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Peri-implant health around screw-shaped c.p. titanium machined implants in partially edentulous patients with or without ongoing periodontitis

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Abstract: The relationship between periodontitis and peri-implantitis remains a matter of debate. The present study compared, "within" randomly chosen partially edentulous patients (n=84 subjects, 97 jaws), the marginal bone loss around teeth and implants during 5 years (range 3 to 11 years) following the first year of bone remodelling. The patients had all been rehabilitated by means of screw-shape c.p. titanium implants with a machined surface (Brånemark system®). During the 5 years observation interval, periodontal parameters (marginal bone and attachment loss, the latter for teeth only) were collected together with data on confounding factors (smoking, oral hygiene, tooth loss). Marginal bone loss was measured through long-cone intra-oral radiographs. The mean "interval" bone loss was significantly (P=0.0001) higher around teeth (0.48±0.95 mm) than around implants (0.09±0.28 mm). The corresponding data for the "worst" performing tooth (0.99±1.25 mm) and implant (0.19±0.32 mm) per subject showed the same tendency. Neither attachment nor bone loss around teeth correlated with marginal bone loss around implants. This study indicated that the rate of bone loss around screw-shape c.p. titanium implants with a machined surface (Brånemark system® implants) was not influenced by the progression rate of periodontal destruction around the remaining teeth within the same jaw.

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Some endosseous implants have been successfully used as prosthetic abutments for the oral rehabilitation of fully and partially edentulous patients, and peri-implant tissues can be kept in a healthy clinical state for a prolonged period of time (for review, see van Steenberghe et al. 1999a). Besides a number of patient-related factors such as smoking (Bain & Moy 1993), bone quality (Jaffin & Berman 1991; Hutton et al. 1995), and systemic diseases or chemotherapy, surgical trauma or bacterial contamination during implant insertion, and excessive load are reported to be the most important causes of early implant failure (for review, see Esposito et al. 1998, 1999; Quirynen et al. 2001). Factors associated with failures occurring after loading are less well understood and seem to be related either to microbiological and/or biomechanical challenges (for review, see Tonetti 1998; Mombelli & Lang 1998; Mombelli 1999; Quirynen et al. 2001).

For some implant designs, these ''late'' failures have been assigned to peri-implantitis (for review, see Esposito et al. 1998, 1999). The microbiota involved in the peri-implantitis process resemble that associated with periodontitis (for review, see Mombelli & Lang 1998; Mombelli 1999). Several studies indicated that, at least in partially edentulous patients, teeth might act as a reservoir for the colonization of the subgingival area around implants (Apse et al. 1989; Quirynen & Listgarten 1990; Leonhardt et al. 1993; Mombelli et al. 1995; Quirynen et al. 1996). An association between susceptibility for periodontitis and peri-implantitis, especially in partially edentulous patients, was therefore suggested. This hypothesis was also supported by 2 case studies that reported a very high implant failure rate in patients with a history of rapidly progressing periodontitis (Malmstrom et al. 1990; Fardal et al. 1999).

The present study aimed to compare, ''within'' subjects, the periodontal destruction around teeth and implants over the same period of time, in order to prove the statement that ongoing periodontitis does not necessarily imply an increased chance for peri-implantitis around c.p. titanium implants with a machined surface.

Material and methods

Subjects

Eighty-four partially edentulous Caucasian patients (56 females and 28 males), rehabilitated with a total of 289 Brånemark system® implants (n=289, Nobel Biocare, Gothenburg, Sweden) in either the lower jaw (n=29), the upper jaw (n= 42) or both jaws (n=13), were involved in this study. They had been selected from 300 randomly chosen files from the group of partially edentulous patients treated at the Department of Periodontology of the University Hospital of the Catholic University Leuven on the basis of the following prerequisites: rehabilitation with a fixed partial prosthesis, a loading period of at least 4 years, long-cone intra-oral radiographs at 2 follow-up visits with good visibility and without blurring of the implant threads and of the teeth with an interval of at least 3 years, the first radiographical set taken at least after the 1st year of implant loading, probing depth data for the teeth at both follow-up visits, and oral hygiene parameters for both abutment types at their last visit. The mean age of this patient group, at their last visit, was 62.5 years (ranging from 30 to 81 years, S.D.= 12.3). Single tooth replacements were excluded. The patients had been scheduled for a bi-annual follow-up visit involving an oral hygiene control and if indicated a professional cleaning. This follow-up schedule was, however, not always respected by the patients.

