

Evaluation of implant treatment based on a review of the literature. A critical look at the “success” of treatment

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ABSTRACT

Prosthetic rehabilitation with dental implants is continuously evolving and becoming more widespread. Therefore, it is essential to standardize methods for evaluating treatment outcomes, particularly in terms of verifying the definitions related to treatment success. It is important to distinguish between “full” treatment success and mere “survival” of the implant in the mouth. Currently, the literature lacks standardized criteria for defining implant treatment as a “success”. Factors such as peri-implant tissue health, bone loss, and technical aspects of the prosthetic restoration are commonly highlighted. Bone level follow-up examinations should be conducted using appropriate radiological techniques. This paper reviews the literature addressing the evaluation of implant treatment, focusing on the various

criteria used to classify therapy in terms of “success”. A proper evaluation of implant treatment requires a long-term follow-up period due to the potential for late complications. A shorter observation period may lead to an overestimation of the success rate for this type of therapy. The choice of therapeutic method should be individualized for each patient, and patients should be informed about potential complications. Studies reporting success rates for implant therapy should account for the occurrence of complications. Further research is needed to establish standards and algorithms for managing complications in implant-prosthetic therapy.

Keywords: dental implant; success; criteria; complications; failure.

INTRODUCTION

Teeth with severely compromised clinical crowns that require root canal treatment can be managed using conservative methods or extraction followed by implant-based prosthodontic restorations. Dental implants are artificial abutments placed in the alveolar process of the maxilla or alveolar part of the mandible, designed to support fixed or removable prostheses, thereby restoring missing natural teeth. Several types of dental implants exist, such as subperiosteal implants, placed under the periosteum directly on the bone surface, and endosteal implants, the most common type, which are placed within the bone and oriented like natural tooth roots [1].

The introduction of dental implants as a prosthodontic treatment was made possible by the discovery of osseointegration by Brånemark in 1985 [2]. In Poland, one of the first cases of implantation followed by immediate prosthetic restoration was performed by Majewski [1]. As new technologies in dental materials and procedures emerge, the popularity of dental implants continues to rise. In 2006, over 5.5 million dental implants were placed in the USA [2]. Dental implants are offered by various manufacturers worldwide. The most common brands in Poland include: Nobel Biocare, Straumann,

Camlog (Switzerland), Bicon, Zimmer, Intra-Loc, Astra Tech (USA), Sky (Germany), and Dentis (South Korea).

The invention of dental implants was a breakthrough in dental treatment, providing many patients with the opportunity for satisfactory rehabilitation of the stomatognathic system. However, it is important to recognize that no solution in medicine is perfect, and no prosthesis can fully replicate natural dentition. It is not uncommon to see recommendations for the extraction of teeth that could otherwise be preserved through conservative, endodontic, or periodontal treatment. Today, these treatment methods have high success rates and can offer long-term, functional outcomes for initially problematic teeth.

While dental implants offer an excellent solution when natural teeth must be extracted, the decision to proceed with implants should only follow a thorough analysis and careful comparison of the risks and benefits. For many years, dental implants were mistakenly believed to have an always favorable prognosis. However, in cases of failure, implants may require additional treatment, which is not always successful, or removal from the oral cavity.

As dental implant-based treatments and their popularity evolve, it is essential to base treatment decisions on individual patient assessments, reliable information, and success

indicators. This review study analyzed the literature on the evaluation of implant-prosthetic therapy.

In 1986, Albrektsson, Zarb, and Worshington established the following criteria for dental implant success: immobility upon clinical examination, absence of radiolucencies indicating bone loss around the implant on radiographs, bone loss not exceeding 0.2 mm per year after the first year, and no signs of infection, neuropathy, paresthesia, or damage to the mandibular canal.

The minimum criterion for therapy success was defined as an 85% success rate after 5 years post-implantation and 80% after 10 years. In implant therapy, it is important to distinguish between the success rate, which is the percentage of cases that meet all the established criteria, and the survival rate, which refers to the percentage of implants remaining in the oral cavity, regardless of whether they meet all success criteria (Fig. 1).

