Biological factors responsible for failure of osseointegration in oral implants

*Hadi SA1, Ashfaq N2, Bey A2, Khan S2

1Postgraduate Student, Postgraduate Certificate in Oral Implantology-2010, IGNOU, India.
2Department of Periodontics and Community Dentistry, Dr. Z.A. Dental College and Hospital, A.M.U., Aligarh, India.

Corresponding Author: syedabdul_hadi2000@yahoo.com

Abstract

Oral implantology (implant dentistry) is the science and discipline concerned 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. Osseointegration, a term coined by Branemark and co-workers in early 1960s, represents a direct connection between bone and implant without interposed soft tissue layers. The aim of the present review is to discuss various factors responsible for loss of oral implants. The factors contributing to failure of osseointegration have been identified as: medical status of the patient, smoking, bone quality, bone grafting, irradiation, bacterial contamination, lack of preoperative antibiotics, degree of surgical trauma, and operator experience. Furthermore, it appears that implant surface properties, roughness and premature loading influence the failure pattern.

Keywords: Implants; Osseointegration; Failure; Alloplast.

Introduction

Dental implants are inert, alloplastic materials embedded in the maxilla and/or mandible for the management of tooth loss and to aid replacement of 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 (screw- or cylinder-shaped are the most typical forms) placed within a drilled space within dentoalveolar or basal bone. They implants have become an important therapeutic modality in the last decade, mainly after the works developed by Bränemark (1960s), in which the direct contact between the bone functional tissues and the biomaterial titanium was termed osseointegration.

Success and failure

Albrektsson (1986) proposed the criteria 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 fixture removal. Adell (1981) reported the success rate of 895 implant fixtures over an observational period of 5 years after placement. Eighty-one per cent of maxillary and 91% of mandibular implants remained stable.

Despite high success rates, implant fixture 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 implants failed to achieve osseointegration following placement. Using a meta-analysis, failure rates for Branemark dental implants were 7.7% (excluding bone grafts) over five years. Interestingly, failure rates within edentulous patients were almost double those for partially dentate patients (7.6% versus 3.8%).

Implant complications and failure

A multifactorial background for implant complications and failure has been extensively reviewed by Esposito and co-workers (1998). Factors affecting early failure of dental implants may be broadly classified as: implant- and patient- and surgical technique/environment-related (Table I). Three major etiologic factors have been suggested:

1. Infection: Bacterial infection that leads to implant failures can occur at any time during implant treatment. Several terms are currently used indicating failing implants or complications. These are: peri-implant disease, peri-implant mucositis, and peri-implantitis. Peri-implant disease is a collective term for inflammatory reactions in the soft tissues surrounding implants. Peri-implant mucositis is a term describing reversible inflammatory reactions in the soft tissue surrounding implants. Other soft tissue complications (hyperplastic mucositis, fistulations and mucosal abscesss) seem mainly to have an infectious etiology. Fistulations and hyperplastic mucositis are often found in relation to loose prosthetic
components. Abscesses can occasionally be seen in relation to food particles trapped in the peri-implant crevice.

2. Impaired healing: It is believed that the magnitude of the 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 impaired healing.

3. Overload: Implant failures related to overload include those situations in which the functional load applied to the implants exceeds the capacity of the bone to withstand it. Failures that happen between abutment connection and delivery of the prosthesis, probably caused by unfavourable loading conditions or induced by the prosthetic procedure, considered to have an overload etiology. Other attributes to implant failures are poor surgical technique, poor bone quality and poor prosthetic design in addition to the traumatic loading conditions.

Esposito et al (1999) defined biological failures 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, or failed implants. This article provides an overview of the important biological factors that affect osseointegration and thus lead to loss of implant.

Patient factors
Patient factors are important determinants 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 provide a contraindication to implant treatment. Hutton et al (1995) showed that subjects 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 loss. Weyant and Burt (1993) observed a 30% increase in the probability 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 seem to occur in a small subset of individuals.

Medical status

a) Diabetes
Diabetic patients experience delayed wound healing, which logically affects the osseointegration process. Uncontrolled diabetes has been shown to inhibit osseointegration and leads to implant failure. Fiorellini et al (2001) demonstrated a lower success rate of only 85% in diabetic patients, while Olson et al (2000) found that the duration of the diabetes had an effect on implant success: more failures occurred in patients who had diabetes for longer periods. Fiorellini et al (2001) also observed that most failures in diabetic patients occurred in the first year after implant loading. Special review programs and contingency plans are prudent commitments in the treatment planning for this category of patients.

b) Cigarette smoking
The adverse 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 implant occurred in smokers (11.3%) than in non-smokers (4.8%). The 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 demonstrating similar results. Kan et al (1999) reported that smoking also affects implants in the grafted maxillary sinuses.

