



# Factors influencing proximal contact loss between fixed implant prostheses and adjacent natural teeth: a retrospective study

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**Abstract** (J Korean Assoc Oral Maxillofac Surg 2025;51:26-32)

**Objectives:** To investigate the causal factors of proximal contact loss (PCL) between an implant prosthesis and the adjacent natural teeth using cast model analysis.

**Materials and Methods:** Patients who underwent restoration using dental implants in the posterior region were analyzed. To identify factors associated with PCL incidence, cast model analyses were conducted based on sex, implant site, jaw position, Angle's classification, anterior overbite, pre-existing interproximal gap between consecutive (mesial side) natural teeth adjacent to the implant, generalized gap of the full arch, and mandibular anterior crowding. Chi-square, multivariate logistic regression, and multivariate generalized estimating equation (GEE) analyses were used to evaluate the impact of each factor. The incidence of PCL over time was analyzed using Kaplan–Meier analysis.

**Results:** Of 653 implants, 293 implants were selected from 240 patients. Ninety implant sites (30.7%) showed PCL between the implant prostheses and the adjacent teeth. The analysis of PCL incidence revealed a gradual increase over time, with half of PCL cases occurring by 19.2 months. The chi-square test revealed significant associations between a pre-existing interproximal gap between adjacent natural teeth and a generalized overall gap in the corresponding arch and PCL ( $P=0.002$  and  $P=0.027$ ). The logistic regression ( $P=0.007$ , odds ratio [OR]: 2.684) and GEE ( $P=0.003$ , OR: 3.255) showed significant correlations between PCL and a pre-existing interproximal gap between adjacent natural teeth.

**Conclusion:** The occurrence of PCL between implant prostheses and adjacent teeth is influenced by the pre-existing interproximal gap between consecutive natural teeth adjacent to the implant. This factor should be carefully monitored.

**Key words:** Dental implants, Tooth migration, Food impaction, Proximal contact loss

[paper submitted 2024. 11. 21 / revised 2024. 12. 7 / accepted 2024. 12. 10]

## I. Introduction

Food impaction is a challenging problem in implant dentistry because it causes discomfort, caries in adjacent natural teeth, and periodontal problems<sup>1-3</sup>. In natural teeth, food impaction is related to the contour of the marginal ridge, integrity of the interproximal contact, type of occlusion, and contours of the lingual and buccal surfaces<sup>4,7</sup>. Food impaction in implant restorations might be influenced by similar

factors<sup>8</sup>. However, a crucial distinction between natural teeth and implants is that natural teeth are subject to mesial drift, which leads to space loss and crowding, whereas implants maintain a fixed position within the jawbone<sup>9-12</sup>. Previous studies have shown that 28.6%–64.3% of food impaction cases occur between natural teeth with loose or open adjacent contacts, whereas 94.2% of cases between implant prostheses and natural teeth had loose or open contacts<sup>1,5,8</sup>. This indicates that the interproximal contact of implants might be more susceptible to food impaction than that of natural teeth. Consequently, meticulous attention must be paid to proximal contact loss (PCL) between implant prostheses and adjacent natural teeth.

Several studies have shown that PCL increases over time<sup>3,13,14</sup> and have investigated the potential involvement of several factors in the formation of PCL between implant prostheses and the adjacent natural teeth: age<sup>2,3,15,16</sup>, sex<sup>16,17</sup>, presence of splinting in implant prostheses<sup>3</sup>, maxillary or

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mandibular location<sup>14,16-18</sup>, type of prosthesis<sup>2,16</sup>, opposing dentition<sup>3</sup>, and bone loss in the adjacent natural teeth<sup>14</sup>. Nevertheless, there is no consensus about the etiology of PCL between fixed implant prostheses and adjacent natural teeth.

Identifying the underlying cause of PCL intraorally can be challenging. Consequently, a cast model analysis, which compares the model cast at the time of implant restoration with the intraoral situation following PCL, is an essential tool. Analyses of occlusal forces and occlusal patterns can also help to deduce the cause of PCL.

