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Evaluation of a New Dental Implant Cervical Design in Comparison with a Conventional Design in an Experimental American Foxhound Model

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Abstract: The aim of this study was to evaluate osseointegration and crestal bone height in implants with a triangular cervical design in comparison with a standard rounded cervical design. The control group consisted of 24 implants with a standard cervical design, and the test group of 24 implants with a triangular cervical design. The implants were inserted in healed bone in six American Foxhounds. Crestal bone height and tissue thickness in the cervical portion were measured after 12 weeks healing. Data analysis found mean crestal bone loss of: 0.31 ± 0.24 mm on the buccal side, 0.35 ± 0.14 mm on the lingual in the test group, and 0.71 ± 0.28 mm buccal loss, and 0.42 ± 0.30 mm lingual in the control group; with statistically significant differences on the buccal aspect ($p = 0.0019$). Mean tissue thickness in the test group was 1.98 ± 0.17 mm on the buccal aspect, and 2.43 ± 0.93 mm in the lingual; in the control group it was 2.48 ± 0.61 mm buccal thickness, and 2.88 ± 0.14 mm lingual, with significant differences on both aspects ($p = 0.0043$; $p = 0.0029$). The results suggest that greater thickness of peri-implant tissue can be expected when the triangular cervical implant design is used rather than the standard cervical design.

Keywords: crestal bone loss; bone-to-implant contact; new implant design

1. Introduction

Dental rehabilitation by means of implant placement has become increasingly popular in recent years. The main treatment goal is to guarantee survival of implants in the long term. For this reason, it is important to maintain the bone surrounding the implant neck, which is crucial to obtaining optimal bone support and gingival contour stability over time. Preservation of the alveolar ridge increases the size and formation of dental papillae and improves long-term aesthetic results [1].

Factors related to crestal bone reduction around implants include the timing of implant placement (immediate post-extraction or delayed) [2–4], the position in which it is placed (crestal or subcrestal bone level), and implant design [5,6].

Previous studies have shown that during the first months following tooth loss, bone resorption occurs as a consequence of bone remodeling [7–9]. This bone loss and the changes to soft tissue that occur after extraction can compromise both aesthetic and functional outcomes [10].

A great deal of research has focused on maintaining peri-implant bone and assessing the possible factors involved in preserving it. In this regard, the design of the implant and its abutment would appear to influence crestal bone loss and soft tissue remodeling, and may be critical in determining the extent of bone loss around the implant [5,11–13]. Implant design includes a range of design variables such as length, diameter, surface roughness, and implant geometry [14–16].

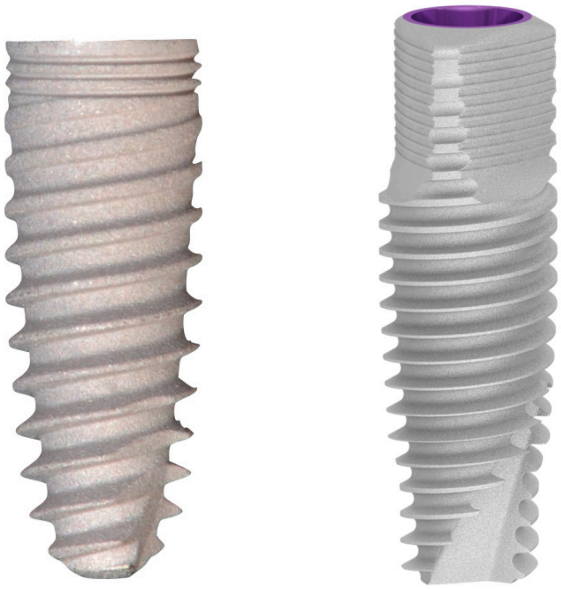
It has been observed that implants with a design of microthreads can preserve peri-implant marginal bone [9,17]. Microthreads appear to favor the implant's mechanical stability and successful integration [18,19]. Moreover, research has shown that an implant design with a short and smooth neck reduces bone loss, and also reduces the exposure of metal at the implant margin, which improves the aesthetic outcome [20]. Therefore, it would appear that the implant's neck design influences in the final outcome, especially in critical cases.

The aim of this study was to compare the thickness of surrounding implant tissue and crestal bone height prospectively, assaying a new implant of triangular cervical design in comparison with an implant with a conventional neck design.

2. Materials and Methods

2.1. Implant Characteristics

Forty-eight conical implants were used in the study. The implants were divided into two groups according to their cervical design: 24 control group C1® implants with conventional circular neck (MIS, Barlev Industrial Park, Ahihud Junction, Israel), and 24 study group V3® implant (MIS, Barlev Industrial Park, Misgav, Israel) with a new triangular cervical shape. V3® implants are characterized by a decrease in the diameter of the neck with regard to diameter of the main implant body, which aims to avoid bone loss at the neck level. It also has a triangular shape at the neck, designed to decrease bone tension in this area. Figure 1 shows the two implant designs compared in the study.



