Original Article

Analysis of proximal contact loss between implant-supported fixed dental prostheses and adjacent natural teeth: A two-year prospective study

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Running title: Contact loss between implant & adjacent teeth

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DOI: 10.6926/JPI.202309_12(2).0002

Abstract

Aims: *This prospective study aimed to evaluate the incidence of interproximal contact loss (ICL) between implant-supported fixed dental prostheses (FDPs) and adjacent teeth and to analyze the possible causative factors of this phenomenon.*

Materials and methods: *Patients in need of maxillary or mandibular posterior implant-supported partial FDPs (≤3 units) or single crowns (SCs) were recruited. All patients were followed up with clinical and radiographical examinations at 6, 12, and 24 months after delivery of the definitive implant restorations. The condition of interproximal contacts between implant-supported FDPs and adjacent mesial natural teeth were evaluated during the follow-up period. Prosthesis materials, implant positions, retained type, the condition of the mesial natural tooth, orthodontic treatment history, bruxism habit, and wearing conditions of the dentition were also assessed.*

Results: *Twenty-seven patients with 68 implant-supported FDPs (62 SCs and 6 partial FDPs) were enrolled in this study. One participant dropped out because the adjacent mesial tooth was extracted due to a fracture before the 24-month follow-up. The overall mesial ICL rate was 13.2%, 23.5%, and 37.3% at 6-, 12-, and 24-month follow-up, respectively. Age ($p = .002$), orthodontic treatment history ($p = .010$), condition of the mesial natural tooth ($p = .016$), and obvious wear facets of natural dentition ($p = .047$) were significantly associated with the presence of ICL at 24-month follow-up.*

Conclusions: *This study found that the longer the follow-up period was the higher the prevalence of mesial ICL. Furthermore, older age, patients not wearing an orthodontic retainer, a mesial tooth with crown or partial FDP, and severely worn dentition contributed to the mesial ICL of implant-supported FDPs.*

Key words: Implant-supported fixed dental prosthesis, proximal contact loss

Introduction

Implant therapy, which was introduced more than three decades ago, has been shown to have high survival and success rates. The reported survival rate of implant-supported single crowns (SCs) 10 years after loading is 95.2%.[1] However, complications associated with implant-supported fixed dental prostheses (FDPs), such as abutment screw loosening or fracture, restorative material chipping,[1] and mesial interproximal contact loss (ICL),[2,3] have been reported. Among these complications, the development of open contact between implant-supported FDPs and the adjacent teeth has been underestimated.

Several systematic reviews have reported that 34–66% of implant-supported FDPs next to natural teeth develop ICL after a short period.[2,4,5] Wei et al. observed ICL between implant-supported FDPs and adjacent teeth in more than 50% of the patients examined.[6] Byun et al. reported that only 46% of the proximal contacts examined were still tight after a mean follow-up period of 57 months and the risk of ICL increased 9.4% annually during the follow-up period.[7] A retrospective study of 4325 implants reported an overall ICL rate of 17%, which increased over time and reached 29% at eight years after insertion.[3]

The physiology of lifelong craniofacial growth and physiological differences between teeth and implants are likely to be the cause of ICL between implant-supported FDPs and adjacent teeth. Implants are ankylosed in the bone,[8] whereas natural teeth are suspended by the periodontal ligament, which allows a certain amount of movement over the life span of the individual.[9] Therefore, osseointegrated implants maintain their internal relationship with the bone under significant changes due to craniofacial growth and migration of adjacent teeth.

Clinical studies investigating ICL between implant-supported FDPs and natural teeth have proposed that the rate of ICL along the mesial aspect of the implant-supported FDPs was significantly higher than that along the distal aspect. Previous studies have suggested that contact loss along the mesial aspect can be explained by mesial migration of the adjacent natural teeth.[6,10,11] Factors such as gender, aging, vitality of adjacent teeth, type of opposing dentition, location of implant prostheses, strength of occlusal force, and splinting of adjacent teeth have been proposed as factors likely to be associated with ICL, but these relationships remain unclear.[6,7,10,11,12,13] Most studies investigating ICL showed higher incidences of contact loss on the mesial side rather than on the distal side.[6,10-14] Therefore, the purpose of this prospective study was to investigate the prevalence and potential contributing factors of ICL between implant-supported FDPs and adjacent mesial teeth. We tested the null hypothesis that there was no significant difference between implant-supported FDPs and adjacent teeth in developing ICL.

