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Biological complications in implant-supported oral rehabilitation: as the pendulum swings back towards endodontics and tooth preservation

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Abstract

The decision whether to retain a tooth by additional endodontic and restorative treatments or to extract it and replace it with an implant-supported restoration has been extensively debated, and the common approach to this clinical question has shifted back and forth many times. However, in recent years, it has become clear that implants are more prone to technical and biological complications, and require more postoperative treatments to maintain them than the natural dentition. A review of the currently available literature regarding the biological complications of implant-supported oral rehabilitation, and the ensuing effects on the clinical decision-making regarding the preservation of the teeth by endodontic treatments is presented.

Keywords: Biological complications, Dental implants, Endodontics, Decision-making

Introduction

The decision whether to retain a tooth by additional endodontic and restorative treatments or to extract it and replace it with an implant-supported restoration has been extensively debated. The common approach to this clinical question has shifted back and forth many times (Iqbal and Kim 2008; Tsesis et al. 2010; Setzer et al. 2017; Rosen et al. 2017). In the early days of implant dentistry, it was assumed that implants provide definite, perfect and risk-free solution to most patients. Thus, the pendulum tilted significantly towards extraction of the teeth that required relatively complex endodontic, periodontal, and/or restorative procedures, while replacing them with dental implants (Rosen et al. 2017).

As for up-to-date evidence, according to contemporary dentistry principles, reasonable efforts should be done to preserve the natural dentition while keeping in mind that the goal of dental implants is to replace missing, and not present, the teeth (Iqbal and Kim 2008; Tsesis et al. 2010). Thus, many factors such as the long-term prognosis, the alternatives in case of treatment failure, and, most importantly, the expected post-treatment complications and quality of life should all be evaluated and incorporated in the practitioners' decision-making (Iqbal and Kim 2008; Tsesis et al. 2010; Rosen et al. 2017; Tsesis 2014).

Although endodontic treatments may sometimes be technically difficult to perform, the survival of endodontically treated teeth is comparable to dental implants (Setzer et al. 2017; Iqbal and Kim 2007; Doyle et al. 2006), and in the context of the expected post-treatment complications, based on up-to-date relevant literature, it has become clear that implants are more prone to technical and biological complications and require more postoperative treatments to be maintained compared to natural dentition (Tsesis 2014; Hannahan and Eleazer 2008).

As the information regarding the complications of implant-supported restorations gathered, especially concerning the significant incidence and extent of peri-implant diseases, the benefit of teeth extraction and their replacement with implants may be questioned. The benefit to maintain even the compromised teeth, by additional endodontic and restorative treatments, is nowadays well

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established (Tsesis et al. 2010; Setzer et al. 2017; Rosen et al. 2017).

Thus, in recent years, the pendulum swings back towards maintenance of the natural dentition by additional endodontic and restorative procedures while avoiding tooth extraction whenever possible (Setzer et al. 2017; Rosen et al. 2017). This study aims to review the currently available literature concerning the biological complications of implant-supported oral rehabilitation and the ensuing effects on the clinical decision-making regarding the preservation of the teeth by endodontic treatments.

Review

Biological complications in implant-supported oral rehabilitation

Peri-implant diseases may affect both the surrounding hard and soft tissues. Peri-implant mucositis is a bacteria-induced, reversible inflammatory process of the peri-implant soft tissue with reddening, swelling, and bleeding on periodontal probing. Peri-implantitis is an inflammatory process of the peri-implant soft and hard tissues associated with clinically significant progressive crestal bone loss after the adaptive phase following prosthetic loading (Canullo et al. 2015). Peri-implant diseases are typically described as the result of an imbalance between host response and bacterial load, supported by gram-negative anaerobic microflora. Peri-implant mucositis may not result in peri-implantitis; however, apparently, all peri-implantitis cases had pre-existing mucositis (Ericsson et al. 1992; Leonhardt et al. 1993; Lindhe et al. 1992; Pontoriero et al. 1994; Renvert and Quirynen 2015; Salvi et al. 2012).

