Evaluation of transverse and tensile bond strength of repaired nylon denture base material by heat, cold and visible light cure acrylic resin

Firas A.F., B.D.S., M.Sc. [1]
Ghazwan A.A., B.D.S., M.Sc. [1]
Ali A.M., B.D.S., M.Sc. [1]

ABSTRACT

Background: Denture fracture is one of the most common problems encountered by the patients and prosthodontists. The objective of present study was to evaluate the transverse strength of nylon denture base resin repaired by using conventional heat polymerized, autopolymerized and visible light cure {VLC} resins, surface treatment that used for repair and adjustment of insufficient nylon denture bases and in case of addition of artificial teeth. As these corrective procedures are common chair side procedures in dental clinic.

Materials and methods: One hundred twenty nylon specimens were prepared by using metal patterns with dimension of (65x10x2.5 mm) length, width, and thickness respectively for transverse strength test while for tensile bond strength a dumbbell-shaped with measurement (65x12.5x25mm) length, width, and thickness respectively were flasked with stone. The nylon specimens were molded by reflasked with dental stone that used as an index for these specimens in the repair procedure and repaired with 45 degree bevel joint by using metal holding device. The two parts of nylon specimen to be repaired were realigned in its repair index and adhere with special adhesive material to stabilize the combination during repair procedure. The dough of heat and cold cure resin was packed into the joint and then cured. The specimen repaired with cold cure resin was placed in the Ivomat containing water at (40°C) and pressure (30lB/inch²) for 15 minutes. The specimen repaired with {VLC} was placed in the light cure unit for 4 minutes following manufacturer's instruction. The fractured nylon specimens were divided according to the type of repaired materials into (40) specimens received heat cure acrylic and the (40) specimens received cold cure acrylic and the other 40 specimens received {VLCR}. Each 40 specimens were subdivided according to the type of surface treatment received into 20 specimens were treated with coarse stone bur (control), 20 specimens were treated with combination of coarse stone bur and monomer of the heat cure acrylic. After that the specimens were subjected to transverse {Tr} and tensile bond {TB} strength tests. For each test 10 specimens.

Results and conclusions: This study showed that specimens treated with combination of coarse stone bur and monomer of the acrylic (heat, cold or VL cure) had the highest transverse and tensile strength values, followed by the specimens treated with coarse stone bur. The results showed that the specimens repaired with heat cure acrylic had transverse and tensile strength values higher than the specimens repaired with cold and VL cure acrylic when compared between subgroups of heat, cold and VL cure acrylic that received the same treatments.

Key words: Transverse and tensile stress, denture repair. (J Bagh Coll Dentistry 2013; 25(Special Issue 1):1-5).

INRODUCTION

In recent years, nylon polymer has been attracting attention as a denture base material because of a host of advantages: favorable esthetic outcome, toxological safety to patients allergic to conventional metals and resin monomers, higher flexibility which than conventional heat-polymerizing resin facilitate denture retention by utilizing the undercuts of abutment teeth in the denture base design. This meant that metal clasps can be eliminated from denture bases, which also meant that problems resulting from metal clasps such as excessive stress on abutment teeth, esthetic compromise can be reduced. In this study, a nylon denture base polymer was subjected to surface treatment with a coarse stone bur to form a rough surface to assess the effect of this surface treatment on the transverse strength of nylon repaired with different types of acrylic resins the final strength of an acrylic resin repair relies on the type of repair material used.

Transverse strength of a conventional heat-cured repair is about 80% of that of the intact material, while repairs conducted with a chemically activated resin can reach 60% of the strength of the original denture base material. When choosing a repair technique, other factors besides strength must be considered, such as the working time demanded and the degree to which dimensional accuracy is maintained during repair [1,2].

The objective of present study was to evaluate the transverse strength of nylon denture base resin repaired by using conventional heat polymerized, autopolymerized and visible light cure {VLC} resins, surface treatment that used for repair and adjustment of insufficient nylon denture bases and in case of addition of artificial teeth.

