Original Article

DOI: 10.7860/JCDR/2021/51730.15644

Dentistry Section

Comparison of Dimensional Accuracy of Acrylic Resin Denture Base using Conventional and RS Tension Methods of Packing- An In-vitro Study

RAJEEV SRIVASTAVA[1], UMESH PALEKAR[2], VIVEK CHOUKSE[3], PRABHA SHAKYA NEWASKAR[4], VAIBHAV AWINASHE[5], JYOTI NADGERE[6]

ABSTRACT

Introduction: Retention and stability are some of the important aspects of a successful denture. Laboratory procedures such as methods of packing have a great influence on the outcome of the denture. Different methods such as methods of closing, impression quality, type of acrylic resin, the processing cycle, cooling procedure, and water sorption have been suggested by the researchers to reduce the discrepancy in the dimensional accuracy of the complete removal dentures. Here, an attempt is made to compare conventional and Rafael Saide (RS) Tension techniques in the present study.

Aim: The aim of present study was to evaluate and compare the dimensional accuracy of the heat cured denture base processed by the Conventional and RS (Rafael Saide) tension method of packing.

Materials and Methods: The present in-vitro study was conducted at the Department of Prosthodontics, Crown and Bridge and Implantology, Modern Dental College and Research Centre, and at Shri Govindram Seksaria Institute of Technology (SGSITS) Indore Madhya Pradesh, India, from September 2014 to October 2015. A metal die with the base and counter was used to fabricate 60 specimens of heat-cured acrylic resin by conventional and RS tension method of clamping. After finishing these denture bases the samples were decoded. All the samples were assessed for the discrepancy in dimensional accuracy when compared with the metal die at five different specified locations. The student's t-test was used to compare the measurements of the two methods.

Results: The average mean marginal gap between all the points by the conventional method was 275.42 µm (minimum 264.5 µm, maximum 282.7 µm), p-value >0.001 and RS tension method was 171.8 µm (minimum 88.66 µm, maximum 248.82 µm), p-value <0.001. There was significant difference in dimensional accuracy when the mean marginal gaps of the two techniques were compared (p-value <0.001).

Conclusion: The RS tension clamping method for the fabrication of dimensionally more accurate and more retentive removable complete dentures should be recommended in the laboratories.

Keywords: Conventional clamping technique, Dimensional stability, Maxillary complete denture, Polymethyl methacrylate, Rafael saide tension

INTRODUCTION

Acrylic resins were first utilised in dentistry in 1937 and are still considered one of the best materials for removable prosthesis denture bases. The disadvantages of Polymethyl Methacrylate (PMMA) are possible stress problems, low chemical resistance, brittle material, and has low impact resistance [1,2]. The dimensional changes that happen during polymerisation shrinkage play a significant role in the retention of the prosthesis as well as the stability [3].

Furthermore, the base is responsible for artificial tooth attachment and force distribution across tissue-bearing regions, and other parameters, such as resin flasking method, curing time, and temperature correlation during curing procedures, may significantly affect the base's dimensional stability. A combination of factors, including polymerisation shrinkage, thermal contraction caused by flask cooling, and strain caused by stress release during deflasking, results in the denture adapting less to the tissue surface [4]. Later stress, water gain or loss, and insufficient denture polymerisation all contribute to the dimensional changes that occur after the denture is withdrawn from the stone cast and are the most likely cause of denture instability [5]. Dimensional changes that occur during polymerisation may be difficult to compensate after processing the resin base.

Linear shrinkage has the greatest effect on the post dam area of the upper denture, creating a space between the supporting region and denture base [6]. Release of residual internal tension before polymerisation occurs while using the traditional technique of flasking PMMA resin, which can result in movement between the flask's upper and lower members upon removal from the bench press and placement into the clamp [6].

Consani RXL et al., developed a novel processing technique in which the flask is held under constant pressure by two iron plates, which demonstrated a significant reduction in the magnitude of this gap [7]. Since the flask halves remained connected after the flask was removed from the press, the reduced dimensional variations in the denture base produced by the RS technique demonstrated that the flask closure retained acrylic resin dough under consistent pressure. This inhibited the release of residual internal stresses from the acrylic resin dough before polymerisation. The adaptability of the denture base with the oral tissue increases with increase contact between the denture base and cast. This close adaptation between the denture surface and the oral mucosa results in a more retentive denture [8]. It is necessary to assess whether this novel approach has any advantages or disadvantages over the conventional approach.