In recent years, it became apparent that these serious peri-implant biological complications are extremely frequent, and the incidence of mucositis has been reported to be around 80% and that of peri-implantitis between 28 and 56% (Lindhe et al. 2008). After 10 years in function, 10 to 50% of the dental implants showed signs of peri-implantitis (Roos-Jansaker et al. 2007). A recent meta-analysis reported that peri-implant mucositis is present in 43% (range 32–54%) of patients, while peri-implantitis in 22% (range 14–30%) of patients (Jepsen et al. 2015). Another recent long-term, cross sectional analysis has shown 91.6% implant survival rate, while peri-implant mucositis was found in 33% of the implants and 48% of the patients at the same time and peri-implantitis was detected in 16% of the implants and 26% of the patients. Which means that, after 11 years, in 1 out of 4 patients and 1 in 6 implants will suffer from peri-implantitis (Daubert et al. 2015).

However, although bacterial infection due to plaque accumulation is the main etiologic factor (Jepsen et al. 2015), this is not the only cause for the disease, as patient-, surgical-, and prosthetic-related factors also contribute to its development and severity (Albrektsson et al. 2012a; Albrektsson et al. 2012b; Carcuac and Berglundh 2014; Konstantinidis et al. 2015).

Risk factors are environmental, behavioral, or biological factors that if present directly increase the disease probability and if absent or removed that probability is reduced. Single factors may not be sufficient to produce a disease; therefore, several factors are usually present. Risk factors may be classified as local and general (Renvert and Quirynen 2015; Smeets et al. 2014). Local factors influence bacterial composition and load while the general are related to the individual and may influence the patient's susceptibility to infection.

Among the general risk factors, present and past periodontal disease, faulty oral hygiene, parafunction, genetic predisposition, history of one or more implant failures, smoking habits, diabetes, immunosuppression, cardiovascular diseases, and an inadequate maintenance program have been reported. Among the local risk factors, inaccessibility for oral hygiene, deep peri-implant pockets, implant supra-structure connection, soft tissue characteristics (keratinized tissue), iatrogenic causes (cement remnants, implant malposition, surgical procedure), implant surface roughness, bone augmentation procedures, and full-arch rehabilitations have shown effect on disease development.

Successful periodontal treatment prior to implant placement lowers the risk for peri-implantitis. Residual pockets (PPD >5 mm) at the end of active periodontal therapy represent a significant risk for peri-implantitis and implant loss. Periodontal patients showed increased susceptibility to peri-implantitis (4.1 OR) (Derks et al. 2016). Patients experiencing recurrent periodontitis had a significantly greater risk for peri-implantitis and implant loss (Ong et al. 2008; Pjetursson et al. 2012; Salvi and Zitzmann 2014). Several studies have suggested that in partially edentulous patients, periodontal pathogens may be transmitted from the periodontally compromised teeth to the newly installed implants implying that periodontal niches may serve as reservoirs for bacterial colonization (Apse et al. 1989; Bragger et al. 1997; Kohavi 1993; Koka et al. 1993; Leonhardt et al. 1992; Mombelli et al. 1995; Quirynen and Listgarten 1990). The importance of treating existing periodontitis prior to the placement of dental implants has been widely reported (Mombelli et al. 1995; Quirynen and Listgarten 1990; Mombelli et al. 1987).

A positive relationship between peri-implantitis and the history of periodontal disease was found in several clinical evaluations. Although microorganisms initiate the infection, tissue breakdown is mainly caused by the host response. Individuals genetically predisposed to overproduce pro-inflammatory cytokines may have increased tissue destruction. Patients that previously suffered from periodontitis (especially aggressive periodontitis) (Theodoridis et al. 2017) are at higher risk to develop peri-implantitis and implant loss (Renvert and Quirynen 2015; Ong et al. 2008; Safii et al. 2010). Long-term survival and success rates are lower in patients with a history of periodontal disease, even adhering to maintenance (Salvi and Zitzmann 2014).

