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Assessing the improvement in cement effectiveness by the geometry of implant abutment surface

Dr Chetan Chandra
MDS, Professor in Department of Periodontology, Saraswati Dental College, Lucknow, Uttar Pradesh
Email: chetanchandra321@gmail.com

Dr. Priyadarshini Rangari
MDS, Associate professor, Department of Dentistry, Sri Shankaracharya Institute of Medical Sciences, Bhilai, Durg, Chhattisgarh
Corresponding author email: panhealth121013@gmail.com

Dr. Ankita Singh
MDS, Associate Professor, Faculty of Dental Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh
Email: ankitasingh.18642@gmail.com

Dr. C. P. Vijeyakumar
MDS, Senior Lecturer, Department of Periodontics, JKK Nattraja Dental College and Hospital, Komarapalayam, Tamilnadu
Email: drcpvijeyakumar.mds@gmail.com

Dr Uday Bhan Singh
MDS [Oral & Maxillofacial Surgery], PhD, M. Phil [Dentistry], MBA, Private Practitioner, Recarve Maxillofacial Center, Delhi
Email: drudaybhansingh20021987@gmail.com

***Abstract*---**Aim: The present study was conducted to assess the effect of the topography or surface geometry of implant abutments for their effect on the retentive strength of the prosthesis cemented using zinc phosphate on grooved, sandblasted, and standard machined implant abutments and to compare them. Methods: 12 implant abutments of a similar shape were divided into 3 groups of 4 each having a 6-degree taper and 6mm height. The 3 groups were Group I included standard machined abutments without grooves, Group II included group I abutments sandblasted, and Group III included abutments having prefabricated circumferential grooves. In addition, among these 12 abutments, 4 each were taken to assess the retentive force of zinc

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phosphate cement. 12 similar cast copings were made to fill the 12 abutments, and were cemented with zinc phosphate. After 6 days of storage in the water bath and thermal cycling, using the tensile testing machine, a retention test was done. Results: Concerning zinc phosphate cement, among three study groups the statistically significant difference was seen with $p<0.05$. The present study results showed that better retention is provided with circumferential grooves on the implant abutment surface compared to sandblasted and standard machined abutment surfaces irrespective of the appreciable differences. Conclusion: The present study concludes that the implant abutment surface and the luting agent used both govern the retention of the restoration. Also, the addition of the retentive grooves can increase prosthesis retention especially in cases with short abutments.

***Keywords*---**abutment geometry, circumferential grooved, implant abutments, luting agents, retentive strength, sandblasted abutments.

Introduction

The practice of implants in Prosthodontics was initiated by Branemark was aimed at treating fully edentulous subjects. However, the abutments introduced by Branemark et al were not esthetically acceptable. Owing to the introduction of osseointegrated implants to treat completely edentulous subjects, few changes were needed for the transmucosal projections. It was only after the 1980s that clinical use of removable abutment with implant prototype version was started. Experiments were conducted with two-part implants in the 1970s. Wider prosthetic choice and better properties of temporary restorations were seen after using the removable abutment version, especially in subjects requiring the single tooth replacement in esthetic zones like maxillary anterior region, and in subjects having compromised interocclusal space.[1]

When the implant and the associated restorations work for the purpose for which it was placed, they are considered as successful. Maintenance of the prosthesis placed on the implant abutments and osseointegration are the two vital factors determining the success of the placed implants. Restorations in the implants can be either cement-retained, screw-retained, or combined. Previous literature data depicts those crowns retained with cement are better for occlusion and esthetics, whereas, easy retrievability is essential for screw-retained crowns.[2]

Common complications of the implants based on mechanical properties include prosthesis screw fracture in nearly 4% of subjects, screw loosening in 7%, loss of prosthesis retention in nearly 30% of subjects as suggested by Goodcare et al. This study also suggested that most common mechanical complication seen in implants is loss of retention of the cemented prosthesis. Thus, it is vital to focus on increasing the retention of the prosthesis retained with the cement on the surface of the abutment. Cement-retained prosthesis use has increased owing to its ability to improve loading characteristics, cost reduction, passive fit, increase esthetics, and optimum occlusal interdigitation.[3]

