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PHOTOELASTIC ANALYSIS OF STRESS DISTRIBUTION IN SINGLE TOOTH PLATFORM SWITCHED IMPLANT ABUTMENTS.

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ABSTRACT

Statement of problem: Peri-implant crestal bone levels are critical to the success of implant therapy. This bone loss can be minimized by using abutments that are undersized compared to the diameter of implant. However the amount of stress transferred in such situations is not studied extensively. **Purpose**: The aim of this study was to evaluate, by photoelastic analysis, the stress distribution in the cervical and apical site of platform matched and platform switched implant abutments. **Material and methods**: 6 photoelastic models of implants were fabricated and divided into two groups of Group A (platform matched and B (platform switched). The models were kept in a circular polariscope and Axial and Oblique loads were applied of 10Kg (100N) and the stress patterns were assessed qualitatively and quantitatively. **Results:** The values of stress around group B models were significantly less than Group A. **Conclusion:** Platform switching concept reduces cervical area stress concentrations around implants and hence reduces bone loss.

KEYWORDS: Dental implants, biomechanics, platform switching, photoelastic stress analysis.

INTRODUCTION

Implant therapy is one of the preferred treatment options in the replacement of missing teeth in both partially and completely edentulous arches.[1] Despite the high success rates,[2] one common problem that arises is bone loss up to the first thread in osseointegrated implants, upon initial loading.[3]

When evaluating the success of dental implants, a dental implant must have less than 2 mm of vertical bone loss apical to the implant-abutment junction (IAJ) during the first year of function and less than 0.2 mm annually after the first year.[4,5] This bone resorption around the implant neck depends on many factors, like location of the inflammatory conjunctival tissue area, biological width, bacterial micro leakage,[6-10] location of the implant/abutment joint, micro-movement and cervical area stress concentration.[11] Previous studies [12] have shown that crestal bone loss around dental implants can be prevented by applying the concept of platform switching (PS). In a standard protocol, implants are rehabilitated with abutments of the same diameter. In PS technique, the abutments used are undersized compared to the diameter of the implant.[13]

The advantages of the PS technique are as follows:-[13]

1. There is an increased surface area created by the exposed implant seating surface, as a result of which the amount of crestal bone resorption necessary to expose a minimum amount of implant surface to which the soft tissue can attach is reduced.[9,13]
2. The implant abutment junction is moved inward as a result of which the inflammatory cell infiltrate (ICI) is moved away from the bone resulting in less effect of the ICI on the surrounding bone and soft tissue.

The clinical advantages and biological benefits of the PS technique have been demonstrated by previous studies.[9-12, 14-16] However, very minimal research has been done on the biomechanical aspects of this technique.[17, 18]

One method used for such study is photoelasticity, which involves evaluation of the mechanical response of a photo elastic model when load is applied.[19]

Photoelastic stress analysis is a useful technique to demonstrate stress patterns allowing direct visualization of stress induced on an actual sample being tested. The benefits of the property of freezing the stress patterns into the models for later evaluation are also provided.

Thus, the aim of this study was to evaluate the stress distribution of platform switching implants using a photo elastic method.

AIMS AND OBJECTIVES

- To compare the stress concentrations generated around platform non switched and platform switched implant abutment junctions in a photoelastic model.
- To analyse and compare the specific areas around implants where the stress is maximum and minimum.

MATERIAL AND METHODS

A wax block made from modeling wax was fabricated of dimensions 5cm (50mm) breadth, 3.5cm (35mm) length and thickness of 1.5cm (15mm). Fig 1. This wax block was considered to represent a block of mandibular bone. A putty index of this wax block was made. Fig 1.

Fig.1 wax block and putty index

The photo elastic resin and hardener chosen for this study was Epoxy resin, Araldite CY 230-1 in and Aradur hardener (Huntsman Advanced Materials Llc, Delaware, USA).

6 Internal Hex, Tapered Implants (Lance, MIS Implants, MIS Tech. Ltd., Israel) of standard length of 10mm and diameters of 3.75mm, 4.2mm and 5mm were chosen. They were divided into 2 groups- Group A and Group B. To group A, non platform switched abutments (Standard Abutments- SA)were connected and to Group B, platform switched (PS) abutments were connected.

