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CROWN-TO-IMPLANT RATIO OF SHORT LOCKING-TAPER IMPLANTS PLACED IN POSTERIOR AREAS OF THE MAXILLA: A RETROSPECTIVE STUDY 2 YEARS AFTER LOADING

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Abstract. Introduction: The purpose was to study any relationship between crown-to-implant ratio and peri-implant bone loss of short, plateau-design, locking taper implants in posterior maxillary areas.

Methods: This retrospective clinical study was conducted between May 2013 and September 2013. The sample was composed of patients who had received at least one short implant (5-to-8-mm-long) between January 2009 and December 2011. The outcome variables were implant failure and peri-implant bone loss in relation to crown-to-implant ratio. Analysis of variance (ANOVA) was used to check out correlations between crown-to-implant ratio and peri-implant bone loss.

Results: Thirty-six subject who received 79 locking-taper implants were followed for an average of 24 months. Four implants failed, giving a cumulative survival rate (CSR) of 94.9%. The mean crown-to-implant ratio was 2.01. The peri-implant bone loss between prosthetic loading and last recall was 0.21 mm. No statistically significant relationship was observed between increasing crown-implant ratios and marginal bone loss ($P = .93$).

Conclusion: The crown-to-implant ratio, although high, was not associated to increased bone loss. However further studies with longer follow-up are needed to confirm our data.

Keywords: plateau-design implants; implant-abutment connection; resorbed posterior maxilla; retrospective study

● INTRODUCTION

The use of endosseous dental implants as tooth replacements has become today an accepted treatment modality in dentistry, giving high predictable results in terms of implant and prosthetic survival success rate. In regions affected with poor bone volume and quality, as are often observed the posterior areas of edentulous maxillae, the gold standard treatment for implant placement is pre-prosthetic surgery, which aspires to restore adequate bone levels before implant insertion [1, 2]. In patients who cannot afford this type of surgery because of systemic diseases or socio-economic conditions, short implants have been proposed as alternative therapy with increasing outcomes [3-5]. The criteria for implant success were described in 1986 by Albrektsson et al. [6], who established that the mean bone loss for healthy implants was 1.5 mm in the first year, followed by a mean bone loss of 0.1 mm per year.

Several factors can affect the success of implant therapy both in the medium and long term, and the crown-to-implant ratio appears to be a key factor in the maintenance of Osseo integration. Many studies [7-17] in literature gave particular importance on the length of the implant, often with conflicting results, concluding that an excessive crown-

to-implant ratio is a decisive factor on implant survival. Instead, other studies have shown that disproportionate crown-implant ratio is not related to increasing bone loss, also for short implants [15-21]. The importance of the C/I ratio relies on the theory that occlusal forces, including non-axial and overload, represent one of the biologic and technical complications for the implant failure [22]. The aim of this study was to assess the impact of crown-to-implant ratio on peri-implant bone resorption for short plateau-design locking-taper implants.

● MATERIALS AND METHODS

Study design and Sample. The present work is a retrospective clinical study after 2-years. Study samples were selected from a population of patients who received treatments for insertion of at least one short (5-to-8 mm long) plateau-design, locking-taper implant (Bicon® Dental Implant, Boston, USA) in the posterior areas of upper maxilla between January 2009 and December 2011 at the Department of Surgery, Clinic of Dentistry and Maxillofacial Surgery, University of Verona. All the implants observed were placed and restored by a single operator. Sample variables were grouped into the following categories.

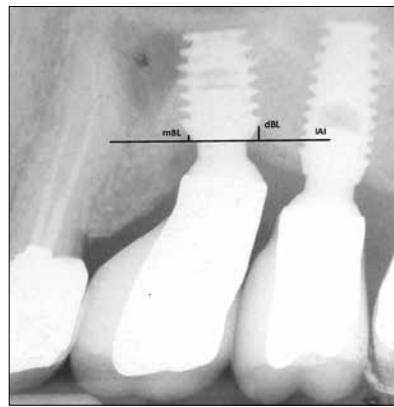


Fig 1. Marginal bone levels. Measurements from the IAI (implant/abutment interface) were obtained mesial (mBL) and distal (dBL).

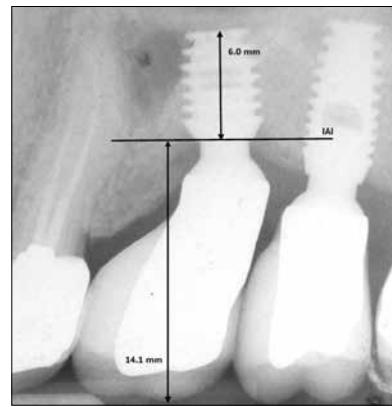


Fig 2. To obtain C/I ratio, implant height was divided by crown height. IAI: implant/abutment interface.

