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Assessing the effect of chemical surface treatment and joint surface preparations on transverse strength of repaired denture base resin

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***Abstract*---**The present study was conducted to assess the effect of chemical surface treatment and joint surface preparations on transverse strength of repaired denture base resin. The study included 120 specimens divided into 8 groups of 15 samples each based on the combination of chemical surface treatment with either methyl methacrylate, ethyl acetate, or methylene chloride and chemical surface treatment of rounded joint, 45° bevel, and butt joint. Following surface treatment, dentures were repaired with self-cure resin. After treatment, to assess the transverse strength, they were subjected to a 3-point bending test. Surfaces that were fractured were assessed under the microscope and were analyzed to AutoCAD for assessing cohesive or adhesive failure type and the area was measured. The study results showed that a statistically significant difference was

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seen in most of the comparisons done. Specimens with rounded joints and methylene chloride used for 60 seconds showed the gain of strength of 60%-70& in the present study. The present study concludes that to attain better bond strength in a specimen repaired, the fractured segments of the specimens should be etched with methylene chloride for 60 s and should be given the rounded joints.

***Keywords*---**chemical surface treatments, denture fracture, joint surface design, methyl methacrylate, ethyl acetate, methylene chloride.

Introduction

The loss of teeth in any gender and age can be a matter of great concern in the affected subjects. Missing teeth are usually replaced by dentures. Replacing the missing teeth with a denture is a method providing functional, social, and psychological rehabilitation to the edentulous subjects. The dentures are usually formed and made of polymethyl methacrylate material. However, for the repair of fractured or broken dentures and prostheses, various techniques and materials are used.[1] In the repaired prosthesis, the success is largely governed by the adhesion phenomenon between repair material and techniques used. The present study was conducted to assess the effects of three different repair materials along with 3 joint surface preparations used commonly with an assessment of cohesive and adhesive areas of failure.[2]

The objectives of the present study were to assess the effects of changes in the design of prepared surfaces of the segments fractured for the transverse strength of repaired acrylic denture that formed the control group and to assess the surface treatment effects provided to the prepared fractures segment surfaces with chemicals including methyl methacrylate, methylene chloride, and ethyl acetate on the transverse strength of the acrylic denture resin repaired. Also, their comparative evaluation was done concerning the exposure time.[3] The present study also assessed failure types such as cohesive, adhesive, and combination following fracture of the specimens repaired and the percentage of cohesive/adhesive failure in the specimens repaired with the AutoCAD software.

Materials and Methods

The present study was conducted to assess the effect of chemical surface treatment and joint surface preparations on the transverse strength of repaired denture base resin. The present study was conducted after obtaining clearance from the concerned Ethical committee. The samples for the study were procured from the Department of Prosthodontics of the Institute. The study included 120 specimens that were prepared from the denture resin base that was heat-cured with the dimensions of 2.5mm, 20mm, and 65mm of height, width, and length respectively based on the ADA/ANSI specification number 12. On the specimens, a central line was marked followed by them cutting into 1mm on both sides of the central mark using a saw that worked mechanically. The shapes given to the joint surface were rounded joints, bevel joints, or butt joints. A dental stone was used

to prepare a repair index where the specimen will snugly fit. The index and sample were numbered on both sides for the realignment in the same position.
The samples were divided into 8 groups where Group I was IS (Intact specimen), Group II had Repaired specimen without chemical etching of specimen and was named as NCT, Group III was MC30 having specimens repaired after etching with methylene chloride for 30 s immersion, Group IV was EA 30 having specimens repaired after etching with ethyl acetate for 30 s immersion, Group V was MMA 30 having specimens repaired after etching with methyl methacrylate for 30 s immersion, Group VI having specimens repaired after etching with methylene chloride for 60 s immersion, Group VII where specimens were repaired after etching with ethyl acetate for 60 s immersion, and Group VIII having specimens repaired after etching with methyl methacrylate for 60 s immersion.

The sparkling technique was used along with auto polymerizing repair resin for the gap which was filled to a level that was a little overfilled to repay for the polymerization shrinkage. The samples were stored in distilled water for 24 hours after finishing and polishing. After 24 hours, the samples were subjected to a 3-point bending test followed by a compression testing machine facilitated evaluation of transverse strength with a crosshead spread of 5mm/min. The formula used for calculating the transverse strength was-S=3PL/2bd2, where d was the thickness of the specimen, b was the width of the specimen, L was the distance between support, and P was the breaking load.