As plaque is the main etiological factor, there is, evidently, a close association between peri-implant bone loss and poor oral hygiene. Indeed, patients with poor oral hygiene or with no or even limited access for proper oral hygiene have been shown to be up to 14 times at greater odds of developing peri-implantitis (Lindhe et al. 2008). In a cohort of 23 patients with 109 implants, only 4% of the implants in patients with optimal oral hygiene presented with peri-implantitis, while 48% of implants presenting peri-implantitis had no accessibility and/or capability for proper oral hygiene (Jepsen et al. 2015; Serino and Strom 2009).

Smokers have been proven to present impaired humoral immune response. Nicotine may impair wound healing, especially considering that nicotine concentrations in the gingival crevice fluid are approximately times 300 than in the plasma. Although, the gingival blood and gingival crevice fluid flow increase already 3–5 days after smoking cessation, the enhanced susceptibility of smoking patients is reflected by a highly increased risk for peri-implantitis, bone loss, and implant failure, especially in the maxilla (Renvert and Quirynen 2015; Apatzidou et al. 2005; Cesar-Neto et al. 2006; Gamal and Bayomy 2002; Graswinckel et al. 2004; Keenan and Veitz-Keenan 2016; Morozumi et al. 2004; Ryder et al. 1998a; Ryder et al. 1998b; Tanur et al. 2000; Tipton and Dabbous 1995; Tran et al. 2016; Veitz-Keenan 2016).

Implants placed too close together, too deeply, or buccally may result in bone loss, and higher ORs were observed for implants in the mandible (OR, 2.0) and for a distance from the prosthetic margin to the crestal bone at baseline of 1.5 mm or less (OR, 2.3) (Derks et al. 2016). The proficiency of the clinician performing the oral rehabilitation has been shown to influence the odds ratio for peri-implantitis by 4.3 (Derks et al. 2016). Cement excess seems to be an important risk factor, 81% of implants with cement remnants had peri-implant disease, and in the same patients, no excess cement found in any of the healthy implants. In 74% of the implants, removal of excess cement leads to absence of peri-implant disease. All implants with cement remnants in patients with a history of periodontitis developed peri-implantitis (Renvert and Quirynen 2015; Linkevicius et al. 2013a; Linkevicius et al. 2013b; Wilson 2009; Korsch et al. 2015).

Patients with four or more implants had an increased risk for peri-implantitis (OR, 15.1) (Derks et al. 2016). Implants from certain brands and surface treatment seem to be more prone to disease than others (Derks et al. 2016).

Enrollment in regular maintenance program including anti-infective preventive measures usually leads to higher long-term survival and success rates of dental implants and their restorations. Therapy of peri-implant mucositis should be considered as a preventive measure for the onset of peri-implantitis. The simple fact of including patients in a regular maintenance program may reduce the risk of peri-implantitis from 43.9 to 18% at patient level (Aguirre-Zorzano et al. 2015; Costa et al. 2012). Patient compliance to these programs may represent a fundamental factor for peri-implantitis prevention (Frisch et al. 2014).

Preventive measures

Due to the lack of long-term efficacy and evidence-based guidelines for the treatment of peri-implantitis, prevention strategies are extremely important. Prevention of peri-implant disease starts with a thorough evaluation of individual risk factors, establishment of optimal soft and hard tissue conditions, the choice of the correct implant design followed by a maximally atraumatic approach, and regular clinical examinations and maintenance (Smeets et al. 2014).