The photoelastic material was mixed in the ration of 5:1 (5 ml of resin with 1ml of Hardener) according to Manufacturer's instructions, and was poured into the putty index. The implants were embedded into the resin and their straight insertion was ensured my means of a Dental Surveyor.

It was ensured that the implants did not sink into the resin by means of a Self Cure Acrylic Stop secured to the rim of the putty index. Fig 2.

Fig.2 pouring of Araldite resin into the putty index with implant embedded in it

They were placed in a pressure pot at 40lbs/sq inch pressure for 8 hours, to remove the internal air bubbles. After the models had set, they were retrieved from the putty index and finished and polished. Wax copings were fabricated over these abutments and casted to form metal copings. The orifice of the abutments were sealed with Zinc Oxide Eugenol cement and the copings were cemented onto the abutments with Glass ionomer cement, Fig 3.

Group A Group B

Fig 3 photoelastic models

The models were de-stressed prior to load testing to release the stresses that may have been incorporated during fabrication and finishing- polishing procedures. The models were placed in a water bath in an Acrylizer preset to a temperature of 50°C for 10 minutes.

The models were then placed in a circular polariscope one by one and an axial and oblique load (at 45° angulation) of 10Kgf (100N) was applied, Fig 4.

Fig.4 circular polariscope

RESULTS

Using the polariscope in circular mode an axial load and oblique load at 45 degree, was applied on each implant-abutment. The images of the isochromatic fringes were obtained and captures with a digital camera, Fig 5- 8. These fringes show the distribution of stress around the implant abutments. The fringes were evaluated in crestal and apical area of the implant both qualitatively and quantitatively. The number and proximity of the fringes indicated more stress concentrations in the area being assessed.

In Group A, when axial load was applied maximum proximity of fringes was observed the crestal area of 3.75x10mm implant and least was seen in 5x10mm.

While in Group B (Platform switched), the fringes were fewer in number at the crestal areas and more in the apical area with the least number of fringes in 5x10mm implant.

Upon application of oblique load, the stress concentration was more on the contra lateral crestal side than the ipsilateral side of load application. And more fringes were observed in the Group A than Group B.

The quantitative assessment was made using the stress optic law for which first the fringe constant of the epoxy resin was calculated which was found to be 20.38.

Then for each examination site the following formula was apllied:-

$$\sigma_1 - \sigma_2 = f_\sigma \frac{N}{h}$$

where σ1 and σ2 are the principal stresses at that point, fσ is the material fringe constant, N is the fringe order and h is the thickness of the photoelastic model.

The quantitative analysis is shown in table 1 and 2

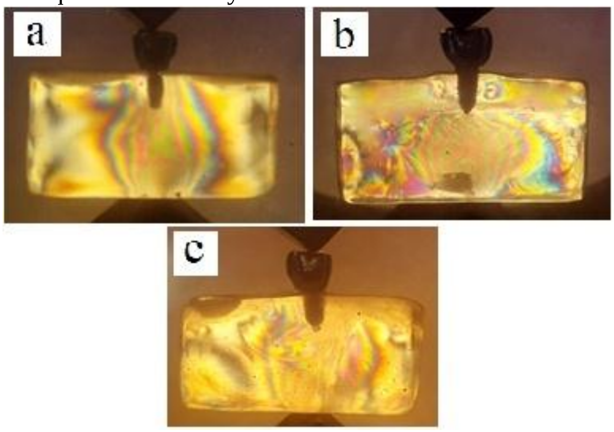

Fig 5: Group A – Axial loading with implant dimensions of a) 3.75x10, b) 4.2x10, c) 5x10

