Clinical, Cosmetic and Investigational Dentistry

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Proximal Contact Loss and Interproximal Caries in Natural Teeth Adjacent to Dental Implants. A Review

Mohammed Alsaloum[1–3], Sami A Almohefer[4], Abdulaziz Alzaid[1–3], Faey Alburidy[1], Fatimah Alanazi[1], Layan Tarabzoni[1], Rana K Alkattan[1–3], Ahmed A Madfa[4], Ahmad Alkhodair[1–3]

[1]Restorative and Prosthetic Dental Science Department, College of Dentistry, King Saud Bin Abdulaziz University for Health Sciences, Riyadh, 14611, Saudi Arabia; [2]King Abdullah International Medical Research Center, Ministry of National Guard Health Affairs, Riyadh, 11481, Saudi Arabia; [3]Dental Services King Abdulaziz Medical City, Ministry of the National Guard- Health Affairs, Riyadh, 11426, Saudi Arabia; [4]Department of Restorative Dental Science, College of Dentistry, University of Ha'il, Ha'il, Kingdom of Saudi Arabia

Correspondence: Mohammed Alsaloum, Email Saloumm@ksau-hs.edu.sa

Abstract: Proximal contact loss (PCL) between implant restorations and neighboring natural teeth can lead to interproximal caries and other dental problems. This review assessed the frequency of interproximal caries on teeth adjacent to implants and implant infraocclusion across different age groups. Factors influencing PCL, including implant placement and adjustments for patient age and gender, were evaluated. The review also examined the impact of implants on surrounding bone and oral microbiota. Understanding these effects helps guide implant planning and follow-up care, aiming to reduce complications, preserve the integrity of neighboring teeth, and maintain overall oral health. Implants can trigger local inflammation and microbial imbalance, leading to bone loss around adjacent natural teeth and potentially increasing caries risk. Interproximal contact loss (PCL) between implants and neighboring teeth is common and heightens susceptibility to interproximal caries, affecting oral health. Factors such as implant placement, follow-up duration, and microbial changes influence PCL development and its consequences. Timely implant placement and consideration of patient age and gender are essential to manage growth-related changes. Proper treatment strategies combined with regular monitoring help minimize risks, maintain interproximal integrity, and protect oral health, ensuring implant restorations function effectively without compromising adjacent natural teeth.

Keywords: proximal contact loss, dental implant, complications, impact oral health, interproximal caries, growth modification

Introduction

Implants are currently leading the way in clinical practice and are the standard care approach in prosthodontics.[1,2] A dental implant is a prosthetic tool inserted into the jaw to replace one or more missing teeth, offering support for removable or fixed prostheses. Additionally, it connects to the jawbone through a procedure known as osteointegration.[3–6] Implants have been shown to enhance quality of life, chewing ability, and happiness.[7–10] Restorative dentists restore implants using metals, ceramics, or polymers.[3] In addition to the materials used for restoration, there is a variety of designs for implants including endosteal, subperiosteal, or transosteal implants. Although the implant design is important, caution should be exercised in selecting the patient and placing the implant. When placing implants, it is important to take into account the neighboring vital structures. Different patients have varying eligibility when it comes to dental implants. People with uncontrolled metabolic diseases, acute illnesses, bone infections, and anomalies are typically not good candidates for dental implants when compared to healthy individuals. Conditions such as diabetes, osteoporosis, HIV, and individuals undergoing radiotherapy in the head and neck area are considered relative contraindications for dental implant surgery.[3]

Implants are known to have a high success rate of 95%.,[3] however, there is always a chance of complication, including biological, technical, and mechanical issues.[11–17] Firstly, a variety of mechanical issues, including cement failure, screw/implant fracture, and loosening of the screws, might impact implants.[11] Overloading the implant, which

https://doi.org/10.2147/CCIDE.S585610
Received: 1 December 2025
Accepted: 6 March 2026
Published: 30 March 2026

occurs when the bite force exceeds its capacity, can lead to screw loosening, screw/implant fracture, and cement failure. Peri-implant vertical bone loss raises the possibility of an implant fracture if it is severe enough to coincide with the screw's apical limit. Secondly, fractures are caused by technical issues including strain and increased rigidity in the connection between the implants and fixed framework.[11,18,19] Moreover, the weak strength of the material may cause the porcelain veneer to shatter, which would cause the framework to chip.[11] Lastly, there are biological consequences, which include infection brought on by microbial plaque accumulation, per-implantitis, and infra-occlusion of implants.[11,18–20]

Interproximal Contact Loss (PCL) is a frequently seen complication, with reported prevalence rates ranging widely from 18% to over 65% in various studies, underscoring its commonality. PCL is caused by various factors leading to clinical consequences such as food impaction, discomfort, pain, patient dissatisfaction, and the start of cavities.[21–36] The open embrasure facilitates plaque accumulation, with one study finding a direct association between food impaction and inflammatory peri-implant soft tissue conditions in over half of the cases examined.[31] However, the soft and hard tissues around implants are more prone to disease compared to natural teeth.[35,37–40] This is particularly critical as PCL has been significantly linked to both peri-implant bone loss and soft tissue inflammation, highlighting its role as a biological risk factor.[38,39]

Implant-supported restorations may experience occlusal plane disparity due to the non-eruption potentiality of implants. The infraocclusion/infraposition is the term used to describe this disparity.[41,42] This is not a rare occurrence; long-term studies have documented infraposition in a substantial portion of patients, with mean vertical discrepancies of 1–2 mm observed over follow-up periods exceeding 15 years.[20,41] One of the main factors for dental implant failure and complication has been identified as growth alterations.[12,42–46] According to current research, adults may experience the same complications as young, developing children.[12,44,45] This is evidenced by continuous, albeit slow, vertical eruption of natural teeth measured at approximately 0.1 to 0.2 mm per year in adults which can lead to significant clinical infraposition of the static implant.[12,45] The primary objective of this review is to elucidate the frequency of interproximal caries on the natural teeth next to implants and the infra occlusion of implants in patients of all ages.

Infra-Position

Age and Growth

Several studies have well-documented the impact of growth on implants in growing patients. However, alterations from implants in adults are not fully apparent, and in the past, many researchers held these beliefs. Recent research has shown that adults experience growth changes that can affect implants. Behrents, Bishara, and Forsberg's studies indicated that contrary to popular belief, adults do continue to grow slowly throughout their lives, debunking the myth that adults do not grow. Conversely, these modifications are observed to a greater extent in children who undergo more accelerated development.[47–50] Research suggests that there may be notable variations in growth for both sexes between the ages of 25 and 45. As a result, these modifications would impact the stability and placement of dental implants, which may eventually result in problems such misalignment or infraocclusion.[50] The consequences of skeletal growth on the placement of dental implants in growing individuals are clearly defined and well-researched. However, the subtle structural changes that occur in adult implant sites have just come to light. Adults still undergo minor growth, according to research, which can have an impact on dental implants. According to Andersson, patients with single-implant restorations in their upper front teeth would have infraposition after 15 to 20 years. Luis Huanca, Grethe Jonasson, and Stavros Kiliaridis discovered that in females, the anterior maxillary teeth exhibit greater eruption than the posterior maxillary teeth.[45] In contrast, Thilander demonstrated continued growing eruption in three adult patients who had a single implant during adolescence.[51,52] There is a significant risk of implant infraposition in younger individuals whose maximum growth has not yet occurred. Andersson et al[20] conducted research on the age-infraposition association and noted that older individuals may still experience implant submersion after the age of 17 to 19 years. According to Bernard et al[5] both young patients with residual growth potential and mature adults may experience similar alterations in the location of their natural teeth next to implant-supported crowns. Moreover, Haunca et al[45] demonstrated that female patients had ongoing tooth eruption, particularly in the upper incisor region. According to Jemt et al[12] a 25-year-old woman had implant infusion after nine years, and she displayed obvious symptoms of the condition. According to

Schwartz-Arad et al[53] implant infraposition remains constant throughout life but changes with age. It is particularly noticeable in the second and third decades as opposed to the fourth and fifth.

