

STRESS FACTORS AS A CAUSE OF FAILURE IN DENTAL IMPLANTS: A REVIEW

* Dr. P.R.Verma B.D.S., M.D.S. **Dr.Jasjit Kaur P.G.Student

**Prof and Head –Department of Prosthodontics, Himachal Dental College, Sunder Nagar, Himachal Pradesh.*

*** Pursuing her postgraduate degree in Department of Prosthodontics, Himachal Dental College, Sunder Nagar, Himachal Pradesh. Pin code : 175002*

ABSTRACT

This literature review summarizes research with aim of providing dentist with evidence based guidelines to apply when planning treatment with osseointegrated implants. English-language peer-reviewed articles published between 1969 and 2009 were identified using medline, as well as a hand search, and reviewed. Topics reviewed include the stress factors which are causative factors for the failure of the implants. These factors should be considered while planning an implant treatment. Limitations in the current body of knowledge are identified, and direction for future research is suggested.

INTRODUCTION

In 1969, Branemark et al¹ published landmark research documenting the successful osseointegration of endosseous titanium implants. Since then, these methods for surgical placement of dental implants had a profound influence on the practice of dentistry. For the success and longevity of dental implant osseointegration is very important. To prevent the failure in implants stress should be evaluated at the implant bone interface. Most common complication in an implant reconstruction is related to occlusal overload and stress related factors. Excess stresses to an implant interface may cause early to late implant failures, crestal bone loss, porcelain fractures, unretained restorations, implant component failure and screw loosening.

CAUSES OF OVERLOADING

- a. Overloading Factors related to Patient
- b. Overloading Factors related to the Implants

An implant team should evaluate more than 60 force factors before developing a treatment plan. Some force factors are more important than others. So these forces should be evaluated in the (1) Magnitude, (2) Duration (3) Type (4) Direction (5) Multiplication Factors.²

Several factors may multiply or increase the effect of the other conditions.

Dental conditions primarily include the following:

- 1) Parafunction
 - i) Bruxism

- ii) Clenching
- iii) Tongue Thrust
2. Crown Height
3. Masticatory Dynamics
4. Position of the Abutment in the Arch
5. Direction of Load
6. Nature of the Opposing Arch

1) Parafunctional Forces

Parafunctional forces on teeth or implants are characterized by repeated or sustained occlusion and have long been recognized as harmful to the stomatognathic system. The most common cause of implant failure after successful surgical fixation or early loss of rigid fixation during the first year of implant loading is the result of parafunction. Such complications occur with greater frequency in the maxilla, because of a decrease in bone density and an increase in the moment of force.³ The parafunctional groups presented in this chapter are divided into bruxism, clenching, and tongue thrust or size of the tongue.

- A) **Bruxism** - The forces involved are in significant excess of normal physiologic masticatory loads. Bruxism may generate several hours per day of increased force on the teeth. A 37-year-old patient with a long history of bruxism recorded a maximum bite force more than 990 psi (4 to 7 times normal).⁴
- B) **Tongue Thrust**- is the unnatural force of the tongue against the teeth during swallowing.⁵A force of approximately 41 to 709 g/cm² on

the anterior and lateral areas of the palate has been recorded during swallowing. A tongue thrust habit may lead to tooth movement or mobility, which is especially of consequence when implants are present in the same quadrant.

1) Crown Height

The crown height is the vertical cantilever or the lever. The greater the crown height, greater the movement of force under lateral loads. Because the stresses are concentrated at the crest of rigidly fixated implant, the crown height multiplier increases stress rapidly. For every 1mm crown height increase, force increase may be 20%. Therefore the crown height increased from 10-20% may increase the stress by 200%. As the bone resorbs, the crown height become larger, but the available bone height decreases. An indirect relationship is found between the crown and implant height which magnifies the stresses.



Fig. 1) Bone resorption occurs at the crest, increases the crown height results in more stresses.

These are responsible for the amount of force exerted on implant system. The dentist evaluates the several conditions under this heading: patient size, sex, age and skeletal position.⁶ The size of the patient can influence the amount of bite force. The larger athlete men generate greater forces; than patient of weak physical condition.

2) Position within the Arch

Maximum bite forces in the anterior incisor region range from 35 to 50 psi; those in the canine region range from 47 to 100 psi and those in the molar area range from 127 to 250 psi, Mansour et al⁷ in addition, the force at the second molar was 10% higher than at the first molar, indicative range from 140 to 275 psi.

3) Direction of Load

The direction of the occlusal load results in significant difference in the amount of force exerted on an implant. Forces are tensile, compressive, or shear to the implants. Bone is strongest to compressive forces, 30% weaker to tensile loads, and 65% weaker to shear loads; three dimensional stress analyses has shown that almost all the stresses occur in the coronal half of the implant bone interface. Much less stress occurs with vertical loads compared with the angled load on implant. Lateral forces represent the 50 -200% increase in stress compression as compared with the vertical loading.

