Review Article

Failures in Dental Implants

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Abstract
Failures are stepping stones to success. Implant failures are common, a better understanding of the factors associated with implant failures will facilitate clinical decision making and may enhance implant success. This review article summarizes and classifies implant failures into early and late failures, surgical and prosthetic failures.
Key words: Dental implants, prosthetic failures, surgical failures

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Introduction:
Dental implants have been a successful treatment alternative for restoring missing teeth. The concept of failure beyond the loss of integration has included esthetic, functional and phonetic reasons. With high patient expectations successful implant integration does not necessarily result in a satisfied patient. A better understanding of the factors associated with implant failures will facilitate clinical decision making and may enhance implant success.

Table 1: Incidence of implant and implant supported prosthesis

Arch/Prosthesis	No. of implant studied /lost	Mean incidence
Maxillary Overdenture	1103/206	19%
Maxillary fixed CD	4559/443	10%
Mandibular. FPD	3297/213	6%
Mandibular. FPD	2567/157	6%
Mandibular. Overdentures	5683/242	4%
Mandibular. Fixed CD	9991/255	3%
Mandibular & Maxillary single crown	1512/42	3%

Table 2: Timing of loss

Prosthesis	No. of Imp	Before Prosthesis	After
Implant Fixed CD	248	135(54%)	113(46%)
Overdentures	293	176(60%)	117(40%)
FPD	170	104(61%)	66(39%)
Single Crown	15	7(47%)	8(53%)

Classification:

Truhlar[1] classified failures as.

Early failures: Those that occur from weeks to few months after placement caused by factors that interfere with normal healing process or by an altered healing response.

Late failures: Those that arise from pathologic processes that involve a previously osteo integrated implant. Heydenrifik[2] further classified the late failure into.

A) **Soon late failures**: Those occurring during the first year of loading.

B) **Delayed late failures**: Implants failing in subsequent years over a period of 5 years

A) Early Failures

1. Surgical Factors

Infection: Is one of the many factors contributing to failure of implants.

Presently no single micro-organism has a) been closely associated with infection of the implant/site of implant placement.[3] The microbial flora is the same that is traditionally associated with periodontitis.[4-5]

Staphylococci are present within the oral cavity and their isolation from Periimplant infector is significant as both staphylococcus aureus and coagulase negative staphylococci are frequently responsible for infections associated with metallic biomaterials and in dwelling medical infect in general.[6-7]

Staphylococcus aureus is demonstrated to have the ability to adhere to titanium surfaces. This may be significant in the colonization of dental implants and subsequent inflectional.[8]

Table 3: Classification of Implant failures

IMPLANT FAILURES

Early

Surgical factors

- Infection
- Dehiscence of area
- Malposition/angulation of implant
- Lack of 1° stab
  - Incorrect tapping
  - Too wide osteotomy
  - Too low insert torque value
  - Too high insert torque values

Prosthetic factors

Due to immediate loading of implant

Late

Surgical factors

- Maxillary sinusitis
- Mandibular fracture
- Loss of osseointegration
- Periimplant lesions
- Implant displacement

Prosthetic factors

- Implant screw fracture
- Implant & tooth prosthesis
- fracture
- Improper planning
  - No of restorations less than no of root support
  - Prosthesis offset from implant centre
  - Prosthesis extension/ cantilever
  - Height of restoration
  - Lack of prosthesis
  - Fit factor
  - Sink depth/apico-occlusal depth

b) Dehiscence and fenestrations of the implant site: Osseous dehiscence and fenestrations in the vestibular cortical bone happen when implants are placed in a prosthesis guided axis position but main problem lays in good would closure that may allow a primary scarring. It is necessary for the design and the management and release of the flap to allow a under extension and thus achieve a better cover and tension free surgical site.[9] Osseous dehiscence and bone fenestrations can pass unnoticed in those cases when an implant is placed after an exodontic procedure /transmucosal flapless surgery[10] so as to values concerning, probing depth and insertion level are less favourable when compared with implants placed in integral alveolar crest.[11] This should be prevented by correct palpation of alveolus before inserting implant.[12]

c) Malposition/angulation of implant: For an optimal restoration there has to be optimal placement. In this regard 3 factors have to be considered while inserting the implant position angulation and depth.

