Eur. J. Prosthodont. Rest. Dent., Vol.22, No. 3, pp 125-129
Printed in Great Britain

doi:10.1922/EJPRD_1365Nobre05

The influence of implant location and position characteristics on peri-implant pathology.

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Abstract - *Peri-implant pathology is a multifactorial disease, incorporating biological and biomechanical components in its pathogenesis; however, few studies address the possible risk factors. This study investigated the effect of implant location and position characteristics on the occurrence of Peri-implant pathology. A total of 1350 patients with dental implants were included 270 patients with peri-implant pathology and 1080 healthy controls. Results demonstrated that in the absence of bacterial plaque and smoking, the variable proximity of the implant to other implants or teeth revealed a significant difference between groups with a protective effect, but not in the presence of bacterial plaque and smoking.*

KEYWORDS: Peri-implant pathology, dental implants, biomechanics, tilted implants

INTRODUCTION

Peri-implant pathology is defined as inflammatory lesions with loss of supporting bone tissue surrounding the implant in function" (1).

It is thought to be a pathology with a median prevalence around 9%, considering studies performed in different periods on different populations, although a wide range is reported (between 7.5% and 56%) (2-9). Recent literature and systematic reviews addressed this issue (10-12), attributing the extreme variations in the prevalence of the disease to the following reasons: different disease definitions that yield different prevalence figures (10-12); differential diagnosis and lack of consistent definite diagnostic criteria used to describe the condition (11), the chosen thresholds for probing depths and bone loss (10); the differences in treatment methods and aftercare of patients (including medical and dental selection criteria of subjects, indications for therapy, implant system and type, operating procedures, quality control) (10); and dissimilarities in the composition of study populations due to all publications reporting data from convenience samples that may not be representative of the general target population for dental implants (10). These issues may in fact be major factors for the probable underestimation of the real incidence of peri-implant disease reported in the literature (12).

The pathogenesis of the pathology has been described previously between the classical pathway, attributed to the exposure to dental plaque and consisting in an infection process progressing from the soft tissue apically to the bone (1); or the retrograde pathway that progresses from the bone to the soft tissue, involving biomechanical aspects such as overloading or loading the implant too soon that can provoke micro fractures and consequent bone loss (13).

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There is a limitation of the number of studies in the literature dealing exclusively with causal relationships between variables and the occurrence of peri-implants pathology (2,3,5-9,14-18), with most studies focusing on the long term survival outcome of dental implants.

The parameters related to implant location are factors that may influence the dental implant outcome. The bone characteristics (quantity, quality and crestal width) on the implant site may impact the failure rate with lower survival rates registered in the maxilla, with this fact being explained mainly by the different bone quality and loading conditions in these areas (19). Frequently, the mandible cortical layer is denser and thicker compared to the maxilla. Also the trabecular component is denser in the mandible relative to the maxilla and in anterior areas comparative to posterior areas. On the other hand, the cortical layer on both arches has a tendency to become thinner and more porous in the anterior-posterior direction. Additionally, implants inserted in posterior regions are submitted to higher occlusal loads (20), placing them at higher risk of complications. Another implication of the bone quantity is related to the choice of implant orientation: In the presence of jaw atrophy, implant tilting has been proposed as an alternative to bone grafting procedures for implant supported rehabilitations (21).

The proximity of the implant to other teeth and implants follows an unclear pattern relative to its potential influence: On one hand it was described as a possible risk factor through a possible bacteria translocation between implants or from teeth to implants (22), indicating a higher frequency of periodontal pathogenic bacteria in individuals with implants and teeth comparatively to individuals with implants only; furthermore a periodontally compromised tooth may act as a reservoir for pathogenic bacteria with potential to colonize the implant and this way posing a risk factor for peri-implant pathology through the classical pathway. On the other hand, the implants next to other teeth or implants may benefit from a more uniform distribution of occlusal forces (23), and this way protect the implant from the retrograde pathogenic pathway for peri-implant pathology.

The aim of this preliminary study was to determine the influence of implant location and local characteristics on the distribution of peri-implant pathology.

MATERIALS AND METHODS

This article was written following the Strobe (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines (24) and was approved by the National Comission of Data Protection (Portugal) and the Faculty of Medicine-University of Lisbon Ethical Board.

