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REASONS FOR IMPLANT FAILURE

Dr. Shirish Pawar	Senior Lecturer, Department of Prosthodontics, MIDSR Dental College, Latur.
Dr. Yogita Mundada*	PG Student, Department of Prosthodontics, MIDSR Dental College, Latur.*Corresponding Author

ABSTRACT This study reviews the literature regarding the factors contributing to failures of dental implants. It may be suggested that the following situations are correlated to increase the implant failure rate: a low insertion torque of implants that are planned to be immediately or early loaded, inexperienced surgeons inserting the implants, implant insertion in the maxilla, implant insertion in the posterior region of the jaws, implants in heavy smokers, implant insertion in bone qualities type III and IV, implant insertion in places with small bone volumes, use of shorter length implants, greater number of implants placed per patient, lack of initial implant stability, use of cylindrical (nonthreaded) implants and prosthetic rehabilitation with implant- supported overdentures. Moreover, it may be suggested that the following situations may be correlated with an increase in the implant failure rate: use of the non- submerged technique, immediate loading, implant insertion in fresh extraction sockets, smaller diameter implants. Some recently published studies suggest that modern, moderately rough implants may present with similar results irrespective if placed in maxillas, in smoking patients or using only short implants.

KEYWORDS : dental implants, failure, implant mobility

INTRODUCTION

Dental implants have become an important in 1960s, after the work of Branemark. He termed Osseo-integration as direct contact between biomaterial and bone.1 It is a foreign body response and long-term clinical function which is dependent on equilibrium of tissues.2 Clinical examination as a first indicator of successful Osseo-integration is important. This concept stresses not only the clinical definition but also the histo- morphometric definition. Both of these, impacts significantly on the clinical determinants of implant success.[3]

Dental implant failures that mandate immediate implant removal do occur. The prime requisite for each Implantologist to deliver successful implant to the patients by knowing factors responsible for failure and methods to prevent them.4 Implant failure can be classified into biological failure i.e. early or late, mechanical failure i.e. occlusal overload, fracture, Iatrogenic failure i.e. wrong alignment, surgical trauma and inadequate adaptation i.e. aesthetic dissatisfaction. It can also be described as ailing, failing or failed implants.5 Implant survival depends on the success of dental implants. Predictors for implant success and failure are generally divided into patient related factors like general health status, smoking habit, bone quality, bone quantity, oral hygiene maintenance and implant characteristics like dimension, coating, loading, implant location and clinical experience. Identifying failing implants in time is essential to avoid continuous loss of alveolar bone which can complicate the option of replacing failed implants with new one and aesthetic outcome. There has been a huge increase in scientific knowledge about the biomechanical and biological factors of implant success.[6]

Failure of endosseous dental implant is either early or late which depends on weather it occurs before or after loading with a prosthetic superstructure.7 Implant failure may be of a primary or secondary nature. Implant that never Osseo-integrate due to overheating or poor surgery are primary failure. Frequency of such failures is 1-2% in most clinical cases. Secondary failure is preceded by marginal bone resorption.8 some implant failures may be due to bacterial contamination at the time of insertion of implant. It is difficult to treat the infections around biomaterials and almost infected implants have to be removed.9

Though the success rates of implant therapy are high, failures do occur and a thorough knowledge regarding the many aspects of failures is deemed necessary. This library dissertation thus aims to review failures in implant therapy, various causes of implant failures, early detection of a failing implant.

PARAMETERS USED FOR EVALUATING FAILED & FAILING IMPLANTS

The most common diagnostic criteria employed for the evaluation of established implant failures (failed implants) are as follows10-

(A) Clinical signs of early infection
During the healing period (3 to 9 months) complications such as swelling, fistulas, suppuration, early / late mucosal dehiscence and osteomyelitis, can occasionally be present and may indicate implant failure. Infection is the most rational and common explanation for this. 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.

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

(C) 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. Rotation mobility
2. Lateral or horizontal mobility
3. Axial or vertical mobility.

