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A Scanning Electron Microscopy Analysis of the Surface Changes in Platform Switched and Non-Switched Implant Abutment Junctions (IAJ) At Different Bone Levels Under Cyclic Fatigue Test – An In Vitro Study.

[1]Dr. Atreyee Deka, Postgraduate, Department of Prosthodontics and Crown and Bridge Vokkaligara Sangha Dental College and Hospital, Rajiv Gandhi University of Health Sciences (RGUHS), Bengaluru, Karnataka, India.

[2]Dr. Bharat Raj R, Reader, Department of Prosthodontics and Crown and Bridge Vokkaligara Sangha Dental College and Hospital, Bengaluru, Karnataka, India.

[3]Dr. Surendra Kumar G.P., Professor, Department of Prosthodontics and Crown and Bridge Vokkaligara Sangha Dental College and Hospital, Bengaluru, Karnataka, India.

[4]Dr. Anupama N.M., Professor and Head, Department of Prosthodontics and Crown and Bridge Vokkaligara Sangha Dental College and Hospital, Bengaluru, Karnataka, India.

[5]Dr. Archana Shetty, Reader, Department of Prosthodontics and Crown and Bridge Vokkaligara Sangha Dental College and Hospital, Bengaluru, Karnataka, India.

Corresponding Author: Dr. Atreyee Deka, Postgraduate, Department of Prosthodontics and Crown and Bridge Vokkaligara Sangha Dental College and Hospital, Rajiv Gandhi University of Health Sciences (RGUHS), Bengaluru, Karnataka, India.

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Abstract

AIM: A Scanning Electron Microscopy Analysis of the Sur face Changes in Platform Switched and Non-Switched Implant Abutment Junctions (IAJ) At Different Bone Levels Under Cyclic Fatigue Test – An In Vitro Study.

Method: Sixteen implants of L11.5mm and D5mm were divided into four groups with four samples each.

Group A: Platform switched implants at 0mm bone level.

Group B: Platform switched at 3mm bone level.

Group C: Non-switched at 0mm bone level.

Group D: Non-switched implants at 3mm bone level. The loading was conducted with a servo hydraulic electric testing machine with a 15 Hz sinusoidal Pul sating load. The implants were loaded at different force levels of 50N to 350N until the specimens survived up to 10,00,000 cycles and SEM Analysis was done.

Result: Group A, Plat form switched implants at 0 mm bone level had superior results followed by groups C, B, and D.

Conclusion: Platform switching decreases the stress con centration in all the areas except for the retention screw. Least surface changes were seen in platform switched compared to non-switched im plant abutment junctions.

Keywords: hydraulic, specimens, surface

Introduction

Modern implant approach aims for more than the im plant's successful Osseo integration. An aesthetic and functional restoration must be surrounded by stable peri-implant tissue levels that are harmonious with the pre-existing dentition in order to be successful. Marginal bone loss associated with dental implants is a major con cern and clinical challenge, as the resistance to fracture of implants when in function is given by the set formed between the walls of the implant and the amount of bone tissue around the walls.[1,2]

An innovative implant-to-abutment link known as "platform switching" has been developed in an effort to enhance long-term bone maintenance surrounding the im plants. Platform switching, where the implant diameter is larger than the abutment diameter to promote long-term implant bone maintenance, was first described by Lazzara and Porter in 2006. For the best load distribution and proper maintenance of the biologic width, horizontal repositioning of the implant abutment junction moves the perimeter of the IAJ inwards toward the central axis of the implant and the infiltration of inflammatory cells is shifted outward from the IAJ.[2]

Crestal bone undergoes remodelling and resorption pro cesses following the placement of the implant and its pro sthetic connection. In particular, the crestal bone levels developed about 1.5 to 3 millimetres below the implant-abutment junction after a year following the prosthetic repair (IAJ). Occlusal overload and peri-implantitis are the main causes of crestal bone loss, despite the fact that the exact etiological processes behind bone loss are not yet fully understood. Some studies have linked the relationships between IAJ and bone crest to the loss of bone tissue in response to submerged implants.[3,4]