MATERIALS AND METHODS

A metal pattern were prepared with measurement (65x10x2.5mm) length, width, and thickness respectively used for produced sixty nylon specimens for transverse strength test while

(1)Assistant Lecturer. Department of Prosthodontics. College of Dentistry, University of Baghdad.

for tensile bond strength test a dumbbell-shaped metal pattern of (65x12.5x2.5) length, width, thickness respectively was constructed to produced sixty nylon specimens for that test according to ADA No.12, 1999. The metal pattern was flasked with metal flask by using dental stone (*Geastone, Zeus sriLoc. Tamburine Roccastrada, GR, Italy*). The metal patterns were coated with a separating medium and a sprue wax gauge 5 mm was attached to the middle of the metal mold and allowed to dry after investing them in the lower half of the flask which contain mixed stone according to the manufacturer instruction (100 g/31ml) ;(p/w) and allowed to set. The set lower half was coated with separating medium and then the upper half of flask was assembled and filled with stone mixture and the sprue wax should appear to be easily recognized during injection process. After wax elimination procedure the metal patterns were removed and the two halves of the flask were coated with a separating medium to be ready for injection with nylon denture base (*Valplast international corporation, USA*) [2-4].

One hundred twenty (120) nylon specimens were prepared and divided according to the type of acrylic resin received each type 40 specimens, for heat **{H}** and for cold **{C}** cure acrylic resin, and for visible light cure resin {**VL}**, the specimens were subdivided according to the type of surface treatment received into (20) specimens for coarse stone bur surface treatment (control) for heat cure {**H1**}, for cold cure {**C1**}, for light cure {**VL1**} and (20) specimens for combination of coarse bur and heat cure monomer (experimental) for heat cure {**H2**}, for cold cure {**C2**}, for light cure {**VL2**} as shown in diagram below.

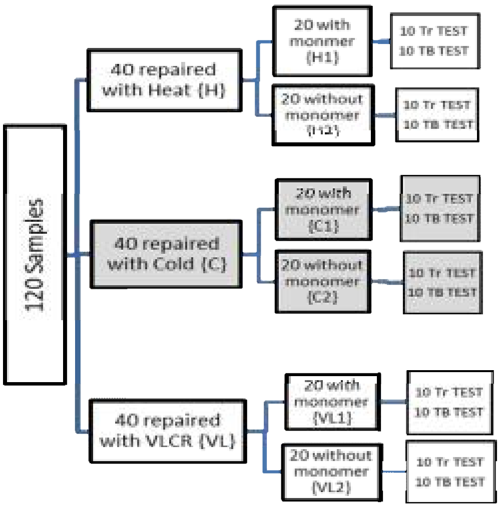

Diagram showed groups distribution

Preparation of the repaired nylon specimens

Fracturing and joint preparation

The nylon specimens were molded with stone mix with metal flask to make an index after fracture procedure. The nylon specimens were repaired with 45 degree bevel joint by using metal holding device having a central recess figure (1). The dimension of the central recess of the holding device was (31mm length x12.5 mm width from posterior end of the recess x 2.5 mm thickness. The nylon specimen was placed in the central groove and cut with a fissure bur near the bevel end. The cut end was prepared with course stone bur. The same procedure was done for the other half. By this method the gap space between these two halves was (3mm) with 45 flaring downward [5,16].

Figure 1: Holding device with 45° bevel joint

Repair by the HEAT cure acrylic resin

The nylon specimens were placed on the stone mold that had been done previously for repairing procedure and divided according type of repaired material. For heat cure acrylic resin, the two parts of nylon specimen to be repaired were realigned in its repair index and adhere with special adhesive material to stabilize the combination during repair procedure. After painting it with separating medium, and the repaired specimen was treated according to the classification of surface treatment received, for the combination surface treatment the monomer was applied by painting over the nylon specimen 10 seconds before the dough heat cure resin packed into the fracture joint area, pressed and then cured [3,6].