Materials and methods

Subject selection

Patients in need of maxillary or mandibular posterior implant-supported SCs or partial FDPs were recruited at the Department of Dentistry of Chi Mei Medical Center. The participants were selected according to the following inclusion criteria: age ≥18 years; needed implant-supported SCs or partial FDPs in the maxillary and mandibular premolar and molar area; and full-mouth plaque scores and full-mouth bleeding scores of <25%. Patients were excluded from the study for the following reasons: their oral hygiene was inadequate; they had serious systemic disease; they had uncontrolled metabolic diseases; they had uncontrolled periodontal diseases or uncontrolled progressive dental diseases, such as dental decay, apical periodontitis, and secondary occlusal trauma; or they were in need of more than four units of implant-supported FDPs.

The participants provided written informed consent prior to inclusion in the study. The Institutional Review Board of the Chi Mei Medical Center, Taiwan approved the study protocol (application number: 10105-L02).

Surgical and prosthetic procedures

All surgical and prosthetic procedures were performed by experienced clinicians according to the manufacturer's instructions. Two implant systems, Straumann (Standard or Standard Plus Implants; Straumann, Basel, Switzerland) and Nobel Biocare implants (Mark III Implants, Nobel Biocare, Gothenburg, Sweden), were used in this study. After osseointegration, either metal–ceramic or zirconia-based partial FDPs or SCs were made and inserted at 35 Ncm of torque . All prostheses had opposing natural dentition or tooth- or implant-supported FDPs.

Clinical assessments

All patients were followed up with clinical and radiographic examinations at 6, 12, and 24 months after delivery of the implant-supported SCs and partial FDPs. Waxed dental floss (Essential floss, Oral-B Laboratories Inc., Redwood City, CA, USA) was used to access the interproximal contact between the implant-supported FDP and adjacent teeth.[15] A tight contact was one that had resistance with a "click" sound when passing through the interproximal contact area. In contrast, an open contact was one with neither resistance force nor a "click" sound, or had a distinct gap between the prosthesis and adjacent teeth. Apart from the condition of mesial contact, the following parameters were also assessed during the follow-up period: age, gender, the material used for the prostheses, implant position, the type of prosthesis retention, the type of prosthesis (SC or 3-unit partial FDP), history of orthodontic treatment, the restorative condition of the adjacent teeth, the presence of bruxism, and dentition with or without obvious wear facets.

Data analyses

Descriptive statistics were used to summarize the data. The rate of prevalence of mesial ICL and the associated parameters were compared and analyzed with Fisher's exact test. The level of significance was set as $p < .05$.

Results

Based on the inclusion and exclusion criteria, 27 patients between 30 and 68 years of age (mean age 50.88 years) with a total of 68 implant-supported FDPs (38 in males and 30 in females; 62 SCs and 6 partial FDPs) were enrolled in this study (Table 1). The overall mesial contact loss rate was 13.2%, 23.5%, and 37.3% at 6-, 12-, and 24-month follow-up, respectively. One participant dropped out because the adjacent mesial tooth was extracted due to a fracture before the 24-month follow-up (Table 2). There were no statistically significant differences in mesial ICL and all parameters at the 6- and 12-month follow-ups ($p > .05$). However, the parameters age (p = .002), orthodontic treatment history ($p = .010$), condition of the mesial natural tooth ($p = .016$), and obvious wear facets of natural dentition ($p = .047$) were significantly associated with the presence of ICL at the 24-month follow-up (Table 3). Therefore, the null hypothesis was rejected. Other parameters including gender, the prosthesis material, implant position, retained type, prosthesis type, and bruxism were not related to ICL at the 24-month visit.

Table 1. Description of the study sample.

Gender	**Male**		**Female**
	38 (55.9%)		30 (44.1%)
Prosthesis material	Porcelain fused to metal		All ceramic
	19 (27.9%)		49 (72.1%)
Implant position	Premolar		Molar
	20 (29.4%)		48 (70.6%)
Retention	Screw-retained		Cement-retained
	16 (23.5%)		52 (76.5%)
Prosthesis type	Crown		FDP
	62 (91.2%)		6 (8.8%)
Orthodontic treatment history	No		Yes
	58 (85.3%)		10 (14.7%)
Condition of the adjacent mesial teeth	Virgin	Crown	FDP
	39 (57.4%)	26 (38.2%)	3 (4.4%)
Bruxism	No		Yes
	50 (73.5%)		18 (26.5%)
Obvious wear facet	No		Yes
	35 (51.5%)		33 (48.5%)

FDP, fixed dental prosthesis

Table 2. Rate of mesial contact loss at 6-, 12-, and 24-month follow-up.

