Received: 9 January 2023 | Revised: 30 May 2023 | Accepted: 2 July 2023

DOI: 10.1111/clr.14130

ORIGINAL ARTICLE

CLINICAL ORAL IMPLANTS RESEARCH WILEY

Influence of abutment shape on peri-implant tissue conditions: A randomized clinical trial

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Abstract

Objective: To analyze the influence of 3-mm high abutments with different shapes (cylindrical abutment vs. wide abutment) on marginal bone-level changes (bone loss and bone remodeling). The influence of abutment shape on implant success, probing pocket depth (PPD), and bleeding on probing (BoP) was studied as secondary objectives.

Materials and Methods: Patients with a partially edentulous area requiring fixed dental prostheses by two implants in the posterior mandible or maxilla were included. The implants were 1 mm subcrestally placed, and osseointegration healing was submerged. Three-mm high abutments with two different shapes were randomly placed in second-stage surgery: cylindrical abutments (cylindrical group) and wide abutments (wide group). Marginal bone-level changes were measured using parallelized periapical radiographs at abutment placement, at definitive prosthesis placement, and at 1, 3, 6, and 12 months after loading. PPD and BoP were likewise measured at the control visits.

Results: Sixty-four dental implants in 25 patients were included. Statistically significant differences were found in bone-level changes. The cylindrical group exhibited less mean marginal bone remodeling (MBR) and marginal bone loss (MBL) than the wide group ($p < .05$). Moreover, the cylindrical group showed significantly less BoP ($p < .05$).

Conclusion: Abutment shape had a significant influence upon marginal bone-level changes during the first 12 months. Cylindrical abutments caused less MBR and MBL than wide abutments. More clinical studies involving longer follow-ups and analyzing other abutment modifications are needed to improve our understanding of how abutments can affect peri-implant tissue stability.

KEYWORDS
dental implant, implant abutment, marginal bone loss

1 | INTRODUCTION

The prevention of marginal bone loss (MBL) is important for avoiding exposure of rough implant surfaces (which are ideal for osseointegration) to the oral environment. The formation of oral biofilms on these rough areas, and the presence of various local and host risk factors could stimulate the development of peri-implant disease (Lindhe et al., 2008; Renvert & Quirynen, 2015). Several factors have been suggested to influence MBL, and such factors need to be understood.

The influence of the prosthetic abutment or transmucosal component design on supracrestal peri-implant soft tissue and MBL has been suggested (Valente et al., 2020). According to a recent systematic review (Soulami et al., 2022), the emergence angle of the implant-abutment seems to have a relation to peri-implant disease. Emergence angle >30° presented a higher prevalence of peri-implantitis and MBL compared to emergence angle <30°. Another systematic review with meta-analysis (Canullo et al., 2020) showed narrow abutment design occasioned less MBL with statistically significant differences but no influence could be observed on soft tissues.

Three randomized clinical trials have analyzed prosthetic abutment shape. Two of these studies (Patil et al., 2014; Weinländer et al., 2011) involved very small changes in abutment shape, resulting in no statistically significant differences. However, one of the trials (Pérez-Sayans et al., 2022) involved greater changes in abutment shape and recorded statistically significant differences in MBL. This study comprised a short follow-up period (6 months), and it was carried out with two potential confounding factors: the insertion depth was not constant, and abutments with heights of 2 and 3 mm were used. Abutment height has a direct influence on the full transmucosal profile of the abutment-prosthesis complex: short abutments imply that this complex widens closer to the implant, allowing less vertical space for peri-implant soft tissues between implant and prosthesis. The insufficient evidence available on this topic justifies the conduction of new studies on the potential effect of abutment shape modifications on peri-implant tissue conditions. Such research may clarify whether it is really abutment height or if it is shape that influences peri-implant bone-level changes.

The main objective of the present randomized clinical trial was to evaluate the influence of two different abutment shapes (cylindrical vs. wide) in 3 mm-high prosthetic abutments upon peri-implant bone-level changes around bone-level implants. The influence of abutment shape on implant success, probing pocket depth, and bleeding on probing (BoP) was studied as secondary objectives.

The null hypothesis to be tested was that prosthetic abutment shape would not influence peri-implant hard and soft tissue conditions.

2 | MATERIALS AND METHODS

2.1 | Trial design

A simple-blind randomized clinical trial with two parallel experimental arms was carried out at the Oral Surgery Unit (Department of Stomatology, University of Valencia, Valencia, Spain). The study protocol was approved by the Institutional Review Board of the University of Valencia (Ref. H1524219380739), and the principles outlined in the Declaration of Helsinki on clinical research involving human subjects were followed. Written informed consent was obtained from each enrolled patient. This clinical trial was recorded on ClinicalTrials.gov with registration number: NCT03888339. The study is reported according to the CONSORT guidelines (Schulz et al., 2010).

Two study groups were established (Figure 1):

- Cylindrical group: 3-mm high commercially available abutments (rotational esthetic straight abutment, Nueva Galimplant SLU), referred to as "cylindrical abutments."
- Wide group: 3-mm high abutments with a shape modified to imitate the emergence of commercially available 1-mm high abutments, referred to as "wide abutments."

The abutment design of both groups shared the same height and connection design, including the presence of switching platform. The only difference between them was the abutment width.