Patients must be made aware that implants are more susceptible to plaque-related diseases than the natural teeth (Pjetursson et al. 2012; Fardal and Grytten 2013). Implant therapy must not be limited to the placement and restoration of dental implants but to the implementation of peri-implant maintenance therapy to potentially prevent biologic complications and hence to heighten the long-term success rate. Mean peri-implant preventive maintenance therapy interval was demonstrated to influence the incidence of peri-implantitis. The maintenance program must be tailored to a patient's risk profiling, with a minimum recall interval of 5 to 6 months (Tonetti et al. 2015). However, it must be stressed that even with regular preventive maintenance, biologic complications might occur (Monje et al. 2016). Professional mechanical plaque removal as the sole element of professional preventive care is inappropriate since education and behavior change are fundamental to sustained improvements in health status. The use of adjunctive chemical approaches to biofilm control in support of mechanical plaque removal protocols in high-risk patients should be considered.

Therapeutic strategies

Long-term results of peri-implantitis treatments have been proven unpredictable, with advanced lesions usually commanding implants retrieval. Furthermore, most treatment protocols involve a surgical intervention, which leads to considerable gingival recession accompanied by esthetic and functional impairment. There is no reliable evidence suggesting which could be the most effective interventions for treating peri-implantitis. Systematic reviews have found no evidence that the more complex and expensive therapies were more beneficial than the non-surgical therapies, which basically consisted of simple subgingival mechanical debridement combined or not with some type of anti-infective treatment. Follow-up longer than 1 year suggested recurrence of peri-implantitis in up to 100% of the treated cases for some of the tested interventions, making re-treatment necessary. Larger well-designed RCTs with follow-ups longer than 1 year are still needed (Esposito et al. 2012).

Different preventive/treatment protocols have been suggested. One of the first ones was the Cumulative Interceptive Supportive Therapy (CIST) described by (Lang et al. 2000).

CIST is cumulative in nature and includes four steps, which should not be used as single procedures but rather as a sequence of therapeutic procedures with increasing antibacterial potential depending on the severity and extent of the lesion. Diagnosis, therefore, represents a key characteristic of this maintenance care program.

Evidence posterior to the Lang et al. 2000 publication has revealed that chlorhexidine was not more effective than placebo for treatment of peri-implant mucositis and that locally applied chlorhexidine, as rinses and gels, have limited antimicrobial effects in peri-implant lesions (Porras et al. 2002; Renvert et al. 2006; Carcuac et al. 2015; Menezes et al. 2016), and no statistically significant differences were found between the test and control groups at any time. Recent clinical evaluations have shown limited evidence that systemic antibiotics are helpful (Lindhe et al. 2008). Accordingly, application of local slow release antibiotic devices, which remain at the site of action for at least 7–10 days in a concentration high enough to penetrate the submucosal biofilm, has been proven an effective treatment approach.

Only once infection is successfully controlled, with absence of suppuration and reduced edema, it is reasonable to discuss treatment approaches to either restore the bony support of the implant by means of regenerative techniques or to reshape the peri-implant soft tissues and/or bony architecture by means of resective surgical techniques, depending on the esthetic considerations and morphological characteristics of the lesion.

However, even if the bone fill of peri-implant defects may be achieved using the biological principle of guided tissue regeneration (Hammerle et al. 1995; Persson et al. 1996), re-osseointegration of a previously contaminated implant surface into a regenerated one does not seem to be a usual outcome (Wetzel et al. 1999).

Deep circumferential and intrabony defects may be treated thorough debridement, implant-surface decontamination, and defect reconstruction while defects without clear bony walls or predominantly supra-bony by thorough debridement and apical repositioning of the marginal mucosa (Figuero et al. 2014). Although the new bone, and/or the bone graft, may fill the osseous defects, as documented by an increase in radiographic bone density, in most cases, it is apparently a simple healing process, where this radio-opaque material is not really connected to the implant surface. A recent meta-analysis has shown that despite the clinically important improvements, a complete disease resolution may not be expected by any of the treatment protocols investigated (Schwarz et al. 2015). Furthermore, the major drawback of surgical therapy for peri-implant disease seems to be that healing usually leads to marked gingival recession compromising the esthetic and functional result of the restoration (Schwarz et al. 2015); therefore, this type of treatment should be considered only in cases where non-surgical therapy was not effective.

