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A two-year prospective study to compare the peri-implant parameters of posterior implant-supported single crowns with and without mesial proximal contact loss

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Abstract *Background/purpose:* Interproximal contact loss may lead to food impaction and result in subsequently periodontal complications. The purpose of this prospective study was to investigate the peri-implant parameters of posterior implant-supported single crowns (SCs) with and without mesial proximal contact loss after 2 years of follow-up.
Material and methods: Twenty-six patients with a total of 40 posterior implant-supported SCs with mesial adjacent natural teeth were observed for 24 months after crown insertion. The mesial proximal contacts were assessed by dental floss, then were classified as tight, weak, and open contacts. The following peri-implant parameters were evaluated, including modified plaque index (MPI), modified gingival index (MGI), and probing depth (PD) were conducted at six sites per tooth (mesiofacail, midfacial, distofacial, mesiolingual, mid-lingual and distolingual) in the 6-, 12-, 18- and 24-month following visits. Furthermore, radiographs were taken regularly in 12- and 24-month recall sections for measuring the marginal bone loss (MBL).
Results: At 12-month observation, the incidence rates of weak and open contacts were 22.5 % and 12.5 %; whereas after 24 months of clinical service, the rates came up with 12.9 % and 25.6 %, respectively. No significant differences were found between the tight, weak, and open contact groups in the parameters of MPI, MGI, or PD ($P > 0.05$) at 12- and 24-month follow-up. None of the mean differences of the peri-implant parameters: MPI, MGI, PD and MBL had significant differences between the tight, weak, and open contact groups after 1 and 2 years of clinical service ($P > 0.05$).

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Conclusion: The presence of open, weak, and tight mesial proximal contacts had no significant effects on the peri-implant tissue conditions.

Introduction

The high success and survival rate had turned implant therapy into the first treatment option when reconstructing both partial and complete edentulous arches. Though some studies had revealed various post-treatment biological, mechanical and technical complications, such as screw loosening, fracture or wear of superstructure implant components, marginal bone loss, implant loss, porcelain fracture or porcelain chipping and so on.[1–6] In daily practice, receiving food impaction over the implant site could be one of the common patients' compliant and this could be attributed to the loss of interproximal contact between implant-supported fixed dental prostheses (FDPs) and the adjacent teeth.

The incidence rate of interproximal contact loss of implant-supported FDPs had been shown to be 34—66 %.[7,8] One study pointed out that the prevalence of interproximal contact loss was rated 13.2 %, 23.5 % and 37.3 % at 6-, 12- and 24-month recall visits, respectively.[9] Some authors explained this phenomenon was due to the craniofacial growth and consequentially altered the positions of natural dentition, and others pointed out was because of higher occlusal force of dynamic oral function which results in severe wear of dentitions.[10] Some previous studies concluded that high occlusal force on the adjacent tooth might enhance mesial migration.[11,12] From the aspect of anthropology, a direct relationship was found between occlusal load, interproximal wear and the mesial migration of teeth. It was said that higher occlusal load could cause obvious occlusal and interproximal wear that was responsible for mesial movement of the adjacent teeth.[8,10] Interesting knowing that interproximal contact loss was about three times more prone to occur in the mesial side of the restorations than in the distal after the implant-supported single crowns (SCs) had been delivered over 11 years and was known to be associated with food impaction.[1,4,10,13,14]

The interproximal contact plays an important role to protect the periodontal and peri-implant tissue against the damage caused by food impaction.[13,15,16] Interproximal contact loss may lead to food impaction, and results in subsequently complications such as periodontal defects,[13,17,18] recurrent decay,[19] and peri-implant tissue complications.[2,19,20] In terms of periodontal tissue, some studies reported that interproximal open contacts were related to clinical attachment loss, deeper probing depths, and processing bone loss.[2,17,21,22] Peri-implant tissue is more susceptible to pathosis in comparison to natural teeth, because only the circular arrangement of periodontal fibers seals the mucosa around dental implant.[23–25] One retrospective study showed a positive relationship between interproximal contact loss and marginal bone loss.[26] Latimer et al. pointed out that interproximal open contact was associated with higher peri-implant probing depths, plaque index scores, and gingival index scores, and those were significantly related to peri-implant mucositis and peri-implantitis.[27] However, Byun and colleagues found that there were no direct relationship between open contacts and the incidence of inflammatory peri-implant.[28] More clinical studies, especially prospective studies, were needed to elucidate the impact of interproximal contact loss to peri-implant tissue conditions. Therefore, this two-year prospective study was to investigate the incidence of mesial interproximal contact loss, and its relationship to the peri-implant tissue health and marginal bone loss.

