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Complications and clinical solutions in implant prosthodontics: a narrative review

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Abstract

Objective

This narrative review synthesizes the current literature on complications in implant prosthodontics, focusing on the management and prevention of the most common issues in implant-supported fixed restorations. Its objective is to offer practical guidance for clinicians in their decision-making processes.

Method

A non-systematic literature review was conducted using PubMed/MEDLINE and Scopus. The following keywords were used: “complications” AND “implant” AND “prosthesis” OR “restoration”. Filters applied: from 1 January 2016 to 31 December 2025 (last 10 years). Subject area: Dentistry. This study focused on articles, clinical studies, and in vitro studies concerning complications in implant prosthodontics, with particular reference to the management and prevention of complications in implant-supported fixed restorations.

Results and discussion

Implant-supported fixed restorations can present various complications, which can be divided into main categories. Biological complications affect the hard and soft tissues surrounding the implant and are classified as early or late. Mechanical and technical complications, on the other hand, involve the components of the prosthetic restoration and the structure of the implant itself. Aesthetic complications concern all aspects that negatively impact the patient’s aesthetic satisfaction, while functional complications compromise masticatory and biomechanical function. Issues related to implant-supported prostheses are fairly common. They can range from minor, easily resolvable situations to serious and complex complications requiring significant intervention, both in terms of time and cost, sometimes necessitating a complete redo of the restoration. Preventing such complications begins with a meticulous selection of the clinical case, which first and foremost involves assessing the patient’s compliance and their systemic health. Accurate surgical and prosthetic planning is then the next crucial step in minimizing the risk of complications. Implant placement and angulation, prosthetic design, selection of prosthetic materials, and occlusion are key factors that must be carefully planned during the preliminary phase to effectively prevent potential complications.

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Conclusion

A comprehensive understanding of complications in implant prosthodontics is a key factor in clinical success, and knowing how to prevent them or detect them early is crucial to patient satisfaction. Implant-supported fixed restorations can be subject to various complications, which are primarily categorized as biological, mechanical, and technical, in addition to those of an aesthetic and functional nature. These fairly common issues can affect all components of the implant-prosthesis system and range from minor, easily manageable situations to more complex circumstances that require interventions that are more demanding in terms of both cost and time. In some cases, a complete redo of the restoration is necessary. Among the main causes that increase the likelihood of complications are implant malposition and occlusal overload, factors that significantly impact biomechanical risk, placing a heavy strain on both the prosthesis and the supporting implants. Full-arch implant-supported fixed prostheses are considered to be at the highest risk of complications and the need for re-treatment compared to other types of restorations.

Keywords: Implant prosthodontics; Implant-supported restorations; Biological complications; Prosthetic complications; Complication prevention; Complication management; Clinical solutions.

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Introduction

Implant-supported fixed restorations are a modern alternative to conventional prosthetic treatments; they represent the gold standard for treating partial and complete edentulism, allow for the stable and long-lasting replacement of missing teeth, and can restore masticatory function and aesthetics, thereby improving oral health and enabling a return to a normal lifestyle [1-3]. Several studies have documented that implant-supported fixed restorations demonstrate a favorable long-term prognosis, highlighting favorable clinical outcomes with high implant and prosthetic survival rates, high levels of patient satisfaction, and improved masticatory function and aesthetics [4-7]. Advances in imaging techniques, virtual surgical planning, implant design, prosthetic connections, prosthetic technologies, and fabrication materials have contributed to the evolution of implant prosthodontics, simplifying the implementation of these solutions from both a design and fabrication perspective [8]. The retention method, framework design, and combination of prosthetic materials are the main differences among the implant-prosthetic treatment options available today. Dentists now have access to a wide range of prosthetic material combinations with varying degrees of mechanical and aesthetic performance, selected based on clinical criteria and the patient's financial resources [3]. Fixed implant-supported prostheses, however, regardless of the extent of the restoration, the design, and the materials used, are not without complications: they can present problems at all levels due to various variables and especially in cases where biomechanical risk factors are present. The realization of a fixed implant-supported prosthesis capable of providing aesthetics, functional stability, and a favorable long-term prognosis requires understanding, preventing, and managing potential complications. This study aims to provide a narrative review synthesizing the current literature on complications and clinical solutions in implant prosthodontics. The review focuses on the management and prevention of the most common issues in implant-supported fixed restorations. Its objective is to offer practical guidance for clinicians in their decision-making processes.

Methods

A non-systematic literature review was conducted using PubMed/MEDLINE and Scopus. The following keywords were used: "complications" AND "implant" AND "prosthesis" OR "restoration". Filters applied: from 1 January 2016 to 31 December 2025 (last 10 years). Subject area: Dentistry. This study focused on articles, clinical studies, and in vitro studies concerning complications in implant prosthodontics, with particular reference to the management and prevention of complications in implant-supported fixed restorations.

