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ORIGINAL ARTICLE

COMPARATIVE STUDY OF THE FLEXURAL STRENGTH OF MAXILLARY DENTURE BASES MADE IN CONVENTIONAL AND HIGH IMPACT HEAT CURE ACRYLIC RESIN

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ABSTRACT

OBJECTIVE: To compare the flexural strength of maxillary denture bases made in high impact and conventional heat cure acrylic resin.

METHODS: This experimental laboratory-based study was conducted in Peshawar Dental College, Materials Research and Centralized Resource Laboratories University of Peshawar, Pakistan. Total 120 edentulous maxillary casts, sixty each of conventional acrylic (30 in subgroup-IA for shallow palate and 30 in subgroup-IB for deep palate and high impact acrylic (30 in subgroup II-A for shallow palate and 30 in subgroup II-B for deep palate) were made. These were then tested for flexural strength using universal testing machine. The load was applied at the rate of 5.0 mm/min. Independent samples t-test was applied for statistical analysis.

RESULTS: Mean values of deflection at fracture, fracture load and flexure strength were 0.309±0.059 cm, 87.729±22.497 kg and 13.645± 4.453 kg/cm^2 respectively. Mean Flexure Strength (kg/cm^2) was 8.30±1.27, 16.54±1.77, 10.88±1.01 and 18.85±1 in subgroups I-A, I-B, II-A and II-B respectively (<0.001). Mean deflection at fracture (cm) was 0.24±0.04, 0.29±0.03, 0.35±0.03 & 0.368±0.03 in subgroups I-A, I-B, II-A and II-B respectively (<0.001). Mean Fracture Load kg was 69.97±3.12, 114.9±6.75, 63.28±7.05 and 102.8±5.5 in in subgroups I-A, I-B, II-A and II-B respectively (<0.001).

CONCLUSION: High impact acrylic resin was found to have significantly higher flexure strength as compared to conventional acrylic resin.

KEY WORDS: Flexural Strength (MeSH); Acrylic Resins (MeSH); Palate, Hard (MeSH); Acrylic denture (Non-MeSH); Maxillary (Non-MeSH); Dental Bases (MeSH)

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INTRODUCTION

Polymethyl methacrylate (PMMA) was introduced in 1937 for dental use and soon it became the most popular removable denture base material.[1] Although it is very popular as a denture base material, but its mechanical properties are far from ideal.[2] Fracture is the most common mechanical failure of PMMA denture where a maxillary denture opposes natural or fixed mandibular teeth.[3]

Most of the earlier research to determine flexural strength were performed on rectangular specimens and real denture bases were not used for testing because previous researchers were only interested in flexural strength of the materials. Therefore, most of the research do not correlate with clinical settings. However, actual denture bases if used as test specimens would better represent the clinical situation for comparison of different materials if used as test specimens.[4]

Maxillary denture bases were fabricated on casts with different palate depths in two different forms of acrylic resins. The results indicated that the bases made in resin with high impact had better flexural strength than those made in regular heat cure resin.[5] It is worth mentioning that any standardized technique such as International Organization for Standardization (ISO) standard was not followed in the fabrication of the test specimens in the previous studies.[6]

Previous studies showed that many factors affect the flexural strength of acrylic denture bases such as type of material, morphology of palatal vault, fibers reinforcement, molding technique and thickness of denture bases.[7-9] High impact acrylic resin has high flexural strength than conventional resin. The flexural strength of acrylic resin dentures can be increased by addition of copolymer. The performance of the denture bases made using high impact heat cure resin was better than those made in conventional heat cure resin. It was also noted that fracture occurred in the midline.[10,11] The null hypothesis of the study was that there is no influence of the type of material on the flexural strength of the denture bases made in conventional and high impact heat cure acrylic resin. This study was conducted to investigate and compare the flexural strength of denture bases made in conventional and high impact heat cure resin.

METHODS

This was an experimental laboratory-

based study carried out in Peshawar Dental College, Materials Research and Centralized Resource Laboratories University of Peshawar. Pakistan from January 2017 to May 2017.

A total of 120 specimens, 60 each of conventional heat cure acrylic resin (Group I having 30 specimens each in subgroup-IA for broad shallow and subgroup-IB for deeper palates) and high impact heat cure acrylic resin (Group II having 30 specimens each in subgroup II-A for broad shallow and subgroup II-B for deeper palates respectively) were fabricated on dentoform edentulous casts with standard and deep palatal vault were included in the study. Specimens with visible cracks, voids and porosity or imperfections were not included in the study.