Our aim in this study was to investigate the causal factors of PCL between an implant prosthesis and the adjacent natural teeth by using a cast model analysis.

## II. Materials and Methods

This study was approved by the Institutional Review Board of Seoul National University Bundang Hospital (No. B-1501-284-108) and was conducted in accordance with the Declaration of Helsinki and the International Conference on Harmonization Guidelines for Good Clinical Practice. Written informed consent was waived because this study is retrospective.

This study analyzed data from patients who received fixed partial implant prostheses at the Department of Prosthodontics, Section of Dentistry of Seoul National University Bundang Hospital between January 2006 and December 2014.

The inclusion criteria were as follows: (1) Patients who received fixed partial implant prostheses in the premolar or molar region. (2) Patients whose working cast models were preserved at the time of implant prosthesis fabrication. (3) Patients with two or more adjacent natural teeth present on the mesial side of the implant prosthesis. (4) Patients who received regular clinical examinations at least once a year.

The exclusion criteria were as follows: (1) Patients with a removable prosthesis in the opposing dentition. (2) Patients for whom an occlusion analysis was not possible due to multiple prosthetic treatments. (3) Patients with follow-up periods of less than 12 months.

### 1. Clinical assessment

Electronic medical records were examined to collect each patient's age, sex, time of restoration, follow-up period, and implant site and jaw position. Each patient with an implant restoration was routinely examined for PCL by a single prosthodontist during every follow-up appointment. The

prosthodontist examined interdental spaces with wax-coated dental floss (Oral-B Essential Floss; Procter & Gamble) and recorded them. To assess PCL, the resistance level of the dental floss during insertion and removal was recorded as tight, reduced, or loss of resistance. Reduced resistance and loss of resistance were considered to indicate PCL between the implant restorations and the adjacent natural teeth.

### 2. Cast analysis

Occlusal patterns were classified according to the positional relationship of the maxillary and mandibular first molar teeth using Angle's classification. The presence of a pre-existing gap between the natural teeth on the mesial side adjacent to the implant prosthesis was investigated. Patients with three or more gaps within the same dental arch were classified as having a generalized gap in the dental arch, and patients with an overbite of 4 mm or more in the anterior teeth were classified as having an anterior deep bite. This investigation was conducted to determine whether mandibular anterior crowding occurs when the implant is positioned in the mandible.

### 3. Data analysis

Among the patients who met the inclusion criteria, multiple implant prostheses placed in different locations (e.g. maxillary/mandibular, left/right) were treated as independent cases. There was a minimum of one case and a maximum of four cases per patient. The correlation between PCL incidence and the analyzed factors (sex, implant site, jaw position, Angle's classification, gap between adjacent teeth, generalized tooth gap in the dental arch, anterior deep bite, and mandibular anterior tooth crowding) was analyzed using the chi-square test and logistic regression test. A multivariate generalized estimating equation (GEE) was used to consider within-individual effects. Each analysis was conducted with the significance level set at  $P < 0.05$ . The incidence rate of PCL over time during the observation period was assessed using a Kaplan–Meier analysis. For factors that demonstrated a statistically significant correlation with PCL, differences in the Kaplan–Meier analysis were examined based on their presence or absence. The statistical analysis was performed using IBM SPSS Statistics for Windows ver. 24.0 (IBM).

## III. Results

Out of 653 implants, 293 implants from 240 patients who

met the predefined inclusion criteria were analyzed. The characteristics of the patients included in this study are summarized in Table 1.