FIGURE 1 Illustration of the abutment shapes at left, 3 mm height wide group abutment. At right, 3 mm height cylindrical group abutment.

2.2 | Participants

The inclusion criteria were as follows: partially edentulous patients requiring at least two consecutive implants for a 2–3 crown bridge in each posterior mandible or maxilla. The patients were required to be at least 18 years of age and able to sign the informed consent. Likewise, the enrolled patients were required to have no systemic conditions contraindicating implant surgery (immunosuppression, irradiation of the head and/or neck, patients treated with intravenous amino-bisphosphonates, uncontrolled diabetes, pregnancy or lactation, addiction to alcohol or drugs, psychiatric problems). The patients were required to be non-smokers or smokers of <10 cigarettes/day, and to be periodontally healthy without history of periodontitis (Silness and Löe plaque index and BoP of <25% [Löe, 1967] and PPD of ≤3 mm). Likewise, the patients were required to present healed bone for at least 3 months and without infection. Bone volumes were required to allow the placement of implants at least 8 mm in length (bone height at least 11 mm from compromised anatomical structures, because the implants were placed 1 mm subcrestally) and 3.5–4.0 mm in width (7 mm wide bone crest), without bone regeneration procedures. The required minimum vertical supracrestal soft tissue thickness was 2 mm. Patients unable to complete follow-up, and implant failures, were excluded.

2.3 | Interventions

2.3.1 | Screening visit

Potentially eligible patients were screened based on their clinical history, anamnesis, oral exploration, preoperative panoramic radiographic study, and cone-beam computed tomography (CBCT, Giano HR, NewTom®, Cefla S.L). The CBCT scan was made with two cotton swabs to separate the tongue and the buccal mucosa from the edentulous area. This was useful to measure the soft tissue thickness of the latter. To record a visual baseline, preoperative intraoral digital photographs and study models were made. Patients were informed of the nature of the study and signed the corresponding informed consent form. An oral hygiene session was scheduled within 10 days prior to implant placement.

2.3.2 | Implant placement

Local anesthesia was performed using 4% articaine with 1/200,000 adrenaline. A crestal incision was made, and after raising of the buccal flap, the soft tissue thickness was registered with a periodontal probe. The implants were placed following the drilling protocol suggested by the manufacturer. Implants were placed 1 mm subcrestal. Healing of the implants was submerged. The implant used was Galimplant IPX (Nueva Galimplant SLU), which is a bone-level implant with an internal conical connection. The implant sizes used were as follows: 3.5–4 mm in diameter and 8–12 mm in length, depending on the available bone.

2.3.3 | Second surgery

Second-stage surgery was performed after 10 weeks. After the incision and flap elevation, the cylindrical or wide abutments were placed according to the allocation of the groups (Figure 2). The torque recommended by the manufacturer was 30 N cm. Once the abutments were screwed, periapical radiographs were taken. The abutments were not unscrewed thereafter during the rest of the study.

2.3.4 | Prosthetic treatment

The impressions were taken at the abutment level 2 weeks after the second surgery for fabricating a screw-retained prosthesis (fixed dental prostheses [FDP]). All the restorations were metal-ceramic. All the structures were designed by the same dental technician and were CAD-CAM designed and drilled out of chromium-cobalt. The same dental technician then provided the feldspathic ceramic veneering (IPS d.SIGN, Ivoclar Vivadent). All screws were tightened with a torque of 25 N cm according to the specifications of the manufacturer. The access hole of the screw-retained crowns was closed with a Teflon pellet and a hybrid resin composite.

2.3.5 | Control visits

Monitoring was performed at months 1, 3, 6, and 12 after placement of the definitive prosthesis. Periapical parallelized radiographs and peri-implant probing were performed (Figure 2).

2.4 | Outcome measurements

2.4.1 | General variables

Patient age and sex, smoking habit (no smoking or ≤10 cigarettes/day), brushing habit (0, 1–2 or 3 times/day), edentulism (interdental or free end), phenotype (thin or thick), antagonist (natural teeth, bridge on teeth, implant rehabilitation or removable rehabilitation), cause of dental loss (caries, periodontitis or fracture), arch, quadrant, and soft tissue thickness (in mm) were collected.

2.4.2 | Changes in peri-implant marginal bone level

Parallelized periapical radiographs were obtained at abutment placement (baseline time [TB]), delivery of the prosthesis (T0), and at months 1 (T1), 3 (T3), 6 (T6), and 12 (T12) after definitive