Gender

The majority of authors advise waiting until bone growth is finished, which is usually about 15 or 18 years old for women and males, respectively, before using implant-borne restorations in the anterior region.[20,46,52] Infraocclusion still develops in adults. Neighboring teeth keep erupting vertically and shift the occlusal plane, and this process continues through adult years.[45,47,54] Males continue to grow their faces until they are about 25 years old, which can have an impact on when dental implants are placed.[49,50] Therefore, as the jawbone and face continue to expand, the stability and location of dental implants may be impacted, which may result in implant misalignment or other issues. In contrast, female growth is finished by the time they are 17 years old; although, modest modifications in growth may occur. However, these alterations are quite slight less than 1 mm and often do not pose a serious risk to the implantation of dental implants.[20,45] Bernard et al concluded that male and female patients do not differ in the degree of vertical eruption or the location of the implants.[41] However, among the 40% of patients who exhibited indications of submersion,[20,52] frequently found that females had a higher incidence. It was noted by Schwartz-Arad et al[53] and Jemt et al[55] that there were greater but not statistically significant rates of submersion and tooth movement in females next to implants. A study found that most females exhibit greater infraposition, albeit to minor degrees roughly 1 mm or less.[20] Both adult and pediatric patients may experience similar significance from the neighboring teeth's ongoing eruption process. This finding does not suggest that younger patients have a high eruption potential. It should be emphasized that growing individuals in the pre-pubertal and pubertal growth stages were not included in the current sample since in these circumstances the alveolar vertical alterations were anticipated to be quite high.[41]

Growth in the Jaw Bones

The predicted lifetime of implant prostheses means that aging-related modifications to these devices should be considered.[54,56–60] The maxilla and mandible's skeletal alterations have a significant effect on single-tooth implants because the teeth erupt and move in the new space formed when the arches separate. Consequently, unlike ankylosed implants, which are unable to adjust to changes in alveolar and maxillomandibular growth, these changes in maxillo-mandibular growth led to adaptive alterations in the teeth over time.[61–63] Teeth adjust to changes in growth in all directions vertically, transversely, sagittally, and aligned. As a result, surrounding natural teeth may become misaligned with the implant, or the implant may cease to be vertically occluded.[47] Maxillo-mandibular growth corresponds with the skeletal chronology. The transversal plane stops growing first, then the sagittal plane, and finally the vertical plane. Unlike natural teeth, implants do not undergo the same regular bone remodeling.[64]

Maxillary Growth (in Growing Patients)

Most maxillary changes develop from remodeling that continues after age seven.[65] The front maxillary quadrant often shows tooth loss from trauma and cases of congenital absence, so this area needs close evaluation.[66]

Transverse Growth

Transverse maxillary development at the midpalatal suture is another growth mechanism that causes rotational growth, which anteriorizes the location of the maxillary molars. It is advisable to wait until a person is fifteen years old for girls and seventeen years old for males before placing osseointegrated dental implants in the maxillary posterior quadrant.[66] First, the sutura palatina mediana grows more rapidly than the anterior section of the maxilla, which completes its growth before the growth spurt.[64,65,67] The midpalatal suture typically closes after puberty, which occurs between the ages of fifteen and twenty-seven.[64,67] The lengthening of the jaw is positively correlated with the growth of the posterior part of the maxilla. Little alterations take place at the intercanine distance (mean increase, 0.9 mm) beyond the age of 10.[57] However, the sutural widening in this region which is three times greater in the posterior than the anterior suggests a modification of the dental arch, whereas the increase in intermolar distance is less pronounced.[62] Arch dimensions continue to shift until full eruption. Posterior segments show gradual changes during young adulthood.[64] Intercanine

width settles first, then intermolar width. Implants placed during this period can lead to spacing issues and occlusal mismatches.[56,57,59]

Implications of Transverse Growth

In a young child, the placement of an implant next to a natural tooth in the central incisor region may cause diastema, which would move the midline to the implant side.[64,65,67] It also happens when the transverse growth is not fully completed and both central incisors are replaced. There are no appreciable transversal difficulties in comparison to vertical concerns, according to case studies where implants were implanted in young individuals (as young as nine years old).[64,65,67] The implantation of orthodontic appliances that use a midpalatal implant as anchorage is another factor to take into account; this is best planned at or after the age of fifteen.[64,65,67]

Sagittal Growth

Sutural growth and bone apposition at the maxillary tuberosity cause the maxilla to grow longer while maintaining stability in the anterior region. However, when the maxilla follows the mandibular growth, up to 25% of this sutural growth is lost at the anterior site. Sagittal growth stops earlier even though it relates to overall body height changes.[65,67] Teeth drift mesially during this period, and the lateral maxillary segment from the canine to the first molar shifts forward. This segment moves about 5 mm between ages ten and twenty-one, while the maxillary incisor moves only 2.5 mm buccally. The difference in movement produces crowding.[64,65,67]

Implications of Sagittal Growth

The gradual loss of bone on the labial side of an implant could result from resorption in the anterior part of the maxilla as reported in the case report in which labial fenestrations were seen in a thirteen years old boy after eleven months of implant placement and in eleven years and half old girl as early as eleven months after implant placement as well. Moreover, the labial fenestration problem worsens with time as the patient grows-up. Teeth normally migrate mesially while implant is ankylosed and it does not play a role in "spontaneous tooth migration" theory. Therefore, an implant placed in the lateral region may hasten the mesial drift of the other teeth leading to an asymmetrical arch and the implant itself will move more palatal with time.[64,65,67]

Vertical Growth

Sutural growth (displacement), remodelling, and ongoing tooth eruption are limited to the maxilla's vertical expansion as a result of expanding the orbit and nasal cavities, the maxilla's downward movement away from the cranium, and the maxillary sinus' remodelling. For girls, the vertical growth typically lasts until the age of seventeen or eighteen, while it lasts longer for boys. However, depending on the type of facial growth and the teeth's ongoing eruption, alterations may still happen, albeit considerably more slowly than during the active development phase. Significant modifications throughout decades have an impact on the utilization of osseointegrated implants.[64,67] Long-term data shows that infraposition exceeding 1 mm can be observed in a significant portion of patients after 15–20 years, highlighting the cumulative effect of these subtle changes.[20,55] Implant placement in the anterior maxillary quadrant should be attempted before the age of fifteen in female patients and seventeen in male patients for the purpose of achieving a unique treatment planning and with bring attention on the only determination of skeletal age and proper informed consent on the needs of implant change in future.[66]

The maxillary incisors will shift around 2.5 mm buccally and 6 mm downward between the ages of 9 and 25.[64] Even at the age of eighteen,[18,64] the average eruption velocities reach 1.2 to 1.5 mm/year during the active growth phase and 0.1 to 0.2 mm/year after adulthood.[45] According to Ranly's calculations, an implant placed in the maxilla's front region at the age of seven will be situated nine years later, 10 mm more apically than the teeth next to it.[64,67] Clinical follow-ups showed the same pattern. Children who received single implants around age twelve showed a relative infraocclusion of about five to seven millimeters after four years, and some cases also showed a small labial fenestration. Similar changes appeared in the molar region as well.[64] Bernard et al later reported that implant placement in the front maxilla did not change how much the neighboring teeth continued to erupt vertically.[52]

