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An In-Vitro Comparison of the Retention of Cement-Retained Implant-Supported Crowns with and Without Circumferential Grooves on Implant Abutment

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Abstract

Aim: To evaluate and compare retentive property of provisional and permanent luting agents within two different group of implant systems by using implant abutments with and without circumferential grooves on it.

Materials And Methods: Totally 60 implant abutments are to be taken, in which Group A(Adin Dental Implant Systems Ltd.) will consist of 30 abutments and similarly Group B(***MIS Implants*** Technologies Ltd.) will consist of 30 abutments. Both Group A and Group B will again be divided into **subgroup a (with circumferential grooves)** and **subgroup b (without circumferential grooves)** with 15 abutments each. Further in these subgroups of 15 abutments 5 abutments each are to be taken to check retentive force of three luting agents ie.non-eugenol provisional cement, resin modified glass inomer cement and zinc phosphate cement. 15 identical cast copings will be prepared to fit all 60 abutments. The castings will be cemented to each group of abutments with above mentioned luting agents. After thermal cycling and storage for 6 days in a water bath, retention test is to be done with a tensile testing machine (Instron) (5mm/min) and retentive forces will be recorded. Data will be subjected to One way ANOVA test and student` t' test.

Results: F=0.21for ZO, 0.18 for RMGIC, 0.69 for $ZnPO_4$<3.24 for p=0.05 shows no significant difference between all subgroups within the each cement.F=53.37 for Group A, 15.82 for Group B>2.62 for p=0.05 shows significant difference between all cements within the group a and group b.

Conclusion: Circumferential grooves on implant abutments (subgroup a of both the Groups) gives better retention when compared with standard machined(plain) abutments and Resin modified GIC gives 10 times better retention than non- eugenol and 2 times better retention than zinc phosphate cement.

Clinical Implications: Retention of restoration depends on the surface of the abutment as well as the luting agents used. Incorporation of retentive grooves can enhance retention of prosthesis especially in situation of short abutments.

Keywords: luting agents, circumferential grooved implant abutments, retentive strength

Introduction

The success of oral rehabilitation of dental implants not only depends on osseointegration but also on maintenance of the prosthesis on the implant abutment.[1] implant restorations can be screw retained ,cement retained, or combination of both.[2] Many dental professionals concluded that cement-retained crowns are finer for esthetics and occlusion and screw-retained crowns are a necessity for easy retrievability.[3] According to Goodacre et al[4] common Mechanical implant complications are

- Loss of retention of prosthesis (376/113 prostheses) is 30%
- Prosthesis screw loosening (4501/312 screws) is 7%
- Prosthesis screw fractures (7094/282 screws) 4%

According to the above study loss of retention of the cemented prosthesis is *most common* mechanical complication. Hence, it is more important for us to concentrate on increasing the retention of the cement retained prosthesis on the implant abutment . Nowadays there is an increased use of cement retained prosthesis as it provides the ability to optimize occlusal interdigitation, enhance esthetics, provide a passive fit, decreased cost, and improve loading characteristics. There are various parameters which influence the retention of cemented prosthesis such as; abutment height, abutment width, surface of an abutment, convergence angle between the walls of abutment and cements[5]. Factors controlled by the physician are surface roughness which increases retention by creating microretentive ridges and luting agents[6]. The types of surface treatments which can be done to increase the retention includes; increasing the size of an abutment, increasing the surface area by sandblasting the abutment, roughening the surface with diamond bur or introducing retentive circumferential grooves of particular depths on implant abutment, preparing occlusogingival height of abutment, controlling the taper[7].

The purpose of this study was to evaluate and compare retentive property of provisional and permanent luting agents within two different group of implant systems by using implant abutments with and without circumferential grooves on it as the different implant systems provide different groove depth and numbers.

Materials and method

Sixty straight shoulder type titanium abutments in that 30 were (MD CPS01; MD-TAD10; MIS Implant Technologies Ltd, Misgav, Israel) (0.5 mm shoulder width) with abutment screws as well as prefabricated plastic copings and corresponding 12 mm-long stainless steel laboratory implant analogs were used,(MIS Implant Technologies Ltd). The abutments were divided into two subgroups of 15 abutments each: without grooves and with grooves. Each groove of MIS Implant Tech measured using steromicroscope 20X magnification was 175.2µm wide and 86.6µm deep (Figure 1). Another 30 were (RP0012 analog of RP0007 and RS3801 abutment and analog of RS5737 Adin Implant System Pvt Ltd) and these abutments also were divided into two subgroups of 15 abutments each: without grooves and with grooves. There were no prefabricated plastic copings provided by this group hence wax pattern was fabricated after application of die spacer of 25µm. Each groove of Adin Implant System measured using steromicroscope 20X magnification was 203.3µm wide and 141µm deep(Figure 2).