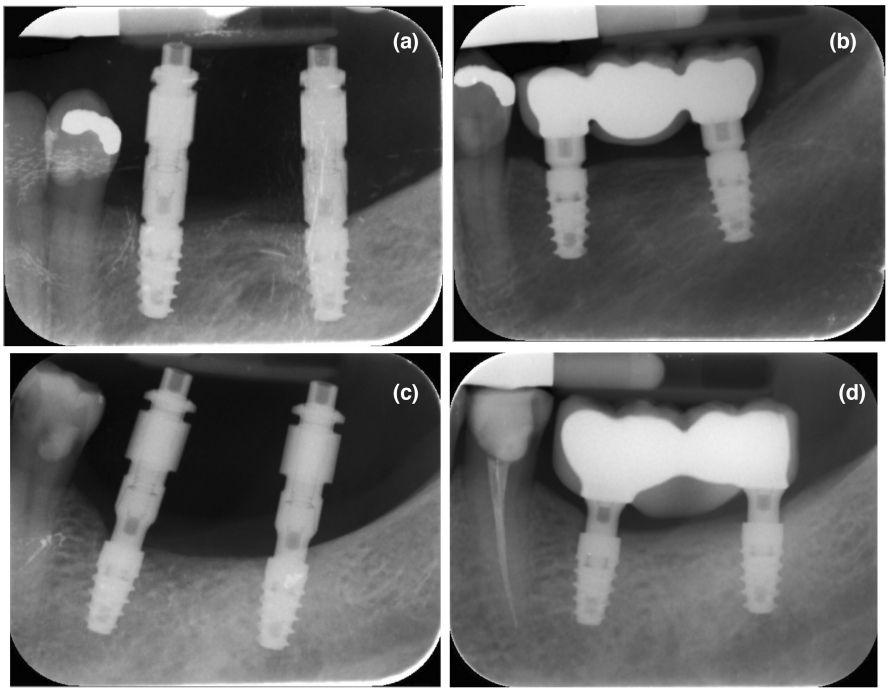

FIGURE 2 Intraoral parallelized radiographies at abutment placement (a and c) and 12 months of follow-up (b and d) for wide group (a and b) and cylindrical group (c and d).

prosthesis placement. A XMIND intraoral system (GroupeSatelec-Pierre Rolland) and an RVG intraoral digital receptor (Bür Dental) were used. Paralleling radiographic technique was performed to reproduce the patient alignments using a rigid cross-arch bar and a Rinn XCP (Dentsplay). This process was performed by the same operator.

Peri-implant marginal bone level was measured to the closest 0.1 mm using Image J (National Institutes of Health). Calibration was performed using the known abutment height (3 mm). For measurement purposes, a straight line was traced at the implant platform level (this line represented the zero height) and perpendicular lines were traced from the mesial and distal aspects of the implant platform.

Peri-implant MBL was defined as a bone-level change occurring in the apical direction with respect to the implant platform, thereby exposing rough implant surface. To calculate this variable, bone levels at each time point were determined from the implant platform to the first radiographic bone–implant contact. The difference in this bone level between implant abutment placement (TB) and each timepoint (at prosthesis delivery [T0], at months 1 [T1], 3 [T3], 6 [T6], and 12 [T12] after definitive prosthesis placement) was calculated. The mean between mesial and distal MBL was calculated for each implant.

Bone remodeling, as described by Linkevicius et al. (2020), was defined as a bone-level change occurring in a coronal direction to the implant platform, and thus not exposing rough implant surface. To calculate this variable, bone levels at each time point were determined from the implant platform to the marginal bone crest following the vertical line of the mesial and distal aspects of the implant. The difference in this bone level between implant abutment placement (TB) and each timepoint (at prosthesis delivery [T0], at months 1 [T1], 3 [T3], 6 [T6], and 12 [T12] after definitive prosthesis placement) was calculated. The mean between mesial and distal bone remodeling was calculated for each implant.

Additionally, radiographs were used to classify each implant into one of the following three situations (Figure 3):

1. Bone loss: bone level apical to the platform, thus leaving rough exposed surface.
2. Bone remodeling: bone level at the implant platform.
3. Bone overlap: bone level coronal to the implant platform, with radiographic appearance of bone contact with the prosthetic abutment.

Whenever the mesial and distal aspects were classified differently, the worse situation was used for the implant. At each time point, these clinical situations were expressed in percentages for the total sample.

The measurements were taken by two independent observers (JVA and DPO). The calibration was completed prior to the study using 15 patients who underwent treatment but who were not part of the study. *K*-statistic was calculated to identify the reliability of the measurements performed by the two examiners in order to determine the MBL. The result was $k = .93$. According to Landis and Koch categorization (Landis & Koch, 1977), this value of K-statistic is "almost perfect" in terms of the peri-implant marginal bone changes measurements.

2.4.3 | Peri-implant soft tissue condition

Peri-implant soft tissue condition was assessed by recording PPD in mm and BoP (yes or no) at month 1, 3, 6, and 12 after definitive prosthesis placement. PPD was measured at six surfaces per implant, and

