Comparison of Crestal Bone Loss along Two Implant Crest Module Designs

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Abstract

Background: Crestal bone loss along the dental implant surface deranges its prognosis and is known to occur with implants having 02 mm smooth crest module/collar design. Implants with rough coated crest module/collar design are said to reduce crestal bone loss. Comparison of crestal bone loss with both crest module/collar designs of implants needs to be done.

Methods: Twenty cases were selected. Each case received one implant with smooth collar design (Group-A) and one implant with coated rough collar design (Group-B). All the 40 implants were prosthetically loaded after a healing period of six months. Crestal bone loss was measured on mesial, distal, buccal and lingual side of each implant using maxillofacial computed tomography at six, twelve and eighteen months time interval after placing the implants. Soft tissue evaluation was carried out around each implant using Gingival, Plaque and Calculus Indices, six and twelve months after loading the implants.

Result: After 18 months i.e. one year after loading the implants, Group-A implants showed an overall average crestal bone loss of 1.53 mm and Group-B implants showed average bone loss of 1.42 mm, the difference being statistically significant ($p < 0.05$). For both types of implants, average crestal bone loss was maximum on the buccal side, followed by mesial, lingual and distal sides. Soft tissue evaluation revealed that the tissues remained healthy till the end of study for both types of implants.

Conclusion: Crestal bone loss was less among implants with rough collar design as compared to smooth collar design.

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Key Words : Crest module design; Implant; Crestal bone loss

Introduction

Dental Implantology has revolutionized the treatment modality for replacing missing single or multiple teeth with implant supported crown/prostheses. Criteria for success of an implant include its ability to osseointegrate with the bone bed in the host, to support a prosthesis and to sustain occlusal stresses during function.

Bone loss around the implant reduces its longevity. Bone loss begins from the crest/collar region of an osseointegrated implant and progresses apically. Possible causes of crestal bone loss could be a local inflammation/infection and mechanical stresses acting on the crestal bone around the implant crest module/collar [1].

Various dental implants with different surface designs are being used for dental rehabilitation of patients. Design of the implant crest module (or collar) can influence bone loss [2]. Many of them are two-stage, submerged implants with a 2 mm smooth coronal collar/crest module design. Bone loss with smooth collar has been observed [3-5]. It has been observed that implants having a rough/coated collar design show reduced crestal bone loss [6,7]. Bone loss with both collar designs needs to be evaluated and compared.

This in-vivo study was undertaken with the aim and objective to evaluate and compare, the vertical crestal bone loss occurring along the implant surface of implants with smooth coronal collar and implants with coated rough coronal collar crest module design. This would substantiate the basis of selecting an implant design which would have reduced crestal bone loss and hence, better success rate in the long term. Also, soft tissue health needs to be evaluated around both types of the implants.

Material and Methods

A total of 20 cases requiring replacement of two missing teeth with implant supported crowns in unilateral or bilateral edentulous areas in mandibular posterior region were selected. Patients were selected based on the criteria of age group- 25 to 50 years, non-smokers, good oral hygiene, availability for follow-up, healthy remaining dentition, adequate quality and quantity of bone, no parafunctional habits, no known systemic complications, no retained roots or pathologic lesions. Diagnostic tools used were study casts, orthopantomographs and intra-oral peri-apical radiographs.

Each patient received one implant with a 2 mm smooth polished crest module/collar design (Group-A implants, Pitt-Easy Bio-Oss™, Oraltronic, Germany) and another implant with a coated rough crest module/collar design (Group-B

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Fig. 1 : Pre-operative OPT of a selected case

Fig. 2 : Immediate post-operative OPT

Fig. 3 : Implant supported crowns in 36 and 46 regions

implants, Nobel Replace Tapered™, Nobel Biocare, Sweden). Both the groups of implants were two-stage, tapered, threaded implants. Suitable size of each type of implant was selected for each patient after carrying out diagnostic procedures. Each type of the implant was placed in the patient according to the surgical protocol recommended by its manufacturer (Fig. 2). Post-operatively, a maxillofacial computed tomography (CT) scan machine (Newtom™-Verona, Italy) was utilized to measure the first crestal bone to implant contact level from the top of the implant along the collar/body surface of each implant on the mesial, distal, buccal and lingual side. These measurements would become the baseline reference levels to measure future bone loss.

