Universidade Estadual de Maringá
Centro de Ciências da Saúde
Departamento de Odontologia
Mestrado em Odontologia Integrada

RADIOLOGIC COMPARATIVE STUDY OF MARGINAL BONE LOSS AROUND NARROW AND REGULAR DIAMETER IMPLANTS INSTALLED IN THE POSTERIOR REGION OF THE JAW

Mestranda: Lívia de Souza Tolentino

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Trabalho de dissertação apresentado ao Programa de Pós-Graduação em Odontologia, da Universidade Estadual de Maringá, em nível de Mestrado.

Mestranda: Lívia de Souza Tolentino

Orientador: Prof°. Dr°. Maurício Guimarães Araújo

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DEDICATÓRIA

Ao supremo DEUS

"Deus está aqui neste momento
Sua presença é real em meu viver
Entregue sua vida e seus problemas
Fale com Deus, Ele vai ajudar você

Seja qual for o seu problema
Fale com Deus, Ele vai ajudar você
Após a dor vem a alegria
Pois Deus é amor e não te deixará sofrer

Deus te trouxe aqui
Para aliviar o seu sofrimento
É Ele o autor da Fé
Do princípio ao fim
De todos os seus tormentos

E ainda se vier noites traiçoeiras
Se a cruz pesada for, Cristo estará contigo
E o mundo pode até
Fazer você chorar
Mas Deus te quer sorrindo..."

Carlos Papae

"Entrega o teu caminho ao Senhor, confia Nele e Ele tudo fará."

Salmos 37:5

Aos meus amados pais, ADÃO e SÔNIA

"Conduta de pais, caminho de filhos."
Provérbio

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"Aqueles que passam por nós não vão sós, não nos deixam sós. Deixam um pouco de si, levam um pouco de nós."

Felipe Cortelline Roque

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Radiologic comparative study of marginal bone loss around narrow and regular diameter implants installed in the posterior region of the jaw

Lívia de Souza Tolentino DDS, MSc;[a] João de Andrade Garcez Filho DDS, MSc;[b] Maurício Guimarães Araújo DDS, MSc, PhD.[a]

[a] Odontology Departmnent, State University of Maringá – UEM, Maringá, Paraná, Brazil.

[b] Private Practicioner, Aracaju, Sergipe, Brazil

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Corresponding Author: Lívia de Souza Tolentino

Rua Campos Sales, 255 - apto 602

CEP 87020-080 Maringá, Paraná, Brazil.

Phones: (55 44) 3305-1940 / (55 44) 8836-6902

liviatolentino@hotmail.com

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ABSTRACT

Objective: The objective of this one-year prospective study was to analyze marginal bone loss around narrow-diameter implants (NDIs) in comparison to regular-diameter implants (RDIs) installed in the posterior region of the jaw.

Material and Methods: A total of 22 patients with a mean age of 57.2 years were included in the study. At least one implant of each diameter was installed either in the maxilla or in the mandible. Panoramic radiographs were obtained immediately after implant installation, and again 1 year after implant loading with single prostheses. Measurements were performed from implant shoulder to the first point of contact bone/implant. Student's *t* test and Kruskal-Wallis nonparametric ANOVA were used to compare mean bone loss around implants and the effect of implant location, respectively. A level of 95% of significance was adopted.

Results: A total of 108 implants were installed (54 RDIs and 54 NDIs). Both implants presented a survival rate of 100%. No statistically significant differences concerning marginal bone loss ($P = 0.94$) were observed around NDIs (0.93 ± 0.30 mm) when compared to RDIs (0.93 ± 0.37 mm), and neither in relation to implant location in the jaw ($P = 0.65$).

Conclusion: This study demonstrated that RDIs and NDIs produced similar marginal bone loss patterns after one year of loading, regardless the implant location in the jaw, indicating that NDIs may be used in the posterior region of the jaw with single prostheses in selected patients.

INTRODUCTION

Nowadays, dental implants have become an important treatment option to support different types of prosthetic restorations. However, when implantology was taking its first steps, implants were only used to treat fully edentulous patients. Thereafter, with the evolution of dental materials and techniques, they started to be used to treat partially edentulous patients until, finally, being used to rehabilitate patients that required single-tooth replacement. Nonetheless, in some specific cases, space constraints are sometimes present in situations where, for example, lower incisors and upper lateral incisors, needed to be replaced. These situations are particularly challenging to clinicians not only from an esthetic point of view, but also in relation to the tooth's emergence profile (Albrektsson 1988; Branemark et al.1985; Adell et al. 1990; Lekholm et al. 1994).