(**a**) (**b**)

Figure 1. Implant designs compared in the study: C1® implant (**a**) and V3® implant (**b**).

2.2. Sample Characteristics

Six female, one-year-old, American Foxhound dogs, with a weight of approximately 14–15 kg were used in the study. Animal examination before study concluded that the animals were in good health, with no disease. All the animals presented good oral health, with no obvious pathology or lesions. The implants were inserted into the hemi-mandibles of the dogs at P2, P3, P4 and M1 locations, placing four implants per hemi-mandible (Figure 2). The distribution of the two groups of implants, and their positions in the mandible were decided using a randomization generator (www.randomization.com).

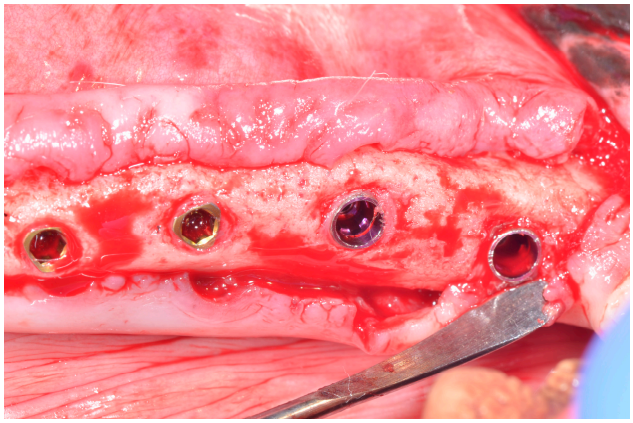


Figure 2. The implantation protocol was 4 implants per hemi-mandible.

The study protocol was approved by the Animal Ethics Committee of the University of Murcia, and fulfilled European and Spanish regulations for animal experimentation, as well as European Commission rules (Directive 2010/63/EU on the protection of animals used for scientific purposes).

2.3. Surgical Procedure

The animals were pre-anesthetized with acepromazine 0.2% (1.5% mg/kg) 10 min before administrating butorphanol (0.2 mg/kg) and medetomidine (7 mg/kg). The mixture was injected intramuscularly in the femoral quadriceps. An intravenous catheter was inserted in the cephalic vein and propofol was infused at a slow, constant rate of 0.4 mg/kg/min. Local infiltrative anesthesia was administered at the surgical sites. These procedures were carried out under the supervision of a veterinary surgeon. Bilateral mandible tooth extractions (P_2, P_3, P_4 and M_1) were performed sixty days before surgery. Teeth were sectioned in a buccolingual direction at the bifurcation using a tungsten carbide bur. Roots were individually extracted using a periotome and forceps without damaging the bony walls. Wound closure was carried out using single non-absorbable sutures [21].

During the first week after surgery, the animals received antibiotics and analgesics: Amoxicillin (500 mg, twice daily) and Ibuprofen 600 mg (three times a day) via the systemic route. Sutures were removed after two weeks. The dogs were fed a soft diet for 14 days after the sutures were removed [21].

Implants were placed after a two-month healing period. After crestal incision, a full thickness flap was reflected, and implants were placed randomly, with 2 mm of healed bone at the gap, between the end of the implant and the buccal plate (Figure 3). We screwed a healing cap at every implant placed. The flaps were closed using single non-absorbable sutures.

Resonance frequency analysis (RFA) was used to measure implant stability. A Smartpeg™ (Integration Diagnostics AB, Göteborg, Sweden) was screwed onto each implant and tightened to approximately 5 N. The transducer probe was aimed at the small magnet on the top of the Smartpeg at a distance of 2 or 3 mm and held stable during pulsing until the instrument beeped and displayed the implant stability quotient (ISQ) value. Measurements were made immediately after implant insertion and repeated 12 weeks later at the moment of euthanasia.

The sutures were removed two weeks after surgery. The animals received the same post-surgical care as following the previous surgical phase and plaque control was performed daily using 0.12% chlorhexidine digluconate.

All animals were sacrificed at 12 weeks after implant insertion by an infusion of sodium pentothal (Abbott Laboratories, Madrid, Spain) through the carotid artery with a fixative containing a mixture of 5% glutaraldehyde and 4% formaldehyde.

