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ORIGINAL RESEARCH

Effect of Insertion and Removal of Tooth Supported Overdentures on Retention Strength and Fatigue Resistance of Two Commercially Available Attachment Systems

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ABSTRACT

Purpose: The main problem with semiprecision attachment retained prosthesis is that they need frequent servicing in terms of replacing the female component. There is a need for a study to assess the life span and frequency of replacement of elastic components in the attachment systems.

Aim: The aim of the study was to test the retention strength and fatigue resistance of Rhein OT cap and Ceka sagix attachment systems fabricated on the models.

Materials and methods: Rhein OT cap (micro) and Ceka sagix attachments were procured. Acrylic resin mandibular models fabricated with teeth embedded at overdenture positions. Bar framework with attachments were cast and cemented on the model. Denture fabricated on this model was subjected to universal testing machine (UTM Instron 5900 series) for retention and fatigue test. The retention strength was measured at various cycles namely 1,440, 2,880, 4,320 and 5,760 cycles to check for the loss of retention and development of fatigue on the basis of average number of removals and placements per day for 1,2,3 and 4 years, respectively. The values of both the attachment systems were recorded at the respective cycles and a graphical analysis was carried out representing the retention loss and development of fatigue.

Results: One-way ANOVA was used as part of the statistical analysis to compare the retention strength and fatigue resistance of both the attachment systems used. The results obtained proved that the retention values of both the attachment systems on tooth supported overdentures had a significant variation as they were subjected to increased number of cycles.

Conclusion: Sagix and Rhein attachment systems showed adequate retention values up to the first 2 to 3 years (2,880-4,320 cycles). Fatigue test simulating 4 years of denture insertion and removal did cause subsequent reduction in the retention values but no component fracture of attachment systems.

Keywords: Retention, Fatigue, Tooth-supported overdentures, Attachments.

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INTRODUCTION

It has always been a challenge for a prosthodontist to fabricate a mandibular complete denture that offers adequate retention, support, stability and comfort to the patient especially when the maxillary denture has an excellent foundation for its construction.[1]

Evolution of the concept of tooth supported overdentures markedly increased the retention and stability component of the mandibular complete denture that was lacking for years. And with the advent of implant retained overdentures, the patient factors of esthetics, phonetics and maintenance of optimum oral health and hygiene can now be looked upon even in those patients who have poor neuromuscular co-ordination.[2,3] It is always justifiable to retain the natural root for overdentures than placing implants if healthy roots are available. So understanding various facets of tooth supported overdentures and its clinical application should be the goal.

Various attachment systems are commercially available, but little or no data has been accessible correlating the attachment system used and the overdenture support configuration especially when dealing with tooth supported overdentures. Basically the problem with the mechanical attachments overdenture is that the elastic component in the denture gets wornout frequently and has to be replaced subsequently. There are no sufficient data in the literature to guide which attachment system to be used and what is the average life, durability of its components with its need to repair or replace over sustained usage in the oral environment. Lehmann and Arnim[4] were of the opinion that during function, stabilization of the overdentures can occur when the retention forces of the attachment systems varied between 5 and 7 Newtons. But on the other hand, daily insertion and removal, oral environment can result in wear, fracture or loss of prosthetic component.

Therefore, this study was undertaken to evaluate the retention strength and fatigue resistance of two attachment systems Sagix attachment (Ceka attachment, 1.7 mm) and Rhein 83 attachment on tooth supported overdentures.

MATERIALS AND METHODS

Class I edentulous mold was selected and petroleum jelly was coated onto the intaglio surface of the mold following which hot molten wax was used to fill the entire surface. After sufficient cooling, the wax model was retrieved and two extracted mandibular canines were embedded into it and acrylization was carried out. Trimming and polishing of the acrylic models were done, tooth preparation was carried out for overdenture copings. Short copings were fabricated with a chamfer finish line with 2 to 3 mm of remaining tooth structure. Elastomeric impression (Aquasil; Dentsply, Caulk, Milford, Delware) was recorded in a single step and master casts were made in type IV dental stone (Elite stone; Zhermack, Badia Polesine, Italy).