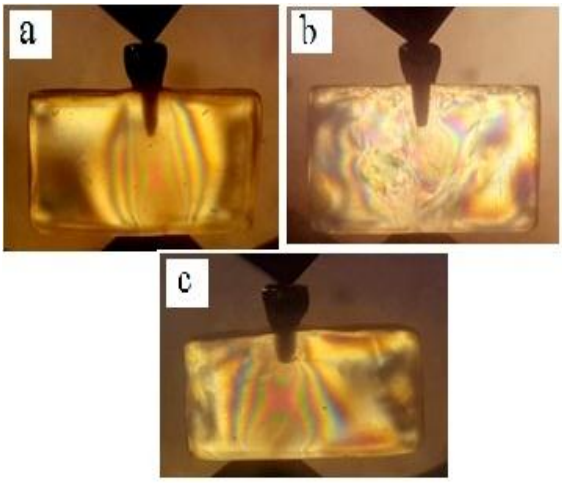

Fig 6: Group B – Axial loading with implant dimensions of a) 3.75x10, b)4.2x10, c) 5x10

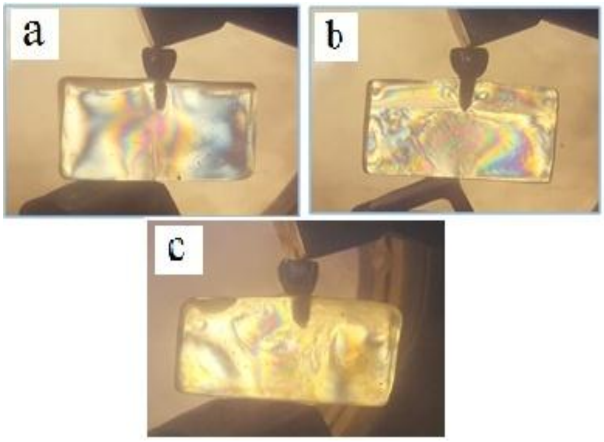

Fig 7: Group A – Oblique Loading with implant dimensions of a) 3.75x10, b) 4.2x10, c) 5x10

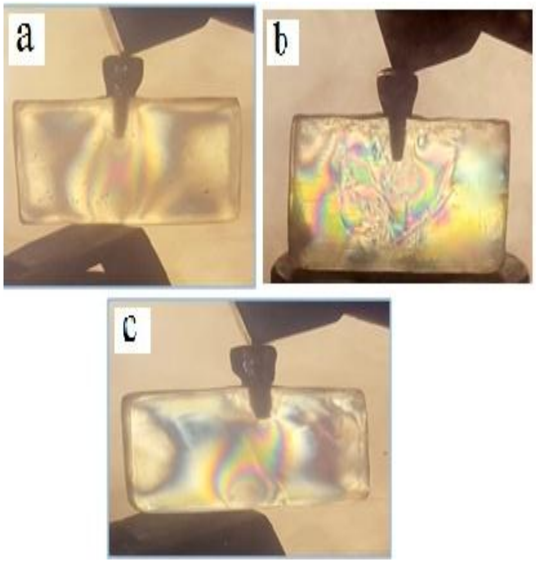

Fig 8: Group B – Oblique Loading with implant dimensions of a) 3.75x10, b) 4.2x10, c) 5x10

TABLE 1: COMPARISON OF MEAN STRESS (IN MPa) UPON AXIAL LOADING IN PLATFORM MATCHED (GROUP A) AND PLATFORM SWITCHED (GROUP B)

IMPLANT	LOCATION	GROUP A	GROUP B
3.75 X 10	MESIAL	7.473	1.087
	DISTAL	12.092	0.951
	APICA.L	5.094	4.619
4.2 X 10	MESIAL	5.502	1.159
	DISTAL	7.744	2.106
	APICAL	5.027	4.434
5 X 10	MESIAL	2.853	1.019
	DISTAL	2.038	0.747
	APICAL	5.434	3.252

TABLE 2: COMPARISON OF MEAN STRESS (IN MPa) UPON OBLIQUE LOADING IN PLATFORM MATCHED (GROUP A) AND PLATFORM SWITCHED (GROUP B)

