TRANSVERSE STRENGTH OF VARIOUS RESIN JOINTS REPAIRED WITH VISIBLE LIGHT CURED RELINE MATERIAL

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يدرس هذا البحث خصائص الانحناء في ثلاثة أنواع من الراتنج المستخدم كقاعدة للصفيحة الكاملة وبعد إصلاحها بمادة التبطين المتصلبة بالضوء المرئي ومقارنتها مع تلك التي تم إصلاحها بالإجراء التقليدي باستعمال الراتنج سريع التصلب .
وقد اتضح بأن العينات المصنوعة من الراتنج المعتاد والمقوي بالألياف الزجاجية بعد إصلاحها بالإجراء التقليدي بواسطة الراتنج سريع التصلب قد أعطت جهد انحناء أعلى من مثيلاتها من عينات الراتنجات التي تم دراستها .
وأن جهد الانحناء بصورة عامة وجد منخفضاً بعد الإصلاح في جميع راتنجات قاعدة الصفيحة التي فحصت.
كما تراوح هذا الانخفاض بعد الإصلاح في الراتنج المعتاد بين ٢ ,٤٨ ٪ - ٤ ,٥٦ ٪ من جهد الانحناء الأصلي قبل الإصلاح بينما كان انخفاض جهد الأنحاء في الراتنج المتصلب بالضوء المرئي ١ ,٢٦ ٪ مقارنة بما تم إصلاحه بمادة التبطين المتصلبة بالضوء المرئي .
واتضح أن نقصان فاعلية مادة التبطين المتصلبة بالضوء المرئي في إصلاح الراتنج المعتاد أو المقوى بالألياف الزجاجية يعود إلى قلة الاندماج الفيزيائي والكيميائي بين مادة التبطين المتصلبة بالضوء المرئي مع هذا الراتنجات .

Specimens of three different denture base resins were repaired with visible light cured (VLC) reline material and with the traditional sprinkle on autopolymerizing PMMA repair resin. Flexural properties were measured before and after repair and compared. These tests revealed that fiber reinforced polymethylmethacrylate, (PMMA) denture base joints repaired with autopolymerizing acrylic resin can produce superior bonding properties. Transverse strength of joints made and repaired with the VLC acrylic resin system gave favorable pre-repair strength and lower post-repair strength. Significant differences were found between the flexural properties of the denture base resins used before and after repair. Plain and fiber reinforced PMMA acrylic resin joints repaired with the VLC reline material, showed a reduction of transverse strength ranging from 48.2%-56.4% of the original values. However, only 26.1% loss of strength was found for VLC denture base resin joints repaired with VLC reline material. This difference in strength reduction could be attributed to the poor adhesive bonding between the VLC reline material and the PMMA resin base.

Introduction

The ultimate goal of any acrylic denture repair is to restore the original strength of the fractured denture and to avoid further fracture. Satisfactory repair should be easy, match the original material in color, rapid and inexpensive. Several techniques and materials have been developed to attain such goal. Attempts to resolve the denture fracture problem have focused on the use of denture base materials of improved mechanical properties and by using effective processing methods. To improve the mechanical properties of denture base materials several techniques have been introduced including the use of high strength resins, using metal wire reinforcement and adding various fiber fillers.[1-5] The inclusion of metal wire may improve the fracture strength of the denture against impact forces but results in poor esthetics. Carbon and Aramid fibers when used to reinforce denture bases acrylic resins were found useful, but problems of polishing and aesthetics restricted their uses.[2-4] However, reinforcing PMMA with glass fibers was found more promising with little difficulty in achieving adequate impregnation of the fibers in the composite.[2,6] Class fibers were used to reinforce acrylic resin denture bases in either loose cut random form, complete reinforcement, or placed accurately in continuous strands at the critical regions of the denture, a technique normally known as partial reinforcement.[4,56]

The Triad (VLC) visible light cured denture base resin was introduced in the dental market to be used in removable prosthodontics

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and direct intraoral relining of complete and partial dentures. It is available in the forms of premixed sheets, ropes, gels or powder and liquid. Triad material is similar to light cured composites but uses organic rather than inorganic fillers. The material is composed of a matrix of urethane dimethacrylate plus small amounts of microfine silica to control rheology. Its applications in dentistry has increased due to the speed of curing and the elimination of the flasking procedure. Although its curing method may pose a potential for distortion defects,[7] the superior strength and acceptable bond of the Triad VLC resin to heat cured processed acrylic resin reported by Ogle et al.,[8] encouraged its use for relining and repairing of other denture bases. Several investigations were directed to study the strength of PMMA denture bases repaired with heat cured, autopolymerizing or visible light cured resins.[915]

This investigation compared the transverse strength of joints repaired with the traditional sprinkle-on technique of self-curing (autopolymerizing) acrylic resin and the VLC reline resin as repair agents on glass fiber-reinforced and plain- non-reinforced, PMMA denture base acrylic resins.

