Prevalence of Interproximal Contact Loss Between Implant-Supported Fixed Prostheses and Adjacent Teeth and Its impact on Marginal Bone Loss: A Retrospective Study

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Purpose: To investigate the prevalence of interproximal contact loss between implant-supported fixed prostheses and adjacent teeth and its impact on marginal bone loss and to identify potential risk factors. ***Materials and Methods:*** Patients who received implant-supported fixed prostheses at Saint-Joseph University between the years 2011 and 2017 and met the inclusion/exclusion criteria were eligible to participate in this retrospective study. Interproximal contacts were evaluated with a 70-µm dental floss and confirmed visually and by periapical radiographs. Contact was considered open if the floss passed without resistance. Plaque Index and bleeding on probing were assessed, and radiographic bone loss around implants was measured at recall. ***Results:*** Eighty-three patients (183 interproximal contact points) were evaluated. Interproximal contact loss between implant-supported fixed prostheses and adjacent teeth occurred in 32.8%; among mesial contact points, 42.1% had interproximal contact loss, whereas 14.5% had interproximal contact loss on the distal side. In interproximal contact loss sites, a mean marginal bone loss of 0.73 mm was noted; the difference was statistically significant compared with marginal bone loss at sites with interproximal contact ($P = .017$). Age, sex, smoking status, periodontal status, implant sites, and the type of restoration were not significantly associated with interproximal contact loss or marginal bone loss. Sites with interproximal contact loss were 2.24 times more likely to present bleeding on probing than others. ***Conclusion:*** Interproximal contact loss occurred in 32.8% of implant-supported fixed prostheses, and a positive relationship between interproximal contact loss and marginal bone loss was found, which suggests that interproximal contact loss should be included as a prosthetic implant complication. Future research aiming at identifying the causative factor for interproximal contact loss is necessary. *Int J Oral Maxillofac Implants 2020;35:625–630. doi: 10.11607/jomi.7926*

Keywords: implant complications, implant prosthesis, interproximal open contacts, marginal bone loss

Osseointegrated dental implants have become a routine treatment modality for partial and total edentulism rehabilitation procedures for more than 35 years, with success rates of more than 95%.[1] These implants are frequently found adjacent to natural teeth. Although many similarities exist between the tissue structures around an implant and a natural tooth, conclusions from periodontal studies may not be directly applicable to implants. Natural teeth are connected to bone through the periodontal ligament; however, implants are ossseointegrated.[2]

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Human growth continues throughout life. Therefore, even osseointegrated implants are subject to move due to the growth of adjacent bone. Several authors have reported that implant position in relation to adjacent teeth might be affected by the growth variations in the maxilla and mandible and teeth in different development stages. Adaptive changes in teeth over time are a result of slow growth, both vertically and horizontally, thus influencing the occlusion and tooth position adjacent to implants.[3]

Many biologic and technical complications may arise around implants.

Interproximal contact loss has recently been identified as a complication that causes food impaction leading to periodontal defects, marginal bone loss, and recurrent tooth caries.[4] Interproximal contact loss between implant-supported fixed prostheses and adjacent teeth is an indication of positional change and can be considered consequential from the alteration in oral structures or the dynamic oral function.[1] In a review by Greenstein et al[5] on the incidence of open contacts,

Fig 1 Clinical image and radiographs of interproximal contact loss occurrence. *(a)* Initial radiograph at prosthesis delivery: note the presence of contact at the mesial site. *(b and c)* Clinical and radiographic evaluation 2 years after prosthesis delivery showing interproximal contact loss.

interproximal open contacts occurred 34% to 66% of the time after an implant restoration was inserted adjacent to a natural tooth. Interproximal contact loss occurred as early as 3 months after prosthetic restoration, generally on the mesial side of the restoration. Varthis et al found that 52.8% of implant restorations demonstrated interproximal contact loss.[6]

Peri-implant inflammation occurs frequently and might ultimately result in marginal bone loss. The presence of contact points protects the periodontium against impairment due to food impaction by deflecting food on the buccal or lingual side. Due to a lack of data in the literature on the association between interproximal contact loss and marginal bone loss, it is important to identify such a relationship, the adverse causative factors, and the effects. Furthermore, the prevalence of interproximal contact loss between implant-supported fixed prostheses and adjacent teeth needs to be assessed and causative factors determined in order to establish guidelines and prevent interproximal contact loss and maintain long-term success of implant-supported prostheses. The aim of this study was to investigate the prevalence of interproximal contact loss between implant-supported fixed prostheses and adjacent teeth and its impact on marginal bone loss and to identify potential risk factors.

