Effect of a Customised Chairside Polishing Protocol for Zirconia- A Comparative Analysis.

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ABSTRACT

Background: The purpose of this study was to develop a customized polishing protocol using standard zirconia polishing kit with polishers of different grit and to study their effect on the surface roughness of zirconia and compare it to that of laboratory polished zirconia samples and machine polished titanium implant abutments. **Methods:** The samples used in this study were 15 zirconia blocks and 10 machine polished titanium implant abutments (5 Biohorizon and 5 MIS). The 15 zirconia blocks were again divided into three groups. The first group consisted of 5 zirconia samples polished by customised polishing protocol (coarse + medium+ fine). The second group consisted of 5 zirconia samples which were sent to lab1 which used Komet company burs and 5 zirconia samples were sent to lab2 which used carborundum burs and sandpaper for polishing. The fourth group consisted of 5 machine polished titanium implants from MIS system and fifth group consisted of 5 machine polished titanium implants from Biohorizon system. After polishing, the mean surface roughness values (Ra) of zirconia samples and titanium implant abutments were calculated quantitatively by optical profilometer and qualitatively by scanning electron microscope (SEM). **Results:** The mean surface roughness value of customised polishing protocol using coarse+medium+fine polisher was 0.11 µm which was almost equal to the mean surface roughness values of lab1 polished zirconia samples - 0.131 µm and that of machine polished titanium implant abutments –Biohorizon: 0.201 µm MIS: 0.0859 µm and was within the optimal range of 0.2µm. **Conclusions:** Within the limitations of this study it was concluded that, the mean surface roughness values of zirconia samples polished by customised polishing protocol , lab1 polished samples and machine polished titanium implant abutments were found to be similar & closer to the critical Ra values (0.2µm) suggesting that the chairside polishing of zirconia can be carried out using the customized polishing technique.

Keywords: Implant abutments, mean surface roughness (Ra value), optical profilometer, SEM, zirconia.

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INTRODUCTION

Zirconia has become a material of choice in restorative dentistry for implant abutments and as copings for crowns and bridges.[1] It is known for its favourable light dynamics and biocompatibility. Studies conducted by several authors found out that there is little difference in the biologic response between titanium and zirconium & even osseointegration of zirconia implants is comparable to that of titanium implants.[2,3]

Surface roughness of any restorative material has a major impact on initial adhesion and retention of oral microorganisms. These microorganisms can lead to biofilm formation on these surfaces and subsequently plaque accumulation and gingival irritation. Smoother surface avoids dental complications such as plaque formation, gingivitis, periodontitis and wear of the opposing dentition. It is also important for patient comfort.[4]

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In implant dentistry, strategies aimed at reducing bacterial adhesion and biofilm formation on implant abutment surfaces are of pertinent clinical interest and can be used for the maintenance of soft tissue health or possibly in the treatment of peri-implantitis.[1] Creating smoother surface, than generally encountered, on currently used titanium abutments reduces bacterial adhesion.[5]

However, clinically it was evaluated that a certain surface roughness is necessary for adhesion of the soft tissues, to resist in attachment loss with passage of time in implants.[1]

A good equilibrium is provided by an optimal surface roughness Ra value of 0.2µm. It reduces plaque adhesion as compared with a rougher surface, yet is still rough enough for fibroblast adhesion and the establishment of a durable epithelial soft tissue seal.[1]

In clinical practice, sometimes it becomes imperative to adjust a restorative surface by grinding on occlusal, proximal and cervical areas for a better fit. Such adjustment shatters the glazed or polished surface resulting in a rougher surface and inferior surface properties of the restoration. Repolishing of the restorative surface to desired smoothness is of prime importance. Dispatching to lab will be strenuous and time consuming. Hence, there is a need to develop a customized chairside polishing protocol which will give smoother restorative surface comparable to a standardized technique.

This study aims at developing a customized polishing protocol using standard zirconia polishing kit with various grit polishers & studies their effects on the surface roughness of zirconia (Yttria Stabilized Tetragonal Zirconia Polycrystal:Y-TZP) and compares it to that of laboratory polished zirconia samples and machine polished titanium. This will enable the clinician to adopt a specific chairside protocol without affecting the biologic properties of zirconia.