Experimental design

From each jaw (n=97), the following data were collected for both follow-up visits (mean time interval 5 years, ranging from 3 to 11 years): (i) the marginal bone level mesially and distally of each implant (expressed as the number of exposed threads and measured up to half a thread), (ii) the marginal bone level mesially and distally of each tooth, measured from the cemento-enamel junction or a fixed reference point with an electronic calliper, (iii) the probing depth for each approximal tooth area recorded to the nearest mm (buccally and orally) by means of a Merrit B® probe (Hu-Friedy, Chicago, IL, USA), (iv) the amount of gingival recession or overgrowth (i.e. the distance from the cemento-enamel junction to the gingival margin) for each approximal tooth site measured to the nearest mm at the same sites (a pseudo-pocket giving a negative value), (v) the clinical attachment level for each location calculated as the sum of the probing depth and the gingival recession. The data set was completed with a plaque score for implants (Silness & Löe 1964) and teeth (Hancock & Wirthlin 1977), the latter after plaque disclosure with a 4% aqueous erythrosin solution. The number of teeth lost during the interval period due to ongoing periodontitis was also recorded, besides the smoking habits (0=non-smoker, 1=1–10, 2=11–20, and 3=>20 cigarettes per day).

Statistical analysis

For each region (molar, premolar, canine and incisor regions), the implant with the most important marginal bone loss during the interval period was selected. These data were transformed from threads to mm (for the Brånemark system® one thread represents 0.6 mm). As such, a total of 187 implants (a mean of 1.9 observations per jaw, ranging from 1 to 3) were included. As mentioned above, data had been collected after the first year of bone remodelling.

To evaluate the natural dentition, the tooth in the same jaw with the most important marginal bone and/or attachment loss was selected for statistical analysis. The overall mean interval bone and attachment loss for all teeth within the jaw, as well as the overall mean bone and attachment level at the end of the evaluation period were also considered.

A linear model was fitted with the variables jaw, smoking, number of teeth lost during the interval, plaque index around the teeth and implants, and the duration of the interval together with one of the 5 variables (largest bone loss around a tooth during interval, largest attachment loss around a tooth during interval, overall mean bone loss in natural dentition during interval, overall mean bone level or attachment level in natural dentition at the end of the interval), to explain the amount of bone loss around the worst performing implant in a region (n=187 observations) or within a jaw (97 observations). Patients were incorporated in the model as a random factor. In order to receive a normal distribution and equal variances of the residuals, the response value was taken to the power 0.8. The models were adapted so that the Akaike's information criterion was as large as possible. This criterion gives information about the fit of the model, incorporating the number of coefficients involved.

In order to visualise the data, lines resulting from a simple linear regression were plotted for the relationship between bone loss around the implants and the 5 above-mentioned teeth variables (without other co-factors). The mean bone loss around both abutment types in this patient population over time was also calculated via a regression analysis (bone loss vs. time). A covariance model was set up containing the two regression lines, and slopes were compared via a t-test. The latter analyses were repeated for the forty and twenty patients with most extreme values for bone loss (e.g. 20 or 10 patients with most and least marginal bone loss around the teeth). The slopes of these lines were again compared via a t-test.