Implications of Vertical Growth

It is recommended that implants be placed beyond the age of eighteen to avoid vertical problems, particularly those resulting from remodelling. The duration of the vertical growth is longer than that of the transversal and sagittal aspects, which concluded earlier.[64,65,67] Implants placed before full skeletal maturity often create an unsteady implant to prosthesis ratio. This situation can force repeated lengthening of the transmucosal component, which raises functional load on the implant.[66] Maxillary bone keeps reshaping at a marked rate after the age of seven. About two-thirds of the total change stems from remodeling, and this process can shift the implant from its intended position over time.[64] Vertical growth of the maxilla also drives slow forward and downward drift, and this movement contributes to displacement around single implants and small implant-supported bridges. The vertical expansion by drift is particularly significant for single implants and/or partial bridges on implants.[64] The implant apex may theoretically even pierce the nose's floor and occupy a portion of the piriformis aperture.[64,67] The general growth parameters that are mentioned for the maxillary anteroposterior area also apply to the maxillary posterior quadrant.[66] Figure 1 shows how a fixed implant fails to keep pace with erupting adjacent teeth. Continued vertical eruption leaves the implant crown in relative infraocclusion and breaks the proximal contact. The open space traps food and fosters bacterial buildup. This process encourages caries and local bone loss on the neighboring tooth, showing that a stable implant can still create harm for the surrounding dentition.

Implants in Syndromic Patients

Ectodermal Dysplasia and Anodontia

Ectodermal dysplasia is frequently linked to congenital anodontia, a rare and heritable disorder. Implants may be a therapeutic option for ED sufferers. Unless there are extremely rare instances of total aplasia, as in ED, implants should be inserted when growth is nearly complete.[66] In order to support the child's function and attractiveness, the National Foundation for ED in the USA recommends a complete denture in cases of total aplasia as early as age three.

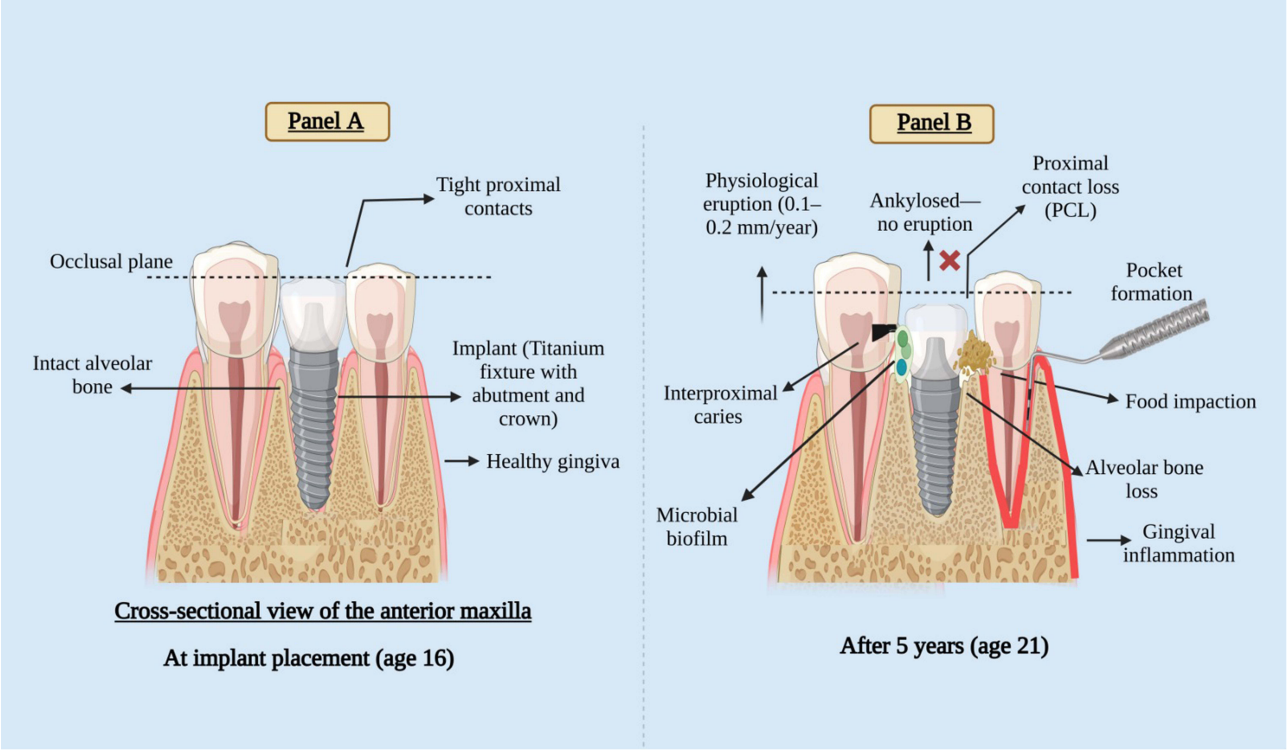

Figure 1 Longitudinal Cross-Sectional Comparison of Implant Infraocclusion and Proximal Contact Loss Over Time [Panel A (age 16) shows ideal occlusion with tight proximal contacts and healthy periodontal tissues immediately after implant placement. Panel B (age 21) illustrates how physiological eruption of adjacent natural teeth, combined with the ankylosed implant's lack of vertical movement, leads to infraocclusion, proximal contact loss (PCL), food impaction, microbial biofilm accumulation, interproximal caries, gingival inflammation, and alveolar bone loss on the adjacent natural tooth].

When the mandible's median suture has already closed, around age six, implants in the lower anterior jaw are advised to support an overdenture. The 1988 National Institute of Health Consensus Development Conference on Dental Implants in Bethesda declared that dental implants might be helpful for young patients with ED.[66] Implants are a viable therapy option for people with ED, and compared to patients who are normally growing, it is recommended to insert the implant earlier, according to numerous studies. Several investigations revealed that implantation of the implants in a developing patient can have some modest issues. Implant submergence, prosthesis remodelling, implant or prosthesis adjustment (implant inclination, vertical height of implant and prosthesis), and implant failure were reported. Maxillary implants were found to have a higher failure rate than mandibular implants. The use of implants in growing patients remains dubious because only clinical reports have been published on the subject, and more clinical studies are required. Parents should be informed about the risks and benefits of having implants placed in their children at a young age, and careful treatment planning that carefully considers benefits and drawbacks is required before beginning any course of treatment.[66]

Acromegaly

Following careful treatment planning and the completion of a patient informed consent form, a fifty-nine-year-old patient with acromegaly received implants in accordance with standard fixed prosthodontic principles. At the time of the final follow-up in the fourth year following implant implantation, the soft tissues were healthy, the bone level surrounding the implant had stabilized since loading, and there were no clinical symptoms of infection. The patient's medical condition, drugs consumed, surgery performed, recall schedule compliance, and at-home and professional maintenance schedule will all affect the prognosis in the future.[68]

Interproximal Contact Loss

Early Presentation of PCL

Some studies indicated that the first PCL can occur within a few months of service, specifically after 3 months,[24,69] 4 months,[26] and 6 months.[29] The approximate prevalence rate of PCL ranged from 3% to 33.5% per year, with a general tendency for the rate to be close to 10% per year.[60] The short-term studies revealed a noticeable prevalence of early PCL. After evaluating proximal contact tightness for 18 participants, Ren et al[69] noticed a statistically significant reduction in tightness after 3 months of service. Within 1 year of service, the prevalence of PCL was found to be 11% in a large-scale study of 4,325 implants,[38] 12.5% in a 7-year prospective analysis,[25] and 24.3% in a 1-year preliminary investigation.[70] According to prospective research, the incidence of PCL increased to 25.7% after two years from 16.5% after one.[71] A comparable prospective study found that the incidence of PCL was 3.3% after one year and surged to 21.3% after two, demonstrating a more than six-fold increase within the second year of function.[72] According to another study, the incidence of PCL decreased to 15% in individuals who used retainers, from 30% in one year to 15%, highlighting a 50% reduction in prevalence with the use of a stabilization appliance.[73]