Biological complications associated with implant-supported restorations

Biological complications affect the peri-implant tissues and include typical conditions such as microbial plaque accumulation, bleeding, suppuration, pain, loss of peri-implant tissues, and sensory disturbances [1,9]. Among the most common biological complications are failed implant osseointegration, peri-implant mucositis, and peri-implantitis. Biological complications can be classified as early or late. Early biological complications include osseointegration problems, inflammation, and infections that can lead to implant failure [1]. These complications are often linked to systemic conditions, surgical errors, inadequate aseptic conditions, and poor oral hygiene. Early implant failures result from the bone tissue's inability to achieve osseointegration. They are statistically associated with smoking, poor bone quantity and quality, reduced fixture length, and the posterior position of the implant [10-12]. The most common late biological complications in implant-supported prostheses are peri-implant diseases, particularly mucositis and peri-implantitis [13]. Peri-implant disease is defined as the pathological inflammatory process that occurs in the soft and hard tissues surrounding an osseointegrated implant and results from an imbalance between the host's defenses and the increasing bacterial load [1]. Among the biological complications, peri-implantitis is the most feared due to its complex management [14]. Peri-implant mucositis, clinically characterized by bleeding, swelling, and redness, can be effectively controlled if treated promptly. Peri-implantitis is a more severe condition, defined as "a pathological condition associated with the presence of plaque, inflammation of the peri-implant mucosa, and progressive loss of supporting bone" [15]. It develops when mucositis goes untreated or persists, and the etiopathogenic pathway is triggered by a bacterial infection that activates a cytokine cascade leading to bone loss. Sites affected by peri-implantitis exhibit characteristic clinical signs such as inflammation, bleeding on probing and/or suppuration, mucosal margin recession, and/or increased probing depth with radiographically detectable peri-implant bone loss. In implant-supported prostheses, peri-implantitis represents the most frequent biological complication and the leading cause of late implant failures [4,16-17]. In sites with peri-implantitis, probing depth is an indicator of disease severity [15]. For this reason, the stability of the peri-implant bone tissue is one of the most important clinical parameters in determining the prognosis and success of implant rehabilitation. Numerous local and systemic factors, as well as iatrogenic factors and other factors not yet fully recognized, can influence the outcome of implant-prosthetic therapy [18]. The current literature has sought to identify factors that could increase a site's susceptibility to peri-implantitis, identifying five factors — implant design, implant site, prosthesis, and operator- and patient-related variables — that may have a synergistic effect on the host's overall response to bacterial plaque at implant sites [19]. There is still limited evidence linking peri-implantitis to certain factors such as the presence of submucosal cement or implant placement. The role played by other factors, including occlusal overload, has yet to be defined [15]. Some authors have pointed out that the odds ratio for peri-implantitis in healthy implants is 48.2 in cases of implant malposition, 18.7 in cases of occlusal overload, and 3.7 in cases of technical-prosthetic complications [9]. In a recent retrospective study, a cumula-

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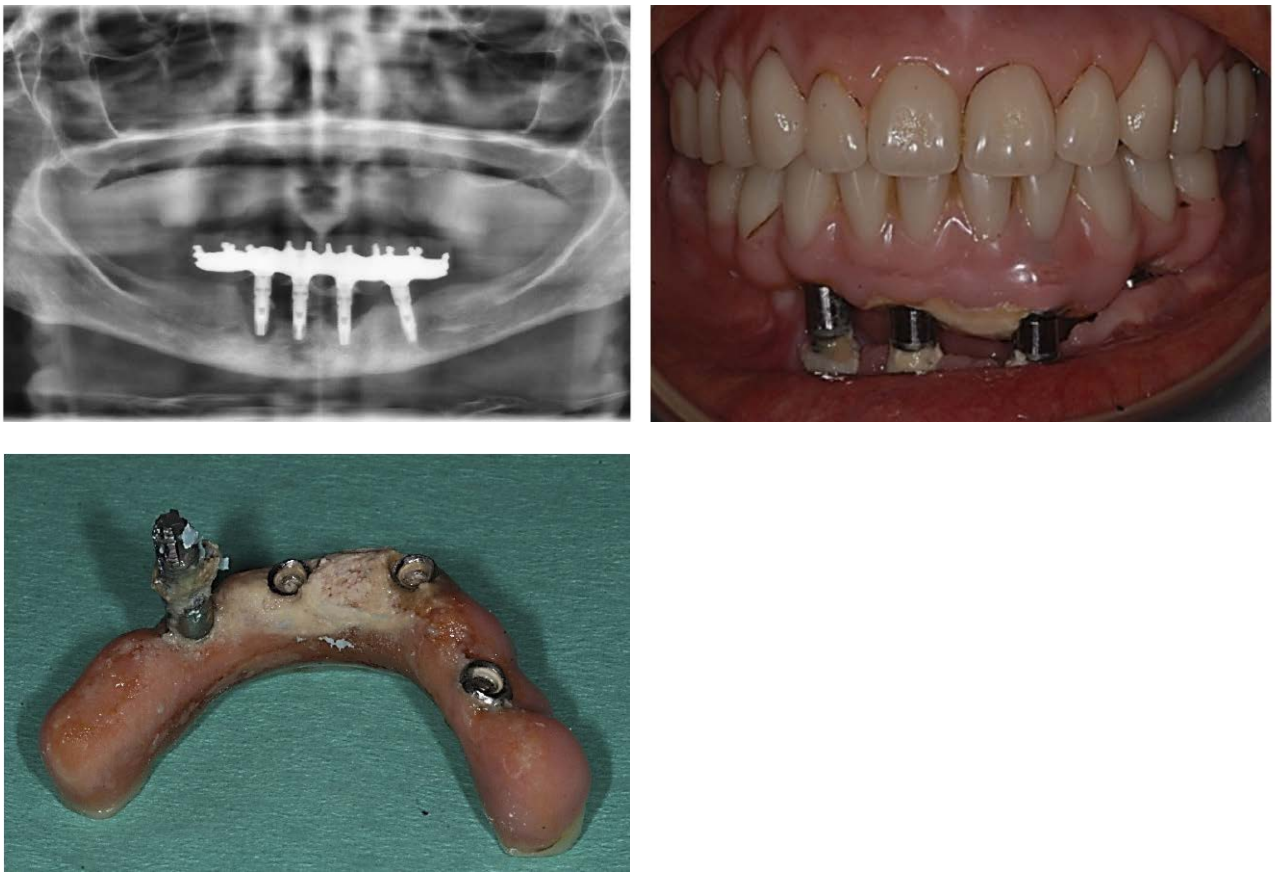
tive gradient of complications over time was observed: specifically, the incidence of peri-implantitis at 10, 15, and 25 years was 15.3%, 21.0%, and 27.9%, respectively [20]. While mechanical and technical complications are usually detectable as early as the initial period following delivery of the implant-prosthetic restoration, biological complications such as peri-implant bone loss typically occur at a later stage [21]. It usually takes about 5 years for peri-implant disease to progress and manifest clinical signs and symptoms [1]. The inability to maintain proper oral hygiene due to prosthetic design errors is a significant complication that can promote biofilm-mediated inflammatory processes [22]. A recent study highlights how, in implant-supported restorations, an over-contoured emergence profile may represent a significant risk factor associated with biological complications and implant failure [23]. Cement-retained restorations, typically used when implant placement does not allow for a screw-retained prosthesis, have been associated with a higher rate of biological complications compared to screw-retained restorations [24-26]. In this type of restoration, failure to remove residual cement from the peri-implant sulcus can trigger peri-implant disease. The consequences range from acute abscesses to chronic infectious processes, loss of peri-implant gingival and bone tissue, and ultimately implant loss [27]. Furthermore, there is a correlation between the depth of cement penetration into the peri-implant gingiva and the severity of the pathological condition [28]. The prosthetic material can also influence the incidence of biological complications: some authors have found a higher incidence of biological complications, such as mucositis and peri-implant mucosal recession, as well as prosthetic complications, such as abrasion and fracture of the occlusal material, in metal-acrylic restorations compared to metal-ceramic ones [29]. Another retrospective study on full-arch implant-supported prostheses with a 5-year follow-up found that biological complications, particularly soft tissue hypertrophy and plaque accumulation, were more frequently associated with metal-acrylic restorations [2] (Figures 1–3).