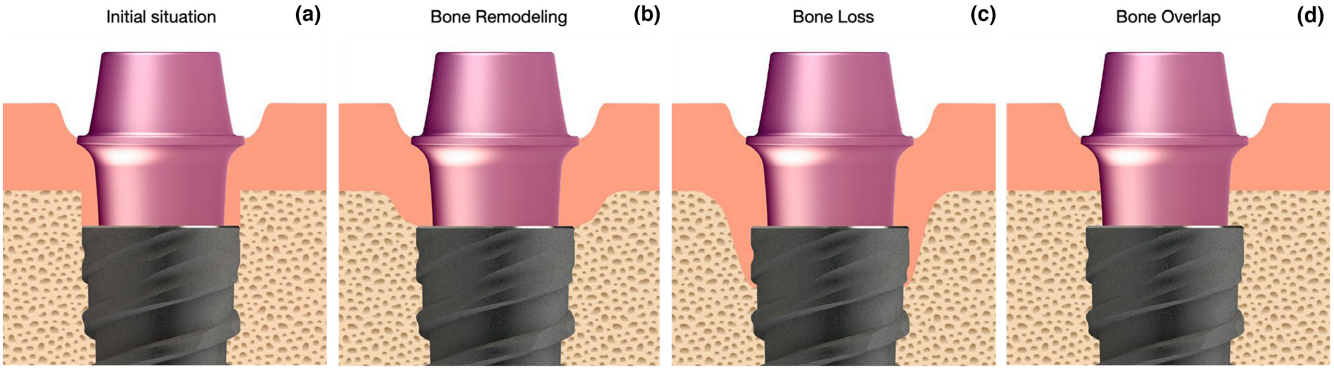

FIGURE 3 Three possible situations for subcrestal placed implants. (a) Initial situation when subcrestal implant was placed with prosthetic abutment, (b) bone remodeling, (c) bone loss, and (d) bone overlap.

the mean of every implant was calculated. The measurements were taken by two independent observers (JVA and DPO). The calibration was completed prior to the study using 15 patients who underwent treatment but who were not part of the study. *K*-statistic were calculated to identify the reliability of the measurements performed by the two examiners in order to determine the PPD. The result was .82, a high degree of reliability in terms of the probing measurements.

2.4.4 | Implant success

The implants were evaluated according to Misch et al. (2008) such as success (optimal health), satisfactory survival, survival compromised, and failure. Misch et al. (2008) defined: three clinical conditions: success (no pain or tenderness on function, 0 mobility, radiographic bone loss <2 mm since the initial surgery and no history of exudates), satisfactory survival (no pain on function, 0 mobility, radiographic bone loss of 2–4 mm and no history of exudates), compromised survival (it may present tenderness on function, 0 mobility, radiographic bone loss >4 mm (less than 1/2 of the implant length, PPD >7 mm and it may have a history of exudates)) and failure (if any of the following aspect is present; pain on function, mobility, radiographic bone loss >1/2 implant length, uncontrolled exudate and absent from the oral cavity).

2.5 | Sample size calculation

The reference study for calculating sample size was published by Blanco et al. (2018). Radiographic peri-implant MBL was used as the primary variable. For this article (Blanco et al., 2018), the mean bone loss detected at 1 year of follow-up was 0.91 ± 0.19 for its control group and 0.11 ± 0.09 mm for its test group. A standard deviation of ±0.14 on MBL, a 95% confidence level, and a statistical power of 80% were assumed. ANOVA model *F*-test for between-subject effects was applied. The effect size corresponding to the difference between 0.91 and 0.11 mm and the standard deviations in the article of reference resulted in an extreme size effect ($f = 2.85$), and a too small sample size ($n = 8$) to apply *t*-tests or ANOVA. A minimum mean MBL difference to be detected of 0.1 mm was empirically determined and used instead, together with the standard deviations of the article of reference. The respective effect size was large ($f = 0.4$) and allowed enough sample size to apply the statistical tests and have a more robust study. The calculation was made for a moderate intraclass correlation coefficient ICC (0.5). The "a priori" total sample size was 62 dental implants for predetermined mean bone loss difference and statistical power. An increment of 10% was added to the sample size to compensate for possible losses. Thus, a total of 68 dental implants were enrolled in the study as the total sample size.

2.6 | Randomization, allocation and blinding

Each patient contributed at least one edentulous area requiring only two implants for a 2–3 crown bridge to the study. For patients with more than one suitable area, randomization was performed for each patient. Randomization was provided through www.randomization.com. The random allocation codes were sealed in sequentially numbered opaque envelopes. Allocation concealment was broken after the incision for the second surgery procedure when the corresponding envelope was opened and the operator was informed whether to place cylindrical or wide abutments. Blinding was maintained for the patients and the statistician; however, the blinding was not possible for the outcome assessor due to the different shapes of the prosthetic abutments were clearly detected by the outcome assessor in the radiography.

2.7 | Statistical analysis

A descriptive and statistical analysis was performed for each variable. A mixed lineal regressive model was performed too. The chi-squared test and Mann–Whitney *U*-test were used to assess the homogeneity between groups at patient and implant level. A general linear model of repeated measures was estimated from generalized estimating equations (GEE) in relation to marginal bone-level changes over time and according to the group. The patient was the unit of analysis (level 2) and the implant was the unit of observation or measurement (level 1). Therefore, a multi-level structure of the database was analyzed through the estimation of GEE models to

control the intra-subject correlation. Main effects and interaction were evaluated using the Wald chi-squared statistic. Multiple comparisons were based on the Bonferroni test. The mean differences of the MBL changes and the clinical variables at a time with respect to baseline were analyzed by a general linear model (equivalent to a *t*-test under the GEE approach). Bonferroni multiple comparisons of the ordinal logistic model with estimates by GEE were conducted to compare statistically different radiological situations of the bone level. The significance level used in the analyses was 5% ($\alpha = .05$). The analyses were performed per protocol.

