Immediate Loading of Essential Spectrum Implant (ESi)

Clinical Case Study

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Abstract **–** In the world of modern dentistry much emphasis has been laid on bone regrowth on the dental implants after immediate and non-immediate loading. This research shows the case study of immediate loading for an ESi implant (SpiralTech, Inc.). Various clinical trials and studies on different patients show initiation of osseointegration and that there is minimal bone loss and that the implant can be used for immediate loading.

1. INTRODUCTION

Dental implants are becoming 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 the esthetic zone or in the posterior area. Osseointegration of dental implants is the main factor for the success. Many implant designs have been developed to improve the interface between implant surfaces and the bone. However, the stresses between internal bone and the implant has not been adequately emphasized. Implant body and thread shape 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 cases are a challenge for long-term dental implant survival and success.

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 to have maximum bone retention at the crestal area. 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 most of the bone resorption takes place in the crestal area where the core (middle) bone portion is the last area to be affected. In this study, immediate loading is inspected by examining bone resorption in the crestal bone area of the implant. The stability and ease of use of the implant is also evaluated.

2. CELLULAR BIOMECHANICS AND ENGINEERING PRINCIPLES

Occlusal trauma in an implant may lead to the marginal bone loss. It is defined as an injury, which may occur due to the excessive occlusion, protrusion or lateral forces [2a]. Some studies indicate that peri-implant bone loss without implant load 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.

2.1 CELLULAR BIOMECHANICS

Bone remodeling at the cellular level is influenced by mechanical strain. The amount of bone strain at the bone-implant interface is directly related to the amount of stress applied through the implant prosthetic. 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 were Kummer et al. in 1972. The study conducted proved that the bone fractures at 10000 to 20000 micro stain units (with a deformation of 1 to 2%). However, at the deformation levels of about 20-40% or 4000 units, bone cells may trigger cytokines to begin a resorption response. Hence, larger amounts of bone strains may result in bone cellular resorption or even a physical fracture [2].

2.2 ENGINEERING IDEOLOGIES

Based on engineering principles, the relationship between stresses determines the modulus of elasticity or stiffness of 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 that of cortical bone as shown in Fig.1. The elasticity is greater for titanium (Ti) compared to bone. When stress is at the Y-axis and strain on the X-axis the modules of elasticity can be obtained. The modulus of elasticity of titanium is five to ten times greater than that of a 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 photo elastic and three-dimensional finite element analysis, as well as clinical evaluation.

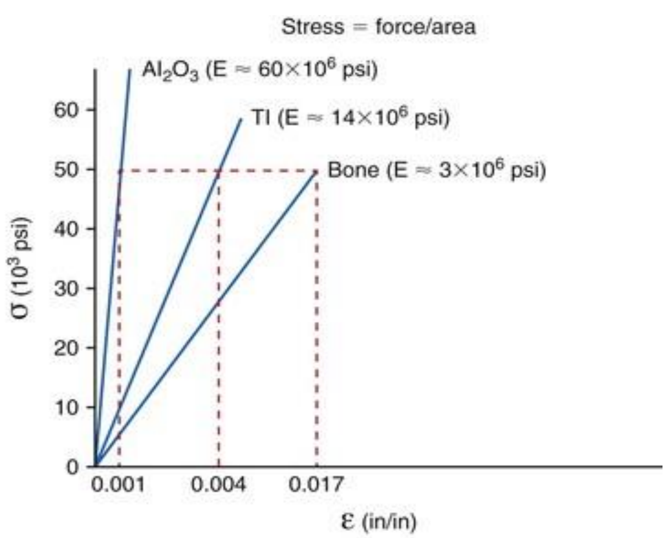
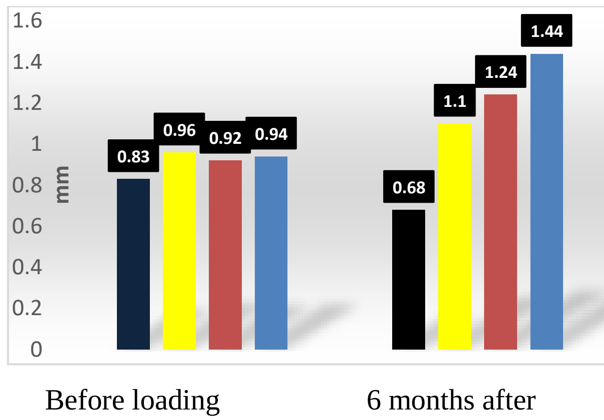


Figure 1. Modulus of elasticity for titanium [2]

2.3 BONE MECHANICAL PROPERTIES

The bone density is an important factor to determine the elastic modulus of the bone and define the strength of the bone. Denser bone h less strain under a given load compared with softer bone. Since denser bone has less strain, there is lesser bone remodeling, which in turn results in decreasing bone loss. The high correlation between bone type to crestal bone loss and its correlation to loading stress is shown in Fig. 2, which leads to crestal strain and its atrophy. 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 lesser peri-implant bone loss was observed after prosthesis delivery. 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].



