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CLINICAL RESEARCH

Interproximal contact loss between implant-supported restorations and adjacent natural teeth: A retrospective cross-sectional study of 83 restorations with an up to 10-year follow-up

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ABSTRACT

Statement of problem. Interproximal contact loss between implant-supported restorations and adjacent natural teeth is a frequently encountered complication that could negatively affect surrounding tissues and/or patient satisfaction with treatment. The effect of interproximal contact loss on peri-implant tissue health and patient awareness of food impaction is currently unknown.

Purpose. The purpose of this retrospective cross-sectional study was to explore the effect of interproximal contact loss on peri-implant tissue health and determine whether interproximal contact loss leads to increased patient awareness of food impaction around the affected area. This study also aimed to identify whether specific patient or local factors could cause interproximal contact loss.

Material and methods. Eighty-three participants with posterior single-unit implant-supported restorations were examined. The mean follow-up time after prosthesis insertion was 4 ±2.2 years (range 4 months to 10.6 years). Interproximal contacts were evaluated by using waxed dental floss. Patient age, sex, implant location, opposing tooth status, presence of endodontically treated adjacent tooth, and regular use of an occlusal device at night were recorded. Peri-implant probing depths and the presence of bleeding on probing were also recorded. Each participant was asked to indicate whether they had noticed increased food impaction around their implant-supported restoration. Statistical analysis included nonparametric Mann-Whitney U tests, the Spearman rank-order correlation, the Pearson chi-squared tests, and the paired *t* test (α=.05).

Results. Among all examined mesial contacts, 34.1% were recorded as open, with an overall mesial interproximal contact loss (open and loose contacts combined) incidence of 48.8%. Restorations placed in premolar sites exhibited significantly tighter mesial interproximal contacts compared with those placed in molar sites (U=566, P=.041). A significant negative correlation was found between follow-up time after insertion and mesial contact tightness (r_s=−0.226, P=.041).

Conclusions. Interproximal contact loss appears to increase over time, with more surfaces being affected after longer periods of service. This study did not find an association between interproximal contact loss and peri-implant inflammation as measured by bleeding on probing, with the exception of the distolingual implant surface. Participants with interproximal contact loss were more aware of food impaction around their implant crown. Use of an occlusal device at night did not prevent interproximal contact loss. (J Prosthet Dent 2022;127:418-24)

Replacement of missing teeth with implant-supported restorations is a predictable treatment option that yields high patient satisfaction.[1] However, in spite of the high survival and success rates, biologic and technical complications associated with implant-supported restorations are common.[2,3] Abutment screw loosening or fracture, restorative material chipping,[2] and mesial interproximal contact loss[4,5] have been reported as common complications associated with single-unit implant-supported restorations. Loss of interproximal contact between

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Clinical Implications

Interproximal contact loss between implant-supported restorations and adjacent teeth is a frequent complication and can cause noticeable food impaction. Informed consent must include discussion of this possibility with the patient. Retrievable designs and close monitoring of affected areas are recommended to reduce the risk of a carious lesion in the adjacent tooth or tissue inflammation.

implant-supported restorations and adjacent natural teeth may result in food impaction, increasing the risk of tissue trauma and/or inflammation or caries in the adjacent tooth.[4] It can also cause discomfort during mastication.[6]

Interproximal contact loss (ICL) between a posterior implant-supported restoration and its adjacent natural tooth was first reported in 2008 by Wei et al.[7] The authors observed ICL, which occurred as early as 3 months after insertion, in more than 50% of the examined patients. The authors speculated that the greater occlusal loads shared by the remaining natural teeth anterior to the implant could result in their migration and subsequent loss of the contact between the implant-supported restoration and the adjacent tooth. In 2010, Koori et al[8] reported an ICL rate of 43%. Similar results were reported in 2015 by Byun et al,[9] who found that only 46% of the examined proximal contacts were still tight after a mean follow-up period of 57 months. The authors reported that the risk for ICL increased 9.4% annually during the follow-up. Food impaction was noted by 47% of the examined patients. Wong et al[6] reported a 65% ICL rate and food packing associated with 40% of the examined prostheses. Varthis et al[4] reported an overall ICL prevalence of 52.8%, with 40% of patients reporting food impaction. A recent retrospective study including 4325 implants reported an overall ICL incidence of 17%.[5] ICL was found to increase over time and reached 29% at 8 years after insertion.