MATERIALS AND METHODS

Study Design and Patient Enrollment

This retrospective cohort study was conducted in accordance with expressed ethical principles of Saint-Joseph University (USJ-2017-148). Patient informed consent was obtained prior to clinical examination. Patients who received dental implants at the faculty of dental medicine of Saint-Joseph University between the years 2011 and 2017 were eligible to participate.

Inclusion and Exclusion Criteria

The following implant systems were included: Biomet 3i, Straumann, Nobel Biocare, Astra, and Dio. Surgery protocols varied between one stage or two stages and immediate extraction-placement with or without temporization. Implant-supported fixed prostheses loaded for a period of at least 3 months to 5 years and with initial periapical radiographs confirming the presence of an interproximal contact point were included. Implant restorations included in the study were all-ceramic crowns, porcelain-fused-to-metal, and zirconia crowns varying between screw- or cement-retained. Opposing dentitions comprised natural teeth and fixed restorations over natural teeth or implants.

Patients were excluded if they had one of the following parameters: parafunctional habits, mobility of adjacent teeth, periodontitis stage III or IV, systemic diseases (uncontrolled diabetes mellitus, radiation, etc), adjacent fixed prosthesis over implants, previous orthodontic treatment, infantile deglutition, tics, fractured or chipped crowns, or open margins. Moreover, natural teeth generate greater forces than partial or full dentures and may affect the rate of interproximal contact loss.[4] Therefore, in order to reduce possible biases, all patients with a removable prosthesis in the opposing arch were excluded.

Clinical Examination

A bounded restoration was identified as having two interproximal contact points recorded (one mesial and one distal), whereas an unbounded restoration had only one (mesial or distal depending on the position of the implant). All interproximal contact points were evaluated with a 70-µm–thick waxed dental floss (Oral-B, Procter & Gamble). Interproximal contacts were considered open if the dental floss passed without resistance between adjacent teeth. Clinical and radiographic examinations were carried out by two trained and calibrated examiners (A.S., J.N.) (interexaminer kappa coefficient = 0.91); visual and radiographic evaluations were utilized to confirm interproximal contact loss (Fig 1).

Plaque Index and bleeding on probing were assessed at four sites on implants and adjacent teeth using a graduated periodontal probe (PCPUNC 15, Hu-Friedy).

Table 1 Patient Characteristics

	Total (n = 83)	Men (n = 36)	Women (n = 47)	*P*
Age, mean ± SD (y)	57.54 ± 11.33	56.61 ± 11.16	56.49 ± 11.57	.122
Smoking status, n (%)				
Smokers	21 (25.3)	11 (30.6)	10 (21.3)	.335
Nonsmokers	62 (74.7)	25 (69.4)	37 (78.7)	
Periodontal status, n (%)				
Gingivitis	59 (71.1)	24 (66.7)	35 (74.5)	.728
Periodontitis stage I	20 (24.1)	10 (27.8)	10 (21.3)	
Periodontitis stage II	4 (4.8)	2 (5.6)	2 (4.3)	
Supportive periodontal therapy, n (%)	33 (39.8)	17 (47.2)	16 (34.0)	.259
No	2 (2.4)	0 (0)	2 (4.3)	
Yes (3 mo)	48 (57.8)	19 (52.8)	29 (61.7)	
Yes (6 mo)				

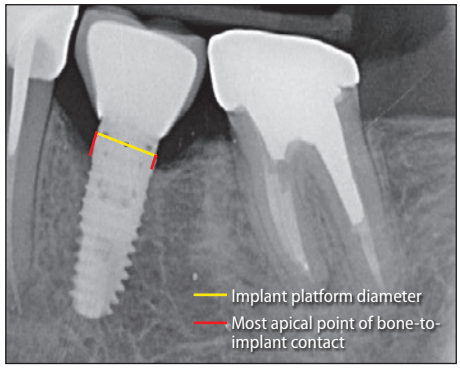

Fig 2 Radiographic measurements and analysis.