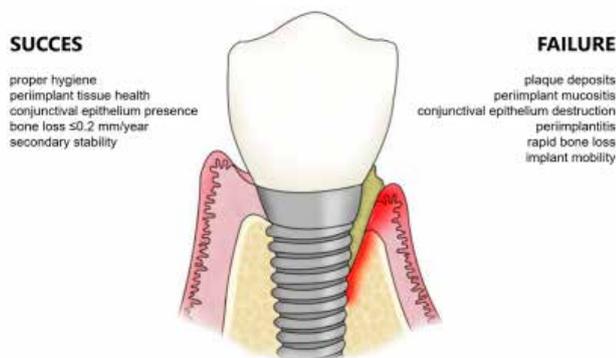


FIGURE 1. Implantological treatment – succes and failure

To evaluate the survival and success of dental implants, a minimum observation period of 5 years is required, starting from the moment the implant is loaded. Defining clear success criteria is challenging due to the variety of dental implant systems, treatment protocols, and evaluation parameters available. Researchers advise caution when interpreting clinical studies on implant therapy, as favorable results may sometimes be emphasized, particularly in studies sponsored by dental implant manufacturers [3].

Górska suggests that implant treatment success is indicated by the absence of peri-implant soft tissue redness, swelling, and bleeding during probing with a force of 0.25 N (with a probing depth of no more than 5 mm). In the first year after implant loading, bone loss should not exceed 2 mm, with no further bone loss expected beyond the initial lowering of the alveolar bone margin. In subsequent years, even successful implants may experience bone loss of up to 0.2 mm per year. Ideally, zero bone loss around the implant is the desired treatment outcome, which, according to current research, is achievable [4].

Among the biological complications associated with dental implants are periimplantitis and periimplant mucositis. The prevalence of these conditions is reported to be 22% (ranging 1–47%) and 43% (ranging 15–65%), respectively. Periimplant mucositis is characterized by inflammation of the soft tissues around the implant, caused by biofilm accumulation, and does not involve bone loss beyond accepted limits. Clinically, it manifests as redness, swelling, and bleeding during probing within 30 s of the examination. Treatment primarily involves professional and home biofilm control.

Periimplantitis, on the other hand, is marked by inflammation of the mucosa around the implant, increased pocket depth over time, and progressive marginal bone loss beyond acceptable levels (2 mm). The process is often non-linear and linked to infection. Predisposing factors include poor oral hygiene, a history of periodontitis, inadequate or absent postoperative care, insufficient periodontal maintenance, poor patient cooperation, smoking, and residual cement left during the cementation of the prosthetic work. Some studies indicate that up to 74% of implants have structures that complicate proper hygiene maintenance around the implant. To diagnose periimplantitis, the following criteria must be met: bleeding and/or purulent exudate upon gentle probing, a pocket depth of 6 mm or greater, and bone loss of 3 mm or more.

Treatment for periimplantitis includes non-surgical procedures, which are often ineffective, and surgical interventions to restore tissue defects. Surgical treatments are challenging and lack sufficient scientific evidence to establish definitive guidelines for their effectiveness [4].

Górska and Konopka reported that acceptable horizontal bone loss around an implant should not exceed 1.2 mm in the first year post-implantation, followed by no more than 0.1 mm annually [5]. In earlier years, bone loss under 0.2 mm per year was not considered indicative of treatment failure. Periimplantitis, however, is characterized by horizontal bone loss exceeding 0.2 mm annually, with initial bowl-shaped cavities visible on radiographs that may eventually encompass the entire implant outline as the condition progresses.

REVIEW OF THE LITERATURE

Various types of studies (including retrospective, prospective, and case studies) have addressed the evaluation of implant treatment. The information gathered from these studies is presented in Table 1. It is important to highlight that the authors of these studies do not consistently follow standardized criteria and indicators when assessing treatment success. Additionally, the observation periods in some studies are relatively short, ranging from 3 months to 3 years.