Of the 293 implant sites examined, 90 (30.7%) developed PCL between the implant and the proximal tooth. The timing of PCL development varied from 5.0 to 51.0 months after implant placement. The Kaplan–Meier analysis of PCL incidence revealed a gradual increase over time, with half of PCL cases occurring by 19.2 months.(Fig. 1)

Table 2 shows the results of chi-square testing of the observed factors. A pre-existing interproximal gap between adjacent teeth ( $P=0.002$ ) and the presence of an overall gap in the corresponding arch ( $P=0.027$ ) were significantly associated with a proximal gap between the implant and adjacent natural teeth. Based on this result, a multivariable logistic regression analysis was conducted to further evaluate and assess the odds ratios for those factors. This analysis indicated a significant increase in the odds of PCL development for implant prostheses when patients had pre-existing interproxi-

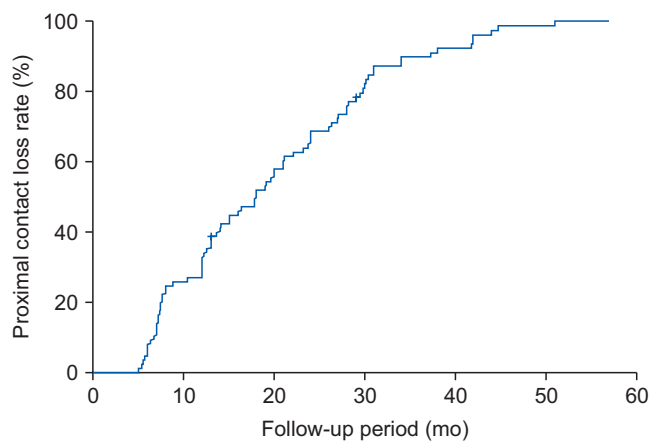
**Table 1.** Baseline characteristics of the participants

Characteristic	Value	Mean±SD
Age, yr	25-84	60.38±11.14
Sex		
Male	119 (49.58)	
Female	121 (50.41)	
Mean follow-up period, mo	12.00-105.36	29.10±13.95
Implant site	293	

(SD: standard deviation)

Values are presented as number only, number (%), or range.

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**Fig. 1.** Kaplan–Meier survival curve of proximal contact loss rates between fixed implant–supported prostheses and adjacent teeth. Jong-Hee Kim et al: Factors influencing proximal contact loss between fixed implant prostheses and adjacent natural teeth: a retrospective study. J Korean Assoc Oral Maxillofac Surg 2025

mal gaps between the adjacent natural teeth ( $P=0.007$ ). However, in patients with an overall gap in the same dental arch, no significant correlation with PCL incidence was observed ( $P=0.075$ ).(Table 3)

The outcomes were similar when a multivariate GEE was used to correct for within-individual effects.(Table 4) Those results show no correlation between the incidence of PCL and sex, implant site, jaw position, anterior deep bite, Angle’s classification, mandibular anterior crowding, or the presence of an overall gap in the corresponding arch. However, a significant correlation was observed between a pre-existing interproximal gap between the adjacent natural teeth and the incidence of PCL ( $P=0.003$ ).

The Kaplan–Meier analysis revealed differences in the

**Table 2.** Correlation between the variables and proximal contact loss in the chi-square test

	Total implant site	No. of contact losses	P-value
Sex			
Male	153	44 (28.8)	0.447
Female	140	46 (32.9)	
Implant site			0.468
Premolar	100	28 (28.0)	
Molar	193	62 (32.1)	
Jaw position			0.585
Maxilla	147	43 (29.3)	
Mandible	146	47 (32.2)	
Angle’s classification			0.521
Class I	248	78 (31.5)	
Class II division 1	8	1 (12.5)	
Class II division 2	18	4 (22.2)	
Class III	19	7 (36.8)	
Gap between adjacent natural teeth			0.002*
No	257	71 (27.6)	
Yes	36	19 (52.8)	
Generalized tooth gap in dental arch			0.027*
No	240	67 (27.9)	
Yes	53	23 (43.3)	
Anterior deep bite			0.238
No	257	82 (31.9)	
Yes	36	8 (22.2)	
Mandibular anterior crowding			0.221
No	76	28 (36.8)	
Yes	70	19 (27.1)	

\* $P<0.05$ .

