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EVALUATION OF RETENTION AND SURFACE ROUGHNESS OF DIFFERENT RETAINING MATERIALS IN IMPLANT-SUPPORTED OVERDENTURES - AN IN-VITRO STUDY

Prosthodontics

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ABSTRACT

Implant-supported overdenture housings are retained in denture base with various types of materials. Inadequate adhesion between the housing and the denture creates a gap that weakens the construct .Surface roughness contributes to plaque accumulation. This study was conducted to evaluate the retention and surface roughness of materials used to retain the housings. 80 polymethyl methacrylate denture base specimens were fabricated and divided into 4 groups depending on the retaining material used to retain the housings in denture base specimen: autopolymerizing acrylic resin (GROUP A),composite resin (GROUP B), pattern resin (GROUP C) and heat polymerizing acrylic resin (GROUP D). SEM images were made to inspect the PMMA denture base-retaining material-housing interfaces for any adhesive failure. The surface roughness of the retaining materials was measured with a profilometer. Statistically significant differences were observed in terms of both retention and surface roughness. Within the limitations of this study it was concluded that Pattern resin was most suitable in terms of both retention and surface roughness.

KEYWORDS

Implant-supported Overdenture, Housing, Retaining Materials

INTRODUCTION

The implant supported overdenture is increasingly becoming a popular treatment alternative for the edentulous patient.[1,2] Implant-supported overdenture may be the treatment of choice when there are unfavorable ridge relations, an inadequate number of implants, poor implant distribution or alignment, a desire for easy removal to provide abutment and prosthesis hygiene, or financial limitations that may prevent the use of fixed implant prosthesis.[3]

Implant-supported overdenture consists of a male component (ball abutment) which is inserted into the implant body and a female attachment or housing which is integrated into the intaglio surface of the denture. Various procedures are available for relating the female attachment or housing of the attachment in the overdenture to the male component of the attachment of the abutment.

Generally, autopolymerized polymethyl methacrylate (PMMA) resin is used tosecure the attachment housings in the overdenture base. In addition, different kinds of hard reliningmaterials and attachment retaining materials arecommonly used for housing retention in overdentures.[3]

The bond between the housing retaining material-denture base and retaining material-housing is important for the success and longevity of an overdenture. The lack of bonding between overdenture components and acrylic resin may weaken the prosthesis. In addition, gaps that form as a result of adhesion failure can lead to microleakage between the retaining material and the housing. These gaps may serve as a passage of fluids and microorganisms and can increase staining and accelerate discoloration.[4]

Another factor that effects plaque accumulation, staining, and discoloration is surface roughness. The denture surface should be as smooth as possible in order to achieve optimum oral hygiene, reduced plaque accumulation, and also favour esthetics. The surface roughness values of the repair materials have been reported to be greater than that of Polymethyl methacrylate denture base.[5]

Thus, the purpose of this in vitro study was to evaluate the retention and surface roughness of 4 different materials used to retain the housings in implant-supported overdenture.

MATERIALS & METHODS

80 heat polymerized acrylic resin blocks measuring 30×11×8mm was fabricated. A 7(±0.5)mm diameter × 5(±0.5)mm depth hole was drilled at the center of each acrylic denture block using a drill press.[6] All the 80 acrylic denture blocks were randomly divided into four groups according to the retaining material used [Table 1].

Table 1: Grouping of samples.

GROUP	RETAINING MATERIAL	BRAND NAME	NO. OF SAMPLES
GROUP A	Autopolymerizing Acrylic Resin	DPI-RR Cold cure	20
GROUP B	Composite Resin	3M ESPE, USA	20
GROUP C	Pattern Resin	GC Pattern Resin	20
GROUP D	Heat Polymerizing Acrylic Resin	Coltene Heat cure denture base polymer resin	20

Stainless steel housings (ADIN) of dimensions of 4mm in diameter × 3mm in height were used in this study. The stainless steel housings were seated in the denture blocks by direct attachment transfer technique.Housing retaining material was filled upto two-third of the hole created at the center of each acrylic denture block. The stainless steel housing was placed inverted on a glass slab. The denture block was then inverted and placed over the stainless steel housing such that the housing seats inside the hole. The denture block was pressed against the glass slab for 10 minutes under finger pressure. This simulated the clinical direct housing attachment transfer technique (Pick-up technique).[6] The heat-polymerized resin, used for housing retention, was polymerized in a curing pressure pot under 0.6 MPa at 100^0C.[7] Once the retaining material was set the excess material was removed with a tungsten carbide bur and the repaired surface was finished using 200- and 600- grit abrasive paper. The surface was then checked for any voids. Samples if found with voids were rejected and fabricated again.

An anodized aluminium matrix of 10×10×50 mm dimension was fabricated. A dental implant analog (ADIN - 3.75mm×10mm) was then mounted at 90^0 in this anodized aluminium matrix.A 2mm hex ball abutment (ADIN) was torqued to 35 Ncm with a manual torque wrench into this implant analog.[8] A standard white plastic cap (ADIN)was placed inside the stainless steel housing. This plastic cap helps to accurately fit the implant ball abutment inside the housing. The acrylic block containing the metal housing was then seated on the ball abutment-implant analog.