Reduced mesio-distal prosthetic space, tooth agenesis, severe alveolar ridge reduction after extractions, or considerable bone resorption resulting from periodontal diseases or trauma, may result in insufficient bone, preventing the use of regular-diameter implants (RDIs). When the buccolingual dimension is reduced and the amount of available bone is less than 4 mm thick, the placement of an RDI often leads to the exposure of implant threads. This exposure may not only compromise the stability of the implant, but also the esthetic results of the future restoration (Hämmerle et al. 1998; Carlsson et al. 2000; Chiapasco et al. 2001; Nedir et al. 2009). In an attempt to overcome some of these challenges, narrow-diameter implants (NDIs) (< 3.75 mm) were introduced into the clinical practice (Andersen et al. 2001). In addition to allowing implant installation in a reduced mesio-distal space, their use may also avoid surgical procedures for bone augmentation, which are not only more traumatic, but also more costly and time consuming to the patient.

After implant installation, a more significant marginal peri-implant bone loss is normally observed during the healing and remodeling period, within the first year of prostheses installation. From then on, small losses can also be observed in later annual follow-ups (Albrektsson et al. 1986; Behneke et al. 1997; Levy et al. 1997; Becker et al. 1997; Ross et al. 1997; Penarrocha et al. 2004). Many factors have been identified as possible reasons for this phenomenon such as: occlusal overload (Mish et al. 1999), microgaps (Hermann et al. 2000), implant neck surface (Hammerle et al. 1996), soft tissue height around the implant, biological width, peri-implantitis, host response (e.g., smoking), and others (Hermann et al. 2000).

Marginal bone loss around RDIs has already been assessed in several studies (Adell et al. 1981; Lindquist et al. 1988; Weber et al. 2000; Mericske-Stern et al. 2001; Romeo et al. 2004). These clinical studies observed an average marginal bone loss ranging from 0.6 to 1.6 mm during the first year of loading, and annual losses of 0.05 to 0.13 mm thereafter. Likewise, other clinical studies, which assessed marginal bone loss around NDIs found values averaging 1.41 mm (Andersen 2001) within the first year of loading, and between 0.04 and 0.11 mm annually, thereafter (Andersen 2001; Comfort et al. 2005; Romeo et al. 2006).

According to the literature (Albrektsson et al. 1986), implant success is achieved when the bone around implants presents a maximum vertical loss of 1.5 mm within the first year of loading, and annual losses of < 0.2 mm in the following years. Therefore, according to the current literature, both RDIs and NDIs produce similar marginal bone loss patterns, which are within the parameters of success. However, so far, no clinical controlled trials have been carried out to specifically compare marginal bone loss around those two different types of implants. Therefore, the objective of this controlled prospective study was to analyze marginal bone loss around NDIs in comparison with that of RDIs installed in the posterior region of the jaw after one year of loading with single prostheses.

MATERIALS AND METHODS

Patients and implants:

The study design was duly approved by Ethics Committee for Research with Humans Beings at the Federal University of Sergipe, and all patients signed an informed consent before taking part in the study. The sample was constituted of 22 patients, (11 males and 11 females) with a mean age of 57.2 years, who required single-tooth prosthetic rehabilitation supported by implants in the posterior region of the jaw. Sample size was properly calculated with the aid of the statistical program BioEstat 2.0, with a power test and an alpha level of 0.80 and 0.05, respectively.

The following inclusion criteria were met by all participants: (i) posterior edentulous areas that needed at least 2 implants in the maxilla, or 2 implants in the mandible (one NDI and one RDI); (ii) bone height ≥ 8 mm; (iii) need of single-crown rehabilitation; (iv) absence of parafunction; and (v) bone thickness ≥ 5 mm and ≥ 7 mm in the areas where NDIs and RDIs would be installed, respectively. Patients who had undergone bone graft prior to implant installation, presented periodontal disease, showed alterations in the oral soft and/or hard tissues, made use of any drug that could affect bone metabolism, smokers (> 10 cigarettes/day), pregnant or lactating women, and immunocompromised individuals (HIV-positive, AIDS, or under therapy with immunosuppressive drugs) were excluded from the study.