Figures 1-3: Biological complications: peri-implantitis and implant failure in an implant-supported full-arch hybrid metal-acrylic resin prosthesis case.

Complications of technical and mechanical nature in implant-supported restorations

Mechanical complications in implant-supported restorations can affect the osseointegrated implant itself, as well as the prosthetic framework and prefabricated components. By contrast, technical complications are more specifically linked to problems with the veneering material [14]. Mechanical complications can lead to the failure of the implant-supported restoration, with a prevalence comparable to that of biological and aesthetic failures [30]. Mechanical and technical complications are usually a consequence of biomechanical overload, and factors influencing their frequency include the type of implant-abutment connection, prosthetic design, restoration material, excessive occlusal loads, and implant malposition [1,31]. Bruxism is considered a biomechanical risk factor: patients with bruxism exhibit a higher prevalence of both mechanical and technical complications, as well as increased rates of implant failure [32-33]. Another risk factor is related to prosthetic design and type: full-arch implant-supported prostheses

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show a higher probability of mechanical complications, while single restorations are less prone to them [34]. The cantilever is a significant biomechanical risk factor [35]: it acts as a class I lever and subjects the implants, the implant-prosthetic connection, and the peri-implant bone to alternating tensile and compressive stresses during function. In this regard, a recent study reports that implant-supported zirconia-ceramic and metal-ceramic prostheses with cantilevers exhibit higher complication rates compared to prosthetic designs without cantilevers [36]. Although the absence of cantilevers or the presence of short cantilevers is associated with fewer complications, the presence of cantilevers does not appear to affect the survival of implant-supported restorations. It does not seem to play a role in peri-implant marginal bone loss [37]. Among mechanical complications, the most common in implant-supported prostheses is “screw loosening,” i.e., the loosening of the abutment or prosthetic fixation screw, followed by fracture of the fixation screw [22,30,38]. The incidence of screw loosening ranges from 7% to 11% depending on the type of implant restoration [39]. Some authors report that screw loosening has an incidence of 5.6% after 5 years, rising to nearly 60% within 15 years [22]. Single implant-supported crowns are more prone to this complication than multi-unit restorations [27]. A recent study reported a complication rate of 16.2% in single metal-ceramic crowns [40]. Furthermore, implant restorations in the mandibular molars appear to be more susceptible than those in the maxillary molars [1]. Although screw loosening is not a catastrophic complication, if it occurs frequently, it can compromise the success of implant therapy and patient satisfaction. Furthermore, if it occurs in cement-retained prostheses, it can still be a challenging complication to manage [31]. Factors influencing the frequency of screw loosening include the implant-abutment connection, the type of restoration, parafunctional habits, and the presence of cantilevers [31,33,41]. Implants with external connections are more prone to this complication, with an average incidence exceeding 18% at 5 years, unlike internal connections, which have an incidence of 2.7% [22]. The presence of cantilevers may contribute to increasing the rate at which the screws loosen and fracture [33,41]. In full-arch prostheses, the presence of extended cantilevers increases the likelihood of screw loosening, particularly in abutments on distal implants [42]. Stripping of the fixation screw — which occurs when the screw thread is damaged due to excessive torque, repeated tightening maneuvers, or misalignment during insertion — is a mechanical complication that predisposes the screw to loosening and compromises the retention of the restoration [27]. Another mechanical complication, albeit less common than screw loosening, is the fracture of the fixation screw [22]. This complication in single or splinted multiple implant restorations has been reported to have an incidence of 0.6% [39] and is more common in single restorations than in multi-unit restorations [22]. A recent study on metal-ceramic crowns reported screw fracture as the third most frequent complication, with a rate of 1.8% [40]. As with screw loosening, screw fracture is often localized in the first molar region; another area at risk is the maxillary central incisor region [39]. Implant fracture is the most feared mechanical complication and is associated with several factors, including the presence of a cantilever, overloading, and the size of the implant. Furthermore, the risk of fixture fracture increases in the presence of peri-implant bone resorption, particularly when vertical bone loss occurs closer to the apical limit of the screw [1]. Implant fracture may also result from design and manufacturing defects in the implant itself [1]. A recent study on metal-ceramic crowns reported an implant fracture rate of 0.5% [40]. Another study reported an incidence of implant fracture in single restorations of approximately 3% and identified suboptimal fixture placement and the resulting unfavorable prosthetic design as a likely cause: in particular, the presence