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Risk Factors Influencing the Success of Dental Implants: A Comprehensive Review

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Abstract

Several systemic and local factors influence the success of dental implants. Smoking impairs tissue healing, reduces osteoblast activity, and increases implant failure rates—roughly twice as high as in non-smokers. Diabetes, though not always a direct risk factor, contributes to post-surgical complications due to impaired bone metabolism and inflammatory responses. Long-term studies show similar survival rates in diabetic and non-diabetic patients, though increased bone resorption is observed. Osteoporosis leads to reduced bone density and quality, especially in older women. While implant failure rates are not significantly different in osteoporotic patients, marginal bone loss is often greater. Bone quality, measured using tools like CT and resonance frequency analysis, correlates strongly with implant stability and success. Bruxism, a parafunctional habit involving tooth grinding, causes excessive occlusal loading on implants, increasing the risk of complications like fractures and screw loosening. Studies show slightly lower survival rates in bruxers, particularly in men. Finally, implant surface characteristics play a critical role in osseointegration. Rough surfaces enhance initial bone contact but may lead to greater marginal bone loss over time compared to machined surfaces. Ongoing research is needed to optimize implant designs and treatment protocols for high-risk patients.

Keywords: Risk Factors, Smoking, Osseointegration, Implant

Introduction

Dental implants have been widely used in partial or full edentulism for oral rehabilitation. Long-term prospective studies and systematic reviews have demonstrated that more than 95% survival rate could be expected after 5-

year of loading.[1,2] However, several etiologies might still contribute to early or late failure of dental implants such as biological, mechanical or iatrogenic factors.[1,3]

Albrektsson et al.,[4] defined that a successful implant must present no mobility, no peri-implant radiolucency, bone loss less than 0.2 mm per year after the first year of loading, and no persistent pain, discomfort, or infection. Failure of a dental implant is determined when an implant is with mobility, pain on function, uncontrolled exudates, or severe bone loss.[5] In this case, the implant should be removed.

Several local and systemic factors have been proposed and associated with an increased risk of peri-implantitis, for examples, smoking,[6,7,8] diabetes, previous history of periodontal diseases, poor plaque control and occlusal overload. Other predisposing local factor related to peri-implantitis is retained.

Several studies have examined the effects of a limited number of patients, or implant characteristics on implant success. However, few studies, have included enough patients or implants to simultaneously examine the effects of multiple factors on implant survival. Such an analysis could provide valuable guidance to clinicians providing implant therapies for patients. Therefore, the purpose of the article is to provide information on these risk factors that can cause implant failure.

Discussion

Advancement in the field of dentistry has become extensive specially in the recent times, with every passing day newer materials modification of older material in order to improve their prognosis has become a trend. One of the breakthroughs in field of dentistry is the introduction of dental implants. The implant introduced by branemark has undergone considerable changes till date. Though implant tends to be successful treatment option, but under certain conditions they can be subjected to failure. There can certain predisposing factors that have contributed to theses failure, these factors can be said as risk factors associated with implant failure**.**

Clinical studies have introduced several risk factors that may affect the short- and long-term implant success, including quality and volume of bone, jaw location, implant dimensions and augmentation procedures, as well as systemic and environmental conditions.[9]

In 1986 Albrektsson et al.[4] proposed what is now known by most as the "gold standard" criteria for implant success. This criterion is as follows:

- Individual unattached implant that is immobile when tested clinically
- Radiography that does not demonstrate evidence of peri-implant radiolucency
- Bone loss that is less than 0.2 mm annually after the implant's first year of service
- No persistent pain, discomfort, or infection
- By these criteria, a success rate of 85% at the end of a 5-year observation period and 80% at the end of a 10-year period are minimum levels for success.

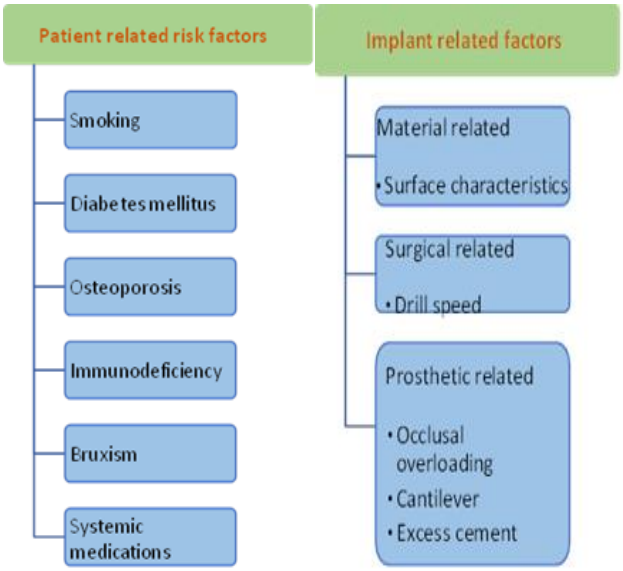
The International Congress of Oral Implantologists published a more detailed list of The criteria for implant success (Figure: 1), survival and failure in 2007 (published by Misch et al., 2008).[5]

