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Effect of abutment height on interproximal implant bone level in the early healing: A randomized clinical trial

Juan Blanco[1,2] | Alexandre Pico[1] | Leticia Caneiro[1] | Lourdes Nóvoa[1] | Pilar Batalla[1] | Pablo Martín-Lancharro[3]

[1]Periodontology Unit, School of Medicine and Dentistry, University of Santiago de Compostela, Santiago de Compostela, Spain

[2]Odontología Médico-Quirúrgica (OMEQUI) Research Group, Health Research Institute of Santiago de Compostela (IDIS), Santiago de Compostela, Spain

[3]Statistics, Clinic University Hospital, Santiago de Compostela, Spain

Correspondence
Juan Blanco, Periodontology Unit, School of Medicine and Dentistry, University of Santiago de Compostela, Santiago de Compostela, Spain.
Email: jblanco@blancoramos.net

Funding information
LASAK, Praha, Czech Republic

Abstract

Objective: The aim of this randomized clinical trial was to compare the effect on the interproximal implant bone loss (IBL) of two different heights (1 and 3 mm) of definitive abutments placed at bone level implants with a platform switched design.

Material and methods: Twenty-two patients received forty-four implants (6.5–10 mm length and 3.5–4 mm diameter) to replace at least two adjacent missing teeth, one bridge set to each patient—two implants per bridge. Patients were randomly allocated, and two different abutment heights, 1 and 3 mm using only one abutment height per bridge, were used. Clinical and radiological measurements were performed at 3 and 6 months after surgery. Interproximal bone level changes were compared between treatment groups. The association between IBL and categorical variables (history of periodontitis, smoking, implant location, implant diameter, implant length, insertion torque, width of keratinized mucosa, bone density, gingival biotype and antagonist) was also performed.

Results: At 3 months, implants with a 1-mm abutment had significantly greater IBL (0.83 ± 0.19 mm) compared to implants with a 3-mm abutment (0.14 ± 0.08 mm). At 6 months, a greater IBL was observed at implants with 1-mm abutments compared to implants with 3-mm abutments (0.91 ± 0.19 vs. 0.11 ± 0.09 mm). The analysis of the relation between patient characteristics and clinical variables with IBL revealed no significant differences at any moment except for smoking.

Conclusions: Abutment height is an important factor to maintain interproximal implant bone level in early healing. Short abutments led to a greater interproximal bone loss in comparison with long abutments after 6 months. Other variables except smoking showed no relation with interproximal bone loss in early healing.

KEYWORDS

abutment height, implant–abutment connection, interproximal bone loss, platform switching

1 | INTRODUCTION

Success of dental implant treatment depends on osseointegration but also on aesthetic outcomes and absence of complications (Buser, Weber, & Lang, 1990; Papaspyridakos, Chen, Singh, Weber & Gallucci, 2012). Peri-implant soft tissues are essential, acting as a biologic seal prevailing contact between bone and the oral cavity and the contamination of implant surface by pathogenic flora (Berglundh et al., 1991). Peri-implant mucosa stability is related to marginal bone loss being essential for the maintenance of interproximal crestal bone. However, since decades, bone remodelling (1.5–2 mm) during first year after loading and an annual bone resorption <0.2 mm was generally

accepted as success for two-piece implants according to Albrektsson, Zarb, Worthington and Eriksson (1986).

Several factors have shown to influence on interproximal bone loss, including surgical trauma, micro-gap, biologic width, location of implant–abutment micro-gap or implant characteristics (Buser, Martin, & Belser, 2004; Hermann, Buser, Schenk, & Cochran, 2000; Hermann, Buser, Schenk, Higginbottom, & Cochran, 2000; Oh, Yoon, Misch, & Wang, 2002). The position of this micro-gap at the level or below the bone crest results in a more intense remodelling and apical displacement of the peri-implant bone as a consequence of the colonization of the micro-gap (Broggini et al., 2006). Bone remodelling due to biologic width establishment has been observed in early healing stages, being unrelated to submerged or non-submerged healing (Berglundh & Lindhe, 1996; Ericsson, Nilner, Klinge, & Glantz, 1996). Experimental studies performed in Beagle dogs and humans have shown a complete maturation of peri-implant mucosa 6–8 weeks after implant installation with similarities in terms of composition and dimensions between soft tissues around teeth and implants (Berglundh, Abrahamsson, Welander, Lang, & Lindhe, 2007; Berglundh et al., 1991; Tomasi et al., 2014). A minimum dimension of mucosa thickness is required for the establishment of mucosal attachment as demonstrated by Berglundh and Lindhe (1996). In a study performed in Beagle dogs, they reduced vertical dimension of the peri-implant mucosa in test group, and peri-implant osseous resorption was observed to allow the establishment of a mucosal attachment thickness (biologic width) similar to control group (Berglundh & Lindhe, 1996), but in a more apical position.