Several factors have been suggested as contributing to open contact formation between implant-supported restorations and adjacent teeth.[10,11] Examination of worn dentitions in Paleolithic skulls demonstrated proximal surface wear that had been compensated for by mesial drift, leading to a reduction of the arch length.[12] Dental implants are ankylosed in the bone[13]; therefore, drifting of the natural teeth mesial to the implant may result in an open contact. Because these changes are outside the dentist's control, prevention of this complication might not be possible.[10,11]

Interproximal contact tightness cannot be easily determined intraorally. It has been reported that adjacent, natural, unrestored teeth at rest exhibit a space of up to 21 μm interproximally, which closes during clenching.[14-16] Interproximal contact tightness cannot therefore be considered a static factor because it can change during function and parafunction,[16,17] as well as throughout the day.[18] As per the current clinical guidelines, contacts of restored proximal surfaces should be adjusted until microscopic clearance or passive contact with the adjacent tooth is achieved.[19] Generally, a satisfactory contact allows dental floss to pass interdentally with firm resistance.[19,20] For implant-supported restorations, proximal surfaces should be adjusted until 2 shim stock sheets can pass through the contact area.[21]

The purpose of this cross-sectional retrospective study was to determine whether ICL influences peri-implant tissue health and patient awareness of food impaction. The null hypotheses were that ICL has no effect on peri-implant tissue health or patient awareness of food impaction. A secondary aim of this study was to determine whether certain patient or clinical factors have any effect on interproximal contact tightness.

MATERIALS AND METHODS

The study protocol was reviewed and approved by the Institutional Review Board of the Oregon Health & Science University (OHSU). Eighty-three adult participants who had received a single-unit screw-retained dental implant-supported restoration in the posterior region in the predoctoral clinic between May 1, 2005 and May 31, 2015 were included in the study. Exclusion criteria were the presence of adjacent implants, proximal surface modification of adjacent teeth (placement of direct or indirect restorations after delivery of the implant-supported crown), or opposing removable denture (partial or complete).

All restorations were screw-retained and fabricated by the same dental laboratory using castable abutments. Crowns were either metal-ceramic or cast metal. Experienced faculty supervised all restorative phases, including definitive restoration delivery. Evaluation of interproximal contact strength was performed by using waxed dental floss (Reach; Johnson & Johnson Healthcare Products). Treatment notes indicated that interproximal contacts at delivery were deemed adequate when floss was passed interproximally with moderate to heavy resistance.

A written consent was obtained from all participants. Their implant-supported restoration was examined in a single visit by the same calibrated examiners (D.B., S.E.) by using a structured assessment process. Before dismissing the participant, any disagreements were discussed until consensus was reached. Interproximal contact tightness was evaluated by using waxed dental floss (Reach; Johnson & Johnson Healthcare Products). If

Figure 1. Visually open mesial interproximal contact between implant restoration on mandibular left first molar and mesially adjacent natural tooth (second premolar).

there was visual lack of contact (Fig. 1) or if floss passed between the implant-supported restoration and the adjacent tooth surface without resistance, the contact was considered open. If floss passed with light resistance, the contact was considered loose. Contacts were considered tight if floss passed through with moderate or heavy resistance. The presence of an open or loose contact was classified as ICL.

Shim stock occlusion foil of 12 μm in thickness (Almore International Inc) was used to measure the interproximal space between implant-supported restorations and adjacent teeth. Shim stock strips were sequentially inserted between each implant-supported restoration and the adjacent teeth until firm resistance was noted and no more strips could be inserted. The total number of shim stock strips that could be inserted in each interproximal space was recorded.

Patient age and sex, implant location, restoration insertion date, opposing tooth status, presence of endodontically treated adjacent teeth, and regular nighttime use of an occlusal device (as reported by the participant) were recorded. Peri-implant probing depths and presence of bleeding on probing (BOP) were also recorded. Radiographic comparisons were not attempted because of a lack of standardization with existing radiographs. Before the examination, each participant was asked to indicate whether they had been aware of food impaction around their implant-supported restoration.