Various authors have reported that initial rotational mobility, independent of whether it occurs in cortical or trabecular bone does not necessarily lead to an inferior integration of unloaded implants. However, initial total implant mobility within the cortical layer resulted in statistically less amount of bone around the implants as compared to stable control.

Misch's clinical implant mobility scale11
0 - Absence of clinical mobility with 500 g in any direction 1 – Slight detectable horizontal movement
2 – Moderate visible horizontal mobility up to 0.5 mm 3 – Severe horizontal movement greater than 0.5 mm
4 – Visible moderate to severe horizontal and any visible vertical movement

(D) Radiographic signs of failure
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 radiolucency at periphery of fixture and / or progressive marginal bone loss or "saucerization". 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.

The peri-apical 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 osseo-integrated may escape detection. Radiographic evaluation of implants requires the use of serial radiographs made with a standardized technique. Thus the evaluation of properly made serial radiographs for peri-mplant radiolucency is a valuable means of determining clinical success.

(E) Dull sound at Percussion

It has been suggested that a subdued sound upon percussion is indicative of soft tissue encapsulation, whereas a clear crystallization sound indicates successful osseo- integration. Although it is a rather subjective test without a solid scientific background, it can provide a useful indication to the examiner. It has also been suggested that a dull tone on percussion might be present long before radiographic signs of implant failure.

CLASSIFICATION OF IMPLANT FAILURES

Implant failure includes a large variety of clinical situations, ranging from all symptomatic mobile implants to implants showing more than 0.2 mm of perimplant bone loss after the first year of loading or bleeding pockets exceeding 5 mm of probing depth.

Abdel Salam El Askary, Roland M. Meffert and Terrence Griffin (1999) quoted in a review article by Prashanti et al12 have divided the failures into seven categories.

A. ACCORDING TO ETIOLOGY

I. Failures because of host factors

- Osteoporosis and other bone diseases, uncontrolled diabetes
- smoking, Para functional habits
- poor home care, juvenile and rapidly progressive periodontitis, irradiation therapy.

II. Restorative problems

prosthetic design and improper occlusal scheme, bending moments, connecting implants to natural dentition, premature loading and excessive torquing.

III. Surgical placement

- Off axis placement (Severe angulation)
- Lack of initial stabilization
- Impaired healing and info am because of improper flap design or others
- Overheating the hone and exerting too much pressure
- Minimal space between implants
- Placing the implant in immature hone grafted sites
- Placement of the implant in an infected socket or a pathologic lesion
- Contamination of the implant body before insertion.

IV. Implant selection

- Improper implant type in improper hone type
- Length of the implant (too short, crown- implant ratio unfavouzAblc)
- Diameter of the implant

B. ACCORDING TO ORIGIN OF INFECTION

- Perimplantitis (infective process, bacterial origin)
- Retrograde perimplantitis (Traumatic occlusion origin, no infective, forces off the long aNis., premature or excessive loading)

C. ACCORDING TO TIMING OF FAILURE

- Beline stage II (after surgery)
- At stage II (With healing head and or abutment insertion)
- After restoration

D. ACCORDING TO CONDITION OF FAILURE (CLINICAL AND RADIOGRAPHIC STATUS)

- Ailing implants
- Failing implants
- Failed implants
- Surviving implants

E. ACCORDING TO RESPONSIBLE PERSONNEL

- Dentist (Oral surgeon, Prosthodontist. Periodontist)
- Dental hygienist
- Lahoratory technician
- Patient

F. ACCORDING TO FAILURE MODE.

- Lack of osseointegration (usually mobility)
- Unacceptable esthetics
- Functional problems
- Psychological problems

G. ACCORDING TO SUPPORTING TISSUE TYPE

- Soft tissue problems (lack of keratinited tissues, inflammation etc.)
- Bone loss (Radiographic changes etc.)
- l3oth soft tissue and hone loss

FAILURE OF DENTAL IMPLANT DEPENDING ON THE ETIOLOGY

(A) Host factors

(1) Osteoporosis and other bone diseases

Osteoporosis is a disorder characterized by a generalized diminution bone mass, may therefore represent "didactic contraindication" or a risk factor for osseointegration. Investigators have reported results of a series of osteoporotic patients treated with dental implants and concluded that the results did not provide a compelling theoretical or practical basis to expect osteoporosis to be a risk factor for osseointegrated dental implants. The presumption that osteoporosis represents a risk factor for osseointegration may partly be derived from the belief that the disease is associated with a deficiency in bone formation thus, compromising the healing capacity and the apposition of bone at the bone-implant interface.

