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RESEARCH ARTICLE

AN EVALUATION OF RETENTION OF IMPLANT SUPPORTED CROWN ON SHORT ABUTMENT WITH SURFACE MODIFICATIONS USING DIFFERENT LUTING AGENTS

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ABSTRACT

Aims and Objectives: This study was done to compare and evaluate the retention of crown on abutment with polished surface, circumferential grooves, sandblasted and abutment both with grooves and surface abrasion using different cements. **Materials and Methods:** In this study, 10 test samples each with polished surface, circumferential grooves, sandblasted, both with grooves and surface abrasion were used. The copings were fabricated in conventional way with a wax ring attached to the occlusal portion. Different cements tempbond, Resin modified GIC (GC Fuji Cem), polycarboxlate cement (Harvard Cement) was applied. Each coping was seated and a static load of 50 N was applied. The specimens were assembled in the universal testing machine and subjected to a pullout test. The forces required to remove the copings were recorded in new tons. To compare the mean values between Cements and Models two way ANOVA was applied, for pair wise comparison of mean values Tukey HSD post hoc test were used. **Results:** The mean peak load was highest 272.85 in grooves and sandblasted surface using polycarboxylate cement .The mean break load highest 40.080 in sandblasted surface. The mean ultimate tensile strength was significantly highest 15.142 in grooves & sandblasted using polycarboxylate cement. **Conclusion:** The retention of the crown on abutment with the sandblasted Surface and grooves provided better retention under peak load and impart ultimate tensile strength. The break load was maximum in sandblasted surface using definitive cement GC Fuji cem.

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INTRODUCTION

Implant supported prosthesis are established treatment option and have gained acceptance in replacing missing teeth. Their use often represents a better alternative over traditional options of tooth replacement where in the retention depends upon the factors physical, biological, chemical, mechanical. However, the mode of retention in implant-supported fixed prostheses is influenced by the passivity of the framework; inter arch space, occlusion, esthetics and retrievability of prosthesis (Michalakis, 2000) And hence, the method of crown retention poses a challenge that involves recognition of the desired treatment outcome. There are many factors that influence the amount of retention that can be achieved when luting a restoration to either an abutment or a natural tooth. Basically, these factors are similar to those affecting the luting of crowns to natural teeth that include convergence of axial wall, surface area, (Goknil Ergun Kunt, 2010) height of the abutments (Barıs *et al*., 2011; Covey 2000; Akca *et al*., 2002; Kent, 1996; Clayton, 1997), surface roughness *(*Goknil Ergun Kunt, 2010; Barıs, 2011*)*and the type of luting agent used. Retention of cemented crowns on natural or artificial abutment increases with a decrease in convergence angle of the preparation. Most manufacturers provide for 6 degree taper abutments *(*Clayton, 1997; Murat Kurt, 2013; Hebe, 1997*)* which is about 3 times greater than the retention of natural teeth (Eames, 1978). The choice of luting agent is critical in providing retention of the implant supported crown. Therefore, the selection of cement that is too retentive could lead to damage to implant, implant abutment, abutment screw and the prosthesis if an aggressive removal technique is used. But if the cement is not retentive enough, it could be a potential source of failure of retention on the restoration. The retentive value of provisional luting agents are smaller than those of the permanent luting agent (Alvarado, 2010; Breeding, 1992; Pan *et al*., 2006; Bernal *et al*., 2013; Rosenstiel, 1998; Mansour *et al*., 2002; Mona Wolfart, 2006; Rachel, 2001).

In addition there is no risk of decay for the abutment; provisional cements can be used for the cementation of implant restorations. Nevertheless problems do encountered with provisional cements on account of inadequate retention to resist functional force, quick cement washout, mobility of restoration, higher risk of loss of retention as a result of low tensile strength and high solubility (Akca, 2002; Alvarado *et al*., 2010). On the other hand, definitive cements significantly enhance the cement failure loads of the prosthesis luted to titanium abutments in comparison to provisional luting agents. But controversy exists as to whether provisional or permanent luting cements should be used for cementing implant prosthesis (Bernal, 2003; Ayad, 2009; Dixon *et al*., 1992). Zinc oxide-based cements (provisional cements) and zinc phosphate cements are commonly used for the definitive cementation of implant-retained restorations (Merrie, 1999). But recent studies have shown that resin and glass ionomer based luting agents to be the most retentive than zinc phosphate (Ayad, 2009; Zhen Chun Li, 1999; Konstantinos *et al*., 2000). However, in certain cases where interocclusal space is limited, lack of retention has been the common cause of failure due to shorter abutments. Increasing the size, surface area, parallelism of opposing walls, controlling taper and making retentive guiding grooves enhances the retention in these abutments. In addition, the surface modification on a shorter abutment can increase the retention of cast coping as in natural teeth. This surface modification can be in the form of air-borne particle abrasion (Nejatidanesh, 2014), retentive grooves on the abutment or by using diamond rotary cutting instrument. Surface roughness increases the retention approximately by 31% (Jasvinderjukdev, 2014; Cano-Batalla, 2012). Many studies have been conducted to evaluate the retention of short abutment by using different cements. However, there is no adequate evidence to prove the effect of grooves and sandblasting on the retention of short abutments. Hence, this study was done to evaluate the effect of surface modifications on abutments to enhance the retention of crowns using different luting agents.