Material and methods

Study design and patient enrollment

This two-year prospective study was conducted at the Department of dentistry of the Chi Mei Medical Center. All the procedures and materials were approved by the local ethical committees (the Institutional Review Board of the Chi-Medical Center, Taiwan, Application Number:10105-L02). All study participants were selected according to the inclusion and exclusion criteria listed down below:

Inclusion criteria

1. Healthy patient without any systemic diseases.
2. Good oral hygiene (full-mouth plaque scores and full-mouth bleeding scores of <25 %) with routine dental check-ups.
3. Patient without smoking and any other oral parafunctions.
4. Patients' age over 18 years old.
5. Patients without pregnancy and were cooperated to take radiographs.
6. Either maxillary or mandibular posterior edentulous area which needs implant-supported single crown for reconstruction.
7. Implant-supported single crown located distally to the adjacent natural tooth.
8. The opposing dentition should be either natural dentition, SCs or three-unit FDPs.

Exclusion criteria

1. Patients with severe medical diseases (acquired immune deficiency syndrome, cardiovascular disorders, diabetes, hepatic diseases).

2. Patients with long-term medicine intake including antibiotics, non-steroidal anti-inflammatory drugs and/or steroid and bisphosphonate.
3. Patient underwent radiotherapy and chemotherapy.
4. Poor oral hygiene
5. Implant-supported single crown is not located adjacent to the natural dentition.

The informed consent was given to the patients prior to the clinical practice and examinations.

Treatment procedure

All the selected patients were taken computed tomography with a vacuum-formed surgical stent for the pre-surgical planning. The soft tissue level implants (Straumann, Basel, Switzerland) were inserted according to the predetermined implant positions. After three-month osseointegration, impressions were made with polyvinyl siloxane (Dentsply sirona; Charlotte, NC., USA) with closed-tray technique for the fabrication of posterior implant-supported SCs. Prefabricated SynOcta Cementable Abutment (Straumann), Variobase Abutment (Straumann) and customized SynOcta Gold Abutment (Straumann) were selected. The restorations were made either with Ceramill modified monolithic zirconia[29–31] (Amann Girrbach; Koblach, Austria) or metal-ceramic SCs with screw-retained or cement-retained design. With regard the screw-retained SCs with modified monolithic zirconia design, the milled zirconia crowns were cemented on the titanium base abutment with RelyX Unicem resin cement (3M ESPE; St. Paul, MN., USA), making it a one-piece screw-retained SCs. For the fabricating procedure of metal-ceramic SCs, traditional lost-wax technique was performed in order to produce metal framework (Argedent 500; San Diego, CA., USA), and the veneering porcelain was layered on by using conventional technique. After the fabrication had been completed, both screw-retained SCs and the titanium abutments used for cemented-retained SCs were inserted with 35Ncm, and the screw holes were restored with gutta percha (GC, Alsip, IL., USA) and Filtek Z250 light-polymerized composite resin (3M ESPE). The cement-retained SCs were cemented with the Premier® Implant Cement™ (Premier Dental; Plymouth meeting, PA., USA).

Clinical periodontal examination

After the definitive restorations were inserted, all patients were followed at six months, 12 months, 18 months and two years. During the follow-up period, all prostheses were evaluated with clinical and radiographic examinations. The mesial interproximal contact between implant crowns and mesial adjacent teeth were assessed by 70μm dental floss (Oral-B; Boston, MA., USA). "Tight contact" was defined as when dental floss could only be passed through the contact area under pressure, whereas a slight snap effect and visible open contact was defined as "weak contact" and "open contact", respectively. Interproximal contact loss was defined as weak or open contact.

The peri-implant parameters were carried out at six sites per tooth (mesiofacial, mid-facial, distofacial, mesiolingual, mid-lingual and distolingual), including modified plaque index (MPI), modified gingival index (MGI), and probing depth (PD). The MPI were measured using disclosing agent around the restoration: "0" regarded as no plaque, "1" regarded as a film of plaque adhering to the free gingival margin and the adjacent area of the tooth, "2" considered as moderate accumulation of soft deposit and "3" thought as abundance of soft matter accumulated. The PD was detected around the restoration with light force, approximately 0.25N. Besides, the MGI scored 0 to 4, "0" considered as absence of inflammation, "1" regarded as mild inflammation with a slight change in color and texture of the gingiva, "2" thought as mild inflammation with color and texture change entirely the gingival unit, "3" regarded as moderate inflammation and "4" considered as severe inflammation. Moreover, the marginal bone level was measured as the distance between the implant platform to the first implant-bone contact by using the digital periapical films with parallel technique. All radiographs were viewed and calculated on a calibrated computer screen through the software program. Distortion ratio was calibrated by dividing the length of implant in the radiograph to the realistic length of the implant. The baseline of MPI, MGI, and PD were recorded two weeks after the crown insertion, and marginal bone level was documented at the time of crown insertion. The marginal bone loss (MBL) was calculated by the difference of marginal bone levels between the baseline and the follow-up time.

