Print ISSN: 2321-6379
Online ISSN: 2321-595X

Review Article

Relation of Biological Factors with Failure of Osseointegration of Dental Implants

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Abstract

Osseointegration, a term explained by Branemark and co-workers in the early 1960s, represents a direct connection between bone and implant without interposed soft tissue layers. The purpose of the present topic is to discuss various factors responsible for the loss of implants. The factors influencing the failure of osseointegration have been identified as the medical status of the patient, smoking, bone quality, bone grafting, irradiation of bone, bacterial contamination, lack of pre-operative antibiotics, degree of surgical trauma, and operator experience. Furthermore, it appears that implant surface properties, roughness, and premature loading influence the failure rate. Dental implantology is the science associated with the diagnosis, design, insertion, restoration, and/or management of alloplastic or autogenous oral structure to restore the loss of contour, comfort, function, esthetic, speech, and/or health of the partially or completely edentulous patient.

Key words: Alloplast, Failure, Implants, Osseointegration

INTRODUCTION

The implants have become an important therapeutic modality in the last decade, mainly after the works developed by Brånemark, in which the direct contact between the bone functional tissues and the biomaterial titanium which was termed osseointegration.

Dental implants are inert, alloplastic materials embedded in the maxilla and/or mandible for replacing lost tooth/teeth and lost orofacial structures as a result of trauma, neoplasia, and congenital defects. The most common type of dental implant is endosseous, comprising a discrete, single implant unit placed within a drilled space within dentoalveolar or basal bone.

SUCCESS AND FAILURE

Adell (1981) reported the success rate of 895 implants over an observation period of 5 years after placement. Eighty-one percent of maxillary and 91% of mandibular implants remained stable.

Albrektsson (1986) proposed the formula for successful integration of dental implants have been. Of these, a lack of mobility is of prime importance as "loosening" is the most often cited reason for implant body removal.

Despite high success rates, implant failure may occur and is defined as the inadequacy of the host tissue to establish or maintain osseointegration. One review (Adell, 1990) suggested that 2% of implant fixtures failed to achieve osseointegration following placement. Using this meta-analysis, failure rates for Branemark dental implants were 7.7% (excluding bone grafts) over 5 years. Interestingly, failure rates in edentulous patients were almost double than those for partially dentate patients (7.6% vs. 3.8%).

IMPLANT COMPLICATIONS AND FAILURE

Factors associated for implant complication and failure have been extensively reviewed by Esposito *et al.* (1998). Factors affecting early failure of dental implants may be briefly classified as:

- Implant
- Patient and
- Surgical technique/environment related.

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Month of Submission : 03-2020
Month of Peer Review : 04-2020
Month of Acceptance : 05-2020
Month of Publishing : 05-2020

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Esposito *et al.* (1999) defined biological failure related to biological process and mechanical failures related to fractures of components and prostheses. Koutsonikos (1998) added the categories of iatrogenic failure and failure due to patient adaptation. El Askary *et al.* (1999) further defined failure as ailing, failing, and failed implants. This article gives an overview of the important biological factors that affect osseointegration and thus lead to loss of implant [Table 1]. Three major etiologic factors have been suggested as follows:

Infection

Infections caused due to bacteria occurs any time after implant placement. Many terms are currently used, indicating failing implants or complications. They are peri-implant disease, peri-implant mucositis, and peri-implantitis.

Peri-implant disease is a collective term for inflammatory reactions in the soft tissues which surround implants.

Peri-implant mucositis is a term that describes reversible inflammatory reactions in the soft tissue surrounding implants.

Other soft-tissue complications (hyperplastic mucositis, fistulas, and mucosal abscesses) seem mainly to have an infectious etiology. Fistulations and hyperplastic mucositis are often found in association to lose prosthetic components. Abscesses can occasionally be seen in relation to food particles trapped in the peri-implant crevice.

Impaired Healing

It is believed that the amount of surgical trauma (lack of irrigation and overheating), micromotion, and some local and systemic characteristics of the host play a major role in implant failures related to impair healing.

Overload

When the load applied to dental implants beyond the withstanding capacity of the bone, overload occurs, causing implant to failure. Failures that happen between abutment connection and delivery of the prosthesis, probably caused by unfavorable loading conditions or induced by the prosthetic procedure, considered to have an overload etiology. Other attributes to implant failure are poor surgical technique, poor bone quality, and poor prosthesis design in addition to the traumatic loading conditions.