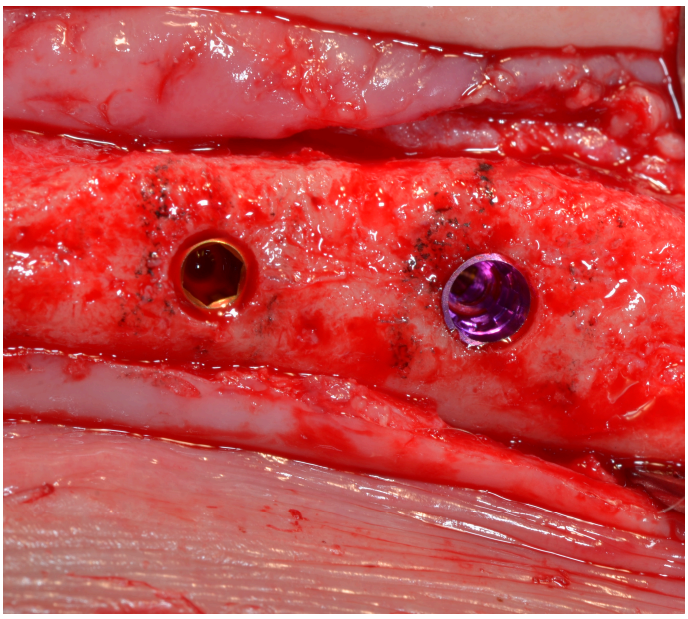


Figure 3. Each hemi-mandible received four tapered implants positioned at crestal bone level.

2.4. Histological Preparation

As soon as the veterinary surgeon had confirmed the dog's death, the jaw of each animal was dissected, and each study area was extracted using a diamond bur at high speed.

Samples were fixed in formalin and dehydrated in a graded ethanol series. The samples were degreased and dried using ethanol from low to high concentrations: 50%, 70%, 80%, and 90% for 15 min each, drying the surfaces with acetone at 30%, 50%, 70% and 90% for 15 min each, followed by 100% acetone for 30 min [21].

Implants and surrounding bone were stained with Picrosirius red stain (Polysciences Inc., Warrington, FL, USA).

Using a micro-cut diamond bur (Exakt-Apparatebau, Norderstedt, Germany), 100 µm-thick sections were cut in the vestibule-lingual direction along the axis of each implant.

These sections were reduced to a thickness of 50 microns by polishing with extrafine paper discs with grain granulometry number 2000.

2.5. Histological Analysis

Crestal bone levels were measured by analyzing histological images captured by a video camera (Sony 3CCD, Berlin, Germany) with 10× magnification. The images were digitalized (Axiophot-System, Zeiss, Oberkochen, Germany), stored, and reference points were marked on each image, measuring the distances between points.

The crestal bone level was obtained by measuring the distance from the shoulder of each implant to the point of first bone-to-implant contact (BIC) for both implant types (V3® and C1® implants).

Buccal and lingual tissue thickness was measured from the level of the implant shoulder to the most external portion of the epithelium (Figure 4).

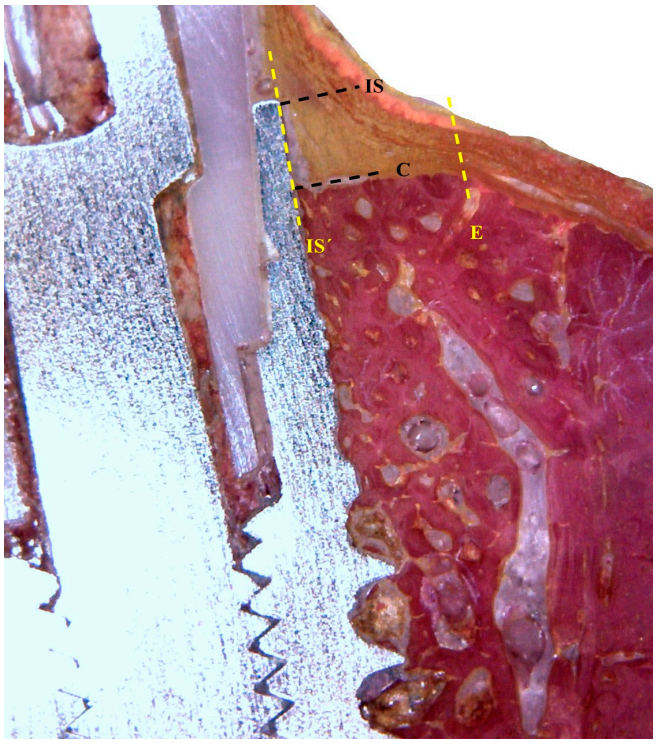


Figure 4. Linear measurements to assess peri-implant bone remodeling and peri-implant soft tissue remodeling. IS: implant shoulder; C: first bone-to-implant contact; IS´: implant surface; E: the most external portion of the epithelium.

2.6. Statistical Analysis

Statistical analysis was performed using the SPSS 15® statistical software package (SPSS Inc., Chicago, IL, USA). Histological measurements were expressed as means ± standard deviations. An ANOVA test was applied to the two groups, which were compared using a Friedman test. $p < 0.05$ was considered statistically significant.

3. Results

There were no complications affecting animals and/or implants during the study period and the study was developed with no incident.

After 12 weeks healing, all implants were osseointegrated, and thereby available for histological evaluation and analysis.

Mean Implant Stability Quotient (ISQ) values obtained with Resonance Frequency Analysis (RFA) for the two implant designs (study and control) are indicated in Table 1. The Friedman test identified significant differences between groups at both study times. At baseline, a higher mean ISQ value was obtained by the V3 group (73.82 ± 2.78), with significant difference ($p = 0.048$) compared with the C1 group (69.56 ± 3.17). Comparison at 12 weeks followed the same pattern, whereby the V3 group presented significantly higher ISQ values ($p = 0.041$) compared with the control group (Table 1).