Statistical analysis

Descriptive statistics were applied to the data. The evaluated parameters of PD and MBL were compared and analyzed with Kruskal-Wallis H test. MPI and MGI were analyzed with Pearson's Chi-square test. The level of statistically significant were set at $P < 0.05$. The data analysis was performed using SPSS statistical software (version 17.0; SPSS Inc., Chicago, USA).

Results

Twenty-six patients with the mean age of 48.9 ± 6.95 years old were participated in this study. A total of forty implant-supported SCs with mesial adjacent natural teeth either in the posterior maxilla or mandible were fabricated. Among these forty implant-supported SCs, one adjacent tooth had been extracted because of severe periodontal bone loss during the second year of clinical observation and was excluded for the 2-year statistical analysis. After 12-month of clinical follow-up, 26 out of 40 (65 %) SCs were classified as tight contact, nine (22.5 %) SCs and five (12.5 %) SCs were classified as weak and open contact, respectively (Table 1). While after 24-month recall visits, tight, weak and open contact were shown to be 61.5 % (n = 24), 12.8 % (n = 5) and 25.6 % (n = 10), individually. At the baseline, the mean of MPI, MGI and PD were recorded as 0.33 ± 0.42, 0.15 ± 0.38 and 2.43 ± 0.85 (Table 2). After 12 months, the mean of MPI were shown 0.63 ± 0.69 in tight contact groups whereas in weak and open groups revealed 0.50 ± 0.50 and 0.40 ± 0.42, respectively (Fig. 1a). Furthermore, the mean of MGI were 0.54 ± 0.62, 0.11 ± 0.22 and 0.20 ± 0.27, and

Table 1 Incidence of proximal contact loss after 12 and 24 months of clinical follow-up.

	12-month		24-month	
Tight	26 (65 %)		24 (61.5 %)	
Weak	9 (22.5 %)	35 %	5 (12.8 %)	38.5 %
Open	5 (12.5 %)		10 (25.6 %)	
Total	40		39	

the mean of PD were 2.85 ± 1.04, 2.72 ± 0.87 and 2.40 ± 0.65 in the tight, weak and open contact groups (Fig. 1b). With regard to the parameters of MPI, MGI or PD, no significant differences were found in those three groups ($P > 0.05$). After 24 months of clinical observation, the mean MPI of the implant crowns with tight, weak and open proximal contact were 0.77 ± 0.53, 0.40 ± 0.65 and 0.60 ± 0.32 (Table 2) (Fig. 1a). Regarding the mean of MGI, the implant crowns with tight, weak and open proximal contact were shown to be 0.52 ± 0.60, 0.30 ± 0.27 and 0.20 ± 0.35; however, reports shown to have 2.60 ± 0.93mm, 2.20 ± 0.27mm and 2.50 ± 0.58mm in the mean of PD. While there were no significant differences between tight, weak, and open contacts group after two-year period ($P > 0.05$) (Table 2).

In terms of the differences of peri-implant parameters between baseline and 12-month observation (Δ12M), the mean Δ12M-MPI showed +0.25 ± 0.60 in the tight group while +0.39 ± 0.60 and 0.00 ± 0.35 in the weak and open contact groups, individually (Table 3 and Fig. 1a). When concerning the mean of Δ12M-MGI of each group (tight, weak, and open contact groups), data were shown +0.37 ± 0.67, 0.00 ± 0.35 and +0.10 ± 0.42, though the mean of Δ12M-PD were revealed +0.37 ± 1.13, +0.28 ± 0.79 and +0.30 ± 0.67, individually (Table 3) (Fig. 1b–c). On the other hand, the mean of MBL were displayed −0.130 ± 0.395, −0.076 ± 0.332 and +0.188 ± 0.377mm, respectively in the groups of tight, weak, and open contact (Table 3)(Fig. 1d). No significant differences were found among these groups in the parameters of MPI, MGI, PD and MBL ($P > 0.05$). As for the differences of peri-implant parameters between baseline and 24-month observation (Δ24M), the mean Δ24M-MPI of the implant crowns with tight, weak and open proximal contact were +0.42 ± 0.56, 0.00 ± 0.61 and +0.35 ± 0.34, separately. The mean of Δ24M-MGI of Implant crowns with tight, weak and open proximal contact showed +0.33 ± 0.75, +0.20 ± 0.45 and +0.10 ± 0.46, whereas the mean of Δ24M-PD revealed +0.00 ± 1.01mm, −0.10 ± 0.42mm and +0.30 ± 0.82mm apart. Regarding to the mean of MBL, results demonstrated −0.127 ± 0.409mm, −0.034 ± 0.402mm and −0.017 ± 0.413mm in tight, weak and open contact, individually. After two-year period, none of the mean differences of MPI, MGI, PD, and MBL had significant difference among these three groups ($P > 0.05$) (Table 3).