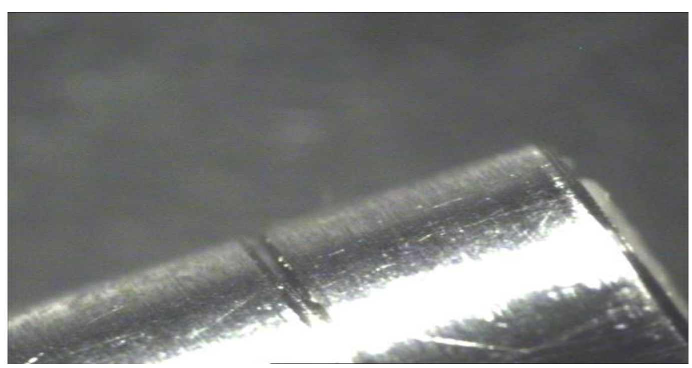


Figure 1:Grooves of MIS System

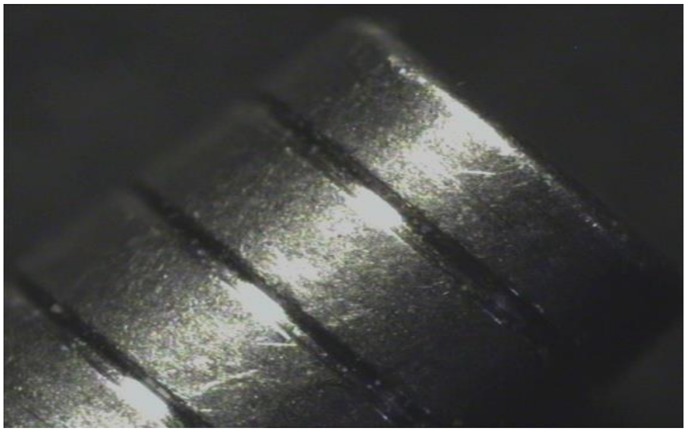


Figure 2: Grooves of Adin Implant System

For fabrication of wax patterns each implant abutments were placed in each analog. Die spacer (Gold-15µ + Red-10µ) (Heartman,Colour Spacer) of 25µm was applied over the abutments(figure 3) and then wax patterns were fabricated with inlay wax(S.U.Inlay wax,Germany) over the abutments following the shape and finish line of the abutments(figure 4)**.** On these wax patterns loops made with the sprue wax of 2mm diameter of dimensions 7mm long and 3mm wide were added to the occlusal surface of each coping to allow the samples to be attached to the tensile testing machine. The prepared wax pattern was sprued with 2.5mm gauge of spruing wax (Yeti dental Duron, Germany) following the principles of spruing. Then the wax pattern were invested. Specimen were then cast in a Ni-Cr alloy (Remanium Dentaurum, Germany) with a centrifugal casting machine(Degutron, Degussa, Germany) at 2200^0F-2500^0F (1200^0C-1370^0C) for the fabrication of metal coping(figure 5).

Figure 3: Application of die spacer

Figure 4: wax pattern

Figure 5: metal coping with loop

All cast copings were inspected for accuracy and fit with calipers and a ×16 magnification microscope. The copings were numbered 1 to 20 for identification during testing and assigned to correspondingly numbered abutments. Finally, the intaglio of all copings was airborne-particle abraded for 20 seconds with 110µm aluminum oxide particles. at a pressure of 0.2 MPa, washed with water, and dried with compressed air before initial testing. Laboratory analogs were paired with numbered abutments (and cast crown copings) and connected to the encased abutment screw. The implant abutment screws with the abutments were tightened to the analogs with a screwdriver to a torque of 20 Ncm. The access screw hole was blocked with composite resin. To cement the copings onto the abutments in a repeatable manner, a base was fabricated with acrylic resin with a vertical hole prepared in the center. The analog with its abutment was placed in the hole while the cast coping was cemented. To avoid introduction of bias caused by reuse of specimens, the specimen in each group were divided into three subgroups, so that all the cements were tested in the same number of new and reused specimens. All cements were mixed strictly according to the manufacturers' instructions. The castings were cemented to each group of abutments with a zinc oxide-based non eugenol provisional cement, resin modified GIC and a zinc phosphate definitive cement. Each coping was seated on the abutment 30 seconds after the start of mixing, and a static load of 50 N was applied by using digital weighing balance for 10 minutes(figure:6)