Blue - type 1, red - type 2, yellow - type 3, black - type 4.

Figure 2. Relation between type of bone to crestal bone loss.

3. DESIGN OF IMPLANT

ESi implant was designed to filter and reduce stress load which has been converted to strain and bone loss at crestal area.

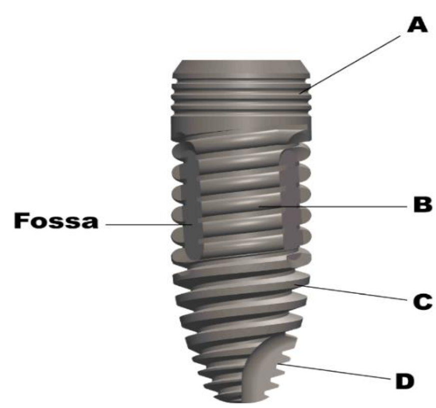


Figure 3. Different zones of ESi implant

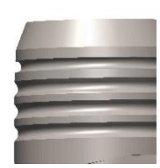


Figure 3.1 Zone A – Micro Rings

Micro rings or threads at the top of the implant are the most critical aspect in any implant system for the interface between implant fixture and its peripheral crestal bone area. To avoid activity of bone resorption and the stimulation of osteoclast, the micro rings must have a certain minimum depth. After extraction or osteotomy preparation for placement of the implant a healing phase will be initiated which creates bleeding and osteogenic momentum of bone generation and migrations towards the center of the osteotomy, which is the healing phase followed by osseointegration. During this step, a bone will migrate towards the micro rings/threads walls of the implant, which is not recognized as a foregone object. Several months later, when implant loading occurs, there is a slowdown in the osteogenic migration. Four to six weeks after implant placement is a critical phase of slowing down the healing osteogenic migration and bone-resting phase transform to mechanical retention. A proper design of minimum depth and shape for microgroove/thread will avoid or prevent a tendency towards atrophy towards the core of the bone. A convergent angle is used to ensure a less stressful environment and the regeneration of osteoblast in the first few months after the placement of the implants.

Figure 3.2 Zone B – Semi rounded threads

Wider and semi-rounded threads with fossa in zone B creates zero to light contact between implant and bone. The fossa is geared to store bone particles, which accumulates from the thread of zones D and C. The fossa will lessen the stress environment at the implant-bone contact (IBC), permitting more blood flow, capillary establishment, and creating a shorter and more successful osseointegration phase.

Figure 3.3 Zone C – Trapezius threads

A trapezius thread in zone C assists in the stability of the implant, as well as paving the penetration at time of insertion. These threads help by compressing bone laterally, channeling bone particles towards the fossa at the middle third, creating bone condensation, and lessening bone removal by the drill. (Note that type 2,3,4; bone osteotomy can be 1.5 mm less than the diameter of the implant)

Figure 3.4 Zone D – Self-tapping shard threads

The apical portion of the implant has sharp threads, which assists in further penetration and is the reason for the self-tapping ability of the implant. It can also help with the redirection of the implant by withdrawing out a portion of the implant and repositioning it into its desired area.

3.1 FIVE POINTS OF STABILITY

There are five points of stability for the implant (see Fig. 5), which are also the crucial stress concentration points at the bone implant contact (BIC). The remainder of the implant area is considered to be of lesser to none stressed area. At the BIC, there are four points at the middle (upper end of trapezius threads) and crestal third of the implant as shown in Fig. 5. The drill bit will make an opening (about 0.75mm to 1mm) less than the length of the implant itself. At its final position, the epical implant portion penetrates the bone due to the self-tapping ability of the zone D threads. As a result, a fifth point of BIC will tighten the implant into its final position leading to a much greater stability.

