Effect of different palatal vault shapes and woven glass fiber reinforcement on dimensional stability of high impact acrylic denture base [Part I]

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ABSTRACT

Background: Change in palatal vault shape and Reinforcement of high impact acrylic denture base resin may in turn affect the dimensional accuracy of acrylic resin and affecting the fitness of the denture.This study evaluated tostudy the effect of fiber reinforcement for high-impact acrylic resin denture base with different palatal vault shapes on adaptation or gap space between the denture base and the stone cast and compare with non-fiber reinforcement and effect of palatal vault shapes on adaptation of non-reinforced and fiber reinforced high impact denture base acrylic resin

Material and method: Three different palatal vault shapes were prepared on standard casts using CNC (computer numerical control) machine. 60 samples of heat polymerized high impact acrylic resin maxillary denture base were fabricated onto each definitive cast according to manufacturer instruction. Samples divided into three main experimental groups represented the three different palatal vault shapes (20 samples for each main group); 1st rounded 2nd U-shaped and the 3rd groups V-shaped. Each main group divided into two subgroups (10 samples for each subgroup) representing non fiber reinforced high impact acrylic group as a control and the fiber reinforced high impact acrylic. The measurements of gap-space changes of denture bases done at two stages, 1st 24 hour after polymerization and 2nd measurement done after one month storage in distilled water at room temperature.

Results and conclusion: Dimensional changes of high impact acrylic denture base not affected by glass fiber reinforcement p-value for all reference pointes ≥ 0.05, while topographical change in maxillary vault shapes effects on the gap-space in non-fiber reinforced high impact acrylic denture base p-value < 0.05 in point one, four, and seven.

Key words: High impact acrylic resin, topographical change in vault, woven glass fiber reinforcement. (J Bagh Coll Dentistry 2014; 26(4):90-94).

الخلاصه

المقدمه:دعم الاكلريلك عالي الصدمات المستخدم في قاعده الطقم ممكن ان يؤثر على الاستقرار البعدي للراتنج الاكلريك ويؤثر بالتالي على ثبوتيه الطقم

الهدف من الدراسه: هو بحث تاثير الياف االزجاج الداعمه وتاثير تغيير شكل القحف على الاستقرار البعدي للطقم العلوي المصنوع من راتنج الاكلريك عالي الصدمات

المواد والطرق المستعمله:تم تحضيرثلاثه اشكال من القحف للفك العلوي باستعمال جهاز النحتبالكومبيوتر الرقمي, ثم يستنسخ القالب الحجري باستعمال ماده السليكون الخاص للحصول على60 قالب صخر . 60 عينه قاعده طقم علوي من ماده الاكلريك عالي الصدمات تحضر لكل قالب صخري حسب تعليمات المنشاء . لقياس التغيير بالابعاد (60 عينه لكل طريقه): تقيس مسافه الفراغ بين القالب الحجري وقاعده الطقم . ثم العينات تقسم الى ثلاث مجموعات رئيسيه حسب شكل القحف وهي الدائري ,وشكل حرف- vوحرف-u, ولكل مجموعه 20 عينه, ثم كل مجموعه رئيسيه تقسم لمجموعتين فرعيتين(10 عينات لكل مجموعه فرعيه): مجموعه فرعيهالاولى تستخدم الاكريلك عالي الصدمات غير المدعم والمجموعه الفرعيه الثانيه تستخدم الاكلريلك عالي الصدمات المدعم بالالياف الزجاجيه. كل القياسات لمسافه الفراغ بين القالب الحجري وقاعده الطقم تقاس لمرحلتين :المرحله الاولى بعد 24 ساعه من الطبخ والمرحله الثانيه للقياس تتم بعد 30 يوم من حفظ العينات بالماء المقطر بدرجه حراره الغرفه.