Discussion

In the present study, the incidence rates of mesial contact loss were found to be repectively 35 % at 12-month and 38.5 % at 24- month follow-up, which were relatively low when compared with the rates of interproximal contact loss in previous studies.[1,9,21] The difference may be due to the different study designs and assessments of each study. In this study, the incidence of open contact after 24 months of clinical service was more than that of 12-month observation (25.6 % versus 12.5 %), which indicated that the condition of interproximal contact loss was getting worse in the processing time.

According to the results of this study, the condition of proximal contact had no significant effects on the peri-implant tissue conditions including MPI, MGI, PD and MBL, which were consistent with the previous studies of Byun et al. which reported the rates of interproximal contact loss was significantly affected the food impaction group, while not the periodontal/peri-implant tissue conditions (presence of plaque, PD, bone level).[28] The results were partially different from the results of Koori et al., which pointed out a greater amount of clinical attachment loss and deeper probing depths in those cases with PCL.[20] Moreover, the results were also different from the studies of Saber et al. and Latimer et al. which mentioned the presence of interproximal contact loss was associated with higher peri-implant PD, PI and GI scores, and marginal bone loss.[26,27] This conflict could be attributed to the different study design and the assessment of peri-implant conditions. In the present study, only patients with complete-mouth plaque scores and complete-mouth bleeding scores less than 25 % were included, and the patients' oral conditions were also closely monitored in each recall visits, which means the oral hygiene were under well controlled. The absence of good oral hygiene had been shown to be the main risk factor of peri-implant and periodontal inflammation.[32–34] Block et al. also reported that the deficiency of keratinized gingiva and bad oral hygiene could lead to implant failure.[35] Oral hygiene should be the key factor affecting the impact of interproximal open contact to the

Table 2 The measurements at the baseline, after 12 and 24 months of clinical follow-up, significant difference when $P < 0.05$.

	Baseline			After 12 months			After 24 months		
	MPI	MGI	PD	MPI	MGI	PD	MPI	MGI	PD
Tight	0.33 ± 0.42	0.15 ± 0.38	2.43 ± 0.85	0.63 ± 0.69	0.54 ± 0.62	2.85 ± 1.04	0.77 ± 0.53	0.52 ± 0.60	2.60 ± 0.93
Weak	X	X	X	0.50 ± 0.50	0.11 ± 0.22	2.72 ± 0.87	0.40 ± 0.65	0.30 ± 0.27	2.20 ± 0.27
Open	X	X	X	0.40 ± 0.42	0.20 ± 0.27	2.40 ± 0.65	0.60 ± 0.32	0.20 ± 0.35	2.50 ± 0.58
P-value	X	X	X	0.688	0.085	0.637	0.286	0.240	0.594

MPI, modified plaque index; MGI, modified gingival index; PD, probing depth.

(a). The measurements of modified plaque index in 12-, 24-month and the difference between baseline
(b). The measurements of modified gingival index in 12-, 24-month and the difference between baseline
(c). The measurements of probing depth in 12-, 24-month and the difference between baseline
(d). The measurements of marginal bone loss in 12-, 24-month and the difference between baseline (M, month)