Results

General data

The mean overall probing depth and attachment loss around the teeth in the

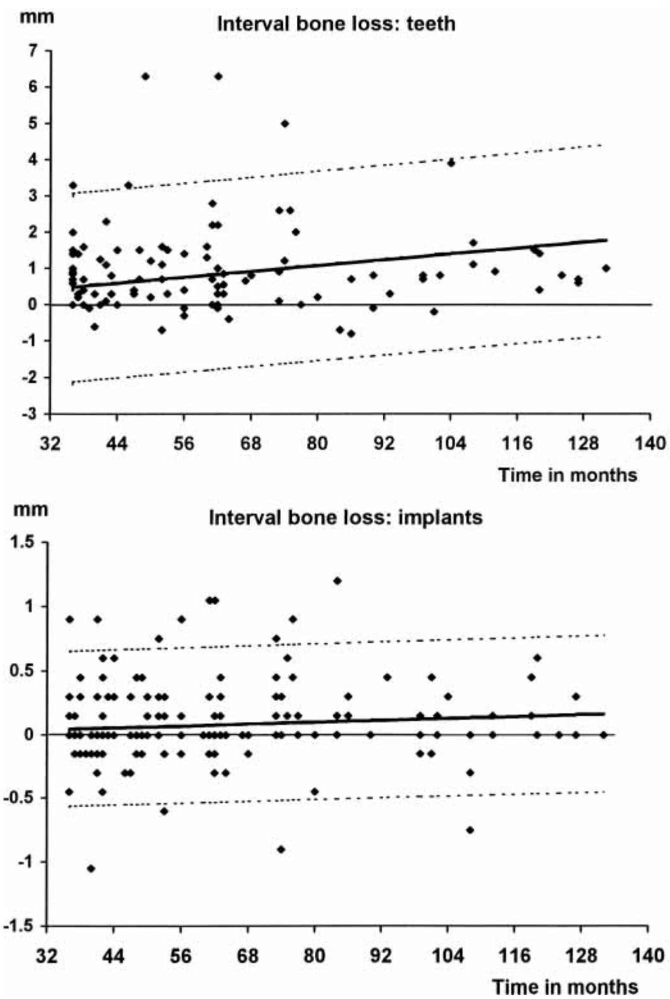

Fig. 1. Interval bone loss around teeth (worst tooth per jaw, n=97) or implants (worst condition per region, n=187) expressed in mm, in function of time (months) including regression line and 95% confidence interval. Upper figure represents teeth, lower figure the corresponding implants.

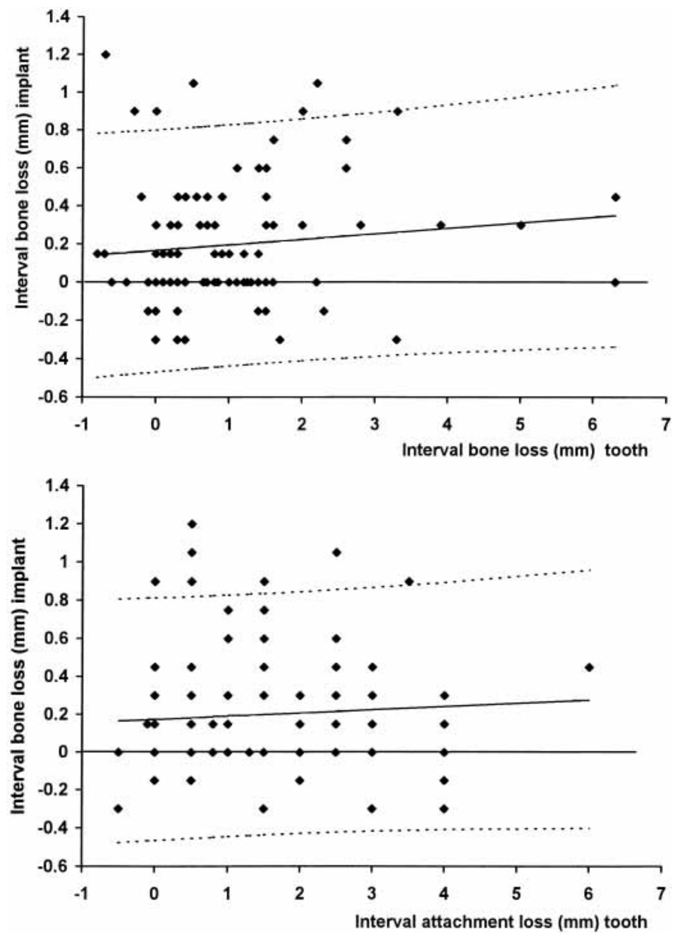

Fig. 2. Interval bone loss and interval attachment loss for "worst" tooth per jaw (n=97) in relation to corresponding interval bone loss around implants ("worst" condition per jaw), both expressed in mm, including regression line and 95% confidence interval. Some dots might represent 2 observations. The slope of both regression lines was not significantly different from zero.

experimental jaws, at the first registration (=baseline for this study) was 3.4 mm (ranging from 1.5 to 7.5 mm, S.D.= 1.05 mm) and 4 mm (ranging from 1.5 to 10.5 mm, S.D.=1.68 mm), respectively. 23% and 26% of the subjects showed an overall mean probing depth >4 mm, and a mean bone level 3 mm or more apically of the cemento-enamel junction.

