JOIS

CLINICAL STUDY

Influence of bone quality on success and bone level changes around platform-switched morse taper connection implants supporting fixed partial prostheses: a one-year prospective clinical study

RELATO DE CASO

Influência da qualidade óssea no sucesso e alterações do nível ósseo em implantes com conexão cone morse com próteses parciais fixas de suporte com *platform-switching*: estudo clínico prospectivo de um ano

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Abstract

Evaluate the influence of bone quality on success and bone level changes around Morse taper implants with platform-switching supporting fixed partial prostheses, within one year after implant placement. Platform-switched Morse taper connection implants with hydrophilic surfaces were placed to support metal-ceramic prostheses. Bone quality was surgically assessed by the surgeons according to their perception of resistance during implant site preparation and confirmed on periapical radiography. Implants were divided into two groups: bone type I/II and bone type III/IV. To evaluate bone level changes, periapical X-rays were obtained at screening, immediately after implant placement, 6 months, and one year after surgery (T12). Forty-nine implants, inserted in 12 patients, were assessed. Twenty-seven implants were evaluated as presenting bone type I/II and 22 implants were bone type III/IV. Implant survival and success rates were 100% for both bone types one year after surgery. Mean bone loss at T12 for the bone type I/II group was 0.93± 0.46mm and 1.00±0.58 mm for the bone type III/IV group. Within their limits, the present results suggest that platform-switched Morse taper connection implants with hydrophilic surfaces supporting fixed partial prostheses may achieve high success rates and excellent marginal bone level maintenance in poor and high-quality bone types, one year after surgery.

Palavras-chave: Cone Morse; Nível ósseo; Próteses e implantes; Sucesso; Qualidade óssea.

Resumo

O objetivo deste estudo é avaliar a influência da qualidade óssea no sucesso e alterações do nível ósseo em torno de implantes Cone Morse com próteses parciais fixas de suporte com platform-switching, um ano após a colocação do implante. Foram colocados implantes de conexão Cone Morse com superfícies hidrofílicas para suportar próteses metalo-cerâmicas. A qualidade do osso foi avaliada cirurgicamente com a percepção de resistência durante a preparação do local do implante e confirmada por radiografia periapical. Os implantes foram divididos em dois grupos: tipo de osso I/II e tipo de osso III/IV. Para avaliar as alterações do nível ósseo, foram obtidas radiografias periapicais no início, imediatamente após a colocação do implante, 6 meses e um ano após a cirurgia (T12). Foram avaliados 49 implantes, inseridos em 12 pacientes. Vinte e sete implantes foram avaliados como apresentando tipo de osso I/II e 22 implantes como tipo de osso III/IV. As taxas de sobrevivência e sucesso dos implantes foram de 100% para ambos os tipos de osso um ano após a cirurgia. A perda óssea média em T12 para o grupo de tipo ósseo I/II foi de 0,93±0,46 mm e de 1,00±0,58 mm para o grupo de tipo ósseo III/IV. Dentro das limitações, os resultados sugerem que os implantes de conexão Cone Morse com superfícies hidrofílicas que suportam próteses parciais fixas podem alcançar elevadas taxas de sucesso e uma excelente manutenção do nível ósseo marginal, tanto em tipos de osso pobres como de alta qualidade, um ano após a cirurgia.

Introduction

Implant-supported prostheses are a well-established procedure to replace missing teeth, and implant materials and designs are continuously developed to improve their efficiency [1-2]. One of the factors that could directly influence implant survival and success is marginal bone loss, which could lead in the last instance to implant loss[3].

Several risk factors have been associated with marginal bone loss[4-5] including patient-related aspects such as smoking habits, periodontal disease, diabetes, and oral hygiene[6-7]. In addition to that, surgery-related factors such as site preparation[8], loading protocol, grafting procedure, occlusal schemes[9-10], as well as implant-related factors such as implant shape and the design of abutment-implant connection[11-12] may also play a role.