Given that the peri-implant mucosa must be large enough to allow for effective epithelial-connective tissue connection, inadequate tissue size would result in some peri-implant bone resorption, which would assure the stabilization of an attack with sufficient biological width. Particularly, bone loss could be caused by soft tissue inflammation that is focused at the implant-abutment contact after the same soft tissues try to establish the biologic width.[2,4]

However, many authors have recognised the potential etiologic mechanism as the existence of a micro gap at the implant-abutment interface, which leads to bacterial colonisation of the implant sulcus. After the prosthetic connection, it's conceivable that there is a bacterial leak age within the implant system. Bacteria and their pro ducts will then enter the micro gap between the implant and abutment. This would set off an inflammatory process near the crestal bone, leading to the loss of bone support.

A sufficient level of crestal bone has been regarded as a crucial clinical factor for the long-term effectiveness of implant treat ments. A well-established factor in the success of implants is the stability of the bone sur rounding them. The biomechanical anchorage of the prosthesis will be greatly impacted by bone loss from the peri-implant ridge, which may jeopardise the longevity of the treatment. The amount and quality of peri implant tissues have been maintained by implants with various cervical designs and platforms. However, it was noted that the adoption of a platform switching mode can alter the resorption caused by biological processes following prosthetic restoration.[6,7,8]

Reduced abutment diameter may encourage less likely fracture, separation, or loosening under various loads and cycles. Due to the persistent masticatory force dental implants endure in the oral environment during their service life, mechanical fatigue is the main cause of dental implant issues. It has been demonstrated that the level of implant insertion, independent of implant type, directly affects the degree of fracture resistance to external forces.[5]

Bone loss in the vicinity of the cervical implant site contributes to significant flexion stress in this location. The portion of the implant that corresponds to the end of the abutment screw is where the resistance to flexion is reduced when bone loss (peri-implant tissue in flam mation) eventually reaches this area of the implant.

Although switching platform implant designs have gained popularity across the globe, there are few studies of their mechanical function. The current in vitro study compared a platform-switched implant system with a non-platform switched implant system to determine the maximum cyclic fatigue strength values and the damage done to the sets (abutment and implant) after testing. Two distinct implant insertion levels were analyzed as well. Using the ISO 14801:201630 norm, the combinations are evaluated in the current study by mimicking various rates of bone loss surrounding the implants.

Methodology

Sixteen implants of Length 11.5mm and Diameter 5mm were divided into four groups with four samples each (Fig. 1 and 2).

- Group A: Platform switched implants at 0mm bone level.
- Group B: Platform switched implants at 3mm bone level.
- Group C: Non-switched implants at 0mm bone level.
- Group D: Non-switched implants at 3mm bone level.

All the implant specimens were mounted on epoxy resin (similar to the elastic modulus of bone ~ 3MPa).

Fig. 1: Platform Switched Implant and Abutment

Fig. 2: Non-Platform Switched Implant and Abutment

Sample Preparation

In order to create the specimens, a cylindrical piece of card board was prepared, and the implants were sus pended at the mold's centre using 0.7mm wire (Fig. 3). Epoxy resin was poured, cured, and polished after being mixed in a 2:1 ratio; two parts resin to one part hardener (Fig. 4). The implant manufacturer's ratchet was used to secure the abutments to the implant with a torque of 25 Ncm (Noris Medical) (Fig. 5). The 3 Shape Lab Scanner was used to scan each and every specimen (Generation Red E2) (Fig. 6). The next step involved designing and milling a hemispherical crown (Fig. 7). Using poly car boxy late cement, the crowns were attached to the abutment (Duco Cement, Devcon, Riviera Beach, FL) (Fig. 8).



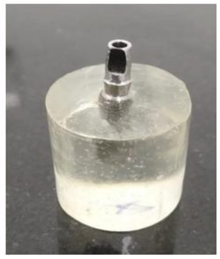


Fig. 3: Cardboard mold Implant suspended at the centre using 0.7mm wire (left).

Fig. 4: Implant embedded inside the epoxy mold (Center).

Fig. 5: Abutment secured to the implant embedded inside the epoxy mold (right).


Fig. 6: 3 Shape Lab Scanner scanned specimen (left).

Fig. 7: Designing and milling a hemispherical crown (Center).

Fig. 8: Cementation of the crown to the abutment (right).