The development of platform switching (PS) concept based on the use of a narrower abutment in relation to implant diameter can reduce peri-implant bone resorption (Lazzara & Porter 2006). A significant difference (0.49 mm) was observed between PS and PM (platform matching) implants in a systematic review by Strietzel, Neumann, and Hertel (2015). It has been hypothesized that a reduction in the vertical component of mucosal attachment by creating a horizontal space, because of a mismatching between implant and abutment, allows harbouring the inflammatory infiltrate far from the peri-implant crestal bone (Galindo-Moreno et al., 2015). For the same reason, it was suggested that a less peri-implant marginal bone loss could be observed if a higher abutment is used to allow the establishment of the biologic width (Piattelli et al., 2003).

Recent retrospective radiological studies have demonstrated that abutment height may influence on interproximal marginal bone level (IMBL) (Galindo-Moreno et al., 2015; Nóvoa et al., 2016).

The aim of this randomized clinical trial was to assess radiographically the influence of two definitive prosthetic abutments height on interproximal implant bone loss (IBL) in bone level and platform switching implants.

2 | MATERIAL AND METHODS

2.1 | Study design and patient selection

This randomized clinical trial (parallel design) was realized in accordance with the Declaration of Helsinki, following CONSORT guidelines and approved by the Ethic Investigation Committee of Galicia (2016/593). All subjects were selected consecutively among the patients of the Master of Periodontology in the University of Santiago de Compostela. Once signed the informed consent, participating patients had to fulfil the following inclusion criteria:

1. At least eighteen years old
2. American Society of Anaesthesiologists (ASA) physical status of I or II
3. Need for restoration of at least two missing adjacent teeth (bridge units)
4. Periodontal stability or enrolment in a periodontal maintenance programme
5. Adequate bone volume for implant installation
6. No bone augmentation procedures before and during implant placement
7. Mucosa thickness ≥3 mm
8. Signed informed consent form for participation and permission to use obtained data or research purposes

Mucosa thickness was measured with a periodontal probe (15 mm, PCP-UNC 15; Hu-Friedy, Chicago, IL, USA) just before implant installation.

Individuals who took any medication or systemic disease that can affect bone metabolism, including patients with medical history of bisphosphonate therapy, pregnant or lactating women, poor oral hygiene, uncontrolled periodontal diseases, need of single-implant restoration or simultaneous guided bone regeneration techniques, and sites with acute lesions, were excluded. Lack of primary stability also led to exclusion at surgery.

3 | MATERIAL

Bone level BioniQ implants (LASAK, Praha, Czech Republic) of 6.5–10 mm length and a diameter of 3.5–4 mm were placed. Implant body presented micro-threads in the coronal portion and a bioactive surface with reduced roughness in the fixture cervical area in contact with connective tissue. Designed based on platform switching concept and internal connection abutments, prosthetic restoration provides different horizontal distances between the abutment diameter (at the abutment/fixture interface) and the fixture platform diameter (platform switching). The horizontal distances of bridge abutments were: 0.3 mm in implants with a diameter of 3.5 and 0.55 mm in 4-mm implants. All products used were registered products, commercially available and used within their cleared indications.

3.1 | Randomization

A randomization list was generated by the statistic program Epidat vers 4.1 (Consellería de Sanidade, Xunta de Galicia, España). Investigators received a sealed envelop for each bridge to either 1 or 3 mm group. Consecutive patients who met inclusion criteria were randomized.

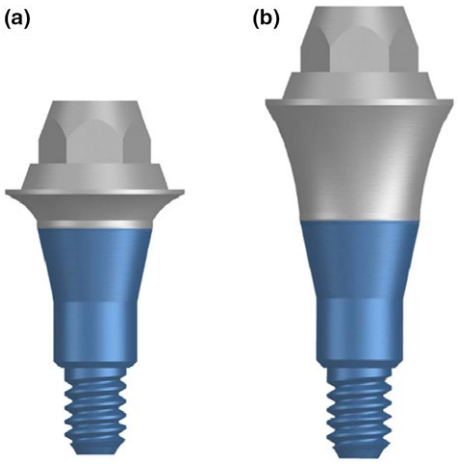

FIGURE 1 1 mm (a) and 3 mm (b) screw-on titanium abutments

3.2 | Surgical and restorative procedures

Patients received a complete oral clinical examination and intra-oral X-ray and CBCT scan to assess bone dimensions for implant placement. An individualized film holder was also designed to have reproducible and comparable X-rays. Once enrolled in the study, a full-mouth professional prophylaxis was scheduled. At the time of surgery, and under local anaesthesia (Artinibsa®; Inibsa, Barcelona, Spain), thickness of the mucosa was measured, a mid-crestal incision was performed and the buccal and lingual flap elevated. Before implant osteotomy, sealed envelopes containing the randomization were opened. A conventional implant placement protocol was performed according to manufacturer's recommendations for 3.5- or 4-mm-diameter implants based on available bone and in a non-submerged technique. Implant stability was assessed using torque control with the hand-piece device.

