Different Implant Surface Modifications on ESI dental implant system

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Introduction

Dental implants are increasingly popular and represent a reliable treatment option in oral rehabilitation of partially or fully edentulous patients [1]. Dental implants have become a standard procedure for single tooth replacement although it is still challenging in sophisticated patients. Osseointegration of dental implants is the main factor for the success of dental implants. Many implant designs have been developed to improve the interface between implants surfaces and bone. However, internal bone to implant interaction stress had not been not emphasized. Osseointegration on the implant surface is important to the survival rate of dental implants. Implant surfaces are modified topographically and chemically. Surface characteristics contribute to the biological process during osseointegration and influence long-term survival rates of dental implants. Osseointegration might be impaired in patients with heavy smoking, diabetes mellitus, osteoporosis, and co-medication with bisphosphates or after radiotherapy. Such patients are a challenge for long-term dental implant survival and success. The bioactive surface modifications can accelerate osseointegration in these patients after implant insertion. Furthermore, modifications of implant surfaces to bioactive surfaces accelerate osseointegration for convenient, early loading protocols.

The Essential Spectrum Implant (ESI) system is designed and developed by surgeons, dentists, and engineers, with an orientation toward reduction of bone-implant internal stress especially at the crestal and middle portion of the implant. The ESI implant was also developed to permit the dynamic penetration of the implant without deviation or resistance while navigating the osteotomy of all bone types. Studies show that the majority of bone resorption takes place in the crestal area where the core (middle) bone portion is the last area to be affected. The ESI implant was designed to minimize stress on the crestal or middle portion of the implant, resulting in maximum retention of crestal bone. We elected to use immediate loading to examine bone resorption in the crestal bone area as well as the stability and surgical friendliness of the implant.

Cellular biomechanics, Engineering principle, Bone mechanical properties

"Marginal bone loss on an implant may be due to occlusal trauma which is defined as an injury to the attachment apparatus because of excessive occlusion forces" [2a]. Some studies indicate that peri-implant bone loss without implant failure is primarily associated with infection or complications [2c,2d,2e]. Other studies suggest that crestal bone loss is correlated with excessive occlusal force. Several authors conclude that trauma from occlusion is a related factor in bone loss although bacteria is a necessary agent [2a,2f,2g,2h]. To establish further correlation between marginal bone loss and occlusal overload, it is important to use engineering principles and cellular biomechanics to study implant/bone mechanical properties and how implant design influences these properties.

CELLULAR BIOMECHANICS

Bone remodeling at the cellular level is influenced by mechanical stress. Strain is defined by the change in length divided by the oriented length, and units of strain are expressed as a percentage. The amount of strain is directly related to the amount of stress applied. Occlusal stress applied to implant prostheses and components can transmit stress to the bone-implant interface. One of the earliest to model the direct relationship between stress and remodeling was Kummer in 1972. He observed that bone fractures at 10000 to 20000 micro stain units (1% to 2% deformation). But, at levels 20 % to 40% value or 4000 units, bone cells may trigger cytokines to begin a resorption response. "Therefore, excessive bone strain may result in physical fracture as well as bone cellular resorption." [2].

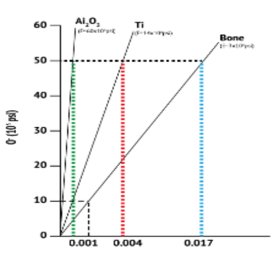
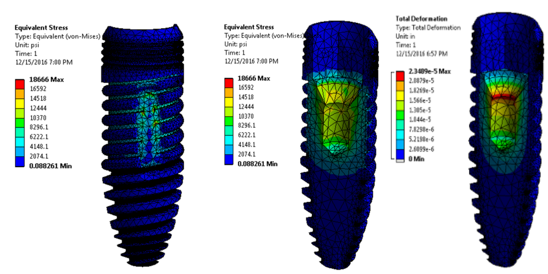


Figure: **Misch, Carl E. Contemporary Implant Dentistry. St. Louis: Mosby, 2007. 78. Print.**

Engineering principles

Based on engineering principles, the relationship between stresses determines the modulus of elasticity or stiffness of a material. The modulus conveys the amount of dimensional change in a material for a given stress level. The modulus of elasticity of a tooth is like cortical bone. The modulus of elasticity of titanium is five to ten times greater than cortical bone. The stress contour will increase when two types of elastic moduli are placed together [2]. "In an implant-bone interface these stress contours are of greater magnitude at crestal bone region. This phenomenon was observed in both photoelastic and three-dimensional finite element analysis, stress contours are of greater magnitude at the crestal bone region" [2].



Figures: Stress Analysis

Misch, Carl E. Contemporary Implant Dentistry. St. Louis: Mosby, 2007. 78. Print.

