

# Study of Factors Affecting Success Rate of Immediate Implant Loading

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**Abstract** - This paper aims at providing a preliminary understanding in a biomechanics effect of immediate dental implant loading. Immediate loading of an implant interface has been used for completely and partially edentulous patients. Forces may be influenced by patient factors, implant position, cantilever forces, occlusal load direction, occlusal contact intensity. The surface area of load distribution may be increased by implant size, implant design, and surface condition of the implant body. This article addresses the effect of implant material on stress and strain in the bone. These factors affect the amount of stress on the developing at implant interface and hence may affect the risk of immediate occlusal loading for implant prostheses.

**Keywords** - Immediate implant, Occlusal loading, Osseointegrate, Bruxism, Masticatory forces, Parafunctional forces, Bone implant interface.

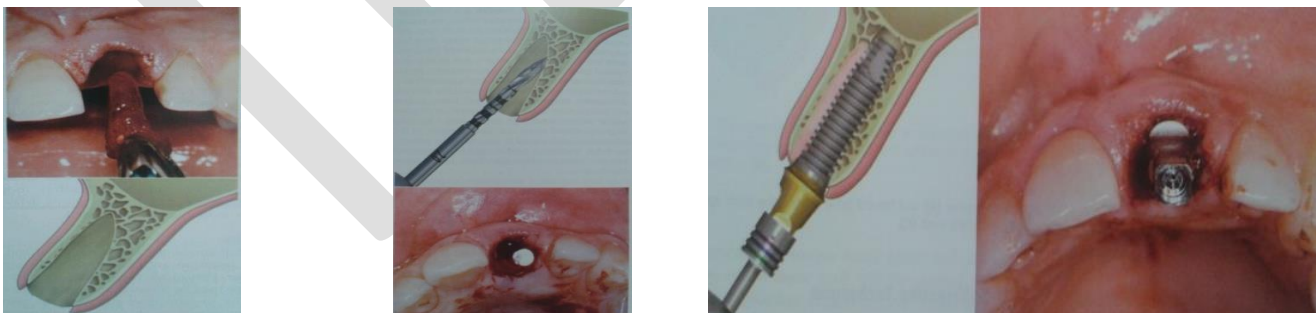
## Introduction

Dental implants function to transfer the occlusal load to surrounding biological tissues. Thus the primary functional design objective is to dissipate and distribute biomechanical loads to optimize the functioning of implant supported prosthesis. Immediate loading of dental implants not only includes a non-submerged one stage surgery, but actually loads the implant with provisional restoration at the same appointment<sup>[1]</sup>. Immediate function or immediate loading is defined as the placement of a dental implant fixture, abutment and functional (provisional) restoration all at stage one surgery. The abutment and restoration is placed into "limited" function within the first 48 hours and allowed to osseointegrate during the ensuing months<sup>[2]</sup>. Immediately after the placement of the implants, a bone remodeling begins on the bone/implant interface, accelerated by the loads which induce the bone cells stimulation<sup>[3]</sup>. In addition, the patient's diet has a major importance during the bone apposition and remodeling after the immediate loading procedures. Consequently, small portions of soft diet should be indicated during the initial period (3 to 4 months) of the healing process and bone deposition<sup>[4,5]</sup>. The benefits of "Immediate Function" are shortened treatment time, better clinical efficiency and less trauma to the patient - it is now possible to go from suffering from tooth loss to having functional and aesthetic teeth in one treatment session. There are advantages and disadvantage with the use of the immediate loading concept as outlined below:

**Advantages** - Decreases treatment time; Improves patient comfort; No transitional prosthesis i.e. denture, bonded bridges; Limits unwanted exposures and maintains gingival contours; Minimizes number of surgeries; Less trauma to soft and hard tissues; Cost savings to patient and doctor; Improves acceptance rates for treatment; and Psychological benefit to the patient.

**Disadvantages** - Clinically demanding; Generally cannot be undertaken when guided bone regeneration is required; Provisional crown - single tooth, Partially edentulous bridge should be out of occlusion in centric and free in lateral movements; Requires good bony support and implant stability; Strict patient compliance required.

The patient does not need to wear a removable restoration during initial bone healing, which greatly increases comfort, function, speech, and stability and enhances certain psychologic factors during the transition period<sup>[5]</sup>. Immediate implant loading prevents any change in shape of bone and gum surrounding the extracted tooth. It is convenient for the patient as it allows the surgical treatment as shown in Fig.1 (a),(b),(c),(d),(e),(f),(g) to be completed in one insertion.



