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CLINICAL RESEARCH

Influence on peri-implant bone loss of different fixed partial dentures retained on 2 implants

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ABSTRACT

Statement of problem. Marginal bone loss is key to determining the success of dental implants. However, how different factors, including the extension or span of implant-supported restorations and implant position, affect bone loss is unclear.

Purpose. The purpose of this prospective clinical study was to analyze peri-implant bone loss 3 years after loading by evaluating the influence of implant position and prosthetic type and comparing splinted crowns and 3- or 4-unit fixed partial dentures (FPDs) to determine whether 2 dental implants can achieve comparable success when replacing 2, 3, or 4 missing teeth.

Material and methods. Sixty-two adjacent dental implants in 23 participants were investigated. The implants supported noncantilevered restorations: 2 splinted crowns or 3- or 4-unit FPDs. Bone loss was evaluated 3 years after loading from periapical radiographs using AutoCAD software. Nonparametric comparisons were made. The Wilcoxon test was applied to determine homogeneity of related samples. The Mann-Whitney test was applied to measure homogeneity of bone loss in 2 independent samples and the presence/absence of a pontic in the restoration (α=.05).

Results. Mean ±standard deviation peri-implant bone loss was 0.9 ±0.7 mm. The peri-implant bone loss of the restorations analyzed was similar to the average values of 1.1 ±0.8 mm for 3- and 4-unit FPDs and 0.8 ±0.6 mm for splinted crowns. The type of prosthodontic restoration and implant position did not show significant influences on bone loss (P>.05).

Conclusions. Mean bone loss values were within an acceptable range. Statistically significant relationships were not found between the restoration types, suggesting that 3 or 4 missing teeth can be replaced by 2 implants. Further studies with longer follow-ups are needed to obtain clinically applicable conclusions. (J Prosthet Dent 2019;122:295-300)

Peri-implant bone loss is considered an essential indicator of long-term implant success.[1] After placing and loading dental implants, physiological bone remodeling takes place and usually extends to the first thread of the implant body. Acceptable bone remodeling is considered to be approximately 1.5 mm during the first year of functional loading, with an annual vertical loss of 0.2 mm in subsequent years.[2,3] Peri-implant bone loss may be influenced and aggravated by occlusal stress affecting the crestal area of peri-implant tissue[4]; surgical trauma; implant-related properties; the implant-to-crown ratio; prosthetic characteristics; and patient-specific risk factors, such as periodontal status, oral hygiene, parafunctional habits, or smoking.[5-10]

In biomechanical terms, resistance to loading decreases in implant-supported restorations with increased lever arms.[6] It also differs substantially between single crowns and splinted implant restorations.[7] Other prosthetic parameters, including implant neck design, insertion torque and depth, and the location of implants, can also affect the implant outcome and marginal bone resorption.[8-14]

The number of implant-supported dental treatments has increased in the recent years.[14] Given the range of factors that may provoke bone loss, each should be

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Clinical Implications

The present results suggest that it may not be necessary to place more than 2 implants when replacing 3 or 4 adjacent missing teeth. This approach would reduce both economic cost and surgical time.

considered in isolation.[15-20] In this context, 1 influential factor on marginal bone loss could be the number of teeth, or span, being replaced by the prosthesis and supported by 2 implants.

The purpose of this prospective clinical study was to analyze whether peri-implant bone loss around pairs of implants restored with 2 splinted crowns and 3- or 4-unit fixed partial dentures (FPDs) was different. The hypotheses tested were that peri-implant bone loss would be greater with implant-supported FPDs than pairs of splinted crowns supported by 2 implants and that peri-implant bone loss around restorations by means of implant-supported FPDs and splinted crowns would be greater in the maxilla than the mandible.

MATERIAL AND METHODS

This prospective clinical study included 62 dental implants placed in 23 participants. All participants were treated in the Department of Prosthodontics and Occlusion at the University of Valencia (Spain) between May 2013 and May 2016 by a single clinician (R.A.-P.). The study design was approved by the University of Valencia Research Ethics Committee. All participants provided informed consent.