Patient-Related and Prosthesis-Related Factors

Gender, age increment, vitality of adjacent teeth, the type of opposing dentition, the location of implant prostheses, the strength of occlusal force, and splinting of the adjacent teeth are proposed as potential factors to be considered in regard to PCL, but the correlation remained unclear.[25,26,74] A systematic review by Bento et al[75] stated a prevalence of PCL in 41% in women and 36% in men across a wide age range (19–91 years), suggesting PCL is not exclusively associated with a specific gender or age group. The hierarchy of evidence for these risk factors is summarized in Table 1, which distinguishes between well-supported and inconclusive associations. Findings from long and short follow-up cohorts point to the same pattern. Findings from long and short follow-up cohorts point to the same pattern. Gender shows no measurable effect on proximal contact loss, even when assessed across different age groups and prosthesis locations.[24,25,29,38,76] Age shows a steady rise in both frequency and size of contact loss. This rise appears early in adulthood and becomes more pronounced with advancing age. Mesial contacts show the strongest age-related shift, with several analyses reporting wider and more frequent gaps in older individuals.[25,28,29,38] Saber et al[39] reported no measurable age effect on proximal contact loss. Bompolaki et al[22] found slightly more intact contacts in men, though

Table 1 Evidence Summary of Proposed Risk Factors for Proximal Contact Loss (PCL) Between Implant-Supported Restorations and Adjacent Natural Teeth ["Level of Evidence & Consensus" is Based on the Consistency of Findings Across the Longitudinal and Cross-Sectional Studies Cited in This Review]

Risk Factor	Level of Evidence & Consensus	Key Findings
Time in Function	Strong/High Consensus	Proximal contact loss (PCL) prevalence and gap size increase with time. Incidence rises from 3.3% at 1 year to over 21% by 2 years. Up to 50% of contacts may be lost within 5–9 years.[27,28,38,72]
Surface (Mesial vs. Distal)	Strong/High Consensus	Mesial surfaces are at higher risk. Studies report mesial PCL rates 2.1–5.4 times greater than distal rates, primarily due to physiological mesial drift.[26–28]
Arch Location (Anterior vs. Posterior)	Moderate/Inconclusive	Some studies report higher risk in posterior teeth, while others report higher prevalence in anterior teeth, showing inconsistent findings.[39,75]
Jaw (Maxilla vs. Mandible)	Weak/Inconclusive	Conflicting evidence exists. High-quality studies report higher PCL in both jaws without a definitive pattern.[25,28,70,75]
Patient Age	Weak/Inconclusive	Older age is sometimes associated with higher PCL incidence or gap size, but other studies show no significant effect.[22,25,28–30,39]
Patient Gender	Weak/No Consensus	Gender does not significantly affect PCL, though occasional non-significant trends are observed.[25,29,30,76]

the difference lacked statistical strength, and contact tightness stayed stable across age groups. Yen et al[30] observed a mild male trend toward contact loss that also failed to reach significance and confirmed no age influence. Age, sex, craniofacial growth pattern, and the presence of an implant have been proposed as factors that shape contact behavior over time. Mechanical loading and daily function formed the main drivers across reports. Men with heavy wear, younger patients with active drift, and teeth with limited bone support around single-rooted teeth showed a higher rate of mesial contact loss than distal areas. Removable antagonist prostheses produced a lower rate of contact changes, pointing toward reduced force transmission as the likely reason for slower mesial drift.[25–29]

Location-Specific Differences (Mandible vs Maxilla, Anterior vs Posterior, Mesial vs Distal)

The dental literature of Spyridon Varthis shows high percentages of interproximal loss (PCL) between implant restorations and neighboring teeth, with the mesial side more damaged than distal contacts. The percentages vary from 18% to 66% in the mandible and 37% to 54% in the jaw.[37] In his comprehensive review, Victor Augusto Alves Bento of the studies that were chosen, half had an PCL rate greater than 50%, and the other half had an PCL rate less than 50%. The majority of research that examined the variations between the mesial and distal sides indicated that the mesial side showed greater loss. A higher loss was seen in the maxilla in 50% of the investigations, and a higher loss was seen in the mandible in the other 50%. For the posterior vs anterior regions most of the studies concluded that the posterior region has higher loss.[75]

Pang et al[25] showed a clear pattern of stronger proximal contact loss on the mesial side than the distal side, driven mainly by continuous mesial drift of the adjacent tooth. Their work also showed a higher mesial loss in the maxilla than the mandible. Bompolaki et al[22] tracked contact changes over time and found progressive reduction in mesial tightness during follow-up, while distal contacts remained stable Their analysis showed higher loss at molar sites, with 42.6% at molars, 22.2% at second premolars, and 10% at first premolars. French et al[38] described a different pattern with more openings in the mandible, although this trend was not consistent across studies. Byun et al[27] found more mesial openings next to implants than distal openings and recorded a statistically significant increase in mesial loss, with a 2.1-fold rise compared with distal loss ($P = 0.048$). Proximal contact loss can appear quickly, with noticeable gaps forming within three months of placing the prosthesis. Natural teeth continue to drift mesially and erupt to compensate for wear and alveolar changes, while an osseointegrated implant remains fixed. This difference causes the natural tooth to move away

from the implant restoration, creating an open contact. The gap allows food to accumulate and plaque to build up, which can trigger inflammation in the surrounding soft tissues.[76–80] Varthis et al[23] reported that mesial surfaces have a higher rate of contact loss, with 57.9% of cases involving the maxilla due to growth-related factors affecting the mandible and maxilla, contributing to PCL. PCL was observed in 47.8% of anterior and 53.6% of posterior implant restorations. Saber et al[39] found mesial interproximal contact loss in 42.1% of cases, compared to 14.5% for distal contacts, with no significant difference between the maxilla and mandible. In contrast, the anterior region showed a higher PCL prevalence than the posterior region. Shi et al[70] reported higher PCL rates in the mandibular arch (37.2%) than in the maxilla (9.1%; P>0.01), while arch location overall did not significantly influence PCL. Koori et al[28] observed interproximal contact loss in 43% of patients, with 51.8% of mesial contacts affected versus 15.6% of distal contacts, and greater loss in the mandible than the maxilla. Ren et al[69] demonstrated that distal contacts maintained significantly higher tightness than mesial contacts at one year (P<0.001). Chao-Hua et al[26] found 27% of mesial contacts and 5% of distal contacts were open, showing a 5.4-fold higher PCL rate on the mesial side, consistent with mesial drift. Jui-Ying et al[30] confirmed that distal contacts have lower PCL risk than mesial contacts (P<0.05), with no significant difference between mandibular and maxillary arches. Mehanna et al[76] reported no statistically significant differences in PCL between maxilla and mandible or between mesial and distal surfaces. These findings constantly show that mesial contacts are more susceptible to PCL than distal contacts, and mandibular and maxillary arches can both be affected, though the extent varies by study. Figure 2 describes a 3D schematic of the dental arches illustrates the common sites for PCL between implant-supported restorations (gray) and natural teeth. The image highlights the significantly higher prevalence of PCL on the mesial surface (52%) compared to the distal surface (16%). The mandible is noted as a higher-risk site. The detailed view (right)