of horizontal cantilevers in molar crowns increases the torque on the restoration and implant and thus the risk of fracture [43]. Another significant mechanical complication is framework fracture, which occurs in approximately 5% of implant-supported full-arch restorations [43]. A recent study on full-arch implant-supported prostheses made of zirconia-ceramic and titanium-ceramic confirmed these percentages, finding framework fractures in 4.5% of cases [35]. Lower rates were observed in a recent 6-year follow-up study on monolithic zirconia full-arch implant-supported prostheses, with only 2 framework fractures in a sample of 115 prostheses and a survival rate of 98.6% [44]. The type of occlusion, prosthetic design, and implant distribution determine the risk of framework fracture in full-arch restorations [45]. It is interesting to note that a recent study on monolithic zirconia restorations found high rates of framework fracture in mandibular implant-supported prostheses, to the extent that these solutions were identified as a risk factor [46]. Implant-supported restorations for partial edentulism, even though the frameworks and prosthetic components appear to be subjected to more unfavorable loads compared to what occurs with the frameworks of full-arch restorations that connect implants bilaterally, are less affected by this complication [1]. Passive fit of the framework is a non-negotiable requirement for the success of implant-supported prostheses; a lack of passive fit can cause stress and other prosthetic complications. In contrast, no correlations with biological complications have been demonstrated [47]. A widely used component in zirconia implant-prosthetic restorations is the prefabricated titanium base, known as the Ti-base, which enables a titanium-to-titanium implant connection. This component can present complications such as fracture and debonding, although there is currently little data regarding incidence [22]: a recent study reported the complication of Ti-base abutment de-cementation in 2.61% of cases [34]. Fracture of the ceramic veneer is among the most common complications and is a prosthetic complication of a technical nature. Occlusal overload, incorrect prosthetic design, inefficient structural support, and mismatched thermal expansion coefficients between materials are the main risk factors [38]. Data on this complication vary depending on the type of restoration and materials used [38]. In implant-supported full-arch restorations, the incidence is 12%, while in implant-supported partial restorations it stands at 6%; the incidence is even lower for single crowns, at approximately 2% [43]. A recent study on metal-ceramic crowns reported ceramic fracture as the second most common complication, with an incidence of 3.1% [40]. Partial restorations using zirconia-ceramic systems have

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significantly higher rates of ceramic chipping compared to monolithic solutions: in particular, single veneered crowns show significantly higher annual chipping rates (1.65%) than monolithic crowns [48-49]. In full-arch restorations, ceramic veneer fracture is significant in metal-ceramic systems and even more so in zirconia-ceramic systems, significantly affecting restoration success rates. Success rates have increased significantly with monolithic zirconia restorations (90.9%), unlike zirconia-ceramic systems (60.4%) [50]. Another study on partial and full-arch zirconia-ceramic restorations confirms clinically unacceptable rates of ceramic veneer fracture: at 5 years, these reach 22.8% for partial restorations and 34.8% for full-arch restorations [51]. Bruxism and failure to use a night guard appear to be associated with an increased risk of ceramic chipping [52]. Fracture, wear, or detachment of the prosthetic tooth is a very common complication in implant-supported prosthodontics, particularly in fixed full-arch hybrid metal-acrylic resin/composite prostheses [53]. Fracture of the prosthetic tooth is reported with an incidence of approximately 28% [43]. Meanwhile, the complication of prosthetic tooth wear has an incidence of approximately 15% [43]. A study on metal-acrylic hybrid prostheses identified occlusal wear as the primary complication, with particularly high rates (82.8% of patients) [42] (Figures 4 and 5). Other authors highlight that, after an average observation period of approximately 5 years, there is a statistically significant difference in wear rates between full-arch metal-resin prostheses and prostheses with ceramic occlusal surfaces [52]. Bruxism, occlusal pattern, and male gender appear to be significant predictors of complications involving wear and major chipping in full-arch metal-resin restorations [54]; another study highlights that metal-resin restorations in the mandibular arch of female patients demonstrate a lower complication rate [55]. Although it is difficult to determine the lifespan of acrylic dentures, a 2016 study found that replacement due to wear was necessary after an average of 7.8 years following the initial fitting [56]. The most common minor complication (20% of all complications) in implant-supported prostheses is the loss of the sealing material in the access hole to the fixation screw. This complication has an incidence of approximately 25% in implant-supported full-arch restorations [4,54]. Also among minor complications, prosthetic decementation of implant-supported restorations has an incidence ranging from 6% for partial restorations to 2% for single restorations [43].

