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Socket regeneration after immediate loading implants with tissue and bone graft: 1-year clinical follow-up

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Aim: Evaluation of ridge alteration after 1 year follow up after immediate loading implant placement. **Methods:** Ten patients were included in the study, in whom the ridge volume, height, and thickness were evaluated from region of interest (ROI) of tomographic images of the operated areas (test group) and compared to the opposite tooth (control group). **Results:** After one year, there was no implant loss and all patients were satisfied with the treatment. In the test group there was a statistically significant increase in ridge height (2.89±1.05 mm) when compared to the control group. No significant difference in relation to ridge volume and thickness was observed. In the intragroup evaluation, a significant gain in ridge height (2.65±3.08 mm) was observed when compared to baseline. **Conclusion:** The placement of an immediate implant, temporary crown, and tissue regeneration in sockets with buccal defects promotes the regeneration of the buccal wall while preventing the reduction of bone volume and thickness.

Keywords: Dental implants. Heterografts. Minerals.

Introduction

A tooth may be compromised and need removal to reestablish oral health[1]. Amler et al.[2] demonstrated that the extraction socket undergoes a series of morphological changes until complete bone formation occurs, at which point it is almost identical in density to the surrounding alveolar process. A limited reduction in vertical bone height is expected along with a considerable reduction in horizontal width, mainly in the buccal region, which can decrease by up to 50% compared to the pre-extraction ridge[3,4].

Different approaches have been employed to preserve the dimensions of the ridge after tooth extraction[5]. Aimetti et al. analyzed the changes in dimension in compromised extraction sockets after a ridge augmentation procedure in comparison with spontaneous healing. The authors found almost two-fold more horizontal shrinkage of the ridge in the spontaneous healing group[6]. Another study showed that bone remodeling was significantly higher when a bone graft was not performed, increasing both loss in bone height and thickness[7].

When performing bone grafts, a reduction in the alveolar ridge dimensions will occur[8]. Furthermore, the healing process following the extraction of periodontally compromised teeth differs from that of healthy ones, with a delay in wound repair and new bone formation as well as a reduction in bone dimensions having been observed[9,10]. To counteract this remodeling process, soft tissue grafts are recommended to increase the thickness of the mucosa, ensuring that the soft tissue margin remains stable throughout the years while also promoting a better esthetic result[11].

Immediate implant placement has been demonstrated as a viable treatment in intact sockets since the treatment time and morbidity are significantly reduced, while the ridge contour can be preserved by both bone and soft tissue grafting[12-14]. There is limited evidence concerning the treatment of compromised sockets and the number of overall alterations that can be expected in the alveolar ridge height, thickness and volume after tooth extraction and implant placement. It is clinically important to understand and quantify the bone alterations that occur when an implant, temporary crown and grafts are immediately placed. Therefore, this study aimed to evaluate the impact of performing these procedures on the bone volume, height, and thickness of maxillary incisor sockets that present a buccal bone defect.

Material and Methods

This was a longitudinal retrospective clinical study conducted after approval by the local research ethics committee (CAAE 06045612.9.0000.5416).

Patient selection

The sample consisted of male and female patients who sought care at the Araraquara Dental School at São Paulo State University and who signed a consent form. The inclusion criteria were: presence of a maxillary incisor indicated for extraction; presence of a buccal bone defect > 4mm confirmed by tomographic examination;

good oral hygiene based on visible plaque index < 20%; presence of adjacent teeth to the tooth to be extracted; absence of proximal bone loss in adjacent teeth; harmonic gingival architecture on the tooth to be extracted; age ≥ 18 years old; clinical insertion level > 3 mm; the implant should have an insertion torque greater than 32 Ncm. The exclusion criteria were: history of periodontal surgical procedures in the operated region; systemic alterations that made it impossible to carry out the surgical procedures; presence of active infection involving the gingival margin; apical bone quantity less than 3 mm for implant placement; loss of posterior occlusal containment; patients who smoked, suffered from bruxism, were alcoholics, were drug addicts, had diabetes, were pregnant or wishing to become pregnant in the year following surgery, who had a history of radiotherapy treatment in the head and neck region, who were taking medications that interfered with bone remodeling, or had pathologies that affected bone metabolism. Ten patients with a mean age of 52 years old were selected, and all were subjected to a cone-beam computed tomography acquisition (CBCT) using the iCat Classic device (Imaging Sciences International, Hatfield, USA) prior to surgery for treatment planning.