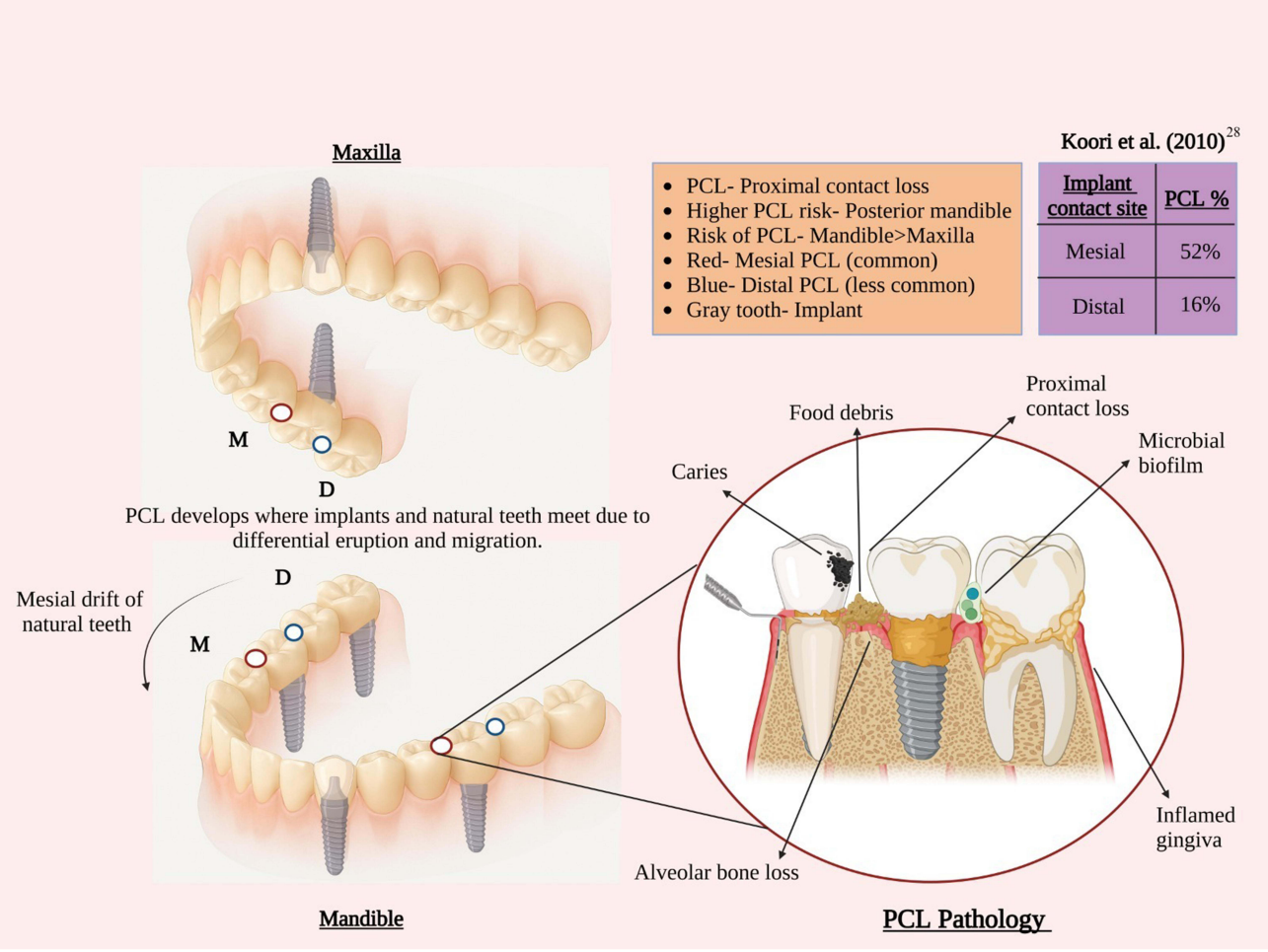

Figure 2 Etiology, Prevalence, and Consequences of Proximal Contact Loss (PCL).[28]

depicts the pathological sequelae of PCL: the mesial drift and continued eruption of the natural tooth away from the ankylosed implant create an open contact. This space leads to food impaction, microbial biofilm accumulation, gingival inflammation, alveolar bone loss, and ultimately, interproximal caries on the adjacent natural tooth.

Time in Function (Timing of Placement)

Proximal contact loss (PCL) increases with time following implant-supported restoration placement. Studies have observed measurable contact loss as early as three months after prosthesis delivery, and this loss continues progressively over the years.[28–30,38,69,70,76,77,81] The Kaplan-Meier method indicates that 50% of proximal contacts may be lost within three to nine years depending on the cohort and study design.[27,28,77] Short-term prospective studies can precisely track the timing of PCL, while retrospective and cross-sectional analyses report cumulative losses without exact timepoints.[25,28,38,70,75] The number of open contacts and the distance between the implant restoration and adjacent teeth increase over time.[28,77] Early PCL can appear within months after crown insertion, with some sites showing contact loosening within the first year, which may worsen progressively during follow-up periods extending up to twelve years.[28–30,38,69,70,76,77,81] Mesial contacts show a higher prevalence and earlier loss than distal contacts, reflecting the ongoing physiological mesial drift of natural teeth.[26,28,77] Long-term observations report that PCL rates continue to rise steadily, with approximately half of the interproximal contacts affected by five to nine years.[26–28] During follow-up periods, the PCL rate can increase by 9% annually, while tight contacts gradually loosen, and open contacts accumulate over time.[26–28,77] The loss occurs in both anterior and posterior regions, and both maxillary and mandibular arches are affected, though the extent varies by site and arch.[26–28,70,77] Functional loading contributes to the progression of PCL, and contact tightness diminishes gradually during the first few months after restoration delivery.[69,76] Cumulative data indicate that mesial contact loss predominates, with a higher proportion of open contacts observed in molar sites compared to premolars.[26,28,77] Distal contacts remain comparatively more stable, and early contact loss at distal surfaces is less frequent even over extended follow-up.[26,28] The timing of PCL differs across studies due to variations in study design, follow-up duration, and measurement methods. Prospective longitudinal studies provide precise timing of contact loss, while cross-sectional or retrospective analyses report prevalence at discrete timepoints, which may underestimate early events.[25,28,38,70,77] The progressive nature of PCL emphasizes the need for continuous monitoring of implant restorations, as interproximal contact deterioration can occur shortly after prosthesis delivery and continue throughout the functional life of the restoration. Early identification and management of open contacts may prevent food impaction, plaque accumulation, and peri-implant tissue inflammation.

Prevention of PCL (Retainer Usage)

Numerous studies have reported various strategies to avoid or prevent PCL, including tightening the proximal contact during restoration installation, scheduling routine follow-ups, and employing a removable retainer to lessen the movement of the natural teeth.[70,76,82] The proximal contact tightness between an implant-supported prosthesis for a single tooth and the neighboring natural teeth, both with and without the use of an Essix retainer, was assessed in a study by Kandathilparambil et al[73] According to this study, using an Essix retainer, primarily on the mesial side, reduced the incidence of PCL by 15%. The use of Essix retainers has been suggested by many studies to minimize movement of teeth post-restoration delivery, thus maintaining the arch integrity.[26,40,70,73,74,83,84]

PCL as a Risk Factor for Interproximal Caries

The clinical significance of proximal contact loss extends beyond mechanical issues and patient discomfort to pose a direct biological threat to the adjacent natural dentition. The open embrasure created by PCL serves as a site for food impaction and plaque retention, fundamentally altering the local ecological niche.[77] This stagnation promotes a shift in the oral microbiota, facilitating the formation of a cariogenic biofilm that is notoriously difficult for patients to remove through routine oral hygiene measures.[33,40] The association between food impaction from PCL and adverse peri-implant soft tissue conditions has been directly documented, with one study finding inflammatory changes in over 50% of cases where food was impacted.[31] This localized inflammatory environment compromises the periodontal health of the adjacent tooth and, combined with prolonged plaque accumulation, creates ideal conditions for caries initiation.[40] The

inability to clean the open contact effectively allows for sustained acid production by cariogenic bacteria, leading directly to demineralization of the vulnerable proximal surface of the adjacent natural tooth.[21,77] PCL should be regarded not merely as a prosthetic complication but as a significant and direct risk factor for the development of interproximal dental caries.