MATERIALS AND METHODS

40 custom made stainless steel model was prepared simulating abutments of 4mm height, 6 degree taper with o.5mm shoulder width using a CNC milling Machine having hexagonal base of 4mm height and 7mm diameter. In this study, the abutments were divided into 4 groups of 10 abutments each.

Group 1: 10 Abutment test samples with polished surface (Figure1.1)

Group 2: 10 Abutment test samples roughened with sandblasted (Figure1.2)

Group 3: 10 Abutment test samples with grooves.(Figure1.3)

Group 4: 10 Abutment test samples with sandblasted and grooves (Figure 1.4)

Impression of the custom-made stainless steel model was made using addition silicone (Aquasil, Densply) using two stage technique. (Figure 1.5) The die of the abutment was poured with Type IV dental stone. (Figure 1.6) Inlay casting coping ring with a loop on the occlusal surface was designed (Figure 1.7), invested and casted by Co-Cr alloy. (Figure 1.8) Inspection and accuracy of fit of all cast copings were done with caliper and were verified with stereomicroscope. Air borne –particle abraded the intaglio surface of all copings for 20 seconds with 110µm aluminum oxide particles (Renfert, Harlingen, Germany) at a pressure of 0.2MP a, washed with water and dried with compressed air before initial testing. All the 120 samples were applied in a thin 3 mm width layer to the cervical margin of the inner surface of copings. The castings were cemented to each grouped abutment with tempbond, Resin modified GIC (GC FujiiCem) and polycarboxlate cement (Harvard Cement). Cements were mixed according to the manufacture instructions. Each coping was seated on the abutment 30 seconds after the star of mixing, and a static load of 50 N was applied for 10 minutes. After setting, excess cement was removed with a plastic curette (Universal Implant Deplaquer; Kerr Hawe, Bioggio, Switzerland).Cementation was performed at an ambient temperature of 23 ±1°C.The specimens were stored in 100% humidity at 37°C for 1 hour, thermo cycled 500 times between 5°Cand 55°C with a dwell time of 10 seconds and the stored in 100% humidity at 37°C for 6 days.

The specimens were assembled in the Universal testing machine (Model NO. KIC-2-050-C, K-Test Series) (Figure 1.9) and subjected to a pullout test at a cross head speed of 5mm/min. (Figure 1.10)The forces required to remove the copings were recorded in newtons. Ultimate tensile strength, peak load, break load was measured and recorded. After the pullout test, cemented cast copings and abutments were placed in an ultrasonic cleaner for 5 minutes, followed by mechanical cleaning with a plastic curette and cotton applicators soaked in petroleum-ether. It was assumed that the cleaning procedures had no relevant effect on the retention and cementation. The results obtained were statistically analyzed with two -way ANOVA method to compare the mean values, Standard deviation, F value and p value of each test group and a $p<0.05$ was considered statistically significant. Tukey`s HSD post hoc test was used for pair wise comparison. All the data were analyzed statistically using IBM SPSS.

RESULTS

The Kolmogorov-Smirnov results showed that the samples follow Normal distribution. To compare the mean values between Cements and Models two way ANOVA was applied, for pair wise comparison of mean values Tukey HSD post hoc test were used. The samples analyzed were considered statistically significant if P- value < 0.05.