النتائج: مسافه الفراغ بين القالب الحجري وقاعده الطقم في الاكريلك عالي الصدمات لاتتأثر بالدعم من الالياف الزجاجيه, وتغيير شكل القحف يؤثر على مسافه الفراغ الموجود بين القالب الصخري وقاعده الطخم. بالاضافه تغيير شكل القحف يؤثرعلى مسافه الفراغ في الراتنج الاكريلك عالي الصدمات الغير مدعم بينما لايؤثر على الراتنج الاكريلك عالي الصدمات المدعم بالالياف الزجاجيه

الاستنتاج: تغييرومسافه الفراغ الموجود بين القالب الحجري وقاعده الطقم لايتاثرباستعمال الياف الزجاج الداعم, لكن تغيير شكل القحف يؤثر في مسافه الفراغ في الاكريلك عالي الصدمات

INTRODUCTION

Most fractures of maxillary dentures are caused by a combination of fatigue and impact which is reported more in case where maxillary denture base oppose the mandibular natural teeth. The fracture of denture bases when dropped is due to impact force and authors have suggested that repeated flexing from chewing ultimately fatigues the denture in the mouth, in most situations, fractures occur in the midline of the maxillary dentures [(1, 2)].

Considering only the strength though the incorporation of fillers like rubber and fibers to heat-cured poly methyl methacrylate resin improves the impact strength and fatigue resistance[(3)],improvement may in turn affect some of the properties of heat-cured poly methyl methacrylate resin such as dimensional accuracy, dimensional stability, water sorption, and affecting the fitness of the denture [(4)]. High-impact acrylic denture base is made by the heat-cured dough method; Impact resistance arises from the incorporation of rubber phase into the beads during their suspension polymerization [(5)], an alternative of the direct addition of elastomers is the use of acrylic/elastomer copolymers. These are, typically, methyl methacrylate-butadiene or methyl methacrylate-butadiene styrene copolymers which are now available in certain commercial products [(6)].

Dimensional changes caused by water uptake are influenced by the storage period and may compensate the polymerization shrinkage to a certain extent [(7)]. However, after 3 weeks of storage in water, no further significant dimensional changes were observed [(8)].

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MATERIAL AND METHODS

The study involves preparation of 60 samples of heat polymerized high impact acrylic resin maxillary denture base without artificial teeth onto definitive casts according to the recommendations of manufacturer, the samples divided into three main experimental groups represented the three different palatal vaults shapes (20 samples for each main group); 1st rounded, 2nd U-shaped and the 3rd groups V-shaped.

Each main group divided into two subgroups (10 samples for each subgroup) representing the non-fiber reinforced high impact acrylic group (NF group) and the fiber reinforced high impact acrylic (WF group) (table 1). According to cross-arch forms three casts with different palatal vault shapes were prepared by carving palatal vault of standard cast using CNC machine (Computer Numerical Control).

rounded palat vault	U-shape palatal vault	V-shape palatal vault
WFO 10	WFU 10	WFV 10
NFO 10	NFU 10	NFV 10

Table 1: Research methodology and grouping of the samples

Denture base without reinforcement preparation

For denture base preparation in three different palatal vault shapes in non-fiber reinforced groups (NFO, NFU, and NFV) heat polymerized high impact acrylic powder and liquid was placed in clean, dry porcelain jar and mixed according to manufacturer instruction 10ml/21gm W/P ratio, mixing time 30 second until the monomer and polymer were thoroughly companied, the jar sealed and the mixture left for 5min at room temperature 22C° (±2) until reaching the dough stage. The resin removed from the jar, rolled and packed into the mold of each flask.

Denture bases with glass fiber reinforcement preparation

Reinforced high impact acrylic include groups WFO, WFU and WFV, woven type glass fibers were shaped to provide 2mm shorter border than the boundaries of acrylic resin bases [9]. Also a study recommended that woven glass fiber reinforcement should be placed on the tensile side of the specimens under loading resulted in considerably higher flexural strength and flexural modulus values [10]. As result, in clinical situations the fiber reinforcement in complete maxillary denture base should be close to the oral surface of the denture and perpendicular to the midline. So, two layers of high impact acrylic resin precisely prepared to encase the woven glass fibers by using 2 and 3mm thickness record bases.

Finally for or all specimens (fiber reinforced and non-fiber reinforced high impact denture base) pressed in the hydraulic press under the load of 100 Bar for 5 min. the flasks were placed in clamp and immersed in water bath 70°C for 90 min then the temperature raised to100°C for 30 min according to manufacturer instruction. After curing the flask was left to cool on bench for three hours [11].