The inclusion criteria were adult patients in good general health. They had to be partially edentulous with the absence of 2 to 4 adjacent teeth in the same sextant requiring restoration with 2 implants, have natural dentition in the antagonist arch and normal occlusion, have periodontally healthy teeth, be nonsmokers, and have no parafunctional habits. Exclusion criteria were active periodontal disease, poor oral hygiene, smoking, parafunctional habits, or treatment with bisphosphonates or anticoagulants.

Implant placement followed a standardized procedure based on the manufacturers' recommendations. Twenty-three participants received 62 tapered implants (Kohno; Sweden & Martina) (Fig. 1A). Metal-ceramic crowns were fabricated to fit onto machined grade V titanium antirotational abutments prepared with a 1-mm chamfer with the finish line at the gingival margin (Fig. 1B). The crowns were fabricated by computer-aided design and computer-aided manufacturing (CAD-CAM) procedures from milled cobalt-chromium (Adhoc; Phibo) using a porcelain veneer (IPS d-Sign; Ivoclar Vivadent AG). They were cemented onto the abutments with resin cement (Premier Implant Cement; Premier Dental Products Co) (Fig. 1C).

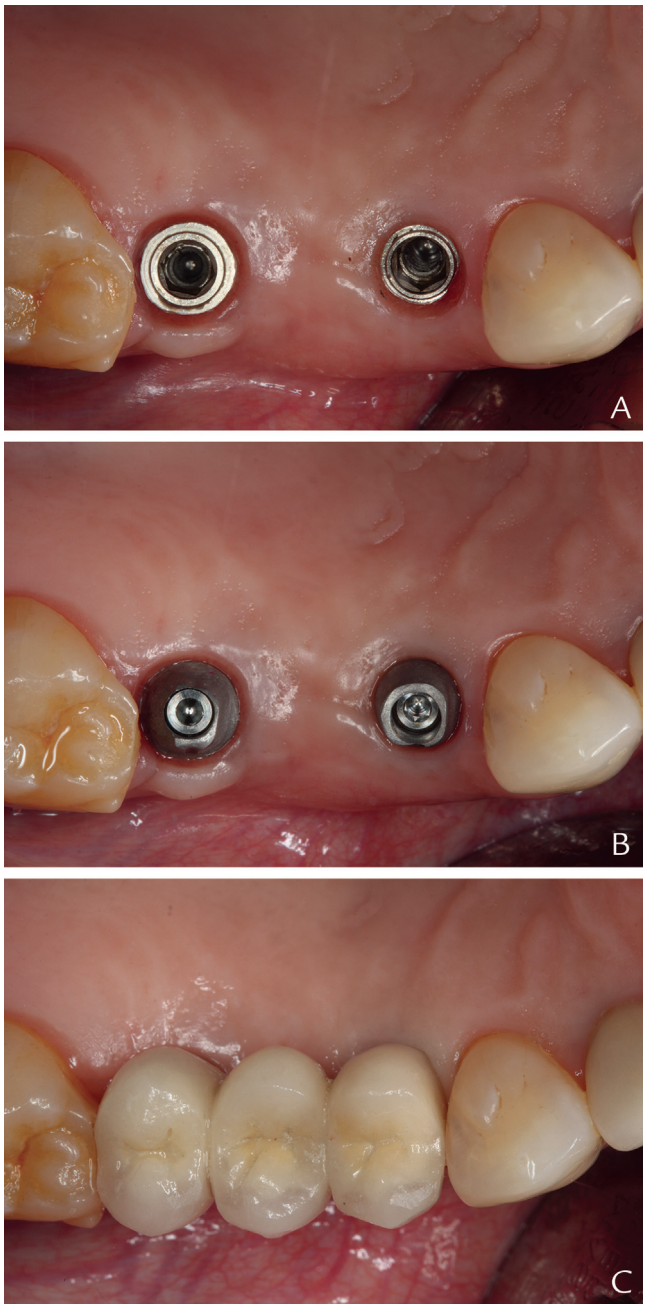

Figure 1. Participant treated with 2 Kohno dental implants. A, Before receiving 3-unit fixed partial implant-supported restoration. B, Partially modifiable titanium abutments with antirotation system. C, Definitive restoration with 3-unit FDP supported by 2 implants. FDP, fixed dental prosthesis.