Clinical Implications

PCL between implant-supported restorations and neighboring natural teeth can cause food impaction, discomfort, caries, and patient dissatisfaction. PCL is more common in the mandibular arch due to mesial drift of adjacent teeth, arch growth patterns, and occlusal plane changes. Preventive measures include ensuring firm proximal contacts when placing restorations, scheduling regular follow-ups, and using removable retainers like Essix retainers. Controlling occlusal plane discrepancies can prevent implant infraocclusion, and monitoring long-term changes is critical in younger patients. Regular radiographs help track peri-implant health and identify complications early. These practices reduce PCL risk and help maintain implant function and patient satisfaction.

Conclusion

PCL, or the space created between neighboring natural teeth and implant restorations, is a common problem that raises the risk of interproximal caries, which can have a serious negative effect on oral health. Important roles are played by variables such implant placement, follow-up length, and microbial dysbiosis in the development of PCL and its aftereffects. Timely placement of dental implants and age and gender modification in growth should be taken in consideration during implantation. It takes suitable treatment techniques and routine monitoring to reduce these risks and preserve oral health.

Data Sharing Statement

The data supporting the findings of the article is available within the article.

Funding

No funding was received for this research.

Disclosure

The authors have no potential competing interests to declare for this work.

References

1. Misch CE. *Dental Implant Prosthetics*. 2nd ed. St.Louis: Elsevier Mosby; 2015.
2. Levine R, Martin W. Esthetic risk assessment in implant dentistry. *Inside Dentistry*. 2012;8(8):66–71.
3. Gupta R, Gupta N, Weber DK. *Dental Implants*. Treasure Island (FL): StatPearls; 2022.
4. Howe M-S, Keys W, Richards D. Long-term (10-year) dental implant survival: a systematic review and sensitivity meta-analysis. *J Dent*. 2019;84:9–21. doi:10.1016/j.jdent.2019.03.008
5. Blanes RJ, Bernard JP, Blanes ZM, Belser UC. A 10-year prospective study of ITI dental implants placed in the posterior region. II: influence of the crown-to-implant ratio and different prosthetic treatment modalities on crestal bone loss. *Clin Oral Implants Res*. 2007;18(6):707–714. doi:10.1111/j.1600-0501.2006.01307.x
6. Moraschini V, Poubel LA, Ferreira VF, Barboza Edos S. Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: a systematic review. *Int J Oral Maxillofac Surg*. 2015;44(3):377–388. doi:10.1016/j.ijom.2014.10.023
7. Jofre J, Castiglioni X, Lobos CA. Influence of minimally invasive implant-retained overdenture on patients' quality of life: a randomized clinical trial. *Clin Oral Implants Res*. 2013;24(10):1173–1177. doi:10.1111/j.1600-0501.2012.02529.x
8. Tang L, Lund JP, Tache R, Clokie CM, Feine JS. A within-subject comparison of mandibular long-bar and hybrid implant-supported prostheses: evaluation of masticatory function. *J Dent Res*. 1999;78(9):1544–1553. doi:10.1177/00220345990780090901
9. Topcu AO, Yamalik N, Guncu GN, et al. Implant-site related and patient-based factors with the potential to impact patients' satisfaction, quality of life measures and perceptions toward dental implant treatment. *Implant Dent*. 2017;26(4):581–591. doi:10.1097/ID.0000000000000623
10. Zhang L, Lyu C, Shang Z, Niu A, Liang X. Quality of life of implant-supported overdenture and conventional complete denture in restoring the edentulous mandible: a systematic review. *Implant Dent*. 2017;26(6):945–950. doi:10.1097/ID.0000000000000668
11. Hanif A, Qureshi S, Sheikh Z, Rashid H. Complications in implant dentistry. *Eur J Dent*. 2017;11(1):135–140. doi:10.4103/ejd.ejd_340_16
12. Jemt T. Measurements of tooth movements in relation to single-implant restorations during 16 years: a case report. *Clin Implant Dent Relat Res*. 2005;7(4):200–208. doi:10.1111/j.1708-8208.2005.tb00065.x