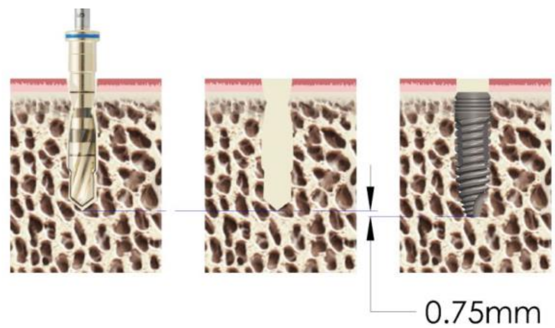


Figure 4. Drill and insertion depth variance 0.75 to 1 mm shorter than the implant height

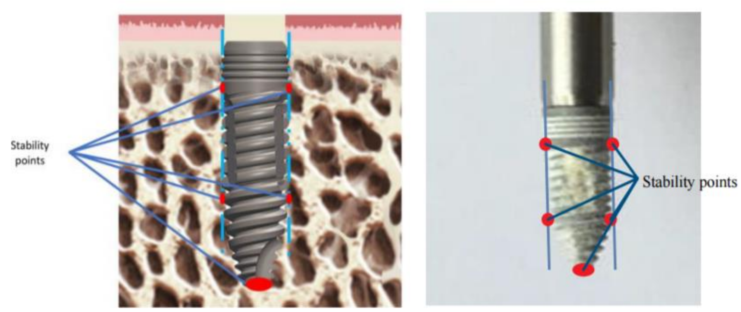


Figure 5. Five critical points of stability for ESi implant

4. CLINICAL CASE STUDIES

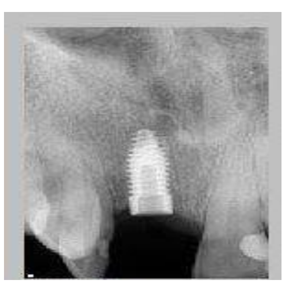
For the reduction of internal stress at the bone-implant interface, root-form endosseous implants have long been presented as the ideal option for permanent tooth replacement, with a success rate average of 98.6%. Clinical studies from a few patients were hence collected for this study. The aim for this research is to review multi thread system in ESi implant and their effect on osseointegration at immediate loading of posterior and anterior teeth. Studies were also conducted to evaluate early osseointegration, and to ensure long-term implant bone contact without substantial marginal bone loss.

Cases from three patients who complained of fractured or missing teeth were enrolled in the study. All patients had a good oral hygiene. Moreover, patients where free from diseases such as diabetes mellitus or osteoporosis. Three days prior to surgery, patients were prescribed amoxicillin. Follow up x-rays after implant placement and after six months or more were analyzed for crestal bone loss, both transverse and vertical.

4.1 CASE ONE

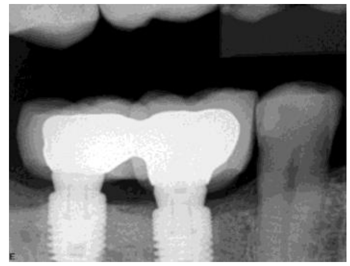
This case report mentions the extraction of a fractured right maxillary central incisor with failed endodontic treatment, followed by immediate placement of an ESi implant (5.0 by 13 mm internal hex) in a well-prepared socket. This ESi implant was treated with SLA surface treatment. For the surgical 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 apical portion of the root which uncovers a new layer of bone at the socket. For this period, 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 required a torque of 30 Ncm. The zones A and B made the implant strongly stable inside the bone. Sutures were placed at the mesial and distal papilla, and then followed by placement of a modified PEEK abutment followed by splinted acrylic temporary crowns. Patient followed up in the intervals of 6 months, one year, two years and four years to evaluate crestal bone resorption, which showed insignificant bone loss.

After extraction



Placement of the implant

Placement of implant with temporary abutment, 4/10/13



The implant showing minimal to no bone loss as of August 15, 2017

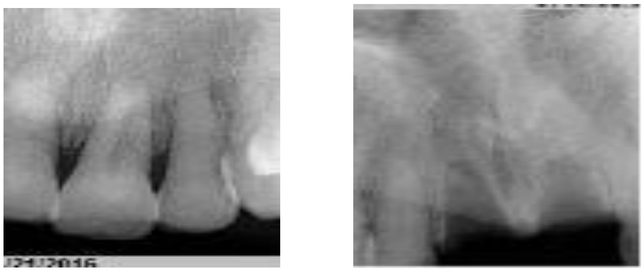
Figure 6. Tooth Number 8, Age: 64, Sex: Male

4.2 CASE TWO

This case report describes immediate tooth extractions, followed by placement of ESi implant (4.3mm diameter, 13mm length – internal hex) 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 the implant. Stabilization was achieved with an insertion torque of 30 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. Note that there is 1.5 mm bone resorption at the crestal height of tooth 8. This is due to strain of the crown up on the implant at the time of placement especially in the distal wall. It was mentioned earlier no detailing stress should be applied on the abutment to avoid strain and bone loss at the crestal height.