3 | RESULTS

A total initial sample of 68 dental implants were placed in 27 patients (9 men and 18 women). The recruitment phase was conducted from January 2021 to March 2021 and the follow-up was finished in June 2022. Two patients, one each group, missed their follow-up appointments and were excluded (Figure 4). A total sample of 25 patients with 64 dental implants (8 men and 17 women, aged 61.0 ± 9.3 years [range 44–76]) was finally studied. All the implants showed success according to the classification of Misch et al. (2008). A summary of every variable of the study and the correlation between MBL and other possible confounding factors is shown in Table 1.

Regarding the radiographic bone-level changes (Table 2), MBL and MBR were significantly influenced by the study group ($p < .001$) during follow-up. The mean MBL was −0.03 ± 0.22 mm in the cylindrical group and 0.42 ± 0.31 mm in the wide group ($p < .001$) at 12 months of follow-up and mean MBR was −0.04 ± 0.58 mm in the cylindrical group and −0.79 ± 0.93 mm in the wide group ($p < .001$) at 12 months of follow-up. Significantly greater marginal bone-level changes were observed at all study time points in the wide group

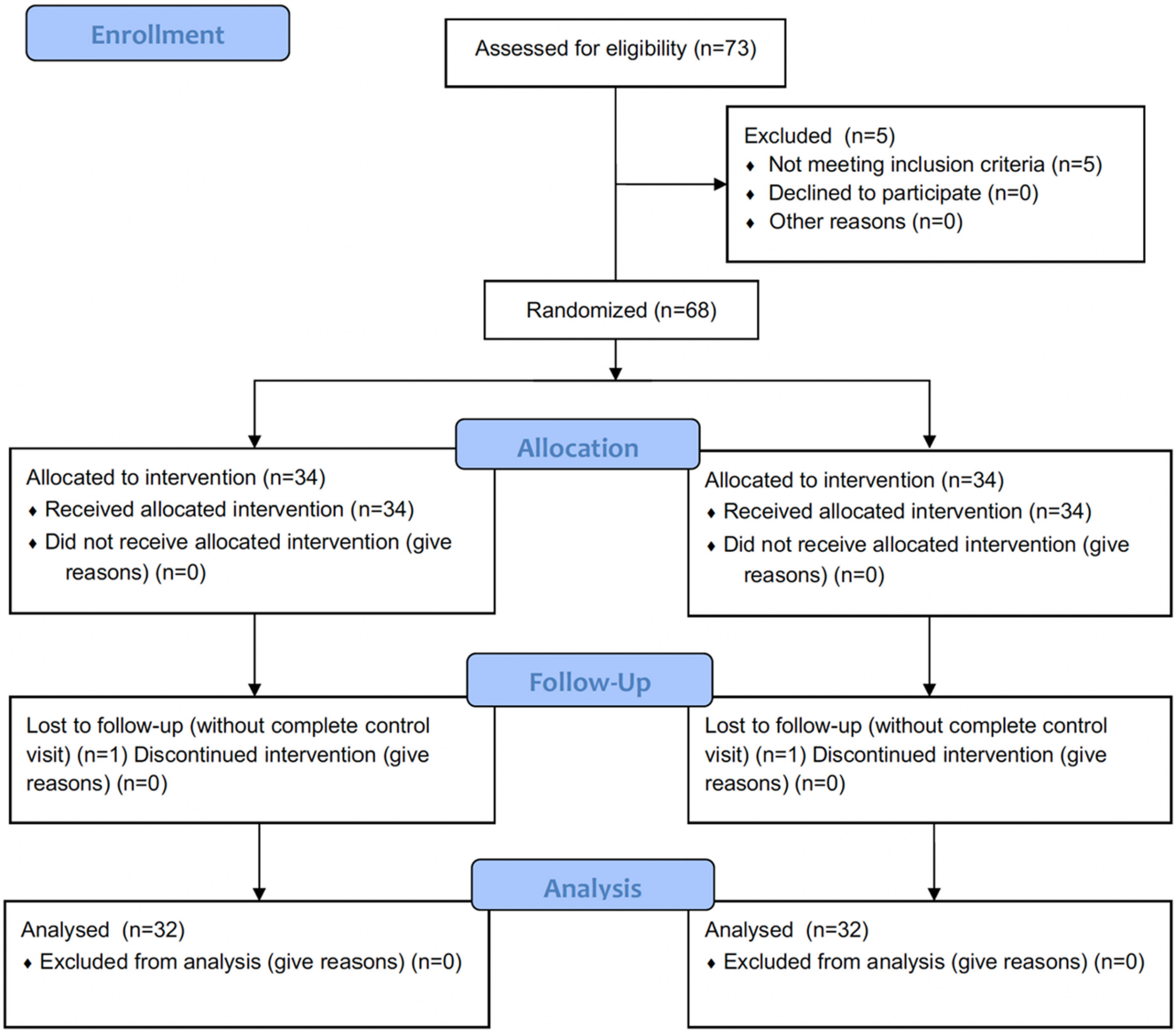

FIGURE 4 CONSORT flow diagram 2010.

TABLE 1 Descriptive and analytical statistic for categorical variables at patient level (25 patients).