Immediately after implantation, screw-on definitive titanium abutments (Figure 1) were placed and protected with a titanium cover (one-abutment one-time). Mucoperiosteal flaps were then sutured with Supramid 5/0 (Aragó; Barcelona; Spain) obtaining primary closure. A standardized intra-oral radiograph was made to check implant position and abutment seating immediately after surgery (baseline data).

All patients were advised to have soft diet and minimize the trauma in the implant area. Patients were also instructed to rinse with 0.12% chlorhexidine/digluconate (Perio-aid; Dentaid, Spain) solution twice per day for 2 weeks and systemic antibiotics (Amoxicillin 500/8 hr/7 d) and anti-inflammatories (Ibuprofen 600 mg/8 hr/3 d) prescribed. Sutures were removed 1 week after surgery and patients received thorough dental hygiene instructions and were advised to clean the titanium cover with extra soft toothbrush.

Eight weeks after surgery, prosthetic phase was initiated. Custom impression trays, impression copings to the definitive abutments and a full-arch polyether material were used (Impregum Penta Soft; 3M ESPE). One month later, after final impression was taken, screw-retained metal ceramic prosthesis was positioned, the internal screws tightened at 15 Ncm^2 torque according to manufacturer guidelines, and screw access closed with light-cured composite. Occlusion was also checked to obtain an adequate distribution of occlusal contacts.

3.3 | Radiographic variable

To evaluate interproximal bone levels around implants, a standardized intra-oral X-ray technique was used. A customized X-ray film holder (Rinn holder) was made for each patient. It was used at each visit and fitted onto the antagonist jaw. The periapical radiographs were taken using the long-cone paralleling technique (Meijndert, Meijer, Raghoebar, & Vissink, 2004). A phosphor plate X-ray (Durr Dental, Bietigheim-Bissingen, Germany) and an X-ray tube (Planmeca, Helsinki, Finland) with the same setting for each patient were used. Two independent and calibrated examiners (A.P., P.M.) measured the distance from implant shoulder (S) to the mesial and distal first visible bone contact (fBIC) to the nearest 0.1 mm using IMAGE J software (1.47 V Wayne Rasband; National Institutes of Health, Bethesda, MD, USA) and the mean of the two measurements were calculated. The scale was set and calibrated by the height of the dental implant, which yielded a pixel/mm ratio. Radiographic interproximal bone levels were calculated between implant placement (baseline), loading (3 months after surgery) and 6-month follow-up after surgery (Figure 2).

3.4 | Clinical variables

Data related to age, gender, history of periodontitis, smoking, implant location, implant diameter, implant length, insertion torque, width of keratinized mucosa, bone density, gingival biotype and antagonist were also gathered to evaluate the influence of these factors on IMBL. Periodontal disease history was determined by assessment of attachment loss using a periodontal probe (15 mm, PCP-UNC 15; Hu-Friedy). Patients with the presence of proximal attachment loss of ≥3 mm in ≥2 non-adjacent teeth were considered to have periodontitis (Tonetti & Claffey, 2005). Smoking status was classified as: non-smoker/smoker. Data relative to implant location (upper/lower), insertion torque (≤35 Ncm^2/>35 Ncm^2), width of keratinized tissue (<1 mm/≥1 mm), bone density (Lekholm & Zarb, 1985) categorized in types I–II (cortical) and types III–IV (cancellous), biotype (thin/thick. De Rouck, Eghbali, Collys, De Bruyn, & Cosyn, 2009) and antagonist (natural tooth/implant restoration) were also registered.

3.5 | Statistical analysis

The trial was designed to assess whether the average efficacy of both treatments can be considered different in interproximal crestal bone levels maintenance. To achieve 80% power at a significance level of 0.05, sample size was computed considering to detect a difference of 0.5 mm in a design with four repeated measurements. Using PASS version 12 (NCSS, LCC, Kaysville, UT, USA), it was determined that 20 patients/20 bridges (10 per group) were required.