d)

To prevent prosthesis complications during the planning phase appropriate radiographic scans combined with study cast can provide comprehensive information concerning (3D) anatomy of the site.[13]

- Surgical templates should be used as they provide guidance in 3 planes (Buccolingually, Mesiodistally and occlusoapically).[14]
- There should be a smooth transition from the surgical to prosthesic phase of therapy, the tissue crevice should be managed to permit a transfer coping/abutment to be seated without much difficulty. “Running Room” is the Peri-implant crevicular depth measured from the implants prosthetic platform to free gingival margin. It is the vertical distance to make transition from a smaller prosthetic platform of implant to larger cross sectional shape of tooth being restorated.[15] For example the neck of a standard implant is 3.75 – 4mm whereas diameter of central incisor at CEJ is 7mm hence the running room desired should be 3mm at least.

Positional Issues

Bucco-lingual Malposition: Buccally malpositioned implants can jeopardize labial cortical plate of the bone. Jumping distance of upto 2mm has to be maintained to account for bone loss that may occur during implant placement or as a result of osseous resorption during the healing phase.[16-18] Injury to the plate has a detrimental effect on height of overlying soft tissues and may result in mid - buccal recession and produce an unesthetic result. Lingually placed impants create other problems.[19] If it is necessary to position the implant lingual to ideal position to remain in bone during the osteotomy development then a more apical insertion will allow additional running room & better emergence profile. Lingual positioning of implant many also cause a problem if there is a deep overbite. In such a case the palatal placed implant is on restorable. Also a palatally placed implant may encroach on tongue space hence impending the speech of the patient.

Mesiodistal Malposition: Two different scenarios may occur to much space or too little space between adjacent teeth or implants. Too little space may cause injury to interproximal bone[20] and soft tissue and will necessitate restorations that are smaller than usual. If there is too much space between implants additional pontic can be cantilevered however that will increase stress on the supporting implants.

Angulation Issues

Buccolingual Angulation Issues: Endo-osseous root form implants distribute occlusal loads most effectively when forces are applied in axial direction. Angulation of 15^{o} or less is acceptable as even natural teeth are perpendicular to the curve of Wilson, (the lateral curve on the occlusal table formed by the inclination of posterior teeth). However if it approaches or exceeds 25^{o}; the supporting bone is compromised through transmission of occlusal forces. If the implant is included buccolingually the prosthetic construction is off set relative to implant head for improved occlusion /or esthetics. The inclination will introduce a bending moment on the implant and will lead to potential biomechanical problems like restoration fracture, retaining screw fracture, abutment fracture, implant body fracture, osseous destruction cause of unfavorable loading, plaque accumulation under ridge lap pontics.

Mesiodistal Angulation issues: Minor mesiodistal angulation issues are due to the anatomy at the intended implant site such as to avoid root of adjacent tooth or a vital structure (e.g mental foramen), penetration into maxillary sinus. The surgeon should evaluate the position of osteotomy after use at pilot drill by placing parallel pin in pilot hole and taking a radiograph. If angulation is not correct, a Lindmann side cutting, drill can be used to adjust angulation before continuing preparation of implant site. In multiple implant cases, Mesiodistal inclination has a lesser influence on occlusal load transfer to implant and does not influence destructive forces. Because the prosthetic super structure redirects occlusal forces. Survival of Mesiodistal angulated implants in multiple implant cases has been reported in literature with success of 93% to 97.5. [21-28]

d. Lack of primary stability (Spinners): Primary stability depends mainly on bone density and cortical bone thickness hence easily obtainable in mandibular implants then maxillary implants.[29] Methods of measuring implant stability following implant placement.

- Subjective evaluation
- Resonance frequency analysis (RFA).[31, 32] In this method the stiffness of bone implant interface is calculated from a resonance frequency in reaction to oscillation applied to implant bone system of smart peg (osstell) which attaches to the implant, more stable the implant higher the frequency.
- Insertion torque – 30 Ncm.

Inadequate insertion torque: Can be a factor in implant failure loose implants are subject to movement during healing process which interferes with osseointegration.

There are few reasons why an implant lacks primary stability-

- Over preparation of the site with excessive in and out motion during drilling.
- Use of dense bone drills/Tapping drills in low density bone.
- Following an elliptical /imprecise pathway during drilling.