Cyclic Fatigue Test

All the specimens were stored in artificial saliva (Wet Mouth) for 24 hours. The specimens were mounted on the servo hydraulic electric testing machine at an angle of 30° +/- 2° in reference to the loading axis with a 15 Hz sinusoidal pulsating load and a cross head speed of 1mm/sec with ISO 14801:201630 Standardization (Fig. 9).[12,13,14] Testing for all specimens were carried out with a cyclic load of 50N to 350N at 15 Hz until all the specimens survived up to 10,00,000 cycles or underwent some amount of displacement or failure (Fig. 10). Following the completion of the test, all the specimens were cleaned in 70% isopropanol. The results were depicted in a line graph format (Graph 1).

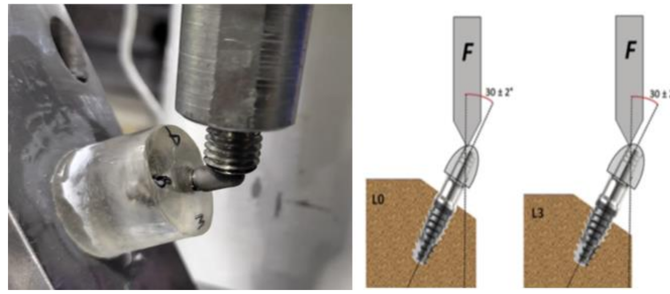
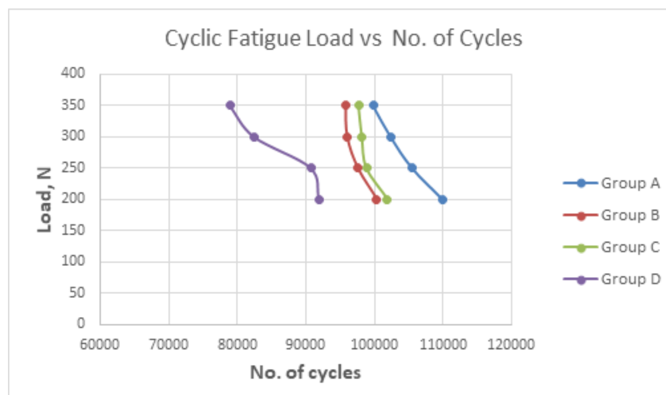


Fig. 9: Specimens were assembled according to ISO 14801 Standard

Fig. 10: Cyclic load of 50N to 350N at 15 Hz up to 10,00,000 cycles were applied.



Graph 1: Line Graph Plotted for All The 4 Groups.

Scanning Electron Microscope Analysis

After all the specimens underwent the Cyclic Fatigue Testing then, Scanning Electron Microscope Analysis was done (JOEL; MODEL: JCM 6000 PLUS; Volt: 5 Kv To 10 Kv; 20 X Magnification) (Fig. 11). SEM Analysis observed the Implant internal hex and the abut ment outer hex for the various surface changes with Plat form Switched Implant and Abutment at 0mm and 3mm

(Table 1) as well as Non-Platform Switched Implant and Abutment at 0mm and 3mm (Table 2) after the cyclic fatigue loading of 50N to 350N at 15hz with up to 10,00,000 cycles.

Fig. 11: Scanning Electron Microscope

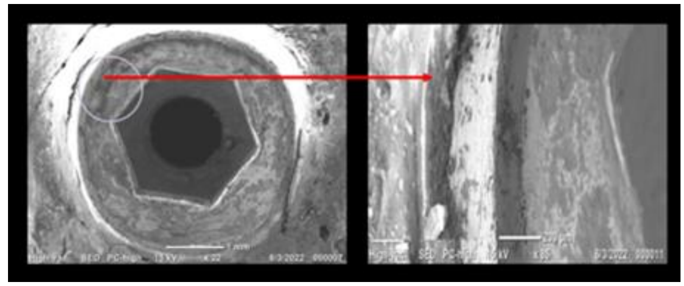


Fig. 12: Platform Switched Implant at 0mm.

