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The implant loading influence on crestal bone remodelling around hybrid titanium implants: a prospective clinical study

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Abstract. The aim of this work was to analyze the changes of the mesial and distal cortical bone peaks around the hybrid titanium implants in relation to the masticatory load up to 7 years of follow-up. The analysis aims how occlusal loads may affect the peri-implant bone years after insertion through two-dimensional analysis using intraoral digital radiographs. Twelve hybrid T3 implants (Biomet 3i) were placed in 9 healthy patients with the 2-stage surgical approach. Standardized digital Rx were taken after early loading (6-8 weeks) after placement (T0); after 12 months (T1); after 30 months (T2); after 4 years follow-up (T3), after 5 years follow-up (T4), after 6 years follow-up (T5), after 7 years follow-up (T6). The marginal bone gain and loss was digitally measured. From T2 to T4 (5 years follow-up) there was a new bone formation demonstrating that well-balanced load forces can ensure good maintenance, with a crestal bone gain during the 2.7 to 7-year follow-up period.

Keywords: correct implant loading, peri-implant bone resorption, marginal bone loss, dental implant, loading procedure.

INTRODUCTION

Prosthetic rehabilitation through the insertion of implants requires achieving osteointegration and maintaining the height of the cervical bone (6). In the analysis of the longevity of the rehabilitation treatment, occlusal biomechanics plays a fundamental role in preventing the failure of already osseointegrated implants and favouring their correct maintenance, since occlusal overload is one of the main causes of loss of bone insertion around implants (3).

In the last decade, it was already defined how the behaviour of bone structures can be predicted in the face of a constant stimulus, which translates into the preservation of bone tissue (5). An ineffective mechanical stimulus can lead to reabsorption due to disuse. Conversely, exacerbated values can lead to disorganizations, due to remodeling, which in turn cause irreversible structure micro-deformation (8).

When osseointegration processes are achieved, newly formed bone directly contacts the titanium surface, and bone remodeling allows the implant to be fixed into the vital bone during occlusion (12). Peri-implant bone preservation can be considered the paramount aspect for long-term successful treatment outcomes. The bone quantity/quality surrounding an implant, affects the osseointegration process and shape/outline of the above soft tissue, both important for treatment function and aesthetic efficacy (9).

In this light, data on a management procedure aimed at preventing or minimizing bone resorption, and short/long term is still lacking.

Therefore, it was the purpose of the present preliminary series to investigate in a cohort of 9 patients whether crestal bone changed in a time-dependent manner from early loading of hybrid implants to 7 years follow-up.

MATERIALS AND METHODS

Nine healthy patients were enrolled in the present prospective study and received 12 T3 implants (Biomet 3i, Palm Beach Gardens, FL, USA) using the 2-stage surgical approach (Table 1). A careful phase of general and specific intraoral anamnesis was performed for all patients, followed by first and second level radiographic examinations to analyze the quality and quantity of available bone.

Furthermore, diagnostic wax-ups were performed for each patient to guide the insertion of the implants from an occlusal biomechanical point of view. Surgical and prosthetic protocols followed manufacturer guidelines and were performed by a single investigator in a private clinic (T.T.). The implants had submerged healing for 3.1 ± 0.2 weeks.

The final restorations were placed 7.5 ± 0.6 weeks after implant placement (14). Six implants were restored with cemented porcelain fused to metal and six implants with cemented monolithic zirconia, on screw-retained abutments. A long-term follow-up period was established: the implants were checked 12 months (1 year), 30 months (2.7 years), 4, 5, 6, and 7 years after the final delivery of the restoration (13).

Digital intraoral radiographs and computer processing were done to measure levels of crestal bone remodeling as it was a high-quality method for scientific evaluations with an accuracy of <0.1 mm (2). X-ray recordings Radiographs were performed with a digital sensor adopting complementary metal oxide semiconductor technology capable of recording 1.92-megapixel images with a pixel size of 18.5 μm (Kodak RVG 6100 Digital Radiography System: Carestream Health Inc., Rochester, NY, USA). A multiphase follow-up method was used to identify the time course of bone changes induced by each clinical procedure up to 7 years of follow-up.