Bone mechanical properties

"Bone density is directly related to the strength and the elastic modulus of the bone,"[2]. Denser bone seems to have less strain under a given load compared with softer bone, [2]. Due to denser bone having lesser strain, there is less bone remodeling in denser bone. Less bone remodeling can result in a decrease in bone loss [2]. Referring to the graph of quality of bone via peri-implant bone loss below, the initial peri-implant bone loss ranged from 0.68 mm for quality 1 to 1.1 mm for quality 2, 1.24 mm for quality 3 and 1.44 mm for quality 4-type bone [2].

Therefore, the denser the bone, the less peri-implant bone loss was observed after prosthesis delivery [2]. "Increase in bone density is related to bone strength, elastic modulus, bone remodeling and a decrease in marginal bone loss, these entities may be related to each other" [2].

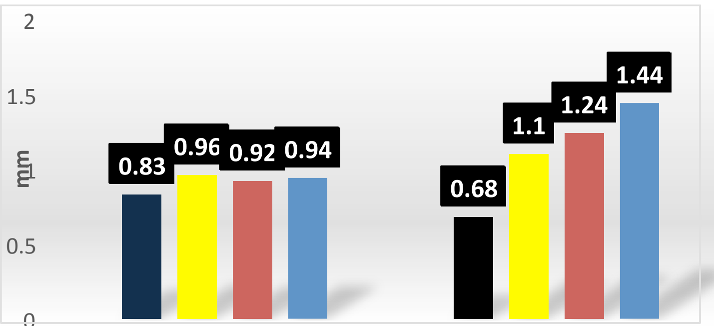
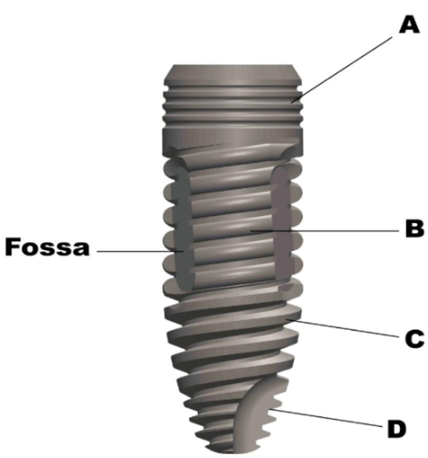
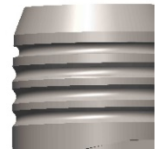


Figure: Misch, Carl E. Contemporary Implant Dentistry. St. Louis: Mosby, 2007. 78. Print.

Four zones of the threads

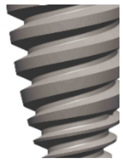


ESi Implant



Zone A: Micro rings assisting in Osseointegration and crestal bone stability. The most critical aspect in any implant system is the interface between implant fixture and its peripheral bone area, primarily at the crestal 2-3mm. To avoid bone resorption and the stimulation of osteoclast in the large diameters, ESI implants will have 4.3 mm or larger diameter at convergent angle to ensure a less stressful environment and the regeneration of osteoblast in the first few months after the placement of the implants.

Zone B: Note: Refer to picture to the left. Wider thread and a semi-round shape with fossa which reduces tight contact between implant and bone. The fossa is geared to store bone which accumulates through the thread at zone A and B as well as lessening the stress environment at the Implant-bone contact(IBC), permitting more blood flow, capillary establishment, and thus, enhances osseointegration.



Zone C: Note: Refer to pictures above and to the left. Trapezius type of thread which assists in the stability of the implant, compressing bone laterally, as well as channeling bone particles to the fossa at the middle third, creating bone condensation, and being conservative in bone removal by the drill.

Zone D: The epical portion of the implant has a thread of a knife edge which assists in further penetration and fine tuning to the needed area. It can also help with the redirection of the implant, by withdrawing out a portion of the implant and repositioning it into its needed area. (Note: This will tighten implant to bone leading to outstanding stability)

RBM Surface Treatment

The role of a roughened surface aiding in implant fixation has been well established. Recent concern regarding embedded media from glass beading and grit blasting operations has prompted interest in developing a method to avoid this contamination. Osseointegration failure is a primary concern, and has been shown to be related to the particulate debris. Bio-Coat has succeeded in developing RBM, a process that provides a roughened surface to aid in osseointegration without the presence of unwanted debris embedded in the implant surface.

Objectives

For the reduction of internal stress at the bone-implant interface, root-form endosseous implants have long been presented as the ideal option for permanent tooth replacement with a success from 96-98%. The aim for this research is to review cases of a few patients' ESI multi thread system implant and their effect on osseointegration at immediate loading of posterior and anterior teeth as well as to facilitate early osseointegration and to ensure long-term implant bone contact without substantial marginal bone loss.