Variable	Categories	Cylindrical *n* (%)	Wide *n* (%)	Sample homogeneity		Mixed lineal regression model	
				p value	Statistic test	*p* value	Statistic test
Sex	Male	5 (41.7)	3 (23.1)	.411	FIS	.905	MMGEE
	Female	7 (58.3)	10 (76.9)				
Age	≤55 years old	5 (41.7)	3 (23.1)	.406	MW	.267	MMGEE
	55–65 years old	3 (25)	3 (23.1)				
	>65 years old	4 (33.3)	7 (53.8)				
Smoking habit	0 cig/day	7 (58.3)	11 (84.6)	.202	FIS	.186	UMGEE
	≤10 cig/day	5 (41.7)	2 (15.4)				
Brushing habit	1–2 per day	8 (66.7)	9 (69.2)	1.000	FIS	.611	UMGEE
	3 per day	4 (33.3)	4 (30.8)				
Ginigva Phenotype	Thin	2 (16.7)	4 (30.8)	.645	FIS	.859	UMGEE
	Thick	10 (83.3)	9 (69.2)				
Edentulism	Free distal	6 (50)	4 (30.8)	.327	Chi^2	.071	MMGEE
	Interdental	6 (50)	9 (69.2)				
Antagonist	Edentulism	0 (0)	1 (7.7)	.667	FIS	.478	MMGEE
	Natural teeth	7 (58.3)	9 (69.2)				
	Removable prosthesis	1 (8.3)	0 (0)				
	Fixed prosthesis	4 (33.3)	3 (23.1)				
Dental loss cause	Periodontal disease	2 (16.7)	3 (23.1)	.758	Chi^2	.410	MMGEE
	Caries	8 (66.7)	69.2 (9)				
	Other	2 (16.7)	1 (7.7)				
Implant number	2	9 (75)	10 (76,9)	.894	MW	.605	UMGEE
	4	2 (16.7)	3 (23.1)				
	6	1 (8.3)	0 (0)				

Abbreviations: Chi^2, chi-squared test; Fis, Fisher's exact test; MMGEE, multivariate lineal general multiple model with estimation for generalized estimation equation; MW, Mann–Whitney test; UMGEE, univariate lineal general multiple model with estimation for generalized estimation equation.

TABLE 2 Bone-level changes: MBR and MBL.

	Marginal bone remodeling ($n=64$)		Marginal bone loss ($n=64$)	
	Cylindrical group ($n=32$)	Wide group ($n=32$)	Cylindrical group ($n=32$)	Wide group ($n=32$)
TB	1.20 ± 0.57	1.00 ± 0.90	0.06 ± 0.20	0.06 ± 0.18
T0	0.89 ± 0.65*	0.16 ± 0.41*	0.12 ± 0.17*	0.35 ± 0.31*
T1	0.93 ± 0.62**	0.12 ± 0.30**	0.09 ± 0.16**	0.38 ± 0.28**
T3	1.00 ± 0.61***	0.13 ± 0.29***	0.06 ± 0.11***	0.47 ± 0.25***
T6	1.07 ± 0.58***	0.18 ± 0.40***	0.04 ± 0.09***	0.53 ± 0.32***
T12	1.15 ± 0.60***	0.21 ± 0.44***	0.03 ± 0.09***	0.48 ± 0.29***
Δ (T0–TB)	−0.31 ± 0.52***	−0.84 ± 0.91***	0.05 ± 0.17***	0.28 ± 0.31***
Δ (T1–TB)	−0.27 ± 0.78***	−0.88 ± 0.89***	0.03 ± 0.18***	0.32 ± 0.32***
Δ (T3–TB)	−0.20 ± 0.51***	−0.87 ± 0.89***	−0.01 ± 0.20***	0.41 ± 0.28***
Δ (T6–TB)	−0.13 ± 0.81***	−0.82 ± 0.92***	−0.02 ± 0.23***	0.47 ± 0.34***
Δ (T12–TB)	−0.04 ± 0.58***	−0.79 ± 0.93***	−0.03 ± 0.22***	0.42 ± 0.31***

Abbreviations: TB, time baseline (abutment placement); T0, time 0 (definitive prosthesis placement); T1, time 1 (first month); T3, time 3 (third month); T6, time 6 (sixth month); T12, time 12 (twelfth month); Δ, mean variance.

*$p \le .05$; **$p < .01$; ***$p < .001$

versus the cylindrical group. The percentages of implants according to the bone-level situation at each timepoint are shown in Figure 5.

Regarding the peri-implant soft tissue parameters (Tables 3 and 4), the mean PPD increased significantly during follow-up in both groups ($p < .001$). PPD at 1 year of follow-up was 2.90 ± 0.61 mm in cylindrical group and 3.19 ± 0.50 in wide group—the difference failing to reach statistical significance ($p = .475$). BoP in turn decreased significantly during the follow-up period in both groups, but the pattern differed. After 1 year of follow-up, 15.6% of the measured points and 8% of the implants were found to be positive for BoP in the wide group compared to 15.6% and 6% in the cylindrical group, respectively. The differences in BoP were statistically significant only after 1 month.

4 | DISCUSSION

The objective of the present study was to evaluate the influence of different abutment shapes (cylindrical abutments vs. wide abutments) upon marginal bone-level changes and peri-implant soft tissue condition. As such, the cylindrical abutments exhibited less mean MBR and MBL than the wide abutments with statistically significant differences.