IMPLANT	LOCATION	GROUP A	GROUP B
3.75 X 10	MESIAL	9.511	5.774
	DISTAL	4.416	0.815
	APICAL	5.774	7.133
4.2 X 10	MESIAL	7.713	4.415
	DISTAL	5.774	0.815
	APICAL	8,492	5.774
5 X 10	MESIAL	2.038	6.114
	DISTAL	0.815	0.815
	APICAL	5.502	4.415

Statistical Analysis

The statistical analysis is shown in Table 3 and 4. Student T test was performed and the T value was calculated to compare the results of Group A and Group B. It was found that, upon axial loading, significant (T value > 2.17) results were obtained when comparing the crestal areas of both the groups while non significant results (T value < 2.17) were obtained when comparing the apical aspects of 3.75 and 4.2 implants of both platform non switched and switched models.

Upon oblique loading, again significant results were found in both the groups except the distal crestal area and apical area of 5x10mm implant of both groups.

TABLE 3: STATISCAL ANALYSIS WITH WITH STUDENT T TEST AXIAL LOADING

IMPLANT	LOCATION	GROUP A		GROUP B		T VALUE
		MEAN	SD	MEAN	SD	
3.75 X 10	MESIAL	7.47	1.07	1.09	0.43	11.36 (S)

	DISTAL	12.09	0.78	0.95	0.43	22.63 (S)
	APICAL	5.09	0.58	4.62	0.15	1.25 (NS)
4.2 X 10	**MESIAL**	5.50	0.37	1.16	0.33	11.65 (S)
	DISTAL	7.74	0.60	2.11	0.25	13.65 (S)
	APICAL	5.03	0.60	5.43	1.15	0.68 (NS)
5 X 10	**MESIAL**	2.85	0.15	1.02	0.46	5.25 (S)
	DISTAL	2.04	1.15	0.75	0.70	4.14 (S)
	APICAL	5.43	0.29	3.25	0.14	7.45 (S)

TABLE 4: STATISCAL ANALYSIS WITH WITH STUDENT T TEST OBLIQUE LOADING

IMPLANT	LOCATION	GROUP A		GROUP B		T VALUE
		MEAN	SD	MEAN	SD	
3.75 X 10	**MESIAL**	9.51	0.48	5.77	0.48	18.57 (S)
	DISTAL	4.42	0.48	0.81	0.35	2.53 (S)
	APICAL	5.77	0.48	7.13	0.48	2.53 (S)
4.2 X 10	**MESIAL**	7.17	0.46	4.41	0.48	5.25 (S)
	DISTAL	5.77	0.48	0.82	0.35	10.59 (S)
	APICAL	8.49	0.48	5.77	0.48	5.06 (S)
5 X 10	**MESIAL**	2.03	0.48	6.11	0.48	7.59 (S)
	DISTAL	0.82	0.35	0.82	0.35	0 (NS)
	APICAL	5.50	0.58	4.42	0.48	1.82 (NS)

DISCUSSION

The Platform Switching concept was accidentally discovered in the 1980s and early 1990s, when commercial dental implant manufacturers introduced implants of larger diameter before producing the corresponding abutments of the same diameters. About 14 years later, when those treatments in which abutments were of lesser diameter than implants, were evaluated, it was found that a better preservation of hard and soft tissue was seen that abutments of same diameter.[3,20] Previous studies have been conducted to show the clinical and biological advantages of this technique[9-12, 14-16], however the biomechanical aspects have been minimally researched. So this study was aimed at analyzing the magnitude of stress imparted by platform switched and non switched implants. Previous studies have used implants that are not commonly used in India. This study was conducted on Lance, MIS implants, Israel, which is commonly used in India.

This study, 6 implants of standard length of 10mm and diameters of 3.75mm, 4.2mm and 5mm (LANCE, MIS IMPLANTS, MIS TECH. LTD., ISRAEL) were considered in this study. They were divided into two groups A and B. To group A, platform matched abutments were connected and to group B platform switched abutments were connected and the samples were embedded in a photoelastic resin EPOXY RESIN, ARALDITE CY 230-1 IN AND ARADUR HARDENER (HUNTSMAN ADVANCED MATERIALS LLC, DELAWARE, USA) in the ration of 5:1. Load of 100N (10 kg) was applied on the implants and the stress pattern was analysed in a circular polariscope.