FACTORS RELATED TO PATIENT

The patient factor is an important determinant of implant failure. Ekfeldt *et al.* (2001) identified the patient risk factors leading to multiple implant failures and concluded that a combination of several medical situations could be a contraindication to implant treatment. Hutton *et al.* (1995) showed that people with one implant failure would be likely to have others, and Weyant (1994) stated that a positive medical history is associated with an increase in implant failure. Weyant and Burt (1993) observed a 30% increase in the chances of removal of a second implant in patients with multiple implants presenting with one failure. This evidence indicates that implant failures are not randomly distributed in the population, but seems to occur in a small subset of individuals.

Table 1: Factors associated to failure of dental implants

Factor	Comments
Implant fixture	Previous failure Surface characteristics Surface purity and sterility Fit discrepancies Intra-oral exposure time
Mechanical overloading (overload)	Premature loading of implant Traumatic occlusion due to inadequate Restorations
Patient or local factors	Bone quantity/quality Adjacent infection/inflammation Oral hygiene Gingivitis Presence of natural teeth Periodontal condition of natural teeth Lodging of foreign bodies (including Debris from surgical procedure) in the implant pocket Soft tissue viability
Patient (systemic factors)	Vascular integrity smoking alcoholism Predisposition to infection, e.g., age, obesity, steroid therapy, malnutrition, metabolic disease (diabetes) systemic illness chemotherapy/ radiotherapy hypersensitivity to implant components
Surgical techniques/ environment	Surgical trauma Overheating (use of handpiece) Perioperative bacterial contamination, e.g., through saliva, perioral skin, gloves, armamentarium, operating room air, or air expired by the patient

MEDICAL STATUS

Diabetes

Diabetic patients experience delayed wound healing, which logically affects the osseointegration process. Uncontrolled diabetes has been proven to inhibit osseointegration and leads to implant failure. Fiorellini *et al.* (2001) demonstrated a low success rate of only 85% in diabetic patients, while Olson *et al.* (2000) found that the duration of diabetes had effects on implant success: More failures occurred in patients who had diabetes for a longer period. Fiorellini *et al.* (2001) observed that most failures in diabetic patients occurred in the 1st year after implant is loaded. Special

review programs and contingency plans are prudent commitments in the treatment planning for this category of patients.

Cigarettes Smoking

The ill effects of cigarette smoking on implant treatment are well documented. A longitudinal study by Lambert *et al.* (2000) found more failures in patients who smoked, and Bain and Moy (1993) observed that a significantly greater percentage of failures occurred in smokers (11.3%) than in non-smokers (4.8%). This difference was highly significant for implants placed in all regions of the jaws, with the exception of the posterior mandible. Several retrospective short-term studies in different populations and with different implant systems have been published and they demonstrate similar results. Kan *et al.* (1999) reported that smoking also creates problems in implants in the grafted maxillary sinuses.

Cigarette smoking is associated with significantly higher levels of marginal bone loss around implants, and the effect of smoking status on the hard and soft peri-implant tissues has been clearly shown. Lemons *et al.* (1997) again showed that smoking reduced bone density in the femur and vertebrae as well as in the jawbone.

The short-term advantage of a smoking cessation protocol suggested by Bain (1993) further explained the causal relationship between smoking and implant failure. The protocol specifically states that complete smoking cessation for 1 week before and 8 weeks after surgery. The results indicated that the smokers who undergone the cessation protocol displayed short-term implant failure rates similar to non- smokers, and significantly lower than smokers who did not follow the protocol. Although the meta-analysis published by Bain *et al.* in 1993 suggested that patients who smoked <12 cigarettes per day did not significantly affect the osseointegration of implant, the adverse effects mentioned by the previous mentioned studies should not be ignored.

Age

In young patients, implants such as "ankylosed (osseointegrated)" devices can introduce problems in growing jaws. Op Heij *et al.* (2003) reported that jaw bone growth can compromise oral implants and questioned the minimum age of a patient for implant treatment. Other studies have also discussed complications in similar situations, including submerging the implants in the jaw, changing position of the implants, potential for interference with normal jaw growth, and occlusal problems.

Theoretically, patients with more age will have more systemic health problems, but there is no scientific proof correlating old age with implant failure. Although Salonen *et al.* (1993) stated that advanced age was a possible contributing factor to implant treatment failure, other reports have shown no relationship between old age and implant failure.