The mean Navy plaque index around the teeth in the study population was 0.62 (ranging from 0 to 1.5), with 25% of the subjects ≥1.0. The corresponding data for the implants (Silness & Löe plaque index) was 0.33, with 8% of the subjects ≥1.0. During the observation period, 12 subjects lost 1 tooth, and 6 two or more teeth due to progressive periodontitis. During the same interval 4 implants were lost. All these implants fractured, with the remaining part still osseointegrated. They showed no signs of peri-implantitis. These fractures were explained by improper implant angulation (due to severe jaw bone resorption, n=2), unfavourable implant/suprastructure length (n=1), and bruxism (n=1). The total number of implants ever lost in these patients (including non-integration and/or early failures) was 12, indicating an absolute success rate of 95.8%.

Intra-subject comparison of bone loss around teeth and implants during observation period

The mean marginal bone and attachment loss around the teeth during the observation period was 0.48 mm (range −0.8 to +6.3 mm, S.D.=0.95) and 0.65 mm (range −0.5 to +6.0 mm, S.D.= 0.92), respectively. The corresponding data per jaw for the tooth with the most severe periodontal tissue loss were 0.99 (range −0.8 to 6.3 mm, S.D.=1.25) and 1.22 mm (range −0.5 to 6.0 mm, S.D.= 1.27). Fig. 1a shows the regression analyses for the bone loss around teeth in relation to time. The slope of the regression line is 0.013, indicating a mean "annual" bone loss of 0.16 mm for the study population.

The mean marginal bone loss around the implants during the same observation interval was 0.09 mm (range −0.53 to +1.05 mm, S.D.=0.28). The corresponding result for the worst performing implant per jaw was 0.19 (range

***Table 1.* Impact of different parameters on periodontal tissue loss around teeth to explain the marginal bone loss around implants (considering either all implants *n*=187, or the worst performing implants *n*=97)**

Periodontal parameters	Significance of parameter*		Estimates of regression line**			
			Intercept	*P*-value	Slope	*P*-value
All implants (*n*=187)						
Interval bone loss: "worst tooth"	0.40[a]	0.24[b]	0.064	0.030	0.020	0.30
Interval attachment loss: "worst tooth"	0.29	0.74	0.077	0.018	0.005	0.79
Interval mean bone loss: all teeth	0.99	0.56	0.078	0.003	0.012	0.65
Final attachment level: all teeth	0.35	0.32	0.025	0.690	0.013	0.32
Final bone level: all teeth	0.42	0.26	0.023	0.675	0.016	0.24
"Worst" implant (*n*=97)						
Interval bone loss: "worst" tooth	0.54	0.63	0.166	0.001	0.029	0.26
Interval attachment loss: "worst" tooth	0.38	0.90	0.174	0.002	0.018	0.50

* Data obtained including all co-factors (smoking, tooth loss, and plaque indices around teeth and implants) before[a] and after[b] the removal of the co-variables based on the Akaike's information criterion.

** Data obtained via regression analyses between periodontal parameters around teeth versus bone loss around implant. In order to calculate the bone loss around an implant one can use the following formula: bone loss implant=intercept+slope×bone loss tooth.