The surfaces that were fractured were assessed under a stereomicroscope to evaluate the nature and type of failure under the magnification of 8X. The fracture type was assessed as either cohesive type, adhesive type, or the combination type of failure. Areas of the self-cure and heat-cured acrylic resins were computed using AutoCAD photographs where all the groups and all the specimens were photographed for evaluation. Depending on area computation and photographic evaluation percentage evaluation was done for cohesive and/or adhesive failure in all specimens of all the groups. The collected data were subjected to the statistical evaluation using SPSS software version 21 (Chicago, IL, USA) and one-way ANOVA and t-test for results formulation. The data were expressed in percentage and number, and mean and standard deviation. The level of significance was kept at $p<0.05$.

Results

The present study was conducted to assess the effect of chemical surface treatment and joint surface preparations on the transverse strength of repaired denture base resin. The samples were divided into 8 groups where Group I was IS (Intact specimen), Group II had Repaired specimen without chemical etching of specimen and was named as NCT, Group III was MC30 having specimens repaired after etching with methylene chloride for 30 s immersion, Group IV was EA 30 having specimens repaired after etching with ethyl acetate for 30 s immersion, Group V was MMA 30 having specimens repaired after etching with methyl methacrylate for 30 s immersion, Group VI having specimens repaired after etching with methylene chloride for 60 s immersion, Group VII where specimens were repaired after etching with ethyl acetate for 60 s immersion, and

Group VIII having specimens repaired after etching with methyl methacrylate for 60 s immersion.
The study results showed that the comparisons that were made between the test specimens were all showed significant differences statistically with $p<0.005$. The gain of strength for the specimens etched with methylene chloride for 60 seconds was 60%-70%. The study results also showed that the strengths of the intact specimens were significantly higher compared to the test groups where transverse strength was significantly lower. The highest transverse strength was seen for methylene chloride 60-sec treatment and rounded joint, whereas, the lowest strength was seen for butt joint and no chemical treatment group. All these differences were statistically significant with $p<0.005$.

On assessing the transverse strength of the various groups and in the various specimens, it was seen that for Group I and Group II, it was evident that the transverse strength of the repaired specimens was only $1/3^{rd}$ of the strength of the intact and non-repaired specimens. It was also seen that in specimens of group II, rounded joint repaired specimens had greater strength of 24.12 MPa compared to 45^{o} bevel with 18.54 MPa and butt joint with 15.01 MPa respectively. For all the groups, higher transverse strength was seen with the rounded joints compared to 45^{o} bevel and butt joints. This difference was statistically significant with $p<0.005$ as shown in Table 1.

The study results showed that the transverse strength was higher for the repaired specimens treated with chemicals for 30 seconds with all the three chemicals assessed and all the three joint preparations. However, the repaired specimens following 60 sec of acid etching were higher than all other groups and specimens with values higher by 2 folds. Using AutoCAD, it was seen that round joints with 60sec treatment of methylene chloride showed no adhesive failure in any specimen showing complete union between repair resin and heat-cured resin. However cohesive failure was noted in 9 cases was seen and a combination failure in 13 cases. In 45^{o} bevel, cohesive failure was seen in 9 cases. The butt joint showed the highest cohesive failure of 15 cases with all chemical treatments showing it to be the weakest joint showing less strength as depicted in Table 2.

Discussion

The present study was conducted to assess the effect of chemical surface treatment and joint surface preparations on the transverse strength of repaired denture base resin. The samples were divided into 8 groups where Group I was IS (Intact specimen), Group II had Repaired specimen without chemical etching of specimen and was named as NCT, Group III was MC30 having specimens repaired after etching with methylene chloride for 30 s immersion, Group IV was EA 30 having specimens repaired after etching with ethyl acetate for 30 s immersion, Group V was MMA 30 having specimens repaired after etching with methyl methacrylate for 30 s immersion, Group VI having specimens repaired after etching with methylene chloride for 60 s immersion, Group VII where specimens were repaired after etching with ethyl acetate for 60 s immersion, and Group VIII having specimens repaired after etching with methyl methacrylate for 60 s immersion. The study results showed that the comparisons that were made between the test specimens were all showed significant differences statistically