Table 1. ISQ analysis and measurements at baseline and 12 weeks. Results presented as mean values and medians. A Friedman test was applied for inter-group comparisons. ($p < 0.05$); * indicates statistically significant differences (<0.05).

ISQ Values	Baseline		12 Weeks		*p* Values Intergroup
	Mean ± SD	Median	Mean ± SD	Median	
Implants C1® (Control group)	69.56 ± 3.17	69.91	70.35 ± 3.42	71.35	0.17
Implants V3® (Test group)	73.82 ± 2.78	70.79	74.02 ± 3.96	74.56	0.21
p Value intergroup	0.048 *	–	0.041 *	–	–

After twelve weeks of healing, histological analysis revealed bone in direct contact with all implants on both vestibular and lingual surfaces. No soft tissue was evident between bone and implants. A decrease in both lingual and buccal cortical bone was observed as a consequence of bone remodeling. This reduction was higher in the control group of implants with conventional neck design.

The mean value of bone-to-implant contact was measured for each group, on both buccal and lingual aspects (Table 2). A measurement was taken from the top of the implant collar (line IS) to the first point of bone-to-implant contact (line C). In the test group, the mean was 0.31 ± 0.24 mm on the buccal aspect and 0.35 ± 0.14 mm on the lingual; in the control group it was 0.71 ± 0.28 mm on the buccal aspect and 0.42 ± 0.30 mm in the lingual. Data analysis found a statistically significant difference between the groups at 12 weeks on the buccal aspect ($p = 0.0019$) but no difference on the lingual aspect ($p = 0.132$).

Tissue thickness was measured from the top of the implant shoulder (line IS´) to the most external portion of the tissue (line E). Mean tissue thickness in the test group was 1.98 ± 0.17 mm on the buccal aspect and 2.43 ± 0.93 mm on the lingual, and in the control group it was 2.48 ± 0.61 mm on the buccal aspect and 2.88 ± 0.14 mm on the lingual (Table 3). Statistically significant differences between the groups were found at 12 weeks on both the buccal ($p = 0.0043$) and lingual ($p = 0.0029$) aspects. The bar graphs in Figures 5 and 6 represent the measurements obtained for crestal bone and tissue thickness, respectively.

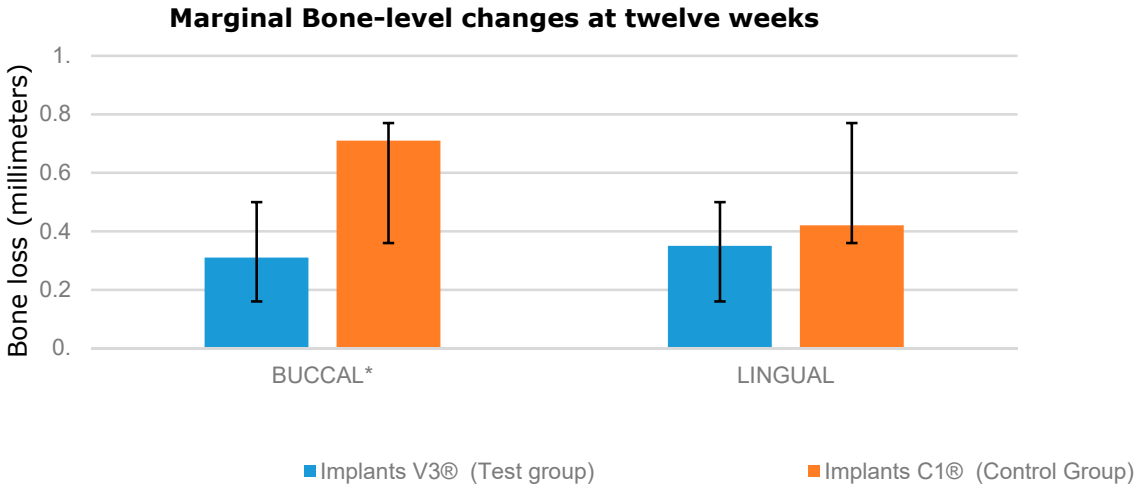


Figure 5. Marginal bone-level changes between baseline and 12-week study times. Marginal bone loss (mean ± SD); * indicates significant differences ($p < 0.05$).