Clinical methods

Initially, the surgical procedures started with local anesthesia with 2% lidocaine 1:100.000 UI. Then the compromised teeth were extracted using minimally traumatic techniques. After cleaning and inspection of the remaining socket, a titanium Flash® implant (Conexão Sistemas de Prótese, Arujá, Brazil) with a diameter of 3.5 mm was placed with anchorage in the palatal bone wall, with a minimum torque of 32 Ncm and maximum torque of 60 Ncm. Immediately after the implant placement, all sockets were grafted with a resorbable collagen membrane (Bio-Gide®, Geistlich Pharmaceutical, Wolhausen, Switzerland) and deproteinized bovine bone material with 10% collagen (Bio-Oss Collagen®, Geistlich Pharmaceutical, Wolhausen, Switzerland). After the placement of implants, patients were also given a soft tissue graft to increase the thickness and stability of the peri-implant region in the long term. Temporary abutments were then installed over the implants for construction of a temporary crown up to 48 hours after the surgical procedure. After the surgical procedures, all patients received the appropriate medications: antibiotic (amoxicillin taken by mouth, 500mg t.i.d. for 7 days), anti-inflammatory (nimesulide taken orally, 100mg every 12 hours for 3 days), analgesic (dipyrone taken orally, 500mg every 6 hours in case of pain), and a mouthwash (rinse of 0.12% chlorhexidine digluconato 12/12hours for 7 days).

Six months after placing the implants, the prosthetic procedures for making a ceramic crown were initiated. To standardize the methods, zirconium abutments were manufactured using a CAD/CAM system for the cemented prosthesis, and the ceramic crowns were created. The abutments were installed over the implants with a 15 Ncm torque. The implants were clinically evaluated for stability and success. One year after implant placement, the patients were clinically evaluated and a new CBCT acquisition was performed if clinical and radiographic information were not sufficient to establish a diagnosis. The acquisition took place with the aid of a lip and cheek mucosa retractor. Acquisition parameters were 120 kVp, 36.12 mAs and 0.25mm³ of voxel size in the same CBCT (iCat Classic device - Imaging Sciences International, Hatfield, USA). Images were exported in DICOM format and randomized.

Volumetric and linear measurements

One examiner was calibrated to independently perform linear and volumetric measurements on the tomographic images using specific software (ITK-SNAP v.3.8.0. Cognitica, Philadelphia, PA, USA) to allow subsequent intra and intergroup assessments[10]. The examiner had 3 years of experience in Dental Implantology. To calibrate the examiner prior to the measurements, intra-observer reliability was determined by assessing the volumetric and linear measurements from four random patients. The intraclass correlation coefficient obtained was 0.8565.

The semi-automatic segmentation tool provided by ITK-SNAP was used[10]. First, a region of interest (ROI) was selected, with the following boundaries: upper limit – the end of the root apex of the maxillary incisor; lower limit – the end of the alveolar ridge; lateral limits: at the end of adjacent teeth reconstruction image; vestibular limits: the end of the vestibular bone; palatal limit: the last slice in which the palatal bone was seen. Then a threshold range was set by the examiner to determine the voxels to be included in the three-dimensional segmentation of the alveolar bone. Finally, manual adjustments were made by the examiner. For the CBCT images with the implant placed, the segmented volume of the baseline alveolar socket was superimposed so that the limits of the ROIs would be the same (Figures 1–6).