(a) Incisor is Atraumatically  
Position  
Extracted in Maxillary Bone.

(b)The Implant Drills Prepare the Site  
and then Rotated Under Incisal Edge.

(c) A Implant is Threaded into

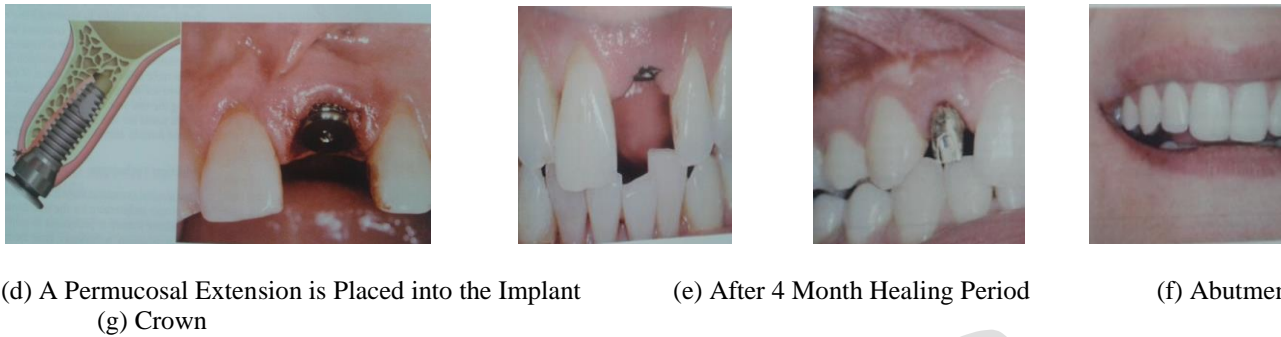


Fig.1: Surgical Process of Immediate Implant

The risk in the immediate implant loading is reduced by bone microstrain, loaded bone changes its shape. Microstrain conditions 100 times less than the ultimate strength of bone may trigger a cellular response. Frost<sup>[6]</sup> has developed a microstrain language for bone based on its biological response at different microstrain levels as shown in Fig.2. Bone fractures at 10,000 to 20,000 microstrain units ie 1% to 2% strain. However, at levels of 20% to 40% of this value, bone already starts to disappear or form fibrous tissue and is called the pathologic overload zone.