Figures 4 and 5. Technical complications: fracture and wear of prosthetic teeth in a fixed full-arch hybrid metal-acrylic resin prosthesis case. Detachment of a prosthetic tooth in a case involving a full-arch hybrid metal-composite prosthesis.

Complications related to the aesthetic outcome of implant-supported restorations

Aesthetic complications in implant-supported prostheses can be biological, prosthetic, or iatrogenic in nature, and some of these relate to concepts previously discussed [57]. Biological aesthetic complications include mucosal recession, mucosal hypertrophy, lack of keratinized tissue, and tooth displacement. Gingival hyperplasia or hypertrophy is a relatively common complication. It causes both a noticeable aesthetic problem and functional impairment due to difficulty accessing the hygiene areas of the implant-supported prosthesis. Gingival hypertrophy is particularly common in full-arch implant-supported restorations, with an incidence of approximately 10%, and occurs when the prosthetic design results in limited or insufficient space for oral hygiene, thereby increasing the likelihood of gingival hypertrophy [43]. Other aesthetically relevant complications of peri-implant soft tissues are related to the absence or deficiency of adherent and keratinized mucosa, insufficient volume, the development of mucosal dehiscences, or a combination of these [58]. Another common biological aesthetic complication is the displacement of a tooth adjacent to a prosthetic implant restoration, which can lead to the formation of mesiodistal gaps or to the submersion (also known as infraocclusion) of the restoration caused by vertical movements. This complication is quite common and can occur in both young and elderly patients; in cases involving aesthetic prosthetic restorations, this has significant implications because it requires either the redo of the implant-prosthetic restoration or the prosthetic restoration of the natural tooth that has shifted [57]. Iatrogenic aesthetic complications include implant malpositioning in the aesthetic zone, such as excessive or insufficient implant depth, an implant angle that is too buccal, or an excessive implant diameter, as well as incorrect abutment size and morphology, which can lead to vestibular dehiscence of the implant. Inappropriate fixture depth can lead to aesthetic problems and the need for rework. For example, the combination of a long crown and excessive implant depth can result in an aesthetic issue that requires both sur-

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gical and prosthetic retreatment. Providing sufficient buccal gingival tissue thickness and an abutment appropriate in shape and size (narrow) allows for abutment coverage. It ensures an adequate gingival margin and the correct contour of the gingival curve relative to the adjacent teeth [57]. Another aesthetic complication can result from insufficient inter-implant spacing — less than 3 mm — which can trigger bone resorption, leading to a lack of interproximal gingival tissue and the absence of the papilla. This is a fairly common aesthetic complication in cases involving two adjacent implants, and managing the problem can be complex. Appropriate prosthetic design and proximal contact are solutions that can promote papilla formation and improve aesthetics in these cases [59]. Among the aesthetic complications related to the incorrect choice of implant abutment is the alteration of the color of the peri-implant mucosa. The thickness of the peri-implant mucosa and the color of the transmucosal abutment influence the color of the peri-implant gingival tissue, which under certain conditions may appear discolored. In these cases, the thin gingival biotype is unable to mask the metallic abutment, resulting in an iatrogenic complication due to incorrect diagnosis and improper selection of implant-prosthetic components [57]. Among the aesthetic complications associated with prosthetic design and prosthetic materials, fracture of the ceramic veneer — the causes of which we discussed earlier — is one of the most common complications. Managing this issue in the aesthetic zone often requires prosthetic retreatment; however, before proceeding, it is advisable to investigate the cause, which is frequently linked to insufficient posterior support [59]. Other prosthetic complications include aesthetic issues resulting from errors in the shape and color of the restoration. It should be noted that the morphology and emergence profile of the prosthesis can be significantly influenced by implant malposition in most cases.

Complications related to the function of implant-supported restorations

Among functional complications, speech difficulties are a common issue observed particularly with full-arch prostheses and are caused by prosthetic design and dimensions or suboptimal implant placement. Phonetic techniques are the most common method of assessing the suitability of full-arch or partial implant-supported restorations and allow for the identification and prevention of potential speech difficulties resulting from prosthetic bulk. Lip length, age, gender, and malocclusions represent possible variables. In these cases, function and aesthetics are directly correlated: for example, in the phonetic test of sibilant pronunciation, mandibular movement (downward and forward) allows for the determination of the minimum inter-incisal phonetic space, which is usually less than 1 mm. This assessment provides information on the vertical and horizontal position of the incisors.