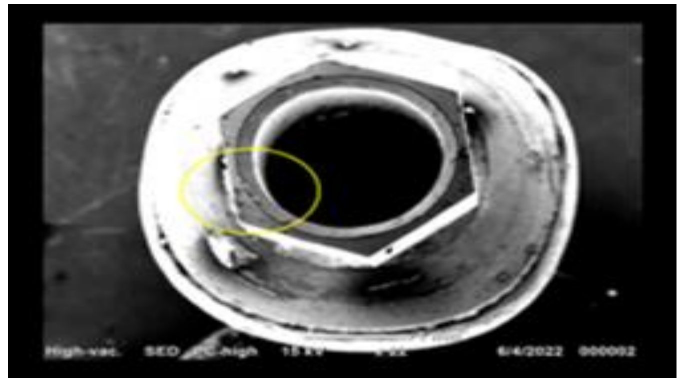


Fig. 13: Platform Switched Abutment at 0mm.

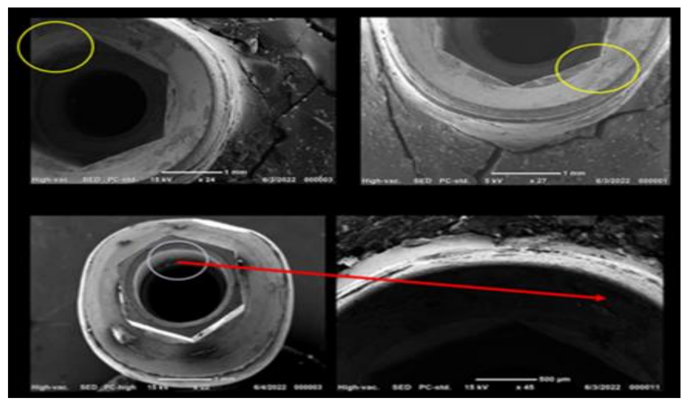


Fig. 14: Plat form Switched Implant and Abutment At 3mm.

Platform Switched Implant At 0 mm (Fig. 12)	Platform Switched Abutment At 0 mm (Fig. 13)	Platform Switched Implant At 3 mm (Fig. 14)	Platform Switched Abutment At 3 mm (Fig. 14)
Very mild burnishing along with debris accumulation	Very minimal abrasion	Adhesive wear seen on the internal hexagon of the implant body along with abrasion and smeary appear ance	Mild burnishing with debris and scuffing seen on one side of the hexagon

Table 1: SEM assessment of Plat form Switched Implant and Abutment At 0mm and 3mm.

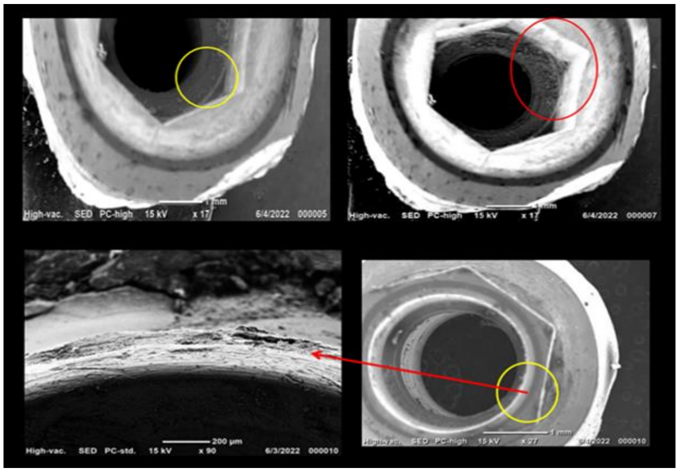


Fig. 15: Non-Plat form Switched Implant and Abutment At 0mm

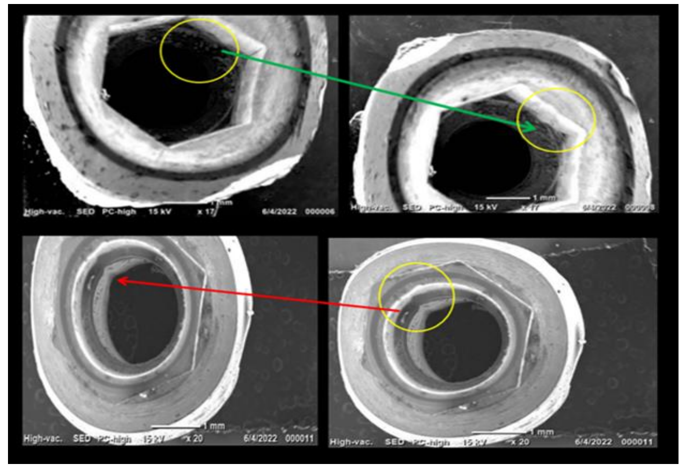


Fig. 16: Non-Plat form Switched Implant and Abutment At 3mm.