It is essential to understand the optimal flasking procedure for enhancing the dimensional stability of the denture base. This study aimed to determine the amount of dimensional changes in the denture base during the polymerisation process using the standard approach and the RS packing method. The null hypothesis was that

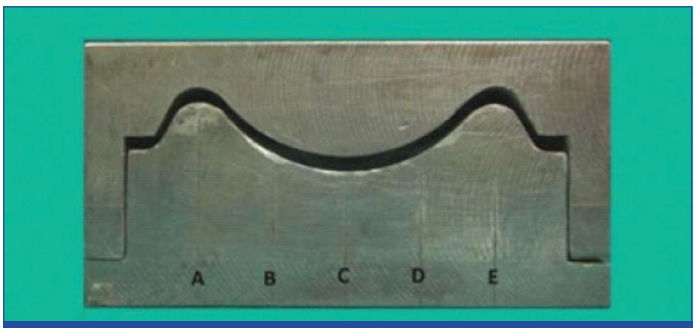
there was no significant difference in the marginal gap between the denture base and the master die in conventional and RS tension methods of packing.

MATERIALS AND METHODS

The present in-vitro study was conducted at Department of Prosthodontics, Crown and Bridge and Implantology, at Modern Dental College and Research Centre, and at Shri Govindram Seksaria Institute of Technology (SGSITS), Indore, Madhya Pradesh, India, from September 2014 to October 2015 after obtaining the Ethical Clearance (S.No./MPMSU/IEC/2014/1179).

Study Procedure

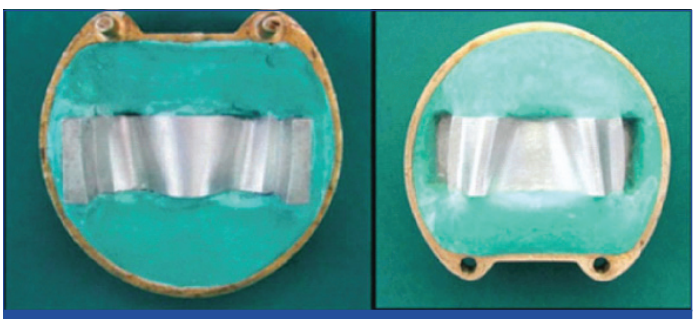
As the posterior palatal seal region is needed for the investigation, a metal master die (aluminum alloy) of an ideal maxillary cast was fabricated with the base and counter and sectioned half to utilise the posterior palatal seal area as reported by Katheng A et al., [9]. On the master die, five points were specified and marked: left ridge crest (A), right ridge crest (E), in the midline (C), one point between the left ridge crest and the midline (B), and another between the right ridge crest and the midline (D) [Table/Fig-1].



[Table/Fig-1]: Master die with base and counter and reference points for readings.

According to Consani RLX et al., sample size of 30 in each group was determined with 95% confidence interval, 80% power of test, with absolute precision of 0.015 [4]. A total of 60 heat-cured acrylic resin specimens (trevalon denture base material by Dentsply) were made, thirty of which were fabricated using the conventional clamping method (samit clamp, India) at the time of flasking, thirty using the RS tension method of clamping. The RS tension clamp (SL Mestra, Spain) is a uniquely constructed fusion consisting of two plates of iron (150×40×8 mm). The lower plate has a 9 mm diameter screw with soldered ends, while the upper plate has two holes with a cross-section diameter of 10 mm [10].

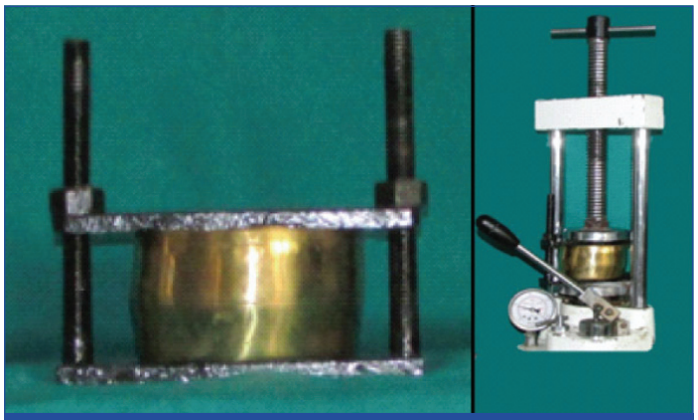
Gypsum mould was prepared for obtaining all specimens [Table/Fig-2], whole procedure was followed according to Savirmath A and Mishra V, except the metal die was filled with wax and ensures the proper closure of the counterpart of the die before the flasking procedure [11].