Demographical and clinical parameters were descriptively reported. For continuous variables, mean and standard deviations (*SD*s) were calculated for each treatment group, and numbers and percentages were calculated for categorical variables. Interproximal bone level

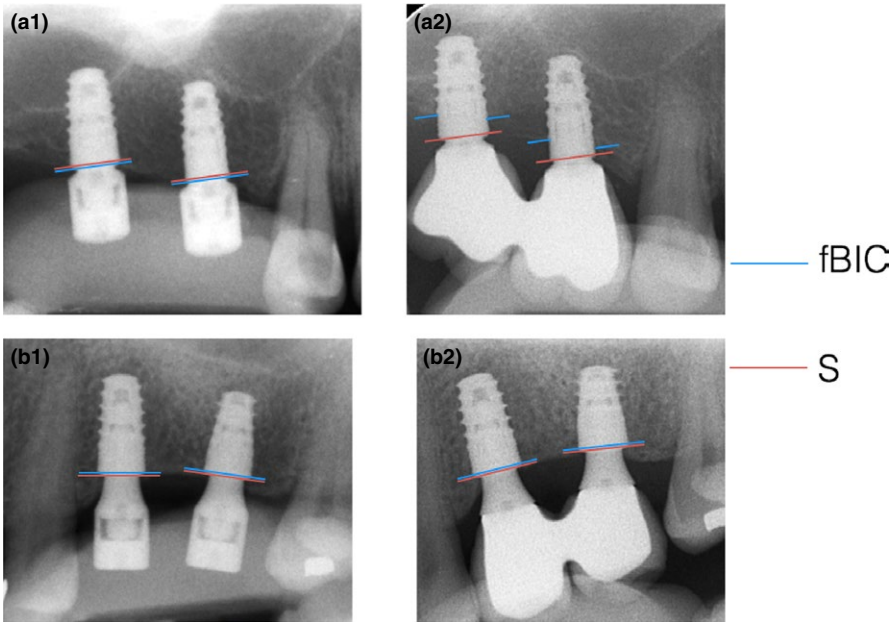

FIGURE 2 Bone loss measurement (S-fBIC) after 6 months of follow-up at 1 mm group (a1, baseline; a2, 6 months post-surgery) and 3 mm group (b1, baseline; b2, 6 months post-surgery) groups

changes (IBLCs) were measured at mesial and distal implant site and averaged to represent the IBL over time. The IBLCs were compared using repeated-measures mixed ANOVA. Association between IBLC and categorical variables was performed with the Student *t* test. All analyses were performed using SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). The level of significance was set at $p < .05$.

4 | RESULTS

4.1 | Subjects and implants

Twenty-two consecutive subjects, with a mean age of 55.82 ± 1.55 in 1 mm and 52.27 ± 2.45 in 3 mm group, were included in this study, and 21 completed the follow-up. Twenty-two implants—11 bridges (50%) in the 1 mm and the same in the 3 mm group (50%). Out of the 44 study implants, a total of 42 implants were available at 6 months. In 3 mm group, two implants in one bridge were not available for analysis. Due to lack of stability of these two implants, prosthesis placement was delayed and implants were excluded. No adverse events were reported after 6 months follow-up after surgery (Figure 3).

General health was assessed with the American Society of Anaesthesiologist physical status classification system (ASA). Nine patients were classified as ASA I (40.9%) and 12 patients as ASA II (59.1%). Implants were placed in seven non-smoker and four smokers patients in 1 mm group and eight and two patients in the 3 mm group, respectively. Ten patients had periodontitis, five in 1 mm group and five in 3 mm group. The majority of implants (30) were 8 mm in length (16 in 1 mm group and 14 in 3 mm group). Twenty-four implants were 3.5 mm in diameter and 18 were 4.0 mm. Twenty-two implants were placed in the lower jaw. In 1 mm group, the mean of insertion torque was 30.23 ± 1.66 and 32.95 ± 1.85 in 3 mm group. Bone density was classified according to Lekholm and Zarb (1985). The majority of implants were placed in bone type III or type IV. No significant difference was observed between groups (Table 1).

4.2 | Radiographic evaluation of interproximal marginal bone levels

The mean interproximal bone loss from surgery to loading (3 months) and from 3 to 6 months was 0.83 ± 0.19 mm and 0.91 ± 0.19 mm in the 1 mm group, and 0.14 ± 0.08 mm and 0.11 ± 0.09 mm in the 3 mm group, respectively. The repeated-measures mixed ANOVA test revealed statistical significant differences between treatment groups at loading (3 months after surgery) and 6 months after surgery (Table 2). A greater bone resorption was observed in implants loaded with short abutments in comparison with long abutments. Figure 4 shows absolute values of IMBL at the three time points and changes of IMBL between the time points.