After allowing six months for healing and osseointegration, second stage surgery was performed to relocate the implants. Crestal bone levels were measured on the mesial, distal, buccal and lingual side of each implant using maxillofacial CT scan machine. Crestal bone loss was calculated by deducting the baseline reference bone levels from present levels, which gave the value of bone loss, occurred after six months of placing the implants. Prosthodontic procedures [8] were carried out for the fabrication of porcelain fused to metal (PFM) crowns and the crowns were luted with a eugenol-free zinc oxide cement (Rely X Temp Bond NE™, 3M ESPE) on the abutments of each type of implant. Upon prosthodontic loading, the implants became functional in occlusion (Fig. 3).

Six months after loading the implants i.e. one year after placing the implants, bone levels around each implant were measured with CT scan and bone loss was calculated by deducting the baseline reference bone levels. Crestal bone loss occurring after six and twelve months of implant loading was tabulated. The implant-abutment assembly penetrates out of the soft tissue over the alveolar bone only after the second stage surgery and prosthetic loading of the implant. Hence, peri-implant soft tissue evaluations were done six months after loading the implant with the crown using Löe and Silness Gingival Index, Silness and Löe Plaque Index, and National Institute of Dental Research Calculus Index. A William's graduated probe was used to record the scores around each implant. Twelve months after loading the implants i.e. 18 months after placing the implants, bone levels were again measured and crestal bone loss was calculated around each implant. Soft tissue evaluation was also carried out at this time.

Fig. 4 : Graphical comparison of mean crestal bone loss

Results

Statistical analysis was carried out using 'Paired t-test' to compare the bone loss along Group-A and B types of implants. Soft tissue evaluation scores obtained after six and twelve months of loading the implants were also analysed.

Table 1 depicts the mean values obtained for crestal bone loss and soft tissue evaluation done at specified time intervals. Fig. 4 is the graphical representation of comparison of the average crestal bone loss occurring around each type of implant at 6, 12 and 18 months after placing the implants.

The average crestal bone loss around the perimeter of Group- A and B implants after six months was 0.62 mm and 0.59 mm, after 12 months was 1.09 mm and 1.00 mm and after 18 months was 1.53 mm and 1.42 mm respectively. After 18 months i.e. one year after loading the implants, there was statistically significant difference in crestal bone loss along Group- A and B implants, average bone loss being more along Group- A implants ($p < 0.05$). The average scores for soft tissue evaluation indices were not more than 1, which implies that soft tissues remained healthy around Group- A and B implants, even at the end of 18 months after placing the implants.

Discussion

Many improvements have taken place over the last two decades with respect to the implant design and surface characteristics to increase the success rate of

Table 1Mean values ($\pm$ standard deviation)

Evaluation at Months	Bone loss (in mm)								Soft tissue evaluation					
	Group- A implants (Smooth collar)				Group- B implants (Coated collar)				Group- A implants (Smooth collar)			Group- B implants (Coated collar)		
	Mesial	Distal	Buccal	Lingual	Mesial	Distal	Buccal	Lingual	GI	PI	CI	GI	PI	CI
6 (Unloaded implants)	0.61 (0.22)	0.60 (0.23)	0.66 (0.23)	0.61 (0.22)	0.58 (0.26)	0.58 (0.26)	0.62 (0.27)	0.59 (0.26)	- -	- -	- -	- -	- -	- -
12 (Loaded implants)	1.09 (0.26)	1.07 (0.26)	1.13 (0.25)	1.07 (0.27)	1.01 (0.34)	0.99 (0.31)	1.03 (0.30)	0.99 (0.32)	0.55 (0.60)	0.50 (0.60)	00 (00)	0.65 (0.67)	0.60 (0.68)	0.60 (0.68)
18 (Loaded implants)	1.53 (0.28)	1.51 (0.28)	1.58 (0.28)	1.52 (0.29)	1.41 (0.35)	1.39 (0.35)	1.48 (0.34)	1.40 (0.35)	1.00 (0.32)	1.00 (0.32)	00 (00)	0.90 (0.30)	0.90 (0.30)	00 (00)

implants. The criteria for the success of an implant were proposed in 1986 [9]. However, the crestal bone loss occurring during the first year of implant service was not described. The amount of crestal bone lost during the first year of implant service affects the longevity of the implant. Ferracane et al [10], described that the success criteria for implant include an acceptable bone loss of 1.5 mm within the first year of implant service, but subsequent resorption should be less than 0.2 mm annually to ensure that adequate bone remains to provide stability to the implant.