This study complemented a series of studies developed to investigate risk factors for peri-implant pathology (18). The study population consisted of adult patients of both sexes, submitted to implant supported fixed prosthetic rehabilitations at a private practice. A hospital based matched case-control study was chosen to achieve the main objective of this preliminary epidemiologic study, meaning the controls were selected from the same population that produced the cases (from the same clinical center) but with deferring treatment referrals (other than peri-implant disease): The cases represented patients rehabilitated with implant supported fixed prosthesis with a diagnosis of peri-implant pathology; while controls represented patients rehabilitated with implant supported fixed prostheses without a diagnosis of peri-implant pathology, both rehabilitated at the same private practice.

Peri-implant pathology was defined as the presence of peri-implant pockets ≥ 5mm (25); bleeding on probing (26); concurrent presence of bone loss visible in the periapical radiograph compared to the previous evaluation (26); clinical attachment loss equal to or greater than 2mm compared to the previous evaluation (26,27).

The patients were included if they had been rehabilitated through fixed prosthetic implant supported prosthesis and followed for at least 1 year; and provided a an informed consent for participation and authorization to review the medical charts.

The patients were excluded if they were not at least 18 years of age, if the patients refused to participate or were unable to provide an informed consent, if they had been rehabilitated for less than 1 year, if the patients were undergoing active immunosuppressive therapy, or if the medical records were incomplete or missing.

The data for this study was collected between the months of January and July of 2009. The cases were matched with the controls for age [± 2 years of the age presented by the case] and gender, and follow-up [± 2 months of the follow-up presented by the case]. The relation of 1:4 between cases and controls was chosen in order to provide and optimization of the number of cases available for the analysis.

The sample was obtained from a list of patients submitted to implant surgery. There were initially 1763 patients (346 cases; 1417 controls) collected from a list of patients submitted to fixed prosthetic implant supported rehabilitations; from these, 413 patients (76 cases and 337 controls) were excluded from the study due to incomplete medical records (181 patients; 12 cases and 169 controls); refusals to participate (201 patients; 54 cases and 148 controls); and participation in the pilot study (30 patients; 10 cases and 20 controls). The number of patients excluded provided a sample of 1350 individuals for evaluation (846 women and 504 men), from which 364 were smokers (cases: 104, controls: 260), with an average (standard deviation) age of 55.8 (10.2) years.

The patients were submitted to fixed prosthetic rehabilitations supported by dental implants between the years of 1998 (February) and 2006 (November), and peri-implant pathology was diagnosed usually after 3 years of follow-up.

Data collection was performed through indirect documentation, using a digital form, after consulting the patient's records.

The variables evaluated between both groups were: Implant location per jaw (Mandible or Maxilla); implant location in the jaw (anterior-2nd and 5th sextants, or posterior-1st, 3rd, 4th, 6th sextants); implant orientation (straight or tilted), and Proximity of the implant to other teeth and implants (PROXI) (classified as the presence of natural teeth or dental implants adjacent to the implant, or complete edentulous).

STATISTICAL ANALYSIS

A descriptive analysis was performed to the study variables. Inferential analysis was conducted to evaluate the difference between both groups regarding the study variables with a level of significance of 5%: Nominal variables were compared using the Chi-square test. The variables whose distribution was significantly different between both groups were reanalyzed considering the absence or presence of bacterial plaque and smoking habits. Crude Odds ratios (OR) with 95% confidence intervals were calculated for the variables significantly different in the inferential analysis to test the effect of that difference. The OR was calculated to present the probability of having peri-implant pathology between groups. For example, when there were 2 groups, one group was set as the indicator (OR=1.0), with the remaining group compared against the indicator group: if the OR of group 2 was larger than the indicator group, it meant the probability for peri-implant pathology was higher for group 2 compared to the indicator group.

The Statistical Package for Social Sciences 17.0 (SPSS, IBM, New York, USA) was used for statistical analysis.

RESULTS

Considering the implant location, a higher number of implants was inserted in the maxilla (57.1%) compared to the mandible (42.9%), and more implants inserted in the posterior region (68.6%) compared to the anterior region (31.4%). The descriptive results regarding the implant orientation revealed more straight implants (85.1%) than tilted implants (14.9%); The variable PROXI revealed 37.7% of implants inserted for the rehabilitation of complete edentulous jaws and 62.3% of implants inserted adjacent to other teeth or implants (Table 1). Bacterial plaque was registered in 185 patients (14%), and smoking habits were present in 364 patients (27%). A majority of implants with Peri-implant pathology was registered in patients with implants inserted in the maxilla, in posterior regions, in straight implants, and in complete edentulous rehabilitations (PROXI) (Tables 1 and 2).