IATROGENIC FACTORS

a. Overheating of bone during surgery
   The most widely suspected reason for failures occurring within 3 months of insertion is tissue overheating during the surgery. Salonen *et al.* (1993) found that 5.8% of implants were lost due to failures in osseointegration. Bone necrosis can occur if bone is heated to a temperature of 47°C for 1 min. The use of proper irrigation and sharp drills at low rotation speed can be employed to reduce heat generation. Moreover, Brisman (1996) recommended increasing both to allow speed and the load of the handpiece more efficient cutting and less frictional heat.
b. Lack of communication
   Most implant treatments involve multidisciplinary cooperation, and a lot of complications are related to communication errors. Starting from patient assessment with radiographs to the completion of treatment in which the laboratory processes the prosthesis, accurate communication among various team members plays a very important role in therapy. Watanabe *et al.* (2002) have emphasized the importance of thorough communication within the implant team. Tolman and Laney (2002) stressed that many failures are the result of wrong diagnosis, poor treatment techniques, and a lack of communication between members of the treatment team.

LOCAL FACTORS

a. Peri-implantitis
   Peri-implantitis is a chronic, progressive, marginal, and inflammatory process affecting the tissues surrounding osseointegrated implants that result in the loss of supporting bone. It accounts for 10–50% of all implant failures occurring after the 1st year of loading of implant. The exact pathogenesis of peri-implantitis is still not clearly known. Plaque accumulation on natural teeth may play a role in the bacterial composition of the peri-implant sulcus. Apse *et al.* (1989) found raised levels of Gram-negative bacteria in the peri-implantitis sulcus of dentate patients. Studies by Mombelli *et al.* (1987) and Rosenberg *et al.* (1991) showed that there is a presence of periodontal microorganisms around failing implants.

Haanaes (1990) stated that peri-implantitis is similar to periodontitis occurring in natural teeth. Lang *et al.* (2000) suggested a cumulative interceptive supportive therapy protocol to treat peri-implantitis, which includes mechanical debridement, antiseptic treatment, antibiotic treatment, and regenerative or resective therapy.

b. Position of the implant site
Due to the poor quality of bone in the maxillary bone, the results of implant treatment anywhere in the maxillae are generally poorer than those in the mandible. Adell *et al.* (1990) found a failure rate of about 20% for upper jaw implants. A retrospective multicenter evaluation study by van Steenberghe (1989) found that 1 in 6 (17%) implants placed in the maxillary molar region were lost as compared with 2 of 45 (4%) placed in the mandibular molar region. Jaffin and Berman (1991) reported the loss of 8.3% of 444 implants placed in the maxillae in their 15-year experience. In general, mandibular implants survive longer than maxillary implants.

c. Bone quality and quantity
The most important local patient factor for successful implant treatment is the quality and quantity of bone available for implant placement. Patients with low quality and low density of bone were at the highest risk for implant loss. Jaffin and Berman (1991), in their 5-year analysis, reported that as many as 35% of all implant failures occurred in type IV bone due to its thinner cortex, poor medullary strength, and low trabecular density. Unfortunately, the diagnosis of type IV bone is usually made during implant drilling for insertion. Although periapical X-rays offer some diagnostic help in identifying type IV bone, they may be deceiving because a thick buccal or lingual plate may hide the soft medullary nature of the internal bone.
Systemic osteoporosis has also been mentioned as a possible risk factor for failure of osseointegration of implants. Although the prevalence of osteoporosis increases among the elderly persons and after menopause, it appears that osteoporosis, as diagnosed at one particular site of the skeletal bone, is not necessarily seen at another distant site. In the study conducted by Roberts *et al.* (1992) and Dao *et al.* (1993), local rather than systemic bone density seemed to be the predominant factor.

d. Irradiated bone
Implants can be used to provide support for craniofacial prostheses. Radiotherapy in combination with surgical excision is the treatment generally given for malignant tumors in that region, and osteoradionecrosis is one of the oral effects of radiation therapy. Although radiation therapy is not an absolute contraindication for implant treatment, the reported success rate is only about 70%. Long-term studies are limited, but Jacobsson *et al.* (1988) showed increasing implant failure/loss over time.

Adjunctive hyperbaric oxygen (HBO) therapy has been also proposed for previously irradiated implant patients, especially for the region of the maxilla, zygoma, and frontal bones. For implants in the maxillary bone and orbit, Granstrom *et al.* (1992) demonstrated a failure rate of 58% without HBO (1983–1990) and of only 2.6% after HBO pre-treatment (1988–1990). In a later case-controlled study, Granstrom *et al.* (1999) further made a conclusion that HBO treatment reduced the implant failure rate in irradiated bone.

CONCLUSION

There is high success rate with endosseous implants but failures unavoidably occur. At an early stage, lack of primary stability of implant, surgical trauma, perioperative contamination, and occlusal overload seem to be the most important causes of implant failure.

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How to cite this article: Bonde PR and Ozturan S. Relation of Biological Factors with Failure of Osseointegration of Dental Implants. Int J Sci Stud 2020;8(2):23-27.

Source of Support: Nil, **Conflicts of Interest:** None declared.