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

The short-term benefits of a smoking cessation protocol suggested by Bain (1993) further explained the causal relationship between smoking and implant failure. The protocol specifies complete smoking cessation for 1 week before and 8 weeks after surgery. The results indicated that the smokers who complied with 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 (1993) concluded that patients who smoked fewer than 12 cigarettes per day did not significantly
affect implant osseointegration, the adverse effects mentioned by the previous mentioned studies should not be ignored.

<table>
<thead>
<tr>
<th>Table I. Factors related to the failure of dental implants.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
</tr>
</tbody>
</table>
| Implant | Previous failure  
Surface roughness  
Surface purity and sterility  
Fit discrepancies  
Intra-oral exposure time |
| Mechanical overloading | Premature loading  
Traumatic occlusion due to inadequate restorations |
| Patient (local factors) | Oral hygiene  
Gingivitis  
Bone quantity/quality  
Adjacent infection/inflammation  
Presence of natural teeth  
Periodontal status of natural teeth  
Impaction 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 technique/environment | Surgical trauma  
Overheating (use of handpiece)  
Perioperative bacterial contamination, e.g. via saliva, perioral skin, instruments, gloves, operating room air or air expired by patient |

c) **Age**

Theoretically, patients with increased age will have more systemic health problems, but there is no scientific evidence correlating old age with implant failure. Although Salonen et al (1993) stated that advanced age was a possible contributing factor to implant failure; other reports have showed no relationship between old age and implant failure. In young patients, implants such as ‘ankylosed’ devices can introduce problems in growing jaws. Op Heij et al (2003) reported that jaw growth can compromise oral implants and questioned the minimum age of a patient for implant treatment. Other studies have discussed complications in similar situations including submerging the implants in the jaw, relocation of the implants, potential for interference with normal jaw growth, and occlusal problems.

**Iatrogenic factors**

a) **Overheating of bone during surgery**

The most widely suspected explanation 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 of osseointegration. Bone necrosis can occur if
bone is heated to a temperature of 47° C for 1 minute. The use of proper irrigation and sharp drills at low rotation can be employed to reduce heat generation. Moreover, Brisman (1996) recommended increasing both the speed and the load of the hand piece to allow for more efficient cutting and less frictional heat.

b) Lack of communication
Most implant treatments involve multidisciplinary cooperation, and many 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 vital role in therapy. Watanabe et al (2002) have highlighted the importance of thorough communication within the implant team. Tolman and Laney (2002) stressed that many failures are the result of misdiagnosis, 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 reaction affecting the tissues surrounding osseointegrated implants that results in the loss of supporting bone. It accounts for 10% to 50% of all implant failures occurring after the first year of loading. The exact pathogenesis of peri-implantitis is still unclear. Plaque formation on natural teeth may play a role in the bacterial composition of the peri-implant sulcus. Apse et al (1989) found elevated 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 the presence of periodontal microorganisms around failing implants.

Haanaes (1990) stated that peri-implantitis is similar to periodontitis in natural teeth. Lang et al (2000) suggested a Cumulative Interceptive Supportive Therapy (CIST) protocol to treat developing 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 maxillae, 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 maxillary implants. A retrospective multicenter evaluation study by van Steenberghne (1989) found that 1 in 6 (17%) implants placed in the maxillary molar area was 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 inserted in the maxillae in their 15-year experience. Generally, mandibular implants also 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 at the implant site. Patients with low quantity and low density of bone were at 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 thin cortex, poor medullary strength, and low trabecular density. Unfortunately, the diagnosis of type IV bone is usually made during implant site preparation. Although periapical radiographs offer some diagnostic help in identifying type IV bone, they may be deceiving because a thick buccal or lingual plate may obscure the soft medullary nature of the internal bone.

Systemic osteoporosis has also been mentioned as a possible risk factor for osseointegration failure. Although the prevalence of osteoporosis increases among the elderly and after menopause, it appears that osteoporosis, as diagnosed at one particular site of the skeleton, is not necessarily seen at another distant site. In the studies 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 anchorage for craniofacial prostheses. Radiotherapy in combination with surgical excision is the treatment generally employed 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 to implant treatment, the reported success rate is only about 70%. Long term studies are limited, but Jacobsson et al (1988) showed increasing implant loss over time.

Adjunctive hyperbaric oxygen (HBO) therapy has been proposed for previously irradiated implant patients, especially for the region of the maxilla, zygoma, and frontal

Conclusion
Despite high success rate with endosseous titanium implants, failures unavoidably occur. At an early stage, lack of primary stability, surgical trauma, peri-operative contamination and occlusal overload seem to be the most important causes of implant failure.

References