Table 3 exhibits the results of the analysis for the relation of patient characteristics and clinical variables on marginal bone level. At 3 and 6 months, it was observed a statistical significant difference in interproximal bone loss in smokers vs. non-smokers. For the rest of the variables, it was observed a greater interproximal bone loss in implants placed in the upper jaw vs. lower jaw, with high vs. low torque of insertion, in sites with cortical vs. trabecular bone substratum, and in sites with tooth vs. implant restorations as antagonist. The analysis did not reveal statistical significant differences between groups at 3 or 6 months, except for smokers, showing the absence of relation of these factors in interproximal marginal bone levels when we analyse the variables independently.

5 | DISCUSSION

The objective of this randomized clinical trial was to evaluate the effect of two different transmucosal definitive abutment heights, on IBL in the early healing phase from implant installation. The results of this study showed a better maintenance of interproximal

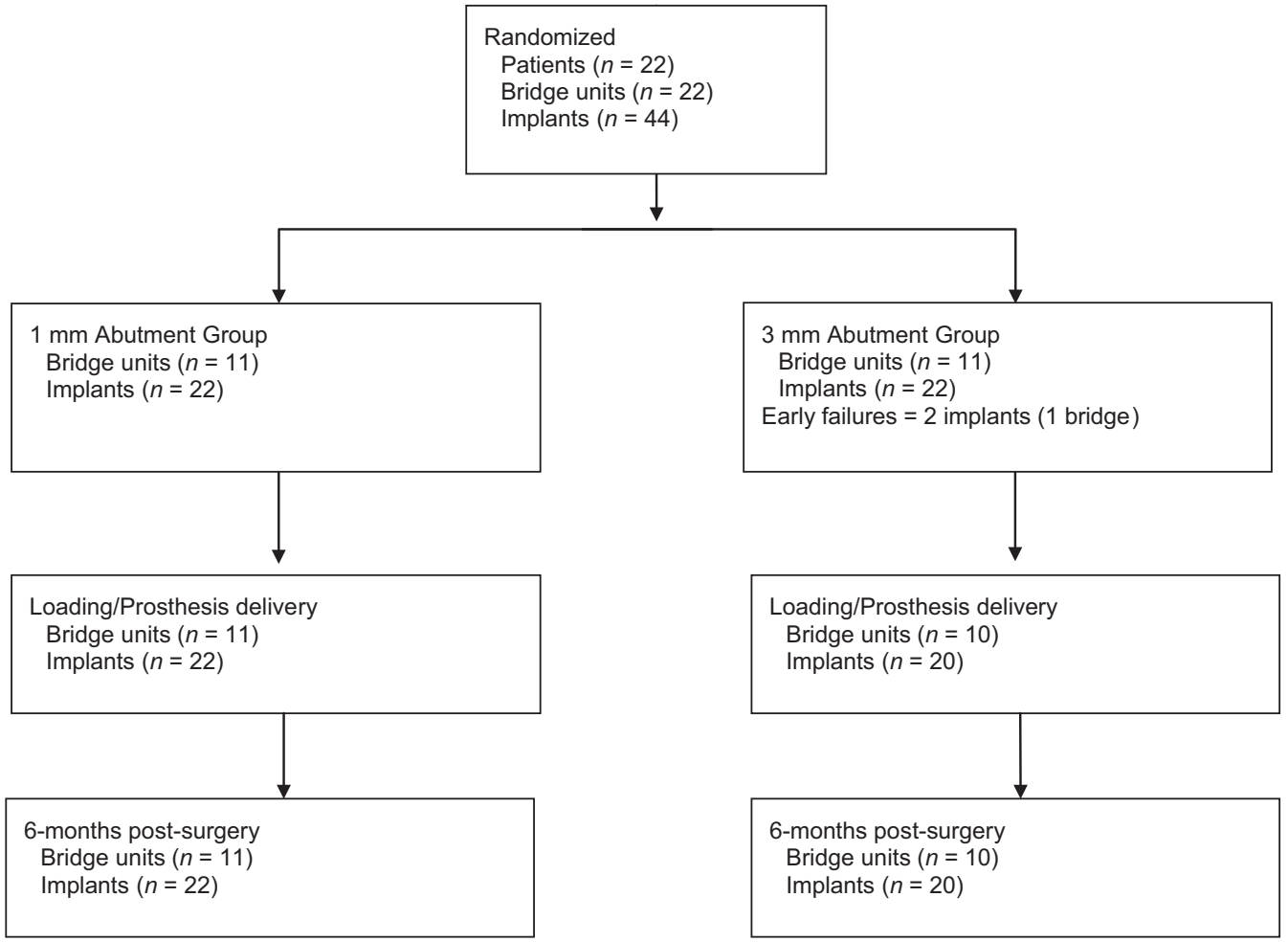

FIGURE 3 Flow chart

marginal bone level when a longer abutment was used to restore PS implants and in non-smoker patients. There were, however, no significant differences when the results of other factors were analysed. Our results confirmed the results published by recent retrospective radiological studies (Galindo-Moreno et al., 2014; Nóvoa et al., 2016; Vervaeke, Dierens, Besseler, & De Bruyn, 2014) and prospective ones (Spinato, Bernardello, Sassatelli, & Zaffe, 2017; Vervaeke, Collaert, Cosyn, & De Bruyn, 2016). Vervaeke et al. (Vervaeke et al., 2014) observed, in a clinical study assessing the influence of initial soft tissue thickness on peri-implant bone level, increasing bone level changes with decreasing abutment heights after 1- and 2-year follow-up. The same group in a prospective and multivariate analysis study stated that after a mean follow-up of 9 years in a group of 39 patients, abutment height was a significant predictor of early peri-implant bone loss (Vervaeke et al., 2016). Galindo-Moreno et al. selected patients with at least two implants splinted in the same screwed prosthetic restoration. The analysis of 6 and 18 months post-loading panoramic radiographs revealed a significant effect of abutment height (Galindo-Moreno et al., 2014, 2015). Nóvoa et al. (2016) observed, in periapical radiographs, greater bone loss at two-piece bone level implants restored with 1 mm than 2.5-mm abutment heights after 36 months. Spinato and coworkers (Spinato et al., 2017), in a prospective clinical and radiographic study in 93 patients, found that the higher the abutment height, the less marginal bone loss.