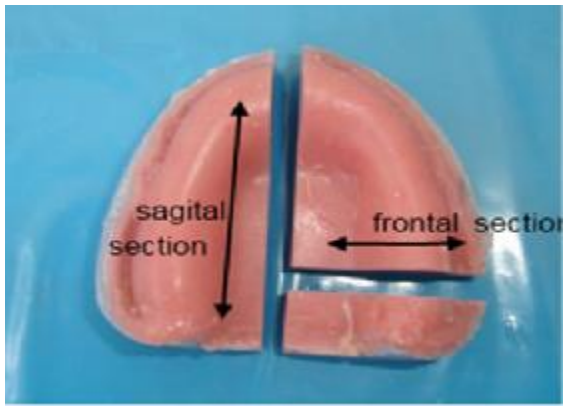

Fig. 1: Maxillary cast with denture base sectioned through two imaginary lines with a precision rotary microtome

The samples deflasked with their corresponding stone cast and sectioned in two positions, first the specimens were sagittal sectioned with a precision rotary microtome in an anteroposterior direction along the imaginary line passing through the midline. A second frontal cross section prepared and its perpendicular to the sagittal section [12,113] (fig 1). The cutting was made on a fixer table under constant water cooling.Four reference points were marked along the resin base/stone cast interface in sagittal section which corresponded to [anterior maxillary ridge (1), anterior part of vault area (2), middle of the vault area (3), posterior termination of vault area (4)] [4] and three reference points were marked at frontal cross section which represent the posterior palatal border gap area measurement which corresponded to[slop of posterior ridge (5), posterior maxillary ridge (6), middle of buccal vestibule (7)](fig 2) [13-16]. Then the prepared acrylic specimens were kept in plastic containers containing distilled water.To determine the adaptation or interfacial gap between high impact acrylic resin bases and the stone casts after water storage a digital microscope used under magnification power of 200X. The total seven reference points at each specimen were

measuredat two periods first 24 hours after polymerization process and storage in distilled water. A second measurement was performed after the storage in distilled water for 30 days [17].

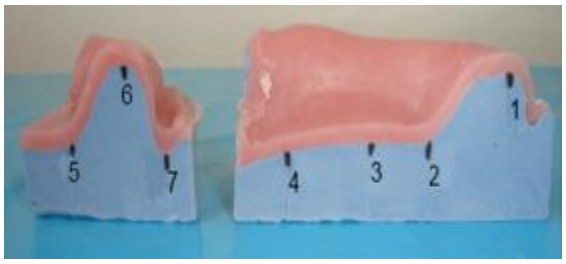

Fig. 2: Total seven reference points for adaptation measurement

RESULTS

Mean difference between two measuring interval calculated (24 hours and 30 daysimmersion in distilled water) for all reference points**,** Standard deviation was examined for mean difference and subjected to statistical analysis (t-test, and ANOVA test).t-test for gap space dimensional changes estimatedbetween non-reinforced and reinforced high impact acrylic in Rounded, U-shaped, and V-shape maxillary vault shapes for seven reference points. The t-test result reveals non-significant difference in all reference points

ANOVA test for gap space dimensional changes affected by change in maxillary vaultshape for all reference points in reinforced and non-reinforced high impact acrylic denture base.When the difference wasfound to be statistically significant LSD test (least significant difference test) was used for examining differences between each 2 groups

Table 2: Gap space (Adaptation) of non-reinforced and fiber reinforced high impact acrylic denture base in different palatal vault shapes

Studied groups		No-fiber			With-fiber			Comparison		
		No.	Mean Difference (mm)	±SD	No.	Mean Difference (mm)	±SD	t-test	p-value	Sig.
O-Shape	1	10	0.01	0	10	0.01	0	0.08	0.93	NS
	2	10	0.012	0	10	0.013	0	0.55	0.58	NS
	3	10	0.015	0	10	0.017	0	0.57	0.57	NS
	4	10	0.01	0	10	0.016	0	0.32	0.74	NS
	5	10	0.014	0	10	0.015	0	0.24	0.8	NS
	6	10	0.009	0	10	0.012	0	0.28	0.82	NS
	7	10	0.01	0	10	0.01	0	1.33	0.19	NS
U-Shape	1	10	0.015	0	10	0.015	0.01	0.06	0.94	NS
	2	10	0.014	0	10	0.016	0.01	0.99	0.33	NS
	3	10	0.016	0	10	0.017	0.01	0.24	0.81	NS
	4	10	0.012	0	10	0.016	0	1.55	0.14	NS
	5	10	0.015	0	10	0.015	0	0.14	0.88	NS
	6	10	0.009	0	10	0.012	0	1.23	0.23	NS
	7	10	0.01	0	10	0.012	0	0.22	0.82	NS
V-Shape	1	10	0.006	0	10	0.008	0	1.41	0.17	NS
	2	10	0.01	0	10	0.016	0	2.1	0.05	NS
	3	10	0.017	0	10	0.016	0	0.39	0.69	NS
	4	10	0.018	0	10	0.018	0	0.02	0.98	NS
	5	10	0.018	0	10	0.019	0	0.45	0.65	NS
	6	10	0.009	0	10	0.012	0	1.62	0.12	NS
	7	10	0.01	0	10	0.011	0	0.16	0.87	NS