DISCUSSION

Retention certainly influences the lack of complications as well as the longevity of implant prostheses. The factors that influence retention of cement retained restorations are well documented (Covey *et al*., 2000; Kim, 2006; Bresciano, 2005) and they are basically the same as those for natural teeth as in convergence of the axial walls, surface area, height, roughness of surface and the type of cement. The influence of surface modification and type of cement on retention of cement retained prosthesis was not documented and so the effect of surface modification and the type of cement was taken into consideration. Taper is the factor that greatly affects the amount of retention that can be produced in the cement retained prostheses

Table 1. Two way ANOVA to compare UTS mean values between Models and cements simultaneously.

Cement	Model	N	Mean	Std. Dev
Polycarboxlate	Polished surface	10	2.3620	0.0316
	Sandblasted	10	3.3757	0.0027
	Grooves	10	7.6436	0.0062
	Grooves & sandblasted	10	15.1420	0.0007
	Total	40	7.1308	5.0961
Fuji cem	Polished surface	10	13.4668	0.0024
	Sandblasted	10	14.4604	0.0010
	Grooves	10	7.6527	0.0012
	Grooves & sandblasted	10	7.7317	0.0007
	Total	40	10.8279	3.1956
Tempbond	Polished surface	10	0.0155	0.0005
	Sandblasted	10	0.1740	0.0052
	Grooves	10	2.2000	0.1333
	Grooves & sandblasted	10	3.1400	0.0843
	Total	40	1.3824	1.3501
Total	Polished surface	30	5.2814	5.9670
	Sandblasted	30	6.0034	6.2259
	Grooves	30	5.8321	2.6132
	Grooves & sandblasted	30	8.6712	5.0294
	Total	120	6.4470	5.2617

Table 2. Tukey HSD Post Hoc Tests for Multiple Comparisons between Cements

Cement		Mean Difference	P-Value
Polycarboxlate	Fuji cem	3.69708	<0.001
	Tempbond	5.74845	<0.001
Fuji cem	Tempbond	9.44553	<0.001

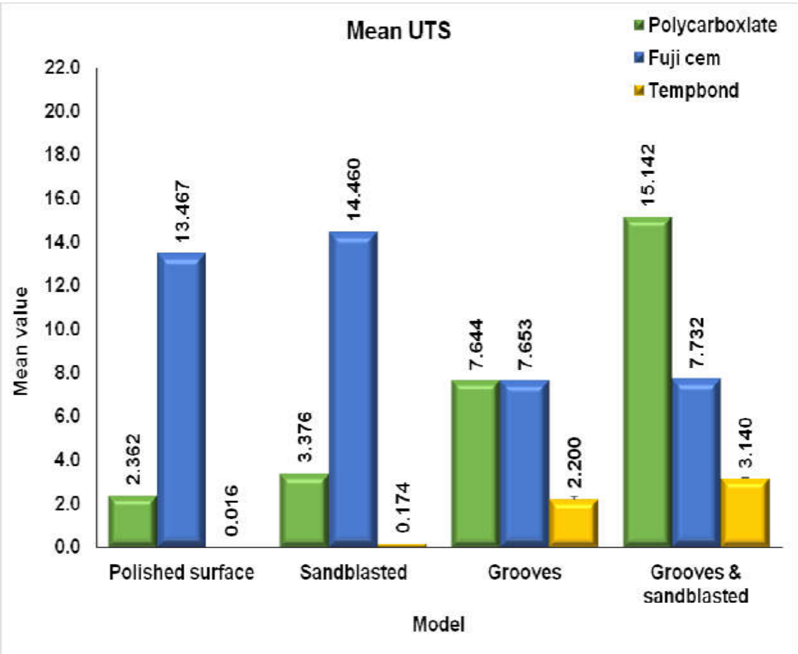

Table 3. Two way ANOVA to compare Break load mean values between Models and cements simultaneously.

Cement	Model	N	Mean	Std. Dev
Polycarboxlate	Polished surface	10	34.570	0.54985
	Sandblasted	10	36.133	0.00823
	Grooves	10	9.080	0.07888
	Grooves & sandblasted	10	36.050	0.07071
	Total	40	28.958	11.6431
Fuji cem	Polished surface	10	38.800	0.9877
	Sandblasted	10	40.080	0.07888
	Grooves	10	11.130	0.08233
	Grooves & sandblasted	10	5.140	0.06992
	Total	40	23.788	16.0101
Tempbond	Polished surface	10	1.300	0.48305
	Sandblasted	10	2.260	0.27568
	Grooves	10	2.750	0.05271
	Grooves & sandblasted	10	3.120	0.06325
	Total	40	2.358	0.7421