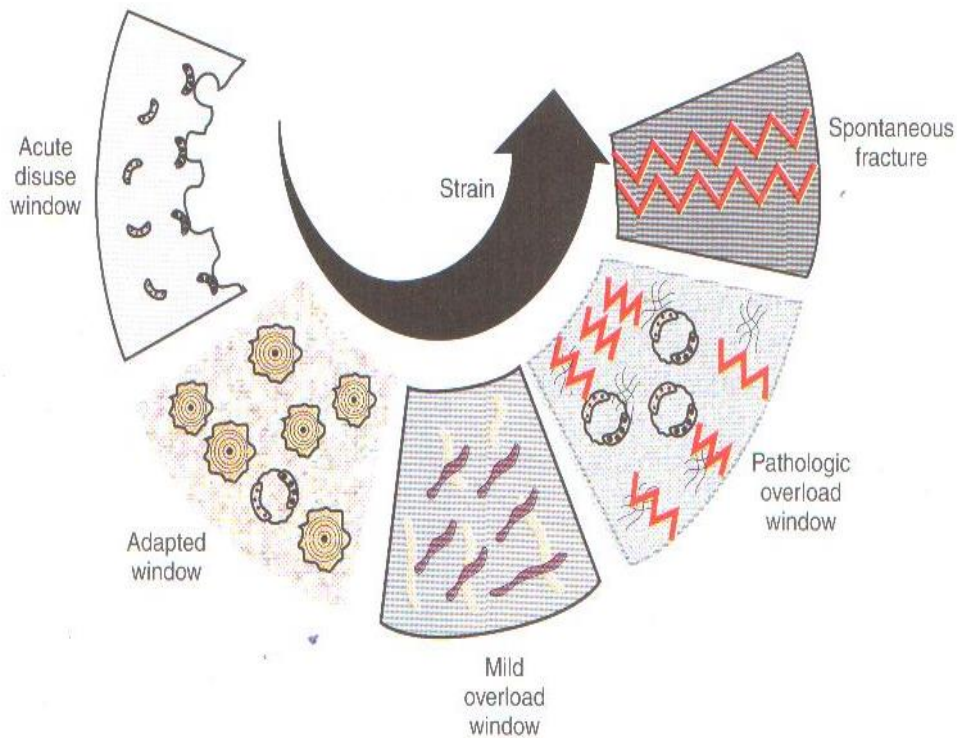


Fig.2 : Biological Response at Different Microstrain Levels<sup>[6]</sup>

The ideal microstrain for bone is called the physiologic or adapted zone. The remodeling rate of the bone in the jaws of a human being that is in the physiologic zone is about 40% each year<sup>[7]</sup>. At these levels of strain, the bone is allowed to remodel and remain an organized, mineralized lamellar bone. This is called the ideal load bearing zone for an implant interface. The mild overload zone corresponds to an intermediate level of microstrain between the ideal load bearing zone and pathologic overload. In this strain region, bone begins a healing process to repair microfractures, which are often caused by fatigue. Rather than the surgical trauma causing this accelerated bone repair, the microstrain causes the trauma from overload. In either condition, the bone is less mineralized, less organized, weaker, and has a lower modulus of elasticity. Bone is strongest to compression and weakest to shear loading<sup>[8]</sup>. Compressive forces decreases the microstrain to bone compared with shear forces.

In Fig.3 the stress strain relation for natural bone and titanium is explained under increasing load situations. The relationship results in two mechanical indexes that is flexibility or modulus of elasticity of both the material. Therefore the modulus conveys the amount of deformation in a material for a given load level. The lower the stress applied to the bone the lower the microstrain in the bone is also shown in fig.3. The microstrain difference between the two zone at the interface 0 to 50 units is disuse loading zone. When the microstrain difference is 50 to 2500 units, the ideal loading zone is present. Between 2500 to 4000 units, the zone is in mild overload. At more than 4000 units, the zone is in pathologic overload. Therefore to decrease microstrain and the remodeling rate in the bone is to provide conditions that increase functional surface area to the implant-bone interface<sup>[9]</sup>. The surface area of load may be

increased by implant number, implant size, number of threads, implant surface conditions, occlusal force direction, mechanical properties of bone.

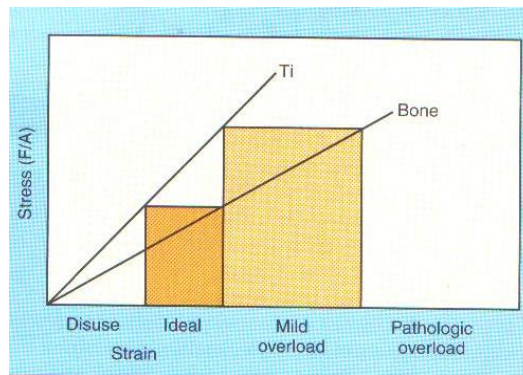


Fig.3: Stress and Strain Curve<sup>[6]</sup>

The dentist may increase the functional surface area of occlusal load at an implant interface by increasing number of implant<sup>[10]</sup>. The implant body design should be more specific for immediate loading because the bone has not had time to grow into recesses or undercuts in the design or attach to a surface condition before the application of occlusal load. Each 3mm increase in length can improve surface area support by more than 20%<sup>[11]</sup>. Most of the stresses to an implant-bone interface are concentrated at the crestal bone, so the increased implant length does little to decrease the stress that occurs at the transosteal region around the implant<sup>[12]</sup>.

The number of threads also affects the amount of area available to resist the forces during immediate loading. The smaller the distance between the threads, the greater the thread number and corresponding surface area<sup>[13]</sup>. The thread design would be more beneficial to an immediate load application.

Implant surface conditions may affect the rate of bone contact, lamellar bone formation, and the percentage of bone contact. The coating or surface condition of the implant is most beneficial during the initial healing and early loading conditions.

The greater the occlusal force applied to the prosthesis, the greater the stress at the implant-bone interface and the greater the strain to the bone. Parafunctional forces such as bruxism and clenching represent significant force factors because magnitude of the force is increased, the duration of the force is increased, and the direction of the force to the implant with a greater shear component<sup>[14]</sup>. Balshi and Wolfinger<sup>[14]</sup> reported that 75% of all failure in immediate occlusal loading occurred in patients with bruxism. Moreover, parafunctional loads may increase the looseness or fracture risk of the abutments and of the temporary restorations<sup>[15]</sup>.

