Effect of Addition Retention Bead and Repair Material on Transverse Strength of Repaired Acrylic Denture Resin

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المستخلص

الهدف: لأنّ من أهمّ النواقص الفعلية في مواد قاعدة الطقم هو الكسر، لذلك أجريت عدّة محاولات لتقوية قاعدة الطقم المرممة. والهدف المطلوب هو الحصول على أعلى قوّة للترميمات. ولتحقيق هذا الهدف، يجب أن تكون هناك قوة التصاق جيدة بين المادّة الأصلية للطقم ومادة الترميم.

المنهجيّة: أجريت الدراسة الحالية لتقييم ومقارنة تأثير قوّة الإنثناء لعيّنات الراتنج الاكريلي المرمّمة بمادتي الراتنج الاكريلي الحراري المبلمر والراتنج الاكريلي الذاتي البلمرة.تمّ تحضير ٥٠ عيّنة من مادّة الاكريلك الحراري، لكل اختبار ١٠ عينات رمّمت بإضافة الاكريلك الحراري البلمرة مع حلقة التثبيت، ومجموعة أخرى رمّمت بإضافة الاكريلك الذاتي البلمرة مع حلقة التثبيت، ومجموعتان أخريتان رمّمت بإضافة الاكريلك الحراري فقط والاكريلك الذاتي البلمرة فقط فضلاً عن المجموعة الرئيسة من الاكريلك الحراري البلمرة غير المرمّمة. قوة الإنثناء فُحِصَت لكل عيّنة باستعمال جهاز الإنثناء لقياس قوّة الإنثناء من خلال تحديد ثلاث نقاط على كل عيّنة.

النتائج: أظهرت النتائج أنّ الراتنج الاكريلي المبلمر والمرمّم مع حلقة التثبيت يمتلك قوة إنثناء أعلى قيمة من الراتنج الاكريلي الذاتي البلمرة والمرمّم مع حلقة التثبيت وكذلك أعلى قيمة من المجموعة التنظيمية غير المرمّمة.

التوصيات: يمكن الاستنتاج بأنّ الراتنج الاكريلي المبلمر والمرمّم مع حلقة التثبيت يُعَدّمقياساً أساسياً مهماً في عمليّة تقوية قاعدة الأطقم الاكريليكية المرممة.

Abstract

Objective: One of the most important practical deficiencies of present denture base materials is fracture, therefore many attempts have been made to reinforce of the repaired denture base resin. A desirable objective for this service is to obtain optimum strength for repairs, which can be achieved by making available a good bond between original and repaired materials.

Methodology: The present study was carried out to evaluate and compare the transverse strength of acrylic specimens repaired by two different materials (hot-cure and cold-cure acrylic resin). A total of 50 specimens were prepared by hot (40) repair: (10) by hot with retention bead, (10) by cold with retention bead and (10) repair by hot only, (10) repair by cold only, and (10) un repair control made from hot cure acrylic resin. Transverse strength was measured for each specimen using three points bending on a brinell transverse testing machine.

Results: The result showed that the repair with heat-cure acrylic resin with retention bead has a significant higher than the repair with cold-cure acrylic resin with retention bead and higher than control specimen (unrepaired).

Recommendations: It can be concluded that the hot acrylic resin with retention bead are an important parameter in the reinforcement of repaired acrylic denture base resin.

Keywords: Auto-polymerizing Resin; Transverse Strength; Repair; Retention Bead

Introduction

Denture base acrylic resin may be subjected to different types of stress, intra orally; repeated masticatory force can lead to fatigue phenomena, while extra orally high-impact force may occur as a result of dropping the prosthesis. As a consequence, fracture of the denture base can result, regardless of the reason of fracture or the method of repair [(1)].

Acrylic resin complete dentures are susceptible to fracture after long periods of clinical use [(2)]. The repair of fractured prosthesis can be accomplished using acrylic resins that are auto polymerized, heat polymerized or microwave polymerized [(3)].

The ultimate goal of denture repair is to restore the dentures original strength and avoid further fracture. Satisfactory repairs must be easily and rapidly completed, match the original color of the material, and maintain dimensional accuracy during repair [(1)].