Materials and Methods

Three different denture base materials were used in this study. Triad visible light cure (VLC) denture base resin material, (Dentsply International Corporation, York, PA, USA) in premix sheet form was used to prepare group A. VLC resin sheets were cut into strips of 3x6x50mm. Test specimens were prepared by adapting the strips in a special aluminum mold[5] and then pressed to produce 2x6x50mm test specimens. After trimming the *excess* material, the specimens were covered with Triad air-barrier coating, (ABC), to inhibit air from the surface layer. The strips were placed in the light curing unit (Triad 2000, Dentsply International) for 10 minutes in one cycle in accordance with manufacturer's instructions.

Autopolymerizing polymethacrylate. PMMA acrylic resin denture base (Kerr Manufacturing Co., Romulus, MI), was used to prepare the specimens in group B. The polymer/monomer ratio used to prepare the specimens in group B was lOg powder/ 6 ml liquid.

Croup C specimens were prepared using the same PMMA acrylic resin, but reinforced with loose untreated glass fibers lOfim in diameter (manufactured by Saudi Glass Fiber Co. for Owens Corning of the USA) cut in pieces approximately 2mm in length. The glass fiber concentration used was one percent by weight to the total weight of the composite. Previous quantitative research work by the first author[5] showed that a glass fiber concentration of one percent mixed in a random loose form with the PMMA acrylic resin composite produced favorable mechanical properties of the denture base acrylic resin. To assure adequate impregnation of the fibers[24] within the composite, the glass fibers had to be thoroughly mixed with the monomer before adding the powder.

All the PMMA denture base specimens were prepared in the same mold, (2x6x50 mm), following the conventional flasking and deflasking techniques in accordance with manufacturer's instructions. Flash was removed and the finished specimens were carefully adjusted to the exact dimensions by grinding the edges on 600 grit silicon carbide paper with running water as coolant and were stored in distilled water at room temperature (23C°) for seven days before testing. Fourteen specimens in each test group were prepared, for a total of 42 specimens. Seven specimens from each category were tested for transverse strength (control) while the others were cut in equal halves by a diamond saw to simulate fractures. The fractured surfaces were rounded with a bur, placed back in the mold but spaced with a 2mm gap, and made ready to receive the repair agent, as suggested by Stipho and Stipho,[9] Harrison and Stansbury,[10] Ward et al.[n].

The surfaces to be bonded were treated with Lucitone monomer (Dentsply International), before receiving the repair agent in accordance with manufacturer's directions. The repaired joints, with VLC reline material serving as bonding agent, were partially processed with hand held visible light unit (Model C 7916. Coltene Whaledent Inc. NJ), for forty seconds, twenty seconds on each side. This process deemed necessary to facilitate handling the repaired specimens with minimum disturbance before final polymerization in the Triad light curing unit as suggested by Lewinstein et al[16]. The cut specimens from the PMMA groups were similarly prepared but repaired with autopolymerizing acrylic resin applying the sprinkle-on technique. After repair, all specimens were carefully adjusted to the original dimension on a 600 grit paper and

were stored in distilled water at room temperature for forty-eight hours before testing. Manufacturer's directions for processing procedures were followed for each material. A universal testing machine (model-E 500, Instron Corp. Canton, Mass.) and a standard bending jig were used in the transverse bend tests. The distance between the tips of the bending jig was 50mm apart. The ends of the specimen were fixed to prevent rotation or any other movement at the supports. Each specimen was loaded centrally at a constant cross-head speed of 12.7 mm/minute until fracture. The fracture load and maximum deformation were recorded for each specimen. The mean fracture loads and maximum deflection at the point of loading for each test group before and after repair were calculated and analyzed using paired t-test. One way analysis of variance (ANOVA), and the LSD Bonferroni were also conducted.

Results

The mean fracture load of the fiber reinforced PMMA test specimens (group C) before repair (Table 1) revealed an increase of 7.5% and 16% over the plain PMMA (group B) and the VLC (group A) denture base resins, respectively. The reduction in fracture load after repair was found to be significant in all groups. The mean fracture load before and after repair for the groups tested with all repair agents were found significantly different at p= 0.05 confidence level. All groups had their mean fracture load reduced after repair in the range of 26.1 - 56.4%. In comparison, visible light cured. Triad, (VLC) denture base resin seemed to lose the least strength after repair with VLC reline material in comparison to the other denture base materials tested. Similarly the maximum deformation (5) in all the denture base resins tested, before and after repair was found significantly different ($p<0.05$), as shown in Table 1. Deflection of all groups decreased after repair loosing 23% and 47.77% of their intact (before the repair) deflection values. It appears that the specimens made and repaired with the VLC resin exhibited minimum loss of deflection after repair, compared with those fiber reinforced PMMA specimens repaired with VLC reline material.

One way ANOVA statistical analysis (Table 2), showed significant differences ($p=0.002$) between the mean fracture load of the materials after repair with VLC reline resin.