Table 4. Tukey HSD Post Hoc Tests for Multiple Comparisons between Cements

Model		Mean Difference	P-Value
Polished surface	Sandblasted	1.267	<0.001
	Grooves	17.237	<0.001
	Grooves & sandblasted	10.120	<0.001
Sandblasted	Grooves	18.504	<0.001
	Grooves & sandblasted	11.388	<0.001
Grooves	Grooves & sandblasted	7.117	<0.001

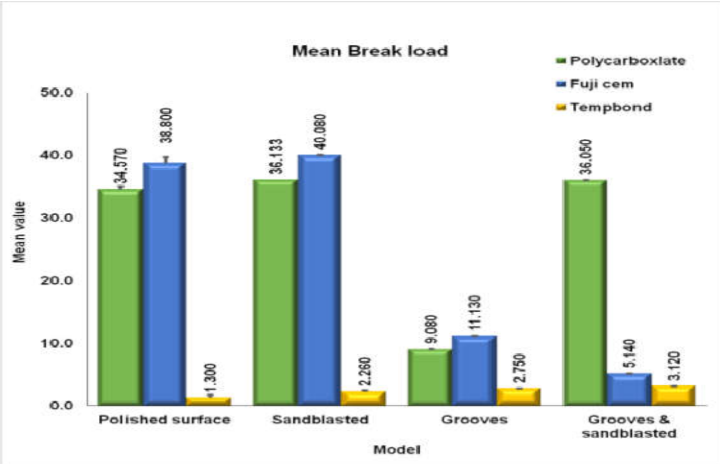

Table 5. Two way ANOVA to compare Peak load mean values between Models and cements simultaneously

Cement	Model	N	Mean	Std. Dev
Polycarboxlate	Polished surface	10	43.091	1.264
	Sandblasted	10	43.804	0.567
	Grooves	10	137.291	0.001
	Grooves & sandblasted	10	272.853	0.948
	Total	40	124.260	95.157
Fuji cem	Polished surface	10	42.927	1.590
	Sandblasted	10	49.493	0.016
	Grooves	10	60.537	0.636
	Grooves & sandblasted	10	74.383	0.013
	Total	40	56.835	12.106
Tempbond	Polished surface	10	0.265	0.0005
	Sandblasted	10	0.276	0.0009
	Grooves	10	0.308	0.0027
	Grooves & sandblasted	10	0.402	0.0008
	Total	40	0.313	0.0544

Table 6. Tukey HSD Post Hoc Tests for Multiple Comparisons between Cements

Cement		Mean Difference	P-Value
Polycarboxlate	Fuji cem	67.42	<0.001
	Tempbond	123.94	<0.001
Fuji cem	Tempbond	56.52	<0.001

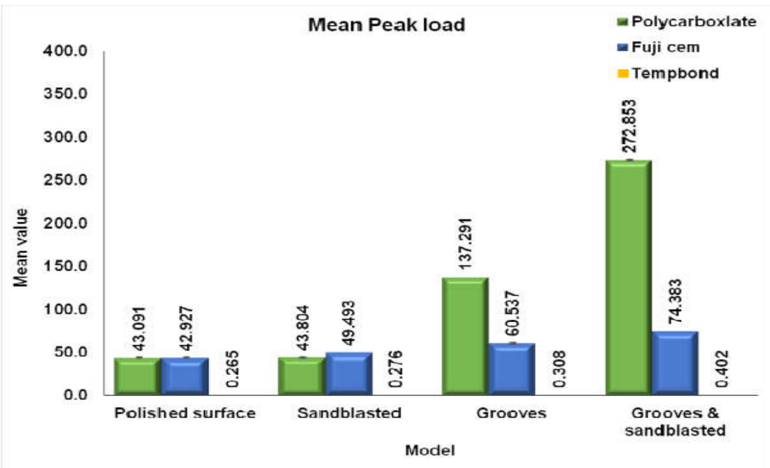

Figure 1.1. Abutment test samples with polished surface.

Figure 1.2. Abutment test samples roughened with sandblasted.

Figure 1.3Abutment test samples with grooves

Figure 1.4 Abutment test samples with sandblasted and grooves

Figure 1.5. Impression using addition silicone

Figure 1.6 Abutment poured with Type IV dental stone.