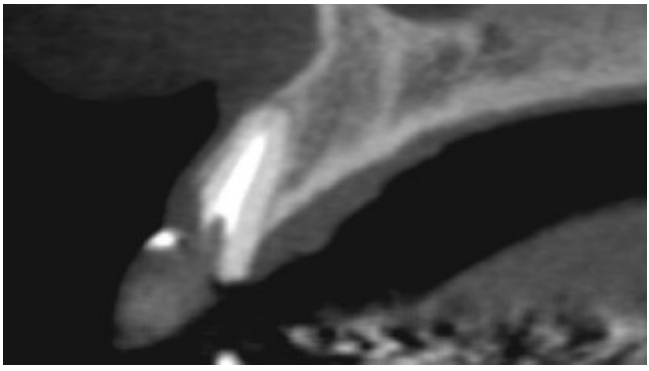

Figure 1. Baseline.

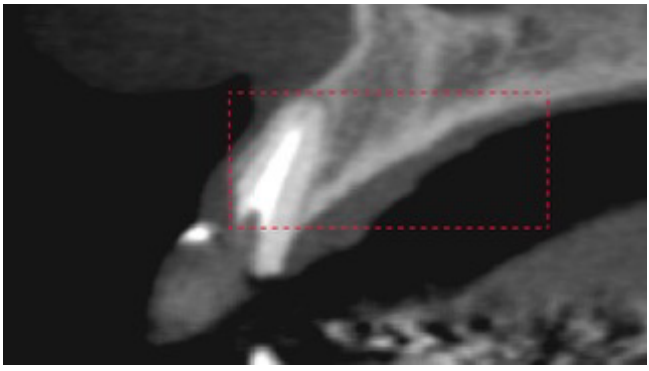

Figure 2. ROI selected.

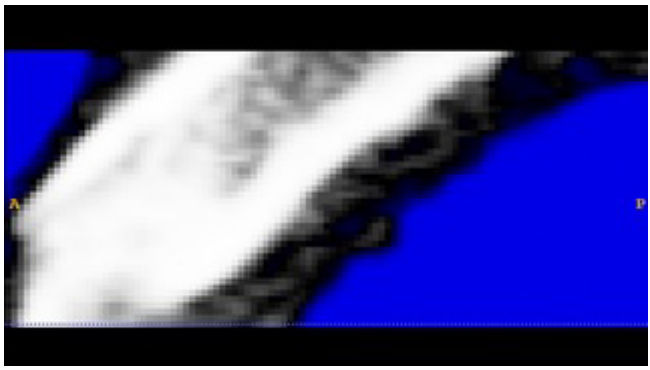

Figure 3. Threshold defined.

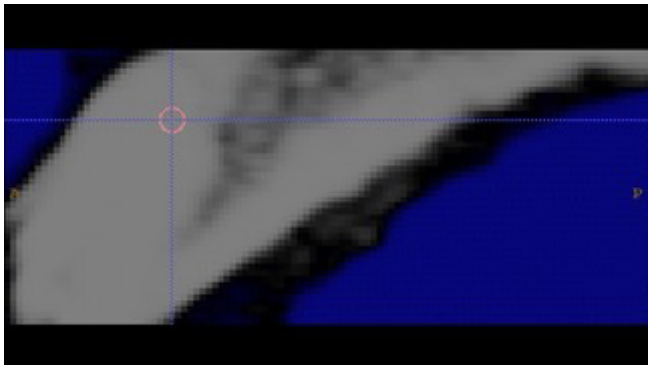

Figure 4. Bubbles added.