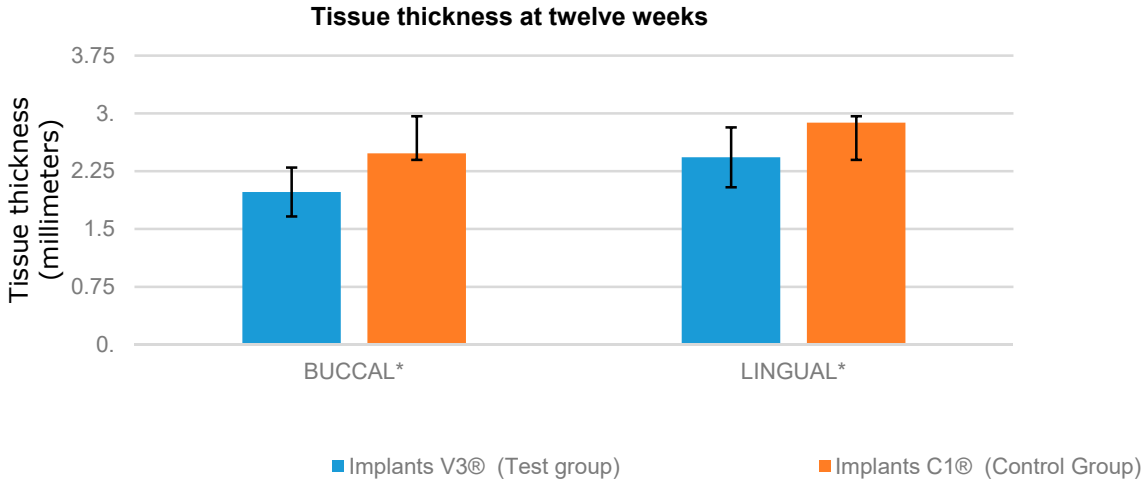


Figure 6. Tissue thickness changes between baseline and 12-week study times. Tissue thickness loss (mean ± SD); * indicates significant differences ($p < 0.05$).

Table 2. Bone-level changes between baseline and 12-week study times (measured from the top of the implant collar (line IS) to the first point of bone-to-implant contact (line C)). Marginal bone loss (mean ± SD); * indicates significant differences ($p < 0.05$).

12 WEEKS	IS-C	
	BUCCAL	LINGUAL
Implants C1® (Control group)	0.71 ± 0.28 mm	0.42 ± 0.30 mm
Implants V3® (Test group)	0.31 ± 0.24 mm	0.35 ± 0.14 mm
p Value	0.0019 *	0.132

Table 3. Tissue thickness changes between baseline and 12-week study times (measured from the top of the implant shoulder (line IS′) to the most external portion of the tissue (line E)). Tissue thickness loss (mean ± SD); * indicates significant differences ($p < 0.05$).

12 WEEKS	IS′-E	
	BUCCAL	LINGUAL
Implants V3® (Test group)	1.98 ± 0.17 mm	2.43 ± 0.93 mm
Implants C1® (Control group)	2.48 ± 0.61 mm	2.88 ± 0.14 mm
p Value	0.0043 *	0.0029 *

4. Discussion

Studies of peri-implant bone loss and their findings point to a range of implant-, clinician-, and patient-related factors, which each play a part in bone remodeling [22]. In the case of implant characteristics, these involve a series of micro- and macro-design features including shape, surface configuration, cervical characteristics, etc. It is well documented that micro threads help to maintain bone levels around implants.

The present study found higher ISQ values in the V3 test group compared with the control group of C1 implants. This could be due to the fact that ISQ values can be influenced by implant design. On the basis of previous research, the presence of a cutting flute area in V3 implants can lead to better ISQ results [23,24]. Nevertheless, further studies are needed to establish conclusive evidence that certain macro-design characteristics can improve primary stability.

Bratu et al. [25] obtained different amounts of marginal bone loss in implants that differed only in neck configuration. The study compared implants with microthreads on the neck with

implants with polished necks. The results for the microthreaded neck obtained almost 60% less bone loss after 6 months, compared with implants with polished neck. This finding agrees with Calvo Guirado et al. [5], who observed that implants with a microrough neck surface with microthreads, tapered design and platform switching obtained a mean bone loss of 3.5 mm after a 3-year follow-up. It would appear that surface roughness not only increases bone-to-implant contact but also reduces bone resorption [7,26]. Shin et al. [27] found that implants with a rough surface and microthreads (as used in the present study) reduced bone resorption. Abrahamsson [26] obtained significantly higher bone-to-implant contact around microthreaded implants (81.8%) than control implants without microthreads (72.8%). These results agree with Nickenig et al. [28] who suggested that a rough microthread surface minimizes bone resorption. These authors conducted a radiographic study to assess bone reduction associated with implants with different neck designs. As a conclusion, the study strongly recommends the use of rough surface and microthreaded implants in order to maintain crestal bone levels.

The present findings concur with other studies that show the importance of neck configuration. In the present study, the implants were identical in all other respects; they were of the same brand and both were of identical composition and surface treatment (microthreaded and with Sandblasted and acid-etched surface). Therefore, the differences found in bone loss rate cannot be explained by any other factor than neck configuration, microdesign of the neck being the only variable: one implant design with a conventional neck and the other with a triangular design.