It was observed that the maximum stress for group A was found in crestal area of 3.75 x 10 (12.092Mpa) implant and least was in the crestal aspect of 5 x 10 (2.038Mpa).For group B maximum stress was observed in apical area of 3.75 x 10 (4.619Mpa) proving the concept of centralization of stresses, and minimum in the crestal aspect of 5 x 10 (0.747Mpa).The results of group B that is platform switched implants were significantly lower than group A in the crestal area, clearly indicating that application of the concept of platform switching in the prosthetic options for implants reduces the stress concentrations around the implant and hence decreases the rate of bone loss.

Analysis of axial loading showed that Group B (platform switching) presented a stress distribution pattern that differed from that of Group A, with more centralization of stresses at the implant apex. This is because of the load concentration at the IAJ,[14] which transfers the stress to a more centralized position.[13] This theory of centralization was verified by **Maeda et al** through finite element analysis, which revealed that stresses on a platform switching implant are located at the center of the implant-abutment joint (at the level of the implant screw).[17]

The results of this study precludes the study of **Maeda et al**, that obtained greater stress at the apex of implants of Internal Hex.[17] Consistent with previous studies,[9,10,11,13] the stress concentrations in Model B decreased at the cervical region. Similar findings have been observed in histological, histomorphometric,[12,21] clinical,[9,10,11] and retrospective studies.[14,16,21] Finite element analysis studies have also shown that the stress concentration is lower in the cervical region of platform switching implants compared with non platform switched implants.[17,18]

Ding et al found that use of wider diameter implants increased the bone-implant contact surface area, thus increasing the amount of bone around the implant causing theoretical improvement of stress distribution in the surrounding bone.[22] In this study, least stress concentration was seen around the wide diameter 5x10mm implant and statistically non significant results were obtained when comparison between platform switched and platform matched wide diameter implants was made. Several other studies using various methods to compare regular and wide-diameter implants found good biomechanical behavior among the wide-diameter implants.[23,24]

Analysis of results from oblique loading showed greater stress concentration on the contra lateral side of load applied in all the models, however results of Group B were still lesser in magnitude than Group A.

The results of this study is in accordance to the study by Eduardo Piza Pellizzer et al[25] and Fabiana Rossi et al[26] who, by photoelastic analysis demonstrated favourable stress distribution in platform switched than non-switched implants.

This technique is an effective way to control circumferential bone loss around dental implants, although it has been tested by few biomechanical studies. The present study showed the favorable biomechanical behavior of the platform switching technique and found no significant differences between wide-diameter and platform switching implants with respect to the magnitude of stress, upon oblique loading.

CONCLUSION

- Stresses around platform switched implants (group B) showed least values in the crestal areas.
- More stresses were seen in the crestal areas of platform matched (group A)
- Less stresses were also seen in wide diameter implants.