TABLE 1. Diverse approaches to implant treatment success verification in the literature

Authors, year	Observation period	Number of patients	Number of implants	Patients' age	Evaluated parameters	Radiographic method	Treatment outcome	Number/percentage of complications in implants
Retrospective studies								
Bianco et al., 2000 [6]	50% – 3 years, 20% – 5 years	214	252	from <21 to >70	implant stability, periimplant tissue health, bone resorption	IOPA (Rinn's technique)	survival: 94.7%	abutment screw loosening – 22, decementation – 13, implant loss – 10, fistula – 9, rapid bone loss – 2, unsatisfying aesthetics – 5, occlusal veneer chipping – 3, abscess – 2, fenestration – 4, tissue recession – 2
Brocard et al., 2000 [7]	7 years	440	1022	from <40 to >60	presence of pain or discomfort, presence of inflammation or infection symptoms, implant mobility, radiolucencies surrounding the implant, bone loss	no data	survival: 5 years – 95.4%, 7 years – 92.2%	implant loss – 68, no data about other complications
Vehemente et al., 2002 [8]	1 year, 5 years	677	677	average: 53.5 ±13.9	no data	no data	survival: 95.2% – 1 year, 90.2% – 5 years	no data
Doyle et al., 2007 [9]	3088 days	405 pre-qualified, no data on the final number	196	≥18	success: implant present in the oral cavity, functionality of the implant, no radiolucencies around the implant on radiograph, immobility of the implant; survival: implant present in the oral cavity, further intervention necessary	no data	success: 73.5%; survival: with intervention – 17.9%, without intervention – 2.6%	aesthetic aspects – 1, implant considered for removal: awaiting for decision – 4, CT grafts – 3, abutment fracture – 1, abutment dislodgement – 1, crown fracture – 3, periimplant surgery following restoration – 2, crown remaking – 7, abutment loosening – 1, screw fracture – 1, screw loosening – 4
Slagter et al., 2021 [10]	5 years	40	40	>18	papilla index, modified plaque index, modified sulcus index, gingival index, probing depth, periimplant mucositis (positive bleeding index, bone loss <2 mm and/or purulent exudate), aesthetics of the prosthetic restoration, patient's satisfaction	standardized digital IOPA	survival: 100%	periimplant mucositis: 22.4% – group A; 17.6% – group B, periimplantitis: 5.6% – group A, 0% – group B

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Prospective studies								
Gotfredsen, 2004 [11]	5 years	20	20	18-59	bleeding index, dental plaque presence, length of prosthetic crown, length of opposite tooth, distance between the incisal edge of the implant-supported crown and the top of adjacent interproximal papillae, bone loss, health of periimplant tissues, technical aspects of the prosthetic restoration, aesthetics of the restoration	IOPA – paralleling technique	survival: implant – 100%, crown – 95%	soft tissue dehiscences – 2, periimplantitis (no specific number of patients), fistula – 1, abutment screw loosening – 2, crown decementation – 2, fracture of ceramic veneer – 2, need for crown remaking – 1
Nentwig, 2004 [12]	examination every 1 year, no data on observation period	943	943	no data	implant stability and functionality, presence of soft and hard periimplant tissues inflammation, presence of progressive bone loss around the implant, presence of progressive mucosa loss around the implant, patient's satisfaction	no data	success: 98.7%	no data
Taylor et al., 2004 [13]	5 years	39	39	no data	plaque index, gingival index, clinical attachment level (using Florida Probe), bone loss	standardized bitewing	survival: 97.4%	no data
Zinsli et al., 2004 [14]	5 years, 6 years	154	298	19-87	periimplant tissues health, mobility, presence of pain, technical aspects of the implant, condition of prosthetic restoration, oral hygiene, probing depth	no data	survival: 98.7% – 5 years, 96.6% – 6 years	infection – 5, fracture – 2
Raes et al., 2018 [15]	8 years	immediate implantation – 11, delayed implantation – 13	immediate implantation – 11, delayed implantation – 13	immediate implantation – 22-68, delayed implantation – 19-75	bone loss, presence of pain, presence of abscesses, fistulae, technical aspects of the implant, technical aspects of the prosthetic restoration, presence of dental plaque, probing depth	standardized IOPA or CT	survival: immediate implantation – 93,8%, delayed implantation – 100%	fistula – 1, progressive bone loss – 1, pain + fistula – 1, pain + progressive bone loss – 1, abutment screw loosening – 3, crown loosening – 3, porcelain chipping – 3, crown loosening + porcelain chipping – 1, crown fracture + porcelain chipping – 1, 38% of the patients experienced at least 1 biological complication, 10% of the patients experienced 1 or more biological complications, 31% of the patients experienced 1 or more technical complications