Table 1. Health Scale for Dental Implants*

Implant Quality Scale Group	Clinical Conditions
I. Success (optimum health)	a) No pain or tenderness upon function b) 0 mobility c) <2 mm radiographic bone loss from initial surgery d) No exudates history
II. Satisfactory survival	a) No pain on function b) 0 mobility c) 2-4 mm radiographic bone loss d) No exudates history
III. Compromised survival	a) May have sensitivity on function b) No mobility c) Radiographic bone loss >4 mm (less than 1/2 of implant body) d) Probing depth >7 mm e) May have exudates history
IV. Failure (clinical or absolute failure)	Any of following: a) Pain on function b) Mobility c) Radiographic bone loss >1/2 length of implant d) Uncontrolled exudate e) No longer in mouth

Risk factors in implant dentistry

Upon reviewing the literature, potential risk factors in implant dentistry can be classified as follows. (figure 2)



Effect of Smoking on Dental Implants

Smoking has numerous deleterious effects on tissues and on the host immunoinflammatory response. Products of tobacco such as nicotine, carbon monoxide, and hydrogen cyanide alter wound healing by decreasing proliferation of fibroblasts and other reparative cells, decreasing tissue perfusion through vasoconstriction, and increasing platelet adhesion.[10]

Effect of Diabetes on Dental Implants

Diabetes mellitus is a chronic metabolic disorder that leads to hyperglycemia, which raises multiple complications caused by micro- and macroangiopathy. Diabetic patients have increased frequency of periodontitis and tooth loss, delayed wound healing, and impaired response to infection. In 1980, more than 150 million people worldwide were affected and that number had grown to 350 million by 2008. This trend highlights the need for better understanding of diabetes and its therapy and its impact on dental implant rehabilitation.[11]

Diabetes negatively impacts bone metabolism, with decreased osteoblast differentiation and proliferation, decreased collagen production, and increased osteoblast apoptosis having been demonstrated in hyperglycemic environments. This pathological mechanism can be explained by the increased serum levels of destructive proinflammatory cytokines (such as interleukin [IL]-1β, IL-6, and tumor necrosis factor alpha [TNF- a]) and of peri-implant crevicular fluid, as a result of the increased production of AGEs and impairment of the chemotactic and phagocytic functions of polymorphonuclear leukocytes in Type 2 Diabetes mellitus patients.[12]

Effect of Osteoporosis and Bone Density on Dental Implants

Osteoporosis is considered a very common skeletal disease and is characterized by low bone density in human bone tissues. Imbalances in bone remodelling cause a constant decrease in bone volume and quantity, and osteoporosis affects many individuals, mainly older women, worldwide. The volume of bone available and quality of the bone are highly associated with the type of surgical procedure and the type of implant, and both factors play a vital role in the success of dental implant surgery. Higher failure seems to be associated with the implants in which the surgeon observes a poor degree of bone mineralization or limited bone resistance by tactile assessment while drilling. It is typical that the bone around the implant has better quantity and quality in the mandible than the maxilla.[13]

Effect of Immunodeficiency on Dental Implants

There is only little evidence for deteriorating influences of immunodeficient conditions on the survival of dental implants. The available literature showed that in a well-controlled population of HIV patients who maintained proper oral hygiene and accepted to follow a proper professional maintenance protocol, implant rehabilitation

can be a suitable option with results slightly worse to those obtained in normal population. A higher incidence of peri implant infections in the first six months was present pointing to the need of a proper protocol of infection control. [14]

Effect of Bruxism on Dental Implants: Bruxism is a condition characterized by grinding and clenching of teeth at night. This is a most commonly occurring parafunctional habit. This is the cause of excessive occlusal load on dental implants due to movement disorder of masticatory apparatus. functioning and aesthetics. Excessive occlusal overload caused in bruxism patients is the leading cause of failure such as fracture of implant, loosening of screw, fracture of screw, and fracture of porcelain. [15]

Effect of Systemic Medications on Dental Implants

Bisphosphonates (BPs) are a class of drugs comm used to decrease osteoclast activity and bone turn-over, typically giving higher bone density. BPs can be administered either orally or intravenously. Several studies suggest that patients using BPs given intravenously are at a greater risk of developing osteonecrosis of the jaw (ONJ), although a direct causal relationship has yet to be determined. [16] Proton pump inhibitors (PPIs) are a group of drugs that suppress gastric acidity by inhibiting functions of the proton pump (H+/K+ ATPase). PPIs are the most effective antiacid medications for upper gastrointestinal acid-related diseases. Although PPIs are well-tolerated, many studies suggest an association between the use of these medications and reduced duodenum calcium absorption, delay of fracture healing and increased fracture risk in adults and infants. [17]

Effect of Implant Surface Implants characteristics on dental Implants

Most of the dental implants used today are designed with a modified surface. Evidence from animal studies verified enhanced bone-to-implant contact and removal torque values with increasing surface roughness. [18] Implants with a machined surface may be advantageous regarding marginal bone com- pared with implants with a rough surface. The comparatively small difference in surface roughness between the two implant types did not influence the long-term peri- implant bone level change. Definite conclusions cannot be drawn as the literature on the subject is limited.

