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Crestal bone loss in ultrashort implants: retrospective study on two different types of fixture

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ABSTRACT

Aim This was to assess variation of mean crestal bone loss (CBL) when two different types of ultrashort implants are placed in the upper or in the lower jaw and to evaluate differences in terms of success and survival rates.

Materials and methods 99 ultrashort implants were retrospectively evaluated assessing differences at three different time-points (placement, prosthetic loading, end of follow-up) in terms of CBL in the upper and lower jaw. Correlations between CBL and diameter, platform switching, site of placement (upper or lower), type of implants, clinical crown/implant ratio and anatomical crown/implant ratio were statistically performed and success and survival rate were assessed.

Results Statistically significant correlations were found between CBL and implant diameter, kind of screw and anatomical crown/implant ratio at the end of follow up. No correlation was highlighted between CBL and platform switching, and site of placement (upper or lower jaw). Survival and success rates were comparable and were found to be 96.37% in the upper jaw and 94.46% in the mandible.

Conclusion CBL in ultrashort implants is an issue deserving great attention, therefore to know features and behaviours of different ultrashort implants in different quality of bone and clinical conditions represents a cut above to obtain and maintaining success in this particular kind of rehabilitation.

KEYWORDS Ultrashort implants, Crestal bone loss, Jaws, Implant morphology.

INTRODUCTION

Bone resorption can be influenced by many factors such as teeth loss, age, gender, periodontal diseases, diabetes, smoking, previous lost implants, kind of prosthetic rehabilitation, time elapsing before implant rehabilitation, and others (1,2). As alveolar ridge volume results from stimulus of natural teeth, a lack thereof inevitably leads to a constant and predictable bone resorption (3,4). Reduced bone availability often precludes the feasibility to place standard length implants. To face this issue, different ridge preservation and bone-regenerative techniques have been developed in order to increase bone height and width (1,5). Literature reports sound results in terms of predictability of these techniques, however they are also difficult to be performed, invasive, time-consuming in addition to the increased risk of postoperative morbidity (6).

In this perspective, short and extra-short implants became a good alternative to face clinical cases with inadequate alveolar ridge levels allowing to avoid challenging surgical procedures, to preserve anatomic structures and to reduce surgical time, cost and patient's discomfort when compared to bone augmentation procedures (7,8).

Although there is no terminology consensus for implant length, a recently proposed classification suggested short implants ranged between 6 mm and 10 mm length, whereas those of 6mm or less are classified as ultrashort (9,10). The posterior region is commonly affected by extensive resorption, resulting in outsized crowns and a high crown-to-implant ratio when short or ultrashort implants are placed (11,12). However, recent literature demonstrated that short and ultrashort implants are preferred for rehabilitating regions with severe alveolar atrophy with notable success and survival rates, on the other hand standard-length implants inserted after bone grafting are of choice when conditions are not right for short and ultrashort implant placement (10,13).

Aims of this retrospective study were to assess variation

of mean crestal bone loss (CBL) for two different types of ultrashort implants when they are placed in the upper or in the lower jaw and to evaluate differences in terms of success and survival rate.

MATERIALS AND METHODS

Study design

Records of 72 patients treated from October 2008 to May 2018 with 6 mm ultra-short implants and subsequently fitted with single crowns or implant-supported fixed prostheses were included in the study.

All records mentioned in this work were extrapolated from a database fulfilled by authors for each patient from recruiting, however some patient dropped-out of study, therefore it was not possible to have the same follow-up for all of them. However, authors preferred to include as more data as possible in order to increase the power of the study. This resulted in the mean follow-up reported.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (University of Verona, Italy) and with the 1964 Helsinki declaration and its later amendments. Institutional research committee evaluated and approved clinical procedures (surgical and prosthetic) shown in this paper and routinely used in clinical practice.

All patients signed an informed written consent for all procedures reported.

Same surgical protocol was followed by the same experienced surgeon (ML) for all patient accordingly to the manufacturer indications, based on clinical and radiographical evaluations and planning. A cone-beam computed tomography (CBCT) in dental scan mode was used to assess bone width and height and to plan surgery.