The cemented prosthesis retention is governed by various factors including convergence angle between cement and abutment, the texture of abutment, abutment width, and abutment height. The factors assessed by the clinician are luting agents and surface roughness. Retention is increased with the surface roughness due to resultant groove patterns and micro retentive ridge. Various surface treatments also result in increased retention, increased surface area, and increased size by various procedures including sandblasting and roughening with the bur that results in controlled taper, opposing wall parallelism, occlusogingival preparation height, and retentive guiding grooves.[4] The present study was conducted to assess the effect of the topography or surface geometry of implant abutments for their effect on the retentive strength of the prosthesis cemented using zinc phosphate on grooved, sandblasted, and standard machined implant abutments and to compare them.

Materials and Methods

The present study was conducted to assess the effect of the topography or surface geometry of implant abutments for their effect on the retentive strength of the prosthesis cemented using zinc phosphate on grooved, sandblasted, and standard machined implant abutments and to compare them. The study was conducted after obtaining clearance from the concerned Ethical committee. The specimens for the present study were prepared with the 12 samples comprising of implant abutments shaped similarly with the taper of 6^{o} and height of 6mm. The specimens were then divided into3 groups of 4 samples each were Group I comprised of 4 samples that were standard machined abutments with no grooves, Group II having specimens of Group I sandblasted using aluminum oxide, and Group III having abutments with pre-existing circumferential grooves. The surface topography was seen under a 10X magnification stereo microscope.

Surface roughness was measured for all three groups. The 12 samples were fixed in self-polymerizing acrylic blocks and one specimen was placed in one analog. 4 standard specimens were placed without any alteration, another 4 were sandblasted with aluminum oxide at 10mm distance for 10 sec at pressure. In other 4, grooves were made using 2X magnification of stereomicroscope. 12 similar nickel-chromium cast copings were made to fit these 12 specimens which were directly made on the abutments followed by wax sprue fabrication which was added to the occlusal surface of every coping for allowing the attachment of samples to the tensile testing machine. Before the cementation, implants, and abutments were cleaned for 15 minutes in an ultrasonic bath and were then steam cleaned. The copings were then luted on the abutments with zinc phosphate cement and a constant load of 50 N was applied on the abutment for 10 minutes following setting. Extra cement was then removed. This was followed by storing specimens for 1 hour at $37^{o}C$ at 100% humidity, and thermocycling was done 500 times for 10 sec.

Tensile strength was then tested using a universal testing machine with a pullout test at speed of 5mm/min. The powers required to remove copings were assessed in newtons (N). The abutment and copings were evaluated for disappointment mode as suggested by the residual cement area. On the abutments, full-thickness buildups were suggested as cement failure role. Durable failure was considered when fractional thickness buildups and disappointment inside cement were seen on the abutment. Blended failure was considered when contradicting surface of this projection shows cohesive or adhesive failure.

Results

The present study was conducted to assess the effect of the topography or surface geometry of implant abutments for their effect on the retentive strength of the prosthesis cemented using zinc phosphate on grooved, sandblasted, and standard machined implant abutments and to compare them. On assessing the parameters of the surface roughness in the three groups, Rq (Root mean square parameter corresponding to Ra), Rz was the Mean value of the maximum peak to valley height of the profile, and Ra was the Arithmetic mean of the absolute departures of the roughness profile from a mean line. Rq values for Group I, II, and III were 0.216, 3.242, and 9.733 µm, Rz values respectively for these groups were 1.001, 13.946, and 44.791µm, and Ra values were 0.184, 2.617, and 8.126 respectively as shown in Table 1.

The pullout test readings in the universal testing machine were also assessed where for Group I, the values for samples 1, 2, 3, and 4 were 219.54, 191.12, 415.54, and 213.66 n with the mean value of 267.91±82.44. These values for Group II for samples 1, 2, 3, and 4 were 756.63, 795.05, 933.27, and 714.44 n respectively, and the mean value was 853.87±130.67. The pullout test readings for Group III for samples 1, 2, 3, and 4 were 1095.62, 1072.14, 870.54, and 868.26 respectively, and the mean value was 1005.33±112.02. The f-value was 30.51 as depicted in Table 2.