Surgical procedure:

Straumann® Standard Plus implants with the SLA-surface, 4.8 mm platform and 3.3 mm (NDIs) and 4.1 mm in diameter (RDIs) (Straumann® Dental Implant System, Basel, Switzerland) were installed in the posterior region of the jaw, always in the same form. Patients received at least one implant of each diameter in the maxilla, or one implant of each diameter in the mandible. The surgical procedures were performed under

anesthesia with mepivacaine 2% and epinephrine (Noraepinephrine 1:100,000). After installation, healing caps were placed on each implant. Then, the flap was repositioned and held in place with interrupted sutures in such a way that a semi-submerged implant installation was obtained. The sutures were removed 10 days after implant installation. Patients were prescribed with oral diclofenac potassium (50 mg), 8/8 hours for 3 days, amoxicillin (500 mg), 8/8 hours for 7 days, and dipyrone (500 mg), 35-40 drops 6/6 hours, just in case of pain. All surgical procedures were performed by the same clinician (JAGF).

Bleeding on probing and probing depth were measured around all aspects of the implants. After a healing period of 6 weeks, an impression of the implant head was taken according to manufacturer's instructions and single crows were fabricated and installed. All patients in this study were included in a plaque control program, which consisted of oral hygiene instruction for the use of interproximal brushes and mouthwashes, and regular prophylactic treatment that took place during follow-up appointments at 2, 6, 9 and 12 months after prostheses had been placed.

Radiologic Data

All panoramic radiographs were obtained with same equipment (Planmeca ProMax®, Planmeca, Helsinque, Finlândia) immediately after implant installation (T0), and again 1 year after implant loading (T1) with the aid of a positioning device. The radiographic film was scanned, and the distance from the implant shoulder (A) to the first point of contact bone/implant (B) was measured (Fig. 1) with the aid of a computer program (Autocad, 2008, version Z, 54.10 - Autodesk, San Rafael, CA, USA) (Fig. 2). All radiographic measurements were performed by the same calibrated examiner (LST), different from the clinician responsible for implant installation. Bone loss was calculated by subtracting the measurements obtained at T1 from those obtained at T0. Measurements were carried out on the mesial and distal sides of each

implant, and the vertical bone loss considered for comparison was the arithmetic average obtained from those two measurements.

Calibrations

In order to permit the examiner's calibration prior to actual radiologic measurements, intraobserver error was determined by measuring bone loss around 30 implants (15 of each size) on radiographs randomly chosen to this aim. Each measurement was performed twice on two consecutive days, with an interval of at least 24 hours. An estimate intraobserver standard deviation (SD) was then determined by using the following mathematical formula:

$$\text{Error} = \sqrt{(\sum d)^2/2n}$$

Where *d* is the difference between the 2 measurements and *n* is the number of measurements made (n = 30).

The error associated with the radiographic technique was also calculated using the same program used for peri-implant bone loss measurements (Canullo et al. 2009a, 2009b). Measurements obtained from radiographs were compared to the actual dimensions of implants. An RDI has a real width (excluding the threads) of 3.5 mm, while an NDI has an actual width (excluding the threads) of 2.8 mm. The difference between the mean variability found on the radiologic images and the real size of implants (3.5 mm and 2.8 mm) was calculated.

Statistical Analysis

Mean values and standard deviation were calculated for bone loss (distance from A to B in the mesial and distal sides) and location. Each patient was considered as a statistical unit.

Mean bone loss for all RDIs and NDIs was analyzed using Student's *t* test for dependent samples, and the alpha value of 5% was considered as significant. The same statistical test was also applied to paired implants of different diameters in the same patient (intrapatient analysis). To analyze the variable implant location, the nonparametric analysis of variance for independent samples (ANOVA) of Kruskal-Wallis was performed ($P < 0.05$).