The effectiveness of the reline material in repairing the plain and fiber reinforced PMMA resin denture bases was further investigated using the modified LSD Bonferroni multiple range tests with 0.05 significance level (Table 3). Significant differences were found between the three tested groups. The transverse strength (S) and modulus of elasticity (E) for the denture base materials tested before and after repair was then calculated using maximum bending moment formula for fixed ends.[5] The results are compared and presented in Table 4.

Discussion

The mean transverse strength of the Triad VLC resin before repair was found slightly less than that of the fiber reinforced acrylic" resin. The mean bending deflection at failure of the VLC before repair was found significantly lower than that of the glass fiber reinforced acrylic resin indicating a greater stiffness of the former resin.

The post-repair mean fracture load for all the denture base resins tested was found to be significantly lower than the original intact resin. The reduction in the mean fracture load was found in the range of 26.1%-56.36%. Within the range of properties tested, all repairs made with VLC reline material gave lower resistance compared with those repaired with autopolymerizing acrylic resin employing the sprinkle-on technique. However, no significant differences were found between the transverse strength of the glass fiber reinforced acrylic resin and the VLC Triad resin before repair, though the VLC denture base resin showed a 10.1% strength improvement over that of the plain (no fiber) PMMA acrylic resin (Table IV). The calculated modulus of elasticity (E) reflected that Triad resin was 39.4% stiffer than the fiber-reinforced acrylic resin. It appears that the VLC reline material is very efficient in the repair of the VLC Triad resin. However, neither the plain PMMA resin nor the fiber reinforced PMMA resin benefit from being repaired with the reline VLC material. The post repair transverse strength of the plain and the glass fiber reinforced PMMA acrylic resin repaired with autopolymerizing self-cured resin using sprinkle on technique was found to be 22.24% and 30.82% higher respectively, than that repaired with the VLC reline material.

It may be concluded that repairing the PMMA resin or the glass fiber reinforced PMMA resin with the VLC reline material, involves additional technical steps that may

Table 1. Paired t-test results for fracture load and maximum deformation before and after repair.

Material (Group)	Mean Fracture Load (KG)	p-Value	Mean Deformation (mm)	p-Value
VLC denture base control before repair	5.45		5.12	
		0.0178		0.0425
VLC denture base after repair with reline	4.03		3.94	
PMMA denture base, no fiber, before	4.95		6.31	
repair		0.0180		0.0180
PMMA denture base, no fiber, after repair with autopolymerizing resin	2.64		4.47	
PMMA denture base, no fiber, before	4.95		6.31	
repair		0.0180		0.0180
PMMA denture base, no fiber, after repair with VLC reline resin	2.16		**4.25**	
PMMA denture base, fiber reinforced,	5.89		7.64	
before repair		0.0180		0.0180
PMMA denture base, fiber reinforced, after repair with autopolymerizing resin	3.99		5.31	
PMMA denture base, fiber reinforced,	5.89		7.64	
before repair		0.0189		0.0180
PMMA denture base, fiber reinforced, after repair with reline VLC resin	**3.05**		3.99	

P< 0.05

Table 2. One-way ANOVA test results for the tested denture base resins, fracture load after repair with VLC reline material.

Source	D.F.	Sum of Squares	Mean Squares	F-ratio	p-Value
Between groups	2	8.5687	4.2844	14.8742	0.0002
Within groups	18	5.1847	0.2880		
Total	20	13.7534			

Table 3. Multiple range modified LSD Bonferroni test results with 0.05 significant level, fracture load after repair with VLC reline material.

Mean	Materials	Groups		
		C	B	A
-2.9233	Group C			
-2.7914	Group B			
-1.5412	Group A	*	*	

* Indicates significant difference at p < 0.05

influence the accuracy of the unit, as reported by Lewinstein et al.[16] The success of the VLC reline material in repairing the VLC Triad denture base resin, in spite of producing lower post repair transverse strength and stiffness, gives favorable important contribution towards the use of the VLC reline material to repair VLC denture base resins. The minimal differences in the fracture strength between the VLC and fiber reinforced PMMA acrylic resin give an important clinical option, however the significant post repair strength differences, should not be overlooked.

Table 4. Computed transverse strength and modules of elasticity compared before and after repair for the denture base resins used.

Material	Transverse Strength (S) (N/Cm>)	Modulus of Elasticity (E) (N/Cm^{l})
VLC denture base:		
Control specimens before repair	8435.31	193027.0
After repair with VLC reline material	6170.94	159113.0
PMMA denture base:		
Control specimens before repair	7579.69	125126.06
After repair with PMMA resin	4042.50	94204.42
After repair with VLC resin	3307.50	81066.18
Fiber reinforced PMMA denture base:		
Control specimens before repair	9019.06	122969.33
After repair with PMMA resin	6109.69	119854.20
After repair with VLC resin	4670.31	121927.54

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