Several materials have been used in repair to restore fracture acrylic denture, including auto polymerized acrylic resin, heat-polymerized acrylic resin, visible light-polymerized resin [(4-5)]. Also, several techniques have been proposed to repair fractured dentures to restore their original strength [(6)].

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However, recent developments in processing methods and materials may result in superior strength of heat polymerized and autopolymerizing acrylic resins to those previously reported. For example, the use of glass fibers and groove or use of wire loops with acrylic resins[6-7]. Retention bead its made from stainless steal used for retention crown and bridge cast base [7].

The purpose of this in vitro study was to evaluate the transverse strength of a heat polymerized acrylic resin, when repaired heat polymerized acrylic resin with auto-polymerizing acrylic resin or heat polymerized acrylic resin and use the retention beads.

Methodology

Sample Groups were as following:

The total of (50) specimen were used in this study, specimens are divided as follow:

Ten Specimens made from hot cure acrylic resin (control Groups).
Ten Specimens repaired by hot cure acrylic resin only
Ten Specimens repaired by cold cure acrylic resin only
Ten Specimens repaired by hot cure acrylic resin with retention bead
Ten Specimens repaired by cold cure acrylic resin with retention bead

General preparation of the acrylic specimens:

Instead of wax pattern preparation which needs more time and effort in its preparation and wax elimination procedure, the metal pattern was constructed with a dimension of (65mm X10mm X2.5mm) length, width, thickness respectively used for transverse strength test [8].

The conventional flasking techniques for complete dentures were followed in the mold preparation. Two metal patterns were coated with a separating medium and allowed to dry before investing them in the lower half of the flask which contained stone mixed according to the manufacture instruction (100gm\31ml); (p\w); the metal pattern were inserted to its full depth and allowed to set. After setting of stone, another layer of separating medium was applied on the stone surface to facilitate the separation of the two halves of the flask later, then the upper half of the flask was placed in position and filled with stone mixtures and allowed to be hardened for (60) minutes before the flask was opened.

After removal of the metal pattern carefully with aid of the wax knife, the two halves of the mold were coated with separating medium to be ready for packing with acrylic dough**.**

Pink heat cure acrylic powder with the liquid was mixed according to manufacture instruction (2.25 gm\1 ml). (P\L), the liquid was placed in a clean and dry mixing jar followed by slow addition of powder. The mixture was then stirred with a wax knife and allowed to stand in a close container at room temperature to the dough stage. The dough then packed into gypsum mold when it was separated cleanly from the walls of the mixing jar.

The resin was removed from its mixing container and; then packed into the mould which had treated with separating medium. The two halves of the flask were closed together and placed under the hydrolic press; and then the pressure was slowly applied to allow even flow of the dough throughout the mold space. The pressure (20 bar) was then released [7].

The flask was opened and the over flowed material (flash) surrounding the mold space was removed with wax knife [3].

Curing was done by placing the clamped flask in a thermostatically controlled water bath and processed by heating is increase slowly from room temperature to (50-73°C) for (7-9) hours and then the temperature is raised to (100°C) for 1-1 hour and ½ hour. After completing the curing, the flask was allowed to cool slowly at room temperature for (30) minutes, followed by a complete cooling of flask with tap water for (15) minutes before deflasking. The acrylic pattern ware then removed from the stone mould [8].

All flash of acrylic were removed with acrylic bur. To get a smooth surface, the stone bur should be used followed by (120) grain size sand paper to remove any remaining small scratching with continuous water cooling.

While polishing was accomplished by using brush and pumice with lathe polishing machine, a glossy surface was obtained with wool brush and polishing soap on dental lathe using low speed (1500 rpm) and the specimens were continuously cooled with water to avoid over heating, which may lead to distortion of the specimens.

The specimens were conditioned for one week in distilled water 37°C [8] before fracture and repaired.

Preparation of the repaired acrylic specimens:

The stone mold which had been used for processing the acrylic samples was used then as an index for these specimens in the repair procedure. The samples and indices were numbered on corresponding ends to allow realignment in the original position. The specimens were prepared with 45° bevel joint by using metal holding device had a central recess. The dimension of the central recess of the holding device for preparation transverse strength specimens was (31 mm X 10mm X 2.5mm).