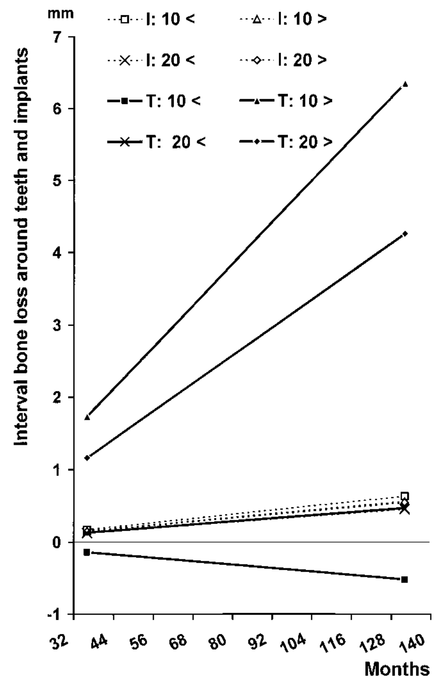

Fig. 3. Regression lines for interval bone loss around most extreme teeth (20 and 10 patients with most versus least interval bone loss, continuous bold lines), together with the corresponding regression lines for their implants (dotted lines). The abbreviations represent: I: 10 (20)< are implants in 10 (20) patients with least bone loss around teeth (see lines with abbreviation; T: 10 (20)<, respectively); I: 10 (20)> are implants in 10 (20) patients with most important bone loss around teeth (see lines with abbreviation T: 10 (20)>, respectively). All lines from the implants are clustered, so that 2 become invisible.

−1.05 to +1.2 mm, S.D.=0.32). Fig. 1b shows the regression analyses for the bone loss around the implants in relation to time. The slope of this regression line is 0.0013 indicating a mean "annual" bone loss, after the first year of bone remodelling, of 0.02 mm. The slope of this line was significantly lower (P=0.0001) than the corresponding slope for teeth.

Relationship between peri-implant and periodontal marginal bone loss

None of the periodontal parameters around teeth had a significant impact (P always ≥0.24) on the prediction of the marginal bone loss around the implants (Table 1). The co-factors smoking, tooth loss, plaque index around teeth or implants were also found to have no significant impact on the marginal bone loss around implants (P=0.15 for smoking, P always ≥0.5 for other co-factors).

The lack of relationship between the periodontal parameters related to teeth and implants is also illustrated by the regression analyses (Table 1). The slope of the regression line between the parameters for periodontal destruction around teeth and bone loss around implant (Fig. 2a & b), was never significantly different from zero. From the data in Table 1, the interval marginal bone loss around the implants can be calculated via the formula: interval bone loss implant=intercept + (slope×interval bone loss around teeth), with an intercept ≤0.17 mm and a slope ≤0.03. The latter indicates that for a tooth with an interval bone loss of 4 mm the corresponding bone loss around the implants only reached (0.17+(0.03×4)) or 0.3 mm.

Fig. 3 shows the regression lines for the bone loss around both abutment types, considering most extreme clinical situations (20 or 10 patients with most versus least interval bone loss around teeth, still considering worst performing tooth per patient). The differences in bone loss around the corresponding implants (slopes of regression lines were nearly identical) between both groups were never significantly different from zero (P>0.7).

Discussion

The hypothesis that an increased susceptibility for periodontitis would also imply an increased susceptibility for peri-implantitis is based on several observations. A series of animal studies for example compared the clinical, histological and microbiological changes around teeth with those around implants, after obtaining plaque accumulation and an intense inflammatory reaction by placement of subgingival ligatures (Hickey et al. 1991; Lindhe et al. 1992; Leonhardt et al. 1992; Schou et al. 1993, 1996; Lang et al. 1993; Akagawa et al. 1993; Ericsson et al. 1995; Tillmanns et al. 1997, 1998; Hanisch et al. 1997; Eke et al. 1998). The placement of subgingival ligatures nearly always resulted in a dramatic marginal bone destruction around both teeth and implants. These soft and hard tissue changes were associated with significant shifts in the composition of the subgingival flora with a significant increase in the proportion of periodontopathogens. The latter suggested that peri-implantitis is induced and promoted by the same mechanisms as in periodontitis. In one animal study (Klinge 1991) the bone loss around Brånemark implants with ligatures remained around 1 mm versus 5 mm for ligated teeth. In the latter study the installation of the ligatures was not as forceful. It was suggested that the abovementioned severe bone loss could also have been the result of a foreign body reaction provoked by the ligatures.

Malmstrom and co-workers (1990) reported on one partially edentulous patient who was rehabilitated by implants after an unsuccessful treatment of early onset periodontitis. Within the first 2 months of subgingival healing, 4 implants had to be removed due to recurrent abscesses. A similar report was recently presented by Fardal and co-workers (1999). These papers were used to prove that patients susceptible for periodontitis would also be susceptible for peri-implantitis. The similarity in microbial flora responsible for periodontitis and peri-implantitis (for review, see Mombelli & Lang 1998; Mombelli 1999) supported the above-mentioned extrapolation from periodontitis to peri-implantitis.