Demographic data and clinical measurements were entered into a spreadsheet (Microsoft Excel 2016; Microsoft). Some participants had more than 1 eligible implant-supported restoration; to account for clustering effects during data analysis, all restorations were listed in order by tooth number (using the universal tooth numbering system), and a random number generator was used to determine which restoration would be analyzed. Statistical analysis was performed by using a statistical software program (IBM SPSS Statistics, v25; IBM Corp). Nonparametric Mann-Whitney U tests were performed to identify significant differences among the participants regarding the tightness level (open, loose, tight) of each interproximal contact of their implant-supported restoration and associated with sex, age, daily use of an occlusal device, presence of endodontically treated adjacent tooth, jaw, implant site, and opposing tooth status (unrestored versus restored opposing occlusal surface). Nonparametric correlation (Spearman rank-order correlation) was used to determine the relationship between follow-up time after implant crown insertion and level of interproximal contact tightness between the restoration and its adjacent teeth. Pearson chi-squared tests were performed to identify differences between different tightness levels and presence of BOP around the implant, as well as patient awareness of food impaction in the area. A paired *t* test within individuals who had both contacts present were used to identify differences between the mean number of shim stock sheets that could fit in the mesial and the distal interproximal spaces (α=.05).

Table 1. Anatomic location of implant restorations (n=83 restorations)

	Region		
Jaw	Molar (%)	Premolar (%)	Total (%)
Maxilla	13 (15.7)	20 (24.1)	33 (39.8)
Mandible	42 (50.6)	8 (9.6)	50 (60.2)
Total	55 (66.3)	28 (33.7)	83 (100)

RESULTS

Eighty-three patients (29 men, 54 women) with a total of 118 implant-supported restorations consented to participate in this study. The mean ±standard deviation age was 63.5 ±11.4 years (range 37 to 86 years). The mean ±standard deviation follow-up time after prosthesis insertion was 4 ±2.2 years (range 4 months to 10.6 years). Twenty-four participants (28.9%) reported daily use of a protective occlusal device. The anatomic sites of all examined restorations are summarized in Table 1.

Among all examined mesial contacts, 34.1% were recorded as open, with an overall mesial ICL incidence of 48.8%. Among all examined distal contacts, 10% were recorded as open, with an overall distal ICL incidence of 26.7%. Mesial interproximal contact levels as per surface (mesial/distal) are shown in Figure 2. The mean number of shim stock sheets that could fit in the mesial interproximal space was 8.23, whereas the mean number of sheets that could fit in the distal space was 5.47. A paired *t* test within individuals who had both contacts present showed a statistically significant difference between the mean number of shim stock sheets that could fit in the mesial and the distal interproximal space (t[59]=3.88, P<.001). Mesial interproximal contact levels as per

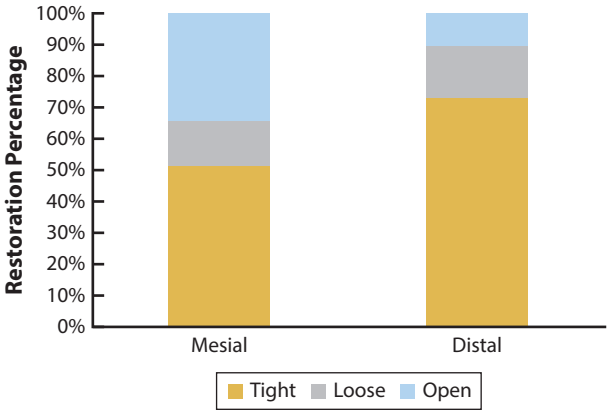

Figure 2. Percentage of open, loose, and tight contacts per implant surface.

various patient and clinically related characteristics are shown in Tables 2 and 3. Cumulative ICL rates as per various patient and clinically related characteristics are shown in Figures 3 and 4.

Implant restorations placed in premolar sites exhibited significantly tighter mesial interproximal contacts than those placed in molar sites (U=566, P=.041). Women had tighter distal proximal contacts than men (U=292, P=.013). Women also had tighter mesial proximal contacts, but that difference was not statistically significant (U =657, P=.286). A significant negative correlation was found between follow-up time after implant insertion and mesial interproximal contact tightness (r_s=-0.226, P=.041), indicating decreased tightness of mesial interproximal contacts with longer follow-up times (Fig. 5). Such an association was not found for the distal contacts (r_s=-0.006, P=.962).

BOP on the distolingual implant surface was more often observed in participants with open or loose distal contacts compared with those with closed contacts (x^2=7.908, P=.019). No association was found between contact tightness and presence of BOP on distobuccal, mesiobuccal, or mesiolingual implant-supported restoration surfaces.