The implant was considered an individual unit to overcome possible problems resulting in a more positive outcome for patients with multiple implants.

Data were analysed after the normality assessment (Shapiro-Wilk test), using the Repeated Measures ANOVA (RMANOVA) followed by the Tukey post hoc test. Statistical significance was set at $P < 0.05$.

Table 1. General characteristics and surgical procedure parameters in patients admitted into the study.

Patient	Age	Sex	IS	OB	BD	ID (mm)	FTDD (mm)	FDUT (Ncm)	IP	IBF
1	64	F	3.6	Native	Normal	4 x 10	4.0	50	Sub.	Tight
			3.6	Native	Normal	4 x 10	4.0	50	Crestal	Firm
2	63	M	3.7	Native	Normal	4 x 10	4.0	50	Sub.	Firm
3	42	F	4.6	Native	Dense	4 x 8.5	4.0	50	Crestal	Tight
			4.5	Native	Dense	4 x 11.5	4.0	50	Crestal	Tight
4	47	M	4.7	Native	Dense	5 x 8.5	5.0	50	Crestal	Tight
5	53	M	3.4	Native	Normal	4 x 11.5	4.0	50	Crestal	Firm
6	48	M	2.5	Native	Normal	5 x 10	5.0	50	Sub.	Firm
7	42	F	3.6	Native	Normal	5 x 11.5	5.0	50	Sub.	Tight
			1.5	Augment	Dense	4 x 11.5	4.0	50	Sub.	Firm
8	40	F	1.6	Augment	Dense	4 x 13	4.0	50	Sub.	Tight
9	50	F	4.7	Native	Normal	5 x 8.5	5.0	50	Sub.	Firm

Abbreviations: IS, implant site; Sub.: Subcrestal.

RESULTS

The implants were perfectly osseointegrated and were loaded early 6-8 weeks after placement (T0) (7). Since loading the implants, no failures have been recorded and all fixed prosthetic restorations were stable at the end of the 7-year observation period. At T0 the mean peri-implant bone level was -0.43. The mean bone level at each step was 0.64 mm (T1), 0.76 mm (T2), 0.58 mm (T3), 0.47 mm (T4), 0.53 mm (T5), 0.49 mm (T6). These data showed that most of the peri-implant bone loss occurred in the period following early loading of the implants (11). There were no statistically significant differences in the comparison between T0 and the other follow-up periods in terms of crestal bone resorption around the implants ($p>0{,}05$). Therefore, implant with regular occlusal loading can maintain adequate crestal bone levels for correct long-term function.

DISCUSSION

Research in implant surgery, requires the maintenance of the crestal bone level over the years. The dependent factors are various, for example correct oral hygiene, a minimum required quantity of adherent gingiva and the occlusal load to which the implants are subjected (4). The most common problem is the absence of reference data on the peri-implant bone level over the long term in literature (>3 years). In the present study we found that in adult patients undergone to surgical procedure with Hybrid implant T3 (Biomet 3i, Palm Beach Gardens, FL, USA), longitudinal X-ray of the crestal bone level showed no differences between the short- and long-term follow-up. Most bone resorption occurred up to about 3 years (T2) (1). This supports the hypothesis that the primary reason for crestal bone loss during the first year of function, and thereafter, is the establishment of biological width. This process can therefore be considered a fast-acting factor (10). An important element is represented by the study carried out by our research group, where the behavior of the crestal bone was analyzed in the period between the second implant uncovering operation and their load. (T2) (11).

The main limitation of the present study is related to the small sample size. Furthermore, method of measuring the crestal bone level performed on digital X-rays, being operator dependent, can bring to a variability of results. In conclusion, the surprising factor that we found with this study was the crestal bone gain registered during the follow-up period from 2.7 to 7 years (T2-T6). We considered the applied load the main responsible for the bone gain stimulation, during a long period of correct functioning of the system crown-implant-bone. Future research is needed to shed lighter on these factors, such as finding a way to standardize bone response as a function of load.

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