ISSN 2765-3633
Vol. 17 No. 1, November 2025
The Journal of Korean Academy of Osseointegration 2025, 17(1) 15-20

Analysis of factors affecting buccal alveolar bone wall thickness after immediate dental implant placement in the anterior or premolar region

Kwang-Min Kim[1], Shidham Lee[1], Hyeyoung Sim[2,3], Hee-Sun Kim[2], Yu-Jin Kim[2], Jae-Rim Lee[2], Yoon-Sic Han[1], Ho Lee[1]

[1]Department of Oral and Maxillofacial Surgery, Seoul Metropolitan Government – Seoul National University Boramae Medical Center, [2]Section of Dentistry, Seoul Metropolitan Government – Seoul National University Boramae Medical Center, [3]Department of Dentistry, School of Dentistry, Seoul National University, Seoul, Korea

Background: This study analyzed factors influencing buccal alveolar bone wall thickness after immediate implant placement following extraction in the anterior or premolar region under proposed clinical conditions for stable outcomes.

Materials & Methods: Patients treated at SMG-SNU Boramae Medical Center between August 2017 and April 2023, who underwent immediate implant placement with bone grafting in the implant–buccal gap, were included. Cone-beam computed tomography was taken preoperatively, postoperatively, and at implant loading. Measurements included initial buccal bone wall thickness (BWT0), immediate postoperative thickness (BWT1), thickness after loading (BWT2), and the gap distance (Gap). Cases were categorized into thin and thick bone groups based on a 1-mm cutoff. Non-parametric correlation and regression analyses were conducted.

Results: This study included 26 patients (35 subjects). In the overall cohort, BWT2 was positively correlated with BWT0 ($P < 0.001$). In regression analysis, Gap significantly affected BWT2 in the thin bone group ($P < 0.001$), whereas only BWT0 influenced BWT2 in the thick bone group ($P < 0.001$).

Conclusions: During immediate implant placement after anterior or premolar extraction, creating an adequate implant–buccal gap is critical for achieving sufficient final buccal bone thickness when the initial buccal bone is thin (<1 mm). Conversely, when the buccal bone is thick (≥1 mm), the effect of the gap is less pronounced. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2025;17(1):15-20)**

Key words: Alveolar bone loss, Cone-beam computed tomography, Dental implants, Tooth extraction, Bone grafting, Bone thickness

INTRODUCTION

Immediate implant placement (IIP) after tooth extraction offers several advantages, including a shorter treatment period, fewer clinical visits, immediate functional recovery, and improved patient satisfaction[1-3]. Compared with early or delayed placement protocols, IIP demonstrates comparable implant survival and success rates, making it a widely adopted treatment method[4].

Following tooth extraction, alveolar bone resorption occurs, with horizontal dimensional changes generally greater than vertical changes[5]. Approximately 87% of anterior sites and 59% of premolar sites present with a thin buccal bone of less than 1 mm[6]. In such situations, post-extraction bone resorption can negatively influence esthetic implant outcomes, and IIP alone cannot fully prevent this bone loss[7,8]. Furthermore, during IIP, dimensional changes are typically greater on the buccal side than on the palatal or lingual side, with horizontal loss more pronounced than vertical reduction[9].

Factors believed to contribute to buccal bone resorption include initial buccal bone thickness, flap elevation, the implant–buccal gap, use of bone grafts, and type of prosthetic restoration[10-14]. However, even recent systematic reviews have suggested that several of these variables remain incompletely understood[15].

The aim of this study was to identify factors influencing final buccal bone thickness in IIP in the anterior and premolar regions. It was further hypothesized that the influence of these variables differs according to initial buccal bone thickness. The study, therefore, analyzed the extent to which each factor affects outcomes in

Received September 17, 2025, **Revised** October 29, 2025, **Accepted** October 30, 2025

Corresponding Author: Ho Lee, Department of Oral and Maxillofacial Surgery, Section of Dentistry, Seoul Metropolitan Government – Seoul National University Boramae Medical Center, 20 Boramae-ro 5 Gil, Dongjak-gu, Seoul 07061, Korea, Tel: +82-2-870-2496, Fax: +82-2-831-0714, E-mail: neo0224@gmail.com

both groups.