Radiographic Assessment

Periapical radiographs taken at prosthesis delivery were considered as baseline and were used to identify marginal bone level at mesial and distal sites of implant fixed prostheses. Radiographs taken at recall (using the long-cone technique XCP-RINN) were used to assess marginal bone loss by comparing them to baseline.

Radiographic images were digitized at a resolution of 400 dpi using a scanner with 24-bit color (VistaScan Mini Plus, Dürr Dental) and analyzed using photographic editing software (ImageJ, National Institutes of Health). Digitized images were calibrated according to implant diameter.

Alterations in marginal bone were analyzed by measuring the distance from the implant shoulder to the most apical point of bone-to-implant contact (Fig 2).

Interexaminer Calibration

To minimize possible biases due to measurement errors, interexaminer and intraexaminer calibrations were realized using peri-implant bone level measurement sites from 10 randomly selected patients. Intraclass correlation coefficient was calculated as an index of interexaminer agreement.[7]

Statistical Analysis

The Statistical Package for Social Sciences software (SPSS for Windows, version 24.0) was used for statistical analysis of the data. The alpha error was set at $P < .05$. The concordance between interproximal contact loss using floss, visual, and radiographic verification was assessed using the kappa coefficient. The Kolmogorov-Smirnov tests were used to assess the normality distribution of the continuous variables. The univariate analyses of categorical and continuous variables were carried out using the chi-square and the Student *t* test, respectively. Pearson and Spearman correlation coefficients were used to assess the relationship between continuous variables.

Logistic regression analysis was used with the interproximal contact loss as the dependent variable. Prosthetic and periodontal variables that showed associations with $P < .20$ in univariate analyses were candidates for the multivariate model, according to the enter method. Collinearity among independent variables was also tested, and independent variables that were highly correlated were excluded.

RESULTS

Patient and Prosthesis Characteristics

Two hundred and six patients were contacted, among which 87 were not compliant with the recall appointment, 29 had lost the adjacent tooth to the implant-supported fixed prosthesis, and 7 suffered from implant failure. Consequently, 83 patients (36 men and 47 women), with a mean age of 57 ± 11.33 years (range: 26 to 80 years), with 183 interproximal contact points (121 mesial and 62 distal), were included in the study. The period of evaluation after implant-supported fixed prosthesis insertion was between 3 months and 5 years. One hundred and nineteen cemented restorations and 64 screw-retained restorations were included in this study: 41 bounded prostheses, 43 unbounded prostheses, 83 single bounded crowns, and 16 single unbounded crowns.

Twenty-one participants were smokers, and their periodontal status was as follows: gingivitis (59/83 patients), periodontitis stage I (20/83 patients), and periodontitis stage II (4/83 patients). Among the participants in this study, 57.8% were under a 6-month supportive

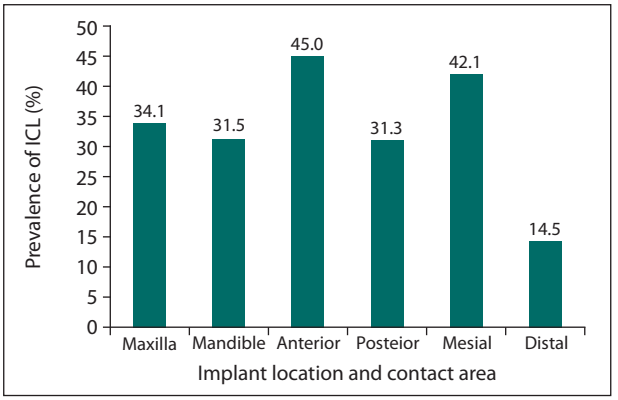

Fig 3 Prevalence of interproximal contact loss (ICL) between implant-supported fixed prosthesis and adjacent teeth.

periodontal therapy (Table 1). No significant difference was identified between implant systems that were included in this study ($P = .23$).

