Acrylic denture base repair (part I): Estimations of repair space, profile designs, and residual monomer calibration curve on strength of denture base.

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ABSTRACT

Aims: To estimate the best profile design used for repair at the fractured area, the suitable space to be left between the two fracture pieces, and to determine the percentage of residual monomer calibration curve of heat cured acrylic resin polymerized by water bath. **Material and methods**: Forty five samples of heat cured acrylic denture base resin were prepared, and repaired by water bath with different profile designs, and different space distances at fractured area, the samples were tested to measure transverse strength. In addition to five samples prepared for determination of the light absorbency of aqueous solution by spectrophotometer. Analysis of variance (ANOVA), and Duncan's multiple range test were used for statistical analysis. **Results**: showed that there is no significant difference between different profile designs, and no significant differences between repaired samples with 2 and 3 mm space at fracture area. The absorbency of aqueous solution at 0.125–0.005 mg/ml concentration is helpful for this study. **Conclusion** Repaired specimens showed less transverse strength than control group**.**Repaired samples with 2 mm repair space and 3 mm repair space were significantly higher than that of 1mm repair space.

Key words: Repair acrylic resin, Profile design, residual monomer.

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INTRODUCTION

Fracture: is the process or act of breaking; state of being broken. Or to cause a fracture in; to break, rupture, or tear.[1] Fracture of denture is a common clinical finding in every prosthodontic practice. The causes of such fracture due to poor fit, lack of balanced occlusion, material fatigue, and dropping of the denture were recognized as possible causes.[2] An effective repair procedure should restore the original strength of denture base, avoid further fracture, have a short duration of curing, possess high strength and durability, and should be simple to use, cheap, good aesthetics, non–allergenic and does not distort the existing denture.[2–4]

The heat cured resins had significantly higher bond strengths than chemically cured repair resin to the denture base.[4]

Wetting the repair surface with different solvents (methyl methacrylate, methylen chloride, Acetone, and chloroform) results in improvement of repaired acrylic denture base.[5–7] Also, acrylic denture base repaired with different space between denture pieces at the fracture area and profile designs have been reported.[8–11] So the aims of this study are to evaluate:

1. The best profile design used for repair at the fractured area.
2. The suitable space to be left between the two fracture pieces.
3. The best range of value for calibration curve used to determine the percentage of residual monomer of heat cured acrylic resin polymerized by water bath.

MATERIALS AND METHODS

Grouping of the Samples: In this study 45 samples were prepared from major heat cured denture base material cured by water bath in dimension of 65 ± 0.3× 10 ± 0.03 × 2.5 ± 0.03 mm (length, width and thickness respectively) for transverse strength test. In addition, five samples were prepared in a special design for residual monomer test. These samples are divided into 10 groups and each group co-ntains 5 samples as follows (figure 1).

I. Control group: Control group of heat cured acrylic resin without fractured area.

II. Profile design of fractured area [11]: All following repaired groups were cured by water bath technique using heat cured acrylic resin material:
1. Group repaired with knife-edge shaped profile design at the fracture area.
2. Group repaired with reverse knife edge shaped profile design at the fracture area.
3. Group repaired with rabbit lap shaped profile design at the fracture area.
4. Group repaired with reverse rabbit lap shaped profile design at the fracture area.

III. Groups according to space between fractured areas**:** All the following repaired groups were cured by water bath technique using heat cured acrylic resin material:
1. Group repaired with no space left between the two fractured pieces.
2. Group repaired by with 1–mm left between the two fractured pieces.
3. Group repaired with 2–mm left between the two fractured pieces.
4. Group repaired with 3–mm left between the two fractured pieces.

IV. Residual monomer samples and its test for calibration curve: Five acrylic resin specimens of 20× 20× 3 mm were prepared. These specimens were daily immersed in 10 ml of fresh distilled water in sealed glass flask for 7 days at 37°C.