Patients Demographic, Health, and Anatomic Variables

- **Demographics:** The patient's gender and age at implant placement were documented.
- **Health status:** General health status was classified according to the American Society of Anaesthesiology (ASA) system. Patients were categorized as healthy (ASA 1), as having mild systemic disease (ASA 2), or as having moderate or severe systemic disease (ASA 3). Current tobacco use was also recorded.
- **Anatomics:** All the studied implants were placed in the posterior upper maxilla. Tooth type (premolar, molar) and proximity of implant relative to teeth or other implants were reported.

Implant, Prosthetic, and Reconstructive Procedures

- **Implant variables:** The implant length and diameter were recorded.
- **Reconstructive procedures:** Internal sinus lift procedures performed at the time of implant placement were recorded. The use of synthetic bone substitute grafting with beta tricalcium phosphate (β -TCP, SynthoGraft, Bicon) was also registered.
- **Restorative procedures:** The use of single crown or splinted prosthesis to restore the studied implants was recorded.

● FOLLOW-UP EXAMINATION

All patients included in the study were recalled for a follow-up examination between May 2013 and September 2013. Clinical and radiographic evaluations were accomplished to pursue the following outcomes.

Primary Outcomes

A periapical radiograph, in which the entire crown and implant were visible, was obtained. All radiographs were made using the paralleling technique [23]. Despite this technique minimizes the actual implant size distortion, some minor distortion may still exist [24]. In any case, accurate measurements of

peri-apical radiographs have been demonstrated in literature to be reliable [25], and distortion involves equally the crown and the implant, so that their ratio is not significantly affected. Radiographs with gross distortion, poor contrast, and poor definition at the implant-crown interface were excluded from the study.

The crown height and the peri-implant bone levels were measured using a software program (Rasband, W.S., Image J, U. S. National Institutes of Health, Bethesda, Maryland, USA) measuring tool in conjunction with a magnification tool. The crown height was measured from the most occlusal point to the implant-abutment interface (IAI).

Crestal bone changes were measured medially and distally by comparing periapical radiographs obtained on the day of the insertion of the definitive restoration to the most recent radiographs available. A negative value implied bone loss over time, while a positive number suggested an increase in crestal bone levels over time. According to previous published criteria, this variable was designated as FBIC (first bone-to-implant-contact), and was measured from the implant-abutment interface (IAI) to the highest level of bone-to-implant contact (Fig 1).

Crown-to-implant ratios were calculated by dividing the digital length of the crown by the digital length of the implant (Fig 2). The peri-implant bone loss was calculated for each implant as the difference between the bone levels observed at prosthetic loading and those observed at the recall visit.

Secondary Outcomes

Implant failure was defined as removal of the implant for any reason. For each subject, the date of the implant placement, the final restoration, the recall visit as well as the eventually implant failure were recorded.

The time between prosthetic loading (and visit recall or implant removal) was defined as the duration of implant survival.

The peri-implant soft tissues parameters, such as modified bleeding index (mBI), modified

Table 1. Patients Demographic, Health, and Anatomic Variables

Variable	n°	%
Gender		
Women	24	66.7%
Men	12	33.3%
Mean age at implant placement	52.4 ± 9.6 y	
Health status variables		
ASA status		
ASA I	26	72.2%
ASA II	10	27.8%
Current tobacco use		
No	23	63.9%
Yes	13	36.1%
Tooth type		
Premolar	43	54.4%
Molar	36	45.6%

plaque index (mPI) and probing depth (PD) [26], were carried out from the perio-chart performed during the last follow up examination.

● DATA MANAGEMENT AND STATISTICAL ANALYSES

A database was created with appropriate checks to identify errors. SPSS statistical software (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp) was used to evaluate the data and to perform statistical analyses. Descriptive statistics were accomplished for demographic variables, implant survival rate and peri-implant soft tissues parameters.

Statistical analysis with analysis of variance (ANOVA) was used to identify any relationship between crown-to-implant ratios and the peri-implant bone loss during observation time. Significance was set at $p < 0.05$.

● RESULTS

A total of 79 implants, with an average follow-up period of 24.4 ± 12.2 months, were placed in posterior regions upper maxillae of 36 patients. The most common implant location for short implant was the premolar site of posterior upper maxilla (43 implants; 54.4%). There were 35 (44.3%) short implants placed with internal sinus lift procedure. Descriptive statistics for the study variables are presented in Tables 1 and 2.

Sixty-three implants (79.8%) were restored with single crown, whereas 13 implants supported splinted prosthesis. Finally, three implants were not loaded. Two of these were removed due to lack of Osseo integration at uncovering, whereas the last one showed around pain and

inflammation one months after placement, so a flap was raised and the implant was removed. An implant restoring a maxillary left second premolar, and supporting a single crown, was found affected by severe bone loss due to peri-implantitis, and was removed 2 years after prosthetic loading. A total of four implant failed in four different patients, giving a cumulative survival rate of 94.9%. Regarding the four failures documented, three implants were placed in female patients, and only one was placed in a smoker. Table 3 summarizes the failed implants features.