RESULTS

A total of 108 implants (SLA - Straumann® Dental Implant System, Basel, Switzerland) were installed (54 RDIs and 54 NDIs). Of the 55 implants installed in the maxilla, 31 were NDIs and 24 were RDIs. Of the 53 implants installed in the mandible, 23 were NDIs and 30 were RDIs. The implants ranged from 6 to 10 mm in length (Table 1). At the end of the follow-up period (12 months of loading), an implant survival rate of 100% was observed. Bleeding on probing index was 3% for NDIs, and 5% for RDIs. However, no bleeding on probing was found in pocket depths ≥ 5 mm.

The intra-observer error identified was 0.03 mm, and the Kappa correlation coefficient was 0.9. With respect to radiologic technique error, the calculation employed confirmed that the distortion observed in the radiographic images obtained with panoramic technique was the same as that established by the radiographic equipment's manufacturer (25%) used for correction.

The average distance from implant shoulder (A) to the first point contact bone/implant (B) for both NDIs and RDIs measured on the initial (T0) and final (T1) radiographs are described on the Table 2. Average bone loss around RDIs was 0.95 mm (SD ± 0.32 mm) for paired implants (installed in the same patient), and

0.93 mm (SD ± 0.37 mm) for all implants installed. For NDIs, average bone loss was 0.93 mm (SD ± 0.27 mm) and 0.93 mm (SD ± 0.30 mm) for paired implants and for all implants installed, respectively. No statistically significant differences (P = 0.94) were observed concerning peri-implant bone loss between RDIs and NDIs (Table 3). Concerning implant location in the mouth (maxilla or mandible), no statistically significant differences were found either (P = 0.65) (Table 4, Fig. 3).

DISCUSSION

The present radiographic prospective controlled study analyzed marginal vertical bone loss around narrow-diameter and regular-diameter implants installed in the posterior region of the jaw loaded with single crowns. Regardless implant diameter (regular or narrow), no statistically significant differences in relation to bone loss, or implant position in the jaw, were found.

In order to ensure more controlled results, only patients who required at least one RDI as well as one NDI, either in the maxilla or in the mandible, were included in this study. This criterion allowed intrapatient assessments were made and compared to interpatient assessments and, thus, eliminating possible biases such as systemic problems not initially identified during patient selection, different healing processes and different bone quality among patients, etc.

Peri-implant bone loss can be analized radiographically. Different kinds of imaging methods can be used for diagnostic and treatment plans, including conventional radiographs (periapical, panoramic, cephalometry) and computerized tomography (Vazquez et al. 2008). The choice for panoramic radiography in this study was due to a number of reasons: (i) the method is more affordable; (ii) image standardization is obtained through a simple and universal positioning device; and (iii) the distortion produced by the

method can be corrected with the assistance of a computer program. Despite the fact that several authors consider other radiological methods more suitable for bone loss measurements (Schropp et al. 2001; White et al. 2001), panoramic radiography is still widely used in clinical situations, and it is considered as the standard imaging method in implantology (Harris et al. 2002; Frei et al. 2004; Vasquez et al. 2008). As a result, recent studies have not stopped using panoramic radiography as a way to access peri-implant bone loss (Weber et al. 2000; Watzak et al. 2006). The main criticism in relation to its use, however, lies in the fact that panoramic radiographs do not provide the same level of clarity and sharpness of periapical radiographs (Penarrocha et al. 2004). In order to circumvent this problem, all measurements were carried out by just one examiner, who was duly and thoroughly calibrated before the actual measurements were made, so that possible misreadings were minimized.

The radiographic peri-implant bone loss measurements performed in this study, demonstrated no statistically significant differences when RDIs were compared to NDIs, confirming the clinical observations previously reported in the literature (Adell et al. 1981; Cox et al. 1987; Jemt et al. 1990; Behneke et al. 1997; Becker et al. 1997; Levy et al. 1997). When intrapatient mean results (0.95 mm e 0.93 mm for RDIs and NDIs, respectively) were compared with interpatient results (0.92 mm and 0.93 mm for RDIs and NDIs, respectively), no significant differences were found either. This result is of particular interest since it suggests a high level of predictability for both implants in relation to the expected bone loss after one year of loading. Bleeding on probing index found after one year of loading demonstrated that the marginal bone loss found was not affected by disease in any of the patients studied. This may have been helped by the periodontal maintenance carried out by the clinician at regular intervals. The results of this study, therefore, are well in agreement with the success criteria for peri-implant bone loss previously established in the literature (Albrektsson et al., 1986).