As a matter of fact, the relevance of abutment height in reducing peri-implant crestal bone might be because the establishment of the biologic width at abutment level instead of implant level. This fact would allow soft tissue healing at abutment level protecting the osseointegration of the implant. Furthermore, bone remodelling due to biologic width establishment has been observed in early healing stages (Berglundh & Lindhe, 1996; Ericsson et al., 1996) and a minimum dimension of mucosa thickness is required for the establishment of mucosal attachment as demonstrated by Berglundh and Lindhe (1996). Experimental studies performed in Beagle dogs have shown a complete maturation of peri-implant mucosa 6–8 weeks after implant installation with similarities in terms of composition and dimensions between soft tissues around teeth and implants (Berglundh et al., 1991, 2007; Tomasi et al., 2014).

Ericsson et al. (1995) analysed in the dog model different characteristics of the peri-implant mucosa surrounding PM (platform matching) implants. After 9 months, they observed an inflammatory cell infiltrated in the connective tissue facing the implant–abutment junction and 1 mm of bone loss at sites with or without plaque control

TABLE 1 Demographical and clinical parameter of the study population and implant sites

Treatment group (patients)	1 mm (*n* = 11)	3 mm (*n* = 10)
Age (y)	55.82 ± 1.55	52.27 ± 2.45
Smoking		
Non-smoker	7 (63.6%)	8 (81.8%)
Smoker	4 (36.4%)	2 (18.2%)
Periodontitis		
Yes	5 (45.5%)	5 (50.0%)
No	6 (54.5%)	5 (50.0%)
Biotype		
Thin	5 (45.5%)	3 (30.0%)
Thick	6 (54.5%)	7 (70.0%)
Implant length		
6.5 mm	1 (9.1%)	0 (0.0%)
8 mm	8 (72.7%)	7 (70.0%)
10 mm	2 (18.2%)	3 (30.0%)
Implant diameter		
3.5 mm	5 (45.5%)	7 (70.0%)
4.0 mm	6 (54.5%)	3 (30.0%)
Implant position		
Upper	6 (54.5%)	4 (40.0%)
Lower	5 (45.5%)	6 (60.0%)
Torque	30.23 ± 1.66	32.95 ± 1.85
Bone quality		
1–2	4 (36.4%)	5 (50.0%)
3–4	7 (63.6%)	5 (50.0%)

in an attempt to close off bacteria present at this level as suggested by the authors.

Platform switching has been hypothesized to reduce the vertical component of the biologic width and a reduction in marginal bone resorption (Atieh, Ibrahim, & Atieh, 2010; Lazzara & Porter, 2006). However, other factors also need to be taken into consideration like soft tissue thickness, amount of keratinized tissue, position of implant–abutment junction, implant design, history of periodontitis, or tobacco consumption (Galindo-Moreno et al., 2005, 2014; Hartman & Cochran, 2004; Hermann, Cochran, Nummikoski, & Buser, 1997; Qian, Wennerberg, & Albrektsson, 2012).