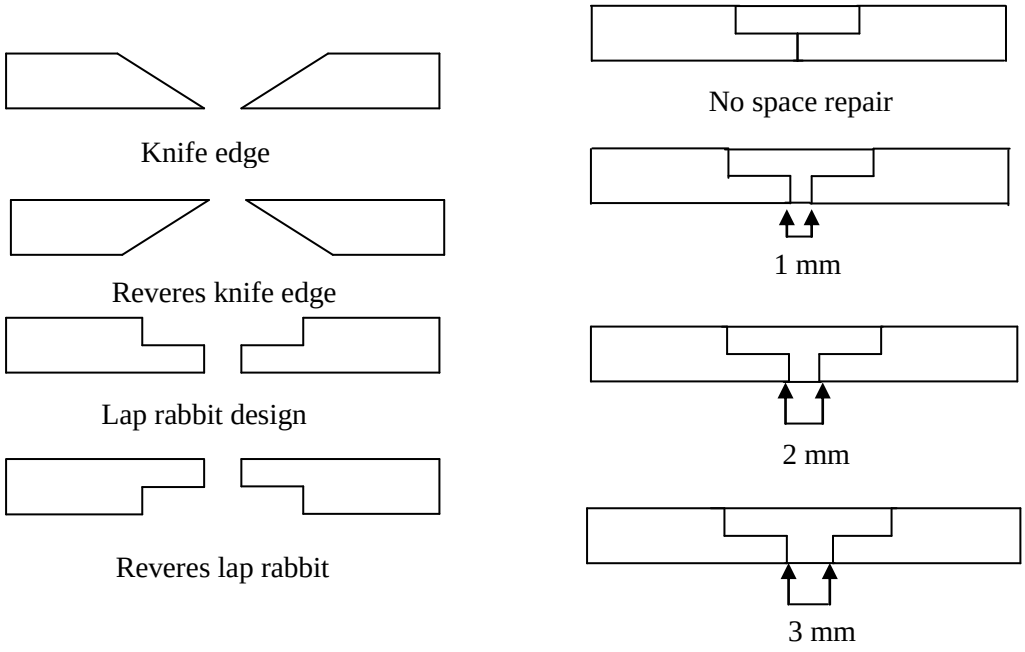


Figure (1): Diagram shows different profile designs and different spaces between the two ends of fracture sites.

Solution of 5mg pure methyl methacrylate (monomer) was diluted in 100ml of distilled water to prepare stock solution in concentration 0.5mg/ml concentration of solution.[12]

From this stock solution 0.25, 0.125, 0.025, 0.01, 0.005 mg/ml concentrations were prepared, and then an ultraviolet visible spectrophotometer (CECIL 2000) was used at 254 nm to measure the absorbency of light for each supernatant solution for each day and above concentration of aqueous solutions.

Acrylic resin specimens were prepared in a mold made by investing a hard elastic foil for specific dimensions according to each test as mentioned previously in dental stone against glass slab which was considered as the polished surface and the other side was considered as the tissue surface.

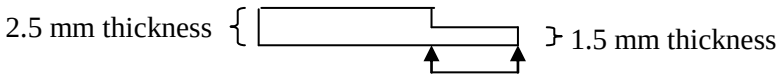
The stone was mixed with water; in a ratio of 28–32 gm of stone to 100 ml of water [(2)], and the stone was poured in the lower half of the flask.

Lubrication of the tissue surface of elastic foil was done before the final set with slurry of stone to prevent the incorporation of air between the stone and the foil. The glass slab was placed over the foils till the stone had set.

After setting of the stone, the separating medium was painted over the stone of the lower half. The second half of the flask was placed over the first one and was filled with stone. Powder (polymer) and liquid (monomer) of heat cured acrylic resin were mixed together in a glass jar 3:1 (according to the manufacturer instructions). The acrylic resin was cured by two steps polymerization of water bath, 70 ˚C for 30 minutes, then proceed at 100˚C for 30 minutes (according to the manufacturer's instructions), in a thermostatically controlled water bath. Then the flask was left aside for slow bench cooling (8 hours) before opening.[(13,14)] The flasks were left for bench cooling at room temperature; the samples were removed and incubated in distilled water at 37±1 ºC for 48 hours (ADA specification no.12 1975) before testing.

Preparation of Fractured Specimens: In order to prepare the mold for the two fractured denture base pieces, a hard elastic foil (master model) was prepared by electrical saw with the following dimensions: 10-mm width, 32.5 mm (for no space specimens) and 31 mm (for 3–mm space) length, and 2.5–mm thickness of foil. At the fracture site of the master mode reduction was done from the thickness (1–mm) for 4 mm in length (Figure 2). Fractured denture base pieces were cured by conventional water bath technique. One surface of cured acrylic denture base was polished in the conventional method.[(9)]

A



B

Figure (2): A: Prepared master model for fractured specimens.B: Diagram demonstrates the dimension of lap rabbit master model preparation.

Repair Procedure and transverse strength test: Two fracture denture base pieces of heat cured acrylic resin were placed in stone mold that had been prepared previously for control group of each test. The tissue surface of the specimens was placed in the mold facing the stone material of the flask.