Repair by the COLD cure acrylic resin

The two parts of nylon specimen to be repaired were realigned in its repair index and adhere with special adhesive material to stabilize the two parts during repair procedure. After painting it with separating medium, and with monomer for combination surface treatment the cold cure resin dough was adapted well into the repair joint area and then placed in the Ivomat containing water at (40°C) and at pressure (30IB/inch²) was applied for 15 minutes. All repaired specimens were stored in distilled water and incubated at 37°c for 48 hours [7,10].

Figure 2: A fracture nylon specimen placed in the stone mold with 3mm gap for repair material application

Preparation of the VLCR

The nylon specimens were fixed on a flat glass plate, then a layer of separating medium was applied on the nylon specimen, then a stone mixture was prepared by mixing the correct water powder liquid ratio which was then poured onto the nylon specimen with vibration to get rid of air bubbles, a second glass plate was placed over the stone mix which stopped by placing a layers of sheet wax (2.5mm thickness) at the two end of glass plate, so the nylon specimen and stone was sandwiched between the two glass plates with 2.5mm thickness of stone.

Repair by VLCR

The same procedure in the repair of nylon specimen with heat and cold cure resin was followed, after application of separating medium, and monomer for combination surface treatment, the light cure sheet was cut into small piece and adapted well on repair joint area. The material adapted well using glass plate weight, access material was removed by using sharp knife and then cured with light curing unit for 4 minutes (following manufacture´s instruction).

Testing procedure

Transverse strength test {Tr}

The specimens were measured by three points bending on Instron Universal testing machine. The load was measured by compression load cell with scale of 100 kg the specimens were deflected until fracture occurred. The values of transverse strength were computed by the following equation: **S = 3PI/2bd** in which S: transverse strength (N/mm²) or (MPa) P: peak load exerted on specimen (N) I: distance between supporting rollers (mm) b: width of the specimen (mm) d: depth of the specimen (mm) [2,8].

Tensile Bond strength test {TB}

The test of specimens were measured by Instron Universal testing machine with grips suitable for the test specimens, at cross head speed of 0.5 mm/min and the chart speed was 20 mm/min. a tensile load cell measured with a scale of 100kgthe recorded at failure was measured.

RESULTS

The mean values of transverse strength and tensile bond strength were classified according to the type of acrylic and subdivided according to the type of surface treatments received for heat cure acrylic **H,** for cold cure **C** and for light cure **VL**.

DISCUSSION

In general the results of the transverse strength (**Tr**) and Tensile bond (**TB**) of repaired specimens with heat, cold or light cure acrylic showed that application of monomer to the nylon specimen has the highest mean value while the strength decreased in the specimens without monomer application; table (**1,7**). The effect of monomer was present clear when compare between the specimens that not treated with monomer for both Tr and TB strength tests as shown in table (**2, 8**). [9,10]

The effect in regard to the type of material of repair: All the flexible specimens that repaired with heat cure acrylic with combination surface treatment (monomer and coarse stone bur) or without monomer showed highly significant difference for both Tr and TB strength than specimens repaired with cold and light cure acrylic table (**3,4,9,10**). This may be due to the higher degree of temperature reached during polymerization of heat cure acrylic resin than other types so more softening of surface layer of flexible specimens and more penetration of repaired material into surface layer [11-13].

The effect of Tr and TB tests in regard to the type of surface treatment applied

The repaired flexible specimens treated with monomer (for heat cure or for cold or VL cure groups) had higher Tr and TB strength mean values, with highly significant differences, this may attributed to the fact that the repaired surface was well dissolved with monomer and this lead to the formation of micropores which act as mechanical retention, thus enhanced bonding of the repaired resin to the treated flexible resin surface [14-16]. Due to the metylmethacrylate act as a reactive solvent with nylon specimen make interlocking bond with repaired material especially heat cure lead to increase the functional sites which produce a stronger Tr and TB strength at which act as chemical retention that shown in tables (**5,6,11,12**).