Wax pattern for overdenture copings were fabricated. A coffee straw was used to form the plastic castable bar. The canines were splinted using the coffee straw bar.[5] Sagix attachment (Ceka Preci-Sagix, 1.7 mm) and Rhein attachment (Rhein 83 USA Inc) were attached to the bar patterns and the overdenture copings on two separate models. The attachments were placed on the distal surface of the canine on either side.

The models were invested, cast and the attachment apparatus was trimmed and polished. Fit and marginal integrity was evaluated on the models before being cemented with resin cement (Rely X Unicem cement 3M ESPE) (Fig. 1).

After the cementation was done, master cast was fabricated after taking an impression with irreversible hydrocolloid impression material (Tropicalgin, Zhermack). Double layer block out was done, wax occlusal rim was made on the record base and teeth arrangement was done. Gingival and root carving was simulated and after placement of processing caps, dentures were acrylized. Trimming and polishing of the dentures were done and the retention caps were placed (yellow for average retention) and checked for retention and fit on the models.

Testing on the retention strength and fatigue resistance of both the attachment systems fabricated on the models using the universal testing machine (UTM Instron 5900 series) was carried out (Fig. 2). The specifications of the testing being: Load cell of 100 kg was selected after load calibration was carried out, temperature of 25°C, speed of 5 mm/min, pretension load of 0 gm and gauge length of 50 mm. The readings of both attachment systems were noted at 0 cycles which would give an initial reading denoting maximal value of retention. The retention strength was measured at 1,440, 2,880, 4,320, 5,760 cycles to check for the loss of retention and development of fatigue. After subjecting the specimen to 1,440 cycles, the retention value was noted with a force gauge that measured the force required to dislodge the dentures placed on the models which were clamped onto the universal testing assembly. Similarly, the retention values were obtained at 2,880, 4,320 and 5,760 cycles and repeated for other attachment system. A graphical analysis was carried out representing the retention loss and development of fatigue.

Fig. 1: Cemented Sagix attachment and Rhein attachment on the model with closeup

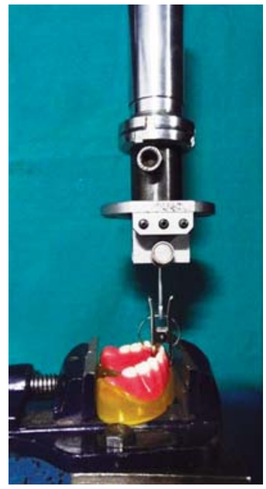
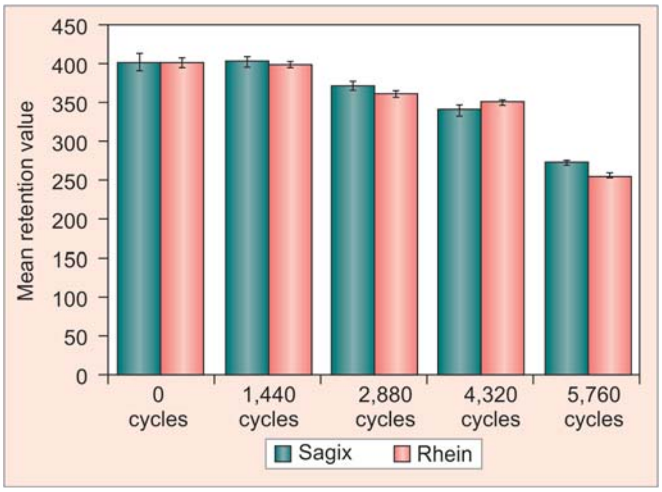


Fig. 2: The test model clamped on the universal testing machine (Instron)

RESULTS

Repeated measures of ANOVA were used as part of the statistical analysis to compare the retention strength and fatigue resistance of Sagix and Rhein attachment systems. The results indicated that the retention values of both the attachment systems on tooth supported overdentures had a significant variation as there was an increase in the number of cycles (Graph 1).