The repair sides were treated with acrylic monomer for 180 sec. by fine brush (No.0)[(15)], or without treatment. Heat cure acrylic resin cured by thermostatically controlled water bath using metal flask and curing cycle mentioned previously. Then the flask was left aside for slow bench cooling before opening.

Each repaired specimen was tested for porosity under reflecting light microscope (Lomo micmed 2). The porous specimen was excluded from the tests (Figure 3). The repaired acrylic resin specimens were stored in distilled water at 37±1 ºC for 48 hours (ADA specification no.12 1975).

Transverse strength test was done for 45 specimens. Load was measured by using compression machine (Inc. Model CN, 472 EVANSTON I11–USA) at cross–head speed of 0.5 cm per minute [(17)] Figure (4). Transverse strength (TS) was calculated according to the following equation:

$TS = 3WL/2bd^2$ [(16)]

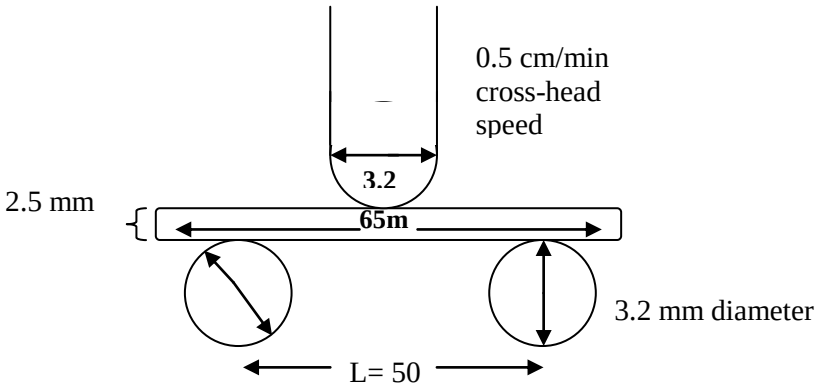


Figure (3) Transverse strength test diagram.

The statistical analysis of mean, standard deviation, analysis of variance (ANOVA) and Duncan's multiple range tests were calculated

RESULTS AND DISCUSSION

Mean and standard deviation of repaired group's specimens showed less transverse strength than control group Table (1). Analysis of variance (ANOVA), Table (2), and Duncan's multiple range tests, Table (3) showed no significant differences ($P > 0.001$). This result agree with ward *et al.*,[17] The mean of transverse strength and standard deviation of control without repair samples (82.2 ± 2.22 MPa) is significantly higher than repaired acrylic resin with a different profile designs [4, 9,10,12].

Table (1): Mean, and standard deviation of transverse strength of denture base with different repair designs.

Profile design	Mean ± SD (MPa)	Number
Control	82.2±2.2249	5
Reveres knife	65.7±8.3111	5
Reveres rabbit lap	68.4±8.7849	5
Rabbit lap	71.7±5.5520	5
Knife shape	67.5±3.8243	5

MPa: Mega Pascal; SD: Standard deviation.

Table (2): Analysis of variance (ANOVA) for denture base with different profile repair designs

Source of variance	DF	Sum of squares	Mean of square	F–value	*P*–value
Repair design	5	1093.067	218.613	4.520	0.005
Error	24	1160.900	48.371		
Total	29	2253.967			

Df : Degree of freedom

Table (3): Duncan's multiple range test of transverse strength for profile design

Profile design	Mean ± SD (MPa)	Duncan's group	Number
Control	82.2±2.2249	A	5
Reveres knife	65.7±8.3111	B	5
Reveres rabbit lap	68.4±8.7849	B	5
Rabbit lap	71.7±5.5520	B	5
Knife shape	67.5±3.8243	B	5

MPa: Mega Pascal; SD: Standard deviation.

The mean of transverse strength and standard deviation, Table (4), shows that repaired samples with 2 mm repair space (71.1±3.1 MPa), and 3 mm repair space (71.7±5.5 MPa) is significantly higher than that of 1mm repair space (58.2 ± 7.5 MPa), and zero repair space (63.7± 9.6 MPa).

The analysis of variance (ANOVA), Table (5), and Duncan's multiple range test, Table (6), shows no significant differences between 2, and 3mm space, and significant differences (P<0.001) in 2 and 3 mm in contrast to 1mm space and with out space at the two fracture pieces. The first group had a better transverse strength value than that of 1mm space, and without space. These results agree with Beyli and Van Fraunhofer.[11]

Table (4): Mean, and standard deviation of transverse strength of denture base with different space between two-fractured sites.