MATERIALS & METHODS

A total of fifteen zirconia samples and ten titanium implant abutments were used in this study. The sample size details are given in [Table 1]. The zirconia samples were rectangular blocks [Figure 1] of dimension 15mm (length) x7 mm (width) x 2 mm (thickness) which were milled from a monolithic circular zirconia block using CAD-CAM technology. The machine polished titanium implant abutments of MIS (5 abutments) and Biohorizon (5 abutments) systems were procured and served as a standard control [Figure 2].

Table 1: Sample size details.

Materials	Zirconia blocks-Customised Polishing	Zirconia blocks-Laboratory Polishing		Machine polished Titanium Implant Abutments	
		Lab1	Lab2	MIS system	Biohorizon system
Sample Size	5	5	5	5	5

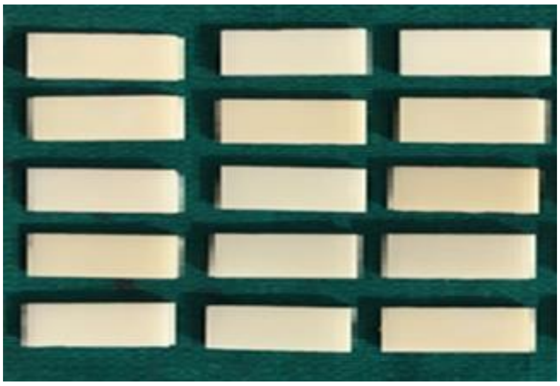

Figure 1: Y-TZP Zirconia samples

Figure 2: Titanium implant abutments

Methodology

Pre polishing: Before subjecting the samples to a polishing procedure, uniformity of all the samples in terms of surface roughness was checked randomly under Optical Profilometer.

Polishing:

Five zirconia (Y-TZP) samples were polished by using DFS Germany polishing burs (Figure-3) - coarse (green) polisher for 2 minutes at 5,000 r.p.m and then subjected to medium (blue) polisher for 2 minutes at 10,000 r.p.m followed by fine (pink) polisher for 5-6 min at 10,000 r.p.m . Polishing was done under the lab microscope (3x) magnification & then viewed under a stereomicroscope (10X) for selection.

Five zirconia (Y-TZP) samples were sent for laboratory polish to lab1which used Komet Company polishing burs.

Five zirconia (Y-TZP) samples were sent for laboratory polish to lab2 which used carborandum burs, diamond finishing burs and sand paper .

Five MIS machine polish titanium implant abutments and five Biohorizon machine polished titanium implant abutments were used whose abutment collar surface served as control.

Figure 3a:Coarse(green)

Figure 3b: Medium(blue)

Figure 3c: Fine (pink)
Figure 3: DFS Germany polishing burs

Pre testing cleaning:

All the samples were cleaned in an ultrasonic bath (confident) for 5 minutes at $300^{\circ}C$ and then steam cleaned (steamer- confident) for 10 seconds at a distance of 5cm and a pressure of 60 Kg/cm2

Pre-testing Preparation of Implant Abutment samples:

Implant abutments were mounted on a wax block such that the collar of abutment was parallel to the base of wax block as shown in Figure 4. This was done to ensure that the collar of implant abutment was relatively flat to the lens of optical profilometer for a more precise measurement.

Figure 4: Titanium implant abutments mounted on wax block

Testing:

Qualitative assessment with scanning electron microscope (SEM):

Qualitative assessment was done using a thermionic emission scanning electron microscope from TESCAN VEGA3 [Figure 5]. Zirconia samples were examined without applying any conductive coating layer. The samples were placed inside the vacuum chamber for the microscopic analysis. SEM readings were made at magnification of 1000 X to compare the samples on the basis of surface topography.