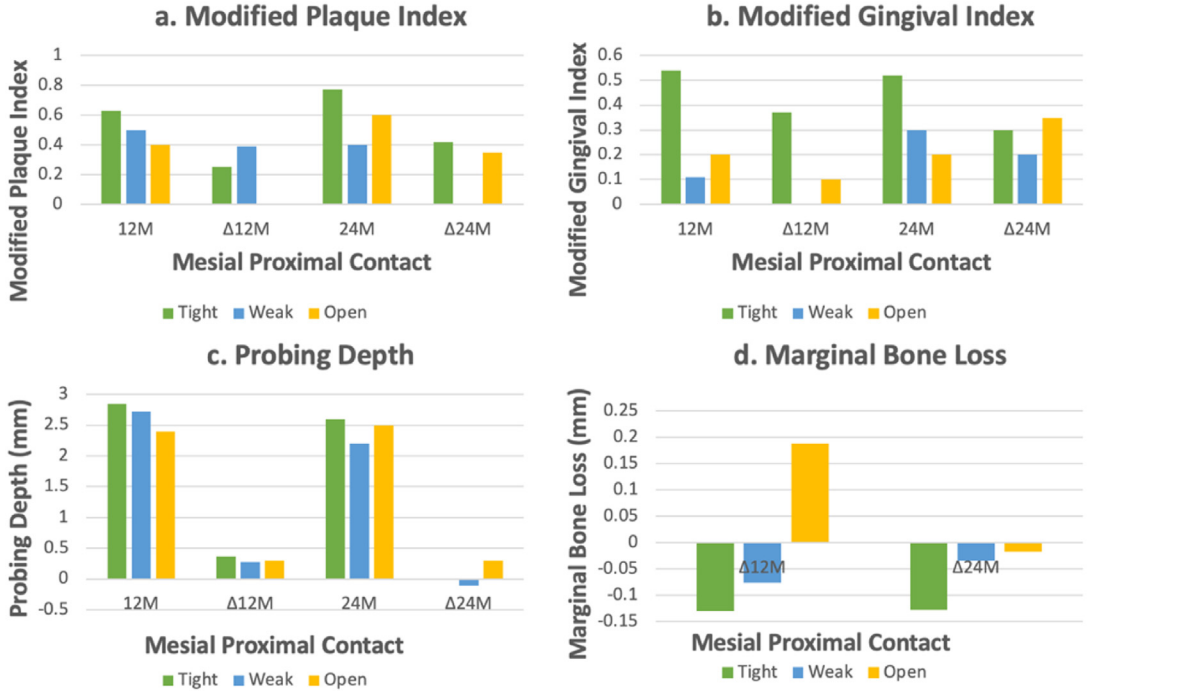

Fig. 1 (a). The measurements of modified plaque index in 12-, 24-month and the difference between baseline (b). The measurements of modified gingival index in 12-, 24-month and the difference between baseline (c). The measurements of probing depth in 12-, 24-month and the difference between baseline (d). The measurements of marginal bone loss in 12-, 24-month and the difference between baseline (M, month).

Table 3 Difference of peri-implant parameters between baseline, 12-, and 24-months follow-up, significant difference when $P < 0.05$.

	12-month differences (Baseline-12 months)				24-month differences (Baseline-24 months)			
	MPI	MGI	PD	MBL	MPI	MGI	PD	MBL
Tight	+0.25 ± 0.60	+0.37 ± 0.67	+0.37 ± 1.13	−0.130 ± 0.395	+0.42 ± 0.56	+0.33 ± 0.75	+0.00 ± 1.01	−0.127 ± 0.409
Weak	+0.39 ± 0.60	0.00 ± 0.35	+0.28 ± 0.79	−0.076 ± 0.332	0.00 ± 0.61	+0.20 ± 0.45	−0.10 ± 0.42	−0.034 ± 0.402
Open	0.00 ± 0.35	+0.10 ± 0.42	+0.30 ± 0.67	+0.188 ± 0.377	+0.35 ± 0.34	+0.10 ± 0.46	+0.30 ± 0.82	−0.017 ± 0.413
P-value	0.494	0.246	0.972	0.244	0.282	0.631	0.629	0.740

MPI, modified plaque index; MGI, modified gingival index; PD, probing depth; MBL, marginal bone loss.

peri-implant tissue health and marginal bone loss. Although interproximal contact loss may not be an important factor influencing peri-implant tissues, food impaction may be occurred in the condition with open contact. A tight proximal contact between implant and adjacent tooth is still an important topic, especially for the patients without good oral hygiene care. Vacuum-formed retainer, large contact areas, retrievable implant restoration and regular follow-up were methods for preventing interproximal contact loss.[8,9,14,36–40]

There are some limitations in the present study including small sample size and short-term follow-up period. Therefore, a long-term clinical investigation with a larger sample size is still necessary to provide a final interpretation and conclusions regarding to the clinical effects of interproximal contact loss to the peri-implant tissue conditions.

Within the limitations of this clinical study, the conclusions could be the incidence rates of weak and open contact were 22.5 % and 12.5 % at 12-month observation period; however, after 24-months, the incidence rates were 12.8 % and 25.6 %, respectively. There were no significant differences ($P > 0.05$) between the tight, weak and open contacts groups with regard to the peri-implant parameters in both 12-month and 24-month follow-up. After one and two years of clinical service, none of the peri-implant parameters had significant differences ($P > 0.05$) between the tight, weak, and open contacts groups.

Declaration of competing interest

The authors have no conflicts of interest relevant to the study.

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