The mean measured crown length for loaded implant was 12.32 ± 2.18 mm, with a range of 5.82 to 17.69 mm (CI95: 11.81 – 12.82). Thus, the mean crown-to-implant ratio calculated was 2.01 ± 0.54 (CI95: 1.89 – 2.14). Forty-five implants (55.8%) had crown-to-implant ratio slower than 2:1, and thirty-four implants (44.2%) possessed crown-to-implant ratios of equal or greater than 2:1. Average mesial and distal marginal bone loss measured from the digital radiographs between prosthetic loading and recall visit were 0.25 ± 0.45 mm and 0.19 ± 0.45 mm respectively, with an average mesial-distal value of 0.21 ± 0.39 mm (CI95: 0.12 – 0.30). The average bone loss for implants with C/I ratio lower than 2:1 was 0.22 ± 0.45 mm (CI95: 0.08 – 0.36), whereas the value for implant with C/I ratio equal or greater than 2:1 was 0.21 ± 0.31 mm (CI95: 0.10 – 0.32).

Statistical analysis with ANOVA were used to evaluate any relationship between crown-to-implant ratios and marginal bone loss. No statistically significant relationships were found

Table 2. Implant, Prosthetic, and Reconstructive Variables

Variable	n°	%
Implant length		
5 mm	25	31.7%
5.7 mm	5	6.3%
6 mm	19	24%
8 mm	30	38%
Implant diameter		
3.5 mm	2	2.5%
4 mm	13	16.5%
4.5 mm	26	32.9%
5 mm	32	40.5%
6 mm	6	7.6%
Type of prosthesis/restoration		
Single crown	63	79.8%
Fixed prosthesis/splinted	13	16.4%
Not loaded	3	3.8%
Immediate extraction		
No	75	94.9%
Yes	4	5.1%
Bone augmentation at implant placement		
None	44	55.7%
Internal sinus elevation	35	44.3%
Augmentation material		
None	34	43%
B-TCP	45	57%

between increasing crown-to-implant ratios and increasing marginal bone loss around the implants, with P values of .93.

Regarding peri-implant soft tissues parameters recorded at the last perio-chart performed for each patient, the average mBI was 0.15 ± 0.20 (CI95: 0.10 – 0.19), the average mPI was 0.05 ± 0.14 (CI95: 0.02 – 0.09), and the average PD was 2.56 ± 0.60 mm (CI95: 2.42 – 2.69).

● DISCUSSION

The placement of endosseous implants in the posterior region of the maxilla could be difficult if the bone volume is significantly reduced due to the pneumatization of the maxillary sinus and/or resorption of the alveolar crest.

For this reason, many Authors used «short» implants (<10 mm length) in cases where the implant placement was not considered possible without the use of ridge augmentation procedures. In the posterior maxilla, the treatment success could be influenced by the need to offset severe vertical discrepancies derived by atrophy. This fact may result in higher crown length and higher crown-to-implant ratios for short implants inserted in this region.

In our study, we analysed the behaviour of 79 short locking-taper implants with a plateau design, inserted in the posterior region of the maxilla. After an observation period of two years from the prosthetic loading, the cumulative survival rate (CSR) was 94.9%. Four implants were lost: three implants failed before loading (length

Table 3. Failed implants characteristics

N°	Length (mm)	Diameter (mm)	Gender	Current tobacco use	ASA Status	Tooth	Bone Augmentation	Graft Material	Type of Prosthesis
1	6	4.5	F	No	1	Premolar	No	No	Not Loaded
2	8	4.5	M	Yes	1	Molar	Internal Sinus Lift	β-TCP	Not Loaded
3	8	5	F	No	1	Premolar	No	No	Not Loaded
4	8	4.5	F	No	1	Premolar	No	No	Single Crown

4.5 x 8 mm; 5 x 8 mm; 4.5 x 6 mm) and one 4.5 x 8 mm implant was lost due to peri-implantitis after 24-months of loading.

In literature, several studies attest the effectiveness of the use of short implants in the atrophic posterior maxilla.

Regarding the implants used in our work, in 2002 Vehemente [27] reported a CSR of 677 implants after 1-year and 5-years follow-up equal respectively to 95.2% and 90.2%.