Early bone loss has been associated with longer term MBL (Galindo-Moreno et al., 2015). Although the underlying etiopathogenesis is multifactorial (Oh et al., 2002), not all factors have been thoroughly studied to date. An improved understanding of the risk factors is needed in order to avoid early bone loss and, consequently, long-term MBL.

According to different systematic reviews (Canullo et al., 2020; Soulami et al., 2022; Valente et al., 2020), the emergence of the transmucosal component (either the intermediate prosthetic abutment or the prosthesis when there is no intermediate abutment) influences MBL. Similarly to the present study, narrow prosthetic emergences and abutments presented significantly less MBL loss than wider ones. However, few randomized clinical trials are available and follow-up periods are mostly short (Canullo et al., 2020).

Considering the shape of the transmucosal portion in a broad manner, some indirectly related data support the results of this study. In a preclinical study in Beagle dogs, Souza et al. (2018) evaluated the effect of an emergence profile of 45° versus 15° in healing abutments. MBL evaluated with micro-computed tomography was significantly lower in the narrow healing abutments (0.12 ± 0.21 mm) than in the wide healing abutments (1.1 ± 0.66 mm). Yi et al. (2020) retrospectively analyzed the prosthetic emergence in 349 implants rehabilitated with no transmucosal abutments. They determined that ≥30° emergence profiles resulted in a higher prevalence of peri-implantitis. Similarly, the retrospective study carried out by Majzoub et al. (2021) showed that prosthetic emergence profiles >30° led to more MBL than prosthetic emergence profiles ≤30° (2.33 ± 1.20 mm and 0.59 ± 0.71 mm, respectively). Katafuchi et al. (2018) in another retrospective study reported that bone-level implants resulted in greater MBL than tissue-level implants if the prosthetic profile exceeded 30° (31.3% vs. 15.1%, respectively; $p = .04$). Addressing transmucosal abutment shape indirectly, a previous retrospective study by our group (Bernabeu-Mira et al., 2021) analyzed the influence of abutment characteristics on MBL changes in immediate loading implant-supported full-arch FDP followed for 1 year. When

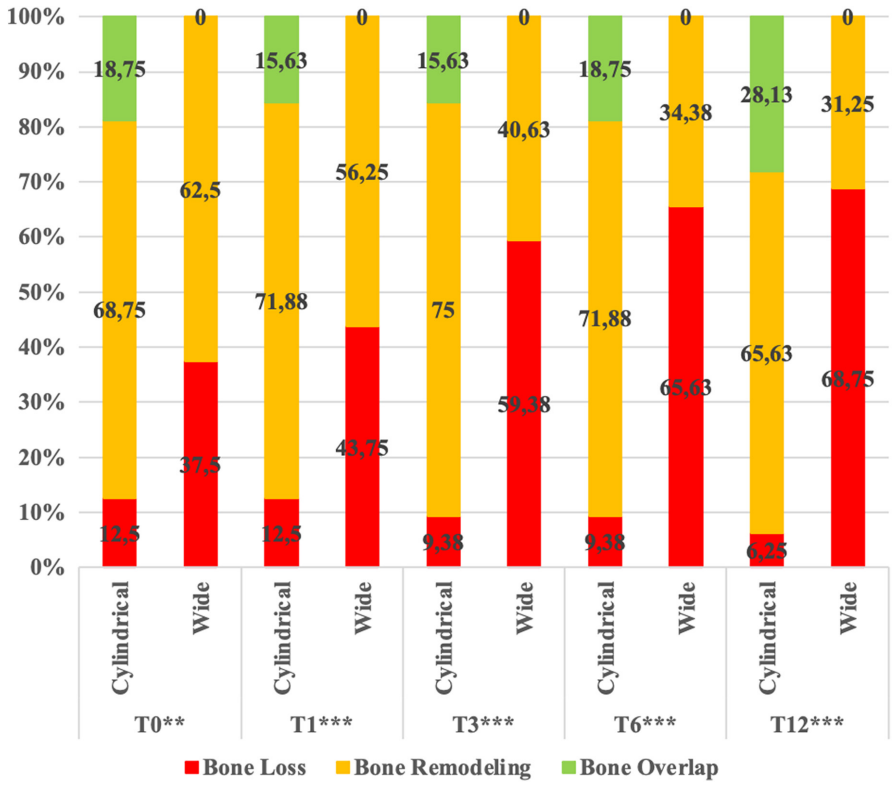

FIGURE 5 Percentage of implants according to bone-level situation at each time point: bone loss, bone remodeling, and bone overlap. TB, abutment placement; T0, prosthesis placement; T1, 1-month follow-up; T3, 3-month follow-up; T6, 6-month follow-up; T12, 12-month follow-up. *$p < .05$; **$p < .01$; ***$p < .001$.

TABLE 3 Probing pocket depth.

	Probing pocket depth ($n=64$)	
	Cylindrical group ($n=32$)	Wide group ($n=32$)
T1	2.59 ± 0.59	2.72 ± 0.50
T3	2.71 ± 0.70	3.07 ± 0.49
T6	2.69 ± 0.75	3.09 ± 0.39
T12	2.90 ± 0.61	3.19 ± 0.50
Δ (T3–T1)	0.13 ± 0.43	0.35 ± 0.43
Δ (T6–T1)	0.10 ± 0.58	0.38 ± 0.47
Δ (T12–T1)	0.31 ± 0.76	0.47 ± 0.57

Abbreviations: T1, time 1 (first month); T3, time 3 (third month); T6, time 6 (sixth month); T12, time 12 (twelfth month); Δ, mean variance; $^{*}p \leq .05$; $^{**}p < .01$; $^{***}p < .001$.