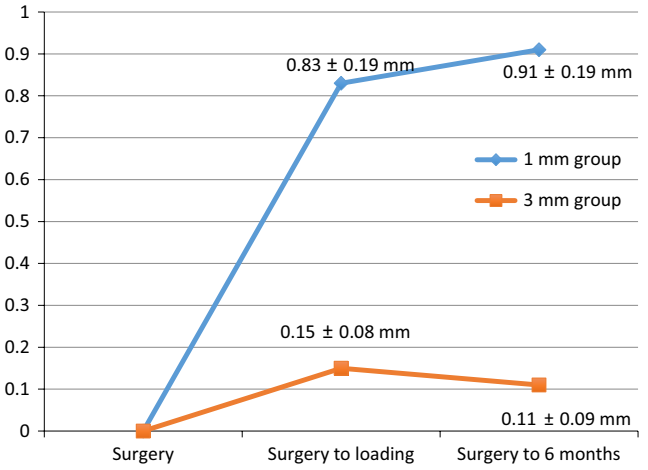

FIGURE 4 Graphic data presented with absolute values of interproximal marginal bone level (IMBL) at the three time points and changes of IMBL between the time points

Initial vertical mucosa thickness may influence in maintaining peri-implant marginal bone crest. Berglundh and Lindhe demonstrated a significantly more bone resorption when tissues are thinned to 2 mm or less (Berglundh & Lindhe, 1996). Linkevicius, Apse, Grybauskas, & Puisys (2009) in a controlled clinical study observed a greater bone loss, when the mucosal thickness was 2 mm or less (1.38 mm) in contrast with to tissues (0.25 mm). Recent studies have demonstrated that platform switching did not prevent marginal bone resorption when a thin mucosa is present (Linkevicius, Apse, Grybauskas, & Puisys, 2010; Puisys & Linkevicius, 2015). In this study, we have avoided this factor including only cases with at least 3 mm of mucosa thickness at the surgical location.

The implant–abutment interface has demonstrated to be one of the most contributing factors to marginal bone changes (Hermann et al., 1997; Hermann, Buser, Schenk, & Cochran, 2000; Oh et al., 2002; Schwarz, Hegewald, & Becker, 2014). Bacterial colonization of the micro-gap and internal surfaces of the different components, in external abutment connection implants, could explain the presence of bacteria at this level (Persson, Lekholm, Leonhardt, Dahlen, & Lindhe, 1996; Quirynen & van Steenberghe, 1993). As a consequence, an inflammatory cell infiltrate and bone remodelling will be expected due to the establishment of the biologic width (Broggini et al., 2003, 2006). In implants with internal abutment connection, such as the ones used in this study, this complication has been overcome (Dibart, Warbington, Su, & Skobe, 2005; Heitz-Mayfield, Darby, Heitz, & Chen, 2013; Koo et al., 2012; Tesmer, Wallet, Koutouzis, & Lundgren, 2009).

TABLE 2 Mean interproximal bone level change (S-fBIC) at 3 and 6 months

	Abutment height 1 mm		Abutment height 3 mm		*p*-Value inter-groups	*p*-Value intra-groups *t**ah[a]
	N	Mean ± *SD* (mm)	*N*	Mean ± *SD* (mm)		
Surgery to loading	11	0.83 ± 0.19	10	0.14 ± 0.08	.001	.042
Surgery to 6 mo	11	0.91 ± 0.19	10	0.11 ± 0.09		

[a]time*abutment height.

TABLE 3 Mean interproximal bone level change as a function of demographic and clinical factors

	Mean interproximal implant bone level change ± *SD*		
Variables	***N***	**3 mo (95% CI)[a]**	**6 mo (95% CI)**
Smoking			
No smoker	15	0.27 ± 0.08 (−1.15, −0.26)	0.30 ± 0.10 (−1.14, −0.17)
Smoker	6	0.97 ± 0.29	0.96 ± 0.29
Periodontitis			
Yes	10	0.46 ± 0.17 (−0.45, 0.46)	0.46 ± 0.18 (−0.41, 0.54)
No	11	0.47 ± 0.15	0.52 ± 0.16
Location			
Upper	10	0.54 ± 0.19 (−0.57, 0.35)	0.59 ± 0.20 (−0.66, 0.31)
Lower	11	0.42 ± 0.13	0.42 ± 0.14
Torque of insertion			
≤35 Ncm^2	16	0.41 ± 0.13 (−072, 0.31)	0.41 ± 0.13 (−0.83, 0.25)
>35 Ncm^2	5	0.62 ± 0.22	0.70 ± 0.25
Bone quality			
1–2	9	0.45 ± 0.15 (−0.50, 0.42)	0.46 ± 0.17 (−0.53, 0.43)
3–4	12	0.49 ± 0.16	0.51 ± 0.16
Keratinized tissue			
<1 mm	2	0.29 ± 0.12 (−0.99, 0.56)	0.30 ± 0.22 (−1.04, 0.59)
≥1 mm	19	0.50 ± 0.12	0.52 ± 0.13
Antagonist			
Tooth	15	0.51 ± 0.13 (−0.37, 0.63)	0.51 ± 0.13 (−0.46, 0.59)
Implant restoration	6	0.38 ± 0.25	0.44 ± 0.25
Diameter of the implant			
3.5 mm	12	0.48 ± 0.15 (−0.45, 0.49)	0.50 ± 0.15 (−0.48, 0.51)
4.0 mm	9	0.46 ± 0.18	0.48 ± 0.20
Biotype			
Thin	8	0.21 ± 0.09 (−0.87, 0.03)	0.27 ± 0.12 (−0.83, 0.12)
Thick	13	0.63 ± 0.16	0.62 ± 0.17