[Table/Fig-2]: Invested metal die for specimen fabrication.

For the preparation of PMMA resin specimens, pre-weighed polymer and monomer were mixed in a ratio of 3:1 by weight according to the manufacturer's instruction in a clean porcelain jar under similar conditions of temperature.

The material was placed in the mould in the dough stage. After two trial closures using Hydraulic press, the flask was clamped under pressure by bench press of 100 kg/cm^2, and this pressure was maintained for 30 minutes to allow proper penetration of monomer into polymer. For Group I conventional clamp was used after removal from the hydraulic press. For Group II RS tension clamps [Table/Fig-3] were used. The whole assembly (flask and RS tension clamp) was placed under a hydraulic press and screws of the clamp were tightened before removal from the hydraulic press [Table/Fig-4]. For curing, the flask was placed in the water bath at room temperature and the temperature of the curing unit was then raised to 73°C, held for one and half hours, and then raised to 100°C and maintained for half an hour.

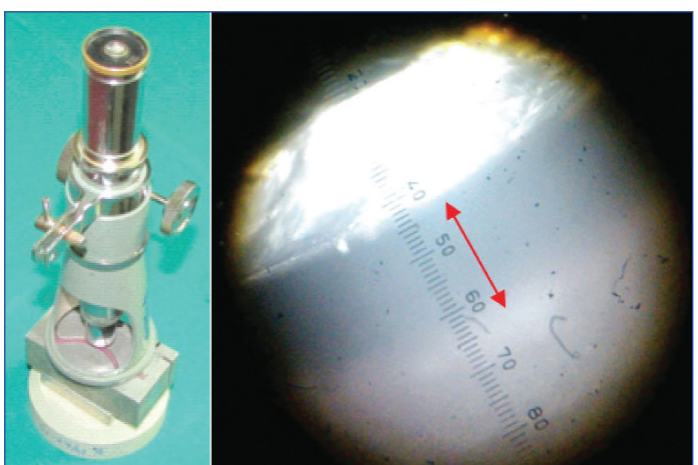


[Table/Fig-3]:RS tension clamp with flask; **[Table/Fig-4]:** Flask and RS tension clamp assembly placed under pressure with the hydraulic press. (Images from left to right).

After the completion of the curing cycle, cooling was done by one of the three methods [11]:

1. **Water Bath:** The flask remained in the water bath for 60 hours.
2. **Air:** The flask was removed from the water bath and bench cooled for 12 hours at room temperature.
3. **Quenching:** The flask was removed from the water bath and quenched immediately under running tap water for half an hour.

After finishing these denture bases, the samples were decoded. Specimens were kept in distilled water for seven days before being evaluated for the marginal gap between the denture base and the master die using a traveller microscope (Manufacturer: Optiregion) up to the accuracy of 0.001 mm [Table/Fig-5,6]. The measurement was made by keeping the specimen on the horizontal table of the microscope with die and counterpart. It has two readings: Main Scale Reading (MSD) and Vernier Scale Reading (VSD) both were recorded and the Total Reading (TR) was calculated with the least count of microscope=0.001 cm [11].



[Table/Fig-5]: Observing the gap between the metal die and denture base specimen under traveller microscope; **[Table/Fig-6]:** Measurement of the gap seen between the denture base and master die under the travelling microscope. (Images from left to right)

STATISTICAL ANALYSIS

The results were statistically analysed by using statistical software (IBM Statistical Package for the Social Sciences (SPSS) Statistics, version 20.0; IBM Corp.) to assess the discrepancy in dimensional accuracy when compared with the metal die at five different specified locations with the help of the student t-test.

RESULTS

The RS invented the new press technique to reduce the gap between the denture base and tissue surface. To reduce the probability of unfavorable dimensional changes in acrylic-based denture base resins, shrinkage during polymerisation, flask clamping method, time, and temperature correlation are all essential. The current study determined that the marginal gap between the denture base and the master die using the conventional method (Group I) and RS tension method (Group II) of packing [Table/Fig-7]. The t-test value and p-value obtained between all the points on the master die indicated that there was no statistically significant difference between any of the points when using the conventional packing method as shown in [Table/Fig-8].