MATERIALS AND METHODS

1. Study sample

This retrospective cohort study included patients who underwent IIP at SMG-SNU Boramae Medical Center between August 2017 and April 2023. The study was approved by the institutional review board (IRB No. 20-2025-13) and conducted in accordance with the Declaration of Helsinki (1964) and its subsequent amendments.

Cases were included if IIP was performed in the anterior or premolar regions with bone grafting in the implant–buccal gap, and if cone-beam computed tomography (CBCT) scans were available preoperatively, immediately postoperatively, and after implant loading. Cases were excluded if they involved smokers, immediate provisional prosthetic restoration, early loading, or bone grafting beyond gap grafting due to significant buccal bone wall loss.

2. Surgical procedure

All surgical procedures were performed by two oral and maxillofacial surgeons with more than 10 years of clinical experience. Before surgery, patients were rinsed with 0.2% chlorhexidine mouthwash. Local anesthesia was administered using standard anesthetics (2% Lidocaine HCl with Epinephrine 1:100,000; Yuhan, Seoul, Korea). Teeth were extracted using forceps or elevators with minimal trauma, and curettage of the extraction socket was performed. Minimal flap elevation was calculated including only the interdental papilla and a limited portion of the marginal gingiva, or flapless surgery was performed when possible.

Drilling was conducted at controlled torque and speed according to the manufacturer's guidelines, and implants were positioned within the extraction socket. After final drilling, implants were inserted using a handpiece and torque wrench. A tapered body implant (TS III, Osstem Implant, Seoul, Korea) with a sandblasted, large-grit, acid-etched surface was used. Freeze-dried allogeneic particulate bone graft (Sure-OSS, Hansbiomed, Seoul, Korea) was placed in the implant-buccal gap, and a resorbable collagen membrane (Collagen Membrane, Dentium, Suwon, Korea) was applied when required. Finally, wound closure was achieved with non-resorbable sutures (4-0 Dafilon, B. Braun, Melsungen, Germany).

3. Variables and data collection methods

Predictor variables included sex, age, presence of diabetes mellitus, implant placement site, flap elevation status, time from implant placement to loading, initial buccal alveolar bone wall thickness before extraction (BWT0), and the gap distance between the buccal alveolar bone wall and the implant (Gap). The outcome variable was the final buccal alveolar bone wall thickness measured after loading (BWT2).

CBCT scans (CS9600, Carestream Dental LLC, Atlanta, GA, USA) were obtained at three time points: preoperatively, immediately postoperatively, and after implant loading. All images were saved in Digital Imaging and Communications in Medicine (DICOM) format. For measurement, DICOM files were analyzed using three-dimensional analysis software (On Demand 3D, Cybermed, Daejeon, Korea) to evaluate BWT0, buccal bone wall thickness immediately after surgery (BWT1), BWT2, Gap, and buccal bone width resorption. All measurements were performed on planes perpendicular to the implant's long axis, using the software's superimposition function to ensure identical slices (Figure 1).

4. Data analysis

The sample was divided into two groups based on BWT0: thin (<1 mm) and thick (≥1 mm). Differences between groups were analyzed using the Mann–Whitney U test and logistic regression.

Correlations between predictor variables and BWT2 were examined for the overall cohort and within each group. Spearman's correlation was used for continuous variables, while Mann–Whitney U and Kruskal–Wallis H tests were applied to categorical variables. Due to the small sample size and the Shapiro-Wilk test showing non-normality, the above non-parametric statistical methods were used.

Variables showing significant correlations within each group were included in multiple linear regression analysis. Subsequently, simple linear regression was conducted with only the significant predictors identified, and regression equations were derived.

All analyses were performed using SPSS version 26 (SPSS Inc., Chicago, IL, USA). A P-value <0.05 was considered statistically significant.