13. Muhlemann S, Lakha T, Jung RE, Hammerle CHF, Benic GI. Prosthetic outcomes and clinical performance of CAD-CAM monolithic zirconia versus porcelain-fused-to-metal implant crowns in the molar region: 1-year results of a RCT. *Clin Oral Implants Res*. 2020;31(9):856–864. doi:10.1111/clr.13631
14. Pjetursson BE, Lang NP. Prosthetic treatment planning on the basis of scientific evidence. *J Oral Rehabil*. 2008;35(Suppl s1):72–79. doi:10.1111/j.1365-2842.2007.01824.x
15. Kreissl ME, Gerds T, Muche R, Heydecke G, Strub JR. Technical complications of implant-supported fixed partial dentures in partially edentulous cases after an average observation period of 5 years. *Clin Oral Implants Res*. 2007;18(6):720–726. doi:10.1111/j.1600-0501.2007.01414.x
16. Kim Y, Oh T-J, Misch CE, Wang H-L. Occlusal considerations in implant therapy: clinical guidelines with biomechanical rationale. *Clin Oral Implants Res*. 2005;16(1):26–35. doi:10.1111/j.1600-0501.2004.01067.x
17. Cooper LF, De Kok IJ, Thalji G, Bryington MS. Prosthodontic management of implant therapy: esthetic complications. *Dent Clin North Am*. 2019;63(2):199–216. doi:10.1016/j.cden.2018.11.003
18. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JYK. Clinical complications with implants and implant prostheses. *J Prosthet Dent*. 2003;90(2):121–132. doi:10.1016/S0022-3913(03)00212-9
19. Pjetursson BE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDP s) after a mean observation period of at least 5 years. *Clin Oral Implants Res*. 2012;23(Suppl s6):22–38. doi:10.1111/j.1600-0501.2012.02546.x
20. Andersson B, Bergenblock S, Furst B, Jemt T. Long-term function of single-implant restorations: a 17- to 19-year follow-up study on implant infraposition related to the shape of the face and patients' satisfaction. *Clin Implant Dent Relat Res*. 2013;15(4):471–480. doi:10.1111/j.1708-8208.2011.00381.x
21. Jo D-W, Kwon M-J, Kim J-H, Kim Y-K, Yi Y-J. Evaluation of adjacent tooth displacement in the posterior implant restoration with proximal contact loss by superimposition of digital models. *J Adv Prosthodont*. 2019;11(2):88–94. doi:10.4047/jap.2019.11.2.88
22. Bompolaki D, Edmondson SA, Katancik JA. 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. *J Prosthet Dent*. 2022;127(3):418–424. doi:10.1016/j.prosdent.2020.09.034
23. Varthis S, Randi A, Tarnow DP. Prevalence of interproximal open contacts between single-implant restorations and adjacent teeth. *Int J Oral Maxillofac Implants*. 2016;31(5):1089–1092. doi:10.11607/jomi.4432
24. Wei H, Tomotake Y, Nagao K, Ichikawa T. Implant prostheses and adjacent tooth migration: preliminary retrospective survey using 3-dimensional occlusal analysis. *Int J Prosthodont*. 2008;21(4):302–304.
25. Pang N-S, Suh C-S, Kim K-D, Park W, Jung B-Y. Prevalence of proximal contact loss between implant-supported fixed prostheses and adjacent natural teeth and its associated factors: a 7-year prospective study. *Clin Oral Implants Res*. 2017;28(12):1501–1508. doi:10.1111/clr.13018
26. Liang C-H, Nien C-Y, Chen Y-L, Hsu K-W. The prevalence and associated factors of proximal contact loss between implant restoration and adjacent tooth after function: a retrospective study. *Clin Implant Dent Relat Res*. 2020;22(3):351–358. doi:10.1111/cid.12918
27. Byun S-J, Heo S-M, Ahn S-G, Chang M. Analysis of proximal contact loss between implant-supported fixed dental prostheses and adjacent teeth in relation to influential factors and effects. A cross-sectional study. *Clin Oral Implants Res*. 2015;26(6):709–714. doi:10.1111/clr.12373
28. Koori H, Morimoto K, Tsukiyama Y, Koyano K. Statistical analysis of the diachronic loss of interproximal contact between fixed implant prostheses and adjacent teeth. *Int J Prosthodont*. 2010;23(6):535–540.
29. Wong ATY, Wat PYP, Pow EHN, Leung KCM. Proximal contact loss between implant-supported prostheses and adjacent natural teeth: a retrospective study. *Clin Oral Implants Res*. 2015;26(4):e68–e71. doi:10.1111/clr.12353
30. Yen J-Y, Kang L, Chou I-C, Lai Y-L, Lee S-Y. Risk assessment of interproximal contact loss between implant-supported fixed prostheses and adjacent teeth: a retrospective radiographic study. *J Prosthet Dent*. 2022;127(1):86–92. doi:10.1016/j.prosdent.2020.06.023
31. Chanthasan S, Subbalekha K, Pisarnturakit PP. Association between food impaction and peri implant soft tissue condition at proximal space between implant supported single crown and natural teeth. *RSU International Research Conference*; 2020.
32. Pjetursson BE, Bragger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). *Clin Oral Implants Res*. 2007;18(Suppl s3):97–113. doi:10.1111/j.1600-0501.2007.01439.x
33. Bidra AS. Nonsurgical management of inflammatory periimplant disease caused by food impaction: a clinical report. *J Prosthet Dent*. 2014;111(2):96–100. doi:10.1016/j.prosdent.2013.06.017
34. Dorfer CE, von Bethlenfalvy ER, Staehle HJ, Pioch T. Factors influencing proximal dental contact strengths. *Eur J Oral Sci*. 2000;108(5):368–377. doi:10.1034/j.1600-0722.2000.108005368.x
35. Gastaldo JF, Cury PR, Sendyk WR. Effect of the vertical and horizontal distances between adjacent implants and between a tooth and an implant on the incidence of interproximal papilla. *J Periodontol*. 2004;75(9):1242–1246. doi:10.1902/jop.2004.75.9.1242
36. Cosyn J, Raes M, Packet M, Cleymaet R, De Bruyn H. Disparity in embrasure fill and papilla height between tooth- and implant-borne fixed restorations in the anterior maxilla: a cross-sectional study. *J Clin Periodontol*. 2013;40(7):728–733. doi:10.1111/jcpe.12116
37. Varthis S, Tarnow DP, Randi A. Interproximal open contacts between implant restorations and adjacent teeth. prevalence – causes – possible solutions. *J Prosthodont*. 2019;28(2):e806–e810. doi:10.1111/jopr.12980
38. French D, Naito M, Linke B. Interproximal contact loss in a retrospective cross-sectional study of 4325 implants: distribution and incidence and the effect on bone loss and peri-implant soft tissue. *J Prosthet Dent*. 2019;122(2):108–114. doi:10.1016/j.prosdent.2018.11.011
39. Saber A, Chakar C, Mokbel N, Nohra J. Prevalence of interproximal contact loss between implant-supported fixed prostheses and adjacent teeth and its impact on marginal bone loss: a retrospective study. *Int J Oral Maxillofac Implants*. 2020;35(3):625–630. doi:10.11607/jomi.7926
40. Jeong J-S, Chang M. Food impaction and periodontal/peri-implant tissue conditions in relation to the embrasure dimensions between implant-supported fixed dental prostheses and adjacent teeth: a cross-sectional study. *J Periodontol*. 2015;86(12):1314–1320. doi:10.1902/jop.2015.150322
41. Bernard JP, Schatz JP, Christou P, Belser U, Kiliaridis S. Long-term vertical changes of the anterior maxillary teeth adjacent to single implants in young and mature adults. *J Clin Periodontol*. 2004;31(11):1024–1028. doi:10.1111/j.1600-051X.2004.00574.x
42. Chang M, Wennstrom JL. Longitudinal changes in tooth/single-implant relationship and bone topography: an 8-year retrospective analysis. *Clin Implant Dent Relat Res*. 2012;14(3):388–394. doi:10.1111/j.1708-8208.2010.00272.x