Furthermore, if the lengths of the maxillary and mandibular incisors or the vertical dimension of the restoration are excessive or insufficient, speech difficulties manifest in the pronunciation of, for example, the “th” and “f” sounds [60]. Other potential functional complications are related to occlusal discrepancies or malocclusion, which can cause patient discomfort, excessive wear, overloading, and poor masticatory efficiency. Full-arch implant-supported prostheses are complex because they involve the design of a new occlusion aimed at improving pre-treatment relationships in the three planes of space, redefining overbite, overjet, functional pathways, and the direction of forces on the teeth [45]. In partial restorations, the work is less complex; however, a potential complication to be avoided is that a prosthetic restoration with incorrect occlusal design may result in poor masticatory efficiency on the rehabilitated side, leading the patient to favor the contralateral side for chewing [61]. Loss of proximal contact between the implant-supported restoration and adjacent teeth has been reported as one of the most common and adverse complications, with repercussions on the restoration’s function and longevity: in addition to the discomfort experienced by patients when food gets stuck while they are chewing, other related issues include caries, as well as periodontal and peri-implant complications. The incidence rates of proximal contact loss reported in the literature vary but remain high, generally around 20%, although some authors cite 2%, while others report as high as 60% [27,43]. A study on the prevalence of proximal contact loss found the problem in 32.8% of implant-supported fixed prostheses, with a positive correlation between contact loss and marginal bone loss [62]. The rate of mesial contact loss (27%) is significantly higher than that of distal contact loss (5%) [63]. It appears to primarily involve the mesial proximal contact of posterior teeth [27,43].

Furthermore, the risk increases over the years of restoration use [63]. The mechanism is multifactorial; however, further research is needed to identify the causal factors. The impact of food and frequent use of interdental brushes appears to play a role [62-63]. Underlying this complication is the biophysiological difference between teeth and implants: while teeth, supported by periodontal ligaments, are free to move over time, implants, anchored to the bone, remain in place, leading to the formation of gaps.

Prevention and management of complications

Preventing the most feared biological complication, peri-implantitis, requires maintaining healthy peri-implant tissues as an effective biological barrier against bacterial contamination. Risk factors for peri-implantitis — including uncontrolled diabetes, smoking, prolonged steroid therapy, radiation therapy, and chemotherapy — must be resolved or mitigated before implant-prosthetic treatment [1]. Prevention involves personalized professional hygiene protocols, education on home hygiene, and appropriate prosthetic design. Furthermore, proper distribution of occlusal loads — even though the link between overloading and peri-implant disease remains controversial — plays a potential preventive role [45]. Early diagnosis of mucositis and peri-implantitis allows for treatment with a favorable prognosis. Treatment strategies such as non-surgical mechanical debridement, local administration of antimicrobials, and surgical therapies in advanced cases are designed to prevent implant failure. Implant removal is justified if peri-implant bone loss exceeds 60% and mobility is present [1]. In the case of cement-retained implant-supported restorations, excess resid-

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ual cement in the peri-implant sulcus is a potential cause of biological complications: prevention involves the use of custom abutments with accessible margins that are not positioned too far subgingivally. A “quantum sufficient” amount of cement and the use of radiopaque material are recommended. Cases of peri-implant cement diagnosed radiographically should be managed, if necessary, with a surgical flap and a repeat radiograph [27]. Accurate prosthetic planning of the final restoration represents the ideal approach to prevent complications from implant malpositioning: it includes pre-treatment diagnostic work-up and the definition of the prosthetic goal with the aid of a wax-up or a set-up aimed at achieving the ideal three-dimensional implant positioning, oriented toward the prosthesis (64). Implant malposition that affects aesthetics can be managed using custom abutments, dedicated prosthetic designs, and materials capable of replicating the gingival component [22,57]. The use of angled abutments allows for the correction of misalignment up to 25° [22], while more complex cases may require a change in the prosthetic design. Cases of aesthetic compromise due to buccal angulation of the fixture may necessitate implant removal to preserve the aesthetic result [57]. Complications related to the abutment/prosthetic fixation screw, such as loosening and fracture, require various preventive strategies [39]: favorable distribution of occlusal loads by limiting excursive contacts, cantilevered contacts, and off-axis centric contacts; precision of the framework, which should be passive and free of misfit; the use of high-quality components and the manufacturer’s original screws; tightening force according to recommended torque values and the use of torque wrenches [27,31]. Screw loosening is a more common complication in systems with an external hexagonal connection, whereas it is less common in systems with internal and tapered connections [27]. Furthermore, the use of a nightguard appears to be associated with a lower prevalence of this complication [5]. The clinical management of the screw fractures involves retrieval of the fractured fragment, a procedure that is more or less complex depending on whether the screw is loose or lodged in the thread [22]. For the removal of fractured screws, ultrasonic or manual instruments used in a counterclockwise direction or removal devices for handpieces with reverse rotation in dedicated kits are recommended [22,59]. Cases of screw stripping must be detected early and managed by replacing the screw [27]. If the screw head is stripped, one proposed solution is to create a horizontal groove in the head to engage the instrument with a driver or alternative tools. In general, the imperative when managing all complications related to screws is to avoid damaging the internal threads of the fixture; otherwise, management involves restoring the threads with dedicated instruments or removing the implant [22,27,59]. About the most feared complication — implant fracture — prevention strategies are aimed at minimizing occlusal overload. In patients who grind their teeth, a prosthetic design without cantilevers or one that limits their extent is recommended: the use of short implants or angled implants can be effective for this purpose [22,45]. In high-load areas, the use of additional implants or large-diameter implants is recommended. Implants with a diameter of less than 3.75 mm are more prone to fracture: a 5-mm-diameter fixture is three times stronger than a 3.75-mm-diameter one, while a 6-mm-diameter fixture is six times stronger [1]. Preventing misfit and poor adaptation of the prosthetic framework involves adopting precise prosthetic procedures and advanced technologies capable of achieving optimal adaptation. In cases of misfit and inaccuracy in cast frameworks, cutting open the framework and re-welding it is a procedure that can further compromise the original fit as well as the prosthetic strength: current manufacturing technologies make remaking the framework a more advantageous option [1,59]. Debonding of Ti-base abutments is managed by recementation. In the event of fractures or recurrence of the problem, management involves prosthetic re-treatment using alternative designs and more reliable solutions, which may include a custom CAD/CAM abutment [22]. Fractures and chipping of the ceramic veneer in metal-ceramic or zirconia-ceramic systems can be prevented by ensuring even distribution of occlusal loads, adequate support, sufficient thickness of the ceramic veneer, and adopting advanced monolithic zirconia materials as well as by using occlusal devices in bruxism patients [45,65-66]. When complications arise, management depends on the extent of the problem. Minor chipping is generally managed with adjustment and polishing. For larger fractures, re-ceramization or prosthetic retreatment is required. Protocols for bonding ceramic restorations to the damaged structure have also been proposed for repair [22]. The use of composite resins for repair is controversial and unreliable. The use of implant-supported restorations in monolithic zirconia or with a ceramic veneer limited to the aesthetic area currently represents the most effective preventive strategy against ceramic chipping [6-7,23,65,67] (Figures 6-10). Fractures and wear of prosthetic teeth can be prevented through proper load distribution and the use of a night guard or splint designed to protect the teeth [43,66]. Cases of advanced wear in metal-resin prostheses must be managed by replacing the prosthetic teeth to preserve vertical dimension and masticatory function [22]. Wear of posterior acrylic teeth is a precursor to fracture or detachment of the anterior elements and must be treated promptly. Major fractures involving the core or framework of the restoration most often require the replacement of the temporary restoration and a remake: the metal framework can be salvaged by welding, albeit with a risk of recurrence; for zirconia frameworks, remaking is mandatory. Prevention involves the proper design of areas of maximum stress concentration (e.g., connectors), sized according to the framework material [59;68]. Hard or soft tissue defects can be managed surgically and/or prosthetically. Surgical management may involve tissue grafting to correct minor buccal and vertical aesthetic defects. However, it is recommended to plan for the management of tissue deficiencies before implant-prosthetic treatment. In this case, hard or soft tissue grafting serves a preventive role against potential biological and aesthetic complications [58]. The alternative to surgical techniques for bone or gingival tissue regeneration or grafting is prosthetic reconstruction of defects. To replace inadequate or absent gingival architecture, creative prostheses incorporating gingival-colored ceramic or acrylic can be designed [22]: a solution that is less time-consuming and cost-effective, as well as less traumatic than surgery [57]. Cases of