The prosthetic concept of using an abutment with a diameter smaller than the implant shoulder is called platform-switching and has been associated with the prevention and reduction of crestal bone loss when compared to the conventional restorative procedure[13]. Also, a systematic review has shown that the amount of marginal bone resorption is inversely related to the extent of the implant-abutment mismatch[14].

Another factor associated with bone loss and implant failure is bone quality. It has been reported that local bone density has a great influence on implant primary stability, and thereby, affects implant success[15-17]. Moreover, long-term implant success rates have been reported to be higher in the mandible than in the maxilla, and the main reason for that is believed to be better quantity and quality of bone in the mandible. Bone type IV is associated with greater implant failure[17].

When treating partially edentulous regions, fixed partial prostheses have the advantage over multiple single crowns in allowing better distribution and transmission of masticatory forces to implants and the adjacent bone, especially in challenging regions for rehabilitation using implants[18]. On the other hand, they have the disadvantage that implant failure, as well as bone loss, may compromise the prosthetic rehabilitation success.

Therefore, this study aimed to assess the influence of bone quality on success and bone level changes around morse taper implants with platform switching supporting fixed partial prostheses, within one year after placement.

Material and methods

Study design and patient selection

This prospective study was approved by the local ethics committee (approval number: 3.070.126) and was conducted by the principles embodied in the Helsinki Declaration of 1975, revised in 2013, for biomedical research involving human subjects. Patients referred to Ilapeo College (Curitiba, Brazil) who needed implant-supported fixed partial rehabilitation between February and July 2019 were enrolled in this study. Exclusion criteria were any contraindication for implant surgery such as titanium allergy or hypersensitivity, presence of acute infection, unsuitable bone volume or quality, uncontrolled systemic diseases, incomplete jawbone growth, and pregnancy. All patients signed a consent form.

Implant information and surgical procedures

Cone beam computed tomography (CBCT), and panoramic and periapical radiography exams were obtained for diagnostic and planning purposes. Implants were inserted at a 2-mm subcrestal position and at least 1 mm of buccal and lingual bone availability around them. A minimum distance of 1.5 mm from the implant shoulder to adjacent teeth and 3mm between two adjacent implant shoulders was planned.

All patients were treated using the placement of hydrophilic tapered implants (Helix Acqua GM, Neodent, Curitiba, Brazil) with a platform-switched Morse taper prosthetic interface, made with commercially pure titanium Grade 4 (ASTM F67). The main feature of the implant is a hybrid thread design, being conical on the apex and cylindrical on the coronal portion.

All implants were placed under local anesthesia and followed the drill sequence indicated by the manufacturer, according to each site´s bone type, along with profuse irrigation. Grafting procedures were performed on three implants to repair bone defects in the esthetic zone. Bovine xenograft bone (0.5-1.0 mm granules) was used for bone augmentation in defects of the vestibular wall. The procedure was standardized by preparing the recipient site, directly applying and gently compacting the granules, which were pre-hydrated with sterile saline solution, followed by the closure of the mucoperiosteal flap to achieve primary stability. Immediate loading protocol was applied when the minimum insertion torque (32 N.cm) was achieved for all implants supporting the same prosthesis. GM mini and micro conical abutments (Neodent, Curitiba, Brazil) and partial fixed provisional acrylic prostheses were inserted. After the soft tissue healing period, these were replaced by splinted metal-ceramic prostheses. Two trained surgeons were involved in the study (P.C. and R.M.), responsible for the surgical procedures, including implant placement. The prosthesis was designed and installed by a prosthodontist, a professional distinct from the surgeons responsible for the surgical phase.

Digital periapical x-rays were obtained (Heliodent Plus, Dentsply Sirona, USA), using the parallelism radiography technique to standardize the images, at

all visits: screening, immediately after placement (T0), 6 months after surgery (T6) and one year after surgery (T12). Experienced clinicians performed surgical and prosthetic procedures.

Bone quality was surgically assessed by the surgeons according to their perception of resistance during implant site preparation and confirmed on periapical radiography, as described by Lekholm and Zarb[19]. Thereby, for radiographic and statistical analysis, implants were divided into two groups, according to the bone quality of the placement site: bone type I/II and bone type III/IV.