The specimens repaired with heat and cold cure showed higher Tr and TB strength than that with VL cure, this result due to higher viscosity exhibited by the VL cure which makes the diffusion of the repair material to the original material less than that shown with other types as showed in table (**1, 7**) [2,17]. Furthermore, the VL cure had poor wettability due to less monomer contain than other types which lack makes interlocking bond with the repaired specimen. [18,19].

Table 1: Descriptive data of Transverse strength of the specimens repaired by Heat H, Cold C, and Light VL cure acrylic

Repaired material	Surface treatments	Statistical analysis	
		Mean	**SD**
Heat cure	H1	124	2.748
	H2	95	1.813
Cold cure	C1	80	1.490
	C2	55.1	1.449
VLC	VL1	45.2	1.316
	VL2	27	1.024

Table 2: t-test between with and without monomer subgroups specimens of Transverse strength test for heat {H}, cold {C} and light {VL}

Subgroups	t-test	P-value	Significant
H1 & H2	27.004	P<0.01	HS
C1 & C2	38.88	P<0.01	HS
VL1 & VL2	27.31	P<0.01	HS

Table 3: t-test of Transverse strength between with monomer subgroups specimens of H, C, and VL

Groups	t-test	P-value	Significant
H & C	59.03	P<0.01	HS
H & VL	74.91	P<0.01	HS
C &VL	47.85	P<0.01	HS

Table 4: t-test of Transverse strength between without monomer subgroups specimens of H, C, and VL

Groups	t-test	P-value	Significant
H & C	74.33	P<0.01	HS
H & VL	88.86	P<0.01	HS
C &VL	45.91	P<0.01	HS

Table 5: ANOVA of Transverse strength test of specimens repaired with monomer H, C, and VL

Groups	F-test	P-value	Significant
H&C&VL	406.41	P<0.01	HS

Table 6: ANOVA of Transverse strength test of specimens repaired without monomer H, C, and VL

Groups	F-test	P-value	Significant
H&C&VL	35.116	P<0.01	HS

Table 7: Descriptive data of Tensile Bond strength of the specimens repaired by Heat H, Cold C, and Light VL cure acrylic

Repaired material	Surface treatments	Statistical analysis	
		Mean	**SD**
Heat cure	H1	103.6	2.674
	H2	74.2	1.813
Cold cure	C1	59.8	1.619
	C2	34.8	1.032
VLC	VL1	24.3	1.337
	VL2	8.5	1.080

Table 8: t-test between with and without monomer subgroups specimens of Tensile bond strength test for heat {H}, cold {C} and light {VL}

Subgroups	t-test	P-value	Significant
H1 & H2	28.11	P<0.01	HS
C1 & C2	50.56	P<0.01	HS
VL1 & VL2	24.44	P<0.01	HS

Table 9: t-test of Tensile bond strength between with monomer subgroups specimens of H, C, and VL

Groups	t-test	P-value	Significant
H & C	51.31	P<0.01	HS
H & VL	74.45	P<0.01	HS
C &VL	51.66	P<0.01	HS

Table 10: t-test of Tensile bond strength between without monomer subgroups specimens of H, C, and VL

Groups	t-test	P-value	Significant
H & C	61.95	P<0.01	HS
H & VL	110.1	P<0.01	HS
C &VL	48.83	P<0.01	HS

Table 11: ANOVA of Tensile bond strength test of specimens repaired with monomer H, C, and VL

Groups	F-test	P-value	Significant
H&C&VL	409.24	P<0.01	HS

Table 12: ANOVA of Tensile bond strength test of specimens repaired with monomer H, C, and VL

Groups	F-test	P-value	Significant
H&C&VL	409.24	P<0.01	HS

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