The acrylic specimen was placed in the central groove and we measure (3mm) in middle of specimen and cut with a fissure bur near the bevel end, the distance about 1.5mm from the cut end we cut with acrylic bur until we obtained 45° bevel joint, the depth of scratch is about 1.5mm to added retention to the new acrylic resin and finish with a (120) grain size sand paper for (1) minute with fixed speed, then polished with pumice for ½ minute [9].

Repair by cold cure:

The two parts of the sample to be repaired were realigned in its index after painting it with separating media.

The proportion for cold-cure is 2.5:1 by volume (P\L) before that the index painting with monomer. The mixtures was packed into joint after dough stage by wax knife, beneath and above the retention bead and apply monomer on the new acrylic, in the space between the specimen. When the thickness of specimen 2.5mm and thickness of retention bead is about 1mm with diameter 2.5mm and the distance between two halves of the specimen is about 3mm (45°bevel joint), with slight excess of material to account for polymerization shrinkage and finishing [5].

Then the repair index with the repaired sample was left on the bench about ½ hours until it is set, after we apply pressure by the clamp then finishing and polishing. All the repaired specimens were stored in distilled water at 37°C for 48 hours before testing [8].

Repair by Heat-cure acrylic resin:

The manufacturer's instructions were followed in proportioning and mixing of the polymer and monomer, the polymer/ monomer ratio used was 2.25 gm/1 ml (for major acrylic resin).

Before that the index painting with monomer than the retention bead put in the space between two half, the mixture was packed in to joint after dough stage by wax knife, beneath and above the retention bead with slight excess of material to account for polymerization shrinkage and finishing.

The two halves of the flask were finally closed together and pressed in hydraulic press under (1500 psi) for 5 minutes before clamping was done and then transferred to the water path.

Curing was carried by placing the clamp in a water path and processed by heating is increase slow from room temperature to (50-73°C) for (7-9) hours and the temperature is raised to (100°C) for 1-1and ½ hours, after completing the curing the flask was allowed to cool slowly at room temperature for (30) minutes followed by a complete cooling of flask with tap water for (15) minutes before deflasking. Then the repaired specimens were removed from the stone mould and then finishing and polishing. All the repaired specimens were stored in distilled water for 48 hours before testing [8].

The transverse strength was measured in air by three points bending on a Brinell transverse testing machine. The device is supplied with a central loading plunger and two supports with polished cylinder surfaces, (3.2mm and at least 10.5mm long and perpendicular to the longitudinal center line).

The distance between the centers of support is in the range of 50mm, and the loading plunger was midway between the supports. The test samples were held at each end the two supports, and the loading plunger was midway between the supports. The specimens were deflected until fracture occurred. The transverse strength was taken from (Parameter) of the testing device.
Then the transverse strength was calculated using the following equation:

$$S = \frac{3\,PI}{2bd^2}$$

Where:-

S= Transverse strength (N/mm²).
P= The load at fracture (N).
I= Distance between the supports (mm).
b= Width of specimen (mm).
d= Depth of a specimen (mm).

Fig -1-

Results

Represent descriptive statistics which include (Mean, SD, SE, Minimum, Maximum). The student t-test of acrylic specimen repaired by hot and cold cure acrylic resin result showed that the highest mean transverse strength values were obtained with hot cure acrylic resin with retention bead (57.1955). While, the lowest transverse strength values obtained with cold cure acrylic resin with retention bead (43.8390). While, the lowest transverse strength values were obtained between hot cure acrylic resin and cold cure acrylic resin.
As show in Table (1),(2) and Figure 1.