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Authors, year	Observation period	Number of patients	Number of implants	Patients' age	Evaluated parameters	Radiographic method	Treatment outcome	Number/percentage of complications in implants
Pol et al., 2020 [16]	1 year	30	30	no data	mobility, marginal bone level, modified plaque index, modified sulcus index, gingival index for periimplant inflammation evaluation, presence of dental calculus, probing depth, survival of the prosthetic restoration, presence of complications linked to prosthetic restoration, patient's satisfaction	standardized IOP	success: 100%	no technical complications (loosening of the restoration, framework fracture, occlusal veneer abrasion), no data regarding biological complications
Case reports								
Gonzalez Lopez et al., 2005 [17]	3 years	1	1	34	restoration's aesthetics, stability of periimplant tissues	IOPA	success	no complications
Fu et al., 2012 [18]	7 years	1	1	24	gingival architecture, marginal bone level, patient's satisfaction	IOPA	success	no complications
Patankar et al., 2016 [19]	18 months	1	1	22	implant stability, marginal bone level, osseointegration, periimplant tissue health, bleeding on probing	IOPA	success	no complications
Wang et al., 2019 [20]	2 years	1	2	40	presence of pain, tenderness, exudate, mobility, presence of radiolucency around the implant on radiograph, marginal bone level	CBCT, control IOPA	success	no complications
Jang et al., 2020 [21]	3 months	1	1	30	no data	CBCT, control IOPA	success	no complications
Randomized controlled clinical trial								
Naenni et al., 2018 [22]	5 years	86	86	>18	probing depth, bleeding on probing, plaque index, technical aspects of the implant, technical aspects of the prosthetic restoration, bone loss	IOPA	survival: 10 mm – 100%, 6 mm – 91%	screw loosening, veneer porcelain chipping

IOPA – intraoral periapical radiograph; CT – computed tomography; IOP – intraoral periapical; CBCT – cone-beam computed tomography

Implant therapy undoubtedly has a high success rate, but complications are not uncommon. Some authors exclude complicated cases from the pool of failed treatments [7]. Vehemente et al. note that the literature provides limited information on the risk factors for implant therapy failure, and the treatment of complications is largely a “trial and error” process, often based on *in vitro* data [8]. Slagter et al. report that implant restorations made of zirconium oxide veneered with porcelain have a lower survival rate [10]. It is also worth noting that late complications, such as periimplantitis and occlusal overloading, may not be recorded during shorter observation periods [23].

The use of implants in prosthetic rehabilitation may require additional pre-implant procedures. In the clinical case described by Fu et al., autogenous bone grafting from the chin area was necessary [18]. Similarly, Jang et al. presented a case where bone augmentation was required at the implant site [21].

Evaluating the marginal bone level around the implant is crucial for assessing the success of implant treatment and determining the next steps in therapy [24]. Intraoral radiographs, conventional computed tomography (CT), and cone-beam computed tomography (CBCT) are used to assess this parameter. The European Association for Osseointegration (EDA) recommends selecting radiographic examination methods on a case-by-case basis, with caution when using 2-dimensional images. Cone-beam computed tomography and CT offer 3-dimensional imaging and allow for precise measurements [25].

Most of the studies in Table 1 used intraoral radiographs to assess marginal bone levels. While these are cost-effective and involve low radiation doses, they provide 2-dimensional images of 3-dimensional structures, limiting their ability to distinguish between bone defects on the buccal and lingual sides [24]. Cone-beam computed tomography offers higher resolution, lower linear measurement error, and a lower radiation dose compared to conventional CT [25]. It is a reliable and accurate method for diagnosing and classifying bone defects around implants. Cone-beam computed tomography has higher sensitivity than intraoral radiographs for detecting small bone defects (less than 1 mm). Song et al. used CBCT to detect dehiscences on the lingual side of an implant, which were not visible on intraoral radiographs. The authors believe that the precise bone assessment provided by CBCT outweighs the risks associated with higher radiation exposure, recommending it as a standard tool in implant management [24].