Radiographic measurements and clinical evaluation

The digital periapical radiographs obtained were evaluated by a trained operator using Sidexis XG version 2.6 software (Sirona, Bensheim, Germany). Artificial lines were drawn to help the marginal bone level measurement. Vertical lines – parallel to the long axis of the implant – and a horizontal line – were drawn at the interface implant platform and prosthetic connection – were used as a reference for the linear measurement of vertical bone height on both the mesial and distal surfaces of each implant. Regarding implants with bone level below the implant platform, the measurement was performed from the most apical point of bone in contact with the implant (towards the implant shoulder), to a horizontal line in the implant platform. In the case of the bone level above the implant, the measurement was performed from the highest point of the alveolar crest to the horizontal line in the implant platform. Mesial and distal values were used to obtain the mean bone level (Figure 1). Measurements were obtained using Sidexis XG software version 2.6 software (Sirona, Bensheim, Germany).

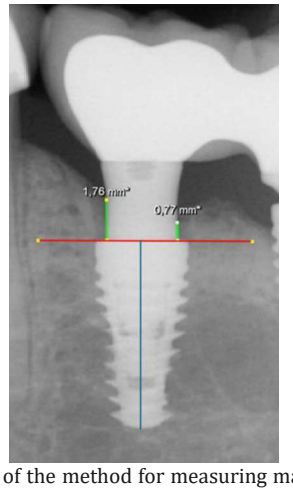

Figure 1: Example of the method for measuring marginal bone level. Vertical lines, parallel to the implant's axis, and a horizontal line at the implant platform-prosthetic interface were used to measure bone height on mesial and distal surfaces. The mean bone level was calculated from the mesial and distal values, measured from the bone crest to the implant platform.

The implant survival rate was calculated for each group and defined as no implant loss. Moreover, implant success was evaluated according to Buser et al.[20], regarding the absence of persistent pain, recurrent infection, mobility, radiolucency, and the possibility of restoration. Prosthetic survival and success were also evaluated, considering if prostheses were in place (survival) and the need for laboratory repair (success) during the follow-up[21].

Statistical Analysis

For intergroup comparability analyses, the Mann-Whitney test was used for age comparison for all other comparations (gender, final insertion torque, performance of grafting procedures, presence of systematic diseases, site status, and loading protocol), the Chi-square and Chi-square continuity correction tests were used. The Chi-square continuity correction was applied when one or more expected cell counts in the cross-tabulation were less than 5.

To compare bone levels and bone loss between groups, normality and equality of variances were tested using the Shapiro-Wilk and Levene tests, respectively. For samples with normal distribution and common variance, Student's T-test was used. For normal distributions with different variances, Welch's T-test was used, and for non-normal distributions, the Mann-Whitney test was used.

All statistical analyses were performed at a 0.05 significance level using JASP free software (JASP version 0.14.1)[22].

Results

Twelve patients (6 male and 6 female), with a mean age of 44.67 ± 3.49 years, consented to participate in this study and had 51 implants inserted. One implant was lost before loading and the adjacent implant was found to have received a single-unit prosthesis both had to be excluded from the sample. Therefore, the final study sample comprised 49 implants placed to support 20 fixed partial dentures. Twenty-seven implants were evaluated as presenting bone type I/II and 22 implants were bone type III/IV.

No complications were observed with any of the study implants, so implant survival and success rates at one year were 100% for both groups. Prosthesis survival and success rates were also 100% for both groups.

Table 1. Intergroup comparability.