Non Switched Implant At 0 mm (Fig.15)	Non Switched Abutment At 0 mm (Fig.15)	Non Switched Implant At 3 mm (Fig. 16)	Non Switched Abutment At 3 mm (Fig. 16)
Abrasion, burnishing and debris seen all around the hexagon	Grooving on the surface and debris accumulation	Marked burnishing, adhesion wear and lot of debris accumulation seen along the internal surface of the implant hexagon	Marked adhesion wear and grooving

Table 2: SEM assessment of non-Plat form Switched Implant and Abutment At 0mm and 3mm.

Results

Data was subjected to normalcy test (Shapiro-wilk test). Data showed normal distribution. Hence parametric tests (ANOVA with post hoc Bonferroni) were applied.

Table 3: Comparison of The Mean Number of Cycles Among the Groups Using Anova.

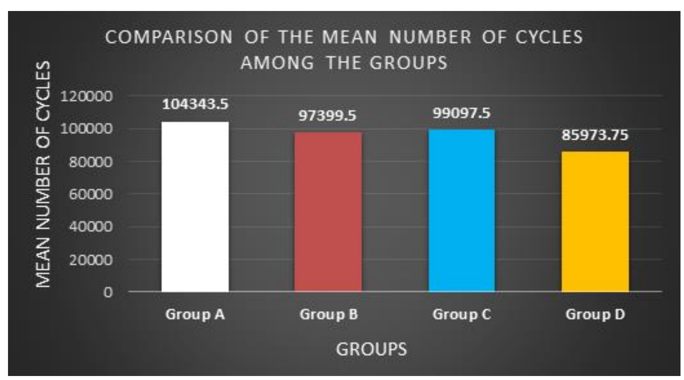
Groups	N	Minimum	Maximum	Mean	S. D	p value
A	4	99758	109856	104343.50	4348.566	0.001*
B	4	95734	100324	97399.50	2109.379	
C	4	97678	101789	99097.50	1851.365	
D	4	78906	91880	85973.75	6310.532	

Table 4: Inter Group Comparison Using Post Hoc Bonferroni.

	Mean diff	p value
Group A Vs Group B	6944.0	.199
Group A Vs Group C	5246.0	.565
Group A Vs Group D	18369.75	.000*
Group B Vs Group C	-1698.0	1.000
Group B Vs Group D	11425.75	.011*
Group C Vs Group D	13123.75	.004*

*Significant

Graph 2: Com parison of the mean number of cyclic fati gue cycles among platform switched and Non switched IAJ at 0mm and 3mm



Discussion

The null hypothesis that surface changes would not differ between platform switched and non-switched implant abutment on the insertion level was rejected based on the results of the cyclic fatigue test and SEM analysis. The combinations were tested in the current study by simulating different levels of insertion loss around the implants using the ISO 14801: 2016 30 standards.

A number of elements play a role in getting good aesthetic results with implants. One of the most crucial factors is the implant's proper placement, along with determining the ideal volume of hard and soft tissues. The ideal placement is 1.5 to 2.0 mm to the palatal side of the tooth to be replaced, which over time assures the stability of the mucosa and buccal bone margins. The platform switching technique uses standard implants that are 5 mm in diameter and abutments that are 4 mm in diameter, and it has been found to maintain constant interproximal bone height after a year.

The Platform Switching Concept was developed to control bone loss after implant placement; it refers to the use of an abutment of smaller diameter connected to an implant neck of larger diameter; this connection shifts the perimeter of the implant-abutment junction inwards towards the central axis (the middle of the implant) improving the distribution of forces

The premise of the platform switching idea is the use of an abutment that is smaller than the implant neck; this kind of connection shifts the perimeter of the IAJ to the implant axis Center. Moving the IAJ inward is expected to bring out bacteria more inwardly, which keeps them away from the bone crest, which would explain the restriction in bone resorption.