TESTING RETENTION:

The acrylic block-aluminium matrix assembly was placed in the micro Universal Testing Machine (Mecmesin, Multitest 10i). A pulling force of 5.5N was applied at 50mm/min speed to detach the acrylic block-housing assembly from the ball abutment-implant analog assembly.[9,10]

After the detachment of the housing from the ball abutment, each specimen was placed under a Scanning electron microscope (FEI, QUANTA 200) to evaluate the adhesion of the retaining material to the housing and acrylic denture block. The acrylic denture base-retaining material junction (Junction 1) and the retaining material-housing junction (Junction 2) were examined at 4 positions per junction, radially across each specimen at ×500 magnification. Scanning Electron Microscopic images at ×500 magnification were made to detect any microcracks that might have formed during detachment at acrylic denture base-retaining material junction and the retaining material-housing junctions. Depending on the location of the microcracks , it was observed whether the loss of retention was an adhesive or a cohesive failure.

TESTING SURFACE ROUGHNESS

After the detachment of the housing from the ball abutment, each acrylic block specimen with the housing was examined under Optical Profilometer (Taylor Hobson Precision, Talysurf CCI) to measure the surface roughness (Ra) of the retaining material in all the groups. The surface roughness (Ra) value of each specimen was measured at 4 positions and the mean values were used for statistical analysis.

For statistical analysis, software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used. Chi square test was used to compare the results of SEM analysis. Kruskal Wallis test was used to evaluate the difference in surface roughness values among the retaining materials. Level of significance was fixed at p=0.05.

RESULTS:

Table 2: Comparison of the results of SEM analysis at Acrylic denture base-retaining material junction (Junction 1) among different groups using chi square test.

			Junction 1			Total
			Adhesive failure	Mixed failure	No failure	
Group	Auto polymerizing acrylic resin (Group A)	Count	7	0	13	20
		% within Group	35.0%	0.0%	65.0%	100.0%
	Composite resin (Group B)	Count	11	4	5	20
		% within Group	55.0%	20.0%	25.0%	100.0%
	Pattern resin (Group C)	Count	5	0	15	20
		% within Group	25.0%	0.0%	75.0%	100.0%
	Heat polymerizing acrylic resin (Group D)	Count	0	1	19	20
		% within Group	0.0%	5.0%	95.0%	100.0%
Total		Count	23	5	52	80
		% within Group	28.7%	6.2%	65.0%	100.0%
Chi square value: 27.513 P value: <0.001						

Statistically significant difference in retention was found between the groups (P< 0.001) at Junction 1. Adhesive failure was not observed in the heat polymerizing acrylic resin group (Group D) at Junction 1 [Table 2].

Table 3: Comparison of the results of SEM analysis at Retaining material-housing junction (Junction 2) among different groups using chi square test.

			Junction 2				Total
			Adhesive failure	Cohesive failure	Mixed failure	No failure	
Group	Auto polymerizing acrylic resin (Group A)	Count	7	0	5	8	20
		% within Group	35.0%	0.0%	25.0%	40.0%	100.0%
	Composite resin (Group B)	Count	7	4	3	6	20
		% within Group	35.0%	20.0%	15.0%	30.0%	100.0%
	Pattern resin (Group C)	Count	2	0	0	18	20
		% within Group	10.0%	0.0%	0.0%	90.0%	100.0%
	Heat polymerizing acrylic resin (Group D)	Count	20	0	0	0	20
		% within Group	100.0%	0.0%	0.0%	0.0%	100.0%
Total		Count	36	4	8	32	80
		% within Group	45.0%	5.0%	10.0%	40.0%	100.0%
Chi square value: 61.778 P value: <0.001							

Statistically significant difference in retention was found between the groups (P< 0.001) at Junction 2. Adhesive failure was observed in all the groups at junction 2 with Group D exhibiting 100% adhesive failure and Group C exhibiting 10% adhesive failure.

Highest surface roughness was recorded for autopolymerizing acrylic resin (3.55 µm) followed by pattern resin (1.11 µm) and composite resin (0.89 µm). Lowest surface roughness was recorded for heat polymerizing acrylic resin (0.80 µm). There was a statistically significant difference in mean surface roughness values between the four retaining materials used (P < 0.001 [Table 4].

Table 4 : Comparison of surface roughness in terms of {Mean (SD)} among all the groups using Kruskal Wallis test.