Prevalence of Interproximal Contact Loss

The prevalence of interproximal contact loss as assessed by dental floss was 32.8% (95% CI [26.0% to 39.6%]) with high concordance with visual and radiographic confirmations (kappa: 0.876; $P < .001$). Food impaction was identified in 26 contact points (14.2%).

Interproximal contact loss varied dependently on implant location (maxilla, mandible, anterior, posterior) and contact area (mesial or distal). No significant difference was noted between the maxilla and the mandible. However, a higher prevalence of interproximal contact loss was identified in the anterior zone. The prevalence of mesial interproximal contact loss (42.1% of total mesial contacts) was significantly higher than the distal (14.5% of total distal contacts) (Fig 3).

Factors Related to Interproximal Contact Loss

In case of interproximal contact loss, the mean marginal bone loss measured (0.73 ± 0.78 mm) was significantly higher compared with marginal bone loss in the presence of contact point ($P = .017$), with a significant association confirmed by logistic regression analysis ($P = .012$). Interproximal contact loss occurred more frequently throughout the loading period ($P = .050$) and was significantly associated with patient complaints of open contact ($P < .001$), food impaction ($P = .001$), and bleeding on probing on adjacent teeth ($P = .024$). Interproximal contact loss and marginal bone loss were not influenced by age, type, or position of implant restorations, periodontal status, supportive periodontal therapy, or Plaque Index on implants ($P > .05$). Plaque Index was significantly elevated on adjacent teeth in the case of interproximal contact loss ($P = .048$). The logistic regression model showed that adjacent teeth with bleeding on probing were 2.24 times more likely to present interproximal contact loss than others ($P = .028$).

DISCUSSION

Interproximal contact loss between implants and teeth has recently gained attention in the dental community and has been identified as one of the complications of implant restorations. In the present study, the prevalence of interproximal contact loss between an implant-supported fixed prosthesis and adjacent teeth and its impact on marginal bone loss has been assessed, and potential risk factors were identified.

Among the 183 interproximal contact points examined between implant-supported fixed prostheses and adjacent teeth, 60 (32.8%) were identified as interproximal contact loss. The present findings are considered similar to earlier studies that have assessed the same outcome, and interproximal contact loss was found to vary between 24.3% and 59.9%[1,5,6,8–10]; this discrepancy in the prevalence of interproximal contact loss might be due to different methods of evaluation, dissimilar study populations, period of monitoring, opposing dentition types, occlusal force, prosthesis design, contact area dimensions of restoration, and different statistical methods.[2,9,11–13] All contacts between implant-supported fixed prostheses and natural teeth were checked using a 70-µm dental floss and verified visually and by radiograph. This method could be considered user-dependent and variable; therefore, some authors have proposed the use of 50-µm metal strips,[8,9,12] or 38-µm Tofflemire matrix bands instead.[14]

In the present study, interproximal contact loss occurred with a greater prevalence in the maxilla than in the mandible with no significant difference ($P = .714$). This result is in agreement with Varthis et al; however, Shi et al found considerably higher percentages in the mandible compared with the maxilla.[6,10] However, studies with large sample sizes using multiple regression methods are needed to confirm this conclusion.

The present results revealed that in bounded cases of implant-supported fixed prostheses, a greater percentage of interproximal contact loss at mesial sites (42.1%) was identified compared with distal sites ($P < .05$). This result was similar to earlier findings.[1,5,6,8,9,12,13] To the best of the authors' knowledge, no study has compared bounded with unbounded implant-supported fixed prostheses. In the present study, no significant difference in the prevalence of interproximal contact loss was found between bounded and unbounded implant fixed prostheses ($P = .06$).