Values are presented as number only, or number (%).

The chi-square test does not compute odds ratios.

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**Table 3.** Correlation between the variables and proximal contact loss in the logistic regression analysis

	Odds ratio	P-value
Gap between adjacent natural teeth	2.684	0.007*
Generalized tooth gap in the dental arch	1.768	0.075

\* $P<0.05$ .

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**Table 4.** Correlation between the variables and proximal contact loss in the multivariate generalized estimating equation analysis

	Odds ratio	95% Confidence interval		P-value
		Min	Max	
		Sex (male/female)	1.366	
Implant (premolar/molar)	1.205	0.717	2.024	0.482
Gap between adjacent natural teeth	3.255	1.511	7.011	0.003*
Generalized tooth gap in the dental arch	1.774	0.949	3.316	0.072
Deep bite	0.754	0.264	2.158	0.599
Mandibular anterior crowding	1.566	0.763	3.213	0.222

\*P&lt;0.05.

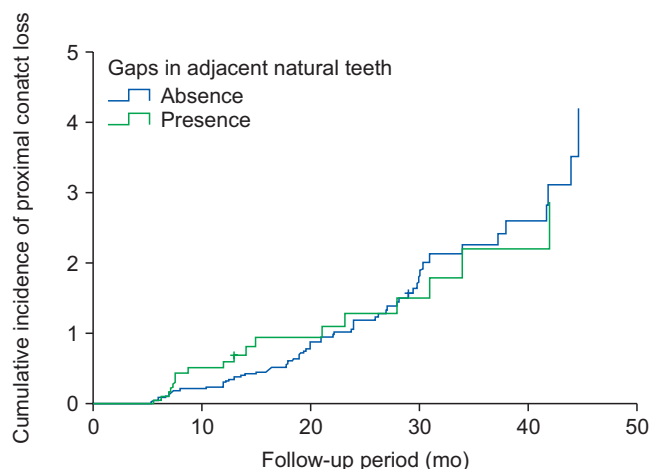
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presence and absence of pre-existing interproximal gaps between the adjacent natural teeth, a factor that was shown to be significantly associated with the development of PCL in the previous statistical analyses. The time to 50% PCL was shorter when pre-existing interproximal gaps were present between the natural teeth adjacent to the implant prostheses. (Fig. 2)

#### IV. Discussion

The incidence of PCL between implant prostheses and the adjacent natural teeth observed in this study was 30.7%. A recent meta-analysis on the formation of PCL for implant prostheses revealed a prevalence of 29%<sup>19</sup>, which is similar to our results. The prevalence of PCL in this study is also similar to previous studies that reported it to be 29%-34%<sup>13,18,19</sup> and lower than that reported in other studies (43%-65%)<sup>2,3,14,20</sup> when studies with less than 1 year of observation were excluded. This difference might be because of the relatively short observation intervals in this study and the fact that the implant maintained the same occlusal contact as the adjacent natural teeth to avoid concentrating forces on the natural teeth. It might also be attributed to the varied methods used to measure PCL across the different studies. Previous studies used a Tofflemire matrix band (38 μm), wax-coated dental floss, and a 50-μm metal strip or contact gauge<sup>2,3,13,21</sup>. The literature on quantitative measurements of the gap size between implant restorations and adjacent natural teeth is limited<sup>15,16</sup>.

This study was designed to consider factors that had been studied in previous research, as well as factors related to the movement of natural teeth adjacent to the implant. Considering the mesial shift of natural teeth as a potential causative factor of PCL, this study was conducted from two perspec-

**Fig. 2.** Kaplan-Meier cumulative incidence of proximal contact loss in implant prostheses according to the presence or absence of gaps between adjacent natural teeth.

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tives. One area of investigation concerned the relationship between the occlusal force and occlusal pattern, and the other focused on the role of the interdental space in PCL development.

