# eISSN: 09748369, www.biolmedonline.com

# Biological factors responsible for failure of osseointegration in oral implants

# \*Hadi SA<sup>1</sup>, Ashfaq N<sup>2</sup>, Bey A<sup>2</sup>, Khan S<sup>2</sup>

<sup>1</sup>Postgraduate Student, Postgraduate Certificate in Oral Implantology-2010, IGNOU, India. <sup>2</sup>Department 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 Brånemark (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' isthe 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-, patient- and surgical technique/environmentrelated (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 periimplantitis. Peri-implant disease is a collective term for inflammatory reactions in the soft tissues surrounding implants. Periimplant mucositis is a term describing reversible inflammatory reactions in the soft tissue surrounding implants. Other soft tissue complications (hyperplasticmucositis, fistulations and mucosal abscess) 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 probably caused prosthesis. bv 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 prosthesis 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 Wevant (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 process. Uncontrolled osseointegration 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 nonsmokers, 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.

Factor	Comments
Implant	Previous failure
	Surface roughness
	Surface purity and sterility
	Fit discrepancies
	Intra-oral exposure time
Mechanical	Premature loading
overloading	Traumatic occlusion due to inadequate
_	restorations
Patient (local	Oral hygiene
factors)	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	Vascular integrity
(systemic	Smoking
factors)	Alcoholism
	Predisposition to infection, e.g. age,
	obesity, steroid therapy, malnutrition,
	metabolic disease (diabetes)
	Systemic illness
	Chemotherapy/radiotherapy
	Hypersensitivity to implant
<b></b>	components
Surgical	Surgical trauma
technique/	Overheating (use of handpiece)
environment	Perioperative bacterial
	contamination, e.g. via saliva, perioral
	skin, instruments, gloves, operating
	room air or air expired by patient

# Table I. Factors related to the failure of dental implants.

## 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.

## latrogenic 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

implant Most treatments involve multidisciplinary cooperation, and manv 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 surrounding the tissues 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 periimplantitis is similar to periodontitis in natural teeth. Lang et al (2000) suggested a Cumulative Interceptive Supportive Therapy (CIST) protocol to treat developing periimplantitis, 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 Steenberghe (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 bones. For implants in the maxilla and orbit, Granstrom et al (1992) demonstrated a failure rate of 58% without HBO (1983-1990) and of only 2.6% after HBO pretreatment (1988-1990). In a later case-controlled study, Granstrom et al (1999) further concluded that HBO treatment reduced the implant failure rate in irradiated bone.

#### 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

Adell R, Lekholm U, Rockler B, Branemark PI, 1981. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. International Journal of Oral Surgery, 10:387-416.

Adell R, Eriksson B, Lekholm U, Branemark PI, Jemt T, 1990. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. International Journal of Oral and Maxillofacial Implants, 5:347-59.

Albrektsson T, Zarb GA, Worthington P, Eriksson AR, 1986. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. International Journal of Oral and Maxillofacial Implants, 1:11-25.

Apse P, Ellen RP, Overall CM, Zarb GA, 1989. Microbiota and crevicular fluid collagenase activity in the osseointegrated dental implant sulcus: a comparison of sites in edentulous and partially edentulous patients. Journal of Periodontal Research, 24:96-105.

Bain CA, Moy PK, 1993. The association between the failure of dental implants and cigarette smoking. International Journal of Oral and Maxillofacial Implants, 8:609-15.

Bain CA, 1996. Smoking and implant failure benefits of a smoking cessation protocol. International Journal of Oral and Maxillofacial Implants, 11:756-9.

Bain CA, Weng D, Meltzer A, Kohles SS, Stach RM, 2002. A meta-analysis evaluating the risk for implant failure in patients who smoke. Compendium of Continuing Education In Dentistry, 23:695-9.

Brisman DL, 1996. The effect of speed, pressure, and time on bone temperature during the drilling of implant sites. International Journal of Oral and Maxillofacial Implants, 11:35-7.

Dao TT, Anderson JD, Zarb GA, 1993. Is osteoporosis a risk factor for osseointegration of dental implants? International Journal of Oral and Maxillofacial Implants, 8:137-44.

De Bruyn H, Collaert B, 1994. The effect of smoking on early implant failure. Clinical Oral Implants Research, 5:260-4.