Also, most other bone diseases are characterized by abnormal bone architectures i.e. proliferating fibrosis in connective tissue stroma, severe resorption or diffuse radiolucencies / opacities (cotton wool appearance) and spontaneous fractures as in Paget□s disease. These characteristics are totally contraindicated for implant therapy, as is fibrous dysplasia in which the fibrous connective tissue replaces the normal bone which makes the initial fixation and stability of the implant impossible.

(2) Uncontrolled diabetes

Diabetes mellitus does not cause the failure of dental implants directly. Consensus was expressed recently that the placement of implants in patients with metabolically controlled diabetes mellitus does not result in a greater risk of failures than in the general population. However a group study stated that the patients with diabetes experience more infection in clean wounds than patients without diabetes. The liability of infection is probably caused by thinning and fragility of the blood vessels so as to alter blood supply. A number of preclinical investigations have established that bone and mineral metabolisms are altered in diabetes. Hence there is a decrease in the rate of bone formation and remodeling is altered. This mechanism of altered bone metabolism has not been fully elucidated, though it may be best explained by collagen abnormalities in response to accumulated glycosylation end products (AGE).

The authors suggest that those characteristics in turn may be because of changes in wound healing response in the diabetic patients. According to some authors metabolic diseases logically represent a risk. But if the diabetes is pharmacologically controlled, it was not a relative contraindication for implant placement. Age, sex and concurrent use of hypoglycemic agents did not correlate with increased implant failure or perioperative morbidity. In the current surgical opinion, patients with well controlled diabetes probably do not encounter inordinate operative risks whereas patients with poorly controlled diabetes still frequently experience wound failure. Therefore, poorly controlled diabetic patients present more difficult management problems and postponement of the surgery is recommended until better control is achieved.13 3) SmokingStudies have shown that one of the primary factors that lead to implant failure is smoking. It seems likely that reduced vascularity of bone is the predominant mechanism for failure in smokers. The effect of smoking on impaired wound healing is due to compromised poly-morphonuclear leukocytes function, increased platelet adhesiveness as well as the vasoconstriction caused by nicotine. Consensus has been reached that smoking has a negative influence on implant survival, though well designed clinical trials on the topic are lacking.14

(4) Para-functional habits
Para-functional habits such as bruxism and clenching create mechanical and biologic complications related to prosthetic components, materials and bone anchored hardware or the state of osseointegration. Bruxism, is the multidirectional non-functional grinding of the teeth. Clenching occurs in one direction (vertically). This is the most common cause of implant bone loss or lack of rigid fixation during the first year after implant insertion.

Failures occur with greater frequency in the maxilla because of the decrease in bone density and the increase in moment force. Bruxism does not represent a contraindication for implants but does influence the treatment planning. There is little clinical evidence that parafunctions (bruxism and clenching) are associated with increased failure rates. Nevertheless, there has to be a general consensus that excessive loading or under stresses induce bone loss and that secondary factors (bone characteristics) may contribute to this outcome.[15]

(5) Oral hygiene
Dental plaque is one of the main factors that lead to implant failure. A direct relationship between accumulation of dental plaque and the onset and progression of gingivitis has been established. Because the suprabony connective tissue fibers are oriented parallel to the implant surface, it is susceptible to plaque accumulation and bacterial ingress in spontaneous loss of the perimucosal seal and an increased number of spirochetes that release proteolytic enzymes dissolving fibrin, trypsin-like enzymes disrupting cell to cell adhesion and metabolic end products that are cytotoxic to gingival tissues. In addition the nature of implant surface seems to increase the bacterial colonization.

