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Implant failure and management: A review

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Abstract
Osseo integrated dental implants have been considered the most esthetical and functional alternative to missing teeth. However, the treatment is not always successful resulting in the implant loss. The implant failure can be classified as early failure (the Osseo integration is not established) and late failure (involving a breakdown of the established Osseo integration). The implant loss can be attributed to factors such as biological, microbiological and biomechanical, but the cause and mechanism of the early implant failure are still obscure. Dental implant failure has led to continuous innovations of various implants systems and to different interceptive treatment modalities. These concerns have also led to selection of implant designs that best suit the various types of bone. There are a variety of reasons for the failure of end osseous implants. Different reasons for the implant failure and their contributing factors have been discussed in the review article.

Keywords: Implants, Osseo integration, Implant Failures

1. Introduction

A revolution in the research and technology of implants during the last two decades has made the replacement of missing teeth with endosseous implants the standard care, and an implant-supported prosthesis is the first line of treatment and long-lasting rehabilitation. The criteria that define the success of dental implants have been changing continuously, and currently include

- The absence of mobility at the start of the prosthetic phase,
- The absence of continuing radiolucency around the implant,
- The absence of peri-implantitis with suppuration, and subjective complaints from the patient [1].

Today, in the general population, long-term success rates of over 90% to 95% are considered to be realistic treatment outcomes. Endosseous implant therapy can greatly improve the function and esthetics of carefully selected partially or completely edentulous patients. Failure of dental implants is thought to be caused by failure of bony healing around the implant and subsequent failure of osseointegration; this could be attributed to local or systemic factors [1],

2. Implant cumulative success rates

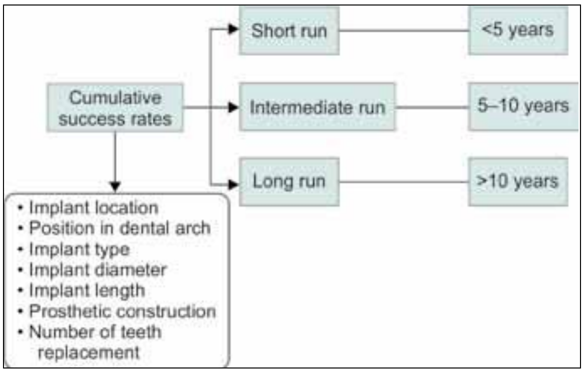

Fig 1: Schematic diagram of implant cumulative success rates

Criteria are required for the definition of implant success vs loosening or failure. Various criteria have been proposed for the evaluation of implant success [1-3]. Cumulative success rates of dental implants are evaluated in years and are affected by many factors [4]. These include implant location in the upper or lower jaw and its position in the dental arch, implant type, diameter and length, prosthetic construction, and whether they are used for single tooth replacement or in an edentulous month [5].

3. Classification of implant failure

3.1 According to Askary *et al.*

- Ailing implant: Implants exhibiting soft tissue problems exclusively are classified as ailing and have a more favourable prognosis.
- Failing implant: An implant that is progressively losing its bone anchorage, but is still clinically stable, can be defined as failing
- Failed implant: Implant with mobility excessive bone loss (>70%) not amenable to treatment are failed implant [1]

A. According to etiology

- Host factor
- Surgical factor
- Implant selection factor
- Restorative factor

B. According to condition

- Ailing Implant
- Failing Implant
- Failed Implant

C. According to timing of failure

- Before stage II
- After stage II
- After restoration

D. According to failure mode

- Lack of osseointegration
- Unacceptable aesthetics
- Functional problems
- Psychological problems

E. According to supporting tissue type

- Soft tissue loss
- Bone loss
- Combination

F. According to origin

- Peri implantitis
- Retrograde Peri implantitis

G. According to the condition of failure

- Clinical and radiographic status

4. Parameters used for evaluating failing/failed implants

While it is possible to clearly differentiate between a successful and a failed implant, it still remains difficult to identify failing implants. The parameters which have been employed clinically to evaluate implant conditions were discussed by Esposito *et al*, with the attempt to identify the most reliable ones [6]. The ideal parameter for monitoring implant conditions should be sensitive enough to distinguish early signs of implant failure. The following parameters have, therefore, been proposed.

4.1. Clinical Signs of Early/Late Infection

A progressive marginal infection can lead to implant failure. However, clinical signs of infection, such as hyperplastic soft tissues, suppuration (spontaneous, on probing or under pressure), swelling, fistulation, color changes of the marginal peri-implant tissues, etc., are signs which call for intervention. In the absence of mobility and radiographic changes, these signs indicate more a complication (amenable to treatment) than a failure [6] bleeding on.