Among participants with mesial or distal ICL, 43.8% reported awareness of food impaction around their implant-supported restoration. Participants with mesial ICL reported being aware of food impaction more than patients with tight mesial contacts (x^2=8.514, P=.014).

No statistically significant differences in mesial or distal interproximal tightness levels were found between participants in relation to their age, presence of an endodontically treated tooth adjacent to the implant site, jaw, or opposing tooth status. Daily use of an occlusal device also did not reveal a significant trend toward closed contacts. Because almost all occlusal devices had been made to fit the maxillary arch, a separate analysis was carried out to assess whether the use of an occlusal device resulted in lower ICL incidence in maxillary implant restorations, but no difference was found (x^2=1.782, P=.182).

DISCUSSION

ICL between implant-supported restorations and the adjacent natural teeth is a complication that has been increasingly reported in the literature.[4-11,25] However, its etiology, potential effects on implants or adjacent teeth, as well as management options remain inconclusive and are based on clinical judgment rather than being based on evidence.

The present retrospective study focused on assessing whether ICL affected peri-implant tissue health or whether it increases patient awareness of food impaction. The first null hypothesis that ICL would have no effect on peri-implant tissue health as defined by the absence of BOP was partially rejected, as significant differences in BOP on the distolingual surface were found between participants with ICL and those with tight distal contacts. No difference was found among patients in BOP on the distobuccal, mesiolingual, or mesiobuccal implant surface; however, these surfaces are also more accessible for oral hygiene compared with the distolingual surface, so it is unclear whether the difference was because of lack of hygiene or because of the presence of an open contact.

The second null hypothesis that ICL between implant-supported restorations and the adjacent teeth would not increase patient awareness of food impaction in the area was rejected because participants with mesial ICL reported being aware of food impaction more than those with tight mesial contacts. Among participants with mesial or distal ICL, a significant percentage (43.8%) was aware of the issue and reported persistent food impaction in the area. This is consistent with the findings of Varthis et al,[4] who reported that 40% of patients with open contacts were aware of food impaction in the area.

The present study also aimed to determine whether patient or local factors influenced interproximal contact tightness. No statistically significant differences were found in interproximal contact tightness levels between participants in relation to their age. Women had tighter distal proximal contacts compared with men. Women also had tighter mesial contacts, but the difference was not statistically significant, which was consistent with the findings of French et al.[5]

In the present study, regular use of an occlusal device was not found to prevent mesial tooth migration and subsequent ICL between the implant and its adjacent teeth. It had been speculated that use of occlusal devices or retainers could mitigate the issue and had been suggested as a potential measure to prevent ICL.[10]

Table 2. Mesial interproximal contact tightness level in regard to patient characteristics (%)

	Sex		Age		Daily Use of Occlusal Device		Patient Aware of Food Impaction	
Mesial Contact Tightness Level	Men	Women	Younger than Mean (63.5yo)	Older than Mean (63.5yo)	Yes	No	Yes	No
Tight	39.3	57.4	57.1	46.8	58.3	48.3	23.8	60.7
Loose	25	9.3	14.3	14.9	12.5	15.5	23.8	11.5
Open	35.7	33.3	28.6	38.3	29.2	36.2	52.4	27.9
P	.286		.326		.432		.014*	

*Statistical significance.

Table 3. Mesial interproximal contact tightness level in regard to clinical characteristics (%)

	Jaw		Site		Adjacent ETT		Opposing Crown	
Mesial Contact Tightness Level	Maxilla	Mandible	Molar	Premolar	Yes	No	Yes	No
Tight	54.5	49	44.4	64.3	40	52.8	52.1	50
Loose	15.2	14.3	13	17.9	0	16.7	12.5	17.6
Open	30.3	36.7	42.6	17.9	60	30.6	35.4	32.4
P	.566		.041*		.200		.992	

ETT, endodontically treated tooth. *Statistical significance.