Mesial shift of natural teeth by the anterior component of force has been suggested as the main causative factor of interproximal contact loss. The implant

functions similarly to an ankylosed tooth and thus has no migration movement,[14] whereas force vectors cause mesial drifting of adjacent natural teeth, leading to interproximal contact loss. Nevertheless, the percentage of distal interproximal contact loss was 14.5%, which could be clinically important, although its associated factors have not yet been identified. It may be assumed that causative factors of distal (and mesial) contact loss might be related to changes in the occlusion, tooth flaring, and craniofacial and jaw growth.[4,6,8,9,15]

In the presence of interproximal contact loss, the effects on or relation to marginal bone loss are still unclear. Thus, the originality of this study was the correlation established between marginal bone loss and interproximal contact loss around implants. The mean marginal bone loss of 0.734 mm was significantly elevated in the case of interproximal contact loss ($P = .017$). This result concurs with Pang et al,[1] who concluded that the bone level on adjacent teeth was significantly correlated with interproximal contact loss, showing that interproximal contact loss rate is inversely proportional to bone support of adjacent teeth. However, marginal bone loss was not significantly linked to age, sex, smoking and periodontal status, supportive periodontal therapy, type of restoration, and implant location, which is comparable to previous reports.[2,9,10] It is noteworthy to mention that marginal bone loss obtained in the present study complies with the success criteria set by Albrektsson and Zarb that is still considered to be the gold standard for marginal bone evaluation.[16]

In the present study, interproximal contact loss was significantly associated with patient complaints of open contact (65.3%, $P < .001$), food impaction (61.5%, $P = .001$), and bleeding on probing on adjacent teeth (40.7%, $P = .024$). Therefore, plaque-induced inflammation can be the cause of bone resorption around implants and teeth.[17] Additionally, the absence of good oral hygiene is commonly shown to be the main risk factor for peri-implant and periodontal inflammation.[18] Block et al[19] stated that the deficiency of keratinized gingiva and bad oral hygiene were some of the most frequent causes for implant failure. Pang et al demonstrated that interproximal contact loss might be considered to be a significant problematic factor that induces inflammation around both implants and teeth.[1]

Due to its high prevalence, patients should be informed about the probability of the occurrence of interproximal contact loss. Patient compliance with periodic assessments is of high importance to detect and ultimately treat such complications.[4,6,8,9,11,13] When clinicians wish to close open contact, the implant-supported fixed prosthesis should be replaced or the adjacent tooth should be restored.[4] In the present study, no significant difference was observed between cement- and screw-retained restorations regarding their effect on interproximal contact loss. These results are in agreement with Shi et al and Wong et al.[10,13] To ease interproximal contact modification, Varthis et al suggested the use of screw-retained crowns in order to retrieve implant restorations. However, when cement-retained restorations are used, it is advised to use temporary cements.[6]

The Essix retainer is a simple technique to decrease masticatory stress and preserve tooth anatomy and restorations.[20,21] Zeng et al[22] proved that by wearing a vacuum-formed retainer for 1 year, the incidence of open contacts between implant-supported fixed prostheses and adjacent teeth has been reduced. Varthis et al also recommended its episodic use in order to prevent interproximal contact loss.[6] However, further research is recommended due to scarce evidence in the literature.

The inability to determine the exact time of interproximal contact loss occurrence, the use of unstandardized periapical radiographs, and a fairly short observation period are considered to be the main limitations of the present study and are mainly caused by the retrospective nature of this study. Future prospective study designs are essential in order to overcome these limitations and pinpoint the main causative factors of interproximal contact loss.

CONCLUSIONS

In this study, 32.8% of implant-supported fixed prostheses demonstrated interproximal contact loss, with a mesial aspect of 42.1%, nearly four times more than distal contacts. Interproximal contact loss sites demonstrated higher marginal bone loss, which suggests that interproximal contact loss is an implant complication. Periodic patient monitoring is of high importance to detect and eventually treat interproximal contact loss and its deleterious effect on the periodontium. Screw-retained prostheses or cement-retained prostheses with temporary luting agent and the use of Essix retainers have been recommended as retrievability and prevention modalities.

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