It is recommended that the patient be recalled frequently preferably at a minimum of 3-month intervals. Periodontal indices, bleeding on probing and radiographic evaluation should be performed using plastic tipped probes for checking pocket depths. Soft tissue debridement should be performed by means of plastic curettes and plastic tips (when indicated) for ultrasonic scalers and topical and systemic antimicrobial drugs should be used. Finally a well-defined maintenance program should be advocated.

(6) Irradiation therapy
The relationship between dental implant failure and the irradiated patient 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 jaws. The main problem withirradiated patients is decreased salivary flow (xerostomia) the liability for infection because of decrease in blood supply and the possibility of osteoradionecrosis.

Irradiated tissues into which the implants are placed have a significantly reduced healing capacity as a result of the very high dose and repeated radiation. The question as to how high a radiation dose a tissue can receive and still be able to integrate implants remains to be answered. If the irradiation doses delivered to the tissues are cumulative, the fractionation of the total dose would allow for some cellular repair between successive applications.16

(B) Surgical Placement
(1) Off axis placement (Severe angulation)
Improper implant placement can result in a framework design that compromises esthetics and distribution of force on implants. The most common problem encountered by many clinicians during implant placement is alveolar process resorption. The clinician has one of the three options-

- Either to graft the area toplace the implant properly
- To place the implant with an angulation
- To use an angulated abutment- So as to achieve the proper alignment with the opposing arch or the adjacent natural teeth.

Endosseous root form implants distribute occlusal load best in an axial direction, but if the occlusal load is in a lateral direction many damaging stresses (especially shear stresses) are generated directly at the crest of bone. This may lead to implant failure. A concept has been proposed that angle change over 25° will cause an implant to fail.

Authors have indicated that angulated abutments have exhibited good preliminary results and may be considered comparable with the standard abutments as a predictable modality in prosthetic rehabilitation as based on a study, performed on Branemark implants. The authors also conclude that use of angulated implants do not increase failure rates. Reports also indicated that the angulated abutments up to 45° did not compromise the long term survival of implants. Occasionally use of angulated abutments to overcome compromised esthetic and functional results in situations of complicated anatomy, especially in the maxillary arch, becomes necessary.

(2) Lack of initial stabilization
Surgical technique is one of the 6 factors that are important for the establishment of osseointegration of titanium implants. Overheating the bone and initial instability of the implants are the two most frequent surgical errors that might occur negatively influencing the integration. Poor initial stability can also be due to poor / inferior bone quality and in such cases use of self-tapping fixtures aiming at a better primarystability as compared to the original technique using pre-tapping can be suggested.The use of excessive force to disengage a locked drill during the preparation, faulty hand positioning of the surgeon during drilling or threading, poor bone quality and the use of finger rest during osteotomy preparation are all factors that may lead to an oversized osteotomy, which in turn results in lack of initial stabilization. There are not enough recorded data regarding the size of the gap between the implant and the bone that would lead to failure. Because the size of the gap (which may be bridged between the implant and the bone) is not definite, slight oversizing of the osteotomy may not be a serious problem.[15]

(3) Impaired healing and infection because of improper flap design or others Wound healing is one of the basic considerations in surgery. A problem with dental implant data regarding the size of the gap between the implant and the bone that would lead to failure. Because the size of the gap (which may be bridged between the implant and the bone) is not definite, slight oversizing of the osteotomy may not be a serious problem.[15]

(4) Overheating the bone and exerting too much pressure Minimal temperature elevation during surgical drilling of the bone is a key factor in atraumatic surgical technique. Temperature control during osteotomy preparation is an important factor, when osseointegration is to be anticipated. Overheating occurs due to excessive pressure application, dull instruments, lack of appropriate coolant and inappropriate surgical technique. Bone cell death occurs at a temperature of 47°C and higher when drilling is performed for 1 minute (Heat necrosis).

Excessive and heat pressure on the implant will lead to bone loss because of bone- cell necrosis. Because of bone cell damage, a connective tissue interface is formed between the implant and the viable bone, thus leading to loss of integration. Slight overheating, which is not damaging can cause postoperative bone loss around the implant site. It is recommended that a speed of no more than 2,000 rpm with a graded series of sizes be used and that external irrigation helps to prevent heating the bone.