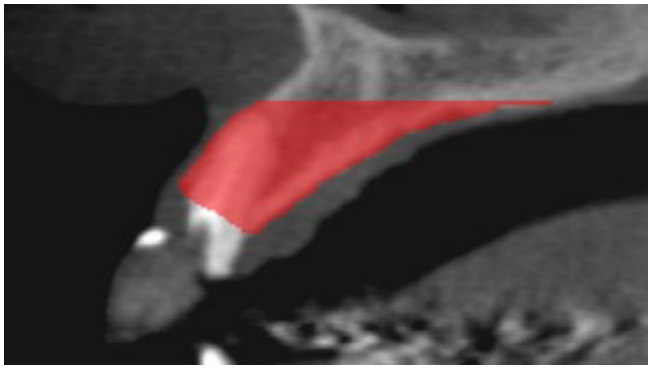

Figure 5. Volumetric segmentation at baseline.

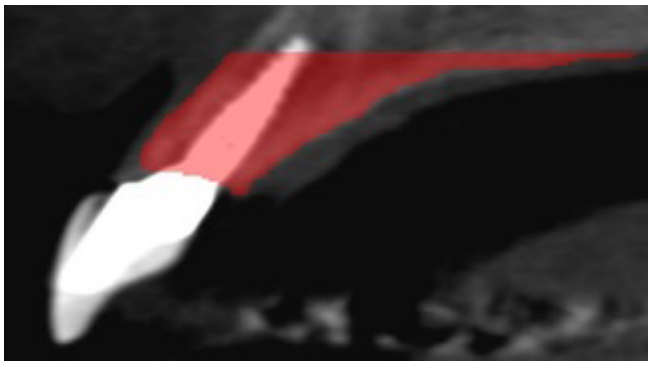

Figure 6. Volumetric segmentation 12 months after implant placement.

For linear evaluation, the center of the alveolar socket/implant was selected and three measurements were performed: 1 – apical bone thickness; 2 – coronal bone thickness; and 3 – bone height (Figures 7–8). To standardize the height of the apical width measurement at the 12-month timepoint, the CBCT images of the different periods were superimposed and then the apical width measurement at 12 months was made using the root apex of the baseline period as a reference point. Both the thickness and volume of the tooth roots and the implants were included in the assessments.

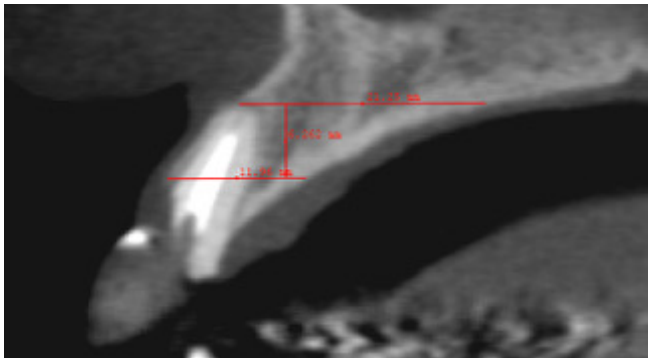

Figure 7. Linear evaluations on the baseline.

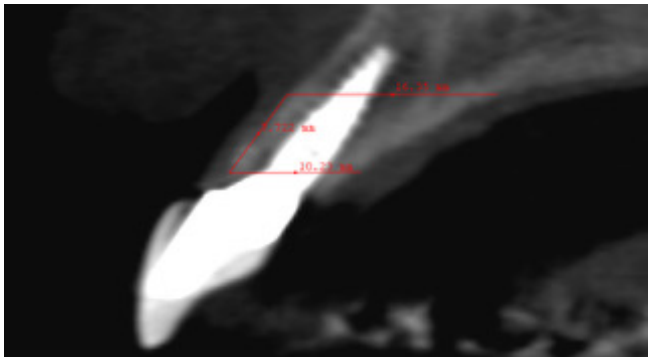

Figure 8. Linear evaluations 12 months after implant placement.

All measurements were performed according to the following groups: A, B – Control Groups (Baseline and 12-month CBCT image, respectively; homologous maxillary incisor); C, D – Test Groups (Baseline and 12-month CBCT image, respectively; alveolar socket of the maxillary incisor).