Ekfeldt A, Christiansson U, Eriksson T, Lindén U, Lundqvist S, Rundcrantz T, Johansson LA, Nilner K, Billström C, 2001. A retrospective analysis of factors associated with multiple implant failures in maxillae. Clinical Oral Implants Research, 12:462-7.

El Askary AS, Meffert RM, Griffin T, 1999. Why do dental implants fail? Part I. Implant Dentistry, 8:173-85.

Esposito M, Hirsch JM, Lekholm U, Thomsen P, 1998. Biological factors contributing to failures of osseointegrated implants (I). Success criteria and epidemiology. European Journal of Oral Sciences, 106:527-551.

Esposito M, Hirsch J, Lekholm U, Thomsen P, 1999. Differential diagnosis and treatment strategies for biologic complications and failing oral implants: A review of the literature. International Journal of Oral and Maxillofacial Implants, 14:473-490.

Esposito M, Thomsen P, Ericson LE, Lekholm U, 1999. Histopathologic observations on early oral implant failures. International Journal of Oral and Maxillofacial Implants, 14:798-810.

Eriksson A, Albrektsson T, Grane B, McQueen D, 1982. Thermal injury to bone. A vital microscopic description of heat effects. International Journal of Oral Surgery, 11:115-21.

Eriksson AR, Albrektsson T, 1983. Temperature threshold levels for heat-induced bone tissue injury: a vital-microscopic study in the rabbit. Journal of Prosthetic Dentistry, 50:101-7.

Fiorellini JP, Chen PK, Nevins M, Nevins ML, 2000. A retrospective study of dental implants in diabetic patients. International Journal of Periodontics and Restorative Dentistry, 20:366-73.

Friberg B, Jemt T, Lekholm U, 1991. Early failures in 4641 consecutively placed Branemark dental implants: a study from stage 1 surgery to the connection of complete prosthesis. International Journal of Oral and Maxillofacial Implants, 6:142-6.

Granstrom G, Jacobsson M, Tjellstrom A, 1992. Titanium implants in irradiated tissue: benefits from hyperbaric oxygen. International Journal of Oral and Maxillofacial Implants, 7:15-25.

Granstrom G, Tjellstrom A, Branemark PI, 1999. Osseointegrated implants in irradiated bone: a case-controlled study using adjunctive hyperbaric oxygen therapy. Journal of Oral and Maxillofacial Surgery, 57:493-9.

Gorman LM, Lambert PM, Morris HF, Ochi S, Winkler S, 1994. The effect of smoking on implant survival at second-stage surgery: DICRG Interim Report No. 5. Dental Implant Clinical Research Group. Implant Dentistry, 3:165-8.

Haas R, Haimbock W, Mailath G, Watzek G, 1996. The relationship of smoking on peri-implant tissue: a retrospective study. Journal of Prosthetic Dentistry, 76:592-6.

Haanaes HR, 1990. Implants and infections with special reference to oral bacteria. Journal of Clinical Periodontology, 17:516-24.

Hutton JE, Heath MR, Chai JY, Harnett J, Jemt T, Johns RB, McKenna S, Mcnamara DC, van Steenberghe D, Taylor R, Watson RM, Herrmann I, 1995. Factors related to the success and failure rates at 3-year follow-up in a multicenter study of overdentures supported by Branemark implants. International Journal of Oral and Maxillofacial Implants, 10:33-42.

Ibbott CG, Kovach RJ, Carlsson-Mann LD, 1993. Acute Periodontal abscess associated with an immediate implant site in the maintenance phase: A case report. International Journal of Oral and Maxillofacial Implants, 8: 699-702.

Jacobsson M, Tjellstrom A, Thomsen P, Albrektsson T, Turesson I, 1988. Integration of titanium implants in irradiated bone. Histologic and clinical study. Annals of Otology, Rhinology and Laryngology, 97:377-40.

Jaffin RA, Berman CL, 1991. The excessive loss of Branemark fixtures in type IV bone: a 5-year analysis. Journal of Periodontology, 62:2-4.

Kan JY, Rungcharassaeng K, Lozada JL, Goodacre CJ, 1999. Effects of smoking on implant success in grafted maxillary sinuses. Journal of Prosthetic Dentistry, 82:307-11.

Koutsonikos A, 1998. Implants: Success and failure — A literature review. Annals of the Royal Australasian College of Dental Surgeons, 14:75-80.

Lambert PM, Morris HF, Ochi S, 2000. The influence of smoking on 3-year clinical success of osseointegrated dental implants. Annals of Periodontology, 5:79-89.