4.2. Probing

Bleeding on probing has been employed to measure peri-implant tissue conditions. However, recent findings suggest that it cannot be used to discriminate between a healthy or diseased peri-implant state and it does not have a scientific support [6].

4.3. Probing Depths

Probing depths around teeth is an excellent proven means to assess the past and present health of natural teeth, but it may be of little diagnostic value, unless accompanied by signs (e.g. radiographic radiolucencies, purulent exudate, bleeding) and/or symptoms (e.g. discomfort, pain). The benefit of probing the implant sulcus has been challenged in the literature, because sound scientific criteria are lacking. Increasing probing depths over time may indicate bone loss, but not necessarily indicate disease for an endosteal implant. Sulcus depths greater than 5 to 6 mm around implants have a greater incidence of anaerobic bacteria and may require intervention in the presence of inflammation or exudate (e.g. surgery, antibiotic regimens). Probing not only measures pocket depth, but also reveals tissue consistency, bleeding, and the presence of exudates.

4.4 Pain or Sensitivity

Subjective findings of pain or tenderness associated with an implant body are more difficult to assess than these conditions with natural teeth. Once the implant has achieved primary healing, absence of pain under vertical or horizontal forces is a primary subjective criterion. Pain should not be associated with the implant after healing. When present, it is more often an improper fitting prosthetic component, or pressure on the soft tissue from the prosthesis. Percussion and forces up to 500gm (1.2 psi) may be used clinically to evaluate implant pain or discomfort. Pain during function from an implant body is a subjective criterion that places the implant in the failure category.

4.5. Clinical Discernible Mobility

Mobility is always a clear sign of failure. Once the clinician has distinguished between the mobility of a poorly connected abutment and the mobility of the underlying implant, the implant must be suspected to be surrounded by a fibrous tissue capsule. Occasionally, clinically discer-nible mobility can be present without distinct radio- graphic bone changes. Therefore, mobility is the cardinal sign of implant failure [6].

4.6. Radiographic Signs of Failure

There seems to be unanimous consensus that progressive marginal bone loss is a pathological sign, which can lead to implant failure. Adell *et al* determined that the mean bone loss for Branemark osseointegrated implants is 1.5 mm for the first year, followed by a mean bone loss of 0.1 mm per year

[1]. This value was confirmed by Cox and Zarb with their 3-year report showing a mean bone loss of 1.6 mm for the first year and a mean of 0.13 mm in subsequent years [11]. There can be two well-distinct radiographic pictures: a thin peri-fixtural radiolucency surrounding the entire implant, suggesting the absence of a direct bone-implant contact and possibly a loss of stability, and an increased marginal bone loss. Since, the distinction between the two radiographic pictures is not always clear, when a suspected peri-fixtural radiolucency or excessive marginal bone loss is observed, it is recommended to remove the prosthetic construction and cheek the implants for stability.

4.7. Dull Sound at Percussion

It has been suggested that a subdued sound upon percus-sion is indicative of soft tissue encapsulation, whereas a clear crystallization sound indicates successful osseointe-gration.[6] although it is a rather subjective test without a solid scientific background, it can provide a useful indication to the examiner.

5. Stages of implant failure

Many causes have been studied on the subject of implant failures. Implant failure can occur at any time during treatment and subsequently when the implant is in function. So, according to timing of failure it can be

- Before stage II (after surgery)
- At stage II (with healing head and/or abutment insertion)
- After restoration [7]

5.1. Before stage II

It usually occurs as a result of Implant misplacement, that is, placement of the implant in an infected socket, pathological lesion, or immature bone previously augmented or placement of a contaminated implant in the osteotomy, infection or soft tissue complications.

Fig 2: Exposure of left implant and soft tissue inflammation overlying the right implant.

The failed dental implant may appear to be an exfoliating fixture accompanied by purulent exudates. In this particular situation, it starts first with exposure of the cover screw, which when palpated with a light touch of a probe on top of the screw, reveals a sinking or damping movement due to the fibrous tissues and the infection surrounding the fixture. It may terminate with exfoliation of the fixture in 10 days to 2 months from the time of fixture placement [7].

5.2. At stage II

Implants can fail at the second stage of surgery, during healing or head placement, at abutment connection, and before prosthetic placement. This could be due to excessive torquing during abutment connection when inserted into grafted bone. It probably happens because of an insufficient bone contact surface area with the implant and possibly because of poor surface treatment of the fixture [1].

A contaminated implant may stay in a dormant condition until torque is applied to the cover screw. Then it comes out because of lack of integration, which can result from the implant being placed in a wide osteotomy, the implant being loaded before the recommended time, or traumatic placement of the implant. It cannot be considered an early failure because it is not early enough, and it is not a late failure because it happened before prosthetic placement [7].