Concerning implant placement location (maxilla or mandible), no statically significant differences for bone loss around the implants were observed either. This finding confirms the observations made in several clinical studies found in the literature (Polizzi et al. 1999; Ivanoff et al. 1999; Hallman et al. 2001; Mericske-Stern et al. 2001; Payne et al. 2004; Vigolo et al. 2004; Comfort et al. 2005). Despite the absence of statistical significance, peri-implant bone loss found in this study was slightly greater in the maxilla than in the mandible, which could be justified by the differences in the remodeling capacity of maxillary and mandibular bone (Kemppainen et al, 1997).

Several clinical studies (Vigolo et al. 2000; Vigolo et al. 2004; Comfort et al. 2005; Romeo et al. 2006) have already demonstrated high survival rates for NDIs installed in posterior region of the jaw. In those studies, however, NDIs were always connected to other NDIs or RDIs through partial-fixed dentures. The reason for this seems to be originated in the concept that NDIs are not capable of properly neutralizing and distributing the forces generated by occlusion in the posterior region, when supporting single crowns (Buser et al. 2000). This observation, however, contrasts with the results of this study, which showed a high NDI survival rate (100%) after one year of loading, even though all implants had only received single crowns.

In general, the level of bone loss found around implants may be dependent on several factors, such as microgaps between the implant and the prosthesis; biologic distance; and host response (Tae-Ju Oh et al. 2002). Besides these factors, peri-implant bone loss can also be related to implant installation (Hammerle et al. 1996). The panoramic radiographs taken in T0 showed that, on average, the distance between points A and B was 1.4 mm. Considering that the known distance from the implant shoulder to the end of the implant neck is 1.8 mm, it becomes clear that implants were consistently installed 0.4 mm (SD ± 0.09 mm) submerged into the bone. This may have resulted in a marginal bone loss greater than that should actually have been due to the polished characteristic of the implant neck surface (Hammerle et al. 1996). It is fair to

infer, therefore, that the final marginal bone loss could have been decreased in 0.4 mm, in case the implants had been installed at crestal-bone level (as recommended by the manufacturer).

Despite not being an object of this study, the different implant lengths used in this experiment did not produce any differences in peri-implant bone loss after one year of loading. Some authors (Jemt et al. 1990; Balshi 1994; Ekfeldt et al. 1994) recommend that short implants (< 12 mm) should be avoided with single crowns. These authors suggest that short implants have a reduced bone/implant contact surface, which may lead to greater bone loss and the eventual failure of the implant. In contrast, however, the study of Levine et al. (1994) showed a high success rate with implants with ≤ 10 mm. Thus, further studies that specifically focus on influence of implant length for both NDIs and RDIs loaded with single crowns in the posterior region of the jaw, concerning peri-implant bone loss and survival, are necessary.

Based on the results obtained in this prospective study, NDIs installed in posterior region of the jaw without sufficient thickness for installation of RDIs presented a high survival rate after one year of function. In addition to that, NDIs presented marginal bone loss patterns similar to those for RDIs, both in the maxilla and mandible, indicating that their use can be safe and predictable in selected patients.

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FIGURES

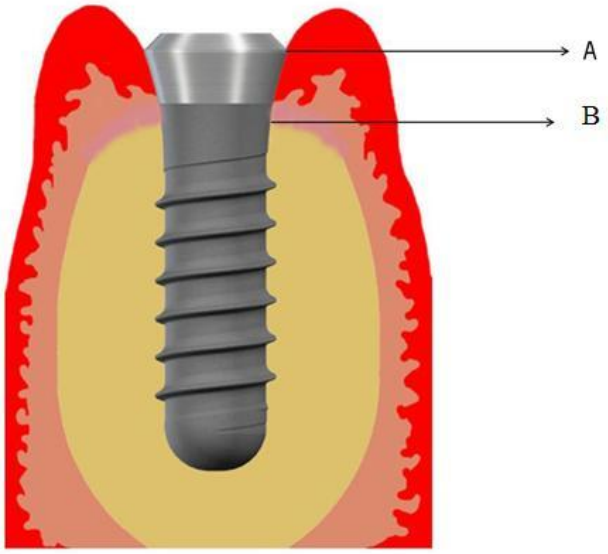

Fig.1. Schematic drawing showing the distance from the implant shoulder (A) to the first point of contact bone/implant (B).