PREPARATION OF TEST SPECIMENS

Two edentulous maxillary casts in dental stone (Die Stone, Dentamerica, San Jose Ave. California, USA) were obtained pouring a standard maxillary edentulous silicone mould in a water/powder ratio of 21ml/100gm. One of the models was used without any modification in its palate depth for the preparation of denture bases in the two denture base materials. The palate of the other cast was modified in terms of its depth by scrapping the mid-palatal and posterolateral slopes of the hard palate thus leaving the rugae and ridge area unmodified bilaterally. These two models acted as master casts. A silicone mould of each of the above was then obtained using laboratory silicone in a duplicating flask. Sixty duplicate models of each master cast were obtained for making the specimens in each of the two group and their subgroups in dental stone. Two additional models (one each for palatal form) were also made. The additional cast of each of the palatal situation was used for making a standardized acrylic template base in each cast.[5]

On each of the two additional casts, standard wax patterns for the denture bases were made and processed in heat curing acrylic resin. The undercuts on these casts were eliminated so that the resulting acrylic template base could easily fit on the casts to be used for making the test specimens. Thus, standardized template denture base with shallow and the deep palate was used for making the test specimens in the two materials. Standard test denture base was fitted to its corresponding model and sealed with wax. It was subjected to dewaxing and the mold created was packed with the resin, processed, and finished.

FLEXURAL STRENGTH

The specimens made of heat polymerized acrylic denture base were tested according to ISO standard 1567:1999 on the Universal Testing Machine (UTM) (Model 100-500KN Testometric Inc. UK). The load applied was at the rate of 5.0 mm/ min on the most prominent point of mid palate between the premolar and molar area with round plunger of UTM. The load to the fracture of denture bases (in kg) and the amount of deflection before fracture in mm (fracture deflection) was recorded. Flexural strength was calculated using standard formula.[7]

Flexural Strength = 1/2 x Fracture load (kg) x Deflection (cm)

The collected data were analyzed using statistical package for social sciences (SPSS, version 20.0, Chicago, IL, USA). Mean and standard deviation were calculated. Independent samples t- test was used to analyze the data and p-value< 0.05 was considered as significant.

RESULTS

In this in vitro experimental study, a total of 120 acrylic denture bases were used to determine their flexural strength. The various subgroups of denture bases on basis of types of the acrylic resin used and the type of palatal vault depth are described in the methods section.

Mean deflection at fracture, fracture load and flexure strength were 0.309±0.059 cm, 87.729±22.497 Kg and 13.645± 4.453 kg/cm^2 respectively Table I.

Mean values of flexure strength (kg/cm^2) was 8.30±1.27, 16.54±1.77, 10.88±1.01 and 18.85±1.24 in

TABLE I: BASELINE PARAMETERS OF ALL THE DENTURE BASES IRRESPECTIVE OF THE RESIN TYPE AND PALATE SHAPE (N=120)

Parameters	N	Min	Max	Mean	S.D
Deflection at Fracture (cm)	120	0.1860	0.399	0.309	0.059
Fracture Load (Kg)	120	52.340	125.560	87.729	22.497
Flexure Strength (Kg cm)	120	6.252	21.405	13.645	4.453

TABLE II: DESCRIPTIVE STATISTICS FOR DEFLECTION AT FRACTURE, FRACTURE LOAD, AND FLEXURAL STRENGTH OF VARIOUS GROUPS OF ACRYLIC DENTURE BASE SPECIMENS (N=30)

Parameters	Conventional acrylic (Group I)		High impact acrylic (Group II)		P value
	Shallow Palate (Subgroup I-A) (Mean±SD)	Deep Palate (Subgroup I-B) (Mean±SD)	Shallow Palate (Subgroup II-A) (Mean±SD)	Deep Palate (Subgroup II-B) (Mean±SD)	
Flexure Strength (kg cm^2)	8.30±1.27	16.54±1.77	10.88±1.01	18.85±1.24	<0.001
Deflection at Fracture (cm)	0.24±0.04	0.29±0.03	0.35±0.03	0.368±0.03	<0.001
Fracture Load (Kg)	69.97±3.12	114.9±6.75	63.28±7.05	102.8±5.5	<0.001

conventional acrylic & shallow palate (subgroup I-A), conventional acrylic & deep palate (subgroup I-B), high impact acrylic & shallow palate (subgroup II-A) and high impact acrylic & deep palate (subgroup II-B) respectively (<0.001). Comparison of mean deflection at fracture (cm) and mean fracture load (kg) in conventional acrylic & shallow palate, conventional acrylic & deep palate, high impact acrylic & shallow palate and high impact acrylic & deep palate respectively are given in Table II.

