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Short Communication

Force Delivery and Failure Mechanisms in Dental Implant

Maaz Vohra[1], Ashrita Suvarna[2]

[1]Department of Prosthodontics, M.A Rangoonwala College of Dental Sciences, Pune.

[2]D.Y Patil Dental College, Pune

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ABSTRACT

A force basically means a push or pull upon an object resulting from that object's interaction with any other object. In dentistry, force per se is stress acting on any dental material or the dental tissue. Types of Stress includes Compressive stress, Tensile stress and Shear stress. Types of Failure mechanism related to stress in dental implant include Fatigue failure, Stress concentration failure, Bending or torsional failure. In order to prevent implant failure and complications related to dental implants, one must understand the types of forces acting and their effect on dental implants.

Keywords: Implant; Osseointegrated; Implant failure

Address for Correspondence:

Dr. MaazVohra

Department of Prosthodontics, M.A Rangoonwala College of Dental Sciences, Pune

EMail Id: Maazvohra390@gmail.com

INTRODUCTION:

A force basically means a push or pull upon an object resulting from that object's interaction with any other object. In dentistry, force per se is stress acting on any dental material or the dental tissue.

Types of Stress:

1.Compressive stress-When a body is placed under a load that tends to compress or shorten it, the internal resistance to such a load is called a compressive stress.

2.Tensile stress-A stress caused by a load that tends to stretch or elongate a body.

3.Shear stress-This type of stress tends to resist the sliding or twisting of one portion of a body over another.

Types of Failure mechanism related to stress in dental implant:

1.Fatigue failure

2.Stress concentration failure

3.Bending or torsional failure

In order to prevent implant failure and complications related to dental implants one must understand the types of forces acting and their effect on dental implants.

CLINICAL SCENARIO	A-P DISTANCE AND CANTILEVER LENGTH
-ARCH FORM 1.Square 2.Tapered	 Less A-P spread,Less Cantilever length More A-P spread,More Cantilever length
-BONE DENSITY 1.Porous bone 2.Dense bone	 Less number of Cantilever space More number of Cantilever space

Failure mechanisms related to stress in dental implants

Various forces acting on the natural tooth causing micro movements of the tooth is greatly influenced by the periodontal attachments of the tooth. Cuspal inclination and location of the cusp in relation to the ridge alters the acting forces. As implants are devoid of periodontal ligaments there implants. Forces acting on the implant differ from those acting on natural teeth. Changing tooth position and cuspal orientation limits the forces acting on the implant. The type of force acting and the consequences of poor fit are related to each other. Prosthesis combining natural teeth with an osseointegrated prosthesis requires new design principles and detailed understanding of failure mechanisms.[1],[3]

Following are the mechanism associated with dental implant failure;

1.Fatigue failure

-Fatigue is the initiation and propagation of cracks in a material due to cyclic loads over a period of time

-Stages of fatigue failure:

a.Crack initiation stage

b.Crack growth stage

c.Ultimate failure stage

-Four factors influence's fatigue failure in implant dentistry:

a.Biomaterial

b.Macro geometry

c.Force magnitude

d. Number of cycles[2]

The geometry of an implant is an important parameter which influences the degree to which it can resist bending and torsional loads and ultimately fatigue fracture. Morgan et al. reported fatigue fractures of Brånemark dental implants caused by cyclic buccolingual loads (lateral loading) in an area of weak bending strength within the fixture. The geometry also includes the thickness of the metal or implant.[4] The fatigue fracture is related to the fourth power of the thickness difference.[2]

The difference in the inner and outer diameter of the screw and the abutment screw space in the implant prove to be a weak link in implant design.[2]

2. Stress concentration failure

-Stress increases the internal energy of an implant either through the movement of ions/atoms or the creation of strain fields. So cyclic loading of an implant body will ultimately lead to stress concentration failure.

3. Bending or torsional failure

-To understand bending or torsional failure of an implant one must know what is moment load and its effects clinically.

-Moment of force or torque is the rotational equivalent of linear force. Torque can act on the tooth/dental implant in three different planes i.e Mesio-distal plane, Facio-lingual plane, occluso-apical plane. These are called moment arms.

These moment arms can also be clinically correlated as occlusal height, cantilever length, and occlusal width.

a. Occlusal height-

Occlusal height is a moment arm for force components acting along the faciolingual axis: working or balancing occlusal contacts, tongue thrusts, or in passive loading by cheek and oral musculature.[2]

b. Cantilever length-

-Cantilever length refers to the length of prosthetic space to be rehabilitated using an implant abutment. Here the implant acts as cantilever abutment.

-Distance away from the implant is referred to as Offset distance and this offset distance produces rotational forces basically acting as a Class 1 lever mechanism.

-Vertical axis force components generally produce large moments. Force applied directly over the implant does not induce a moment load or torque because no rotational forces are applied through an offset distance.

-When a line is drawn from the distal of each posterior implant, the distance to the center of the most anterior implant is called the anteroposterior distance (A-P spread). More the A-P spread between the center of the most anterior implants and the most distal aspect of the posterior implants, the smaller the resultant loads on the implant system from lever forces because of the stabilizing effect of the anteroposterior distance. Clinical experiences suggest that the distal cantilever should not extend 2.5 times the A-P spread under ideal conditions.[2]

c. Occlusal width-

-Larger the occlusal table, higher the offset forces. Narrow occlusal table provides more centric contacts and hence less offset as a result.

-Correlation of increased Occlusal width and Occlusal height

High occlusal width — Increased forces — Increased Crestal bone loss — Increased clinical occlusal height — activation of Facio-lingual moment arm — more deleterious effect of bone — more bone loss — ultimately implant failure.

Ways of preventing stress related implant failures

1.Clinical scenario of short span edentulous spaces-

When facing implant failure, one should always consider the number of teeth necessary for adequate function or what dentition assures oral function?[5] In certain cases the treated area can remain edentulous and this should be considered as an treatment option. An important indicator of oral health status is the number of teeth present [6], 1992 The World Health Organization (WHO) stated that throughout life, the retention of a functional, esthetic, natural dentition of 20 teeth, without requiring prostheses, should be the treatment goal for oral health.

2.Managing the implant prosthesis-

Prosthesis should have low occlusal height, narrow occlusal table such that the cuspal orientation is in line with the residual ridge and for counteracting lever forces A-P length should be managed according to the case.

CONCLUSION:

The magnitude of loads on dental implants can be reduced by consideration of arch position, higher loads in the posterior compared with anterior mandible and maxilla, elimination of moment loads, and increase in surface area available to resist an applied load. Fatigue failure is reduced by reducing the number of loading cycles. Thus aggressive strategies to eliminate parafunctional habits and reduce occlusal contacts serve to protect against fatigue failure.

Authors contribution

Ashrita Suvarna: Manuscript editing, Literature search, data collection

Maaz Vohra: Data Analysis, manuscript editing

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Conflict of interest

All the authors declare no conflict of interest

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