Parameters		Bone type I/II (n=27)		Bone Type III/IV (n=22)		P value
		Mean ± S.D		Mean ± S.D		
Mean age (years)[1]		42.2 ± 6.2		48.1 ± 14.2		0.127
		N	%	*N*	%	
Gender[2]	Female	13	48.1%	14	63.6%	0.278
	Male	14	51.9%	8	36.4%	
Final Torque[3]	< 35 N.cm	3	11.1%	6	27.3%	0.279
	35 to 60 N.cm	24	88.9%	16	72.7%	
Bone graft[3]	Yes	0	00.0%	3	13.6%	0.167
	No	27	100.0%	19	86.4%	
Presence of controlled systemic disease[3]	Yes	0	00.0%	2	9.1%	0.382
	No	27	100.0%	20	90.9%	
Site Healing Status[3]	Healed	27	100.0%	17	77.3%	0.032*
	Post-extraction	0	00.0%	5	22.7%	
Loading protocol[2]	Immediate	5	18.5%	9	40.9%	0.084
	Delayed	22	81.5%	13	59.1%	

Note: [1]Mann-Whitney, [2]Chi-square and, [3]Chi-square continuity correction tests were performed

*p < 0.05 is considered significant.

Table 1 shows the comparability between groups. Only the distribution of site healing status was statistically different between groups *(p=0.032).* The bone type III/IV group had implants placed in both healed (77.3%) and post-extraction (22.7%) sites, whereas the bone type I/II group had implants placed in healed sites

Table 2. Intergroup comparison for mean marginal bone level at T0, T6 and T12.

Time	Bone quality	n	Bone level (mm) Mean ± SD	S.E. mean	IQR	p-value
T0[1]	I/II	27	1.82 ± 0.78	0.150	0.495	0.001*
	III/IV	22	2.38 ± 0.71	0.150	0.954	
T6[1]	I/II	27	0.93 ± 0.86	0.166	0.618	0.004*
	III/IV	22	1.51 ± 0.78	0.167	0.646	
T12[1]	I/II	27	0.90 ± 0.89	0.171	0.550	0.019*
	III/IV	22	1.38 ± 0.83	0.177	0.714	

Note: [1]Mann-Whitney test was performed.

*p < 0.05 is considered significant.

Bone level measurements at the different stages are described in Table 2. Bone type III/IV group presented higher mean bone levels at T0 (2.38 mm ± 0.71), T6 (1.51 mm ± 0.78), and T12 (1.38 mm ± 0.83) than the Bone type I/II group (1.83 mm ± 0.78; 0.93 mm ± 0.86; 0.90 mm ± 0.89, respectively). The difference was statistically significant in all stages (T0, *p=0.001*; T6, *p=0.004;* T12, *p=0.019*).

Nevertheless, no statistically significant differences concerning mean bone loss level changes were found between groups at any of the observational periods, with a mean bone loss of 0.93±0.46 mm for bone type I/II group and of 1.00±0.58 mm for bone type III/IV group, at T12. (Table 3).

Table 3. Intergroup comparison on mean bone loss at the different time periods.

Time period	Bone quality	n	Bone loss (mm) Mean ± SD	S.E. mean	IQR	p-value
T0-T6[1]	I/II	27	0.89 ± 0.45	0.087	0.737	0.901
	III/IV	22	0.88 ± 0.54	0.115	0.841	
T6-T12[2]	I/II	27	0.04 ± 0.10	0.019	0.080	0.082
	III/IV	22	0.13 ± 0.22	0.046	0.206	
T0-T12[1]	I/II	27	0.93 ± 0.46	0.088	0.725	0.628
	III/IV	22	1.00 ± 0.58	0.124	0.904	

Note: [1]Student's T-Test and [2]Welch's T-Test were performed. SD: Standard deviation; S.E. mean: Standard error of the mean.

*p < 0.05 is considered significant.

Discussion

Bone loss and implant success depend on several factors related to patient and implant parameters as well as surgical and prosthetic procedures[5,23]. The reported success rates of hydrophilic implants as well as those obtained by the present study are high, usually ranging from 94.2% to 100%[22,24]. In addition to that, the hydrophilic surface has been reported to improve stability during the early healing period and to provide faster osseointegration by accelerating osteogenesis[25].

Among the factors involved in early implant failure, bone quality, and quantity have been reported as determinant aspects[3]. Good bone quality has also been implicated as a prerequisite for achieving primary stability, while marginal bone loss is considered one of the indicators of treatment success[26]. However, the impact of bone quality on marginal bone loss around platform-switching hybrid implants remains unclear.