The present study, however, failed to find any relationship between ongoing periodontitis around teeth and bone loss around implants (at least for screw-shaped implants with a machined surface) inserted within the same jaw, either on radiographs or applying clinical parameters. These observations are in agreement with Nevins & Langer (1995) who published data on the survival rate and health of Brånemark system® implants inserted in a group of partially edentulous with recalcitrant periodontitis. In contrast to what could be expected, both the survival rate of implants and the stability of the peri-implant tissues were comparable to what is generally reported for this system. Our observations are also supported by a previous report from our centre (van Steenberghe et al. 1999b) in which the same implant system had been followed in 5 partially edentulous patients suffering from refractory periodontitis. Although the teeth did not respond to the periodontal therapy and although the implants were colonized by high numbers of pathogenic species (Papaioannou et al. 1996), the marginal bone level around the implants remained unchanged over time.

Whether the same applies to all implant systems remains a matter of debate. Esposito and co-workers (1998) made a meta-analysis and observed a significantly higher detection frequency of peri-implantitis for the plasma sprayed surfaces when compared to machined surfaces. Ellegaard and co-workers (1997) reported on periodontally compromised partially edentulous patients (defined as subjects with tooth loss due to progressive periodontitis but who had received a thorough periodontal therapy) rehabilitated with implants. About 76–86% of the implants, depending on the implant type (ITI® and Astra®), remained free from radiographic bone loss $\geq$1.5 mm at 36 months. After 5 years of loading, 45% of the ITI implants displayed marginal bone loss of 1.5 mm or more even though all patients participated in a periodontal supportive care program. From these data, it still seems recommendable to adapt the level of plaque and subsequent gingivitis as low as possible, especially around very rough implant surfaces.

Conclusion

The present data demonstrate that partially edentulous patients with a history of a stabilised or even of a progressive periodontitis rehabilitated with Brånemark system® implants do not demonstrate more marginal bone loss than patients with a healthy periodontium.

Résumé

L'étude présente compare chez des patients partiellement édentés (n=84, 97 mâchoires) la perte osseuse marginale autour de dents et d'implants sur une période de quatre années (3 à 11 ans) après la première année du remodelage osseux. Les patients avaient tous été soignés à l'aide d'implants en titane-vis avec une surface usinée *ad modum* Brånemark®. Durant l'intervalle d'observation de cinq ans, des paramètres parodontaux (os marginal et perte d'attache, cette dernière pour les dents seulement) ont été enregistrés avec les données de co-facteurs (tabagisme, hygiène buccale, perte dentaire). La perte osseuse marginale a été mesurée à l'aide de radiographies long-cône. La perte osseuse moyenne était significativement plus importante (P=0.0001) autour des dents (0.48±0.95 mm) qu'autour des implants (0.09±0.28 mm). Les données correspondantes pour les plus mauvaises dents (0.99±0.25 mm) et implants (0.19±0.32 mm) montraient chez chaque sujet la même tendance. Ni la perte d'attache ni la perte osseuse autour des dents n'étaient en corrélation avec la perte osseuse marginale autour des implants. Cette étude indique que le taux de perte osseuse autour des implants-vis en titane avec une surface usinée *ad modum* Brånemark® n'était pas influencé par le taux de progression de la destruction parodontale autour des dents restantes dans la même mâchoire.