Five points	Conventional method (Group I)			RS tension method (Group II)		
	Mean±SD (µm)	Minimum (µm)	Maximum (µm)	Mean±SD (µm)	Minimum (µm)	Maximum (µm)
A	282.7±54.3	200.2	386.1	155.4±51.5	71.5	243.1
B	274.5±59.3	171.6	386.1	154.9±43.6	71.5	243.1
C	264.5±72	128.7	371.8	195.9±39.4	100.1	257.4
D	282.2±56.2	171.6	386.1	180.2±44.5	100.1	257.4
E	273.2±55.8	171.6	386.1	172.6±45.4	100.1	243.1

[Table/Fig-7]: Mean and standard deviation, minimum, maximum of the marginal gap (µm) between the denture base and the master die by conventional (Group I) and RS tension method (Group II) of packing.

Points	Mean±SD (µm)	Mean±SD (µm)	t-test value	p-value
A and B	282.7±54.3	274.5±59.3	0.55	0.291
A and C	282.7±54.3	264.5±72	1.10	0.137
A and D	282.7±54.3	282.2±56.2	0.03	0.486
A and E	282.7±54.3	273.2±55.8	0.80	0.212
B and C	274.5±59.3	264.5±72	0.59	0.278
B and D	274.5±59.3	282.2±56.2	0.51	0.305
B and E	274.5±59.3	273.2±55.8	0.22	0.412
C and D	264.5±72	282.2±56.2	1.05	0.146
C and E	265.5±72	273.2±55.8	0.40	0.343
D and E	282.2±56.2	273.2±55.8	0.77	0.226

[Table/Fig-8]: Marginal gap (µm) between the denture base and the master die at different points using the conventional method of packing (Group I).
*student's t-test

The marginal gap between the denture base and the master die using the RS tension method (Group II) of packing has been shown in [Table/Fig-7]. There was a statistically significant difference between A and C point, A and D point, B and C point, B and D Point, and C and E Point when using the RS tension clamping method [Table/Fig-9].

In the present study, the average mean marginal gap between all points was 275.42 µm (minimum 264.5 µm, maximum 282.7 µm) by using the conventional method and the average mean marginal gap between all points was 171.8 µm (minimum 154.9 µm, maximum 195.9 µm) by using the RS tension method. A highly significant difference was observed when the mean values of both the techniques at different points were compared (p-value <0.001) [Table/Fig-10].

Points	Mean±SD (µm)	Mean±SD (µm)	t-test value	p-value
A and B	155.4±51.5	154.9±43.6	0.04	0.484
A and C	155.4±51.5	195.9±39.4	3.42	<0.001**
A and D	155.4±51.5	180.2±44.5	1.99	0.025*
A and E	155.4±51.5	172.6±45.4	1.36	0.088
B and C	154.9±43.6	195.9±39.4	3.81	<0.001**
B and D	154.9±43.6	180.2±44.5	2.22	0.015*
B and E	154.9±43.6	172.6±45.4	1.53	0.065
C and D	195.9±39.4	180.2±44.5	1.45	0.076
C and E	195.9±39.4	172.6±45.4	2.13	0.018*
D and E	180.2±44.5	172.6±45.4	0.66	0.257

[Table/Fig-9]: Marginal gap (µm) between the denture base and the master die at different points using the RS tension method of packing (Group II).
*Student t-test; *p-value <0.05 was considered significant; **p-value <0.001 was considered highly significant

Points	Group I Mean±SD (µm)	Group II Mean±SD (µm)	t-test value	p-value
A and A	282.7±54.3	155.4±51.5	9.32	<0.001
B and B	274.5±59.3	154.9±43.6	8.90	<0.001
C and C	264.5±72	195.9±39.4	4.57	<0.001
D and D	282.2±56.2	180.2±44.5	7.79	<0.001
E and E	273.2±55.8	172.6±45.4	7.50	<0.001

[Table/Fig-10]: Comparison of the marginal gap (µm) between the denture base and master die by conventional (Group I) and RS tension method of packing (Group II).
*Student t-test; p-value <0.001 was considered highly significant

DISCUSSION

Many variables play a significant part in the efficacy of treatment in complete denture construction. Retention is of the highest significance to the patient and a Prosthodontist. Retention not only enhances the stability of dentures but also enables the patient to deal with various psychological concerns during learning and retraining. Retention is related to its base fitting to the tissue bearing regions of the prosthesis. The adaptability of the denture base depends still on various elements, such as the material utilised and the technique of making the complete denture [10].