Figure 1.7. Coping with wax pattern loop on the occlusal surface

Figure 1.8. Casted coping with Co-Cr alloy

Figure 1.9. Universal testing machine

Figure 1.10. Pullout test

Jorgensen *et al*. (1955) proved that 6 degree taper is ideal for abutment preparation. His study showed that 16 degree taper provides approximately one third of retention of the ideal 6 degree taper and 25 degree taper reduced retention by 75% (Konstantinos *et al*., 2003) Most manufactures machined their abutment approximately 6 degree taper (Michalakis, 2000). The maximum retention was shown between 6-12 degree taper. Studies are reported mean taper ranging from 14-20 degree. Ideally, 6 degree taper had given the highest value of retention (Michalakis, 2000) and hence in this study 6 degree taper was used. Surface area and height are closely related .It has been documented by Kaufmann and coworkers (Kaufman, 1961) that an increase in surface area and height increases retention and resistance form .Usually, implant abutments posses longer axial walls then natural teeth because of sub gingival placement of implants (Konstantinos *et al*., 2000). And an exception is in the molar area with small interocclusal distance where an additional retention is needed .In cement retained prosthesis the solid abutment of 4mm height presented a relatively short, smooth surfaces .Various types of intra occlusal forces and the combinations may induced high stress on the solid abutment at the interface between an abutment and cement layer which results in crown dislodgment. Nejjtidanesh F *et al* showed decreased in retention when 5.5mm abutment is reduced to 3mm height (Nejatidanesh, 2014).

Abutment of 4-5 mm in height are one of the primary requirement for retention (Nejatidanesh, 2014; Sadig, 2007; Kent, 1997), in the present study 4mm height was used. Customizing the abutment so as to resemble natural tooth morphology and the axial walls with the rough surface can offer greater retention (Denis Brajkovic, 2014). Surface modification can be done by providing grooves and sandblasting .Grooves can be provided either in vertical and horizontal to create cement keyways (Hebel *et al*., 1997). Circumferential grooves have shown increased retention of implant supported restorations (Wiskott, 1999; Israel *et al*., 2011). There are many treatment procedure such as sandblasting, tinplating, silicoating and metal primer application that are used to produce irregularities on the internal surface of casting and abutment. Sandblasting with alumina particles is responsible for the bond strength of the cement. In this study, sandblasting was applied using 110µm AL_2O_3 (Dudley, 2008) for 20 seconds.

The size of alumina particles differs with author (Nergiz *et al*., 2004; Filipe de Oliveira Abi-Rached, 2012). Large particles of aluminium oxide was used with regard to this study as it favours mechanical retention (Rachel S. Squier, 2001; de Campos, 2010) and also sandblasting is the easiest and inexpensive method of surface treatment .Sandblasting the surface of the abutment can also increase resistance to dynamic lateral loading (Nejatidanesh, 2014). The null hypothesis that the use of surface modifications would not have any effect on the retention of the cemented copings was rejected since the study revealed that the use of grooves and sandblasting increased the retention. The result proved that polished surface , sandblasting ,grooves, sandblasting and grooves were statistically significant from each other (P‹ 0.001).The study revealed that the retention provided by the surface modifications with sandblasting and grooves provided better retention than others. The ultimate tensile strength of the crowns with modifications in decreasing order are sandblasted and grooves 8.6 >grooves 6.0 >sandblasted 5.8 > polished 5.2.The mean peak load of the crown with modifications in the descending order are sandblasted and grooves 115.87 > grooves 66.0 > sandblasting 31.1 > polished surface 28.7 . The mean break load given in decreasing order sandblasted and grooves was 26.1 >grooves 24.8> sandblasted 14.7 > polished surface 7.6. This study showed that sandblasting and grooves provided for better retention when compared to the other surface modification irrespective of the cement used.

Conclusion

The following conclusions were drawn from the data obtained in this in vitro study

- Abutments with surface modification of sandblasted with grooves provided better bond strength as compared to other surface of polished, sandblasted and only grooves.
- The mean peak load was significantly highest in sandblasted with grooves using polycrboxylate cement and least in polished surface using tempbond cement.
- The break load was maximum in sandblasted surface using definitive cement GC Fuji cem and minimum in polished surface using provisional cement Tempbond.
- A comparision of the different luting cements and its effect on the retention of the crowns revealed that the polycarboxlate cement along with the sandblasted surface with grooves provided better retention under peak load and ultimate tensile strength.

Within the limitation of this study, it has been concluded that the abutment test sample with sandblasted and grooves using polycarboxylate cement had been the most retentive.

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