The participants were divided into 2 groups according to the type of restoration to be placed: receiving 2 splinted crowns (a total of 16 splinted crowns supported by 32 implants); 3- or 4-unit FPDs (15 restorations supported by 30 implants). The implants were always located

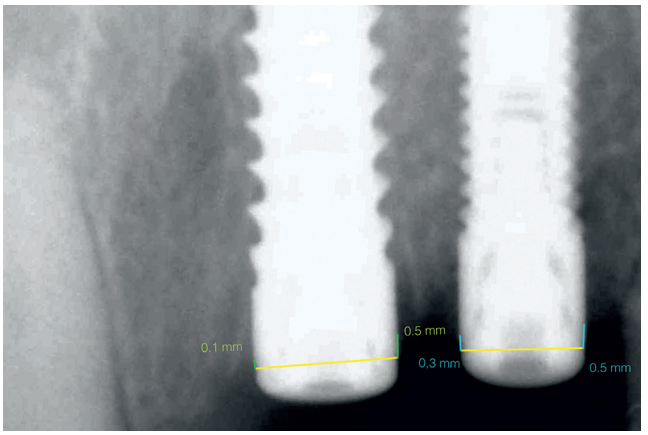

Figure 2. Periapical radiograph showing peri-implant bone measurement carried out before implant loading.

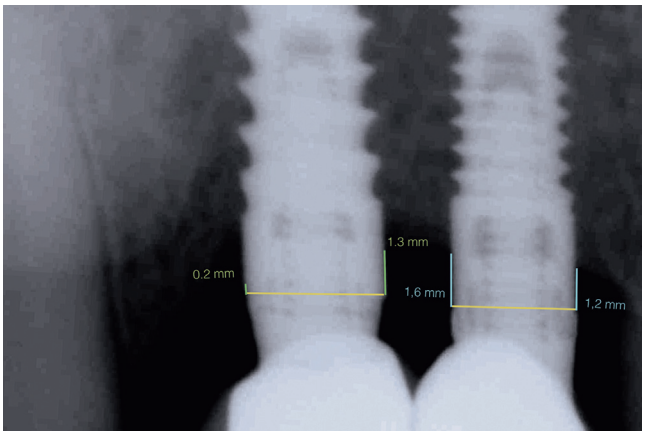

Figure 3. Periapical radiograph with bone loss measurements carried out 12 months after functional loading. For maxillary left first premolar, after subtracting 0.8 mm implant neck, no mesial marginal bone loss was found, while 0.5 mm loss on distal surface was registered. Peri-implant bone loss around maxillary left second premolar was 0.8 mm and 0.4 mm on mesial and distal surfaces, respectively.

at the mesial and distal ends of each FPD with the pontics in the center and without cantilevers. Twenty implants were placed in the maxilla and 42 in the mandible.

Radiographs were obtained at the baseline before implant loading and 36 months after loading. A single clinician (B.M.-M.) measured peri-implant marginal bone loss from the radiographs using software (AutoCAD; Autodesk Inc). Bone loss was calculated as the difference between marginal measurements before loading and 36 months after loading.

Individual magnification factors of the radiographs were considered. To scale and quantify real bone loss, magnification factors were compensated for by dividing implant width as it appeared on radiographs by the actual implant width.

Measurements were made by using the following procedure: 2 visible and reproducible reference points were determined on the mesial and distal surfaces of the implant platform; a straight line was then drawn to create a reference line (height 0). To determine vertical bone loss, mesial and distal lines perpendicular to the reference line were drawn as far as the most coronal point on the bone surface (Fig. 2). The height of the implant neck (0.8 mm) was subtracted from the measurement, as osseointegration only occurred below the implant neck (Fig. 3).

Descriptive statistics including mean, standard deviation, minimum, maximum, and median were calculated for each variable. Nonparametric comparisons were made, applying the Wilcoxon test to determine the homogeneity of the samples; the Mann-Whitney test was used to evaluate homogeneity of distribution of bone loss values between independent samples, considering whether the restoration included a pontic. This test was also used for the same type of restoration, comparing the location in the mandible or maxilla (α=.05). In the Mann-Whitney test, for a confidence level of 95%, considering the large size of the effect to be detected (0.8), the power required to indicate a significant difference was 0.57.