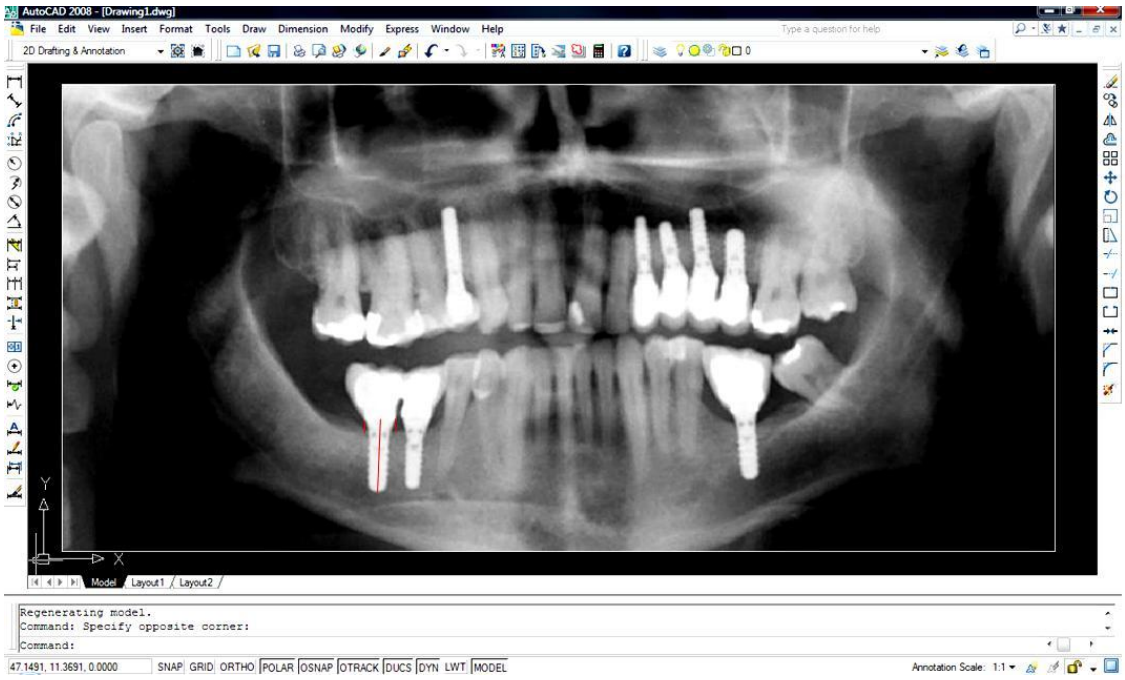

Fig.2. Panoramic radiograph manipulated by the computer program in preparation for measurement.