Previous research has shown that mesial drift of natural teeth occurs because of the anterior component of occlusal force and mesial tilting of natural teeth<sup>15,22,23</sup>. This study used each patient's cast model to analyze Angle's classification, anterior deep bite, and mandibular anterior crowding, which are factors related to occlusal force or occlusion pattern, as potential causative factors of PCL.

A higher incidence of PCL has been reported when the occlusal force is concentrated in the intercanine region<sup>21</sup>. In cases of Angle's class II malocclusion, the posterior teeth play a major role during mastication, leading to a lower intercanine occlusal force than in other classifications<sup>22</sup>. Therefore, it was inferred that the incidence of PCL in Angle's class II malocclusion might be lower, and it was incorporated as a potential causal factor in this study. However, no significant correlation was found between different occlusion types, such as Angle's classification or anterior deep bite, and the incidence of PCL. When analyzing the occlusal force in skeletal patterns, some studies revealed that differences in occlusal forces were caused not by the horizontal pattern of the skeleton but by vertical skeletal factors, such as a lower mandibular angle or higher posterior facial length/anterior facial length ratio<sup>23,24</sup>. Because Angle's classification is based on a horizontal skeletal pattern, it might not relate to occlusal

forces, which might thus be related to PCL incidence. Further research should analyze occlusal forces in a larger number of cases with different classes of Angle's classification.

In clinical practice, the position of interdental spaces has been observed to change over time, differing from the cast model made for implant prostheses. Based on this observation, this study investigated the potential causal factors of PCL, including pre-existing spaces, such as the gap in natural teeth adjacent to the implant prosthesis and the generalized tooth gap in the dental arch. According to our statistical analysis, the odds of developing PCL between an implant prosthesis and proximal natural teeth were approximately three times higher (2.684 times in the logistic regression, 3.255 times in the GEE) in patients with a pre-existing interproximal gap between the adjacent natural teeth than in those without such a gap. These findings underscore the clinical necessity for heightened vigilance and care when dealing with patients who have pre-existing gaps between the adjacent natural teeth.

Factors associated with PCL that have been investigated in previous studies were also examined in the present study. No significant difference has been reported in the incidence of PCL according to sex<sup>16,17</sup>, which is consistent with our results. Additionally, some studies have shown no relationship with the implant site<sup>16,17,21</sup>, which is also consistent with our results. Some of those studies included the anterior teeth<sup>17,21</sup>, whereas others included only premolars and molars, as in the present study<sup>16</sup>. Thus, the movement of adjacent natural teeth might not strongly correlate with their position.

The relationship between jaw position and PCL incidence has been the subject of much debate. Some studies have reported a higher incidence of PCL in the mandible<sup>3,16,17</sup>, whereas others have reported a higher incidence in the maxilla<sup>14</sup>. Another study found no significant correlation between jaw position and PCL incidence, which aligns with the findings of this study<sup>18</sup>. Bone density might play a role in tooth movement, and it was expected that the maxilla, which has a relatively lower bone density, would have greater natural tooth movement and therefore a higher risk of PCL<sup>14</sup>. However, the results did not reveal a significant difference, perhaps due to the involvement of factors other than bone density, such as occlusal force, in the movement of natural teeth.

In this study, the incidence of PCL in cases of implant prostheses gradually increased over time, with a median time to the incidence of PCL of 19.2 months. This timescale is shorter than that reported in previous studies, which indicated that half of the prostheses showed PCL within a period of 3-9

years<sup>3,13,14</sup>. Such discrepancies can be explained by differences in methodology or the recall intervals used in the various studies<sup>14</sup>.