Zusammenfassung

Der Zusammenhang zwischen Parodontitis und Peri-Implantitis bleibt umstritten. Die vorliegende Studie verglich innerhalb von zufällig ausgewählten teilbezahnten Patienten (n=84 Subjekte, 97 Kiefer) den Verlust an marginalem Knochen um Zähne und Implantate über einen durchschnittlichen Zeitraum von 5 Jahren (Bandbreite 3 bis 11 Jahre) nach dem ersten Jahr der Knochenremodellierung. Alle Patienten waren mittels schraubenförmigen reinen Titanimplantaten, welche eine maschinell bearbeitete Oberfläche aufwiesen (Brånemark System®), versorgt worden. Während der Beobachtungszeit von fünf Jahren wurden parodontale Parameter (marginaler Knochenverlust und Attachmentverlust, letzteres nur bei Zähnen) aufgenommen und verschlimmernde Faktoren (Rauchen, orale Hygiene, Zahnverlust) wurden registriert. Der Verlust an marginalem Knochen wurde auf intraoralen Röntgenaufnahmen, welche mittels Langkonus-Technik aufgenommen wurden, ausgemessen. Der mittlere "Intervall"-Knochenverlust war bei Zähnen (0.48±0.95 mm) signifikant (P=0.0001) grösser als bei Implantaten (0.09±0.28 mm). Die entsprechenden Werte für den "schlechtesten" Zahn (0.99±1.25 mm) und das "schlechteste" Implantat (0.19±0.32 mm) pro Subjekt zeigten dieselbe Tendenz. Weder der Attachmentverlust noch der Knochenverlust um Zähne korrelierte mit dem marginalen Knochenverlust um Implantate. Diese Studie zeigte, dass das Ausmass des Knochenverlustes um schraubenförmige reine Titanimplantate mit maschinell bearbeiteter Oberfläche (Implantate des Brånemark System®) nicht durch die Progressionsrate der parodontalen Zerstörung um die verbliebenen Zähne innerhalb desselben Kiefers beeinflusst wurde.

Resumen

La relación entre periodontitis y periimplantitis permanece como un asunto de debate. El presente estudio comparó, dentro de un grupo de pacientes parcialmente edéntulos (n=84 sujetos, 97 maxilares) elegidos al azar, la pérdida de hueso marginal alrededor de dientes e implantes durante 5 años (rango 3 a 11 años) después del primer año de remodelado óseo. Todos habían sido rehabilitados por medio de implantes con forma de tornillo de c.p. titanio con una superficie pulida (sistema Brånemark®). Durante el intervalo de observación de 5 años se recogieron parámetros periodontales (pérdida de hueso marginal y de inserción, esto último únicamente para dientes) junto con datos sobre factores de confusión (tabaco, higiene oral, pérdida de dientes). Se midió la pérdida de hueso marginal por medio de radiografías de cono largo intraorales. El intervalo medio de pérdida de hueso fue significativamente (P=0.0001) más alto alrededor de los dientes (0.48±0.95 mm) que alrededor de los implantes (0.09±0.28 mm). Los datos correspondientes para el diente de peor comportamiento (0.99±1.25 mm) e implantes (0.19±0.32 mm) por sujeto mostraron la misma tendencia. Ni la pérdida de inserción o de hueso alrededor de los dientes se correlacionó con la pérdida de hueso marginal alrededor de los implantes. Este estudio indica que el índice de pérdida de hueso alrededor de los implantes con forma de tornillo de c.p. titanio con una superficie pulida (implantes del sistema Brånemark no fue influida por el indice de progresión de la destrucción periodontal alrededor de los dientes remanentes dentro del mismo maxilar.

要旨

背景：歯周炎とインプラント周囲炎の相関性には見解の相違が残っている。

方法：本研究は、無作為選択した部分無歯顎患者において（ｎ＝８４名、９７顎)、骨リモデリングの最初の年に続く５年間（３年から１１年まで）の、天然歯とインプラントの周囲の辺縁骨喪失を比較検討した。患者は全てスクリュー型ｃ．ｐ．チタン製研磨表面のインプラント（Branemark system®）による補綴治療を受けた。５年の観察期間中に歯周組織のパラメーター（辺縁骨と付着の喪失、天然歯については後者のみ）を、混同因子（喫煙、口腔衛生、歯の喪失）のデータと共に記録した。辺縁骨の喪失は、ロングコーンの口内レントゲン像によって測定した。

結果：平均の“同期間中の”の骨喪失は、天然歯周囲（０．４８mm±０．９５）の方が、インプラント周囲（０．０９mm±０．２８）より有意に多かった（Ｐ＝０．０００１)。各患者について成績が“最悪の”天然歯（０．９９mm±１．２５）とインプラント（０．１９mm±０．３２）の各データは同じ傾向を示した。天然歯周囲の付着と骨の喪失は、インプラント周囲の辺縁骨喪失とは相関していなかった。

結論：本研究は、ｃ．ｐ．チタン製研磨表面のインプラント（Branemark system®）周囲の骨喪失率は、同じ顎内残存歯の歯周組織の破壊進行率によって影響されない事を示した。

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