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Dental Implant Failures: Where we go wrong?

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ABSTRACT

Background: Implant failure can be classified as early failure (the Osseointegration is not established) and late failure (involving a breakdown of the established Osseointegration). The implant loss can be attributed to factors such as biological, microbiological and biomechanical, but the cause and mechanism of the 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 the selection of implant designs that best suit the various types of bone. There are a variety of reasons for the failure of endosseous implants. The aim of this review is to highlight the various aetiology for the failure of implants.

Keywords: Dental Implant, Failure, Osseointegration.

INTRODUCTION

Implantology is continually developing as new research results provide a better understanding of the biological principles that direct the development of a dynamic interface between the living tissue and an artificial structure. The goal of modern dentistry is to restore the patient to normal contour, function, comfort, esthetics, speech and health regardless of the atrophy, disease or injury to the stomatognathic system.[1] As a result of continued research in treatment planning, implant designs, materials and techniques, predictable success is now a reality for many challenging clinical situations.

However, implant dentistry involves risks and complications that can occur with reasonable care. All available implants are subject to failure on occasion. Failures may be difficult to predict, and after failure, the cause of it may be difficult to identify. It is well established that failure can occur even under the best care. Therefore, before deciding to proceed with implant therapy, the patient should be informed of the risk of complications involved in the treatment.[2]

History of dental implants

Modern Implant Dentistry began in the early 19th century. A lot of experiments were conducted on what would work best. Attempts were first made at implanting natural teeth from another patient's mouth, but these implants failed due to infection or were rejected by the host tissue. Implants made of gold, porcelain; silver and even lead being tried, only with a fair measure of success and little or no predictability.[3,4]

In the 1950s, a startling discovery was made, which had great implications for tooth replacement therapy. During an experiment involving the study

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of blood circulation in animals, Dr. Per-Ingvar Branemark discovered that the hollow titanium rod used in the study was not retrievable when the experiment was complete. Further studies showed that the animal bone had directly attached to the titanium surface. This phenomenon was called Osseointegration, defined by the American Academy of Implant Dentistry as - "the firm, direct and lasting biological attachment of a metallic implant to the vital bone with no intervening connective tissue." This firm anchor is what makes the Implant a wonderful option for replacing teeth.[5,6,7]

Implant classification

Dental implants are classified as[8]

Depending on the Anatomical site:

A. Subperiosteal

B. Transosteal

a. Mandibular Staple.

b. Transmandibular Raphe.

C. Endosteal:

a. Plate/ Blade form E.g. Oratronics, Ultimatics, Stranus systems.

b. Root form:

(i) Threaded: Screws, E.g. Venplant, Sterioss etc.

Cylindrical screws, E.g. Branemark, ITI- TPS.

(ii) Non- Threaded:

Bullet Shaped, E.g. IMZ, Biovent, Integral etc.

Basket Form E.g. Corevent, ITI hollow cylinder etc.

D. Mucosal inserts

E. Ramus frame.

F. Endodontic.

Depending on reactivity with bone:

A. Bioactive E.g. Ceramic and Hydroxyapatite.

B. Bioinert E.g. Titanium, Carbon, Vitallium.

Depending on the type of integration:

A. Fibrointegration.

B. Osseointegration.

Success Criteria for Dental Implants Smith and Zarbhave reviewed the success criteria given by different authors.[9]

A Schnitman And Schulman:

1. Mobility less than 1 mm in any direction.

2. Radiologically observed radiolucency graded but no success criterion defined.

3. Bone loss not greater than one-third of the vertical height of the bone.

4. Gingival inflammation amenable to treatment.

5. Functional service for 5 years in 75% of patients.

B Chainin, Silver Branch, Sher, And Salter:

1. In place for 60 months or more.

2. Lack of significant evidence of cervical saucerization on radiographs.

3. Freedom from haemorrhage according to Muhelman's index.

4. Lack of mobility.

5. Absence of pain and tenderness.

6. No pericervicalgranulomatosis or gingival hyperplasia

7. No evidence of a widening peri-implant space on the radiograph.

C Mckinney, Koth and Steflik:

Subjective Criteria

i. Adequate function.

ii. Absence of discomfort.

iii. The patient belief that esthetics, emotional, and psychological attitude are improved.