5.3. After restoration

This particular timing of failure is most common. It starts after an integrated implant is loaded and leads up to the point of discovery of the failure. The most common cause is occlusal trauma. It has its own clinical manifestations, known as peri implantitis [7].

6. Risk factors for dental implants

6.1. Dentist-related Risk Factors

6.1.1 Preoperative Factors

Various radiographic methods have been used for the diagnostic evaluation of bone quality and quantity as well as treatment planning, which include periapical radiographs, the panoramic radiographs, computed tomography, and magnetic resonance imaging [8]. The relationship between dental implant failure and irradiated patients is not clear. Irradiation for the treatment of oral cancer does not seem to reduce the survival rate of implants as compared with those placed in the non-irradiated jaw. The main problem with irradiated patients is decreased salivary flow, the liability for infection because of decreased blood flow and the possibility of osteoradionecrosis. The complication of radiation starts when the dose exceeds 64 Gy. If it does not exceed the limit, then complications are expected [7, 8].

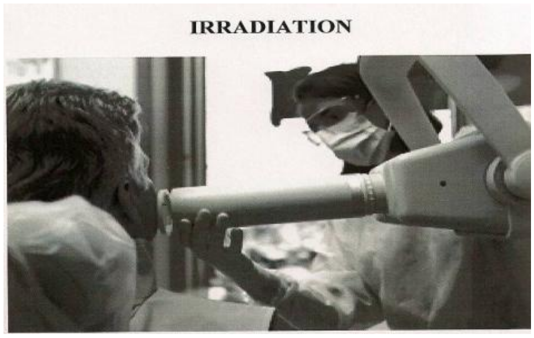

Fig 3: Exposure to radiation

6.1.2 Peroperative Factors

There are various factors which lead to implant failure during implant placement

- Severe angulations
- Lack of initial stabilization
- Impaired healing
- Overheating the bone
- Minimal space between the implants
- Placing implant in immature bone
- Placement in infected socket

6.1.3. Postoperative Factors

Improper design and guidance of the crown contribute to failure. Too high a cusp or too high an occlusal alignment can increase occlusal loading to an unacceptable level. The crown can also contribute to too-wide contact between the counter tooth and the implant, which leads to high occlusal load of the implant in bone. Occlusal forces contribute to implant fractures and peri-implant bone fractures. Crown width, cusp height, guidance, and occlusal alignment can all be used to control occlusal forces [9].

6.2 Implant-related Risk Factors

Dental Implant Material and Surface Characteristics. The ideal dental implant material should be:

(1) biocompatible, (2) of appropriate rigidity for prosthetic function, (3) intimately adaptable to both bone and gingiva surrounding the implant, (4) functionally able to dissipate forces resulting from occlusal load on the prostheses supported by the implant to the underlying bone, and (5) resistant to the large and diverse periimplant microbial load [10]. Use of bioincompatible implant materials leads to implant failure initiated by adverse host tissue responses [11]. The implant surface coatings comprise titanium oxide (TiO2) coating, ceramic coating, or diamond coating [11, 12]. Biodegradable ceramic coating may have the best future prospects. Most dental implant materials presently used in clinics are quite biocompatible in human tissues in their specific dental application. They are usually made of titanium, titanium-aluminumvanadium (Ti-6Al-4V), cobalt-chromium-molybdenum, and more rarely of other alloys [13, 14]. Dental implant materials have been remarkably improved in the past half century to me*et al*l kinds of demands. However, research and development are needed to develop even more biocompatible and functional materials to prevent implant failures and to prolong implant life in service [15, 16].

6.3. Host-related Factors

Host-related factors can be divided into local and systemic risk (prognostic) factors.

6.3.1 Local Risk Factors

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 [17], 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. Systemic osteoporosis has also been mentioned as a possible risk factor for osseointegration failure. In the study conducted by Dao *et al*, local rather than systemic bone density seemed to be the predominant factor [18].

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* showed increasing implant loss over time [19].

Biomechanical occlusal loading

Even well-performed and optimally occlusally restored dental implants tend to lead to peri-implant bone loss. Dental implants lack the stress receptors located in the tensional periodontal ligament tissue in natural teeth, and their stomatognathic sensor system is less sensitive than that of healthy teeth [20]. Therefore, due to non-optimal load protection and forceabsorbing and distributing systems, a dental implant is subjected to implant micromotion ranging from 50 to 150 micrometers [21]. It has been concluded that occlusal loading strains the hard peri-implant bone because implants lack the protective periodontal ligament system.