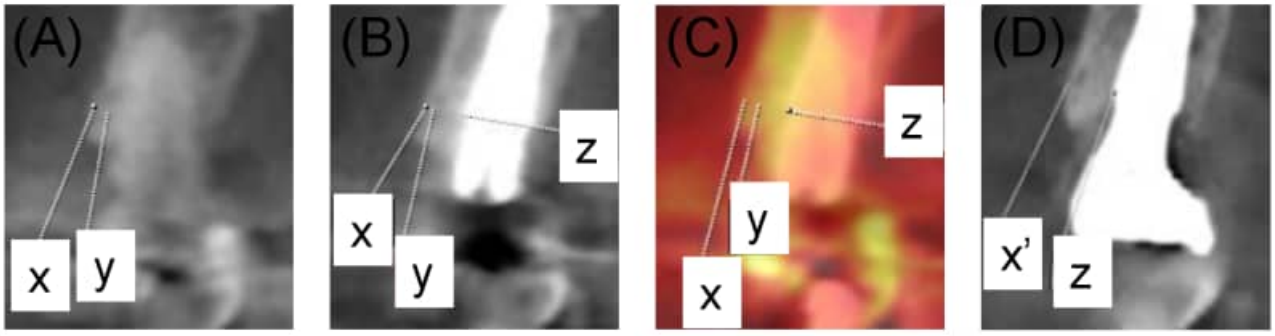

Figure 1. Cone-beam computed tomographic images and measurement methods at three time points: preoperative (T0), immediate postoperative (T1), and post-loading (T2). (A) Buccal bone wall thickness at T0: distance from x to y. (B) Buccal bone wall thickness at T1: distance from x to z. (C) Superimposed images of T0 and T1: gap distance between the implant and buccal wall, calculated by subtracting buccal bone thickness at T0 from that at T1. (D) Buccal bone wall thickness at T2: distance from x′ to z. x, point where the line perpendicular to the implant's long axis at the implant shoulder level meets the outer boundary of the buccal bone at T1; y, point where the line perpendicular to the implant's long axis at the implant shoulder level meets the buccal border of the tooth root in the superimposed images of T0 and T1; z, point where the line perpendicular to the implant's long axis at the implant shoulder level meets the buccal border of the implant; x′, point where the line perpendicular to the implant's long axis at the implant shoulder level meets the outer border of the buccal bone at T2.

RESULTS

1. Descriptive statistics

Analysis of 35 implants in 26 patients showed that the mean BWT0 was 1.2 ± 0.7 mm, mean Gap was 2.1 ± 0.6 mm, mean time from placement to loading was 4.4 ± 1.8 months, and mean BWT2 was 2.5 ± 1.1 mm. In the overall cohort, BWT2 was positively correlated with BWT0, but no significant correlations were observed between BWT2 and other variables including Gap (Table 1).

2. Group comparisons

The mean BWT0 differed significantly between groups: 0.7 ± 0.1 mm in the thin group and 1.8 ± 0.7 mm in the thick group. Gap also differed significantly, measuring 2.3 ± 0.5 mm in the thin group and 1.9 ± 0.6 mm in the thick group. BWT2 was greater in the thick group compared with the thin group. Buccal bone resorption, calculated by subtracting BWT2 from the sum of BWT0 and Gap, was 1.0 ± 0.4 mm in the thin group and 0.5 ± 0.4 mm in the thick group. In the thin group, Gap was positively correlated with BWT2, and BWT2 was lower when flap elevation was performed compared with flapless cases. In the thick group, BWT0 was positively correlated with BWT2, and patients with diabetes had lower BWT2 compared with those without diabetes (Table 2).

3. Regression analysis

In the thin group, multiple linear regression using Gap and flap elevation as predictors showed that only Gap significantly influenced BWT2. In the thick group, regression using BWT0 and diabetes as predictors revealed that only BWT0 significantly influenced BWT2 (Table 3).

Simple linear regression, excluding flap elevation and diabetes, was conducted for each group. The regression equation for

Table 1. Demographics, characteristics and correlation with final buccal bone wall thickness

Variable	Total (N = 35)	*P*-value
Age, mean ± SD, years	76.1 ± 10.9	0.922[a]
Gender, n (%)		0.882[b]
Male	18 (51.4)	
Female	17 (48.6)	
Systemic disease, n (%)		0.487[b]
Diabetes	12 (34.3)	
No diabetes	23 (65.7)	
Implant location, n (%)		0.190[c]
Maxillary anterior	13 (37.1)	
Maxillary premolar	17 (48.6)	
Mandibular anterior	0 (0)	
Mandibular premolar	5 (14.3)	
Flap management, n (%)		0.965[b]
Flapless	29 (82.9)	
Flap	6 (17.1)	
Duration till loading, mean ± SD, months	4.4 ± 1.8	0.780[a]
BWT0[d], mean ± SD, mm	1.2 ± 0.7	<0.001*[a]
Gap[e], mean ± SD, mm	2.1 ± 0.6	0.424[a]
BWT2[f], mean ± SD, mm	2.5 ± 1.1	

*$P < 0.05$, [a]by Spearman correlation test, [b]by Mann - Whitney U test, [c]by Kruskal - Wallis H test, [d]Initial buccal bone wall thickness, [e]Gap distance between buccal bone wall and implant, [f]Final buccal bone wall thickness.