Objective Criteria

i. Good occlusal balance and vertical dimension.

ii. Bone loss no greater than one-third of the vertical height of the Implant, absence of symptoms and functionally stable after five years.

iii. Gingival inflammation is vulnerable to treatment.

iv. Mobility of less than 1 mm buccolingually, mesiodistally, and vertically.

v. Absence of symptoms and infection associated with the dental Implant.

vi. Absence of damage to adjacent tooth or teeth and their supporting structures.

vii. Absence of paresthesia or violation of mandibular canal, maxillary sinus, or floor of the nasal passage. viii. Healthy collagenous tissue without polymorphonuclear infiltration.

Revised Criteria for Implant Success (Alberktson, Zarb, Washington, And Erickson)[9]

i. Individual unattached Implant that is immobile when tested clinically.

ii. Radiograph 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.

iii. Individual implant performance that is characterized by an absence of persistent and/or irreversible signs and symptoms of pain, infections, necropathies, paraesthesia, or violation of the mandibular canal.

iv. In content of criteria mentioned, a success rate of 85% at the end of a 5-year observation period and 80% at the end of 10-year observation as a minimum criterion for success.7

Further, in 1998 Esposito et al. have listed out the various criteria for success.[10]

1. Absence of mobility
2. An average radiographic marginal bone loss of less than 1.5 mm during the first year of function
3. Less than 0.2 mm annually thereafter
4. Absence of pain/paraesthesia It was also suggested that probing depths related to a fixed reference point and bleeding on probing should be measured.

Classification of Implant Failures*:* Implant failures can be further classified as:

Based on the type of Implant used: Endosteal implant failures and Subperiosteal implant failure

Based on when the failure occurs: Intra-operative complications, Short-term complications and Long-term complications

Based on the type of restoration used: Single-tooth implant failure, Implant-supported overdenture complications, Implant-supported bridge complications and Implant denture complications.

Based on the Implant used: Design failures, Biomaterial failure and Fatigue failure

Surgical complications: Oversized osteotomy, Perforation of cortical plates, Fracture of buccal and cortical plates, Antral Perforations, Inadequate soft flap for implant coverage, Hemorrhage, Poor angulation, Injuries to the mandibular neurovascular bundle and Failure of Autogenous graft.

According to Hobo et al. [11]

- Loss of bone anchorage: Mucoperiosteal perforation and Surgical trauma
- Gingival problems: Proliferative gingivitis and Fistula formation
- Mechanical complications: Fixture fractures and Fracture of prostheses, gold screws, abutment screws

According to Misch[12]

- Surgical failure: Inability to place the abutment at the time of surgery
- Osseous healing failure: Period from implant placement to abutment connection is related to healing ability of bone

- Early loading failure: The first year it serves as a prosthetic abutment
- Intermediate Implant: Time period after the 1st yr of loading failure up to following 5yrs of function
- Late implant failure: After the Implant and prosthesis have been loaded for >5yrs but <10yrs.
- Long term failure: Failures after 10 yrs.

Complications/Factors leading to Implant failures[13]

Surgical factors (early failures)

Stage I surgery

1) Overheating of bone - necrosis, osteomyelitis
2) Lack of primary stability - bone loss
3) Infection
4) Lack of Osseointegration
5) Poor placement or angulation, slips, eccentric drills
6) Damage to vital structures
7) Implant fracture
8) Inadequate no. of implants

Stage II surgery

1) Loose abutment

2) Poor fixtures

3) Early loading by Prosthesis

4) Poor abutments

Prosthetic factors (late failures)