DISCUSSION

This study was conducted to determine the flexural strength of edentulous acrylic denture bases in conventional or high impact PMMA resins. From the results, it was noted that the mean flexural strength was higher for denture bases made in high impact acrylic resin than those in conventional resin. The differences between the mean values were highly statistically significantly ($p<0.001$). The thickness of all denture bases of both conventional acrylic resin and high impact PMMA resin were kept constant to control bias. Each denture base thickness was measured with gauge. The previous studies showed that increase in thickness of denture bases improve the flexural strength.[12,13] Though the study conducted by Reddy B, et al. is similar to our but their sample size was small (n=28) and sample size of our study is quite larger (n=120).[14] Another factor which influence the flexural strength might be due to variation in composition of the materials.

The static loading tests for flexural strength showed that the shape of the palatal vault can significantly influence the flexural strength of acrylic denture bases Similar results were reported by Morris JC, et al. (1985) in study on palatal shape and the flexural strength of maxillary denture bases.[6] Morris JC, et al. used conventional acrylic resin of three type of thickness (2.3, 3.2, 3.8mm) in deep palatal vaults and three in shallow palate (1.52, 2.68 ,4.01mm) vaults. In our study the thickness was 2mm for each denture base. Though there was little variation in thickness of denture bases of Morris JC, et al. study but their findings showed less mean flexural strength for the denture bases having shallow palatal vault than those having deep. The mean value of flexural strength in study by Morris JC, et al. of deep vault denture base made in conventional acrylic resin of 2.3mm was 15.67±2,37 kg cm similar to our results. In our investigation we applied load in the center of denture base palate on the highest point at the molar areas similar methods used by Reddy B, et al.[14.]

A study by Ajaj NM, et al.[15]on comparison of flexural strength of high-impact and traditional denture base acrylic resins, reported that the flexural strength of high impact acrylic was higher than conventional acrylic. Their findings are similar to current study. Similarly, another study conducted by Reddy B, et al.[14] also reported that high impact acrylic had higher flexural strength than regular (conventional) acrylic.

Sowmya S, et al.[5] reported that denture bases made in high impact heat cure resin had high flexural strength than those of conventional resin but that study was not conducted according to protocols and specification recommended by ISO.

Although a lot of differences were present between our study and previously published studies like different manufacturing technique, thickness of denture base, environment of curing, powder-liquid ratio, room temperature etc, but the results can be considered comparable because in previous studies similar comparison groups were used with only difference in study variables (palatal height and acrylic type).[16,17]

The denture in mouth of edentulous patients behaves differently than in laboratory testing. Many intraoral variables can affect fracture resistance of denture base like saliva, abnormal habits or bruxism, masticatory forces, and chewing patterns etc.

LIMITATIONS

Though we tried our best to work in controlled environment such as maintaining constant temperature, thickness of denture bases, constant curing time, similar finishing but due to human errors some variations could be expected which can affect the results. Furthermore, it is recommended that more studies should be conducted in vivo to determine the effect of various influencing factors in natural environment. In addition, other relevant properties should such as thermal properties, biological properties, biocompatibility etc. should be tested.

CONCLUSION

Within the limitations of this study, it could be concluded that the nature and type of acrylic resins have significant impact on flexural strength. The flexural strength was higher for high impact acrylic than conventional therefore high impact acrylic resin may be recommended for fabrication of denture bases.

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AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

SA: Conception & study design, acquisition of data, drafting the manuscript, approval of the final version to be published

FA: Conception, drafting the manuscript, approval of the final version to be published

NA: Analysis and interpretation of data, drafting the manuscript, approval of the final version to be published

AH: Analysis and interpretation of data, critical review, approval of the final version to be published

ZR & BH: Acquisition of data, drafting the manuscript, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

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