Table 1. Bone loss values (mm) for mesial and distal dental implants and restorations

		Type of Restoration	
Implants	**Total**	**2 Splinted Crowns**	**2 Abutments+1 or 2 Pontics**
Mesial implants			
N	31	16	15
Mean	1.2	0.9	1.4
Standard deviation	1.1	0.9	1.3
Minimum	0	0	0.1
Maximum	4.9	3.4	4.9
Median	0.9	0.7	1.1
Distal implants			
N	31	16	15
Mean	0.7	0.7	0.7
Standard deviation	0.5	0.6	0.5
Minimum	0	0	0
Maximum	1.7	1.7	1.4
Median	0.7	0.7	0.7

RESULTS

The 23 participants comprised 9 men and 14 women aged between 35 and 68 years (mean age: 52 years). A total of 62 dental implants placed in 23 participants were analyzed. Peri-implant bone loss data were distributed according to restoration/implant location within the arch (Table 1). For 31 mesial implants, mean ±standard deviation bone loss was of 1.2 ±1.1 mm, while distal implants presented mean bone loss of 0.7 ±0.5 mm. No significant association between bone loss and restoration type (splinted crown/FPD) was found. Figure 4 presents

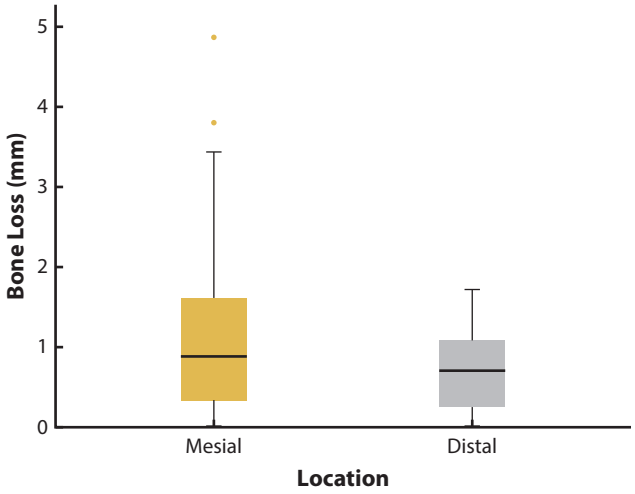

Figure 4. Box plot comparing bone loss around dental implants located in mesial or distal position within implant-supported restorations.

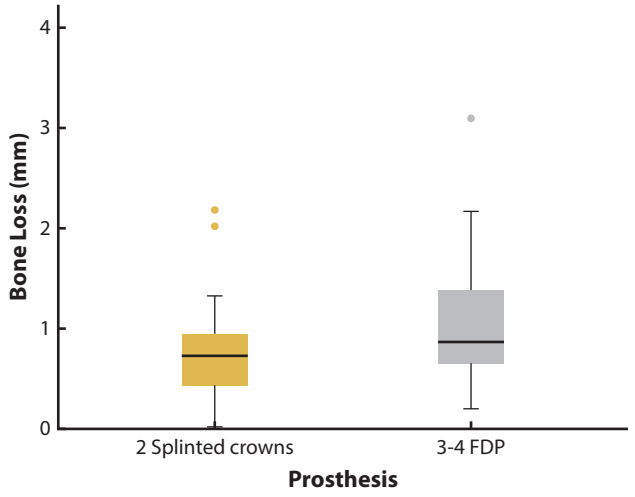

Figure 6. Box plot diagram comparing bone loss around dental implant restored with 2 splinted crowns or 3- or 4-unit FDPs. FDPs, fixed dental prostheses.

these data as a box plot. The Wilcoxon test showed no statistical evidence to suggest that bone loss around mesial implants was different than around distal implants (P=.158).

Discrepancies in means and medians between the restoration type and implant location, whereby some implants suffered atypically high bone loss values, made it necessary to represent the results as a box plot (Fig. 5). No significant relationships were found between mesial-distal regions and restoration type (P=.188 for mesial implants; P=.572 for distal implants).