If the insertion toque is < 10 NCM the risk of osteo-integration failure is greater especially in type IV bone. Whereas a too high torque value (>45 NCM) could lead to bone compression which would lead to bone necrosis. (type I bone) and in osteo-integration failure.[33]

According to a study conducted by Cooper[34] in 2010, on 1084 implants. There was a 6.43 fold lower risk of primary implant stability failure in anterior mandible than any other location. Maxilla had 2.7 fold higher risk of primary stability failure versus Mandible.Females had 1.54 higher risks of primary implant stability failures

versus men. Rough surfaces, a cone design of implants and use of ostestomes in management of implant bed can increase primary stability on low quantity bones.[35-36] When not possible to implement the above solution, better replace the instable implant with a rescue implant with a wider diameter or longer length or as a final resort wait 6-8 weeks before surgical reintervention.

Late Failures:

Mandibular fractures: The central area of the Mandible has a greater risk for this complication since it has poor vascular irrigation which makes it difficult for the bone and periosteum to provide enough blood for the healing process derived from an implant placement[37].The bone in the area becomes sclerotic and undergoes severe resorption due to long period of edentulism and also due to pressure exerted by the prosthesis. A minimum of 10mm in height and 5 mm in width should be available for implant placement.

Bone grafting procedures such as block grafting and GBR can be used to increase the bone volume & strength before implant insertion.

During the healing period after placement or removal of implants patients should limit stress to the jaw with appropriate measures such as a soft diet.

Procedures such as inferior alveolar nerve transposition may make more bone available for implant insertion but may also lead to a fracture as it compromises the structural integrity of atrophied mandible.[38-40]

Infections: An imbalance in the host parasite equilibrium can manifest itself in a inflammatory changes leading to two distinct clinical conditions:

A lesion limited to the superficial soft tissues (peri-implant mucositis)

A lesion involving deeper soft tissues and eventually the marginal portion of bone implant interfaces (peri-implantitis).

Ericson[41] demonstrated changes in peri-implant gingiva in a beagle dog after 3 months plaque accumulation characterized by edema redness and bleeding on gentle probing both around teeth and implants.

Table 4: Difference between peri-implant lesions and periodontal lesions

Peri Implant Lesions	Periodontal lesions
Histomorphometnc analysis shows apical spread of infiltrated connective tissue from gingival margin is 1.3mm	0.9mm apical spread of infiltrated connective tissue
According to Brandes et al[42] rate of tissue destruction is higher.	Rate of tissue destruction is lower
According to lindhe[43] clinical & radiographic signs of radiological destruction were more pronounced at implants.	Not that well appreciated
Less vascular structures observed.	More vascular structures observed.
Peri-implant infiltrate was predominated by neutrophils & plasma cells.	Peri-implant infiltrate was predominated by Macrophages & lymphocytes

Predisposing conditions that may lead to peri-implantitis.

- Infection from activation of residual bacteria in sites with history of endodontic pathology.
- Infection from scar tissues following removal of an impacted tooth.
- In contamination from adjacent tooth with endodontic pathology/periodontal conditions.[44]
- Apical entrapment of gingival epithelial cells during implant insertion.[45]
- Necrosis from excessive heating of bone during osteotomy drills.[46]

There are two types of Peri-implantitis.

- Infected type
- Non infected /active type

Symptoms: Pain, redness tenderness upon touching the face over the apical area of the implant, swelling peri-apical radiolucency at apex of implant & possibly pressure of fistulous tract.

Management: Should be taken up as soon as possible to prevent acute exacerbation of lesion and total loss of osteointegration.

Steps

- Flap elevation
- Creation of a bony window
- Debridement & curretage
- Removal apical portion of infected implant: This is indicated primarily in cases where implant extends into maxillary sinus / nasal cavity or in situation where retention of apical part of implant could obstruct complete mechanical debridement of granulation tissue resulting in failure to eliminate the infection and subsequent loss of implant.[47-48]
- Surface Treatment: with 250mg tetracycline powder with sterile water for 1 min, the area then rinsed & flushed. The procedure repeated true.
- Grafting
- Medication systemic antibiotics such as penicillin G/amoxicillin (500mg ds for 7 days) along with chlorhexidine 0.12% rinse for 3 weeks recommended after surgical intervention.