(5) Inadequate space between implants Most implant manufactures recommend a space of 4-7mm between the neighbouring implants to allow sufficient biologic space to avoid the necrosis that could happen because of blood supply impairment. Also sufficient space between the implants will maintain a proper hygiene protocol.

The proposed minimum space between an implant and a neighbouring natural tooth should not be less than 3mm to avoid impairment of the blood supply of the periodontal ligament, whereas the minimum space between two adjacent implants should range from 3mm to 5mm, depending on the type of bone i.e. in very dense bone (type I), the minimal space should not be less than 5mm to avoid overheating and subsequent death of the bone cells. However, in cancellous bone (type III and IV) this distance may be as small as 3mmbecause of the nature of cancellous bone which will not be subjected to the danger of overheating as much as type I bone.

(6) Placing the implant in immature bone grafted sites One of the most

common causes of prosthetically related implant failure is believed to be the too rapid loading of the implant supported prosthesis. The problem with placing implants in grafted bone is timing i.e. if the implant is loaded before the surrounding bone matures from woven bone into lamellar bone, then the failure incidence is much higher because of the nature of woven bone. Woven bone is the fastest and first type of bone to form around the implant interface. It is only partly mineralized and demonstrates unorganized structures unable to with stand full scale stresses. Conversely, lamellar bone is ideal for implant prosthetic support.

The waiting period is mandatory for implant survival in cases of grafted bone sites (from 6-9 months). Any attempt to put this implant in function before the allotted time means that the woven bone would be loaded. This adversely affects implant survival. On the other hand, there is a correlation between the amount of bone containing the implant and the long- term serviceability of the implant, which would explain the waiting period. 80-85% survival has been reported in various studies when implants have been placed in grafted bone.

(7) Placement of the implant in an infected socket or a pathologic lesion Dental implants may fail because of 1) placement of the fixture into either an infected socket (immediate implant placement) 2) an existing pathological lesion (e.g. cyst) or 3) migration of infection from a neighboring tooth via marrow. During the initial stage of osseointegration, the implant is particularly vulnerable to infection from an adjacent endodontic lesion. It was suggested that an implant does not have the ability to withstand any bacterial challenge during the first stage of osseointegration and that an endodontic lesion can travel through marrow spaces and contaminate an adjacent implant fixture. Such vulnerability could be explained by the absence of a periodontal ligament and because after placement of an implant the interfacial bone undergoes resorption.

(8) Contamination of implant body before insertion Surface properties of the implants are due to its oxide layer. The oxidation parameters such as temperature, type and concentration of oxidizing elements and eventual contaminants, all influence the physical and chemical properties of the final implant product. The implant may be contaminated because of manufacture errors, by the operator, from non-titanium instruments or by bacteria (oral cavity).

(C) Implant Selection
(1) Improper implant type in improper bone type
Qualitative and quantitative evaluation of the bone must be evaluated before placing the implant. The quality of bone supporting the implant is important for long term success.17 The amount of bone available and the position of anatomic structures ultimately define the designs of the implant to be used and its location in the arch. In routine sites of type I and type II quality, the clinician could comfortably use Ti-products without the needfor the added risk or potential risk of HA products. However, there is a significant area in which HA-coated implants seem to significantly outperform Ti-products, namely, type III and type IV bone.

(2) Implant width / diameter
Increase in width increases the surface area over which occlusal forces may be dissipated. But a width equal to natural dentition is not required in implants because it is much stiffer or more rigid than the natural teeth. This can lead to stress shielding effect leading to less loading of bone, hence resulting in its resorption. A 4 mm implant has a fatigue resistance that is approximately 30% higher than that of the 3.75 mm implants.4mm root form implants have 33% greater surface area than 3 mm implants.