A study of Gentile [18], conducted on 172 locking taper plateau design implants, has compared the results obtained with 45 ultra-short implants (5.7 mm length) (11 of which are located in the posterior area of the maxilla) with 127 implants ranging from 8 to 14 mm in length. The cumulative survival rate observed at 1 year was 92.2% (3 failures) for ultra-short implants and 95.2% (9 failures) for the other length implants. The differences between the two groups were not statistically significant, being able to conclude that the results obtained with ultrashort implants are comparable to those obtained with standard implants.

In a retrospective study, Birdi [28] analysed the cumulative survival rate of 309 locking-taper implants (122 placed in posterior maxilla) ranged from 5.7 mm to 6 mm in length, restored with single crown, referring no failure after 2 years of loading.

Urdaneta [29] reports the results of 199 short (8-mm) and 211 ultra-short (6-mm) locking-taper implants. In posterior areas of the maxilla were positioned 96 short- and 94 ultrashort implants. After an observation period of 20 months, 5 ultrashort and 4 short implants failed. Among the failed implants, 6 were localized in the maxilla. The cumulative survival rate was 97.5%. The author concluded that, in terms of survival, both short and ultrashort implants were comparable. The cumulative survival rate we observed seems to be comparable to that of other authors who have studied the same implant system, and in general comparable to the average survival rate observed in other studies on short implants placed in the posterior region of the maxilla.

With regard to the peri-implant bone loss in our study, the mean change observed was equal to 0.21 ± 0.39 mm from the time of prosthetic loading and 2-years recall visit. Many Authors analysed stability of peri-implant bone around short implants. In the retrospective study of Birdi [28], the mesial and distal peri-implant bone loss after 2-years follow-up was 0.2 ± 0.7 mm and 0.2 ± 0.9 mm respectively.

Mangano [30] reported the bone loss around screw 8-mm long implants equal to 0.31 ± 0.24 mm after 1-year, 0.43 ± 0.29 mm after 5-years and 0.31 ± 0.62 mm after 10 years follow-up periods.

In other two studies, Pieri [31] reports a variation of bone level surrounding short implant equal to 0.45 ± 0.34 mm at 3 years while Renouard [4] gives a mean bone resorption of 0.52 ± 0.44 mm after two years from the prosthetic rehabilitation.

Ten Bruggenkate [3] observing the peri-implant bone changes on 2536-mm length implants after an observation period from 1 to 7 years noted no bone loss in 72% of cases, 1 mm of bone loss in 16% of cases, 2 mm bone loss in 9% and more than 3 mm of bone loss in 3% of cases. Short implants tested by De Santis [32] showed a bone loss equal to 0.6 ± 0.2 mm in an observation period of 1 to 3 years after prosthetic loading. The 85% of implants studied by the author had a bone loss ranged between 0.1 and 1 mm.

Analysing the influence of crown-to-implant ratio on the change of bone level, Rokni [17] in 2005 published a study on 199 sintered porous surface implants with a C / I ratio ranging between 1:1 and 2:1. After an observation period of 46 months, the author referred that the crown-to-implant ratio does not affect the stability of crestal bone height.

In another study Schulte [15] observed the cumulative survival rate of 889 short implants with an average C/I ratio equal to 1.3 ± 0.3 . The survival at 2.3 ± 1.7 years was 98.2%.

In the study by Birdi [28] mentioned above the C/I ratio was 2.0 ± 0.4 . The Author concluded that there was not an association between a high or normal C/i ratio and the peri-implant bone level in terms of bone resorption. In addition, Urdaneta [33] reported in his study that a high C/I ratio (range 0.79-4.95) does not affect peri-implant bone levels, increasing however the prosthetic complications. In our study we observed that in cases where the C/I ratio was less than 2:1 overall bone loss was 0.22 ± 0.45 mm and where the C/I ratio was greater than 2:1 we observed a bone loss amounting to 0.21 ± 0.31 mm. Between these two groups there was no statistical significance. Compared with the studies by Birdi and Urdaneta, our study presents the limit derived from the inclusion of implants restored not only by single crowns, but also implants restored with splinted prosthesis were included. However, no differences regarding the peri-implant bone loss were found for implants restored with different types of prosthesis in our study, with an average bone loss of 0.16 ± 0.41 mm for implants supporting single crowns and 0.23 ± 0.28 mm for implants supporting bridge prosthesis.

With regard to peri-implant soft tissues parameters, we found low level of inflammation in our implant population. These conditions were achieved by strictly maintenance recall visits of

our patients reflected on peri-implant bone levels during the observation period.

● CONCLUSION

The implants of this study seem to be able to provide similar results to those of other studies reported in the literature in the maxilla. The reduced implant length has led to an increase in the crown-to-implant

ratio, but even so, peri-implant bone levels appear to remain stable over time. Furthermore, the health of peri-implant soft tissues attests the importance to have an individual recall protocol for each patient.

The analysis of our results allows us to hope that further studies will be carried out for this kind of implant system to verify the reliability after longer observation periods.

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