In the present study, parameters that could influence bone loss such as age, gender, final torque, augmentation procedure, presence of systemic diseases and loading protocol were comparable between groups, except for site healing status. It has been demonstrated that implants placed in healed sites exhibit reduced bone loss and are more likely to be successful[3]. Therefore, placement of implants in healed sites may have an advantage in poor bone quality. Given that the study group comprising bone type III/IV included 22.7% of immediate implants, whereas the bone type I/II group included only implants placed in healed sites, it can be assumed that the observed difference regarding implant site status distribution has not influenced the present results.

The intergroup compatibility concerning final insertion torque and the possibility of immediate loading is another important factor to be highlighted[27]. The results demonstrate that the study implant's hybrid design allows optimal primary stability to be achieved in all bone types.

Although the intergroup comparison concerning mean bone level showed statistically significant

differences in all observational periods, it should be observed that implants in both groups were placed, on average, in a position close to 2 mm subcrestal, as planned. At T6 and T12, the mean subcrestal position of the implants was approximately 1 mm in group I/II and 1.5 mm in group III/IV.

Nonetheless, no statistically significant difference between groups was observed for bone level changes. Mean bone loss found for the type I/II group was 0.93±0.46 mm and 1.00± 0.58 mm for the type III/IV group, during the first year. Corroborating with other authors who have shown that mean bone resorption during the first year can range from 0.4 to 1.5 mm[27-28]. Previous studies have not identified significant differences between bone quality and bone level changes. However, there is evidence that bone loss may be reduced by an increase in bone quality over time[29].

Some authors have evaluated peri-implant bone loss regarding different prosthetic connections. A systematic review has reported that greater loss was found around implants with external connections, followed by those with internal ones. Conical connections seemed to exhibit lower values of bone loss[30]. The same was reported in another study, with higher mean values of bone level changes around external hexagon implants in a follow-up period of 5 years[31]. Therefore, implants with conical connections, such as the ones used in the present study, are expected to present less bone loss.

Hybrid tapered implants have been reported as being suitable for all bone types, in single-unit, partial, or full arch rehabilitations and under immediate or conventional loading protocol. It has been suggested that allowing trabecular bone compaction in the middle and cervical portions, leads to better outcomes regardless of the bone quality[24]. Therefore, the present study corroborates these results, showing that hybrid implants have adequate performance regardless of bone quality since no significant differences were observed regarding bone loss between groups.

The platform-switching characteristic of the implants has also been reported to reduce bone loss[32-34]. A study that compared bone remodeling platform switching and platform matching implants, showed that the ones presenting this concept showed less bone loss after 1 year. The loss, however, was greater (mean bone loss 1.48 mm)[35], than the observed in the present study (mean bone loss 0.9mm and 1.0mm) for the same period.

A limitation of this study was the use of periapical radiographs instead of cone-beam computed tomography (CBCT), which is the gold standard for three-dimensional bone evaluation around implants[36]. Periapical radiographs are commonly used in clinical practice due to their accessibility, lower cost, and reduced radiation exposure compared to CBCT. However, periapical radiographs have limitations in resolution and three-dimensional assessment. Despite this, they remain a reliable tool for monitoring peri-implant bone health, particularly in detecting significant changes over time[37]. Their use is well-established in clinical settings for evaluating peri-implant bone defects[38].

Only one implant system was used in this study to avoid imposing other possible influencing factors such as implant design, material, and surgical procedures. Thus, these results cannot be extrapolated to other implant systems. To the author's knowledge, this is the first study evaluating the influence of bone quality on implant success and bone level changes around platform-switching hybrid implants. Further studies should be considered to assess whether the observed results are also shown when the study implants are used to support single and full-arch rehabilitation.

Conclusion

The present results, within their limits, suggest that the success of implant placement and marginal bone loss around platform-switched Morse taper implants with hydrophilic surfaces is not dependent on the quality of the bone at the implant site. In both groups, 100% success was observed within one year after surgery. Therefore, this study reinforces the suitability of platform-switched Morse taper connection implants with hydrophilic surfaces to support fixed partial rehabilitation, irrespective of the quality of the patient's bone.

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