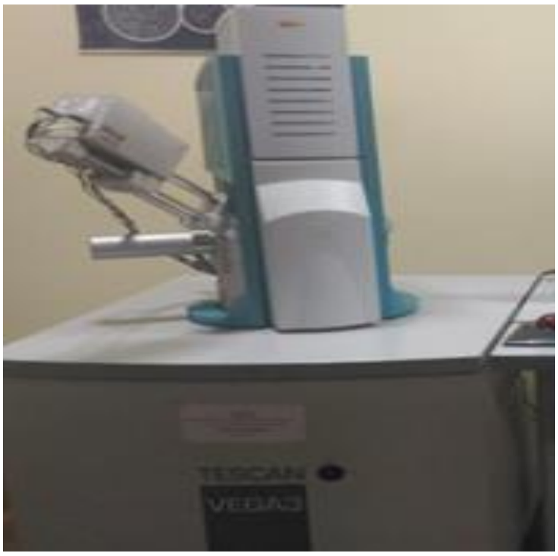

Figure 5: SEM

Quantitative testing with Optical profilometer:

Quantitative measurements were done using an optical profilometer (Taylor Hobson- [Figure 6]). This optical profiler system had blue light noncontact dimensional measuring capability with advanced thin and thick film technology. Measurement technique used was coherence correlation interferometry. All samples were placed under the optical profilometer and surface roughness assessed at 50X magnification.

Figure 6: Optical profilometer

RESULTS

The study used a qualitative analysis method (SEM) and a quantitative method (Optical profilometer) to analyse the surface roughness of all samples. The results of the study are tabulated in Table 2.SEM and Optical profilometry images of the samples are shown in [Figure 7 & Figure 8] respectively.

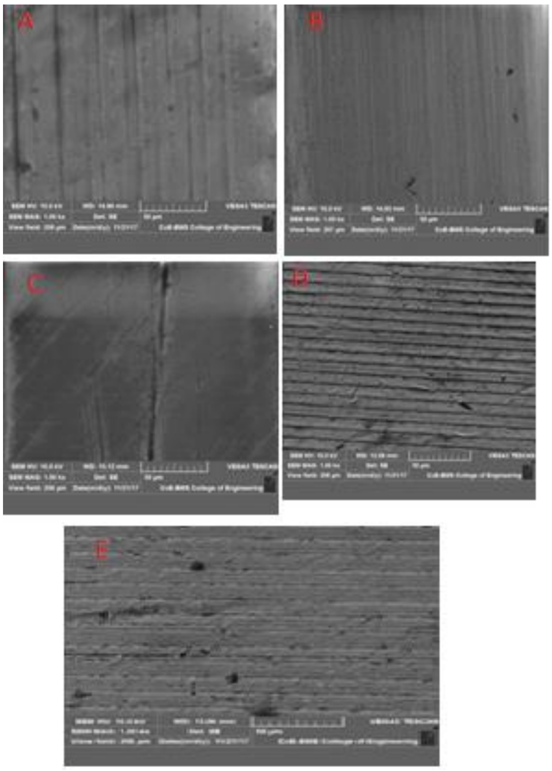

Figure 7: SEM 1000X FIGURES (7a: Customized polishing, 7b:Lab1, 7c: Lab2, 7d: MIS implant abutment surface, 7e: Biohorizon implant abutment surface).

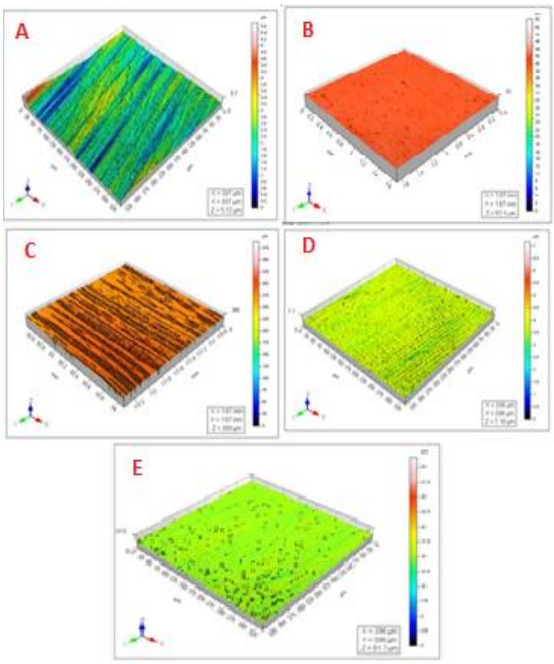

Figure 8: OPTICAL PROFILOMETER(50X) FIGURES (8 a: Customised polishing(0.11), 8b: Lab1-(0.131), 8c: Lab2-(8.26), 8d: MIS implant abutment surface(0.0859), 8e: Biohorizon implant abutment surface(0.201)).