Table 2. Comparison between two groups

Variable	Thin group (<1 mm)	*P*–value[d]	Thick group (1≥ mm)	*P*–value[d]	*P*–value[f]
Age, mean ± SD, years	77.9 ± 11.1	0.221[a]	73.9 ± 10.6	0.516[a]	0.335[b]
Gender, n (%)		0.457[b]		0.560[b]	0.558[e]
Male	11 (57.9)		7 (43.8)		
Female	8 (42.1)		9 (56.2)		
Systemic disease, n (%)		0.930[b]		0.039*[b]	0.833[e]
Diabetes	6 (31.6)		6 (37.5)		
No diabetes	13 (68.4)		10 (62.5)		
Implant location, n (%)		0.336[c]		0.344[c]	0.058[e]
Maxillary anterior	10 (52.6)		3 (18.8)		
Maxillary premolar	8 (42.1)		9 (56.2)		
Mandibular anterior	0 (0)		0		
Mandibular premolar	1 (5.3)		4 (25)		
Flap management, n (%)		0.024*[b]		0.716[b]	0.136[e]
Flapless	17 (89.5)		12 (75)		
Flap	2 (10.5)		4 (25)		
Duration till loading, mean ± SD, months	4.1 ± 1.6	0.820[a]	4.7 ± 2.1	0.764[a]	0.457[b]
BWT0[g], mean ± SD, mm	0.7 ± 0.1	0.054[a]	1.8 ± 0.7	<0.001*[a]	<0.001*[b]
Gap[h], mean ± SD, mm	2.3 ± 0.5	<0.001*[a]	1.9 ± 0.6	0.279[a]	0.049*[b]
BWT2[i], mean ± SD, mm	1.9 ± 0.7		3.2 ± 1.0		<0.001*[b]

*$P < 0.05$, [a]by Spearman correlation test, [b]by Mann – Whitney U test, [c]by Kruskal – Wallis H test, [d]Correlation with final bone wall thickness, [e]by Logistic regression, [f]Correlation between thin and thick groups, [g]Initial bone wall thickness, [h]Gap distance between buccal bone wall and implant, [i]Final bone wall thickness.

Table 3. Results of multiple linear regression analysis with final bone wall thickness

Variable	Thin group		Thick group	
	β ± SE	*P*–value	β ± SE	*P*–value
Gap	1.002 ± 0.217	<0.001*		
Flap	−0.432 ± 0.360	0.248		
BWT0			0.970 ± 0.214	<0.001*
Diabetes			−0.562 ± 0.306	0.089

*$P < 0.05$.

the thin group was BWT2 = −0.540 + 1.080 × Gap ($P < 0.001$, $R^2 = 0.586$); for the thick group, it was BWT2 = 1.313 + 1.058 × BWT0 ($P < 0.001$, $R^2 = 0.582$).

DISCUSSION

This study investigated factors influencing buccal alveolar bone wall thickness after loading in IIP in the anterior and premolar regions, hypothesizing that these factors may vary depending on initial wall thickness. In the thin group, the gap between the buccal alveolar bone wall and the implant significantly influenced final buccal bone thickness; in the thick group, initial wall thickness was the significant factor.

The 1-mm cutoff used to distinguish thin from thick bone in this study was based on previous research, which reported that in the anterior maxilla, where buccal bone can be as thin as 1 mm, bone grafting in the gap was more beneficial during IIP[16].

Levine et al. performed IIP with deproteinized bovine bone grafting in the gap and classified cases into wide-gap and narrow-gap groups using a 2-mm threshold. CBCT scans obtained at least 1 year after loading were used to measure horizontal buccal bone thickness at the implant shoulder and at 2, 4, and 6 mm below the shoulder. Their results showed that the wide-gap group had significantly thicker buccal bone at all levels compared with the narrow-gap group. Moreover, linear regression analysis revealed that gap width was the only factor affecting buccal bone thickness[12]. However, the initial buccal bone plate thickness was not included as a variable in their regression model.