Statistical analysis

Data consisted of continuous quantitative variables – mm for linear measurements, and mm^3 for volumetric measurements. The Shapiro-Wilk test indicated a non-parametric distribution. Intra- and intergroup data were then subjected to a Wilcoxon matched-pairs signed rank test and Mann-Whitney test, respectively. The null hypothesis was that the alveolar socket volume and dimensions did not differ between control (Baseline and 12-month CBCT image, respectively; homologous maxillary incisor) or test groups (Baseline and 12-month CBCT image, respectively; alveolar socket of the maxillary incisor). The statistical significance level was set at .05, and statistical analyses were conducted using GraphPad Prism 8.2 (GraphPad Software, San Diego, CA).

Results

A total of 14 central maxillary incisors and 6 lateral incisors were assessed (50% corresponded to the test group) at the baseline and 12-month timepoints. The data obtained were used to assess the measurements considering different time periods (intra-group assessments) and considering the control group and test group (inter-group assessments).

Intra-group assessments

For intra-group assessments, we compared the same group (control or test) between timepoints (baseline and 12 months). In the control group, there were no significant changes in either volumetric or linear measurements. In the test group, there was a significant increase in bone height ($p < 0.05$) (Table 1).

Table 1. Median, minimum and maximum values, considering intra-group baseline and post-operative analysis for control and test group.

			Measurements			
			Volume (mm^3)	Apex width (mm)	Coronal width (mm)	Height (mm)
Control	Baseline	Median	613.9	10.81	9.08	8.7
		Min-Max	353.5 - 931.1	7.07 - 19.37	7.07 - 11.71	2.31 - 10.98
	12M	Median	599.6	10.97	8.98	8.37
		Min-Max	325.8 - 924.4	6.75 - 20.49	7.21 - 12.09	2.4 - 9.97
Median Difference			-14.3	0.16	-0.1	-0.33
Test	Baseline	Median	575.8	10.04	7.8	3.99
		Min-Max	225.8 - 1017	6.37 - 21.25	3.11 - 11.96	1.2 - 11.19
	12M	Median	537.5	10.3	7.42	8.29
		Min-Max	169.7 - 893.6	6.11 - 17.11	6.04 - 10.23	4.01 - 10.43
Median Difference			-38.3	0.26	-0.38	4.3*

Negative values (-) means a decrease in bone quantity.
Significant difference in test group height. * = $p < 0.05$.

Inter-group assessments

For inter-group assessments, a comparison was made between groups (control and test) using their difference values. The height and the coronal width demonstrated a significant increase and decrease, respectively ($p < 0.05$) (Table 2).

Table 2. Median, minimum and maximum values, considering inter-group analysis for control and test group.

		Measurements			
		Δ Volume (mm^3)	**Δ Apex width (mm)**	**Δ Coronal width (mm)**	**Δ Height (mm)**
Control	**Median**	-22.7	0.26	-0.03	0.09
	Min-Max	-94.8 - 22.4	-1.64 - 2.59	-0.46 - 2.12	-1.81 - 0.65
Test	**Median**	-94.75	-0.14	-0.87	3.9
	Min-Max	-199.3 - 125.9	-4.9 - 3.59	1.73 - 5.04	-1.17 - 6.06
Median Difference (%)		-117.45	0.12	-0.9*	3.81*

Δ = Difference values obtained from (12 Months - Baseline).
Negative values (-) means a decrease in bone quantity.
Significant difference in coronal width and height. $p < 0.05$.

Discussion

An appropriate soft and hard tissue thickness around implants has been associated with long-term peri-implant tissue stability, leading to a higher survival rate of implants and a more esthetic outcome[15]. This study demonstrated a significant increase in bone height in intra-group assessments, suggesting that immediate implant placement with simultaneous bone grafts results in less bone resorption.