The Kaplan–Meier analysis of the presence or absence of a pre-existing interproximal gap between the natural teeth adjacent to the implant prosthesis, a factor that has been demonstrated to be significantly associated with the development of PCL in statistical analyses, showed that 50% of PCL development occurs earlier in patients with a pre-existing interproximal gap between the adjacent teeth than in those without one. Overall, it can be reasonably assumed that the incidence of PCL in implant restorations is higher and more likely to occur at an earlier time in patients with a gap between the adjacent natural teeth.

To ascertain potential causal factors, a chi-square test was initially used. Based on the findings of that preliminary analysis, a multivariate logistic regression analysis was conducted to further evaluate the respective risks. In both analyses, causal factors were prioritized, patient-specific factors were excluded, and each case was treated independently. Therefore, this study also ran a multivariate GEE analysis to account for patient-specific factors. Our objective in using that method was to investigate the correlation between the potential risk factors and the incidence of PCL while simultaneously adjusting for individual effects within each case. When multiple cases are reported in the same patient, case-based analyses ignore the dependency within a patient, which potentially violates the principle of statistical independence and could bias the results<sup>25,26</sup>. Therefore, a statistical analysis method that considers the possibility of data dependence within a patient is needed<sup>26-28</sup>. In dental research, many bilateral or quadrilateral cases have been reported in the same patient, as observed in this study. Therefore, careful consideration is crucial when selecting an analysis unit that adequately accounts for intrasubject correlation. The GEE is known to improve statistical power and facilitate the interpretation of site-specific results<sup>29,30</sup>. The reason for not using the GEE analysis exclusively in this study was mainly that most participants were single cases, and even among those with multiple cases, no consistent trend was observed in their positions. Therefore, analyses using only this method would have limitations. We thus used various analysis methods and compared and interpreted the results together.

In clinical situations, the following factors should be considered. In the short term, food impaction after the placement of fixed implant-supported prostheses can be attributed to errors in the laboratory process or adjustment of the prosthesis.

Therefore, the proximal surfaces of the adjacent teeth must be considered before making an impression, including the removal of calculus and plaque, as well as controlling the path of insertion. The medium-term incidence of food impaction can be addressed by ensuring closer proximal contact in implant prostheses, which will require preparing for anticipated changes in the proximal surface contact when a pre-existing interproximal gap is present between the adjacent natural teeth. In the long term, PCL can develop because of factors such as the anterior movement of the proximal teeth; therefore, implant prostheses must have retrievability to repair the proximal surface when such issues develop.

This study has several limitations, such as the limited number of patients classified with Class II and Class III malocclusion and the choice not to consider the growth of the jaw. Moreover studies examining the relationship between PCL and occlusal schemes such as canine guidance and group function seem to be necessary. A prospective study incorporating a longer observation period and a larger participant cohort should be conducted to yield more comprehensive results.

## V. Conclusion

The incidence of PCL between an implanted prosthesis and the adjacent tooth was 30.7%, with a median time to the occurrence of PCL of 19.2 months. Within the limitations of this retrospective study, the presence of a pre-existing interproximal gap between consecutive natural teeth adjacent to the implant restoration was associated with a high incidence of PCL between an implant prosthesis and the adjacent natural teeth and an earlier onset of its occurrence.

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## Authors' Contributions

Y.J.Y. participated in the study design. J.H.K. participated in writing the manuscript and data collection and performed the statistical analysis. All authors helped to draft the manuscript. All authors read and approved the final manuscript.

## Funding

No funding to declare.

## Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of Seoul National University Bundang Hospital (No. B-1501-284-108) and was conducted in accordance with the Declaration of Helsinki and the International Conference on Harmonization Guidelines for Good Clinical Practice. Written informed consent was waived because the study is retrospective.

## Conflict of Interest

No potential conflict of interest relevant to this article is reported.

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**How to cite this article:** Kim JH, Yi YJ. Factors influencing proximal contact loss between fixed implant prostheses and adjacent natural teeth: a retrospective study. *J Korean Assoc Oral Maxillofac Surg* 2025;51:26-32. <https://doi.org/10.5125/jkaoms.2025.51.1.26>