1. Improper design, shape, contours

2. Poor fit of prostheses

3. Occlusal forces

4. Inaccurate framework

5. Cantilever extension

6. Framework fracture, prosthesis fracture

7. Functional problems

Systematic factors contributing to implant failure

- It is important for the implant team to understand the risk factors responsible for implant failures

- Systematic disease like diabetes, collagen disease like scleroderma, systematic lupus erythematosus, rheumatoid arthritis have microvascular changes that can cause decreased oxygenation due to poor vascularity and have poor wound healing potential and thereby prevent integration of implants

- Therapeutic radiation to the mandible and maxilla and long term steroid therapy also results in poor vascularity and may contraindicate implant use

- Osteoporosis, Paget disease hormone disorders and renal tumours may also compromise implant osseointegration

Perioperative errors contributing to implant failure[14]

- Error due to anatomic variations and abnormalities
- Errors due to implant contamination
- Errors in surgical technique
- Errors in implant position
- Errors in implant exposure
- Errors due to anatomic variation and abnormalities
- Ideal fixture placement depends on a preoperative clinical assessment of bone configuration quality and quantity.
- Periapical and panoramic radiograph of the maxilla and mandible provides additional methods to assess bone conditions
- In addition, careful digital palpation of the lingual surface of the mandible provides information on the configuration of the bony surface.
- Often this area is concave. Perforation of the lingual plate can occur if the bony prominence And concavity are not anticipated preoperatively and the Implant is not angled appropriately.

Errors due to implant contamination[14]

Contamination of implant surface interferes with Osseointegration and must be scrupulously avoided.Any foreign material in the implant site also could affect the success of the Implant. Therefore, the implant site should be irrigated carefully before implant placement. Also, regardless of the implant design or system used, the Implant must be carried directly to the osteotomy site without contacting any other surface.

Errors in surgical technique[14]

- Successful implant placement depends highly on proper surgical technique
- Maintaining an adequate blood supply and reducing hard and soft tissue surgical trauma lessen the perioperative causes of failed Implant
- Incision design preservation of the blood supply to the hard and soft tissue depends on proper incision design.
- Broad-based surgical flaps assure an adequate blood supply to the healing edges of the surgical wound
- Torn mucosal flaps will likely undergo necrosis, delay healing and possibly contribute to implant failure
- When there a minimal amount of keratinized tissue, the incision should be placed buccal or labial to the alveolar crest.
- Such placement minimizes the possibility of compromising the blood supply to this area and preserves the keratinized tissue as a part of the lingually based flap.

Healthy, viable bone is critical for the success of integration between the bone and the implant surface—high-temperature results in bone resorption and fat cell degeneration. Moreover, heat injured bone is replaced by less differentiated tissue, which is incapable of the normal adaptive remoulding ability of bone.

A study by Eriksson and Albrektsson showed that the threshold temperature for heat-induced injury to bone tissue is 47°C applied for 1min.

Error in implant positioning[15]

- An implant may integrate successfully with the surrounding bone but ultimately be a clinical failure because it is too poorly positioned to support a functional prosthetic restoration
- Attention to proper intraoperative angulation as well maintenance of parallelism between implants and between Implant and natural dentition contribute to optimal and successful prosthetic design and function.
- An implant placed too buccal or lingual can cause bone dehiscence, a lack of bicortical support, and eventual implant exposure

Error in implant exposure[15]

- Generally, 4-6 months are allowed for healing.
- If there is an adequate amount of keratinized gingiva but is not located over the Implant, a labial or buccal flap can be elevated, and the tissue shifted to surround the Implant
- When exposing Implant in the anterior maxilla providing sufficient soft tissue bulk for a convex ridge form
- Creation of interproximal papilla
- Proper gingival counter
- Assure that there is keratinized gingiva surrounding the labial aspect of the crown.

Parameters used for evaluating failed and failing implants

The parameters, which have been employed clinically to evaluate implant conditions are discussed as follows-

Evaluation of Failed Implants:

The most common diagnostic criteria employed for the evaluation of established implant failures (failed implants) are as follows.