For Sagix attachment (1.7 mm), the observed mean of the removal force (gm) obtained at zero cycles was 401 gm which remained almost the same after 1,440 cycles, reduced to 371 gm after 2,880 cycles, reduced to 340 gm after 4,320 cycles and finally became 271 gm after 5,760 cycles. On the contrary, Rhein 83 attachment had a similar value of 401 gm at zero cycle which dropped down to 400 after 1,440 cycles, showed a reduction to 360 gm after 2,880 cycles. The value depleted to 350 gm when subjected to 4,320 cycles and finally became 255 gm after 5,760 cycles (Table 1).



Graph 1: Comparison of attachments in five different cycles with retention scores

Repeated measure of ANOVA showed that retention loss was not significant for both the attachment systems at zero cycles and 1,440 cycles when compared to each other, but was highly significant when compared at 2,880 cycles, 4,230 cycles and 5,760 cycles (Table 2).

Pairwise comparison of different cycles by Bonferroni multiple post hoc test also confirmed statistically significant correlation between the two attachment systems when compared to 2,880, 4,320 and 5,760 cycles (Table 3).

DISCUSSION

Over the past decades, the importance of saving a natural tooth and using it as an abutment for construction of over dentures has gained momentum and with the advent of attachments, it has become one of the most sought after treatment modalities.

Retention of various attachment systems on tooth supported overdentures tends to remain more or less similar at the initial values thereby offering optimum patient compliance. However, it was important to know whether these retention values remain the same over a substantial period of time and what is the loss of retention and development of fatigue that builds in due to constant insertion and removal cycles.

The ideology behind selecting the number of cycles being—if a patient inserts and removes his dentures for 3 meals per day and once in the night before sleeping and wearing it the next day, it would subject the dentures to an average of four insertion and removal cycles per day which would account for an average of 120 cycles per month and

Table 1: Mean SD and SE of retention scores in two materials at different cycles

Cycles	*Materials*	*Mean*	*SE*	*95% confidence interval*		*Loss of retention (%)*
				Lower bound	*Upper bound*	
0 cycles	Sagix	401.00	3.81	392.38	409.62	0
	Rhein	401.00	1.72	397.11	404.89	0
1,440 cycles	Sagix	401.50	2.30	396.31	406.69	0
	Rhein	399.60	1.33	396.60	402.60	0
2,880 cycles	Sagix	371.00	1.50	367.61	374.39	7.5
	Rhein	360.20	1.05	357.82	362.58	10
4,320 cycles	Sagix	339.60	1.83	335.45	343.75	15
	Rhein	350.30	0.84	348.39	352.21	12.5
5,760 cycles	Sagix	271.20	1.20	268.49	273.92	32.5
	Rhein	255.20	0.73	253.56	256.85	36.25

Table 2: Comparison of two materials and five different cycles with retention scores by repeated measures of ANOVA

Materials	*Cycles*	*Mean*	*SD*	*SE*	*F-value*	*p-value*	*Effect size*
Sagix	0 cycles	401.00	12.05	3.81	698.7301	0.0000*	0.9984
	1,440 cycles	401.50	7.26	2.30			
	2,880 cycles	371.00	4.74	1.50			
	4,320 cycles	339.60	5.80	1.83			
	5,760 cycles	271.20	3.79	1.20			
Rhein	0 cycles	401.00	5.44	1.72	2601.9670	0.0000*	0.9971
	1,440 cycles	399.60	4.20	1.33			
	2,880 cycles	360.20	3.33	1.05			
	4,320 cycles	350.30	2.67	0.84			
	5,760 cycles	255.20	2.30	0.73			
0 cycles	Sagix *vs* Rhein	p = 1.0000					
1,440 cycles	Sagix *vs* Rhein	p = 0.4830					
2,880 cycles	Sagix *vs* Rhein	p = 0.0000*					
4,320 cycles	Sagix *vs* Rhein	p = 0.0000*					
5,760 cycles	Sagix *vs* Rhein	p = 0.0000*					

*$p < 0.05$

Table 3: Pairwise comparison of different cycles in two materials by Bonferroni multiple post hoc procedures