[a]95% confidence intervals.

The disturbance of mucosal attachment by means of connection/disconnection of the abutment has also been recognized as an important factor affecting crestal bone stability (Abrahamsson, Berglundh, & Lindhe, 1997). Becker, Mihatovic, Golubovic, & Schwarz (2012) observed, after two dis-/reconnection and 8 weeks of follow-up, dimensional changes in soft and hard tissues but without significant differences in comparison with no disconnection group. A recent experimental study has concluded that abutment manipulation presents a negative influence in connective tissue attachment that can predispose to marginal hard tissue resorption, especially in case of thin biotypes (Alves, Muñoz, Ramos, Neves, & Blanco, 2015). These different results could be obtained due to different implant designs. In this study, abutments were placed immediately after implant installation and they were not removed at any moment during the study (one-abutment one-time protocol).

The need of keratinized tissue around implants for maintenance of mucosal health remains controversial. Bouri, Bissada, Al-Zahrani, Faddoul, & Nouneh (2008) observed more plaque accumulation, inflammation and mean bone loss higher on those implants with narrow zones of keratinized mucosa. Chung, Oh, Shotwell, Misch, & Wang (2006), nevertheless, did not observed association between absence keratinized tissue and marginal bone loss. Wennström and Derks (2012) concluded in their review that there was limited evidence on the needs of certain amounts of keratinized mucosa and, due to methodological implications, was not possible to evaluate this association. In our study, we were not able to demonstrate this association. This parameter is related to the presence of plaque and a lower capacity to maintain peri-implant tissue health. It is necessary a longer follow-up to analyse this effect.

The role of smoking and history of periodontitis has been strongly studied and identified as predictors of implant failure and interproximal bone loss. However, its influence has been demonstrated particularly in delayed stages (De Bruyn et al., 2017, Vervaeke et al., 2016; Vervaeke et al. 2015). We could not demonstrate the effect of history of periodontitis on marginal bone loss,

probably due to the short-term analysis (early healing) although we have found differences between smokers and non-smokers. As proposed Albrektsson et al. (1986), a multivariate analysis is needed in a 1-year follow-up. Galindo-Moreno et al. (2005) demonstrated, in a prospective study on 514 implants, that IBL was significantly related to tobacco use or alcohol consumption, increased plaque levels and gingival inflammation. A posterior retrospective study demonstrated lower survival rates and higher marginal bone loss in tobacco smokers with a history of treated and maintained periodontitis (Aglietta et al., 2011). A recent systematic review affirmed that the insertion of implants in smokers yielded to increased failure rates, postoperative infections and marginal bone loss (Chrcanovic, Albrektsson, & Wennerberg, 2015).

The present study has some limitations. The number of patients might seem small, but considering the sample size analysis, the study had a power of 80%. Another limitation could be the length of the study (6 months), but according to the literature we can consider it enough to check the early healing. Biologic width is early established (6–8 weeks) and has a stable dimension over time; therefore, 6 months in humans seem to be enough to demonstrate its influence in crestal bone loss (Berglundh et al., 2007; Cochran, Hermann, Schenk, Higginbottom, & Buser, 1997; Hermann, Buser, Schenk, Higginbottom et al., 2000; Tomasi et al., 2014) Probably, the reason because patient variables did not influence (except smoking) was the short-term analysis.

6 | CONCLUSIONS

Abutment height showed a significant effect on interproximal marginal bone level in this randomized clinical trial. The use of short abutments led to a greater marginal bone resorption in comparison with the use of longer abutments. These results provide a better understanding on implant procedures and abutment selection.

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CONFLICT OF INTEREST

Authors declare no conflict of interest.

ORCID

Juan Blanco http://orcid.org/0000-0001-9251-513X

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