	6 months	12 months	24 months (valid percentage)
No contact loss	59 (86.8%)	52 (76.5%)	42 (62.7%)
Loss of proximal contact	9 (13.2%)	16 (23.5%)	25,(37.3%)
Total	68 (100%)	68 (100%)	67 (100%)

Table 3. Characteristics of patient groups.

		6 months		12 months		24 months	
		Intact contact	Contact loss	Intact contact	Contact loss	Intact contact	Contact loss
Age, years	Mean	50.90	50.78	50.38	52.50	47.79	55.88
	SD	10.263	12.686	10.685	10.066	11.308	6.772
	p-value	0.975		0.485		0.002*	
Gender	Male	33 (86.8%)	5 (13.2%)	29 (76.3%)	9 (23.7%)	23 (62.2%)	14 (37.8%)
	Female	26 (86.7%)	4 (13.3%)	23 (76.7%)	7 (23.3%)	19 (63.3%)	11 (36.7%)
	p-value	1.000		1.000		1.000	
The material of prosthesis	PFM	15 (78.9%)	4 (21.1%)	14 (73.7%)	5 (26.3%)	12 (63.2%)	7 (36.8%)
	Zirconia	44 (89.8%)	5 (10.2%)	38 (77.6%)	11 (22.4%)	30 (62.5%)	18 (37.5%)
	p-value	0.253		0.757		1.000	
Implant position	Premolar	17 (85.0%)	3 (15.0%)	15 (75.0%)	5 (25.0%)	12 (60.0%)	8 (40.0%)
	Molar	42 (87.5%)	6 (12.5%)	37 (77.1%)	11 (22.9%)	30 (63.8%)	17 (36.2%)
	p-value	1.000		1.000		0.788	
Retainer type	Crown	53 (85.5%)	9 (14.5%)	46 (74.2%)	16 (25.8%)	39 (63.9%)	22 (36.1%)
	Partial FDP	6 (100.0%)	0 (0.0%)	6 (100.0%)	0 (0.0%)	3 (50.0%)	3 (50.0%)
	p-value	1.000		0.323		0.664	
History of orthodontic treatment	No	51 (89.5%)	6 (10.5%)	43 (75.4%)	14 (24.6%)	31 (55.4%)	25 (45.6%)
	Yes	7 (70.0%)	3 (30.0%)	8 (80.0%)	2 (20.0%)	10 (100.0%)	0 (0.0%)
	p-value	0.250		1.000		0.010*	
Condition of mesial natural tooth	Virgin	34 (87.5%)	5 (12.8%)	33 (84.6%)	6 (15.4%)	30 (76.9%)	9 (23.1%)
	Crown	22 (84.6%)	4 (15.4%)	17 (65.4%)	9 (34.6%)	11 (44.0%)	14 (56.0%)
	FDP	3 (100.0%)	0 (0.0%)	2 (66.7%)	1 (33.3%)	1 (33.3%)	2 (66.7%)
	p-value	0.753		0.185		0.016*	
Bruxism	No	42 (84.0%)	8 (16.0%)	37 (74.0%)	13 (26.0%)	31 (63.3%)	18 (36.7%)
	Yes	17 (94.4%)	1 (5.6%)	15 (83.3%)	3 (16.7%)	11 (61.1%)	7 (38.9%)
	p-value	0.427		0.529		1.000	
Obvious wear facet	No	30 (83.3%)	6 (16.7%)	29 (80.6%)	7 (19.4%)	26 (74.3%)	9 (25.7%)
	Yes	29 (90.6%)	3 (9.4%)	23 (71.9%)	9 (28.1%)	16 (50.0%)	16 (50.0%)
	p-value	0.484		0.568		0.047*	

FDP, fixed dental prosthesis; **PFM**, porcelain fused to metal; **SD**, standard deviation.
*p < .05.