The inter abutment group comparisons were also done. It was seen that between Group I and II t-value was 7.56, between Group I and III were 10.62, and for Group III and II was 1.74 respectively as shown in Table 3. It was seen that difference between groups II and III was statistically non-significant with p>0.005. However, the difference between machined and sandblasted and machined and grooved abutments was statistically significant with p<0.005

Discussion

The present study was conducted to assess the effect of the topography or surface geometry of implant abutments for their effect on the retentive strength of the prosthesis cemented using zinc phosphate on grooved, sandblasted, and standard machined implant abutments and to compare them. On assessing the parameters of the surface roughness in the three groups, Rq (Root mean square parameter corresponding to Ra), Rz was the Mean value of the maximum peak to valley height of the profile, and Ra was the Arithmetic mean of the absolute departures of the roughness profile from a mean line. Rq values for Group I, II, and III were 0.216, 3.242, and 9.733 µm, Rz values respectively for these groups were 1.001, 13.946, and 44.791µm, and Ra values were 0.184, 2.617, and 8.126 respectively. These results were consistent with the results of de Campos TN et al[5] in 2010 and Cano-Batalla J et al[6] in 2012 where authors reported comparable surface roughness in different abutments as in the present study.

Concerning the pullout test readings in the universal testing machine were also assessed where for Group I, the values for samples 1, 2, 3, and 4 were 219.54, 191.12, 415.54, and 213.66 n with the mean value of 267.91±82.44. These values for Group II for samples 1, 2, 3, and 4 were 756.63, 795.05, 933.27, and 714.44 n respectively, and the mean value was 853.87±130.67. The pullout test readings for Group III for samples 1, 2, 3, and 4 were 1095.62, 1072.14, 870.54, and 868.26 respectively, and the mean value was 1005.33±112.02. The f-value was 30.51. These results were in agreement with the findings of Lewinstein I et al[7] in 2011 and Preiskel HW et al[8] in 2004 where authors reported the highest values for grooved abutments followed by sandblasted, and least for standard machined abutments.

The inter abutment group comparisons were also done. It was seen that between Group I and II t-value was 7.56, between Group I and III were 10.62, and for Group III and II was 1.74 respectively. It was seen that difference between groups II and III was statistically non-significant with p>0.005. However, the difference between machined and sandblasted and machined and grooved abutments was statistically significant with p<0.005. These results were comparable to the results of Kim Y et al[9] in 2006 and Lee A et al[10] in 2010 where authors reported similar significance as in the present study.

Conclusion

Within its limitations, the present study concludes that the implant abutment surface and the luting agent used both govern the retention of the restoration. Also, the addition of the retentive grooves can increase prosthesis retention especially in cases with short abutments. The present study results showed that better retention is provided with circumferential grooves on the implant abutment surface compared to sandblasted and standard machined abutment surfaces irrespective of the appreciable differences. However, the present study had a few limitations including smaller sample size, geographical area biases, in-vitro nature, and single-institution nature. Hence, more studies in vivo are warranted to reach a definitive conclusion.

Conflicts of interest: nil

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Tables

Surface roughness	Standard machined (μm)	Sandblasted (μm)	Grooved (μm)
Rq	0.216	3.242	9.733
Rz	1.001	13.946	44.791
Ra	0.184	2.617	8.126

Table 1: Parameters of surface roughness in the three groups of study specimens

Samples	Standard machined (n)	Sandblasted (n)	Grooved (n)
1	219.54	756.63	1095.62
2	191.12	795.05	1072.14
3	415.54	933.27	870.54
4	213.66	714.44	868.26
Mean± S.D	267.91±82.44	853.87±130.67	1005.33±112.02
f-value	30.51		

Table 2: Pullout test readings in the universal testing machine in the three groups of study specimens

Inter abutment groups	t-value
Group I and II	7.56
Group I and III	10.62
Group II and III	1.74

Table 3: Intergroup comparison in the study groups