Methods and Materials

Cases from three patients from the Department of Prosthodontics with the complaint of fractured or missing teeth were enrolled in the study. All patients must have good oral hygiene. Moreover, patients should be free from diseases such as diabetes mellitus or osteoporosis. Before surgery, patients were prescribed amoxicillin three days prior. Follow up radiographs (x-rays) after implant placement and after six months or more were analyzed for crestal bone loss, both transverse and vertical.

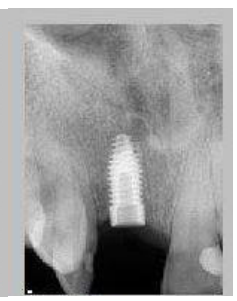
Results

The results of this analysis show that the immediate loading in these three cases doesn't reflect any bone loss at the crestal bone after the loading at the permanent restoration as shown in the following figures. It is determined that the dental fossa in conjunction with the micro rings permit the filtering of sine wave and occlusal forces as well as the establishment of capillaries at the fossa immediately after the placement of the implant. As a result, osseointegration is an immediate response.

Case one

[Tooth number: 8 Age: 64 Sex: Male]

This case report mentions the extraction of a fractured right maxillary central incisor with failed endodontic treatment, followed by immediate placement of an ESI implant (5.0 by 13 internal hex) in a well-prepared socket. This ESI implant surface was treated with SLA surface modification system. Surgical procedure: after careful extraction of root tip with the help of osteotomy, as well as curate of sharpie fibers and the removal of granulation tissue at the epical portion of the root which uncovers a new layer of bone at the socket (ensuring the socket is free of connective tissue as well as the presence of intact buccal bone is critical). Demineralized allograph was placed in the socket, followed by insertion of the implant. Placement of the ESI implant took about 30 newton force (nF), and due to zones A and B was strongly stable. Sutures were placed at the mesial and distal papilla, then followed by placement of a modified PEEK abutment and temporization. Patient followed up in 6 months, one year and two years to evaluate crestal bone resorption which showed non-significant bone loss.



(After extraction) (Placement of the implant)

(Placement of the implant with temporary PEEK abutment)

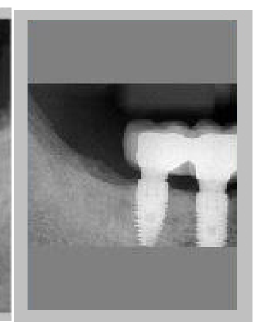
Temporary Crown Permanent Crown

Case two

(**Tooth Number: 30,31 Age:62 Sex: Male**)

This case report showed missing teeth (number 30 and 31) mandibular right first and second molars followed by immediate implant loading of ESI (5.0 by 13 internal hex). Distal incision of tooth number 29 was done. Reflect gingiva buccally and lingually and implant insertion took place. During surgery, a strong stability was noticed due to zone A and B. Note that zone C and D had light contact with bone particles stored in the fossa to permit rapid osseointegration (picture). Sutures were done after the placement of PEEK abutment. Provisional temporary acrylic crowns were placed. 3 months later, patient returned for crown placement. The patient was monitored and at 6 months' recall and radiographic exam, the patient showed no significant bone loss. Implant- bone interface showed excellent result for osseointegration.

(After extraction) (After implant placement)



(After temporary abutment PEEK placement) (After permanent crown placement)

Incision Implant Placement

PEEK Abutment Temporary crown

Case three

(Teeth number: 8,9 Age: 64 Sex: female)

This case report describes immediate tooth extractions, followed by placement of ESI (4.3 by 13 internal hex) implants and provisional restoration of maxillary central incisors. Patient needed implants due to facial trauma with vertical fracture of teeth 8 and 9. The teeth were extracted with a minimally invasive technique resulting in preservation of the surrounding soft and hard tissues. Following extraction, removal of sharpie fibers and connective tissue as well as the refreshment of the bone socket was done. Demineralized allograph (DFDB) was placed in the sockets followed by the placement of ESI implant (4.3 by 13 internal hex). Stabilization was achieved with an insertion torque of30 Ncm. The implants were stable due to zones A and B. Suturing at the distal part of the papilla was done, then a PEEK abutment was placed followed by splinted acrylic temporary crowns. At 6 months after implant placement, radiographic evaluation showed osseointegration at implant-bone interface and no changes in crestal bone level.

(After Extraction)

(Placement of the implant)

(Before Extraction)

(After Extraction)

(After implant placement)

(Placement of the implant with temporary abutment)

(After placement of temporary crown)

(After permanent crown placement)

CONCLUSION

The design of the crestal and middle thread allows the reduction of internal stress at the bone-implant contact (BIC). Following from the three patient cases, it has been shown that there is little to no bone resorption at the crestal area. This study proves the primary goal of the ESI implant toward predictable long term bone preservation and internal stress outcome.

Bone particles channeled to implant fossa and groove

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