Stass et al. performed IIP without flap elevation, provisional restoration, or gap grafting in the maxillary incisor region to investigate the effect of initial buccal bone wall thickness on final thickness after 1 year. In their cases, 85% had an initial buccal bone wall thickness of ≤1 mm, and 25% presented with small buccal bone defects. Seventy-five percent of cases with intact extraction sockets showed a moderate, significant correlation between initial and final buccal bone wall thickness[17]. This is consistent with the finding in the overall cohort of the present study, where BWT0 was the only variable significantly correlated with BWT2.

Ferrus et al. evaluated peri-implant hard tissue changes 16 weeks after performing IIP without gap grafting in the maxillary anterior and premolar regions. In cases with a buccal bone wall <1 mm, horizontal reduction from the implant to the outer buccal wall was greater than in cases with a buccal bone wall ≥1 mm[10]. According to Monje et al., when buccal bone thickness is ≤1.5 mm at placement, the risk of unfavorable dimensional changes in both soft tissue and buccal bone volume is higher[18]. Applying this to the regression equation from the present study by substituting 1.5 mm for the BWT2 value, it can be estimated that a gap of approximately ≥1.9 mm is required when buccal bone is thin. This aligns with previous studies suggesting that securing a ≥2-mm gap is advantageous during IIP.

By contrast, El Nahass et al. reported different findings. They analyzed buccal bone resorption using CBCT after IIP with gap grafting in the esthetic zone. Buccal bone resorption was measured in both thin and thick buccal bone groups; unexpectedly, the thick group showed greater resorption than the thin group[19].

In a systematic review and meta-analysis, Pitman et al. investigated the effect of flap elevation on buccal bone thickness changes during IIP for single-tooth cases. Their results showed that cases with flap elevation exhibited greater changes compared with cases without flap elevation[11]. However, in a similar study, Mazzocco et al. reported that flap elevation did not significantly affect buccal bone thickness[20].

To the best of the authors' knowledge, this is the first study to classify groups based on the anatomical criterion of pre-extraction buccal bone thickness in IIP and to analyze the effects of multiple variables on buccal bone wall thickness after implant loading within each group. In addition, measurement consistency and accuracy were ensured by performing CBCT scans at three time points (T0, T1, T2) on the same site, followed by a detailed analysis using three-dimensional software.

This study has limitations, including its retrospective design, single-institution setting, and limited sample size, which may not fully account for variability in clinical factors. Future research should employ prospective, multicenter designs with larger cohorts to improve generalizability and reproducibility. Furthermore, subsequent studies should incorporate esthetic assessments, such as gingival recession, alongside bone wall thickness in the context of IIP.

In conclusion, when IIP with gap grafting was performed, buccal bone thickness after loading was influenced by gap size in cases with thin initial buccal bone; in thick bone cases, initial thickness itself correlated positively with post-loading thickness. Therefore, in cases with thin buccal bone (<1 mm), creating an adequate gap during IIP is crucial for preserving buccal bone thickness after loading.

ETHICAL STATEMENT

The study was approved by the institutional review board (IRB No. 20-2025-13) of Seoul Metropolitan Government - Seoul National University Boramae Medical Center and conducted in accordance with the Declaration of Helsinki (1964) and its subsequent amendments.

DECLARATION OF COMPETING INTEREST

The authors declare no conflicts of interest related to this article.

ACKNOWLEDGEMENTS

This study was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health and Welfare, Republic of Korea (grant number: RS-2023-KH135514).

We would like to thank Editage (www.editage.co.kr) for English language editing.

DATA STATEMENT

The data used in this study are available from the correspond-

ing author upon reasonable request.