Space	Mean ± SD (MPa)	Number
Zero space	63.7±9.6734	5
1 mm space	58.2±7.5299	5
2 mm space	71.1±3.1105	5
3 mm space	71.7±5.5520	5

MPa: Mega Pascal; SD: Standard deviation.

Table (5): Analysis of variance (ANOVA) of transverse strength for different space between two–fractured sites.

Source of variance	DF	Sum of squares	Mean of square	F–value	*P*–value
Repair space	4	1649.740	412.435	10.536	0.0001
Error	20	782.900	39.145		
total	24	2432.640			

Df : Degree of freedom

Table (6): Duncan's multiple range test of transverse strength for different spaces between two-fractured sites.

Space	Mean ± SD (MPa)	Duncan's group	Number
Zero space	63.7±9.6734	AB	5
1 mm space	58.2±7.5299	B	5
2 mm space	71.1±3.1105	A	5
3 mm space	71.7±5.5520	A	5

MPa: Mega Pascal; SD: Standard deviation.

The absorbency of 0.5 and 0.125 mg/ml concentration of aqueous solutions was much away from the maximum absorbency of supernatant solution, so 0.5 and 0.125 mg/ml concentrations were excluded from the study of residual monomer (Table 7 and 8). According to these results, a linear calibration curve of methyl methacrylate (MMA) concentration as a function of absorbency at 254nm was obtained using MMA standard aqueous solutions ranged 0.005–0.125mg/ml (figure 4).[16,18]

Table (7): Absorbency of aqueous solutions

Concentration of prepared solution	Absorbency (nm)
0.5 mg/ml	1.985
0.25 mg/ml	1.489
0.125 mg/ml	0.573
0.05 mg/ml	0.244
0.025 mg/ml	0.194
0.01 mg/ml	0.077
0.005 mg/ml	0.060

Nm: Nano meter

Table (8): Absorbency (nm) of supernatant solution for control group of heat cured acrylic rein polymerized by water bath.

Samples	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
1	0.170	0.124	0.092	0.069	0.034	0.025	0.010
2	0.155	0.132	0.109	0.071	0.031	0.020	0.014
3	0.163	0.150	0.111	0.068	0.024	0.021	0.011
4	0.165	0.117	0.089	0.059	0.031	0.019	0.012
5	0.166	0.145	0.101	0.073	0.029	0.019	0.016

Nm: Nano meter

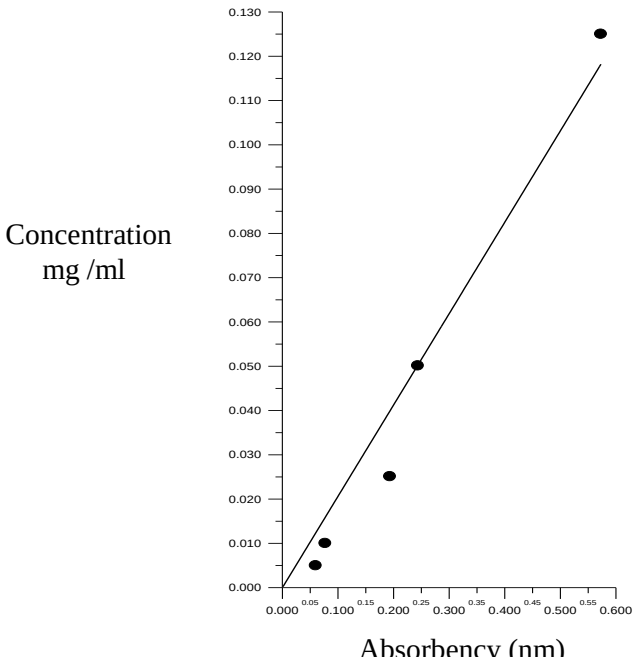


Figure (4) Linear calibration curve of methyl methacrylate (MMA)concentration as a function of absorbency.

CONCLUSIONS

Repaired specimens showed less transverse strength than control gro-up**.** There was no significant difference in the profile design.

Repaired samples with 2 mm repair space and 3 mm repair space were significantly higher than that of 1mm repair space, and no significant differences between 2 and 3mm space. Concentrations of 0.5, and 0.125 mg/ml were excluded from the study of residual monomer to determine the light absorbency of aqueous solution by spectrophotometer.

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