The values obtained from the two labs showed a large discrepancy (mean value of lab1- 0.131 µm and lab 2 - 8.26 µm) in the Ra values, and therefore were subjected to statistical analysis and the same is depicted in [Table 3].

The Mann-Whitney U test which is a non-parametric test was performed to see whether the median surface roughness values were same between lab1 and lab2.It was found that there is a significant difference in median values between the two groups (P-value 0.009)

Table 2: Ra value of all samples obtained from optical profilometry

Labs	N	Q1	Q2	Q3	Minimum	Maximum	P-value
Lab1	5	0.124	0.131	0.164	0.101	0.167	0.009
Lab2	5	8.18	8.26	10.6	3.2	24.9	

P<0.009 - statistically significant, Q1:quartile 1,Q2:quartile 2(median),Q3:quartile 3

Table 3: Mann -Whitney U non parametric test on the two lab values.

Samples	Customised protocol (Ra value in µm)	Laboratory polish (Ra value in µm)		Implant abutments (Ra value in µm)	
		Lab 1	Lab2	Biohorizon system	MIS system
Sample 1	0.0823	0.164	10.6	0.102	0.0855
Sample 2	0.11	0.131	24.9	0.201	0.0859
Sample 3	0.157	0.167	8.26	0.204	0.23
Sample 4	0.141	0.101	8.18	0.231	0.0718
Sample 5	0.0828	0.124	3.2	0.131	0.099

Ra- critical surface roughness

Table 4: Kruskal Wallis ANOVA Test application on the mean surface roughness (Ra) value data

Polishing protocols	N	Q1	Q2	Q3	Minimum	Maximum	P-value
Customised protocol Coarse + medium + fine	5	0.0828	0.11	0.141	0.0823	0.157	0.44
Lab 1	5	0.124	0.131	0.164	0.101	0.167	
Machine polished titanium implants-Biohorizon	5	0.131	0.201	0.204	0.102	0.231	
Machine polished titanium implants-MIS	5	0.0855	0.0859	0.099	0.0718	0.23	

Intergroup Comparison

Mean values of customised polishing protocol, lab1 polished and machine polished titanium implants were statistically assessed and compared for P-value significance. Kruskal Wallis ANOVA Test which is a non-parametric test was used for intergroup comparison [Table 4] to see whether the median surface roughness were same between the groups. It was found that there is no significant difference in median values between the groups (P-value 0.44)

DISCUSSION

The nature of surface roughness can be assessed by SEM (scanning electron microscope) and Optical profilometer. SEM is used to study & compare the surface topography and surface morphology qualitatively, whereas optical profilometer is the ideal device for studying surface roughness quantitatively by measurements that can be calculated and compared statistically. Many researchers used this device to study the effect of polishing and glazing on the surface roughness of dental ceramics.[6-13] The surface roughness is evaluated by the Ra parameter obtained with a profilometer. This parameter describes the overall roughness of a surface and can be defined as the arithmetical average value of all absolute distances of the roughness profile from the center line within the measuring length.

The uniformity of all the samples in terms of surface roughness was confirmed by random optical profilometric assessment before starting the polishing procedures.

Comparison of samples before and after cleaning (Ultrasonic & steam cleaning) was done. It was found that the cleaning protocol successfully removed the remnants and residues of the polishing procedures. Removal of these remnants and residues were essential from all the samples before carrying out further SEM and Profilometric analysis to obtain uniformly clean samples and reduce bias in the readings.

In customized polishing protocol, the samples were subjected to different grit size (coarse, medium & fine) polishers to study the surface roughness. The three step protocol produced the best results.

The results of customized protocol showed that mean Ra value achieved was 0.11µm with minimum value of 0.0823µm and maximum value of 0.157µm. The smoothness of this group could be attributed to the use of fine polishers to eliminate the minute scratches formed on the surface with medium polisher. The Ra value obtained from customized protocol is within the range of critical value of 0.2µm and also within the range of commercially obtained components, so it is recommended.