Materials	Factor1 (I)	Factor1 (J)	Mean difference (I-J)	Std. error	p-value	95% confidence interval for difference	
						Lower bound	Upper bound
Sagix	0 cycle	1,440 cycles	–0.50	3.60	1.0000	–13.7830	12.7830
		2,880 cycles	30.00	2.82	0.0000*	19.5930	40.4070
		4,320 cycles	61.40	3.93	0.0000*	46.9080	75.8920
		5,760 cycles	129.80	3.81	0.0000*	115.7360	143.8640
	1,440 cycles	2,880 cycles	30.50	1.72	0.0000*	24.1510	36.8490
		4,320 cycles	61.90	3.22	0.0000*	50.0210	73.7790
		5,760 cycles	130.30	2.73	0.0000*	120.2470	140.3530
	2,880 cycles	4,320 cycles	31.40	2.39	0.0000*	22.5960	40.2040
		5,760 cycles	99.80	1.56	0.0000*	94.0370	105.5630
	4,320 cycles	5,760 cycles	68.40	2.13	0.0000*	60.5600	76.2400
Rhein	0 cycle	1,440 cycles	1.40	1.79	1.0000	–5.2050	8.0050
		2,880 cycles	40.80	1.67	0.0000*	34.6550	46.9450
		4,320 cycles	50.70	2.11	0.0000*	42.9210	58.4790
		5,760 cycles	145.80	1.76	0.0000*	139.3200	152.2800
	1,440 cycles	2,880 cycles	39.40	1.37	0.0000*	34.3530	44.4470
		4,320 cycles	49.30	1.81	0.0000*	42.6080	55.9920
		5,760 cycles	144.40	1.77	0.0000*	137.8870	150.9130
	2,880 cycles	4,320 cycles	9.90	1.52	0.0010*	4.2790	15.5210
		5,760 cycles	105.00	1.37	0.0000*	99.9590	110.0410
	4,320 cycles	5,760 cycles	95.10	1.06	0.0000*	91.1930	99.0070

*$p < 0.05$

1,440 cycles per year. So keeping this count of 1,440 cycles of insertion and removal that would occur annually, the universal testing machine was used to find out the loss of retention and development of fatigue that would occur over a 4-year period with values being measured at 1,440 cycles (corresponding to 1 year), 2,880 cycles (2 years), 4,320 cycles (3 years) and 5,760 cycles (4 years). So, it was noted that no loss of retention occurred after 1,440 cycles which implies that the retention values offered by both the attachment systems remains comparable after 1 year of service but then the reduction of values occurred subsequently of both the attachment systems used due to development of fatigue. However, no fracture of the components was noted even after subjecting the attachment systems to 5,760 insertion and removal cycles.

It was also seen that retention values were reduced to about 35% of its original value in both of the attachment systems after about 5,760 cycles which can be attributed to constant wear ($p < 0.01$). Wichmann and Kuntze[6] were of the opinion that any attachment system is subjected to wear during the insertion and removal cycles in addition to functional loads which can be attributed to the frictional load that occurs between attachment and the base leading to the lowering of the retention values.

Craig[7] had stated that any material that is subjected to constant stress which lies below its yield strength, no permanent deformation is caused. However, when it is subjected to repetitive stress that occurs in a fatigue test, permanent deformation can occur, which can be justified with the similar retention values that occurred during the first phase of fatigue testing. The interval between each cycle (dwell time) was of 30 seconds for simulating the exact measuring conditions. The time interval between each insertion-removal-insertion cycle was 10 seconds.

The study only simulated the insertion and removal cycles and not the horizontal and lateral forces that in clinical scenario would have represented masticatory and parafunctional forces—thereby lack of consideration of the masticatory chewing cycle force on the attachments can be a limitation for this study. Also, the factors like oral environment, saliva could have also contributed an influence on the results when simulated in the oral conditions.[8] The resiliency of the periodontal ligament might also play a role especially during the masticatory or parafunctional habits (absent in implant restorations) and may have a significant contribution in dissipating the applied forces and load.

CONCLUSION

It can be concluded that:

1. Both Sagix and Rhein attachment systems showed adequate retention values upto the first 2 to 3 years (2,880-4,320 cycles).
2. Fatigue test simulating 4 years of denture insertion and removal did cause subsequent reduction in the retention values but no component fracture of attachment systems.

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