with p<0.005. The gain of strength for the specimens etched with methylene chloride for 60 seconds was 60%-70%. The study results also showed that the strengths of the intact specimens were significantly higher compared to the test groups where transverse strength was significantly lower. The highest transverse strength was seen for methylene chloride 60-sec treatment and rounded joint, whereas, the lowest strength was seen for butt joint and no chemical treatment group. All these differences were statistically significant with p<0.005. These results were comparable to the results of the studies by Ellakwa AE et al[4] in 2006 and Shimizu H et al[5] in 2006 where authors reported higher strength in intact specimens and specimens treated with methylene chloride 60 sec.

For the assessment of the transverse strength of the various groups and in the various specimens, it was seen that for Group I and Group II, it was evident that the transverse strength of the repaired specimens was only 1/3rd of the strength of the intact and non-repaired specimens. It was also seen that in specimens of group II, rounded joint repaired specimens had greater strength of 24.12 MPa compared to 45^{o} bevel with 18.54 MPa and butt joint with 15.01 MPa respectively. For all the groups, higher transverse strength was seen with the rounded joints compared to 45^{o} bevel and butt joints. This difference was statistically significant with p<0.005. These results were consistent with the results of Yadav NS et al[6] in 2015 and Hamid DMA[7] in 2013 where authors reported higher transverse strength in the rounded joints compared to 45^{o} bevel and butt joint.

The study results showed that the transverse strength was higher for the repaired specimens treated with chemicals for 30 seconds with all the three chemicals assessed and all the three joint preparations. However, the repaired specimens following 60 sec of acid etching were higher than all other groups and specimens with values higher by 2 folds. Using AutoCAD, it was seen that round joints with 60sec treatment of methylene chloride showed no adhesive failure in any specimen showing complete union between repair resin and heat-cured resin. However cohesive failure was noted in 9 cases was seen and a combination failure in 13 cases. In 45^{o} bevel, cohesive failure was seen in 9 cases. The butt joint showed the highest cohesive failure of 15 cases with all chemical treatments showing it to be the weakest joint showing less strength. These results were in agreement with the studies of Yunus N et al[8] in 2007 and O Kumbuloglu B et al[9] in 2019 where authors reported higher transverse strength of 60-sec chemical treatment than other treatments and untreated denture specimens.

Conclusions

Within its limitations, the present study concludes that to attain better bond strength in a specimen repaired, the fractured segments of the specimens should be etched with methylene chloride for 60 s and should be given the rounded joints. However, the present study had a few limitations including small sample size, short monitoring period, in-vitro nature, and geographical area biases. Hence, more longitudinal studies with larger sample size and longer monitoring period will help reach a definitive conclusion.

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Table 1
Transverse strength of the specimens in the different groups in the present study

Groups	Rounded joints (MPa)	45^{o} bevel (MPa)	Butt joint (MPa)
Group I		74.94	
Group II	24.12	18.54	15.01
Group III	34.92	35.63	23.94
Group IV	27.12	25.58	25.32
Group V	24.65	22.63	20.37
Group VI	50.63	46.07	43.43
Group VII	39.62	37.81	37.14
Group VIII	35.03	24.12	29.83

Table 2
Assessment of Failure type using AutoCAD software in the study subjects

Groups	Rounded joints (MP)			45° bevel (MPa)			Butt joint (MPa)		
	Adhesive failure	Cohesive failure	Mixed Failure	Adhesive failure	Cohesive failure	Mixed Failure	Adhesive failure	Cohesive failure	Mixed Failure
Methyl methacrylate for 60 s	3	2	3	-	1	7	-	2	6
Ethyl acetate for 60 s	3	1	4	-	2	6	-	3	5
Methylene chloride for 60 s	2	2	4	-	3	5	-	4	4
Methyl methacrylate for 30 s	7	-	1	2	1	5	1	1	6
Ethyl acetate for 30 s	6	-	2	2	1	5	1	2	5
Methylene chloride for 30 s	5	-	3	1	1	6	1	3	4
No treatment	9	-	-	8	-	7	6	-	2