The most frequently used material in the construction of denture bases is PMMA, which is widely renowned for its colour stability, transparency, and ease of processing. It is widely and exclusively used today. When the methacrylate monomer is polymerised to form polymethacrylate, the density of material changes from 0.94 gm/cm^3 to 1.19 gm/cm^3. Volumetric shrinkage of 21% occurs, as a result of this density decreases [1]. Polymethyl methacrylate resin flashing may cause the acrylic resin dough to polymerise with residual internal stresses. The pressure related to stress release during deflasking may result in a denture that is less adaptive to tissues [10].

When a typical thermal resin is mixed at the suggested liquid ratio, approximately one-third of the mass is liquid. The rest of the weight is un-polymerised PMMA. Therefore, the volumetric decrease in the polymerised mass should be around 7%, with a linear shrinkage of 2%, leading to the lifting up of dentures following polymerisation from the posterior palate [1].

In Consani RLX et al., Takamata T et al., Sanders JL et al., and Pasam N et al., studies the greatest discrepancies were seen in the post palatal area between the denture base and tissues [7,12-14].

Farhan FA noted the changes in the denture base dimensions of the posterior palatal seal, as a relatively flat part of the edentulous maxilla is in the centre of the hard palate and an angular slope on the residual ridge [15].

Consani RXL et al., have indicated the influence on the dimensional stability of denture bases by the new press system (RS system) [7]. They suggested that the new press system can generate a more precise denture base, thereby decreasing the imprecision

associated with traditional clamping. They reported a discrepancy of 0.129-0.286 mm between the upper dentures and casts. The greatest mean dimension change was observed when packing in the post dam area traditionally [7].

According to Consani RLX et al., the traditional packing method revealed an overall difference of 0.276 mm between the base of the denture and the cast in three distinct locations [4]. In the present study, the average mean marginal gap between all points was 275.42 µm (minimum 264.5 µm, maximum 282.7 µm) by using the conventional method.

According to Consani RLX et al., the average mean difference between the maxillary denture base and the cast at three distinct locations measured using the RS Tension technique was 0.164 mm [4]. In the present study, the average mean marginal gap between all points was 171.8 µm (minimum 154.9 µm, maximum 195.9 µm) by using the RS tension method. When compared Group I and Group II, the variances of Group II were found to be relatively less than those of Group I. Thus it was discovered that the dimensional accuracy of the denture bases fabricated using the RS tension technique compared to traditional methods was more.

Abby A et al., noted that there is variance in the denture base adaptation to the cast due to planar changes and shrinking in the thinnest parts of the denture base [16]. It was observed that, although the largest decline regions occurred in the back portion, there were differences in the conventional and RS tension methods for each location.

Limitation(s)

In the present study, authors only considered the clamping method and single testing material; the combination of other factors which affect the dimensional accuracy of denture bases should also be considered in future studies. In the future, inclusion of more varieties of acrylic resins with different heating protocols with different clamping methods can be advocated to have all the comparisons in a single study.

CONCLUSION(S)

The current study indicated that the marginal gap between the denture base and the master die was less in the Rafael Saide (RS) Tension way of clamping than in the conventional approach, with a highly significant difference identified between both methods at five distinct places on the master die. The RS tension clamping method for the fabrication of dimensionally more accurate and more retentive removable complete dentures should be recommended in the laboratories.