SEM analysis showed that the surface topography of the samples which followed customized protocol, looked very smooth and had grooves to a very less extent.

The samples polished by lab1 showed a minimum value of 0.101µm and maximum value of 0.167µm with a mean surface roughness of 0.131µm. The Ra value of lab1 polished samples can be attributed to the use of zirconia polishing burs of Komet company (used according to their protocol). The mean surface roughness of customized polishing is comparable to the values obtained by polishing done inlab1.

The samples polished bylab2 showed a minimum value of 3.2µm and maximum value of 24.9µm. so; the Ra value of samples obtained from this lab2 was effectively 8.26µm. There is a large difference between the Ra values of samples polished at lab1 and lab2.The Ra value obtained fromlab2 is very high when compared to the critical value of 0. 2µm.High roughness of samples from lab2 can be attributed to the use of carborandum bur, diamond finishing bur, and sand paper on zirconia samples (creating greater amount of surface roughness and uneven surface).

Lab2 polishing protocol cannot be recommended for polishing of zirconia abutments as it creates a surface roughness which is significantly higher than the critical value of 0.2µm& it can lead to more bacterial and plaque accumulation leading to failure of prosthesis. So, the selection of proper lab which follows correct polishing protocol is extremely important.

The comparison of Ra values of lab1 and lab2 polished zirconia samples shows that the difference is statistically significant.

Qualitative (SEM) analysis of laboratory polished samples also showed greater degree of variations between polishing done in lab1 and lab2. The surface topography of lab1 samples looked almost smooth with less degree of roughness and unevenness, but the samples polished at lab2 looked rough with horizontal pattern of rough spikes and more irregular surface topography.

Amongst the machine polished titanium implant abutment group, the Ra value for MIS abutment is 0.0859µm whereas for Biohorizon abutment group the mean is 0.201µm. A slight variation in the surface roughness between the two implant groups could be attributed to the gold coating on abutment surface for Biohorizons.

SEM analysis of machine polished titanium abutments (MIS and biohorizon implant abutments) it was noted that all the samples showed almost consistent surface topography, revealing a groove shaped relief which is evident by black spots with irregular heights and depths which is in line with the samples treated with customized protocol and laboratory1 polished samples.

SEM assessment in this study revealed a grooved surface with irregular heights and depths showing some amount of unevenness in almost all the polished samples and implant abutments. These grooves and uneven surfaces might help in the adhesion of fibroblast and epithelium attachment to the surface of crown. If the surface was completely smooth with glossiness and without grooves and irregularities then it might result in attachment loss, and more bleeding on probing. Quirynen et al.[14,15] And Bollen et al.[14,15] measured surface roughness values of Ra = 0.05µm and Ra = 0.06µm on high gloss polished abutments. Their clinical research indicated that this is not suitable for implant abutments. Similar kind of study was done by Happe et al.[6] Madson Barros Bandeira et al.[7] and Hussein Muhammed Wajih et al.[8] and all of them obtained similar kind of results.

So, in this study it was finally observed that the mean surface roughness of zirconia obtained after following customized protocol is comparable to the mean surface roughness obtained after polishing of the samples from Lab1 and mean of machine polished titanium implant abutments. So, while adjusting the restorative proximal surfaces for better fit in clinical situations customized protocol can be effectively used to get the desired surface smoothness of crown/abutment.

CONCLUSION

Within the limitations of this study it was concluded that:

1. The mean surface roughness values of zirconia samples polished by Coarse + medium + fine polisher were similar to the critical surface roughness values (0.2µm).
2. The mean surface roughness values of zirconia samples polished bylab2 had a large discrepancy when compared with lab1. The results of lab 1 polishing protocol matched the critical surface roughness values (0.2µm) whereas lab 2 did not.
3. The mean surface roughness values of Machine polished titanium abutments of MIS and Biohorizon implant abutments were similar & found to be closer to the critical values (0.2µm).
4. The mean surface roughness values of zirconia samples polished by customised polishing protocol , laboratory1 polished samples and machine polished titanium implant abutments were found to be similar & closer to the critical Ra values (0.2µm).

Therefore, it can be concluded that the customised polishing protocol of zirconia can be used chairside giving the desired surface roughness and thereby saving the patient's and clinician's precious time.

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