A little more than half (51.0%) of mandibular restorations exhibited mesial ICL. For maxillary restorations, the percentage was slightly less (45.5%); however, the difference was not statistically significant. French et al[5] also reported a higher incidence of ICL for mandibular restorations. The slightly higher incidence of ICL in the mandible is likely related to the continuous mesial drifting of the teeth and the root angulation, which is more prominent in the mandible; this is the same mechanism that results in late mandibular arch crowding, as reported in the orthodontic literature.[22] Mesial tooth drift can manifest as translation, rotation, or tipping, and what factors lead to each type of movement or what mechanisms cause this continuing mesial drift is unclear.[22-24]

Implant-supported restorations placed in premolar sites exhibited significantly tighter mesial interproximal contacts compared with those placed in molar sites; specifically, 42.6% of molars, 22.2% of second premolars, and only 10% of first premolars had open contacts. Mesial tooth drift occurs most commonly in premolars and only occasionally in canines,[23] which may explain these findings; implants placed at molar sites are adjacent to teeth that are more likely to drift over time, whereas implants placed at premolar sites are adjacent to canines, which are less likely to drift.

A significant negative correlation was found between follow-up time after insertion and mesial interproximal contact tightness, indicating decreasing tightness of mesial interproximal contacts with longer follow-up times. The most likely mechanism behind ICL is the continuous mesial drift that occurs in some adults, and therefore, it is logical to expect that the longer a restoration is in the mouth, the more drifting will take place.

No difference was found in interproximal contact tightness when endodontically treated teeth were adjacent to the implant site. Koori et al[8] reported that the presence of an endodontically treated tooth adjacent to an implant leads to increased rates of ICL; this was not supported by the present data.

The present study did not examine the effect of opposing dentition, specifically the effect of opposing acrylic resin teeth. A previous study[8] reported that less ICL was observed in restorations opposing removable partial dentures, which may be explained by the softer material surface being more forgiving of occlusal prematurities. Parafunctional habits and history of orthodontic therapy were also not recorded, and both may play a role in ICL development. Furthermore, other studies have suggested additional contributing factors to ICL, including arch stability, periodontal status of the teeth, continuing jaw growth, type of occlusion, and preferred mastication side.[6,8,10,25] The effect of these factors was not assessed in the present study to reduce the potential for confounding variables. Controlled prospective studies can investigate these parameters to provide a more clear understanding of the risk factors for ICL.

Current recommendations for ICL management predominantly focus on restoration retrievability to allow reestablishment of the contact if necessary.[11] For patients with cement-retained restorations, interim luting agents are recommended.[11] Restorative materials, the magnitude of needed modification, laboratory expertise, and finances have all been described as affecting the decision to repair or replace an existing restoration with an open contact.[10,11] Occlusal devices have been recommended,[10] but there is no clinical

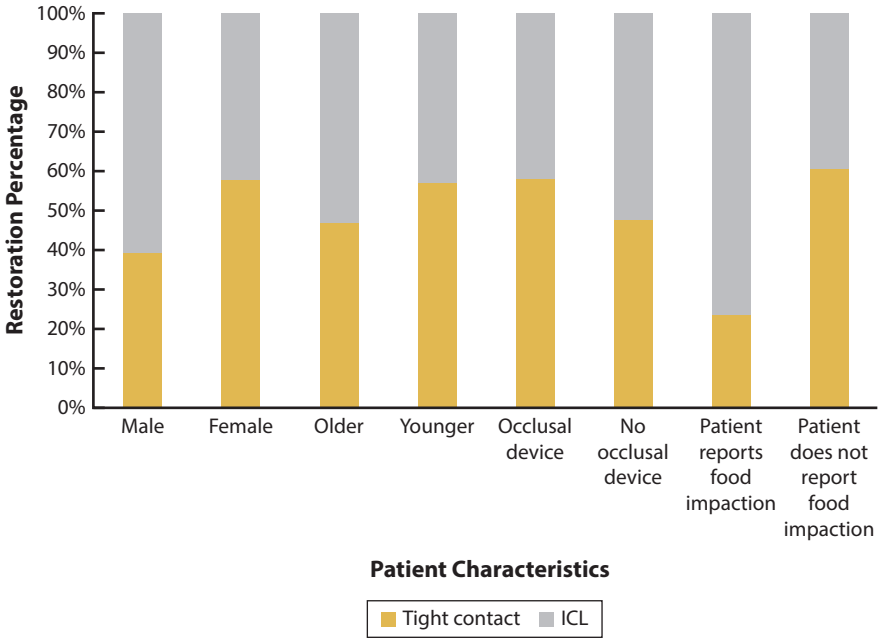

Figure 3. Interproximal contact loss (ICL) incidence in regard to patient characteristics.