REFERENCES

[1] Anusavice KJ Phillips' Science of Dental Materials, 11th ed. St Louis: Elsevier, 2003:739-41.
[2] AlQahtani M, Haralur SB. Influence of different repair acrylic resin and thermocycling on the flexural strength of denture base resin. Medicina (Kaunas). 2020;56(2):50. Doi: 10.3390/medicina56020050. PMID: 31973219; PMCID: PMC7074266.
[3] Lima APB, Vitti RP, Amaral M, Neves ACC, da Silva Concilio LR. Effect of polymerisation method and fabrication method on occlusal vertical dimension and occlusal contacts of complete-arch prosthesis. J Adv Prosthodont. 2018;10(2):122-27. Doi: 10.4047/jap.2018.10.2.122. Epub 2018 Apr 18. PMID: 29713432; PMCID: PMC5917103.
[4] Consani RLX, Domitti SS, Mesquita MF, Consani S. Effects of packing types on the dimensional accuracy of denture base cured by the conventional cycle in relation to the post pressing times. Braz Dent J. 2004;15(1):63-67.
[5] Consani RLX, Domitti SS, Mesquita MF, Sobrinho LC. Dimensional stability of maxillary denture bases flasked with the RS tension system. Braz J Oral Sci. 2003;2(4):152-55.
[6] Arafa KAO. Effect of different denture base materials and changed mouth temperature on dimensional stability of complete dentures. Int J Dent. 2016;2016:7085063. Doi: 10.1155/2016/7085063.
[7] Consani RLX, Domitti SS, Consani S. Effect of a new tension system, used in acrylic resin flasking, on the dimensional stability of denture bases. J Prosthet Dent. 2002;88(3):285-89.
[8] Khalaf BS, Abass SM, Jassim TK. Dimensional stability of heat-activated acrylic resin at different intervals by different flask cooling methods. MDJ. 2008;5(3):274-80.
[9] Katheng A, Kanazawa M, Iwaki M, Minakuchi S. Evaluation of dimensional accuracy and degree of polymerisation of stereolithography photopolymer resin under different postpolymerisation conditions: An in vitro study. J Prosthet Dent. 2021;125(4):695-702. Doi: 10.1016/j.prosdent.2020.02.023. Epub 2020 May 13. PMID: 32416982.
[10] Babu MR, Rao CS, Ahmed ST, Bharat JSV, Rao NV, Vinod V. A comparative evaluation of the dimensional accuracy of the heat polymerised PMMA denture base cured by different curing cycles and clamped by RS technique and conventional method-An in vitro study. J Int Oral Health. 2014;6(2):68-75.
[11] Savirmath A, Mishra V. A comparative evaluation of the linear dimensional changes of two different commercially available heat cure acrylic resins during three different cooling regimens. J Clin Diagn Res. 2016;10(11):ZC50-54. Doi: 10.7860/JCDR/2016/22066.8903. Epub 2016 Nov 1. PMID: 28050504; PMCID: PMC5198457.
[12] Takamata T, Sectos JC, Phillips RW, Boone ME. Adaptation of acrylic resin dentures as influenced by the activation mode of polymerisation. JADA. 1989;119:271-76.
[13] Sanders JL, Levin B, Reitz PV. Comparison of the adaptation of acrylic resin cured by microwave energy and conventional water bath. Quintessence Int. 1991;22(3):181-86.
[14] Pasam N, Hallikerimath RB, Arora A, Gilra S. Effect of different curing temperatures on the distortion at the posterior peripheral seal: An in vitro study. Indian J Dent Res. 2012;23(3):301-04.
[15] Farhan FA. Effect of post-pressing times on adaptation of maxillary heat cured acrylic denture base at posterior palatal seal area. J Bagh Coll Dentistry. 2013;25(1):01-04.
[16] Abby A, Kumar R, Shibu J, Chakravarthy R. Comparision of the linear dimensional accuracy of the denture bases cured by the conventional method and by the new press technique. Indian J Dent Res. 2011;22(2):200-04.

PARTICULARS OF CONTRIBUTORS:
1. Professor and Head, Department of Prosthodontics, Index Institute of Dental Sciences, Indore, Madhya Pradesh, India.
2. Professor and Head, Department of Prosthodontics, Rural Dental College, Pravara Institute of Medical Sciences (Deemed to be University), Loni, Maharashtra, India.
3. Dean, Professor and Head, Department of Prosthodontics, Dr. Hedgewar Smruti Rugna Seva Mandal's Dental College and Hospital, Hingoli, Maharashtra, India.
4. Assistant Professor, Department of Prosthodontics, Rural Dental College, Pravara Institute of Medical Sciences (Deemed to be University), Loni, Maharashtra, India.
5. Associate Professor, Department of Prosthodontics, College of Dentistry in Alrass, Qassim University, Kingdom of Saudi Arabia.
6. Professor and Head, Department of Prosthodontics, Mahatma Gandhi Missions Dental College and Hospital, Navi Mumbai, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Prabha Shakya Newaskar,
Staff Quarters, PMT Campus, Loni, Maharashtra, India.
E-mail: drprabhashakya82@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 06, 2021
- Manual Googling: Oct 08, 2021
- iThenticate Software: Oct 20, 2021 (12%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 05, 2021**
Date of Peer Review: **Aug 28, 2021**
Date of Acceptance: **Oct 15, 2021**
Date of Publishing: **Nov 01, 2021**