REFERENCES

1. Levin L. Dealing with dental implant failures. J Appl Oral Sci 2008; 16(3): 171-75.
2. Astrand P, et al. Implant treatment of patients with edentulous jaws: A 20-year follow-up. Clin Implant Dent Relat Res., 2008; 10(4): 207-17.
3. Luongo R, et al. Hard and soft tissue responses to the platformswitching technique. Int J Periodontics Restorative Dent, 2008; 28(6): 551-57.
4. Albrektsson T, et al. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants, 1986; 1(1): 11-25.
5. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent, 1989; 62(5): 567-72.
6. Quirynen M, van Steenberghe D. Bacterial colonization of internal part of two-stage implants: an vivo study. Clin Oral Implants Res. 1993; 4: 158–161.
7. Ericsson I, Persson LG, Berglundh T, et al. Different types of inflammatory reactions in periimplant soft tissues. J Clin Periodontol. 1995; 22: 255–261.
8. King GN, Hermann JS, Schoolfield JD, et al. Influence of the size of the microgap on crestal bone levels in non-submerged dental implants: a radiographic study in the canine mandible. J Periodontol. 2002; 73: 1111–1117.
9. Chiche FA. The concept of platform-switching. J Parodontologie & d'Implantologie Orale (JPIO). 2005; 1: 30–36.
10. Degidi M, Iezzi G, Scarano A, et al. Immediately loaded titanium implant with a tissue-stabilizing/ maintaining design ('beyond platform switch') retrieved from man after 4 weeks: a histological and histomorphometrical evaluation: a case report. Clin Oral Implants Res. 2008; 19: 276-282.
11. Calvo Guirado JL, Saez Yuguero MR, Pardo Zamora G, et al. Immediate provisionalization on a new implant design for esthetic restoration and preserving crestal bone. Implant Dent. 2007; 16: 155–164.
12. Becker J, Ferrari D, Herten M, et al. Influence of platform switching on crestal bone changes at nonsubmerged titanium implants: a histomorphometrical study in dogs. J Clin Periodontol. 2007; 34: 1089–1096.
13. Lazzara RJ, Porter SS. Platform switching: a new concept in implant dentistry for controlling postrestorative crestal bone levels. Int J Periodontics Restorative Dent. 2006; 26: 9–17.
14. Hurzeler M, Fickl S, Zuhr O, et al. Peri-implant bone level around implants with platform-switched abutments: preliminary data from a prospective study. J Oral Maxillofac Surg. 2007; 65(7): 33-39.
15. Baumgarten H, Cocchetto R, Testori T, et al. A new implant design for crestal bone preservation: initial observations and case report. Pract Periodontics Aesthet Dent. 2005; 17: 735–740.
16. Calvo Guirado JL, Ortiz Ruiz AJ, Go´mez Moreno G, et al. Immediate loading and immediate restoration in 105 expanded-platform implants via the DiemSystem after a 16-month follow-up period. Med Oral Patol Oral Cir Bucal. 2008; 13: 576–581.
17. Maeda Y, Miura J, Taki I, et al. Biomechanical analysis on platform switching: is there any biomechanical rationale? Clin Oral Implants Res. 2007; 18: 581–584.
18. Liu XJ, Li ZY, Xia HB. Influence of implant abutment connection mode on stress distribution in peri-implant bone. Zhonghua Kou Qiang Yi Xue Za Zhi. 2008; 43: 50–53.

19. Caputo AA, Standlee JP. Biomechanics in Clinical Dentistry. Chicago, Ill: Quintessence Publishing Company; 1987.
20. Serrano-Sanchez P, Calvo-Guirado JL, Manzanera-Pastor E, Lorrio-Castro C, Bretones-Lopez P, Perez-Lanes JA. The influence of platform switching in dental implants. A literature review. Med Oral Patol Oral Cir Bucal. 2011 May 1; 16(3): 400-405.
21. Hermann F, Lerner H, Palti A. Factors influencing the preservation of the periimplant marginal bone. Implant Dent. 2007; 16: 165–175.
22. Ding X, Zhu XH, Liao SH, et al. Implant–bone interface stress distribution in immediately loaded implants of different diameters: a three-dimensional finite element analysis. J Prosthodont. 2009; 18: 393–402.
23. Himmlova L, Dosta lova T, Ka covsky A, et al. Influence of implant length and diameter on stress distribution: a finite element analysis. J Prosthet Dent. 2004; 91: 20–25.
24. Holmgren EP, Seckinger RJ, Kilgren LM, et al. Evaluating parameters of osseointegrated dental implants using finite analysis—a two-dimensional comparative study examining the effects of implant diameter, implant shape, and load direction. J Oral Implantol. 1998; 24: 80–88.
25. Eduardo Piza Pellizzer, Rosse Mary Falco n-Antenucci, Paulo Sergio Perri de Carvalho et al. Photoelastic Analysis of the Influence of Platform Switching on Stress Distribution in Implants. J Oral Implantol. 2010; 36(6): 419-424.
26. Rossi F, Zavanelli AC, Zavanelli RA. Photoelastic Comparison of Single Tooth Implant-abutmentBone of Platform Switching vs Conventional Implant Designs. J Contemp Dent Pract, 2011; 12(2): 124-130.