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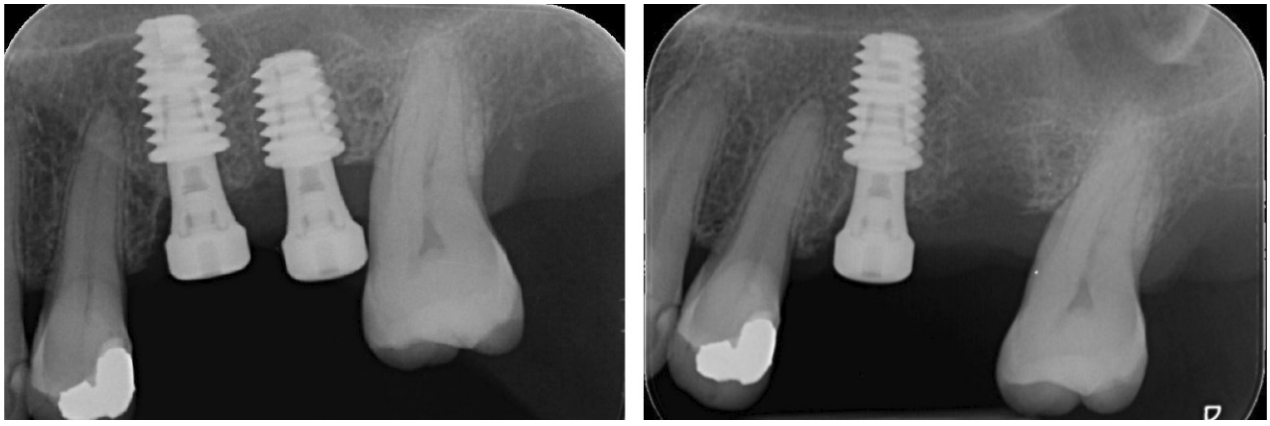
peri-implant mucosal discoloration associated with metal abutments can be managed prosthetically by using zirconia abutments, which are more esthetic than titanium [69]. A possible alternative is connective tissue grafting, a solution that increases the thickness of the peri-implant mucosa, thereby masking the metal [57]. Functional complications related to inadequate occlusal design of the implant-prosthetic system cause patient discomfort, excessive wear, overloading, and poor masticatory efficiency. It is recommended to design the occlusal morphology according to biomechanical principles, protecting the restoration from occlusal overload while respecting occlusal anatomy and masticatory function. In partial restorations, our recommendation is to design implant restorations with an occlusal table reduced by no more than 10% in selected cases and to preserve the occlusal morphology as much as possible [61]. In implant-supported full-arch restorations, the reduction in proprioceptive feedback requires particular attention to biomechanical factors: the choice of occlusal scheme must be defined based on the opposing arch according to criteria of advantageous load distribution. Bilateral stability in centric occlusion, evenly distributed occlusal loads, and freedom in centric occlusion are common characteristics of the various occlusal schemes [45]. The complication of proximal contact loss requires routine check-ups for early detection and can be prevented with retainers or occlusal splints to restrict tooth movement [27,63]. Loss of proximal contact, however, involves complex management that often necessitates prosthetic remanufacturing. To prevent complications arising from speech difficulties, phonetic tests must be carried out during prosthetic assessments and with implant-supported temporary prostheses. This enables any issues relating to the design, positioning, and length of the prosthetic teeth to be identified and resolved. A recent study on the costs of complications in implant-supported prostheses demonstrated that most technical complications can be resolved in a single appointment, unlike biological complications, which require one to three appointments. The authors calculated that the total time required for routine maintenance over 10 years is 77 minutes per year, while the annual maintenance costs amount to 9% of the initial implant treatment cost [70]. Among fixed implant-supported restorations, full-arch rehabilitation has by far the highest percentage of complications: in these cases, the rate of prosthetic re-treatment is very high, at 9% [43]. In terms of materials, full-arch restorations made of monolithic zirconia, despite high initial costs, appear to reduce overall complications compared to traditional materials [71]. Advanced manufacturing technologies and latest-generation materials now offer promising design alternatives in terms of reliability [3,72]. Furthermore, full-arch prostheses supported by 4 implants appear to be associated with higher rates of both mechanical and biological complications compared to restorations supported by 6 or more implants [73-74].