It is well documented that the platform switching technique contributes to the preservation of peri-implant tissues and helps to reduce bone resorption. Several studies have investigated the effects of platform switching on bone resorption, comparing implants of conventional design. Hürzeler et al. [29] found a mean bone level change from baseline to 1 year of 0.12 mm to 0.40 mm for a platform switching group and 0.29 mm to 0.34 mm for a conventional control group. These results agree with Capiello et al. [30] and Fickl et al. [31], who found less bone resorption and better peri-implant tissue behavior when using platform switching.

The present study obtained higher crestal bone reduction on the buccal aspect in the V3 test group compared with the C1 control group, which may be due to the initial thickness of the buccal bony wall, and also the horizontal positioning of the implants when inserted. These explanations are supported by other studies [32,33], which have affirmed the influence of the buccal bone wall and the horizontal positioning of the implant on crestal bone loss.

The level (crestal or sub-crestal) at which the implant is inserted is another of the factors affecting bone resorption. The evidence supporting crestal positioning in order to reduce bone resorption remains contradictory. The implants in this study were inserted at crestal level. The role of the implant-abutment junction has been described as crucial during bone resorption. Herman et al. [34] concluded that subcrestal implants produce more bone resorption when compared with crestal implants. So, if bone resorption is related to the position of the implant-abutment junction, the deeper it is inserted, the greater the inflammatory response will be leading to increased bone resorption [35]. Hammerle et al. [36] found mean vertical bone loss of 2.26 mm and 1.02 mm with subcrestal and crestal implants, respectively. Results obtained by Weng et al. [37,38] are in agreement.

Some authors recommend inserting the implant two or three mm below the alveolar ridge especially in aesthetic areas where their visual impact is greatest [35]. However, in less aesthetic areas, it is recommended that they be inserted crestally [39]. This will be beneficial in areas where good soft tissue support is needed.

5. Conclusions

Within the limitations of the study, the results suggest that greater peri-implant tissue thickness can be expected with this new implant design with triangular cervical design, than with an implant with a conventional neck design. The results showed greater crestal bone height on the buccal aspect of the test implants with triangular design.

Author Contributions: José Luis Calvo Guirado conceived the in vivo experiments; Jose Luis Calvo Guirado performed the experiments with the help of Maria Ángeles Pérez-Albacete Martínez, Carlos Pérez-Albacete Martínez, José Eduardo Maté Sánchez De Val, María Luisa Ramos Oltra and Manuel Fernández Domínguez; Maria Ángeles Pérez-Albacete Martínez and Carlos Pérez-Albacete Martínez analyzed the data; All of the authors contributed to the analyses and the discussion of the results, and also prepared the manuscript. No grants are received for this research and no funds for publish this work.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Degidi, M.; Novaes, A.B., Jr.; Nardi, D.; Piattelli, A. Outcome analysis of immediately placed, immediately restored implants in the esthetic area: The clinical relevance of different interimplant distances. *J. Periodontol.* **2008**, *79*, 1056–1061. [CrossRef] [PubMed]
2. Grunder, U.; Polizzi, G.; Goené, R.; Hatano, N.; Henry, P.; Jackson, W.J.; Kawamura, K.; Köhler, S.; Renouard, F.; Rosenberg, R.; et al. A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of implants. *Int. J. Oral Maxillofac. Implants* **1999**, *14*, 210–216. [PubMed]
3. Mangano, F.; Mangano, C.; Ricci, M.; Sammons, R.L.; Shibli, J.A.; Piattelli, A. Single-tooth Morse taper connection implants placed in fresh extraction sockets of the anterior maxilla: An aesthetic evaluation. *Clin. Oral Implants Res.* **2012**, *23*, 1302–1307. [CrossRef] [PubMed]
4. Chen, S.T.; Buser, D. Esthetic outcomes following immediate and early implant placement in the anterior maxilla—A systematic review. *Int. J. Oral Maxillofac. Implants* **2014**, *29* (Suppl.), 186–215. [CrossRef] [PubMed]
5. Calvo-Guirado, J.L.; Gomez-Moreno, G.; Aguilar-Salvatierra, A.; Guardia, J.; Delgado-Ruiz, R.A.; Romanos, G.E. Marginal bone loss evaluation around immediate non-occlusal microthreaded implants placed in fresh extraction sockets in the maxilla: A 3-year study. *Clin. Oral Implants Res.* **2014**, *26*, 761–767. [CrossRef] [PubMed]
6. Romanos, G.E.; Javed, F. Platform switching minimises crestal bone loss around dental implants: Truth or myth? *J. Oral Rehabil.* **2014**, *41*, 700–708. [CrossRef] [PubMed]
7. Botticelli, D.; Berglundh, T.; Lindhe, J. Hard-tissue alterations following immediate implant placement in extraction sites. *J. Clin. Periodontol.* **2004**, *31*, 820–828. [CrossRef] [PubMed]
8. Araújo, M.G.; Lindhe, J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. *J. Clin. Periodontol.* **2005**, *32*, 212–218. [CrossRef] [PubMed]
9. Negri, B.; Calvo-Guirado, J.L.; Pardo Zamora, G.; Ramírez Fernández, M.P.; Delgado Ruiz, R.; Munoz Guzon, F. Peri-implant bone reactions to immediate implants placed at different levels in relation to crestal bone. Part I: A pilot study in dogs. *Clin. Oral Implants Res.* **2012**, *23*, 228–235. [CrossRef] [PubMed]
10. Palacci, P. Aesthetic treatment of the anterior maxilla: Soft and hard tissue considerations. *Oral Maxillofac. Surg. Clin. N. Am.* **2004**, *16*, 127–137. [CrossRef] [PubMed]
11. Calvo-Guirado, J.L.; López-López, P.J.; Pérez-Albacete Martínez, C.; Javed, F.; Granero-Marín, J.M.; Maté Sánchez de Val, J.E.; Ramírez Fernández, M.P. Peri-implant bone loss clinical and radiographic evaluation around rough neck and microthread implants: A 5-year study. *Clin. Oral Implants Res.* **2016**, *7*. [CrossRef] [PubMed]
12. Hermann, J.S.; Jones, A.A.; Bakaeen, L.G.; Buser, D.; Schoolfield, J.D.; Cochran, D.L. Influence of a machined collar on crestal bone changes around titanium implants: A histometric study in the canine mandible. *J. Periodontol.* **2011**, *82*, 1329–1338. [CrossRef] [PubMed]
13. Schwarz, F.; Hegewald, A.; Becker, J. Impact of implant-abutment connection and positioning of the machined collar/microgap on crestal bone level changes: A systematic review. *Clin. Oral Implants Res.* **2014**, *25*, 417–425. [CrossRef] [PubMed]
14. Oh, T.J.; Yoon, J.; Misch, C.E.; Wang, H.L. The causes of early implant bone loss: Myth or science? *J. Periodontol.* **2002**, *73*, 322–333. [CrossRef] [PubMed]
15. Rodríguez-Ciurana, X.; Vela-Nebot, X.; Segala-Torres, M.; Calvo-Guirado, J.L.; Cambra, J.; Mendez-Blanco, V.; Tarnow, D.P. The effect of interimplant distance on the height of the interimplant bone crest when using platform-switched implants. *Int. J. Periodontics Restor. Dent.* **2009**, *29*, 141–151.