(3) Implant length
A great variety of implant lengths exist in a range between 7mm and 20mm with the most widely used falling in the range between 10mm to 16mm. The success rate is proportional to the implant length and the quantity and quality of available bone. The long- term success of the implant is dependent on the amount of bone-implant contact. Resistance to lateral loading is provided by the strength of the bone and the intimate contact between the bone and implant. Hence longer implants are simply not needed in D1 bone because of a homogenous cortical bone whereas in the softer bone greater length is often suggested. The crown - implant body ratio affects the appearance of the final prosthesis along with the amount of moment of force on the implant and the crestal surrounding bone. The greater the crown implant ratio, the greater the amount of the force with any lateral force.

(D) Restorative problems
(1) Excessive cantilever
For partially edentulous patients, it places offset loads to the implant abutments and results in greater tensile and shear forces on cement or screw fixation. Many problems can be associated with cantilevers supported by dental implants. Such problems include fracture of the prosthesis, loss of osseointegration and bone fracture.18

(2) No passive fit
Achieving passive fit during prosthesis insertion is considered to be one of the keys to success of dental implants.22 A passive fit reduces long term stresses in the superstructure, implant components and bone adjacent to implants. The passive fit should exist at the 10 um level and is required to achieve an optimum load distribution.

(3) Improper fit of the abutment
Immobility of the components of the dental implant is a requirement for success. Achieving a proper abutment-fixture interface fit is critical. Improper locking between the two parts of the anti-rotational implant device leads to an increased microbial components with subsequent bone loss and rapid screw joint failure. Some authors have shown nostatistical correlations between observed marginal bone level changes and different parameters of prosthesis misfit.

(4) Improper occlusal scheme
Occlusal factors are a primary requisite for long-term survival, because a poor occlusal pattern increases and localizes forces.19 Occlusal trauma on dental implants is more offensive than on natural teeth because of the force dissipation difference and because of differences in proprioception. Occlusal materials, bone biomechanics, forces, stress distribution, vertical dimension, centric occlusion and lateral excursions are all important factors that should be considered to achieve a balanced occlusion and a reduced failure rate.

(5) Mechanical complications
Melvyn S. Schwarz (2000) broadly divided mechanical complications of the implant components as

(a) Screw loosening
(b) Screw fracture
(c) Fixture fracture20
Screw loosening / screw fractures

There are two primary factors involved in keeping implant screws tight 1) maximize the clamping force and 2) minimize the joint separating forces.

At the initial delivery of coping fixture, the screw should be tightened to approximately two-thirds to three-fourths of the final torque force and after 4 weeks it may be tightened to the full 20 Ncm torque force. More than 20 Ncm of torque force could lead to implant failure depending on the implant surface used (i.e. Mechanical blasted, acid etched etc.)

The most commonly overlooked separating forces are off axis centric contacts. Normal centric contacts on molar cusp tips may exceed the clamping force threshold especially if the general occlusal force generated by the patient is large. This theory may explain the high incidence of screw loosening in single implant molars.
Fixture fracture

Fixture fracture is the most catastrophic failure of implant hardware because it usually causes the loss of implant. The longer the fixtures are loaded, the incidence of fracture increases, demonstrating that metal fatigue and subsequent fracture is a time dependent phenomena. According to a retrospective analysis the vast majority of implant fractures have occurred in the posterior region in combination with cantilevers and bruxism or heavy occlusal forces leading to bending overload.

The fixture fractures can be minimized by the use of wider diameter fixtures, the use of a third fixture and offsetting the fixture in order to achieve a tripod effect. The greater dimension of the walls of the implants, in conjunction with the superior strength of the cold worked type IV CPTi yields an implant that is sufficiently strong to resist off-axis heavy occlusal forces. Incidence of fixture fracture according to retrospective analysis is upto 5% for standard diameter fixture, 12.5% in maxilla and 14.3% in mandible.

CONCLUSION

Implants are commonly and successfully used as bone anchoring elements in oral prosthetic rehabilitation. Despite the high success rates (81-85% for maxilla; 98-99% for anterior mandible at 10 years) failures ranging from 1.5%- 6.7% are still existent. The failure so far can be broadly categorized into seven groups; namely etiological failures, failures depending on origin of infection, failures according to timing of their occurrence, according to the condition of failure and the responsible personnel, depending on failure mode and finally failures occurring due to breakdown of the supporting tissues.

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