Group	*N*	Mean	Std. Deviation	Chi square value	P value
Auto polymerizing acrylic resin (Group A)	20	3.55540	3.253038	16.280	<0.001 **
Composite resin (Group B)	20	0.89085	0.306206		
Pattern resin (Group C)	20	1.11270	0.723687		
Heat polymerizing acrylic resin (Group D)	20	0.80590	0.346184		
Total	80	1.59121	2.009335		

DISCUSSION

Overdentures supported by implants have a higher rate of success than overdentures supported by the roots of natural teeth.[11] Implant-supported overdenture consists of a male component (ball abutment) which is inserted into the implant body and a female attachment or housing which is integrated into the intaglio surface of the denture.

Polymethyl methacrylate (PMMA) is the most popular material used in the fabrication of denture bases since 1937. The stainless steel attachment housings can be retained in the overdenture base with the help of various materials. Retaining materials of the same composition as the denture base has an added advantage of better bonding.[4]This is attributed to the monomer component of the retaining material which has the ability to swell and penetrate into the swollen surface layers. Dibutyl phthalate in the monomer liquid increases the solubility of the PMMA beads of the denture base powder resulting in increased bonding between the material and the denture base.[12]

Among the materials tested, the heat polymerizing acrylic resin used as the retaining material had the same chemical composition as that of the denture base. This could probably help in better bonding thereby minimizing adhesive failure when heat polymerizing acrylic resin was used as the housing-retaining material.Also polymerization shrinkage of autopolymerizing acrylic resins (2%) is greater than pattern resin (0.37%) resulting in more adhesive failures in Group A (autopolymerizing acrylic resin group). Composite resins do not contain methyl methacrylate monomer. This could have resulted in decreased bonding to the acrylic denture base due to inadequate cross linking.[13]

At the retaining material-housing junction (Junction 2), the adhesion of the materials to the metallic housing is by means of an undercut in the housing. However this may not be sufficient in absence of any surface treatment of the housing to increase its surface roughness as was observed by Domingo et al.[6] The percentage of adhesive failure at junction 2 was 45 % as compared to 28.7% at junction 1. Adhesive failure resulting in microcracks were observed at junction 2 in all the heat polymerizing acrylic resin samples. Microcracks could have been formed due to release of stress caused by heat for polymerization of the material.[12]Also there is a significant difference in the coefficients of thermal expansions of the heat polymerizing acrylic resin and stainless steel housing. Similar results were observed in a previous study by Ozkir et al.[7]

Surface irregularities present in dentures can act as a microorganism reservoirbecause they are protected from oral hygiene proce dures.[14]The adherence of the Candida species to the tissue surface of acrylic resins is known to be the first phase of denture stomatitis.[15]Microbial plaque and bacterial infection are among the primary causes of implant failure.[8]Studies conducted by Berglundh et al demonstrated that plaque induced alveolar bone resorption progressed more quickly around dental implants than around natural teeth.[16] Bollen et al suggested a threshold surface roughness of 0.2 µm for bacterial accumulation and subsequent plaque retention.[17]

The surface roughness values of all the retaining materials used in this study exceeded this threshold level. Highest mean surface roughness of 3.55m was recorded for autopolymerizing acrylic resin group (Group A). Resins polymerized via chemical activation generally display 3-5 % unreacted monomer, whereas heat activated resins exhibit 0.2-0.5 % unreacted monomer. Vaporization of this unreacted monomer results in porosity.[12] Similar result was observed by Ozkir et al in his study.[7]

Although heat polymerizing acrylic resin exhibited least adhesive failure at Junction 1 and least surface roughness, it showed complete adhesive failure at Junction 2. Hence, heat polymerizing acrylic resin may not be used as a retaining material. Cohesive failure was prevalent in composite resin indicating that composite resin may not be strong enough to be used as a retaining material, although it exhibited surface roughness less than both autopolymerizing acrylic resin and pattern resin. Autopolymerizing acrylic resin exhibited the highest surface roughness and significant amount of adhesive failure at both the junctions. Pattern resin however exhibited better retention at both Junction 1 and Junction 2 as compared to all the other retaining materials used. Surface roughness of Pattern resin was also found to be less than Autopolymerizing acrylic resin.

Smooth intaglio surface prevents adhesion of microorganisms and hence surface roughness has an important role in the longevity of any prosthesis. Minimizing denture surface roughness by using materials that are inherently smooth and retentive in nature may be a step towards improving the quality of prosthetic care provided to the patient.

This study can be further improvised by the use of thermocycling to simulate oral environment.

CONCLUSION

Within the limitations of the study the following conclusions were drawn:

1. At the Acrylic denture base-Retaining material junction (Junction 1) highest percentage of adhesive failure of 55% was observed with composite resin (Group B). No adhesive failure was observed with heat polymerizing acrylic resin (Group D).
2. At the Retaining material-Housing junction (Junction 2) heat polymerizing acrylic resin (Group D) revealed 100% adhesive failure. Pattern resin (Group C) exhibited 10% of adhesive failure which was the least.
3. Autopolymerizing acrylic resin (Group A) exhibited highest surface roughness.
4. Pattern resin was highly retentive and exhibited smooth surface indicating that pattern resin is the most suitable retaining material for implant supported overdentures.

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