Displacement of the implant into sinus

The displacement of the implant into the sinus can be either partial or complete.

Early/ Late

Implant could undergo a displacement at any time after cover-screw being placed (osseointegration period) even after avoiding regenerative techniques in a spontaneous and asymptomatic way or ever after attaching the healing abutment[49]. When this happens implant can be retrieved later by opening the lateral wall of maxillary sinus [50] or by endoscopy via nasal window. Guller and delilbasi reported a case in which implant migrated into the sinus cavity after 8 years.[52] Post operative complications of implant displacement into maxillary sinus include[53]

- Asymptomatic implant displacement
- Reactive sinusitis and/or
- Associated oroantral communication
- The fixations could displace from Maxillary sinus and into spheroidal & ethmoidal sinus.[54]
- Migration that ended in the orbital floor has also been seen [55] that ended up lodged between bone and inferior rectus orbital muscle causing pain & diplopia.

The risk of complete displacement is higher when implants are placed simultaneously with lateral window elevation because bone beneath the sinus is poor in quality and lack volume for primary stability.

Implant Fractures

An implant fracture could be infrequent complication[56] caused due to

- Defects in implants design/materials used in their construction.

(Some implants are more likely to fracture at the neck than others, particularly small diameter hex implants.)

- Non passive union between implant and prosthesis or
- By mechanical overload like special cantilever in fixed prosthesis
- Occlusal overload & parfunctional habits[57].

Incidence higher in implants supporting fixed partial prosthesis than complete edentulous patients. More than 80% fractures are located in the molar & premolar regions and mostly occur 3-4 years after being loaded.[58]

Improper planning: Planning is essential for the success of any treatment modality

Table 5: Geometric Risk Factors[59]

Geometric Risk	Score
No of implants (N) less than number of root supports (N<3)	1
Use of wide platform implants (perimplants)	- 1
Implant connected to natural both	05
Implants placed in tripod configuration	- 1
Presence of a prosthetic extension (per pontic)	1
Implants placed offset from centre of prosthesis	1
Excessive height of restoration	05

Table 6: Studies addressing TISP adopted from cong et al/Survival rate of implants and TISP

Authors 5 years follow up	No. of Implant	No. of failure	Survival rate	No. of TISP	No. of failure	Survival rate	Implant type
Block et al	80	1	986	-	-	-	…….
Mau et al	297	51	795	-	-	-	IMZ
Naert et al	339	19	954	-	-	-	Branamark
Bragger et al	19	1	94.8	18	1	94.5	ITI
Kindberl et al	115	9	90.1	41	3	92.8	Branamark
Hosny et al	31	1	97.5	18	0	100	Branamark
Olsson et al	23	2	90.5	23	2	90.5	Branamark
Koth et al	28	6	75.7	15	1	93.4	Branamark
10 years							
Bragger etal	22	5	77.7	22	7	70.2	ITI
Gunne et al	23	2	89.8	23	3	85.1	Branamark
Faitash et al	27	0	100	-	-	-	Branamark
Stefulx et al	28	9	64.7	15	3	79.8	Branamark
Jemt et al	43	8	n/a	12	1	n/a	Branamark

It's not sufficient consider number of teeth, it is necessary to consider number of root support to replace for example: Canine represents one root support while molar represents two supports. This is very important consideration especially if restoration based on three implants or more.

One implant replacing the molar generates a geometric risk score 20 (number of implants less than root support) prosthetic extension). The risk score can be decreased by using a wide platform (-10) or two regular platform

Implants connected to teeth -Tooth Implant Supported Prosthesis (TISP)

Technical & Biological complication associates with connecting teeth to implants[60, 63]

Technical problems are

- Implant fracture
- Tooth inclusion
- Intrusion of teeth with telescopic crowns
- Cement bond breakdown
- Abutment tooth fracture
- Abutment screw loosing
- Fracturing of veneers
- Prosthesis fractures

Biologic Problems

- Peri-implantitis
- Endodontic problems
- Loss of abutment tooth
- Loss of an implant
- Caries
- Root fracture

Lindhe[64] conducted a 2 year follow up of various maxillary prosthesis (N=26),patients one side recovered an ISP and other TISP. Different prosthesis were fabricated according to patient needs and no difference was found in the failure rate of implants. (88% cumulative survival) with different prosthetic designs and no additional bone loss with TISP. (Table 6)

Implants placed in line represents a severe risk of overload. It is necessary that the implants be spread along the alveolar ridge and should be placed in the tripod configuration.[65] Presence of prosthetic extension/cantilever.