Table 1. *Distribution of the variables of interest between the two groups.*

		Implant position per jaw			*Implant position in the jaw*			*Implant orientation*			*Proximity of the implant to other implants or teeth**	
		Mandible	*Maxilla*	*Total*	*Anterior*	*Posterior*	*Total*	*Straight*	*Tilted*	*Total*	*Edentulous*	*Presence of adjacent implants/ teeth*
Cases	Number	107	163	270	92	178	270	227	43	270	145	125
	Group %	39.6%	60.4%	100%	34.1%	65.9%	100%	84.1%	15.9%	100%	53.7%	46.3%
	Sample %	7.9%	12.1%	20.0%	6.8%	13.2%	20.0%	16.8%	3.2%	20.0%	10.7%	9.3%
Controls	Number	472	608	1080	332	748	1080	922	158	1080	364	716
	Group %	43.7%	56.3%	100%	30.7%	69.3%	100%	85.4%	14.6%	100%	33.7%	66.3%
	Sample %	35.0%	45.0%	80.0%	24.6%	55.4%	80.0%	68.3%	11.7%	80.0%	26.9%	53.0%
Total	Number	579	771	1350	424	926	1350	1149	201	1350	509	841
	Sample %	42.9%	57.1%	100%	31.4%	68.6%	100%	85.1%	14.9%	100%	37.7%	62.3%

* Significant difference between both groups (p<0.001) for the variable Proximity of the implant to other implants or teeth;
Implant position per jaw (p=0.226); Implant position in the jaw (p=0.291); and Implant orientation (p=0.593) were not significant

Table 2. *Results from the statistical analysis for the variable "Proximity of the implant to other teeth or implants". Frequencies for both groups, inferential statistics adjusted for the variables smoking habits and dental plaque, and Odds ratio estimate with 95% confidence intervals.*

Smoking habits	*Dental plaque*	*Proximity of the implant to other implants or teeth*	*Cases Frequency(%)*	*Controls Frequency(%)*	*Total Frequency(%)*	*p-value*	*OR*	*OR 95%CI*
Non-smoker	No	Edentulous	53 (18.4%)	235 (81.6%)	288 (100%)		1.0	
		Presence of adjacent teeth/implants	47 (8.1%)	536 (91.9%)	583 (100%)	<0.001	0.39	0.26-0.59
		Total	100 (11.5%)	771 (88.5%)	871 (100%)			
	Yes	Edentulous	32 (48.5%)	34 (51.5%)	66 (100%)		1.0	
		Presence of adjacent teeth/implants	34 (69.4%)	15 (30.6%)	49 (100%)	0.020	2.41	1.11-5.23
		Total	66 (57.4%)	49 (42.6%)	115 (100%)			
Smoker	No	Edentulous	28 (25.7%)	81 (74.3%)	109 (100%)		1.0	
		Presence of adjacent teeth/implants	29 (15.7%)	156 (84.3%)	185 (100%)	0.027	0.53	0.30-0.97
		Total	57 (19.4%)	237 (84.3%)	294 (100%)			
	Yes	Edentulous	32 (69.6%)	14 (30.4%)	46 (100%)		1.0	
		Presence of adjacent teeth/implants	15 (62.5%)	9 (37.5%)	24 (100%)	0.368	0.72	0.26-2.06
		Total	47 (67.1%)	23 (32.9%)	70 (100%)			

OR: Odds Ratio; 95% CI: 95% Confidence intervals

The inferential analysis revealed that PROXI was the only variable with a significant difference between both groups (Table 1), a difference that remained significant after adjusting for dental plaque and smoking habits (p<0.001) (Table 2). The crude OR with 95% CI for the variable PROXI in the absence of bacterial plaque and smoking habits was 0.39 (0.26, 0.59), taking the complete edentulous patients as indicators (Table 2).