Lang NP, Wilson TG, Corbet EF, 2000. Biological complications with dental implants: their prevention, diagnosis and treatment. Clinical Oral Implants Research, 11(Suppl 1):S146-55.

Lemons JE, Laskin DM, Roberts WE, 1997. Changes in patient screening for a clinical study of dental implants after increased awareness of tobacco use as a risk factor. Journal of Oral and Maxillofacial Surgery, 55(12 Supplement 5):S72-5. Lindquist LW, Carlsson GE, Jemt T, 1997. Association between marginal bone loss around osseointegrated mandibular implants and smoking habits: a 10-year follow-up study. Journal of Dental Research, 76:1667-74.

Linden R, Pihakari A, Perala A, Makela A, 2003. The 2002 dental implant yearbook. The Finnish dental implant register. Helsinki: National Agency for Medicines.

Mombelli A, van Oosten MA, Schurch E, Land N, 1987. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiology and Immunology, 2:145-51.

Mombelli A, Lang NP, 1998. The diagnosis and treatment of peri-implantitis. Periodontology 2000, 17:63-76.

Olson JW, Shernoff AF, Tarlow JL, Colwell JA, Scheetz JP, Bingham SF, 2000. Dental endosseous implant assessments in a type 2 diabetic population: a prospective study. International Journal of Oral and Maxillofacial Implants, 15:811-8.

O'Mahony A, Spencer P, 1999. Osseointegrated implant failures. Journal of the Irish Dental Association, 45:44-51.

Op Heij DG, Opdebeeck H, van Steenberghe D, Quirynen M, 2003. Age as compromising factor for implant insertion. Periodontology 2000, 33:172-84.

Salonen MA, Oikarinen K, Virtanen K, Pernu H, 1993. Failures in the osseointegration of endosseous implants. International Journal of Oral and Maxillofacial Implants, 8:92-7.

Sánchez-Garcés MA, Gay-Escoda C. Periimplantitis, 2004. Medicina Oral, Patología Oral y Cirugía Bucal, 9 Suppl:69-74; 63-9.

Santos MC, Campos MI, Line SR, 2002. Early dental implant failure: A review of the literature. Brazilian Journal of Oral Sciences, 1:103-111.

Shernoff AF, Colwell JA, Bingham SF, 1994. Implants for type II diabetic patients: interim report. VA Implants in Diabetes Study Group. Implant Dentistry, 3:183-5.

Smith GC, 1985. Surgical principles of the Branemark osseointegration implant system. Australian Prosthodontics Society Bulletin, 15:37-40.

Smith RA, Berger R, Dodson TB, 1992. Risk factors associated with dental implants in healthy and medically compromised patients. International Journal of Oral and Maxillofacial Implants, 7:367-72.

Roberts WE, Simmons KE, Garetto LP, DeCastro RA, 1992. Bone physiology and metabolism in dental implantology: risk factors for osteoporosis

and other metabolic diseases. Implant Dentistry, 1:11-21.

Rosenberg ES, Torosian JP, Slots J, 1991. Microbial differences in 2 clinically distinct types of failures of osseointegrated implants. Clinical Oral Implants Research, 2:135-44.

Tolman DE, Laney WR, 2002. Tissue-integrated prosthesis complications. International Journal of Oral and Maxillofacial Implants, 7:477-84.

Tonetti MS, Schmid J, 1994. Pathogenesis of implant failures. Periodontology 2000, 4:127-38.

Van Steenberghe D, 1989. Retrospective multicenter evaluation of the survival rate of osseointegrated fixtures supporting fixed partial prostheses in the treatment of partial edentulism. Journal of Prosthetic Dentistry, 61:217-23.

Watanabe F, Hata Y, Mataga I, Yoshie S, 2002. Retrieval and replacement of a malpositioned dental implant: a clinical report. Journal of Prosthetic Dentistry, 88:255-8.

Weyant RJ, 1994. Characteristics associated with the loss and peri-implant tissue health of endosseous dental implants. International Journal of Oral and Maxillofacial Implants, 9:95-102.

Weyant RJ, Burt BA, 1993. An assessment of survival rates and within patient clustering of failures for endosseous oral implants. Journal of Dental Research, 72:2-8.

Zarb GA, Schmitt, A, 1990. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part III: Problems and complications encountered. Journal of Prosthetic Dentistry, 64:185-94.