Inclusion criteria, that we considered to enroll patients for surgery were: patients aged over 18 years old; partial edentulisms in the posterior region of both jaws; bone height ≥ 6 mm in the mandible and ≥ 3 mm in the maxilla; buccal and palatal/lingual bone width around the implant ≥ 1.5 mm; single crowns or implant-supported fixed partial denture; motivated patients. The exclusion criteria of the surgery were set as follows: aggressive and/or severe periodontal disease; acute oral infections; smoking more than 20 cigarettes/day; pregnancy; osteoporosis; neoplasia; psychiatric disease; abuse of alcohol or drugs; a history of chemotherapy or radiotherapy in the head and neck region; immunocompromised status, and undergoing therapy with antiresorptive and anti-angiogenetic drugs (14,15).

Two different implants were evaluated in this retrospective study. The Kx (Winsix®, BioSAFin S.r.l., Ancona, Italy), implant with a semispherical apex and thread geometry widening from the apex to the neck, 0.7 mm long neck with a machine-turned surface and the remainder of the designed intrabony implant length sandblasted and acid-etched (Micro Rough Surface®). The TTx (WINSIX®, BioSAFin S.r.l., Ancona, Italy) truncated cone shape implant, with a tapered apex and a double thread and double pitch geometry. Smooth neck with a 0.7 mm height, and a Micro Rough Surface® along the intrabony length. Implant lengths were 6 mm and implant diameters were 3.8, 4.5 and 5.2 mm, dominated by an external hexagonal connection.

Implants were placed only in healed extraction sites and their diameters were chosen according to bone width available. After elevating a full-thickness flap, the implant sites were prepared according to the implant manufacturer's instructions.

In the upper jaw, where bone density was low or the residual alveolar bone ridge was insufficient to guarantee compliance with the aforementioned inclusion criteria (the sinus floor needed elevation <3 mm), osteotomies were performed using Alternate Osteotome Technique described by Malchiodi et al. (16) in order to increase the bone volume of at least 25%-30%, by means of a combined ridge expansion and sinus floor elevation. Moreover, the site was underprepared in length and width to improve torque and implant stability and a proper torque prescription allowed to avoid excessive bone compression and bone injuries.

Implants were left submerged for 4 to 5 months in maxilla and 3 to 4 months in mandible, therefore provisional and definitive prosthetic rehabilitations were finalized (17).

All patients were included in a quarterly well-established oral hygiene protocol (education and patient motivation to correct and regular oral hygiene at home, and—where necessary—to the use of at-home hygiene aids adequate to implant-prosthesis, supragingival scaling and supragingival air-polishing with powder of glycine in average grain size) (18) and their implants were assessed clinically and with intra-oral radiographs at each visits.

Parameters evaluated

Implant diameters (3.8, 4.5 or 5.2 mm) and implant sites (first premolar, second premolar, first molar or second molar), distinguishing between maxilla and mandible, were extrapolated. For all 72 patients, standardized intra-oral radiographs performed with a parallel cone technique were digitally obtained, converted to 600 dpi resolution TIFF images and analyzed with a dedicated software (ImageJ; National Institutes of Health, NIH) from implant placement to the end of follow-up in order to calculate CBL values, anatomical and clinical crown/implant ratio. Measurement were evaluated on radiographs at different time-points as follows.

- T0: implant placement.
- T1: prosthetic loading.
- T2: end of follow-up (the last observation for each patient).

Parameters were evaluated as follows.

- Mean peri-implant bone level (PBL): distance (mm±SD) between the implant-abutment interface to the most