Table 3: Gap space change in reference points in three different palatal vaults shapes (Rounded, U-shaped and V-shaped) in non- reinforced and fiber reinforced high impact acrylic denture base

Studied groups		ANOVA							
		No fiber				With fiber			
		No.	Mean Difference (mm)	F-test	p-value	No.	Mean Difference (mm)	F-test	p-value
Point 1	O-Shape	10	0.01	3.41	0.048 Sig P<0.05	10	0.01	2.67	0.087 Non Sig P≥0.05
	U-Shape	10	0.015			10	0.015		
	V-Shape	10	0.015			10	0.008		
Point 2	O-Shape	10	0.012	0.89	0.42 Non Sig P>0.05	10	0.013	1.48	0.24 Non Sig P≥0.05
	U-Shape	10	0.014			10	0.016		
	V-Shape	10	0.01			10	0.016		
Point 3	O-Shape	10	0.015	0.31	0.73 Non sig. P>0.05	10	0.017	1.48	0.98 Non Sig. P≥0.05
	U-Shape	10	0.016			10	0.017		
	V-Shape	10	0.017			10	0.016		
Point4	O-Shape	10	0.01	6.05	0 Highly Sig. p≤0.00	10	0.016	0.01	0.99 Non Sig. P≥0.05.
	U-Shape	10	0.013			10	0.016		
	V-Shape	10	0.018			10	0.018		
Point 5	O-Shape	10	0.014	1.65	0.21 Non Sig. P≥0.05.	10	0.015	0.99	0.385 Non Sig. P≥0.05.
	U-Shape	10	0.015			10	0.015		
	V-Shape	10	0.019			10	0.02		
Point 6	O-Shape	10	0.009	0.006	0.994 Non-sig.	10	0.012	0.031	0.97 Non-sig. P≥0.05.
	U-Shape	10	0.009			10	0.012		
	V-Shape	10	0.009			10	0.012		
Point 7	O-Shape	10	0.019	9.13	0.001 Highly Sig. p≤0.00	10	0.015	1.69	0.202 Non Sig. P≥0.05.
	U-Shape	10	0.01			10	0.011		
	V-Shape	10	0.01			10	0.011		

DISCUSSION

The result demonstrated that fiber impregnation into high impact acrylic resin bases does not affect the magnitude of interfacial gap between the base and the stone cast surface, after 30 days of water storage (table 1). This finding is similar with the statement of Polat et al. [18] who reported that the dimensional stability of conventional acrylic resin denture base material not affected with fiber reinforcement.The study also revealed that the smallest dimensional discrepancies were found in the regions corresponding to the crests of the alveolar ridges (point 1 and point 6), these two points have smaller mean difference value than the values found in the median region of the palate (point 1, 3, and 4), and this result agreed with Rizzatti-Barbosa et al. [19], who found that the smallest dimensional discrepancies were found in the regions corresponding to the crests of thealveolar ridges immediately after resin base removal, this result may be due to that palatal region more affected by stress release and from processing pressure on these area.

The results of gap-space changes in different palatal vault shape in non-reinforced high impact acrylic denture base revealed significant difference in points (1, 4, and 7) (table 2). It seemed that change in palatal vault shape and difference of the type of tissues in the posterior area near post-dam area may cause a large discrepancy in gap space in high impact acrylic denture base resin this is in agreement with the results of Chen et al. [20], who found that an increase in dimensional changes in the posterior area of the palate for most dentures analyzed after 30 days of water storage.