Smoking as a Risk Factor for Implant Failure

Studies suggest that smokers have an increased prevalence of periodontal diseases, tooth loss and oral cancer [22]. There are several studies associating implant failures with smoking [22-25]. Bain and Moy suggested that smoking caused both systemic and local injury to the tissues and is a common contributor to decrease tissue oxygenation, which negatively affects wound healing [26]. Nicotine, presenting the main element of cigarette, reduces proliferation of red blood cells (RBCs), macrophages, and fibroblast, which are the main element of healing [26]. With only few studies failing to establish a significant result on the smoking effects on implants, Studies suggest smoking as the factor associated with complications like marginal bone loss, peri-implantitis, bone quality, and quantity, which in turn affect the implant success rate. In fact, success rate of dental implant is found to be twice in nonsmokers as compared to smokers and that too maxillary implant is more affected [26].

Para-functional Habits and Bruxism

Para-functional habits and bruxism are very common occlusal diseases. Heavy occlusal forces constitute a risk factor for loosening of dental implants. Metal fatigue and implant fractures occur more frequently in these patients than in controls [27]. More than 77% of all implant fractures have been reported to occur in patients who have signs and a history of chronic bruxism [28]. Para-functional habits are also related to increased peri-implant bone loss [29].

6.3.2 Systemic Factors

Systemic factors affect both the quality and quantity of bone, which constitute important prognostic factors for dental implant survival. These systemic factors comprise poorly controlled diabetes, osteoporosis, osteomalacia, irradiation and medications [30].

Diabetes Mellitus

Diabetic lesions involve bone, gingival, and vascular tissues [30]. The disease is thought to suppress collagen synthesis, and it increases the expression of MMPs. Most studies of diabetic lesions have been focused on periodontitis, diabetes mellitus has also been considered a risk factor and occasionally even a contraindication for performing dental implantations. Recently, it has been reported that dental implants in diabetes are successful, at least in the short-term [31].

Osteoporosis

Osteoporosis is a very common disease, with the number of elderly people affected increasing. The main pathological features of osteoporosis are low bone mass and a micro architectural deterioration of bone leading to fragility, and then to an increased fracture risk. The multiple pathogenic factors related to osteoporosis comprise genetic predisposition and subtle alterations in systemic and local hormones, together with environmental influences [32]. Both the maxilla and mandible can be affected by osteoporosis, which has been considered a risk factor for implant failures and periodontal diseases. Implants in osteoporosis have been successful in the short-term, but long-term results have not been reported.

Medication and Irradiation

Some medications widely used in clinics cause bone loss. In particular, glucocorticosteroids cause iatrogenic osteoporosis by increasing bone resorption via stimulation of osteoclastogenesis [33]. Other drugs with deleterious effects on bone include chemotherapeutic agents, such as doxorubicin and methotrexate, which inhibit osteoblasts and diminish bone formation. Implants are often used in cancer-surgery patients.

Age

Theoretically, patients with increased age will have more systemic health problems, but there is no scientific evidence correlating old age with implant failure.

7. Methods of implant removal

A mobile implant may easily be removed by rotating it counter clockwise using a driver, counter-torque ratchet technique (CTRT), or forceps. Rotating with minimum luxation allows reduced trauma and damage to the surrounding bone and soft tissue. Methods of immobile implant removal include: use of counter torque ratchets, screw removal devices, piezo tips, high-speed burs, elevators, forceps and trephine burs. The CTRT is the least invasive technique for removing an implant without damaging surrounding structures. The use of CTRT should be considered only if the implant is able to be engaged and reverse-torqued until mobile. The reverse screw technique (RST) is indicated in the removal of a fractured implant when the connection is damaged or in the removal of an external connection implant when the ratchet cannot be engaged to use the CTRT. Piezo tips and high speed burs can be used in conditions where CTRT and RST are not useful to loosen the abutment [1].

8. Treatment alternatives following removal of failed implants

The literature pertaining to treatment alternatives following the loss of dental implants could best be described as negligible. The decision as to which of these alternatives should be selected is complex and involves both biologic and mechanical considerations, as well as psychological aspects with financial considerations being a silent partner. The treatment of choice should be a team decision with the surgeon, restoring clinician and patient having an equal say in the final outcome [1].

9. Conclusion

The various studies done on each of these failures and how to prevent these failures have been discussed too. Failure of implant has a multifactor dimension. Often many factors come together to cause the ultimate failure of the implant. One needs to identify the cause not just to treat the present condition but also as a learning experience for future treatments. Proper data collection, patient feedback, and accurate diagnostic tool will help point out the reason for failure. An early intervention is always possible if regular check-up are undertaken.

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