A. Clinical signs of early infection:

During the healing period, complications such as swelling, fistulas, suppuration, early/ late dehiscences, and osteomyelitis can occasionally be present and may indicate implant failure. The most rational and common explanation for this is infection. Signs of infection occurring during an early stage of healing is more critical than if they occur at a later stage. This is because the infection occurring at an early stage will lead to disturbance in the Osseointegration of the Implant to the surrounding bone.

Therefore, signs of infection alone cannot be used to determine the fate of an implant but should be evaluated in conjunction with other parameters such as radiolucency and mobility. In the absence of these signs of implant failure, clinical signs of infection represent a complication which if left untreated, might lead to an implant failure. [15,16]

B. 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. Several different types of mobility have been recognized.

1. Rotational mobility
2. Lateral or horizontal mobility
3. Axial or vertical mobility

Occasionally, clinically discernible mobility can be present without distinct radiographic bone changes. Therefore, mobility is the cardinal sign of implant failure.

Clinical researches in Osseointegration indicate that when mobility occurs, the implants become tender on Percussion on pressure. Further, the mobility continues to increase and ends up in the removal of the Implant. Thus, mobility is a definitive sign of certain failure. For this reason, the absence of mobility is an important criterion for implant success.[17-20]

C. Pain or sensitivity:

Pain or discomfort is often associated with mobility and could be one of the first signs which indicate an implant failure. Failed implants can also be completely asymptomatic. Further, pain may reflect adverse tissue reactions not primarily related to implant mobility.

D. Radiographic signs of failure[17,21]

In general, intraoral radiographs are taken after the abutment connection in order to confirm that abutments are properly seated. Standardized periapical radiographs should be made at regular follow up intervals to detect peri-fixture radiolucency and/ or progressive marginal bone loss or "saucerization". On the basis of measurements on these radiographs, the baseline value for future marginal bone changes can be established.

The main purpose of the radiographic examination is not solely to diagnose loss of Osseointegration. Radiography is also used to assess the status of the alveolar bone and to monitor whether the bone support has been changed since the last radiographic examination.

There can be two well distinct radiographic pictures: a thin peri-fixture radiolucency surrounding the entire Implant, suggesting the absence of direct bone-implant contact and possibly a loss of stability, and an increased marginal bone loss.

Since the distinction between these two radiographic pictures is not always clear, when a suspected peri-fixture radiolucency or excessive marginal bone loss is observed, it is recommended to remove the prosthetic construction and check the implants for stability. Clinically discernible mobility after bridge removal can confirm the presumptive radiographic diagnosis of implant failure.

The periapical radiograph gives a two-dimensional image that is only useful to evaluate the mesial and distal surfaces of the Implant. No information is provided as to the status of the buccal and lingual aspects. Thus, a considerable portion of the surface of the Implant is not accessible for evaluation, and regions not osseointegrated may escape detection.

Radiographic evaluation of implants requires the use of serial radiographs made with a standardized technique. The radiograph can be used to make measurements of crestal bone loss as well as to detect the presence of peri-implant radiolucency. Thus, the evaluation of properly made serial radiographs for peri-implant radiolucency is a valuable means of determining clinical success.

E. Dull sound on Percussion:

It has been suggested that a subdued sound upon Percussion is indicative of soft tissue encapsulation, whereas a clear crystallization sound indicates successful Osseointegration.

Once the clinician has verified that the abutment is properly attached to the Implant, the test is conducted by tapping the abutment with a loosely held metallic instrument. It has also been suggested that a dull tone on Percussion might be present long before radiographic signs of implant failure.

Evaluation of failing Implants

The clinical signs previously discussed emerge only when the failure process reaches an irreversible state. However, 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.22

A. Radiographically observed progressive marginal bone loss: There seems to be a unanimous consensus that progressive marginal bone loss is a pathological sign which can lead to implant failure. Albertson et al. have suggested less than 1.5 mm of marginal bone loss during the first year of loading and thereafter less than 0.2 mm yearly as success criteria.