Various causes of greater crestal bone loss in the first year of implant function are surgical trauma, occlusal overload, peri-implantitis, presence of microgap, reformation of biologic width and implant crest module design [1].

Implant crest module, or collar, of the implant body is the transosteal region of the implant and this collar is the region which receives the crestal stresses to the implant after loading. Collar is usually designed to minimize plaque accumulation; hence many implants have a polished smooth collar of varying lengths. The tissue height above the implant is on an average 2.5 mm and usually, the toothbrush bristles cannot enter a sulcus more than one mm. Thus, on the contrary, this smooth collar may contribute to bone loss. Crestal bone is weakest against shear forces and strongest against compressive forces. A smooth parallel collar results in shear forces in the crestal bone region. Resulting bone loss may be due to the lack of mechanical stimulation in the crest region. An angled crest module of more than 20 degrees with a surface texture that increases bone contact might result in compressive and tensile components, thus reducing crestal bone loss [2]. Crestal bone loss is reduced if the collar region is modified by incorporating microthreads and roughening it [11].

Sufficient data is not available to substantiate that a rough collared implant results in lesser crestal bone loss as compared to an implant with smooth collar. This in-vivo study was undertaken to compare the crestal bone

loss occurring along the implants with smooth collar surface and with rough collar surface.

In this study, Group- A implants (Pitt-Easy Bio-Oss™, Oraltronic, Germany) were two stages, tapered, threaded implants. The 2 mm crest module/collar was smooth, machine polished and the rest of the body of the implant was titanium plasma spray (TPS) coated. TPS coating increases the surface area manifolds, hence greater surface area of implant is available for osseointegration with the host bone bed.

Group- B implants (Nobel Replace Tapered™, Nobel Biocare, Sweden) were also two stage, threaded implants with entire implant body and collar coated with TiUnite™ coating. TiUnite™ is a highly crystalline and phosphate enriched titanium oxide which presents a microstructured topography without sharp features and is characterized by the presence of uniformly distributed open pores in the low micrometer range. The natural surface oxide of the titanium implant is made to grow in an electrochemical process to result in such a coating.

Both types of implants were placed in the same jaw of the subjects in similar regions i.e. mandibular posterior region, so that their bone beds have similar bone qualities and they receive similar occlusal forces during function.

From the results, it can be observed that six months after placing the implants, overall average crestal bone loss of 0.62 mm with Group- A implants and 0.59 mm with Group- B implants had occurred even when the implants were not prosthetically loaded with crowns. The difference in bone loss with both types of implants at this stage was statistically not significant. Surgical trauma and lack of positive stimulation due to occlusal forces may have caused this observed bone loss and these observations are commensurate with other studies [12].

Six months after loading the implants i.e. 12 months after placing the implants, overall average crestal bone loss was 1.09 mm with Group- A implants and 1.00 mm with Group- B implants. The difference in bone loss with both types of implants even at this stage was

statistically not significant, though the average difference was of 0.09 mm.

Twelve months after prosthetically loading the implants i.e. 18 months after placing the implants, the difference in overall average crestal bone loss was statistically significant, with 1.53 mm bone loss with Group- A implants and 1.42 mm with Group- B implants. It could be due to the fact that in Group- A implants, the 2 mm collar was smooth and parallel, which failed to cause positive stimulation to the adjacent bone and lead to disuse atrophy [3,4], apart from transmitting shear stresses to the crestal bone. Crestal bone being least resistant to shear forces, resorbed as a result. On the other hand, Group- B implants had a rough, parallel collar which could have converted part of the shear force component into compressive and tensile components due to its surface roughness and micropores. The adjacent crestal bone osseointegrates into the micropores, elevations and depressions of the rough collar area. Micromovements of implant occurring under occlusal forces during function may cause commensurate movement of the adjacent osseointegrated crestal bone. Such micromovements could have lead to a positive stimulation of the crestal bone and hence, lesser bone loss was observed.