From the studies conducted by finite element analysis.[66,67] It was possible to observe relative physical properties of materials affect the manner in which stress is distributed.

1. At each increment of 5mm in cantilever length stress increased by 30-37% on cortical bone around the implant.
2. The stiffer the cancellous bone, more stress it takes and less stress on cortical bone.
3. Slight – decrease in stress was observed with longer implant and abutments.
4. Use of Co-Cr alloy contributes to better stress distribution.

Occlusal Risk Factor

Occlusal overload is one of main causes for peri-implant – bone loss and implant prosthesis failure due too crestal bone loss, thus increasing anaerobic sulcus depth and peri-implant disease states.[68,69]

Implant protected occlusion developed by Misch desgined to restore an endo-osseous implant by providing an environment for improved clinical longetivity of implant and prosthesis.[70,71]

Specific occlusal factors that may influence crestal bone loss

- Provision of load sharing occlusal contacts.
- Modification of occlusal table & anatomy
- Increased Implant surface area.

5. Elimination or reduction of occlusal contacts in implants with unfavourable biomechanics.

Basic principles of implant occlusion which include.[70]

1. Anterior guidance when possible.
2. Bilateral stability in centric (habitual) occlusion.
3. Wide freedom in centric (habitual) occlusion.
4. Evenly distributed occlusal contact and forces.
5. Non interferences between the Retruded position and centric (habitual) position.
6. Smooth even lateral excusive movements without working/non working interferences.

Avoiding occlusal prematurity between maximum intercuspation and centric relation occlusion should be noted especially with tooth implant supported prosthesis because "Non mobile implants bear the total load of prosthesis when joined with mobile" natural teeth.

Anterior Guidance

According to Weinberg & Kruger with every 10 degree change in angle of disclusion there is 30% difference in load. They suggested supported prosthesis should be as shallow as possible to avoid greater forces on anterior implants by Steeper incisal guiding angles.

Cusp inclination

Weinberg and Kruger[71] evaluated torque of a gold screw, abutment screw and implant and concluded that cuspal inclination produces most torque, followed by maxillary implant offset, while implant inclination and apical implant offset produce minimal torque.

Kaukineh et al[72] determined difference of force transmission between 33^{o} and 0^{o} cusp. Because the angle of force to implanted body may be influenced cusp inclination, a reduction in cusp inclination can decrease the resultant bending moment with a lever arm reduction and improvement of the axial loading force.

Occlusal table width

30% - 40% reduction in the occlusal table in a molar region has been advocated since any dimension larger than implant diameter can cause cantilever effects and eventual bending moments in single implant prosthesis.[73] Narrow occlusal table promotes oral hygiene & reduces porcelain fracture.[74]

Apico-occlusal issues include

- Inter occlusal clearance
- Bone level
- Tissue thickness
- Implant malposition /angulation

Interocclusal clearance

Cementable single restoration would minimally require 7mm of clearance from the implant platform to opposing dentition.

Why 7mm?

2mm for occlusal clearance between abutment & opposing teeth

45mm "prep" length which assumes excellent parallelism and

0.5 mm for abutment polished collar to interface with the implant[75].

If there is reduced space (4.5 – 5 mm) screw on restoration can be fabricated (also called UCLA type crown).

Gingival tissue thickness

- In relation to esthetics
- Complete seating of prosthetic components

Cement Failure

Cement retained prosthesis have become more popular than screw retained because of the advantage they provide over the latter.

However one disadvantage is that excessive cement may remain beneath the free gingival margin which is associated with peri-implant disease

leading to severe bone loss and implant failure.

A study by Wilson[77] showed excess dental cement associated with clinical and endoscopic signs of peri-implantitis in 81% of the cases and removal of excess of cement resulting in resolution of peri-implantitis in 74% of the cases.

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