Surgical Risk Factors in Dental Implants

Oral rehabilitation with osseointegrated implants has been performed extensively worldwide in diverse clinical situations, with high success rates and excellent predictability. Primary bone repair of the receptor bed plays a fundamental role in osseointegration. Excessive trauma during surgery may negatively affect tissue maturation at the bone-to- implant interface, diminishing the predictability of osseointegration. The threshold level for thermal in- juries on the bone is the 47°C for a minute and the temperature can raise that level easily during drilling by rotational burs. Because of thermal injury, bone is not only resorbed but also replaced with fat cells. As a result, the mechanical structure of the bone is weakened. To prevent the bone from the temperature, raise during drilling, various irrigation systems are used and mostly, sterile saline solutions are the material of choice. One of the important factors that influence the implant micromotion is the drilling speed. Drilling speed can influence the accuracy of the osteotomy, and furthermore, it has an influence on heat generation in the surrounding bone. It has been suggested that low drilling speed in general increases the wobbling and results in the

over preparation of the osteotomy site. Furthermore, lower drilling speed has been suggested to generate more heat than high drilling speeds.[21] Therefore, to preserve tissue viability at the time of implant placement, it is necessary to perform adequate preparation of the surgical bed.[19]

Primary stability pertains to the lack of movement of an implant right after it is inserted, achieved through mechanical contact with the surrounding bone. This stability is influenced by factors such as the quality and quantity of bone, the macro-design of the implant (including its shape, diameter, and thread depth), surface roughness, and surgical methods like undersized drilling or bone condensation. The requirements for immediate loading usually require an insertion torque of at least 30 Ncm or an ISQ of 65 or greater, while lower torque (around 20 Ncm) or an ISQ of approximately 50 may be acceptable if the implants are connected. High torque levels (beyond 50 Ncm) can lead to compression necrosis. Strong primary stability contributes to enhanced secondary (biological) stability and osseointegration. Improved implant designs are beneficial for cases involving softer bone, and evaluations using insertion torque and ISQ facilitate careful loading decisions for both immediate and early loading protocols.[23]

Prosthetic Risk Factors in Dental Implants

Prosthetic risk factors in dental implants include various elements such as implant prosthesis design, crown status, plaque accumulation, gingival color, and crown type. These factors significantly impact peri-implant health, with good crown status associated with lower periodontal pocket depth and reduced plaque accumulation. Additionally, the presence of adequate keratinized mucosa, proper prosthodontic treatments, and careful consideration of prosthetic design elements like abutment height, prosthesis contours, and management of occlusal forces are crucial in preventing peri-implant diseases like mucositis and peri- implantitis. These risk factors highlight the importance of meticulous treatment planning, optimal restoration design, and regular follow-up visits to ensure the success of dental implants by minimizing the chances of developing peri-implant complications.[20] Wilson Jr. TG[27] explored the relationship between excess dental cement and peri-implant disease using the dental endoscope. Over a 5-year period, 39 patients with 42 implants that fit the inclusion criteria were identified. All these patients (20 females and 19 males; range, 41 to 78 years) had received dental implants with cemented single- unit fixed partial dentures. Cement was associated with 34 of 42 test implants (80.95%) and no control implants (0%). Of the 33 test implants available for evaluation at the 1-month interval, the clinical and endoscopic signs of peri-implant disease had resolved in 25 implants. No signs of peri- implant disease were seen around the control implants, on clinical evaluation or when the sulcus was observed with the endoscope. no difference could be detected in the initial presence of disease or response to treatment based on the type of cement used to lute the restoration. The type of implant surface did not seem to have any effect on the presence of inflammation or the retention of cement.[22]

Conclusion

Multiple patient-related factors can influence the success of dental implants. Smoking, particularly during the healing phase or with a long-term history, increases the risk of early and late implant failure. Type 2 diabetes poses a marginal risk, which can be mitigated with proper management and implant selection. Bruxism may contribute to mechanical complications, though evidence remains limited. Immunodeficient conditions, except

Crohn's disease, show minimal impact on implant survival. Despite these risks, successful implant therapy is achievable with thorough patient assessment, individualized treatment planning, and adherence to surgical and prosthetic protocols. Further, Comprehensive research on dental implant risk factors is vital to improve understanding, enhance risk assessment, guide clinical decisions, reduce complications, and ultimately achieve better, more predictable, and patient-focused implant outcome.

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