Table 1. Descriptive statistic for control and treated specimen

	n	Mean	Std. Deviation	Std. Error	Range	
					Minimum	Maximum
Control	10	32.8244	4.8641	1.6214	27.00	43.20
Retention bead (Hot)	10	57.1955	9.2072	2.7761	31.05	64.30
Repair by hot cure acrylic	10	22.3400	1.2756	.4034	20.30	24.10
Retention bead (Cold)	10	43.8390	4.5417	1.4362	40.32	51.30
Repair by cold cure acrylic	10	17.6100	.9712	.3071	16.10	18.80
Total	50					

n=Number; Std. Error= Standard Error; Std. Deviation= Standard Deviation

Table 2. ANOVA with LSD test between control group with hot and cold groups

Groups		ANOVA with LSD test	
		P-value	Sig.
Control	Retention bead (Hot)	.000	HS
	Repair by hot cure acrylic	.000	HS
	Retention bead (Cold)	.000	HS
	Repair by cold cure acrylic	.000	HS
Retention bead (Hot)	Repair by hot cure acrylic	.000	HS
	Retention bead (Cold)	.000	HS
	Repair by cold cure acrylic	.000	HS
Repair by hot cure acrylic	Retention bead (Cold)	.000	HS
	Repair by cold cure acrylic	.051	NS
Retention bead (Cold)	Repair by cold cure acrylic	.000	HS

ANOVA= Analysis of Variance; HS= Highly Significant; LSD= Least significant dose; P-value=Level of Probability at p≤0.05; Sig.=Significance

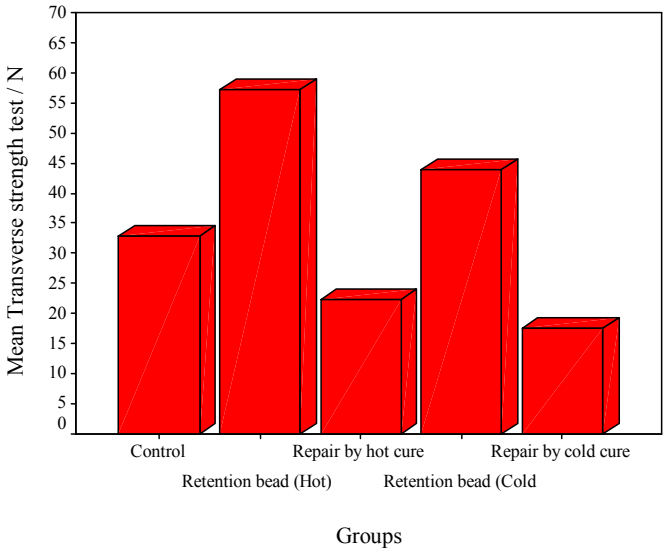

Figure 2. Bar Chart between control group and other groups

Discussion

The effect of types of acrylic resin on the transverse strength test:

The transverse strength of a material is the load at which the material fractures under bending load [(10)].

The result reveal that repairs with cold acrylic resin show lower transverse strength than repairs with hot-cure acrylic, this result may be due to the type of acrylic resin used in the present study and the method of polymerization influence on the repair resin bonding strength, the results are in agreement with the result of. Dar-Odeh and Abu- Hammed 1997 [(11)]. Surface treatment affects the bond strength of repair material that the bond strength of denture base resin was sufficiently high to suggest its clinical applicability as reline material [(12)]. Some studies demonstrated that both auto

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polymerized acrylic resin and heat cured resin have comparable values for transverse strength and also similar results with regard to their mechanical properties [13]. Transverse bond strength of heat cured resin did not differ significantly from that of auto polymerized acrylic resin [14].

A desirable objective for this service is to obtain optimum strength for repairs. So, this can be achieved by making available a good bond between repaired surface and repaired material, bond strength can be affected by several factors, including cross-linking of the materials, availability of the monomer, and the degree of contamination during processing [5].

Effect of retention beads:

Denture fracture often occurs at the interface junction of the original base and repair materials, rather than within these materials [16]. It was reported that the presence of retention bead in repaired prosthesis strengthened the acrylic resin which was similar to the results of the repaired specimens in our study [17].

The important effective factors for variation of transverse strength in repaired samples are the joint surface contours. Processing methods, distance between repaired sits, types of retention bead, repairing acrylic resin, and porosity [17-18]. The repair joint design was 45 º bevels. The strength of repairs made with round and 45 º bevel joint contour were similar and significantly greater than those with a butt joint design [15].