The literature also describes cases of implant therapy failure. Complications after implant placement can be divided into early complications, which occur before or during abutment placement, and late complications, which occur after implant loading. Factors increasing the risk of complications can be grouped into:

- patient-related factors: general health, history of periodontal disease, smoking, uncontrolled diabetes, oral hygiene level, and surgical technique;
- implant-related factors: timing of placement, implant location, dimensions, and type of implant surface;
- prosthesis-related factors: loading, attachment method, and occlusal conditions.

A retrospective study by Lázaro-Abdulkarim et al., involving 1510 patients who received a total of 4,482 implants, found a 10.8% treatment failure rate after 7 years. The criteria for failure included pain, mobility, bone loss exceeding 50% of the total bone level around the implant, uncontrolled effusion, and implant loss. The authors suggest that extending the follow-up period could reveal a higher failure rate due to the potential development of periimplantitis, the most common cause of late implant loss. Their analysis also showed that the risk of complications increases with the number of implants placed in a patient [26].

In a study by Thiebot et al., conducted over 6 years, the most common causes of implant loss were bone density (types III and IV) at the implant site, sinus lift procedures before implantation, smoking, surgical field infection, and rheumatoid arthritis. The authors reported a failure rate of 3.11% based solely on implant loss, with 28–77% of subjects experiencing peri-implant tissue inflammation [27].

In a study by Khan et al., the failure rate of implant treatment was 3.2% of 220 implants placed. Risk factors such as: cigarette smoking, diabetes, preload, age over 50, implant location in the lateral alveolar process of the jaw, parafunctions, and pre-existing periodontal disease were associated with complications. The authors emphasize that while implant rehabilitation is generally predictable, failures still occur in a small but significant group of patients. As the use of implants increases, even a 3% failure rate represents a large number of affected patients [28].

DISCUSSION

Dental implants are often referred to as a “third set of teeth”, which can sometimes discourage patients from pursuing treatment for problematic natural teeth, especially when these teeth seem less promising compared to the “modern, better” solution of implants. It is important to remember that a dentist’s primary responsibility is to preserve functional, natural dentition for as long as possible, and premature replacement with implants may undermine this goal [29]. The preservation of natural teeth is associated with better overall health and quality of life, as demonstrated by the health related quality of life (HRQoL) index [30].

According to the partnership model of care, the decision about which treatment option to pursue is made by the patient, who is fully informed by the doctor about the treatment’s course, benefits, and potential drawbacks. A 2015 survey conducted in China revealed several misconceptions the public holds about dental implants. Some respondents believed that implants are a solution to all dental problems, require no hygienic care, and can be easily replaced if lost. The notion that implants are a perfect, maintenance-free replacement for natural teeth can result in neglect of oral hygiene, leading to periimplant tissue complications. Additionally, some respondents thought that implants are universally applicable, and the procedure is simple enough for any dentist to perform.

Patients who encounter unverified and oversimplified information often form an idealized view of implant treatment, which can influence their decision to seek out this therapy. Importantly, the survey respondents had never consulted a dentist about implant treatment. The significant gap between their opinions and medical knowledge underscores the unreliability of some publicly available information, which can perpetuate harmful stereotypes about the existence of an “ideal” treatment method. This highlights the importance of thoroughly educating patients and correcting misconceptions. The perception of implants as superior to natural teeth may lead to unnecessary extractions of teeth that could otherwise function well for many years [31].

CONCLUSIONS

Implant therapy undoubtedly has a high success rate; however, complications are not uncommon. When evaluating the therapy, it is essential to distinguish between “full” treatment success, which encompasses optimal function and aesthetics, and the mere “survival” of the implant in the mouth, which may persist despite complications or suboptimal outcomes.

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