REFERENCES

1. Kan JYK, Rungcharassaeng K, Deflorian M, Weinstein T, Wang HL, Testori T. Immediate implant placement and provisionalization of maxillary anterior single implants. Periodontol 2000 2018;77:197-212.
2. Wittneben JG, Molinero-Mourelle P, Hamilton A, Alnasser M, Obermaier B, Morton D, et al. Clinical performance of immediately placed and immediately loaded single implants in the esthetic zone: a systematic review and meta-analysis. Clin Oral Implants Res 2023;34:266-303.
3. Esposito M, Grusovin MG, Polyzos IP, Felice P, Worthington HV. Timing of implant placement after tooth extraction: immediate, immediate-delayed or delayed implants? A Cochrane systematic review. Eur J Oral Implantol 2010;3:189-205.
4. Lang NP, Pun L, Lau KY, Li KY, Wong MC. A systematic review on survival and success rates of implants placed immediately into fresh extraction sockets after at least 1 year. Clin Oral Implants Res 2012; 23:39-66.
5. Johnson K. A study of the dimensional changes occurring in the maxilla following tooth extraction. Aust Dent J 1969;14:241-244.
6. Huynh-Ba G, Pjetursson BE, Sanz M, Cecchinato D, Ferrus J, Lindhe J, et al. Analysis of the socket bone wall dimensions in the upper maxilla in relation to immediate implant placement. Clin Oral Implants Res 2010;21:37-42.
7. Chen ST, Buser D. Esthetic outcomes following immediate and early implant placement in the anterior maxilla—a systematic review. Int J Oral Maxillofac Implants 2014;29:186-215.
8. Vignoletti F, Sanz M. Immediate implants at fresh extraction sockets: from myth to reality. Periodontol 2000 2014;66:132-152.
9. Lee CT, Chiu TS, Chuang SK, Tarnow D, Stoupel J. Alterations of the bone dimension following immediate implant placement into extraction socket: systematic review and meta-analysis. J Clin Periodontol 2014;4:914-926.
10. Ferrus J, Cecchinato D, Pjetursson EB, Lang NP, Sanz M, Lindhe J. Factors influencing ridge alterations following immediate implant placement into extraction sockets. Clin Oral Implants Res 2010;21: 22-29.
11. Pitman J, Christiaens V, Callens J, Glibert M, Seyssens L, Blanco J, et al. Immediate implant placement with flap or flapless surgery: a systematic review and meta-analysis. J Clin Periodontol 2023;50:755-764.
12. Levine RA, Dias DR, Wang P, Araújo MG. Effect of the buccal gap width following immediate implant placement on the buccal bone wall: A retrospective cone-beam computed tomography analysis. Clin Implant Dent Relat Res 2022;24:403-413.
13. Sanz M, Lindhe J, Alcaraz J, Sanz-Sanchez I, Cecchinato D. The effect of placing a bone replacement graft in the gap at immediately placed implants: a randomized clinical trial. Clin Oral Implants Res 2017;28:902-910.
14. Slagter KW, Raghoebar GM, Bakker NA, Vissink A, Meijer HJ. Buccal bone thickness at dental implants in the aesthetic zone: A 1-year follow-up cone beam computed tomography study. Journal of Cranio-Maxillofacial Surgery 2017;45:13-19.
15. Mao Z, Lee CT, He SM, Zhang S, Bao J, Xie ZG. Buccal bone dimensional changes at immediate implant sites in the maxillary esthetic zone within a 4–12-month follow-up period: A systematic review and m eta-analysis. Clin Implant Dent Relat Res 2021;23:883-903.
16. Liñares A, Dopico J, Magrin G, Blanco J. Critical review on bone grafting during immediate implant placement. Periodontol 2000 2023; 93:309-326.
17. Staas TA, Groenendijk E, Bronkhorst E, Verhamme L, Raghoebar GM, Meijer GJ. Does initial buccal crest thickness affect final buccal crest thickness after flapless immediate implant placement and provisionalization: A prospective cone beam computed tomogram cohort study. Clin Implant Dent Relat Res 2022;24:24-33.
18. Monje A, Roccuzzo A, Buser D, Wang HL. Influence of buccal bone wall thickness on the peri-implant hard and soft tissue dimensional changes: A systematic review. Clinical Oral Implants Research 2023; 34:8-27.
19. ElNahass H, Tawfik OK, Naiem SN, Zazou N, Moussa M. Evaluation of buccal bone resorption in immediate implant placement in thin versus thick buccal bone plates: An 18-month follow-up prospective cohort study. Clin Implant Dent Relat Res 2024;26:532-544.
20. Mazzocco F, Jimenez D, Barallat L, Paniz G, Del Fabbro M, Nart J. Bone volume changes after immediate implant placement with or without flap elevation. Clin Oral Implants Res 2017;28:495-501.