The modulus of elasticity is related to bone quality as shown in Fig.4. The less dense the bone, the lower the modulus. The strength and elastic modulus of bone is directly related to the density of the bone<sup>[16]</sup>.

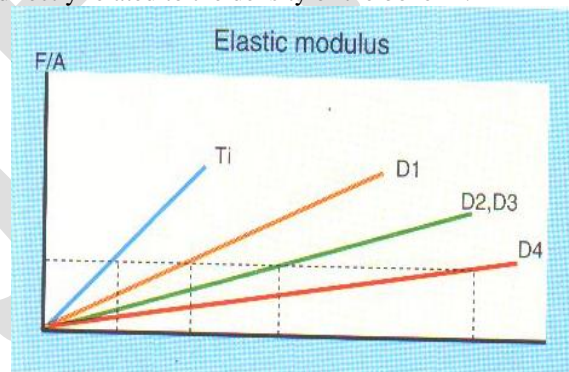


Fig.4: Bone Quality with Modulus of Elasticity<sup>[16]</sup>

The finite element study on immediately loaded implants showed that increased implant diameter better dissipated the simulated masticatory force and decreased the stress and strain around the implant neck, especially when the diameter increased from 3.3 to 4.1 mm. It appears that dental implants of 10 mm in length for immediate loading should be at least 4.1 mm in diameter, and uniaxial loading to dental implants should be avoided or minimized. Further research concerning human bone response to stress and strain is needed<sup>[17]</sup>.

Stress distribution along the implant should be even and minimal to avoid possible complications<sup>[18]</sup>. The increase in stress to an implant body also increases the risk of abutment screw loosening or implant body fracture. The relationship between stress and strain determines the modulus of elasticity(stiffness) of a material<sup>[19]</sup>. The modulus of elasticity of a tooth is similar to the cortical

bone. Dental implants are fabricated from titanium or its alloy. The modulus of elasticity of titanium is five to ten times greater than that of cortical bone as shown in Fig.5.

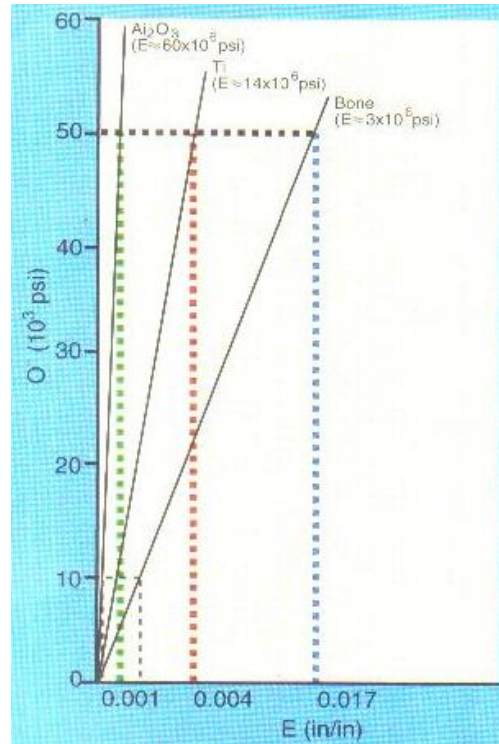


Fig.5: Comparison of Modulus of Elasticity for Bone and Titanium<sup>[20]</sup>

The composite beam analysis states that when two materials of different elastic modulus are placed together with no intervening material and one is loaded, a stress contour increase will be observed where the two materials first come into contact<sup>[20]</sup>. In denser bone, there is less strain under a given load compared with softer bone. As a result, there is a less bone remodeling in denser bone compared with softer bone under similar load conditions<sup>[21,22]</sup>. Bone is relatively brittle material, which if strained past its elastic limit, will break. If masticatory forces on implants can produce stresses at the bone-implant interface greater than the elastic limit of bone, then fractures may occur. Bone implant contact has a major role in stress concentration in immediate loading implants<sup>[23]</sup>.

According to Misch et al.<sup>[24]</sup>, the reduction of the surgical trauma in immediate loading procedures can be obtained by reducing the generation of heat during the surgical steps and reducing the stress on the bone/implant.

## CONCLUSION

Although several studies have demonstrated high success rates for the immediate loading dental implants, several aspects remain without an explicit definition and further studies are needed to elucidate some reservations related to detail study in stress and strain. According to the information described in the literature, a precise and safe indication of immediate loading procedures can be required to reduce complications, thus reducing its potential of failure face to the different variables as per need.

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