Figure 6: Cementation of Coping under static load of 50N using Digital Weighing Balance Machine

After removal of excess cement the cemented abutments were stored in 100% humidity at 37°C for 1 hour, then thermocycled 500 times between 5°C and 55°C in thermocycling chambers (5^0C : Make:LG Model: 051SA,55^0C : Mahavir , India) with a dwell time of 10 seconds and then stored in 100% humidity at 37°C for 6 days. This limited aging protocol was used in a previous study where provisional cements were tested.

After thermocycling and storing the cemented abutments in water at 37^0C water for 6 days they were assembled in the Universal testing machine (computerized ,software based, Model No. STS 248) and subjected to a pullout test (retention) at a crosshead speed of 5.0mm/min (Figure.7). The forces required to remove the copings were recorded in Newton.

After the retention test, the copings and abutments were evaluated for failure mode according to the location of the residual cement (Figure 8). Full thickness residues on the abutment or casting were denoted as adhesive failure. Cohesive failure was denoted when the failure was within the cement and partial thickness residues were seen on the abutment and the opposing surface of the casting. A combination of adhesive and cohesive failure was considered a mixed failure. Standard machined (plain) abutments showed adhesive failure where as grooved abutments showed mixed failure. After the pullout test (of the specimens cemented with provisional cement), 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 and retention tests of the next group were then performed similarly with the same castings.

Figure 7: Removal of coping from abutment after pull out test

Figure 8: Copings and Abutments showing cement failure mode

Results

The mean tensile force required to separate the castings from the abutments is seen in Graph I. It was apparent that the circumferential grooves increased the retention of all the three cements. The 1-way ANOVA test indicated that for each cement type, the additional grooves significantly increased the retention of the castings($P<0.05$).

As shown in table I firstly, for the cement individually F = 0.21 for non eugenol cement, 0.18 for resin modified GIC, 0.69 for zinc phosphate cement is < 3.24 FOR P=0.05 which shows no significant difference between all subgroups within the each cement which means that ***subgroup a*** and ***subgroup b*** of both the groups for all cements showed same type of result ie. ***Subgroup a*** showed increased retention where as ***subgroup b*** showed decreased retention due absence of grooves on them. Secondly, individually for the GROUPS F= 53.37 for GROUP A and F=15.82 for GROUP B is >2.62 FOR P=0.05 which shows significant difference between all cements within the GROUP A and GROUP B.

In table II when both the GROUPS were compared with Student's t test, the abutments of ***subgroup a*** cemented with non - eugenol and Zinc Phosphate cement showed significant difference between GROUP A and GROUP B where as the abutments of ***subgroup a*** cemented with Resin modified GIC showed no significant difference between GROUP A and GROUP B.

Discussion

Cement-retention has become the method of choice for implant-supported prostheses. For cementation of the prosthesis, provisional and permanent luting agents are used. Provisional cements are used primarily to facilitate the removal of interim restorations and for retention of prosthesis for longer duration permanent luting agents are used. Since there is no risk of decay of the abutments, provisional cements can also be used for the cementation of implant restorations as they are much weaker than the definitive cements and permit retrievability of the restorations[8,9]. Therefore, the ideal cement should provide adequate retention while also enabling retrievability[10, 11].

The null hypothesis that the use of circumferential grooves would not have any effect on the retention of the cemented copings was rejected. The results of the present study show that the use of circumferential grooves increased the retention of the cement-retained copings. Therefore, circumferential grooves can help provide retention control while still maintaining retrievability.

The findings of this study suggest that the addition of grooves increased the retention of ZO non eugenol cement, Resin modified GIC and ZP cements.

For ADIN Implant Systems (custom made copings), the mean retentive forces of standard machined abutments (plain) cemented with ZO non eugenol cement showed 48.84N and after addition of circumferential grooves, retention increased by 83.25N. Standard machined abutments (plain) cemented with Resin modified GIC showed 440.51N and after addition of circumferential grooves, retention increased by 720.44N. Standard machined abutments (plain) cemented with Zinc Phosphate cement showed 238.17N and after addition of circumferential grooves, retention increased by 594.35N.