Figures 6 e 7. Biological complication: intraoral radiographs showing early implant failure requiring the removal of the fixture in site 2.6.

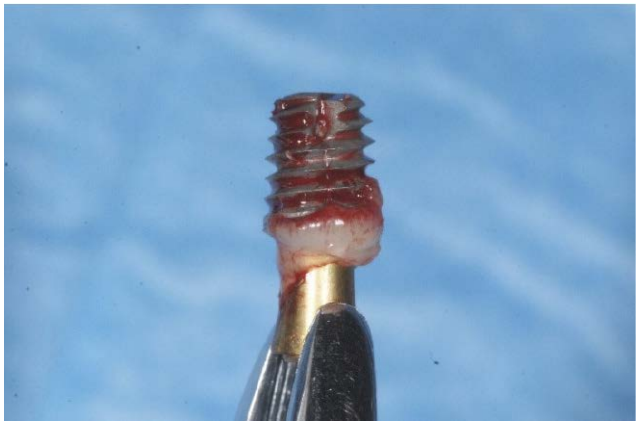


Figure 8. The image shows a close-up of the non-osseointegrated implant immediately after removal.

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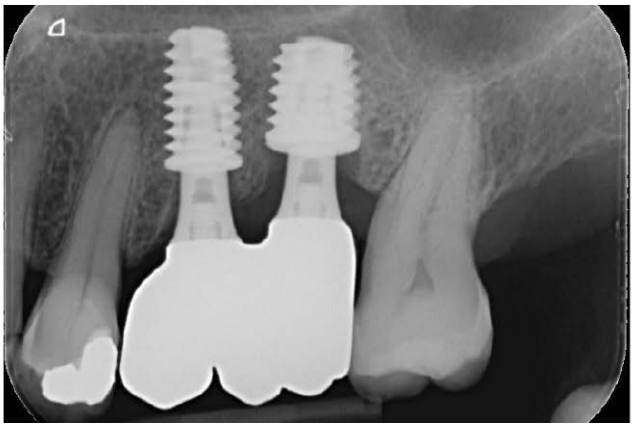


Figures 9 e 10. Management of biological complications and prosthetic restoration. Implant repositioning was carried out after three months. A two-unit implant-supported fixed restoration made from the latest generation of multi-layered monolithic zirconia was chosen for the prosthetic restoration. Monolithic zirconia is an effective preventive strategy against technical complications such as ceramic chipping in heavy-load areas.

Conclusions

Implant-supported fixed restorations can be subject to various complications, which can be categorized as biological, mechanical, technical, aesthetic, and functional. These are common issues that can affect all components of the implant-prosthetic structure, ranging from minor, easily manageable problems to more serious and complex cases requiring lengthy and costly interventions, often culminating in the need to redo the entire restoration. Among the main causes of these complications are factors such as the distribution and angulation of the implants, the design of the prosthetic restoration, the choice of materials used, and the characteristics of the occlusion. A thorough understanding of potential complications is crucial to treatment success: knowing how to prevent them or identify them early is essential to ensuring patient satisfaction. Prevention begins with careful case selection, which requires a thorough assessment of the patient's compliance and systemic health. Subsequently, meticulous surgical and prosthetic planning is essential to reduce the risk of future problems. Among the factors that most contribute to the onset of complications are incorrect implant placement and occlusal overload. These factors not only significantly increase the risk of biomechanical failure of the implants and prosthetic components but may also necessitate design compromises that negatively impact aesthetics and function. In particular, implant-supported full-arch fixed prostheses represent one of the prosthetic solutions most prone to complications and are also characterized by a high risk of requiring re-treatment.

Author Contributions

Conceptualization AB, RFZ and SB; Methodology AB and SB; searching data and data curation AB and RFZ; Discussion AB and SB; Writing - Preparation of the original draft AB and RFZ; Writing – Review and supervisión AB and SB.

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Conflicts of Interest

The authors declare no conflicts of interest.

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