TABLE 4 Bleeding on probing (%): percentage of implants which presented BoP in at least one of the probed sites.

	Bleeding on probing (%) ($n=64$)			
	Cylindrical group ($n=32$)		Wide group ($n=32$)	
	Yes	No	Yes	No
T1	23.4***	76.6***	43.7***	56.3***
T3	23.4	76.6	34.4	65.6
T6	20.3	79.7	34.4	65.6
T12	15.6	84.4	15.6	84.4

Abbreviations: T1, time 1 (first month); T3, time 3 (third month); T6, time 6 (sixth month); T12: time 12 (twelfth month); $^{*}p \leq .05$*, $^{**}p < .01$ or $^{***}p < .001$.

only 3-mm high abutments were considered, significantly greater MBL was recorded at 12 months in angulated abutments (which are wider) than in straight cylindrical abutments.

All these results (Bernabeu-Mira et al., 2021; Katafuchi et al., 2018; Majzoub et al., 2021; Souza et al., 2018; Yi et al., 2020) share in common that when the transmucosal component horizontally invades the space of the peri-implant soft tissue, MBL increases. Similarly, in the present study, cylindrical abutments showed significantly less MBL and bone remodeling than wide abutments.

Three randomized clinical trials have previously evaluated the influence of prosthetic abutment shape on MBL (Patil et al., 2014; Pérez-Sayans et al., 2022; Weinländer et al., 2011). Two of these studies (Patil et al., 2014; Weinländer et al., 2011) compared small modifications of the transmucosal abutment in its apical portion, close to the implant platform. This might explain the absence of a significant influence of shape upon bone loss. In the present study, statistically significant (and potentially clinically relevant) differences were observed between the two abutment designs. Probably the difference between the abutments of the two groups was more important than in the previous studies. A recently published randomized clinical study (Pérez-Sayans et al., 2022) reported less MBL in narrow concave abutments than in cylindrical abutments after 6 months of follow-up. The present study is in agreement with this, since the narrower abutments (in this case the cylindrical abutments) resulted in lower bone loss values.

In the present study, peri-implant bone was classified into three radiographic categories that, in our opinion, might be clinically relevant: (1) bone loss: unfavorable situation because the rough implant surface is exposed, (2) bone remodeling: stable situation with no rough implant surface exposed, which constitutes the minimum desirable radiographic outcome, and (3) bone overlap: desirable situation where bone is observed coronal to the implant platform, which might be related to a highly stable situation. This simple radiographic classification could be a useful tool to better understand and communicate the bone-level changes around subcrestal dental implants. Prospective studies with long follow-ups are necessary to address if these categories help to predict the evolution of peri-implant health over time.

As a limitation of our study, the results obtained should only be considered for subcrestal bone-level implants with a conical internal connection, platform-switching, and this specific implant abutment design. All patients were periodontally healthy without a history of periodontitis with abundant height and width bone and at least 2 mm vertical supracrestal soft tissue thickness. The evaluator of radiographic bone measurements was inevitably not blinded because the abutment shape was clearly identified in the radiography. Further studies are needed to understand the behavior of other abutment designs.

5 | CONCLUSIONS

Abutment shape had a significant influence on marginal bone level during the first 12 months of follow-up. Cylindrical implant abutments caused less MBL and remodeling than wider implant abutments. Further clinical studies involving larger sample sizes and longer follow-up periods are needed, and other abutment shapes could be studied in the future.

AUTHOR CONTRIBUTIONS

Juan Carlos Bernabeu-Mira: Conceptualization; Methodology; Investigation; Writing—original draft; Visualization; Writing—review and editing; Software. **María Peñarrocha-Diago:** Conceptualization; Writing—original draft; Visualization. **José Viña-Almunia:** Conceptualization; Data curation; Visualization; Software. **Francisco Romero-Gavilán:** Conceptualization; Visualization. **Mario Pérez-Sayans:** Conceptualization; Writing—review and editing; Visualization. **David Peñarrocha-Oltra:** Conceptualization; Methodology; Investigation; Validation; Supervision; Visualization; Writing—review and editing; Formal analysis; Project administration.

ACKNOWLEDGMENTS

D. Juan Luís Gómez Martínez for performing an independent and blinded data analysis.

FUNDING INFORMATION

The study was not funded by anyone.

CONFLICT OF INTEREST STATEMENT

There is no interest or relationship, financial or otherwise, that could be perceived as influencing the objectivity of any of the authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CLINICAL TRIAL REGISTRATION

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How to cite this article: Bernabeu-Mira, J. C., Peñarrocha-Diago, M., Viña-Almunia, J., Romero-Gavilán, F., Pérez-Sayans, M., & Peñarrocha-Oltra, D. (2023). Influence of abutment shape on peri-implant tissue conditions: A randomized clinical trial. *Clinical Oral Implants Research*, *00*, 1–10. https://doi.org/10.1111/clr.14130