM

	Anterior	Posterior
Height	18 mm measured from deepest portion of labial sulcus	14 mm measured from deepest portion of buccal sulcus
Width	6mm	9 mm

TABLE II. CAST NUMBERS AND THE TECHNIQUES EMPLOYED

Group	Cast number	Technique
I	1 to 10	Control
II	11 to 20	Posterior palatal strap
III	21 to 30	Kevlar 49 fiber reinforcement
IV	31 to 40	Glass fiber reinforcement

TABLE III. CONTROL – MEASURED POINTS (mm)

Cast Number	A	B	C	D	E	F
1	0.000	0.045	0.000	0.000	0.061	0.005
2	0.000	0.000	0.000	0.005	0.000	0.000
3	0.000	0.132	0.000	0.000	0.000	0.007
4	0.001	0.060	0.050	0.000	0.053	0.000
5	0.000	0.088	0.000	0.000	0.031	0.000
6	0.005	0.020	0.000	0.000	0.024	0.000
7	0.000	0.112	0.006	0.000	0.000	0.000
8	0.000	0.069	0.000	0.000	0.031	0.000
9	0.000	0.072	0.004	0.000	0.019	0.000
10	0.000	0.090	0.000	0.000	0.071	0.000
Mean	0.0007	0.0688	0.0121	0.0005	0.0028	0.0020
SD	0.00157	0.0400	0.02570	0.0016	0.02530	0.0042

GRAPH I. GRAPH REPRESENTING THR GAP BETWEEN THE CAST AND THE DENTURE BASE IN CONTROL GROUP

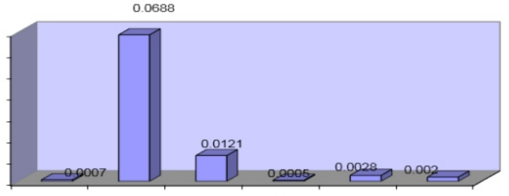

TABLE IV. ANOVA TABLE TO TEST THE HOMOGENIETY OF MEAN GAP ACCORDING TO SITE

Sourse	S.S	D.F	M.S.S	F ratio	P value
Between sites	0.03576	5	0.007153	14.94	P < 0.0001
Error	0.02586	54	0.000479	------	
Total	0.06162	59	------	------	

TABLE V – 95% CONFIDENCE INTERVAL OF GAP ACCORDING TO SITE

Site	Lower bound	Upper bound
A	0.00042	0.00182
B	0.04400	0.09361
C	0.00630	0.03047
D	0.00000	0.00149
E	0.00990	0.04610
F	0.00100	0.00502

TABLE VI – POSTERIOR PALATAL STRAP – MEASURED POINTS (mm)

Cast Number	A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000
Mean	0.000	0.000	0.000	0.000	0.000	0.000
SD	0.000	0.000	0.000	0.000	0.000	0.000

TABLE VII – KEVLAR 49 FIBER REINFORCEMENT – MEASURED POINTS (mm)

Cast Number	A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000
Mean	0.000	0.000	0.000	0.000	0.000	0.000
SD	0.000	0.000	0.000	0.000	0.000	0.000

TABLE VIII - GLASS FIBER REINFORCEMENT – MEASURED POINTS (mm)

Cast Number	A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000
Mean	0.000	0.000	0.000	0.000	0.000	0.000
SD	0.000	0.000	0.000	0.000	0.000	0.000

Figure 1

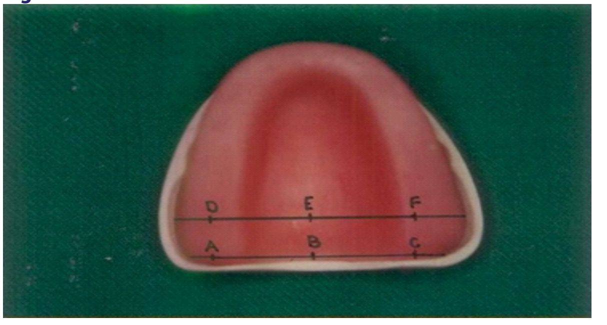

Figure 2

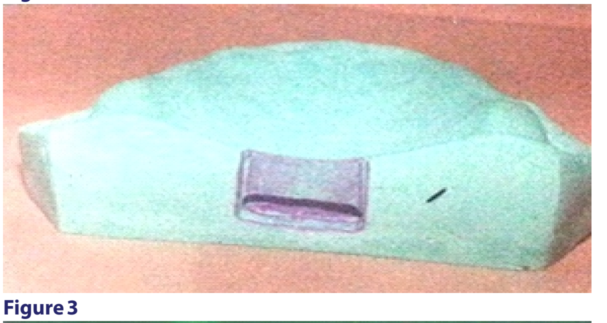

Figure 3

Figure 4

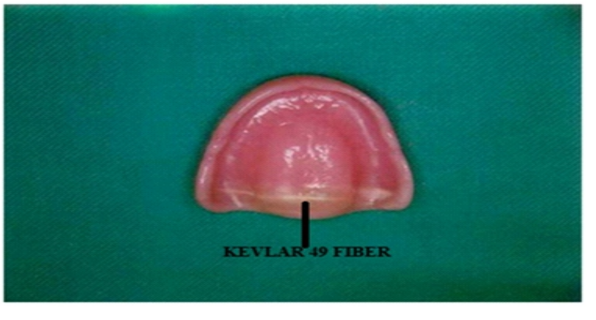

Figure 5

Figure 1 – Lines scribed on the jig for sectioning, with the points designated for the measurement of gap

Line AC - 2 mm anterior to the posterior border of the jig

Line DF - 12mm anterior to the posterior border of the jig

Line BE - Midline portion of the jig

Lines AD and CF - Along the ridges of the jig

Figure 2 - **Cast and acrylic resin specimen with Posterior palatal strap**

Figure 3 - **Pre-preg of Kevlar 49 fiber positioned in place**

Figure 4 - **Specimen reinforced with Kevlar fiber**

Figure 5 - **Sectioned cast with denture base**

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