The conclusions that can be drawn from this study are:

1. Gap-space change of high impact acrylic denture base stored for 30 days in distal water not affected by woven glass fiber reinforcement.
2. Topographical changes in maxillary vault shape effect on gap-space dimensional changes of high impact acrylic denture base.
3. Topographical changes in maxillary vault shape not effect on gap-space dimensional change of woven glass fiber reinforcement of high impact acrylic denture base.

REFERENCES

1. Johnston EP, Nicholls, Smith PE. Flexural fatigue of 10 commonly used denture base resin. J Prostho Dent 1981; 46(5): 478-83.
2. Sung-Hun K, David CW. The effect of reinforcement with woven E-glass fibers on the impact strength of complete dentures fabricated with high-impact acrylic resin. J Prosthetic Dent 2004; 91: 274-80.
3. Uma MB, Patil KG, Nagaraj KR, Shweth K. Comparitive analysis of flexural strength of conventional polymethyl methacrylate resin, high impact resin and glass fiber reinforced resin-an in vitro study. Indian J Dental Sci 2013; 5(4): 77-9.
4. Ranganath LM, Ganguly R, Shet K, Rajesh AG. The Effect of Fiber Reinforcement on the Dimensional Changes of Poly Methyl Methacrylate Resin after Processing and after Immersion in Water: An in vitro Study. J Contemporary Dental Practice 2011;12(4): 305-17
5. O Brain WJ. Dental materials and their selections. 3rd ed. Quintessence Publishing Co.; 2002
6. McCabe JF, Walls AWG. Applied dental materials. 9th ed. Oxford: Blackwell publishing; 2008.
7. Miessi AC, Goiato MC, dos Santos DM, DekonSF, Okida RC. Influence of storage period and effect of different brands of acrylic resin on the dimensional accuracy of the maxillary denture base. Braz Dental J 2008; 19: 204–8.
8. Peroz I, Manke P, Zimermann E. Polymerization shrinking of prosthetic plastic materials in a variety of manufacturing processes. [in German] ZWR. 1990; 99: 292-6
9. Vallittu PK. Flexural strength of acrylic resin polymers reinforced with unidirectional and woven glass fiber. J Pros Dent 1999; 81(3): 318-26.
10. Katja KN, Lippo VL, Pekka KV. The Static Strength and Modulus of Fiber Reinforced Denture Base Polymer. Dental Mater 2005; 21:421-8
11. Al-Khafaji AM. The effect of four different cooling procedures on the dimensional stability of microwave-activated acrylic resin at different time interval. J Bagh Coll Dentistry 2011; 23(2): 1-5.
12. Sykora O, Sutow EJ. Posterior palatal seal adaptation: influence of processing technique, palate shape and immersion. J Oral Rehabil 1993; 20:19-31.
13. Yasir A. Influence of different PH of saliva and thermal cycling on the adaptation of different denture base materials. A master thesis, College of Dentistry, University of Baghdad, 2012.
14. Wong DM, Cheng LY, Chow TW, Clark RK. Effect of processing method on the dimensional accuracy and water sorption of acrylic resin dentures. J Prosthet Dent 1999; 81: 300-4
15. Rafael L.X, Marcelo FM, Mario AC, Simonides C. Influence of the deflasking delay time on the displacements of maxillary denture teeth. J Appl Oral Sci 2003;11(4): 332-6
16. Chung-JL, Sung-BB, Ji-Young B and Hae-H L. Comparative adaptation accuracy of acrylic denture bases evaluated by two different methods. Dental Mater J 2010; 29(4): 411–7.
17. Shadi ELB, Klaus L, Abdulaziz S, Sandra FL, Matthias K. Linear and volumetric dimensional changes of injection-molded PMMa denture base resins. Dental Mater 2013; 29: 1091-7
18. Polat TN, Karacaer O, Tezvergil A, Lassila LV, Vallittu PK. Water sorption, solubility and dimensional changes of denture base polymers reinforced with short glass fibers. J Biomater Appl 2003; 17: 321-35.
19. Rizzatti-Barbosa CM, Machado C, Joia FA, dos Santos SRL. A method to reduce tooth movement of complete dentures during microwave irradiation processing. J Prosth Dent 2005; 94: 301-2.
20. Chen JC, Lacefield WR, Castle Berry DJ. Effect of denture thickness and curing cycle on the dimensional stability of acrylic resin denture bases. Dental Mater 1988; 4: 20-4.