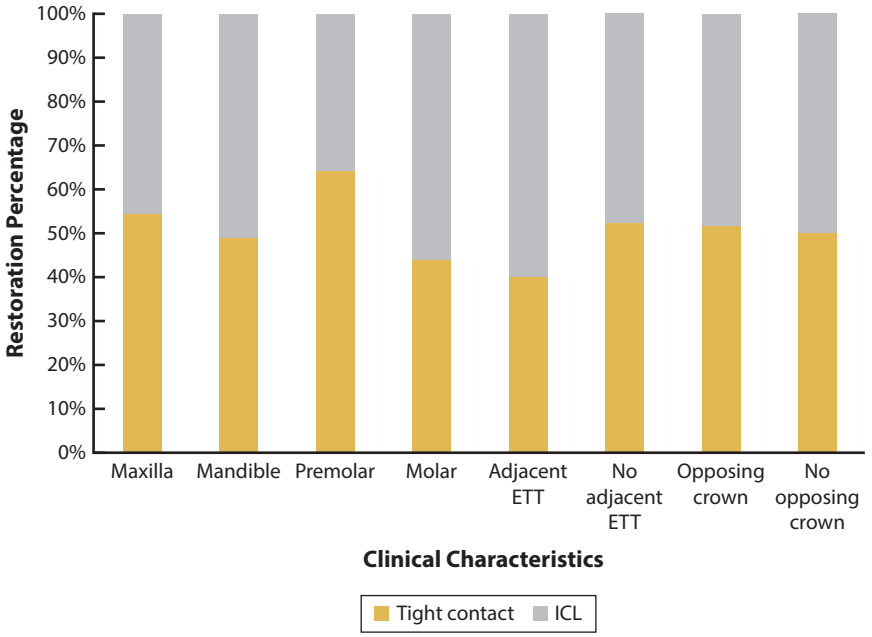

Figure 4. ICL incidence in regard to clinical characteristics. ETT, endodontically treated tooth; ICL, interproximal contact loss.

evidence for their efficacy in preventing ICL, and this study did not reveal any association between regular use of an occlusal device and ICL prevention. Modification of adjacent proximal surfaces before making an impression for the implant-supported restoration has also been recommended to establish a flatter surface and more predictable contact.[11] Monitoring, restoration of the adjacent tooth, and occlusal adjustment have all been described as treatment strategies, with stricter protocols recommended for patients with a high risk of caries or a history of periodontitis.[11] Future studies should investigate interventions for preventing and managing ICL because it appears to be the most commonly encountered technical complication of implant-supported restorations.

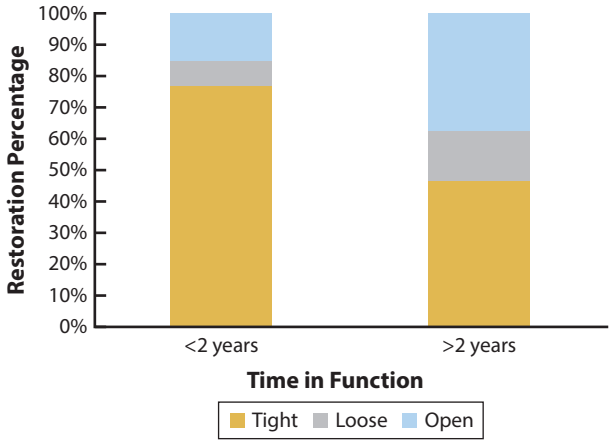

Figure 5. Mesial interproximal contact level as function of follow-up time.

CONCLUSIONS

Based on the findings of this retrospective cross-sectional study, the following conclusions were drawn:

1. For restorations that were followed up for a mean time of 4 years after crown insertion, the incidence of mesial ICL was 48.8%, an incidence that appeared to increase over time.
2. No effect of ICL was found on peri-implant inflammation as measured by BOP, with the exception of the distolingual implant surface.
3. Participants with ICL were more aware of food impaction around the affected site.
4. Implant-supported restorations at molar sites had significantly higher ICL rates compared with those placed at premolar sites.
5. Regular use of an occlusal device was not associated with ICL prevention.

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CRediT authorship contribution statement
Despoina Bompolaki: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Project administration, Writing - original draft. **Sara A. Edmondson:** Funding acquisition, Investigation, Project administration. **James A. Katancik:** Supervision, Validation, Writing - review & editing.

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