4) Opposing Arch

Natural teeth transmit greater impact forces through occlusal contacts than do soft tissue-borne complete dentures. In addition maximum occlusal force with complete dentures is reduced and may range from 5 to 26 psi. Muscle atrophy, thinning of the oral tissues with age or disease, and bone atrophy often occurs in the edentulous patient as a function of time. Complete implant fixed prosthesis does not benefit from proprioception as do natural teeth. And patients bite with a force four times greater than with natural teeth.

STRESS FACTORS RELATED TO IMPLANTS

Available bone describes the amount of bone in the edentulous area considered for implantation. The amount of bone is measured in width, height, length, angulations, and crown height, implant body ratio for proper size of the Implant. Improper selection of implants in relation to available bone increases the stresses at the implant bone interface.

1) Size of the Implant

A) Implant Length-The Implant length corresponds to the height of available bone. Increased implant length is usually not significant at the crestal bone interface, but is beneficial for initial stability and overall amount of bone implant interface. Increased length also provides resistance to torque or

shear forces. An Implant 3 mm longer provides more than 10 % increase in surface area. This increased length does little to decrease the stress at Transosteal region around implant at crest of the ridge.⁸

B) Implant Width-The surface area of each implant is directly related to the width of the implant. Each 0.25 mm of implant diameter, the surface area increases by the 5% -8%. Past theories suggested that the implant height is more important than the width, but it is not true as occlusal load concentrates most at the crest of the bone, so implant width is more important.⁹

2) Implant Design

Threads are designed to maximize the initial contact, enhance surface area and facilitate the dissipation of stresses at the bone implant interface. Functional surface area per unit length of the implant may be modified by varying three thread geometry parameters: Thread Pitch, Thread Shape and Thread Depth.

A) Thread Number- A threaded implant with 10 threads for 10mm has more surface area than one with 5 threads.

B) Thread Depth- A thread depth of 0.2 mm has less surface area than-an implant with 0.4 mm.

C) Thread Shape- The thread shape is an important characteristic of overall thread geometry it include square, v shaped, buttress geometry. The shear force on v thread face is about 10 times greater than the shear force on square thread.



Fig 2) Increased number of Threads provides more surface area for less dense bone

3) Abutment Number

The overall stress on the implant system may be reduced by increasing the number of abutment over which the force is applied. The most effective method to increase the surface area of implant support is by increasing the number of implants used to support prosthesis. The force distributed over three abutments resulted in less stress to crestal bone than two abutments.

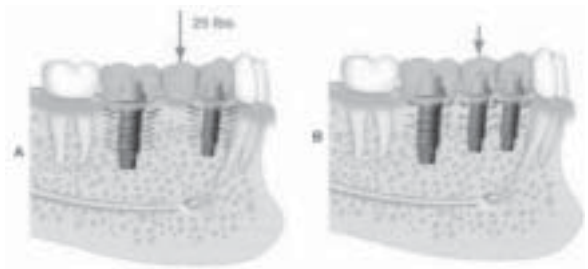


Fig 3) A) Two number abutments results in more forces. B) Three abutment reduces the stress transmission to bone.

4) Abutment Position

Implant positioning also is related to implant number because more than two implants are needed to form a biomechanical tripod, that is, not a straight line. The suggestion is that multiple units be placed in a staggered buccal Abutment offset (tripod effect). Cantilevers are force magnifier and represent a considerable risk factor. Therefore implant number and position should aim at eliminating cantilevers 'whenever possible, especially when other force factors are increased.

SUMMARY

FACTORS MAGNIFIES THE LOAD BY INCREASING THE FORCES ON ABUTMENTS		
1	Parafunctional Forcesa) a) Bruxism	4-7 Times More Forces Than The Normal Bite Force
2	Crown Height Increase In 1mm Height	Force Magnifies By 20%
3	Masticatory-muscle Dynamics	Larger Buillt Person Generate More Forces
4	Directio Of Load a) Axial Load b) Lateral Load	Lateral Load Magnifies The Forces By 50-200%
5	Implant Prosthesis	4 Times More Forces Than The Natural Teeth
FACTOR REDUCES THE LOAD BY INCREASING THE SURFACE AREA OF THE IMPLANT		
1	Implant Length- 3 Mm Increase In Length	10% Increase in Surface Area
2	Implant Width -0.25 Mm Incaresa In Width	5-10 Increase in Surface Area
3	Thread Depth	More Is The Thread Depth, More is the Surface Area
4	Increased Thread Number	increases the Surface Area
5	V Shape- Thread Design Exerts	10 Times Greater Shear Forces than the Square Thread Design

CONCLUSION

Complications and loss of implants can be costly, both in terms of time and financial resources. Loss of integration can be troublesome, resulting in an edentulous space more difficult to restore than prior to implant placement. The ability to reliably identify patients and conditions with greater potential for success would be valuable

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