43. Bonfante EA, Leary J, Daher S, Murcko L, Hirayama M, Bergamo ET. Implants placed in adolescents followed for up to 15.5 years: a retrospective case series. *Int J Oral Maxillofac Implants*. 2021;36(3):561–568. doi:10.11607/jomi.8574
44. Cocchetto R, Canullo L, Celletti R. Infraposition of implant-retained maxillary incisor crown placed in an adult patient: case report. *Int J Oral Maxillofac Implants*. 2018;33(4):e107–e111. doi:10.11607/jomi.6681
45. Huanca Ghislanzoni L, Jonasson G, Kiliaridis S. Continuous eruption of maxillary teeth and changes in clinical crown length: a 10-year longitudinal study in adult women. *Clin Implant Dent Relat Res*. 2017;19(6):1082–1089. doi:10.1111/cid.12545
46. Thilander B, Odman J, Groteborg K, Friberg B. Osseointegrated implants in adolescents. An alternative in replacing missing teeth? *Eur J Orthod*. 1994;16(2):84–95. doi:10.1093/ejo/16.2.84
47. Oesterle LJ, Cronin RJ. Adult growth, aging, and the single-tooth implant. *Int J Oral Maxillofac Implants*. 2000;15(2):252–260.
48. Forsberg CM. Facial morphology and ageing: a longitudinal cephalometric investigation of young adults. *Eur J Orthod*. 1979;1(1):15–23. doi:10.1093/ejo/1.1.15
49. Behrents RG. *Growth in the Aging Craniofacial Skeleton*. Ann Arbor, Michigan: Center for Human Growth and Development, University of Michigan; 1985.
50. Bishara SE, Treder JE, Jakobsen JR. Facial and dental changes in adulthood. *Am J Orthod Dentofacial Orthop*. 1994;106(2):175–186. doi:10.1016/S0889-5406(94)70036-2
51. Thilander B, Odman J, Jemt T. Single implants in the upper incisor region and their relationship to the adjacent teeth. An 8-year follow-up study. *Clin Oral Implants Res*. 1999;10(5):346–355. doi:10.1034/j.1600-0501.1999.100502.x
52. Mijiritsky E, Badran M, Kleinman S, Manor Y, Peleg O. Continuous tooth eruption adjacent to single-implant restorations in the anterior maxilla: aetiology, mechanism and outcomes – a review of the literature. *Int Dental J*. 2020;70(3):155–160. doi:10.1111/idj.12549
53. Schwartz Arad D, Bichacho N. Effect of age on single implant submersion rate in the central maxillary incisor region: a long-term retrospective study. *Clin Implant Dent Relat Res*. 2015;17(3):509–514. doi:10.1111/cid.12131
54. Forsberg C-M, Eliasson S, Westergren H. Face height and tooth eruption in adults-- a 20-year follow-up investigation. *Eur J Orthod*. 1991;13(4):249–254. doi:10.1093/ejo/13.4.249
55. Jemt T. Single implants in the anterior maxilla after 15 years of follow-up: comparison with central implants in the edentulous maxilla. *Int J Prosthodont*. 2008;21(5):400–408.
56. Lundstrom A. Changes in crowding and spacing of the teeth with age. *Dental Practit Dental Record*. 1969;19(6):218–224.
57. Bishara SE, Treder JE, Damon P, Olsen M. Changes in the dental arches and dentition between 25 and 45 years of age. *Angle Orthod*. 1996;66(6):417–422. doi:10.1043/0003-3219(1996)066<0417:CITDAA>2.3.CO;2
58. Carter GA, McNamara JA Jr. Longitudinal dental arch changes in adults. *Am J Orthod Dentofacial Orthop*. 1998;114(1):88–97. doi:10.1016/S0889-5406(98)70243-4
59. Tibana RHW, Palagi LM, Miguel JAM. Changes in dental arch measurements of young adults with normal occlusion--a longitudinal study. *Angle Orthod*. 2004;74(5):618–623. doi:10.1043/0003-3219(2004)074<0618:CIDAMO>2.0.CO;2
60. Abduo J, Lau D. Proximal contact loss between implant prostheses and adjacent natural teeth: a qualitative systematic review of prevalence, influencing factors and implications. *Heliyon*. 2022;8(8):e10064. doi:10.1016/j.heliyon.2022.e10064
61. Odman J, Gröndahl K, Lekholm U, Thilander B. The effect of osseointegrated implants on the dento-alveolar development. A clinical and radiographic study in growing pigs. *Eur J Orthod*. 1991;13(4):279–286. doi:10.1093/ejo/13.4.279
62. Bjork A, Skieller V. Growth of the maxilla in three dimensions as revealed radiographically by the implant method. *Br J Orthod*. 1977;4(2):53–64. doi:10.1179/bjo.4.2.53
63. Richter E-J. Basic biomechanics of dental implants in prosthetic dentistry. *J Prosthet Dent*. 1989;61(5):602–609. doi:10.1016/0022-3913(89)90285-0
64. Op Heij DG, Opdebeeck H, van Steenberghe D, Quirynen M. Age as compromising factor for implant insertion. *Periodontol 2000*. 2003;33(1):172–184. doi:10.1046/j.0906-6713.2003.03314.x
65. Heij DGO, Opdebeeck H, van Steenberghe D, Kokich VG, Belser U, Quirynen M. Facial development, continuous tooth eruption, and mesial drift as compromising factors for implant placement. *Int J Oral Maxillofac Implants*. 2006;21(6):867–878.
66. Mishra SK, Chowdhary N, Chowdhary R. Dental implants in growing children. *J Indian Soc Pedodontics Preventive Dent*. 2013;31(1):3–9. doi:10.4103/0970-4388.112392
67. Salinas T. Implant placement in developing patients. *Prac Procedures Aesthetic Dentistry*. 2005;17(1):14.
68. Kernen FR, Bidra AS. Dental implant therapy in a patient with acromegaly: a clinical report. *J Prosthodont*. 2019;28(4):355–360. doi:10.1111/jopr.13043
69. Ren S, Lin Y, Hu X, Wang Y. Changes in proximal contact tightness between fixed implant prostheses and adjacent teeth: a 1-year prospective study. *J Prosthet Dent*. 2016;115(4):437–440. doi:10.1016/j.prosdent.2015.08.018
70. Shi J-Y, Zhu Y, Gu Y-X, Lai H-C. Proximal contact alterations between implant-supported restorations and adjacent natural teeth in the posterior region: a 1-year preliminary study. *Int J Oral Maxillofac Implants*. 2019;34(1):165–168. doi:10.11607/jomi.6870
71. Abduo J, Lee CL, Sarfarazi G, Xue B, Judge R, Darby I. Encode protocol versus conventional protocol for single-implant restoration: a prospective 2-year follow-up randomized controlled trial. *J Oral Implantol*. 2021;47(1):36–43. doi:10.1563/aaid-joi-D-19-00150
72. Wolfart S, Rittich A, Gross K, et al. Cemented versus screw-retained posterior implant-supported single crowns: a 24-month randomized controlled clinical trial. *Clin Oral Implants Res*. 2021;32(12):1484–1495. doi:10.1111/clr.13849
73. Kandathilparambil MR, Nelluri VV, Vayadadi BC, Gajjam NK. Evaluation of biological changes at the proximal contacts between single-tooth implant-supported prosthesis and the adjacent natural teeth – an in vivo study. *J Indian Prosthodontic Soci*. 2020;20(4):378–386. doi:10.4103/jips.jips_155_20
74. Chen Q, Shi Y, Zhang Z, Song G. A single-center study of a resin inlay dental implant-fixed prosthesis for closing proximal contact loss in 89 patients who underwent 3-year follow-up. *Med Sci Monit*. 2021;27:e933809. doi:10.12659/MSM.933809
75. Bento VAA, Gomes JML, Lemos CAA, Limirio J, Rosa C, Pellizzer EP. Prevalence of proximal contact loss between implant-supported prostheses and adjacent natural teeth: a systematic review and meta-analysis. *J Prosthet Dent*. 2023;129(3):404–412. doi:10.1016/j.prosdent.2021.05.025
76. Mehanna S, Habre-Hallage P. Proximal contact alterations between implant-supported restorations and adjacent teeth in the posterior region: a 3-month prospective study. *J Clin Exp Dent*. 2021;13(5):e479–e86. doi:10.4317/jced.57802

77. Greenstein G, Carpentieri J, Cavallaro J. Open contacts adjacent to dental implant restorations: etiology, incidence, consequences, and correction. *J Am Dent Assoc*. 2016;147(1):28–34. doi:10.1016/j.adaj.2015.06.011
78. Kaplan P. Drifting, tipping, supraeruption, and segmental alveolar bone growth. *J Prosthet Dent*. 1985;54(2):280–283. doi:10.1016/0022-3913(85)90305-1
79. Ito H, Okimoto K, Mizumori T, Terada Y, Maruyama T. A clinical study of the relationship between occlusal curvature and craniomandibular disorders. *Int J Prosthodont*. 1997;10(1):78–82.
80. Wolpoff MH. Interstitial wear. *Am J Phys Anthropol*. 1971;34(2):205–227. doi:10.1002/ajpa.1330340206
81. Wat PYP, Wong ATY, Leung KCM, Pow EHN. Proximal contact loss between implant-supported prostheses and adjacent natural teeth: a clinical report. *J Prosthet Dent*. 2011;105(1):1–4. doi:10.1016/S0022-3913(10)00174-5
82. Latimer JM, Gharpure AS, Kahng HJ, Aljofi FE, Daubert DM. Interproximal open contacts between implant restorations and adjacent natural teeth as a risk-indicator for peri-implant disease—A cross-sectional study. *Clin Oral Implants Res*. 2021;32(5):598–607. doi:10.1111/clr.13730
83. Sfondouris T, Prestipino V. Chairside management of an open proximal contact on an implant-supported ceramic crown using direct composite resin. *J Prosthet Dent*. 2019;122(1):1–4. doi:10.1016/j.prosdent.2018.10.019
84. Littlewood SJ, Kandasamy S, Huang G. Retention and relapse in clinical practice. *Australian Dental Journal*. 2017;62(Suppl S1):51–57. doi:10.1111/adj.12475