After 12 months of loading the implants i.e. one year of implant service, the difference in crestal bone loss between Group- A and B was statistically significant on the mesial, distal and lingual side of the implants. On buccal side, the difference was not statistically significant, though average bone loss was more on the buccal side as compared to other three sides. The reason for greater bone loss on buccal side could be that the buccal plate is more dense and compact as compared to the interdental bone or the lingual plate, hence has comparatively less vascularization and healing potential. Average crestal bone loss was maximum on the buccal side of the implants, followed by mesial, lingual and distal sides. Average annual crestal bone loss after one year of implant service with Group- A implants was 0.91 mm and with Group- B implants, it was 0.83 mm. Both these figures are below one mm of annual bone loss in the first year of implant service and fulfil the success criteria as described by Ferracane [10].

Group- B implants with rough collar showed lesser average crestal bone loss as compared to Group- A implants with smooth collar. These results correspond to results of other studies [6,7].

The soft tissue health was reasonably good during the entire period of evaluation as the average score for all the three indices was not more than one, signifying mild inflammation at the most. Good oral hygiene was stressed before implant surgery as an essential

requirement for successful osseointegration and maintenance of the implants and prostheses.

Further studies with a larger sample size and with longer follow-up are recommended to substantiate the data presented in this study.

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Conflicts of Interest

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References

1. Oh TJ, Yoon J, Misch CE, Wang HL. The cause of early implant bone loss: Myth or science? *J Periodontol* 2002; 73: 322-33.
2. Misch CE, Bidez MW. A scientific rationale for dental implant design. In: Misch CE, editor. *Contemporary Implant Dentistry*. 2nd ed. St. Louis: Mosby 1999; 329-43.
3. Jovanovic SA. Diagnosis and treatment of peri implant complications. In: Newman MG, Takei HH, Carranza FA. *Carranza's Clinical Periodontology*. 9th ed. Philadelphia: WB Saunders 2003; 931-42.
4. Vaillancourt H, Pilliar RM, McCammond D. Factors affecting crestal bone loss with dental implants partially covered with porous coating: A finite element analysis. *Int J Oral Maxillofac Implants* 1996; 11: 351-9.
5. Wiskott HW, Belser UC. Lack of integration of smooth titanium surface : A working hypothesis based on strains generated in the surrounding bone. *Clin Oral Implants Res* 1999 ; 10: 429-44.
6. Pilliar RM, Deporter DA, Watson PA, Valiquette N. Dental implant design-effect on bone remodeling. *J Biomed Mater Res* 1991; 25: 467-83.
7. Hanggi MP, Hanggi DC, Schoolfield J, Meyer J, Cochran DL, Hermann JS. Crestal bone changes around titanium implants. Part I: A retrospective radiographic evaluation in humans comparing two non-submerged implant designs with different machined collar lengths. *J Periodontol* 2005; 76:791-802.
8. McGlumphy EA. Implant supported fixed prostheses. In : Rosenstiel SF, Land MF, Fujimoto J, editors. *Contemporary Fixed Prosthodontics*. 3rd ed. St. Louis : Mosby 2001; 313-53.
9. Albrektson T, Zarb GA, Worthington P, Eriksson AR. The long term efficacy of currently used implants: a review and proposed criteria for success. *Int J Oral and Maxillofac Implants* 1986; 1:11-25.
10. Ferracane JL. Clinical factors concerning implants. In: Ferracane JL, editor . *Materials in Dentistry-Principles and Applications*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins 2001; 318-9.
11. Norton MR. Marginal bone levels at single tooth implants with a conical fixture design. The influence of surface macro- and microstructures. *Clin Oral Implants Res* 1998; 9: 91-9.
12. Singh P, Garge HG, Parmar VS, Viswambaran M, Goswami MM. Evaluation of implant stability and crestal bone loss around the implant prior to prosthetic loading: A six month study. *J Indian Prosth Soc* 2006; 6: 33-7.