For MIS Implant Systems (prefabricated plastic copings), the mean retentive forces of standard machined abutments (plain) cemented with ZO non eugenol cement showed 51.02N and after addition of circumferential grooves, retention increased by 62.56N. Standard machined abutments (plain) cemented with Resin modified GIC showed 591.59N and after addition of circumferential grooves, retention increased by 641.42N. Standard machined abutments (plain) cemented with Zinc Phosphate cement showed 187.43N and after addition of circumferential grooves, retention increased by 424.75N.

The experimental conditions of other studies were not exactly the same. The study done by Lewinstein et al[12] compared the effect of increasing the number of circumferential grooves on the retention of cemented cast copings on implant abutments. They concluded that, for $ZnPO_4$ cement 1 groove was as effective as several grooves, whereas for ZO non eugenol the retention increased gradually with additional grooves. In the present study, increase in the number of grooves increased the retention for all cements used in the present study. ADIN Implant system gave better retention than MIS Implant system as it had more number of grooves. Another study done by Nejatidanesh et al[13] compared the retention values of implant-supported metal copings using different luting agents and concluded that the Resin Modified Glass Ionomer, Zinc Phosphate, Zinc Polycarboxylate, and Panavia F2.0 had statistically the same retentive quality and are recommended for definitive cementation of single implant-supported restorations. Walfart et al[14]investigated the retention of various cements without thermocycling, and found that retentive forces for ZP (Harvard Cement; Harvard Dental International GmbH) was 400N and for ZO (Freegenol; GC Europe NV, Leuven, Belgium) 180N, which are not similar to the current findings as thermocycling reduced the retention values. Squire et al[15]examined the retention of cemented specimens with 5 types of cements subjected to 24 hours of thermocycling (approximately 1000 cycles). The authors found approximately 300N for ZP (Fleck's Cement; Mizzy/Keystone Industries, Cherry Hill, NJ) and 30N for ZO (ZONE; Cadco Dental Products, Inc, Oxnard, Calif). The low retention values for the ZO provisional cement can be attributed to the different thermocycling conditions. In the dental literature, there is no consensus on the thermocycling protocol needed for testing provisional cements. The cement failure mode was generally adhesive in nature, although some cohesive and mixed failure was observed[12]. Cement remnants were found mostly on the casts for Non eugenol and on plain abutments cemented with Resin modified GIC and $ZnPO_4$. For the grooved abutments remnants were found on abutments as well as cast cemented with Resin modified GIC and $ZnPO_4$ cement. This pattern of failure may indicate that the circumferential grooves create a local lock, which affects the failure mode and the location of the remnants.

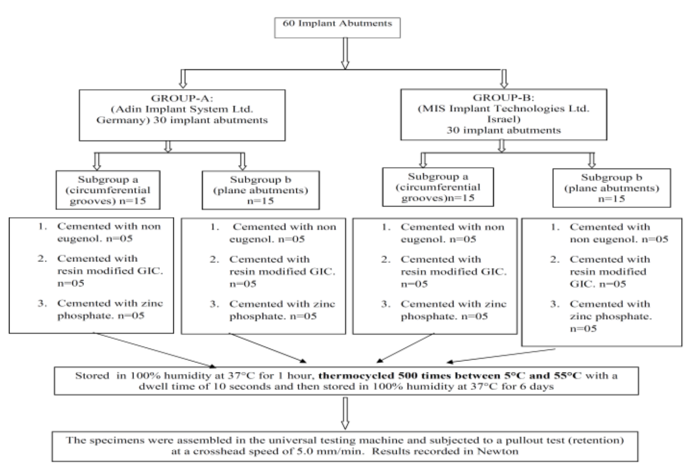
It may be that this local lock increases the length of the fracture-line (plane) and has a greater effect on cements with a high modulus of elasticity such as resin modified GIC and zinc phosphate cements ($ZnPO_4$). Clinically, the circumferential grooves can be effective for increasing the retention of fixed dental prostheses in situations where short abutments are used because of small interocclusal distance. The limitations of this study are, the abutments of two different implant systems differed in height, number of grooves, depth of grooves and degree of taper provided by the manufacturer which changed the retention values. This protocol did not simulate long-term oral conditions. Therefore, additional studies are needed to quantify the effect of grooves on the retention of other cements under long-term simulation, which may assist clinicians in cement selection. The need for retrievability dictates the use of long-term provisional cements for implant-retained fixed prostheses. Since they differ from definitive cements, special protocols are needed for testing such provisional cements.