16. Calvo-Guirado, J.L.; Ortiz-Ruiz, A.J.; Negri, B.; López-Marí, L.; Rodríguez-Barba, C.; Schlottig, F. Histological and histomorphometric evaluation of immediate implant placement on a dog model with a new implant surface treatment. *Clin. Oral Implants Res.* **2010**, *21*, 308–315. [CrossRef] [PubMed]
17. Shin, S.-Y.; Han, D.-H. Influence of microgrooved collar design on soft and hard tissue healing of immediate implantation in fresh extraction sites in dogs. *Clin. Oral Implants Res.* **2009**, *21*, 804–814. [CrossRef] [PubMed]
18. Lee, D.W.; Choi, Y.S.; Park, K.H.; Kim, C.S.; Moon, I.S. Effect of microthread on the maintenance of marginal bone level, a 3-year prospective study. *Clin. Oral Implants Res.* **2007**, *18*, 465–470. [CrossRef] [PubMed]
19. Stanford, C.M. Surface modifications of dental implants. *Aust. Dent. J.* **2008**, *53* (Suppl. 1), 26–33. [CrossRef] [PubMed]
20. Alomrani, A.N.; Hermann, J.S.; Jones, A.A.; Buser, D.; Schoolfield, J.; Cochran, D.L. The effect of a machined collar on coronal hard tissue around titanium implants: A radiographic study in the canine mandible. *Int. J. Oral Maxillofac. Implants* **2005**, *20*, 677–686. [PubMed]
21. Calvo-Guirado, J.L.; Pérez-Albacete, C.; Aguilar-Salvatierra, A.; de Val Maté-Sánchez, J.E.; Delgado-Ruiz, R.A.; Abboud, M.; Velasco, E.; Gómez-Moreno, G.; Romanos, G.E. Narrow-versus mini-implants at crestal and subcrestal bone levels. Experimental study in beagle dogs at three months. *Clin. Oral Investig.* **2015**, *19*, 1363–1369. [CrossRef] [PubMed]
22. Hermann, F.; Lerner, H.; Palti, A. Factors influencing the preservation of the periimplant marginal bone. *Implant Dent.* **2015**, *16*, 165–175. [CrossRef] [PubMed]
23. Jimbo, R.; Tovar, N.; Marin, C.; Teixeira, H.S.; Anchieta, R.B.; Silveira, L.M.; Janal, M.N.; Shibli, J.A.; Coelho, P.G. The impact of a modified cutting flute implant design on osseointegration. *Int. J. Oral Maxillofac. Surg.* **2014**, *43*, 883–888. [CrossRef] [PubMed]
24. Wu, S.W.; Lee, C.C.; Fu, P.Y.; Lin, S.C. The effects of flute shape and thread profile on the insertion torque and primary stability of dental implants. *Med. Eng. Phys.* **2012**, *34*, 797–805. [CrossRef] [PubMed]
25. Bratu, E.A.; Tandlich, M.; Shapira, L. A rough surface implant neck with microthreads reduces the amount of marginal bone loss: A prospective clinical study. *Clin. Oral Implants Res.* **2009**, *20*, 827–832. [CrossRef] [PubMed]
26. Abrahamsson, I.; Berglundh, T. Tissue characteristics at microthreaded implants: An ex- perimental study in dogs. *Clin. Implant Dent. Relat. Res.* **2006**, *8*, 107–113. [CrossRef] [PubMed]
27. Shin, Y.K.; Han, C.H.; Heo, S.J.; Kim, S.; Chun, H.J. Radiographic evaluation of marginal bone level around implants with different neck designs after 1 year. *Int. J. Oral Maxillofac. Implants* **2006**, *21*, 789–794. [PubMed]
28. Nickenig, H.-J.; Wichmann, M.; Schlegel, K.A.; Nkenke, E.; Eitner, S. Radiographic evaluation of marginal bone levels adjacent to parallel-screw cylinder machined-neck implants and rough-surfaced microthreaded implants using digitized panoramic radiographs. *Clin. Oral Implants Res.* **2009**, *20*, 550–554. [CrossRef] [PubMed]
29. Hürzeler, M.; Fickl, S.; Zuhr, O.; Wachtel, H.C. Peri-implant bone level around implants with platform-switched abutments: Preliminary data from a prospective study. *J. Oral Maxillofac. Surg.* **2007**, *65* (Suppl. 1), 33–39. [CrossRef] [PubMed]
30. Cappiello, M.; Luongo, R.; Di Iorio, D.; Bugea, C.; Cocchetto, R.; Celletti, R. Evaluation of peri-implant bone loss around platform-switched implants. *Int. J. Periodontics Restor. Dent.* **2008**, *28*, 347–355.
31. Fickl, S.; Zuhr, O.; Stein, J.M.; Hürzeler, M.B. Peri-implant bone level around implants with platform-switched abutments. *Int. J. Oral Maxillofac. Implants* **2010**, *25*, 577–581. [PubMed]
32. Ferrus, J.; Cecchinato, D.; Pjetursson, E.B.; Lang, N.P.; Sanz, M.; Lindhe, J. Factors influencing ridge alterations following immediate implant placement into extraction sockets. *Clin. Oral Implants Res.* **2010**, *21*, 22–29. [CrossRef] [PubMed]
33. Tomasi, C.; Sanz, M.; Cecchinato, D.; Pjetursson, B.; Ferrus, J.; Lang, N.P.; Lindhe, J. Bone dimensional variations at implants placed in fresh extraction sockets: A multilevel multivariate analysis. *Clin. Oral Implants Res.* **2010**, *21*, 30–36. [CrossRef] [PubMed]
34. Hermann, J.S.; Buser, D.; Schenk, R.K.; Cochran, D.L. Crestal bone changes around titanium implants. A histometric evaluation of unloaded non- submerged and submerged implants in the canine mandible. *J. Periodontol.* **2000**, *71*, 1412–1424. [CrossRef] [PubMed]
35. Vela-Nebot, X.; Rodríguez-Ciurana, X.; Rodado-Alonso, C.; Segalà-Torres, M. Benefits of an implant platform modification technique to reduce crestal bone resorption. *Implant Dent.* **2006**, *15*, 313–320. [CrossRef] [PubMed]