Marginal bone loss around the neck of osseointegrated implants is probably influenced by the implant design, both in short- and long-term period. However, due to complex interactions between surgically induced trauma, stress distribution, microbiota and host response on the marginal bone loss, the exact role played by the various implant designs and surface characteristics remain to be understood.

B. Clinical signs of late infection: A progressive marginal infection can lead to implant failure. However, clinical signs of infection such as hyperplastic soft tissues, suppuration, swelling, fistulation, colour 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 than a failure.

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

D. Absence of keratinized mucosa: A relationship and correlation between implant failure and absence of an adequate band of keratinized mucosa surrounding the abutment have been suggested. Some late losses have been directly attributed to the lack of keratinized mucosa. One hypothesis behind this idea is that the keratinized tissue is more resistant to destructive inflammatory processes induced by the oral microbiota. However, there is no scientific evidence supporting this hypothesis. In conclusion, keratinized mucosa does not appear to be related to implant failure.

E. Sulcular Bleeding Index (SBI): It can be defined as the bleeding tendency of the alveolar mucosa surrounding the implant abutment observed by running a periodontal probe along the abutment circumference 1 mm into the mucosal pocket and parallel to the margins of the soft tissues. Despite its own limitations (eg. in smokers), SBI can be used instead of the BOP for a more objective evaluation of the superficial peri-implant soft tissue conditions. While this parameter might distinguish between healthy and inflamed tissues, it is not able to identify failing implants.

F. Pocket probing depth (PPD): It is defined as the linear distance from the free mucosal margin to the base of the pocket. The base of the pocket is generally defined as the apical termination of the junctional epithelium. Probing cannot be easily performed around all implant or abutment designs. It can be concluded that increased pocket depth can be correlated with a higher degree of inflammation of the peri-implant mucosa, but not necessarily to bone loss. However, absolute PPD alone cannot be used as an indicator of a pathological condition since additional factors, such as tissue thickness and different abutment lengths, may influence the PPD assessments around implants when compared with teeth. Progressive PPD over time might therefore be a better indicator for failing implants than absolute probe measurements.

G. Mucosal recession (REC): REC can be defined as the linear distance between the location of the free mucosal margin and a fixed landmark. When threads or a rough implant surface become exposed, it might be difficult to maintain the area clean from plaque and the prognosis of the Implant may become questionable. Otherwise, the recession is mainly an aesthetical problem and not an indication of failing implants.

H. Probing attachment levels (PAL): PAL are probing depths related to a fixed reference point on the Implant in order to monitor "attachment" loss over time. In other words, PAL is the sum of PPD and REC. It has been suggested that increased measures of 2 mm or more should be interpreted as resorption of alveolar bone. The same practical limitations related to probe penetration and implant shape are evident. Even though this is a more accurate method to monitor implant health, it still provides less precise information than radiographs, particularly when tissues are inflamed or in the presence of infrabony craters.

I. Crevicular fluid analysis: The analysis of crevicular fluids, though able to distinguish between healthy and inflamed sites, has not been demonstrated as being capable of differentiating between destructive and non-destructive inflammation. Therefore, this technique cannot yet be used to identify failing implants.

SUMMARY AND CONCLUSION

Implant Prosthodontics can be straightforward when fixture position and angulation are ideal. If prosthetic components are used properly and if framework design and fit are perfect, complications can be minimized. There have been numerous ways to categorize the possible complications that can be encountered. They may be referred to as early or late, surgical or prosthetic, biological or structural, functional or esthetic, hard tissue or soft tissue related. This categorization helps one to relate to the phase of treatment rather than the specific type of complication encountered. It must be emphasized that complications in one area may affect the other, and consequently, at times, there is no clear differentiation between them. Diligent and precise surgical and prosthetic procedures are critical to the success of implant therapy, but maintenance of implants may be of equal importance in ensuring a long-term favourable prognosis. The dental professional's responsibility in providing supportive therapy and education in maintaining dental implants is crucial.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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