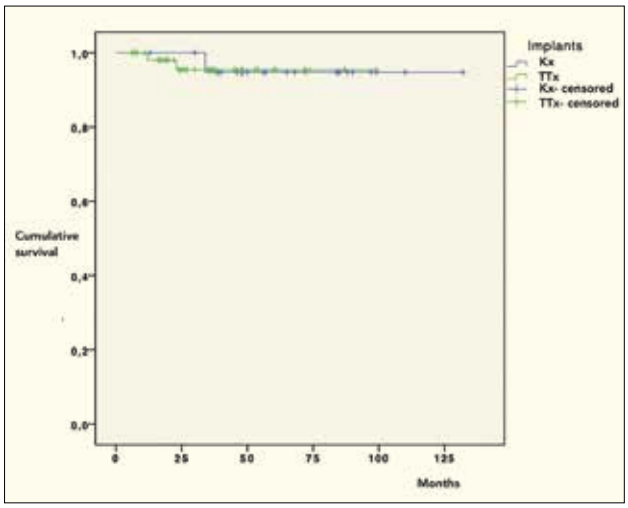

FIG. 1 Kaplan-Meier analysis of cumulative survival of two implants.

apical point of the crestal bone in contact with the implant bone, measured on both mesial and distal sides. Two measurements were averaged to obtain a single value.

- Mean CBL: difference between PBL at T0 and PBL at T2 calculated in mm±SD.
- Anatomical crown/implant (AC/I) ratio: between the prosthetic crown length (from the implant shoulder to the top of the crown) and the implant length (6mm).
- Clinical crown/implant (CC/I) ratio: between the crown length (from the first bone-implant contact to the top of the crown) and the implant length (6 mm) (19).
- Implant success was evaluated as percentage of implants responding to Albrektsson and Zarb criteria (20). Implants satisfying all the criteria were considered successful.
- Implant survival rate was calculated as the percentages of still-functioning implants (absence of clinical mobility, peri-implant radiolucency, pain or suppuration in the implant sites, and signs of peri-implantitis) at the last follow-up, even if all success criteria were satisfied.

All parameters at the different time points were evaluated by the same surgeon (ZF).

Statistical analysis

Kaplan-Meier analysis was performed in order to assess survival rate of 99 ultrashorts implants, both for those in upper and in lower jaw. Statistical analysis was performed on implants data (Fig. 1).
Wilcoxon-Mann-Whitney non-parametric tests were carried out to analyse correlation between site of implant placement (upper and lower jaw) and CBL and to analyse correlation between CBL and two different implants. Furthermore, by Wilcoxon-Mann-Whitney also correlation between CBL and platform switching was tested. A further analysis was performed for testing differences of CBL behaviour depending on type of platform in the upper and in the lower jaws.
Pearson non-parametric test was performed to evaluate correlation between CBL and CC/I ratio, between CBL and AC/I ratio (at T1 and T2) and between CBL and implants diameter.
Descriptive statistic was performed to assess success rate of different implants in different sites of placement.
Test were considered statistically significant for P<=0.05
Pearson coefficient was interpreted as follows: 1= perfect correlation; 0.9-0.5= high correlation; 0.5-0.3= moderate correlation; 0.3-0.1= low correlation; 0= no correlation. Statistical analysis was performed using SPSS® Statistics 22 (IBM®, Armonk, North Castle, New York, USA).

Sex	Men = 26 Women = 44 Total = 72 patients
Mean age	64 ± 10.12 years
Mean follow-up	48,2 ± 17.1 months
Smoker	11 patients

TABLE 1 Demographic data of patients recruited.

RESULTS

Demographic features of cases recruited for this study are shown in Table 1. A case is reported in Figure 2.
Characteristics of implants used are shown in Table 2.
Success rate was 96.6% for TTx and 95.1% for Kx implants. The overall implant-based success rate was 95.9%. The success and survival rates were superimposable.
As regards implant sites, the overall success rates in maxilla and mandible were 96.37% and 94.46%, respectively.
Four of the 99 analysed implants failed (2 TTx in mandible and 2 Kx in maxilla, 2 implants in the same patient and 2 implants in different patients) between the first and third year of follow up, with an overall failure rate of 4.01%. All of them were lost due to peri-implantitis. No other implants failed during the follow-up.
In Tables 3 and 4 values of CBL, CC/I and AC/I are detailed.
The total amount of implant showed no significant differences in mean CBL between the site of placement (upper or lower jaw) (P=0,81).
Moreover, TTx implants showed CBL values comparable to those of Kx in both maxilla and mandible with no significant differences observed during the 48 months of follow up.
Statistically significant differences were highlighted between the two types of implants and CBL (P=0.002); in particular differences were more severe for the TTx implants (0,50 ± 0,54 mm) than the Kx implants (0,17 ± 0,27 mm), during the period from TO and T1, when they were placed in the mandible (P= 0,035).
Platform switching did not result significantly correlated with CBL variation (P=0,150), neither for upper, nor for