36. Hämmerle, C.H.; Brägger, U.; Bürgin, W.; Lang, N.P. The effect of subcrestal placement of the polished surface of ITI implants on marginal soft and hard tissues. *Clin. Oral Implants Res.* **1996**, *7*, 111–119. [CrossRef] [PubMed]
37. Weng, D.; Hitomi-Nagata, M.J.; Bell, M.; Nascimento de Melo, L.G.; Bosco, A.F. Influence of microgao location and configuration on peri-implant bone morphology in nonsubmerged implants: An experimental study in dogs. *Int. J. Oral Maxillofac. Implants* **2010**, *25*, 540–547. [PubMed]
38. Weng, D.; Hitomi-Nagata, M.J.; Bosco, A.F.; Nascimento de Melo, L.G. Influence of microgap location and configuration on radiographic bone loss around submerged implants: An experimental study in dogs. *Int. J. Oral Maxillofac. Implants* **2011**, *26*, 941–946. [PubMed]
39. Pontes, A.E.F.; Ribeiro, F.S.; Iezzi, G.; Piattelli, A.; Cirelli, J.A.; Marcantonio, E., Jr. Biologic width changes around loaded implants inserted in different levels in relation to crestal bone: Histometric evaluation in canine mandible. *Clin. Oral Implants Res.* **2008**, *19*, 483–490. [CrossRef] [PubMed]