DISCUSSION

It was observed in this study a significant different distribution of peri-implant pathology between groups for the variable PROXI (p<0.001), with a protective effect for the occurrence of peri-implant pathology in the absence of bacterial plaque and smoking habits. This result may explain a smaller portion of the disease that was due to biomechanical factors (37%) in the absence of 2 of the most common risk factors (smoking and dental plaque) which were accounted in the remaining 63% of registered patients with peri-implant pathology. The protective effect of PROXI may be explained by the biomechanical aspect. Adjacent teeth may produce a protective effect on the implant in relation to occlusal overload (one of the factors for the occurrence of retrograde peri-implant pathology). It has been previously described that single teeth rehabilitations have a higher success on the long term follow-up compared to partial rehabilitations as registered in a systematic review (28). Single tooth implants may be restored out of functional occlusion, something that is not possible for implants supporting partial and full arch restorations. Similarly, adjacent implants may provide a more even distribution of occlusal loads: A previous retrospective clinical study (23) investigating the outcome and risk indicators for implant failure in edentulous implant-supported rehabilitations in posterior regions with up to 11 years of follow-up, registered a 4.5 fold increase in the probability for implant failure in partial rehabilitations compared with single teeth rehabilitations.

Despite the protective effect of PROXI when acting independently, it has also been suggested that PROXI might consist in a risk factor for peri-implant pathology when associated with the presence of bacterial plaque: Implants near teeth or other implants may have an increased probability for the occurrence of classical peri-implant pathology, since in individuals with this profile, teeth and implants could act as reservoir for periodontal pathogens that colonize the peri-implant sites, especially in individuals whose tooth loss was due to periodontitis (29,30). That fact was also registered in our study, where the combination of bacterial plaque and PROXI increased in 2-fold the probability for peri-implant pathology, nevertheless, this association should be investigated through multivariable analysis together with the influence of other variables of interest such as a periodontally compromised status.

Implant orientation was not found to be significantly related to peri-implant pathology, with no significant difference between straight and tilted implants. This result seems to follow the same pattern previously reported for survival and marginal bone loss, where the outcome seems to be independent from the position of insertion (tilted or straight): A systematic review (31) found no significant difference between straight and tilted implants in failure rate (p=0.52) and for short term marginal bone resorption; while another systematic review (32) found no significant difference in the weighted mean marginal bone loss between straight and tilted implants in the short and medium terms.

Implant location per jaw (maxilla or mandible) and implant location in the jaw (anterior or posterior) did not exert a significant effect on the occurrence of peri-implant pathology.

These outcomes were also not found to be significant in any of the previously referenced studies assessing the risk factors for peri-implant pathology, as the multivariable nature of the causal structure for this pathology implies an association of several conditions potentially related to the classical pathway (such as bacterial plaque or a history of periodontitis) or the retrograde pathway (such as remaining scar or granulomatous at the recipient implant site or occlusal overload) (2,3,5-9,14-18).

The results from the present study point out an important item for the maintenance of a stable condition. In an era where contraindications for implant treatment have the tendency of being substituted by risk probabilities for failure, and more patients with non-ideal conditions receive dental implants, prevention of peri-implant pathology starts early in the rehabilitation process, taking into consideration the biomechanical effects that derive from the decisions taken at the early steps of implant rehabilitation. A previous review (33) identified the best way to address peri-implant pathology as the strategy to avoid it from the beginning of each implant restoration case, including treatment planning with a priority placed on biomechanically over engineering the case, and placing an emphasis on rigorous follow-up and hygiene instruction.

The limitations of this preliminary study are the retrospective design, a single centre, and the lack of control for other variables of interest on the occurrence of peri-implant pathology. A further limitation of this study was the lack of assessment of the patients regarding bruxism habits or wear patterns of the fixed superstructure.

The effects of PROXI should be tested using multivariable analysis in order to control for the presence of other variables of interest in the etiopathogenesis of the peri-implant pathology.

CONCLUSIONS

Within the limitations of this preliminary study, PROXI might influence positively the occurrence of peri-implant pathology when considering the absence of smoking habits and dental plaque, but further studies are required in this area to be able to explore the issues raised in this manuscript.

MANUFACTURERS' DETAILS

The dental implants used were from the Nobel Biocare system, Gothenburg, Sweden.

CONFLICTS OF INTEREST

Professor Maló is currently a consultant for Nobel Biocare.

ACKNOWLEDGMENT

This study was funded by a grant from Nobel Biocare Services AG (grant no. 2012-1126).

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