Recent research suggests that when the base of the abutment is smaller than the implant platform, a connective sleeve forms more consistently, which benefits the ability to create a mucosal seal. Regarding the bio mechanical benefits of using platform switching, the results show that, in contrast to conventional implants, which have a high stress area around the implant's neck and along its lateral surface, the stress area is localised to the centre of the implant in the model with platform switching.

At different loads and cycles, reducing the abutment diameter can promote lower possible loosening, sepa ration, or fracture. Regardless of implant type, the level of implant insertion has been shown to have a direct influence on the degree of fracture strength to external forces.

The loss of bone around the cervical implant portion causes significant flexion stress in this area. Further, in this type of implant, the strong tension is concentrated close to the implant-abutment contact, and the platform switching model's shear force on the cortical bone is lower than it is in the standard model. This bone loss usually occurs as a result of peri-implant tissue inflammation and causes changes at the bone level, eventually reaching the area of the implant that corresponds to the end of the abutment screw where the resistance to flexi on is reduced.

With his to logical changes in the arrangement and dispersion of the fibres, the bio logical space next to an implant is larger than the bio logical space next to a natural tooth. Lazzara and Porter claim that the intentional establishment of a space for the previously indicated physio logical barrier minimises the space for fibre repositioning. An enlarged surface area of the implant is released by moving the junction with the abutment to a more medial location with respect to the axis, which favours carefully relocating the biological space. [10,11]

Platform switched implants showed very little peri-implant bone level changes, according to Enkling et al. with a follow-up time ranging from 11 to 14 years.[7] Wagemberg et al. examined implant survival and crestal bone levels around implants that used the platform-switching approach. The findings of this study confirmed that the platform switching idea was successful in main training interproximal crestal bone levels by showing that 99% of all the surfaces evaluated had less than 2.0 mm of bone loss throughout this observation period.

Cocchetto et al. assessed the biologic impact of using a broad platform-switching restorative strategy in humans on both a clinical and radiographic level. According to the preliminary study's findings, patients receiving broad plat form-switched implants may experience less crestal bone loss than patients receiving conventional platform-switching or non-platform-switching implants when they are properly chosen. [5]

Canullo et al. found that compared to implants with matching implant-abutment diameters, implants recover ed using the platform-switching concept had much reduced marginal bone loss. Additionally, it was found that when implant-abutment mismatch increased, marginal bone levels were even better preserved. The researchers studied the relationship between initial loading with these implants and their effects on soft and hard tissues, and they were in favour of platform switching. [5]

The crucial part played by the micro gap between the implant and abutment in the remodelling of the peri-implant crestal bone was validated by Sapinos and Cappiello et al. Platform swapping appeared to improve the long-term predictability of implant therapy and lessen peri-implant crestal bone resorption.[11,15]

Platform switched implants have been the subject of published articles, which López-Mar et al evaluated in order to evaluate survival rates and define their impact. A review of the literature on the notion of switching implant platforms as it relates to soft tissue and marginal bone loss. The authors came to the conclusion that platform swapping can keep the width, height, and crestal peak between adjacent implants while limiting crestal bone loss to a mean of 1.56 mm +/- 0.7 mm. Similar conclusions were achieved by Atieh et al., who also noted that the degree of marginal bone resorption is inversely related to the degree of implant-abutment mismatch.

Conclusion

Within the scope of the study, the following conclusions were reached:

Surface deformation was observed under SEM at the level of abutment and implant structure of both platform switched and non-switched implant abutments.

The surface changes of platform switched implants were lower than those of non-switched implants at 0mm and 3mm of bone insertion tested. To validate these findings, additional studies involving clinical follow up of these implant models are required. One of the study’s limitations is that no para functional movements were performed to assess the behaviour of the combinations. Having read the literature that is available it can be concluded that platform switching offers multiple benefits and potential applications for implant design Modifications, including situations where a larger im plant is desired but the prosthetic space is constrained and in the anterior zone where preservation of the crestal bone can result in better aesthetics.

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