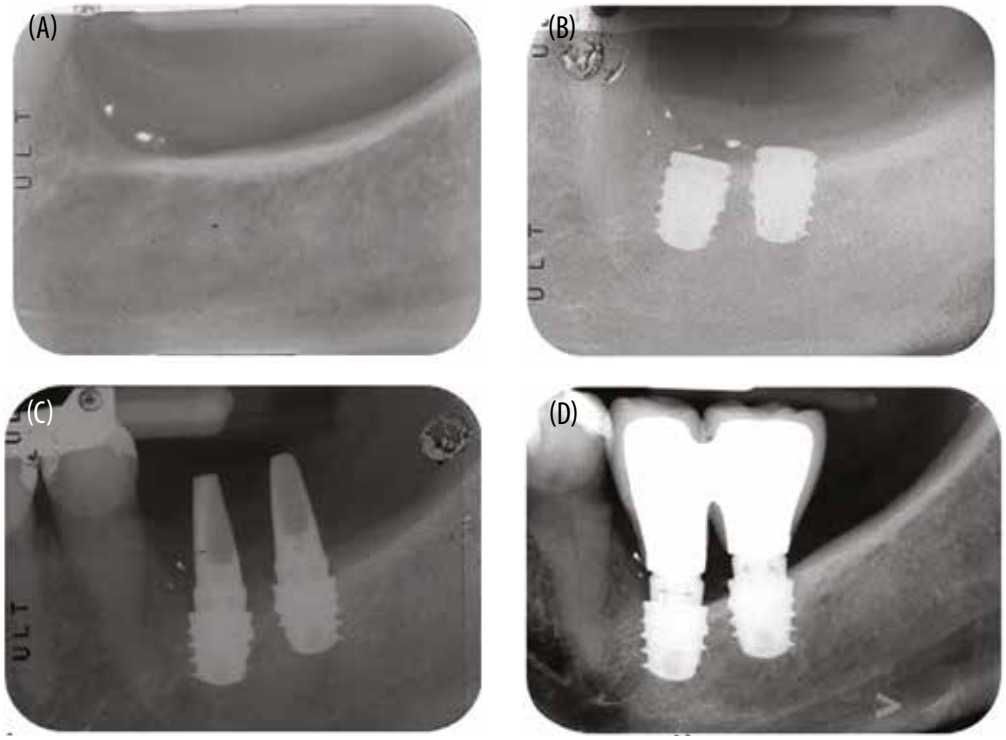

FIG. 2 **A.** before surgery, **B.** implant placing, **C.** 6 months after surgery, **D.** follow-up.

lower jaw. A statistical correlation was found between diameter and CBL (P=0,02).
CBL resulted significantly correlated with AC/I in T2 (P=0,001), whereas no significant correlation was found with AC/I in T1.
CC/I and CBL were not statistically correlated (P=0.118).

DISCUSSION

Ultrashort implants are a valuable choice for implant-prosthetic rehabilitation avoiding, when possible, graft surgery (2). Recent literature reported encouraging results about the viability to use this type of implant avoiding complex procedures, especially in patients ineligible for graft surgeries; moreover, they showed performances similar to those of longer implants (3,21,22). However, some clarification could be useful, especially regarding the feasibility to use the most suitable type of implant for each site, for example in mandible or in upper jaw. This issue shall be taken into account because it could be play a key role in determining more or less CBL.
Aims of this study were to assess variation of mean CBL for two different types of ultrashort implants when they are placed in the upper or in the lower jaw and to evaluate differences in terms of success and survival rate.
Surely, since they are short, CBL is an important and significant issue to take into account when evaluating the outcomes of rehabilitation on ultra-short implants, because even a minor lack of peri-implant bone loss can result in a remarkable decrease of osseointegration.
The overall mean CBL was found to be 0.8 ± 0.52 mm with

Implants		Nº of Implants				
Anatomical location	Maxilla Mandible	55 44				
		Maxilla	Mandible	3.8 mm	4.5 mm	5.2 mm
Type of implants	TTx Kx	29 26	29 15	30 0	19 20	9 21
Prosthetic connection	Platform switching No Platform switching	50 49				

TABLE 2 Characteristics of implants used.