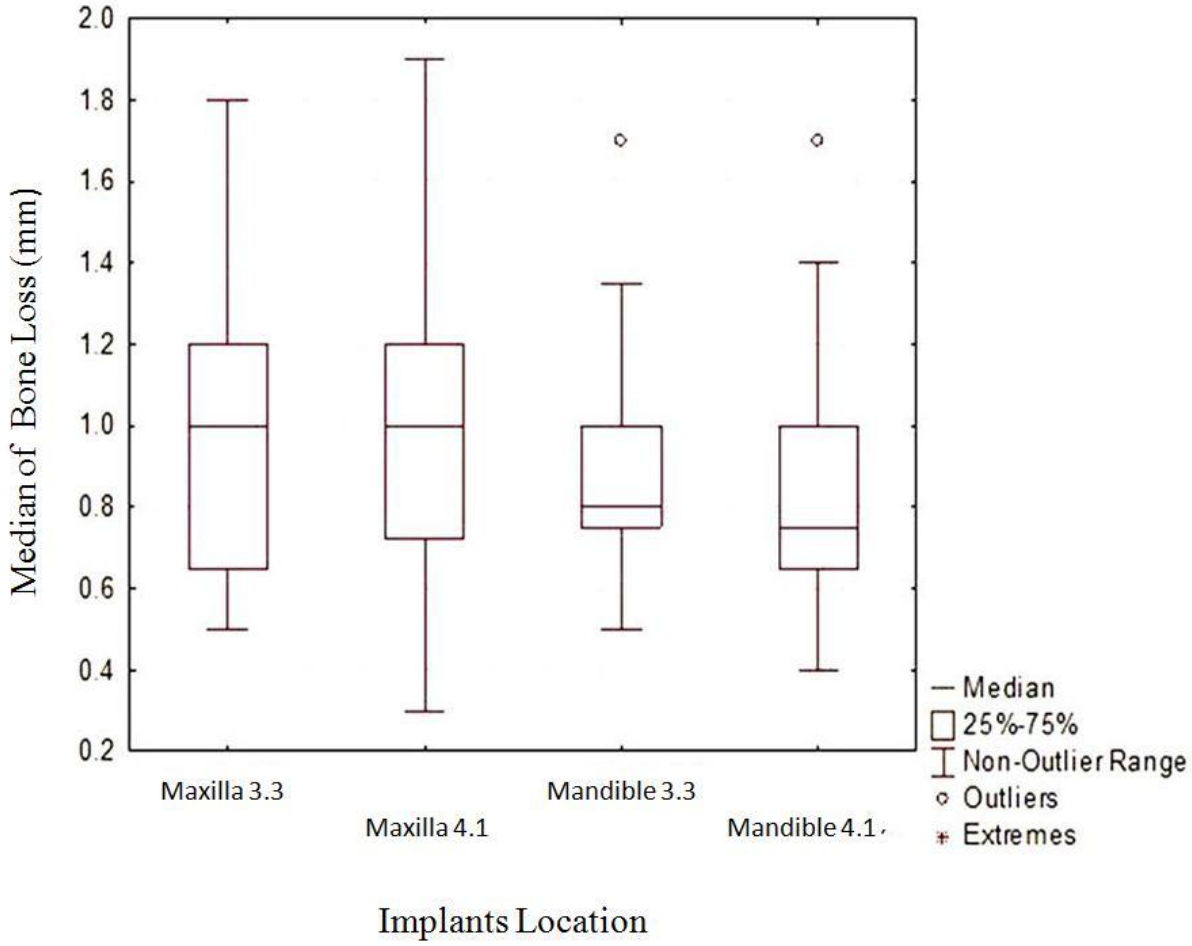

Fig. 3. Box Plot showing peri-implant bone loss around NDIs (ø 3.3 mm) and RDIs (ø 4.1 mm), in relation to implant location.

TABLES

***Table 1*. Number of NDIs (ø 3.3 mm) and RDIs (ø 4.1 mm) installed in the two experimental groups, according to length.**

Implant length	NDIs	RDIs
6 mm	-	6
8 mm	22	28
10 mm	32	20

***Table 2*. Mean marginal bone loss (SD) measured between point A (implant shoulder) and point B (first point of contact bone/implant) for NDIs (ø 3.3 mm) and RDIs (ø 4.1 mm), at T0 (initial) and T1 (final radiographic evaluation one year after loading)**

Radiographic Evaluation	NDIs	RDIs
T0	1.4 mm (SD ± 0.09)	1.4 mm (SD ± 0.09)
T1	2.3 mm (SD ± 0.3)	2.3 mm (SD ± 0.37)

***Table 3*. Mean marginal bone loss in the mesial (M) and distal (D) aspect, all implants and paired implants after one year of loading.**

Implants	Mean marginal bone loss				P* value
	M	D	All implants	Paired	
RDIs	0.89 mm	0.97 mm	0.93 (SD ± 0.37)	0.95 (SD ± 0.32)	0.94
NDIs	0.88 mm	0.97 mm	0.93 (SD ± 0.30)	0.93 (SD ± 0.37)	0.94

*P ≤ 0.05; M = Mesial; D = Distal

***Table 4*. Mean marginal bone loss in relation to location in the maxilla or in the mandible.**

Location	Mean marginal bone loss (SD)		P* value
	NDIs	RDIs	
Maxilla	0.95 mm (SD ± 0.33)	1.02 mm (SD ± 0.42)	0.65
Mandible	0.89 mm (SD ± 0.27)	0.84 mm (SD ± 0.31)	

*P ≤ 0.05