Discussion

Interproximal contact loss between implant-supported FDPs and adjacent natural teeth is a common multifactorial implant complication reported in the literature.[2–4,6,7,10–13] However, its frequency and etiology are not well understood and are determined mostly based on clinical judgment rather than evidence.

In this study, the incidence of ICL increased over time from 13.2% at 6-month follow-up to 23.5% and 37.3% at 12- and 24-month follow-up, respectively. In previous studies, ICL rates varied between 24.3% and 59.9%.[4,6,10,11,15,16] This discrepancy might be because of differences in evaluation methods, study populations, monitoring period, prosthesis design, and statistical methods.[4,10–13,17] In other studies as well as this investigation, the interproximal contacts between implant-supported FDPs and natural teeth were assessed with the aid of waxed dental floss. This method can be considered user-dependent, which may also explain the differences in incidence rates between studies.

The present study also investigated the associated factors potentially influencing ICL. Age was positively correlated with the ICL rate at the 24-month follow-up, a result similar to those of previous studies showing higher ICL between implant-supported FDPs and adjacent teeth in older patients.[10,12,15] This might be due to increased tooth mobility in older subjects, which is positively correlated with age and the Periotest value.[12]

Pang et al. suggested that higher occlusal force displaces natural teeth mesially and causes the more frequent loss of interproximal contact.[15] The present study showed that in patients with severely worn dentition, which indicated higher occlusal force, implant-supported FDPs had a significantly higher rate of mesial contact loss after 24 months of clinical service. Wei et al.[6] suggested that high occlusal force on the adjacent tooth might enhance mesial migration. On mandibular closure, the anterior component of occlusal force drives the tooth mesially. According to an anthropological view of tooth wear, direct relationships exist between occlusal load and interproximal wear and mesial migration of teeth.[18] Occlusal load from mastication of hard food causes obvious occlusal and interproximal wear and is responsible for the movement of adjacent teeth, leading to interproximal wear.

Interproximal contact of an implant-supported FDP adjacent to SCs or other FDPs also leads to a high prevalence of contact loss compared to the virgin tooth. In the meta-analysis by Ng et al.,[19] teeth restored with a crown had a 3.92 times higher chance of survival than teeth without a crown after root canal treatment. Many mesial natural teeth restored with FDPs in this study had received endodontic treatment. Previous studies reported that there is a tendency for non-vital teeth to have a higher ICL rate.[7,10] An implant-supported restoration adjacent to a composite resin restoration showed higher ICL compared to restorations adjacent to unrestored teeth, metal restorations, or ceramic restorations.[20] Composite resin restoration could explain this lower wear resistance and failure to remain in tight contact over time.[21,22] Therefore, in this study, the higher ICL rate of the mesial natural teeth restored with SCs or FDPs may be due to previous endodontic treatment and the different wearing effects of the different restorative materials.

The patients who received orthodontic treatment also had a lower ICL rate at 24 month follow-up. Normally, after achieving proper alignment and occlusion, the surrounding periodontium takes around a year to reorganize and adapt itself.[23] Retainers, defined as orthodontic appliances, are used to prevent the return of dentition to their pre-treatment positions after orthodontic treatment. In addition, they also maintain teeth in their positions instead of driving them mesially. In the present study, the lower prevalence of ICL among patients with a history of orthodontic treatment may be explained by the use of orthodontic retainers. Therefore, some previous studies recommend the regular use of vacuum-formed retainers to prevent ICL.[2,24]

The present study has some limitations, including the small sample size and relatively short observation time. Furthermore, dental floss was used as an easy and simple method to assess interproximal contact.[25,26] However, the assessment of proximal contact with the aid of dental floss was subjective. Adjustment of the proximal surfaces of implant-supported restorations until two shim stock sheets can pass through the contact area has been recommended.[27] Hence, further studies with larger sample sizes, longer follow-up periods, and more objective assessment methods are needed to elucidate the prevalence and contributing factors of ICL.

Conclusions

Despite the limitations of this prospective study, the following conclusions could be drawn:

1. The incidence of ICL appeared to increase over time, with the rate rising from 13.2% at 6-month follow-up to 23.5% and 37.3% at 12- and 24-month follow-up, respectively.
2. Implant-supported restorations in older age, not wearing an orthodontic retainer, a mesial tooth restored with a crown or partial FDP, and severely worn dentition were the various factors contributing to mesial ICL of implant-supported FDPs at 24-month follow-up.

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