Maxilla	CBL T0	CBL T1	CBL T2
TTx	0.18 ± 0.31 mm	0.58 ± 0.49 mm	0.88 ± 0.52 mm
Kx	0.23 ± 0.43 mm	0.45 ± 0.43 mm	0.62 ± 0.41 mm
TTx+Kx	0.38 ± 0.48 mm	0.77 ± 0.53 mm	0.96 ± 0.55 mm
Mandible			
TTx	0.48± 0.51 mm	0.83 ± 0.56 mm	1.03 ± 0.58 mm
Kx	0.33± 0.45 mm	0.65 ± 0.48 mm	0.84 ± 0.50 mm
TTx+Kx	0.20 ± 0.37 mm	0.52 ± 0.47 mm	0.76 ± 0.49 mm

TABLE 3 Crestal bone loss at different time-points in both jaws.

Maxilla	AC/I ratio	CC/I ratio T1	CC/I ratio T2
TTx	2.05 ± 0.39	2.40 ± 0.43	2.60 ± 0.55
Kx	2.23 ± 0.46	2.45 ± 0.43	2.60 ± 0.57
TTx+Kx	1.94 ± 0.40	2.35 ± 0.49	2.53 ± 0.58
Mandible			
TTx	1.86 ± 0.34	2.31 ± 0.51	2.51 ± 0.62
Kx	2.09 ± 0.45	2.42 ± 0.46	2.57 ± 0.51
TTx+Kx	2.13 ± 0.43	2.43 ± 0.43	2.60 ± 0.55

TABLE 4 Anatomical and clinical crown/implant ratios at different time-points.

a mean follow-up of 48 months, in agreement with recent literature (23,24). Also, our results are in accordance with literature findings (25), indeed CBL was found higher in T0-T1 if compared with T1-T2 (Table 3).

CBL was found to be more remarkable at all time-points in TTx implants placed in the mandible, this could be due to the different macro-morphologies of two types of implants. In Kx implants the threads gradually alter in form from quadrilateral to triangular to promote vertical micro-expansion and also alter gradually in depth to promote progressive horizontal micro-expansion. The implants have three discharge grooves wide and deep for the deposit of bone fragments and blood clot formation during implant insertion. This peculiar morphology allows an increased implant stabilisation in trabecular bone, likewise the coronal portion of the screw is less cutting and therefore less aggressive, producing a minor CBL in the cortical area. With this in mind, we can assume that using Kx implants in posterior mandible, where cortical bone is greatly represented, allows to maintain better CBL if compared with TTx implants. This aspect deserves to be highlighted because the greater amount of CBL in TTx implants was found between T0 and T1 where compared with Kx, and therefore it seems to be related more to surgical and morphological features than to prosthetic loading. Hence, a CBL of 0.50 ± 0.54 mm in the first months represents nearly one third of the total CBL allowed in one year for satisfying Albrektsson criteria (20). Furthermore, TTx could be considered more appropriate to be used in the upper jaw because they enable an osteotomy preparation of implant site thanks to their non-cutting morphology.

This sort of consideration becomes more valuable because implants are short and therefore CBL represents the most important parameter able to affect both the success and the survival of rehabilitation. From this perspective, knowing features and behaviours of different implants in different sites allows to take the most suitable choice and consequently the most predictable result of implant-prosthetic restorations.