If clinical signs of infection may not be controlled by any means, or if a previously osseointegrated oral implant has lost most of its bone support and/or becomes clinically mobile, explantation is mandatory (Lang et al. 2000).

Non-surgical treatment

Since the primary objective of surgical treatment in peri-implantitis is debridement and decontamination of the implant surface which may lead to resolution of the inflammatory lesion, and due to the side effects of surgical interventions, non-surgical treatment alternatives are preferable (Lindhe et al. 2008). Most authors recommend surgical interventions only when non-surgical therapy has failed. However, the patient must be fully aware that due to gingival recession, surgical procedures will compromise the esthetic result of the restoration and lead to functional impairment (Figuero et al. 2014). Accordingly, the actual trend is to try to deal with early and moderate peri-implant lesions by non-surgical treatment alternatives.

For periodontal treatment, adjunctive subgingival administration of minocycline following non-surgical periodontal treatment was shown to present a significantly better and prolonged effect compared to scaling/root planing alone on the reduction of probing depth, clinical attachment loss, gingival index, and interleukin-1beta content (Lu and Chei 2005), together with a greater reduction in the proportions and numbers of red complex bacteria (Bland et al. 2010).

Subgingival debridement plus use of locally applied antibiotics as a slow release device has also been proven effective for peri-implantitis treatment (Faggion and Schmitter 2010). Clinical results after application of minocycline microspheres as an adjunct to mechanical treatment of incipient peri-implant infections compared to adjunctive treatment employing 1% chlorhexidine gel application have been evaluated. The combined mechanical/antimicrobial treatment for the chlorhexidine group did not result in any reduction in probing depth and but only limited reduction of bleeding scores. The adjunctive use of minocycline microspheres (ARESTIN®), on the other hand, resulted in improvements in both probing depths and bleeding scores (Renvert et al. 2006; Renvert et al. 2004; Bassetti et al. 2014; Salvi et al. 2007).

Among the non-surgical treatments evaluated, especially in initial/moderate peri-implantitis, debridement in conjunction with local minocycline microspheres in a slow-release device (SRD) application (Arestin®) achieved the greatest additional reduction in probing pocket depth, number of bleeding upon probing positive sites, and counts of Porphyromonas gingivalis and Tannerella forsythia (Renvert et al. 2006; Bassetti et al. 2014; Salvi et al. 2007; Schar et al. 2013).

A recent meta-analysis has shown that ARESTIN® was more effective than slow-release chips containing chlorhexidine for peri-implant inflammation treatment (Faggion et al. 2014).

Besides its antibacterial effect, minocycline microspheres (Arestin®) have also an important anti-inflammatory action. Its application locally reduces cytokine levels (i.e., interleukin 1b), combined with debridement results in serum reductions of cholesterol, C-reactive protein, and interleukin 1 level (Lu and Chei 2005; D'Aiuto et al. 2005; Persson et al. 2006). However, the effect of adjunctive therapy diminishes with time, being the most positive effect is within 1 to 2 months; therefore, the risk for reinfection favors repeated SRD application in peri-implant areas, meaning that this anti-infective/anti-inflammatory must be periodically repeated (Renvert et al. 2006; Bassetti et al. 2014; Salvi et al. 2007; Bonito et al. 2005).