Overall, mean peri-implant bone loss was 0.9 ±0.7 mm (range: 0 to 3.1 mm). The average bone loss for implants restored with 2 splinted crowns was 0.8 ±0.6 mm, while implants restored with 3- or 4-unit FPDs showed similar median bone loss (1.1 ±0.8 mm), without statistically significant difference (P=.290) (Fig. 6). Mean

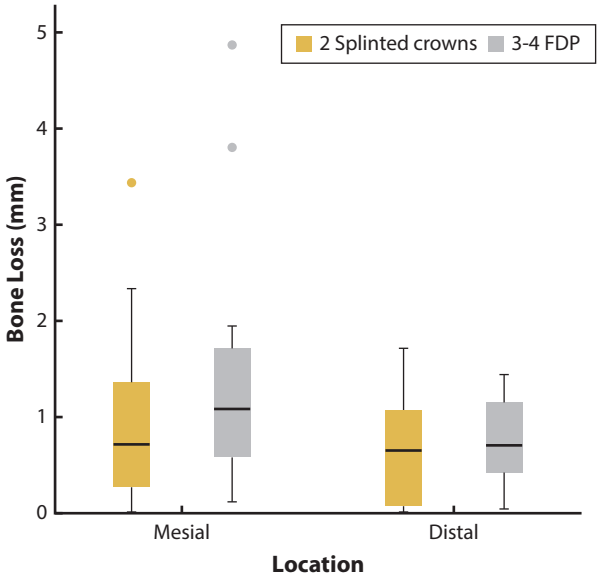

Figure 5. Box plot showing distribution of bone loss values around dental implants located in mesial or distal position within restorations and restoration type (2 splinted crowns or 3-4 FDP). FDP, fixed dental prosthesis.

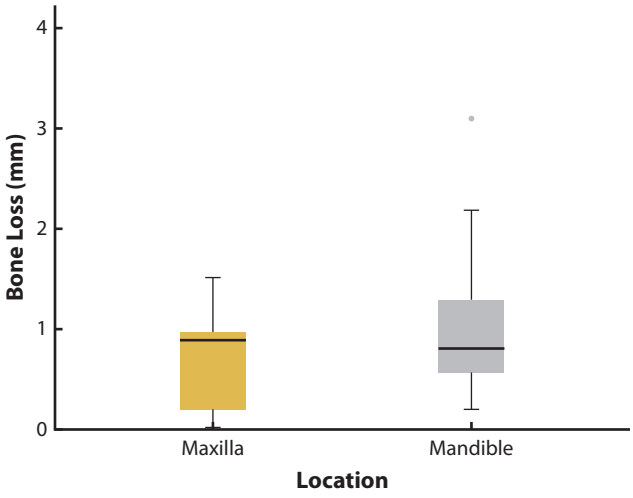

Figure 7. Distribution of peri-implant bone loss values of implant-supported prostheses located in maxilla or mandible.

bone loss around implants placed in the mandible (1.1 ±0.7 mm) was similar to around dental implants placed in the maxilla (0.8 ±0.5 mm) (P=.519) (Fig. 7).

Simultaneous comparison of mean bone loss values around dental implants in relation to the restoration type supported in the maxilla (P=.110) found average bone loss value for implants restored with 3- or 4-unit FPDs of 1 ±0.6 mm, which was similar to that of implants supporting splinted crowns (0.5 ±0.4 mm) (P=.565) In the mandibular arch, the results were similar for both groups: 3- or 4-unit FPDs (1.1 ±0.8 mm) and splinted crowns (1.0 ±0.7 mm) (P=.756).

Applying a Brunner-Langer nonparametric model, relating restoration type (FPD/crown) and implant position (mesial/distal), with peri-implant bone loss as the dependent variable, no statistical effect was detected for restoration type (P=.134), the arch (mandible/maxilla) in which implants were placed (P=.510), or implant position (distal/mesial) (P=.168). No significant interaction was found among the factors such as restoration type/arch (P=.161); restoration type/position (P=.806); arch/implant position (P=.792); or restoration type/arch/implant position (P=.109).