In a meta-analysis carried out by Canellas et al.[16] including several implant placement protocols, immediate implant placement promoted better results at the anterior alveolar bone site, enabling the preservation of hard and soft tissue contours after tooth extraction. In our study there were no volumetric differences between the groups, showing that the proposed procedure was able to maintain the contour of the ridge. Clinically, a reduced treatment time and morbidity can be expected if the implant is placed immediately after tooth extraction.

It is well established in the literature that tissue alterations following tooth removal will result in bone loss, especially on the buccal aspect, leading to a marginal defect that may interfere with future implant placement, affecting the functional and esthetic prognosis[3,17,18]. Other studies[19,20] that assessed horizontal and vertical alterations of buccal alveolar bone showed that the use of bone grafts reduces bone resorption.

Degidi et al.[20] assessed vertical and horizontal alterations of buccal alveolar bone after implant placement in intact alveolar sockets using deproteinized bovine bone material with 10% collagen to fill the buccal gap. All measurements were made after implant placement and 12 months later. A vertical and horizontal reduction of 0.76 ± 0.96 mm and 0.88 ± 0.51 were detected, respectively. In our study there was an increase in bone height since the bone wall was regenerated by the grafting procedures.

The use of a deproteinized bovine bone material with 10% collagen associated with immediate implant to fill the buccal gap between the implant and bone wall is well described in the literature[21]. The present study demonstrated a gain in bone height, consistent with an animal study carried out by Araújo et al.[22] that assessed intact sockets.

The reduction in the coronal thickness of the ridge described in this study occurred since the tooth root was considered in the tomographic measurements prior to surgery. Both the tooth root and implant were included in the analysis in order to evaluate the volumetric alterations of the ridge. Also, it is biologically more challenging to regenerate the ridge when there is a defect in the socket walls, especially in the buccal walls. In this clinical scenario, a reduction of less than 1 mm could be expected and can be compensated by using a soft tissue graft to increase the overall ridge volume[11].

Botticelli et al.[23] evaluated dimensional alterations of hard tissue that occur following tooth extraction and immediate implant placement without bone graft. Greater bone resorption was detected when compared to other studies[24,25] that used bone grafts. Although bone resorption will always occur, it can be diminished by using a bone graft.

Both measurement methods used in the present study have been applied in other studies. For volumetric analysis, semi-automatic segmentation of the alveolar socket with the ITK-SNAP software was used. This method and software have previously been validated[26] and used for segmentation of different anatomical structures[27-29]. For linear measurements, the method applied was based on the methodology used by Misawa et al.[30].

Deproteinized bovine bone material with 10% collagen seems to be a good bone substitute to maintain the dimensional volume of the alveolar socket, and is also easier to manipulate than deproteinized bovine bone material in granules[22]. Further randomized clinical studies need to be done in order to compare their efficacy and any more profound differences between them. The limitations of this study include its small sample size and the absence of long-term follow-up. However, the outcomes of this study can help further studies assess the efficacy of deproteinized bovine bone material with 10% collagen as augmentation material for the regeneration of the buccal wall.

In conclusion, the placement of an immediate implant, temporary crown, and tissue regeneration in sockets with buccal defects promoted significant gain in bone height in intra- and intergroup assessments.

Data Availability

Datasets related to this article will be available upon request to the corresponding author.

Conflict of Interest

None. Also, the reviewers should declare any conflict related to the authors or subject.

Author Contribution

Study conception and design: Nicolas Nicchio, Fausto Frizzera.

Data acquisition: Fausto Frizzera, Sergio Lins de Azevedo Vaz, Fernanda Coelho Silva, Elcio Marcantonio Junior.

Analysis and interpretation of results: Nicolas Nicchio, Fausto Frizzera, Fernanda Coelho Silva.

Manuscript preparation: Nicolas Nicchio, Fernanda Coelho Silva.

Manuscript review: Fausto Frizzera, Sergio Lins de Azevedo Vaz, Elcio Marcantonio Junior.

All authors actively participated in the manuscript findings and have revised and approved the final version of the manuscript.

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