CBL resulted significantly correlated also with diameter of implants, this could be due to the surface on which load is concentrated and therefore to the better occlusal balancing (26). Indeed, the occlusal loading is distributed on the coronal third of the screw, therefore having a greater surface in this area makes it possible to achieve a greater support for prosthetic complex (27,8). It could be interesting to evaluate in further studies the minimum diameter under which the CC/I ratio cannot be maintained constant if implants are tested. Nevertheless, results from literature are discordant because of different ways of measuring this ratio. Some authors identify the fulcrum with implant-abutment interface, on the other hand others report the fulcrum as the most coronal point of the bone-implant interface (29). It is intuitive as these different definitions can generate confusion in reading and interpreting results of literature, and in this way most studies seem to be discordant (30,31,32).

In our study we reported a mean AC/I ratio of 2,5 ± 0,42 mm for all implants, whereas the mean CC/I ratio was found to be 2.57 ± 0.56 in T2. No correlation between CBL and CC/I ratio was reported in this retrospective study. Whereas a significant correlation between CBL and AC/I ratio in T2 was highlighted, giving reason of confirmed CBL after prosthetic loading (15).

Prognosis of implant rehabilitation is strongly related to primary bone-implant stability (33,34), that can be affected both by surgical protocol and by bone features (35).

In this study upper and lower implant rehabilitations surgically performed accordingly with bone quality and characteristics were included (15). Therefore, it was viable

to evaluate differences in terms of CBL for different sites with no statistically significant results. These findings are in agreement with literature reporting success and CBL values fitting between lower and upper jaw (24)(36) Success rate reported in literature ranges between 91.3% and 100% for lower and upper implants; CBL values in recent studies are reported to be between 0.41 ± 0.66 mm and 1.44 ± 0.44 mm in mandible and from 0.63 ± 0.60 mm to 1.02 ± 0.47 mm for upper jaw, our findings are 0.,76 ± 0.49 mm in mandible and 0.96 ± 0.55 mm in upper arch.

Our results showed success and survival rates (96%) concordant with those in literature (22,23) with a loss of 4 implants due to peri-implantitis following Caton et al. classification (37). In this regard, it should be highlighted that in this study we did not report periodontal probing values that are determinant data for a more detailed analysis of implant loss. However, we decided to take into account Albrektsson and Zarb criteria in order to define the success of implants; this decision was due to the desire to remain strictly focused on the aims of the research. This affection does not depend on the length of implants, of course, however it has to be taken into account that the minimum exposure of ultrashort implant screw is significant in terms of stability, in contrast to longer ones (22).

With these analyses in mind, we can assume that ultrashort implants are valuable also for complex rehabilitations observed. No remarkable differences were noticed between upper and lower arch, however where these differences were found, they were due to anatomical features of bone, technical features of screws and surgical protocol required for implant placement.

Surely, it has to be accurately highlighted some bias of this study. First of all, it is a retrospective study and for this it did not allow determining causation, just only association between conditions examined. At the same time, temporal relationships were difficult to be assessed, therefore it might be difficult to correlate results with strong evidences (17). However, the opportunity to have the same surgeon applying same surgical procedures and prosthetic workflow could decrease this risk of bias, even if data were retrospectively collected. It might be possible that in designing the study other risk factors were present and they were not measured.

Choosing the same follow-up for all patients would have meant to sacrifice lot of data. This is due to the heterogeneity of patients and other parameters, typical features of retrospective studies. We are well aware that represents a bias and affects the power of the work; however, it was considered preferable to evaluate a greater sample of patients with different characteristics, even if this meant weaker results. However, the methodological approach of the present study aimed to avoid as much as possible the selection bias, at this regard strict inclusion criteria were placed in recruiting cases to analyse and, because of this, the follow-up period was consequently affected.

Statistical analysis was performed accordingly to those of retrospective studies and data available.

The suggestion is to follow the proper surgical protocol, to choose the most suitable type of implant related to bone quality and conditions and to plan an effective follow-up with scheduled oral hygiene controls.

CONCLUSIONS

This retrospective study explains the importance to know features and characteristics of different ultrashort implants and bone where they are placed, in order to use them in the most suitable way and in the most suitable place. This issue takes even more significance because CBL and bone behavior were found to be related with characteristics of screws and on this depends the real clinical success of implant rehabilitation.

Declaration of interests

None.

Disclosure statement

The authors do not have any financial interest in the companies whose materials are included in this article.

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