As a result, the most important factor for the success of denture repair is the retention between the fractured sites and the repair material; stronger bond reduces the stress concentration and increases the strength of repaired unit [19]. There are numerous studies and methods concerning the strengthening of PMMA or enhancing the adhesion between metal and acrylic resins this study is in agreement with the work of Oraig 2001, Shimizu 2006 [7,20].

Conclusion

The hot acrylic resin with retention bead is an important parameter in the reinforcement of repaired acrylic denture base resin.

References

1. Craig RG, Powers JM. *Restorative dental materials*. 11th ed. Elsevier; St. Louis; 2002.

2. Vallittu PK. Glass fiber reinforcement in repaired acrylic resin removable dentures: Preliminary results of a clinical study. *Journal of Prosthetics Dentistry*, 1997; 28: 39-44.

3. Rached RN, Powers TM, Del-Bel Cury AA. Repair strength of autopolymerizing microwave and conventional heat-polymerized acrylic resin. *J. of Prosthet Dent.* 2004; 92(1): 79-82.

4. Minami H, Suzuki S, Minesaki Y, Kurashige H, Tanaka T. In vitro evaluation of the influence of repairing condition of denture-base resin on the bonding of autopolymerizing resins. *J. of Prosthet Dent*. 2004; 91(2): 164-170.

5. Shen C, Colaizzi FA, Birns B. Strength of denture repairs as influenced by surface treatment. *J. of Prosthet Dent*.1984; 52(6): 844-850.

6. Oraig RG, Powers JM. Restorative dental materials.11th ed. St. Louis: Elsevier; 2001.

7. American National Standers Institute (ANSI). *No. 12 for Denture-base Polymer*. American Dental Association Specification, Chicago: ADA; 1999.

8. AL-Nadawi Mousa. *The effect of different surface treatment and joint surface shapes on some mechanical properties of the repaired acrylic denture-base resin cured by two different techniques*; University of Baghdad; 2005.

9. Craig RG. *Restorative dental materials*. 10th ed. St. Louis: The C.V. Mosby Company; 1997.

10. Dar-Odeh NS, Harrison A, Abu-Hammed D. An evaluation of Self-cured and Visible Light-Cure Denture-base Materials when Used As A denture-based Repair Material. *J. of Oral Rehabitation*. 1997; 24: 755-760.

11. Razavi R, Khan Z, Fraunhofer JA. The Bond strength of a visible light-cured reline resin to acrylic resin denture base material, *J. of Prosthet Dent.* 1990;63: 485-700.

12. Ishigami K, Maeda R, Maeda M, Hamada H, Shou K, Shimada A, et al. Basic Studies on visible light-curing resin as a denture-base Part 17: Transverse and tensile strengths of repaired denture-base resin using a trial repair-resin. *J. of Nihon Univ Sch Dent*, 1993.

13. Lewinstein I, Zeltzer C, Mayer CM, Tal Y. Transverse bond strength of repaired acrylic resin strips and temperature rise of dentures relined with VLC reline resin. *J. of Prosthet Dent*, 1995, 74: 392-400.

14. Ward GE, Moon PC, Levine RA, Behrendt CL. Effect of repair surface design, repair material and processing method on the transverse strength of repaired acrylic denture resin. *J. of Prosthet Dent*, 1992; 67: 815-820.

15. Sarac GL, Kulunk GD. Repair strength of denture-base resin using various methods. *Eur J. Prosthet Dent*, 2005: 183-186.

16. Ogawa T, Hasegawa A. Effect of curing environment on mechanical properties and polymerizing behaviour of methyl-methacrylate autopolymerizing resin. *J. of Oral Rehabil.* 2005; 32(3): 221-226.

17. Nagai E, Otanik Satoh Y, Suzuki S. Repair of denture-base resin using woven metal and glass fiber: Effect of methylene chloride pretreatment. *J. of Prosthet Dent.* 2001; 85: 496-500.

18. Stipho HD. Repair of acrylic resin denture-base reinforced with glass fiber. *J. of Prosthet Dent.* 1998; 80(5): 546-550

19. Shimizu H, Ikuyama T, Hayakawa E, Tsue F, and Takahashi Y. Effect of surface preparation using ethyl acetate on the repair strength-base resin. *J. Acta Odontol Scand.* 2006; 64(3): 159-163.