DISCUSSION

Based on the results obtained in the present study, the first null hypothesis was rejected as no statistically significant differences were found in peri-implant bone loss between crowns and FPDs. Similarly, the second null hypothesis was rejected as no significant differences were found in peri-implant bone loss between restorations placed in the maxilla and mandible.

Dental implants are the treatment of choice for restoring partially edentulous jaws. Treatment may take the form of conventional implant-supported fixed dental prostheses (FPDs)[11] or implant-supported splinted crowns with or without cantilevers.[12,13]

Some clinicians prefer to splint adjacent implant-supported crowns, as nonsplinted restorations with heavier interproximal contacts are associated with increased tensile stresses between implants,[13] whereby the occlusal load tends to concentrate around a specific loaded implant.[5] But splinted restorations share the occlusal load and distribute stresses more evenly among the implants.[13]

Vertical bone loss around dental implants is one of the most widely used parameters for evaluating implant success. Most physiological peri-implant bone remodeling occurs within the first 6 months after implant placement, and most bone loss occurs in the first year after implant placement.[15] Adell et al[3] proposed that a vertical loss of 1.5 mm after the first year of functional loading was acceptable, and a subsequent 0.2-mm annual loss was described by Albrektsson et al[2] as a normal occurrence.

Measurement of radiographs is one of the most common methods for assessing peri-implant bone height.[16] The radiographs must clearly demonstrate the implant threads on both sides.[10] Although panoramic radiographs also provide valuable information about peri-implant bone, standardized parallelized digital intraoral radiographs provide more reliable peri-implant bone loss data.[17] However, the images obtained are 2-dimensional and only allow for bone loss assessment on the implant's mesial and distal surfaces. The present study used periapical radiographs, and the measurement procedure followed previous studies.[6,16] Few studies used the software used in the present study (AutoCAD) for making radiographic measurements of peri-implant bone loss.[17] AutoCAD made it possible to obtain the actual bone loss values once the images were scaled to the diameter of the implant, facilitating calculations and later comparisons.

The present study obtained mean peri-implant bone loss 3 years after functional loading of 0.95 mm, similar to previous studies.[15,18,19] The type of implant-supported restoration did not show any significant relation to peri-implant bone loss. Vázquez-Álvarez et al[5] reported that splinted implants had greater bone loss compared with single implants, but this finding has little bearing on the present study, which did not investigate single implants.

Firme et al[20] performed a systematic review and meta-analysis of the influence of prosthetic design—single fixed prostheses and multiple-unit screw-retained prostheses—on the biological behavior of peri-implant bone. The reported mean bone loss values of 0.9 mm (95% confidence interval, 0.49 to 1.32 mm) for multiple-implant screw-retained prostheses and 0.58 mm (95% confidence interval, 0.37 to 0.80 mm) for single-implant prostheses, without statistically significant differences. These values concur with the present study of cemented restorations. Tarnow et al[21] investigated another important factor associated with peri-implant bone loss: the distance between adjacent implants. The present study did not consider this parameter, as implant positions were determined by the planned prosthetic restorations they supported.

The present study also investigated the possible relation between peri-implant bone loss and whether implants were placed in the maxilla or mandible. In agreement with the results of other studies,[22] median marginal bone loss was similar in both arches. Based on the present results, the hypothesis that peri-implant bone loss around 3- or 4-unit FPDs would be no different from that around implants restored with 2 splinted crowns was affirmed as no statistically significant relationship was found between the type of restoration and peri-implant bone loss.

Given the study's limited sample size, further studies are needed to confirm the present findings. Long-term marginal bone loss or late implant failure should be monitored in studies with longer follow-up periods.

CONCLUSIONS

Based on the findings of this prospective clinical study, the following conclusions were drawn:

1. No differences were found in peri-implant bone loss between 3- or 4-unit implant-supported FPDs and pairs of splinted crowns cemented onto 2 implants.

2. The present results suggest that replacing 4 missing teeth with 2 dental implants can provide a successful treatment outcome, with no statistically significant influence on peri-implant bone loss for at least 3 years.
3. Despite the limits of the present study, peri-implant bone loss around tapered implants after 36 months of functional loading is within acceptable parameters.

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