Conclusion

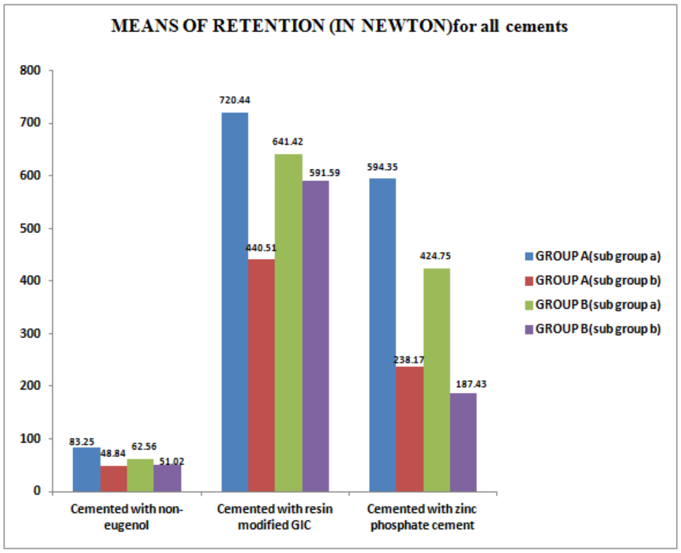
Within the limitations of this study, the following conclusions were drawn:

- The retention of cast copings cemented on plain abutments with resin modified GIC and zinc phosphate cement was about 6 times greater than those cemented with non eugenol provisional cement.
- The addition of circumferential grooves on the abutments increased the retention of cast crowns cemented with Resin modified GIC approximately 60% and was 10 times higher than those cemented with non-eugenol provisional cement and 2 times higher than zinc phosphate cement.
- Statistically, in both the groups, i.e. Group A-Adin Implant Systems and Group B-MIS Implant technologies subgroup a i.e. Grooved Implant Abutment is giving better retention for cemented with resin modified GIC.
- The surface modification of an implant abutment by means of circumferential grooves is an effective method of improving the retention of cast crowns cemented either with non-eugenol provisional cement or resin modified GIC and zinc phosphate cement specially in short abutments

Experimental plan



Graph I



GROUP A (subgroup a) - Grooved Implant Abutment of Adin Implant System

GROUP A (subgroup b)- Standard machined(plane) Implant Abutment of Adin Implant System

GROUP B (subgroup a) - Grooved Implant Abutment of MIS Implant technologies

GROUP B (subgroup b) - Standard machined (plane) Implant Abutment of MIS Implant Technologies

TABLE I: Mean And Standard Deviation (Sd) of Retetion (In Newton).Comparsion Between Groups And Between Cements By F Value, Calculated By One Way Anova

		GROUP A		GROUP B		F VALUE
		SUB GROUP a	SUB GROUP b	SUB GROUP a	SUB GROUP b	
Cemented with non-eugenol	MEAN	83.25	48.84	62.56	51.02	0.21
	SD	8.02	11.49	5.29	19.11	
Cemented with resin modified GIC	MEAN	720.44	440.51	641.42	591.59	0.18
	SD	93.77	111.70	217.17	229.36	
Cemented with zinc phosphate cement	MEAN	594.35	238.17	424.75	187.43	0.69
	SD	86.59	71.79	38.11	52.38	
F VALUE		53.37		15.82		

Table II: Comparsion Between Groups By Student's T Test

COMPARSION BETWEEN		P VALUE
Cemented with non-eugenol	SUB GROUP a : GROUP A AND GROUP B	0.00260(S)*
	SUB GROUP b : GROUP A AND GROUP B	0.8499(NS)
Cemented with resin modified GIC	SUB GROUP a : GROUP A AND GROUP B	0.52286(NS)*
	SUB GROUP b : GROUP A AND GROUP B	0.27024(NS)
Cemented with zinc phosphate cement	SUB GROUP a : GROUP A AND GROUP B	0.007135(S)*
	SUB GROUP b : GROUP A AND GROUP B	0.28655(NS)

* Shows For Subgroup A, Significant Difference Between Group A And Group B For Cemented With Non-Eugenol And Cemented With Zinc Phosphate Cement. No Significant Difference For Cemented With Resin Modified Gic.

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