It should be kept in mind that prevention is always the best treatment alternative. Based on the individual risk assessment for a certain patient, presence of clinical signs of inflammation, and loss of implant bone support, a maintenance and treatment protocol based on three combined actions is suggested: debridement, decontamination, and anti-infective/anti-inflammatory therapy (DDA). Debridement is usually performed with ultrasonic scalers and hand curettes, where the therapeutic action is mainly cleaning and rinsing of the submucosal area and allow access for the decontamination devices. Calculus does not strongly adhere to titanium surfaces; therefore, only light contact with the metal surfaces of the abutment and/or implant is recommended. Release of titanium particles into the soft tissue, due to scaling of the implant surface, may cause a foreign body inflammatory reaction and even bone resorption (Eger et al. 2017).

Decontamination may be performed with a combined application of a sodium hypochlorite gel, with an activating vehicle (PERISOLV®) (Jurczyk et al. 2016; Roos-Jansaker et al. 2017), irrigation and decontamination with hydrogen peroxide 3% which has also lead to good clinical outcomes (Jepsen et al. 2016; Suarez et al. 2013), and submucosal cleaning with a chitosan brush (LABRIDA™). Once bleeding stops, the third step is the submucosal application of the anti-infective/anti-inflammatory minocycline microspheres (Arestin®).

As the pendulum swings back towards endodontics

Dental implants have led to a new era in dentistry and provide excellent and effective functional and esthetic solutions that were not available in the past to patients. However, as presented in the current review, in recent years, it became clear that peri-implant diseases are extremely common and significant, and their prevention and treatment is complex. Thus, their substantial extent may pose significant effects on the post-treatment quality of life of many of the patients (Iqbal and Kim 2008; Doyle et al. 2006; Hannahan and Eleazer 2008).

With the increasing reports regarding the complications associated with implants, the readiness adopted by many clinicians in the past, to easily extract the teeth and replace them with implants, significantly decreased. It seems that in recent years, the pendulum swings back towards maintaining even the compromised teeth by additional endodontic and restorative procedures (Tsesis et al. 2010; Setzer et al. 2017; Rosen et al. 2017).

The increased scientific understanding of the endodontic disease together with recent technological advances in endodontics, such as the use of electronic apex locators, surgical operation microscopes, modern imaging systems, and ultrasonic instruments (Taschieri et al. 2010; Tsesis et al. 2015), have resulted in the ability to predictably treat and retain the teeth that were previously considered untreatable (Rosen et al. 2017).

Furthermore, modern endodontics provides a variety of treatment alternatives including non-surgical and surgical endodontic treatments and management of complications such as root perforations and separated instruments (Rosen et al. 2017). These treatment alternatives may provide predictable prognosis even for complicated cases and the compromised teeth. In fact, to-date the vast majority of the teeth that undergo endodontic treatment survive and function for the long term, and those which are eventually lost, are usually extracted because of non-endodontic-related causes, such as prosthetic and periodontal complications (Rosen et al. 2017; Ng et al. 2010; Salehrabi and Rotstein 2004).

Conclusions

The overall goal of dentistry is to provide long-term functional and esthetic solution to the patient (Tsesis et al. 2010; Setzer et al. 2017; Rosen et al. 2017). Therefore, the option to preserve the natural teeth by additional treatments, and the option to extract compromised teeth and replace them with implants, should be regarded as complementary options and not as competing ones (Iqbal and Kim 2008; Setzer et al. 2017; Rosen et al. 2017; Iqbal and Kim 2007). Modern endodontics provides excellent conservative alternatives that with proper restoration offer predictable results in maintaining even the compromised teeth (Tsesis et al. 2010; Rosen et al. 2017; Tsesis 2014). Furthermore, in light of the severity and extent of per-implant diseases, the option to extract the teeth and replace them with implant-supported restoration should be preserved mainly for cases where all conservative treatments failed and the teeth were determined as clinically hopeless (Tsesis et al. 2010; Setzer et al. 2017; Rosen et al. 2017).

This pendulum swing towards maintaining the teeth by additional endodontic and restorative treatments is expected to be beneficial both for the long-term dental functioning and quality of life of the patients and for the reduction of unnecessary implant-related medical and medico-legal complications that practitioners may face in their daily practice.

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