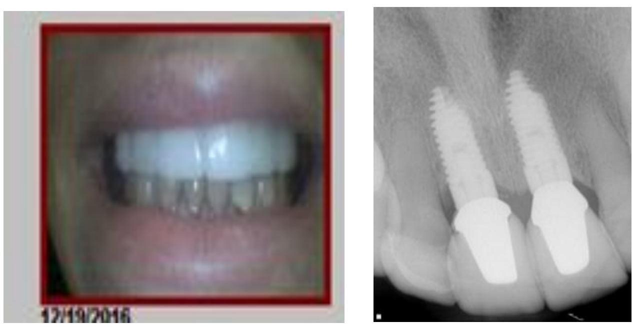
After extraction

Placement of the implant



Before Extraction After Extraction

Placement of temporary abutment Placement of permanent abutment



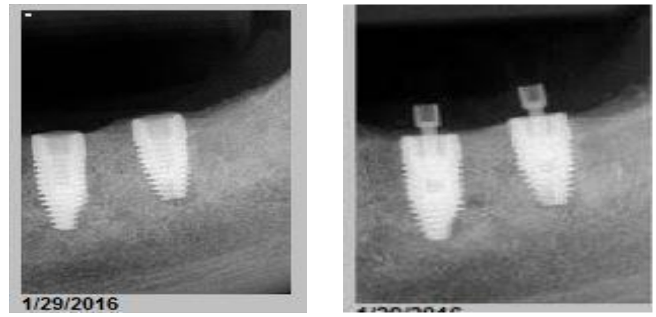
After permanent crown placement

08/22/2017

Figure 7. Teeth number: 8 & 9 Age: 64 Sex: female

4.3 CASE THREE

This case report showed missing teeth (30 and 31) mandibular right first and second molars followed by immediate implant loading of ESi (5.0mm by 13mm – internal hex). Distal incision of tooth number 29 was done. Reflecting gingiva buccally and lingual, 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. Three months later, the patient was monitored when returned for crown placement, and after 6 months during recall and radiographic exam the patient showed insignificant bone loss. Implant-bone interface showed excellent result for osseointegration.



After implant placement Temporary peek abutment placement

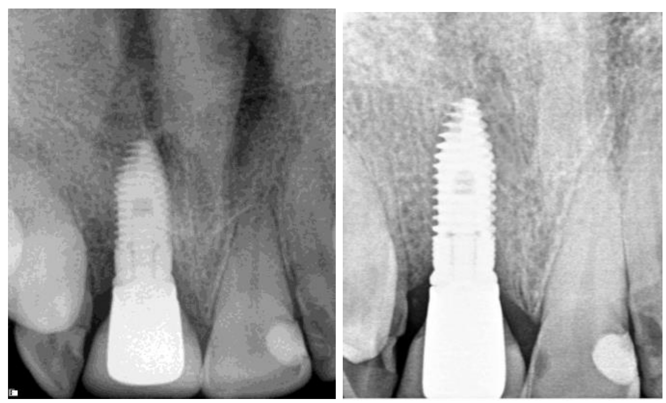
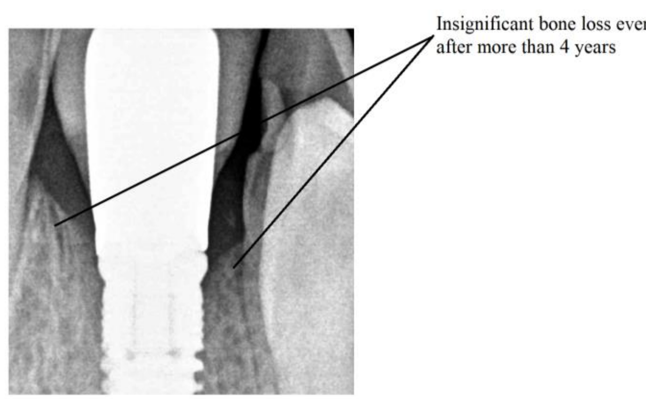


Figure: As of December 4, 2013. As of September 19, 2017



As of September 19, 2017

Figure 8. Tooth Number: 30,31 Age: 62 Sex: Male

5. FINDINGS AND RESULTS

The results of this analysis show that the immediate loading in these three cases reflect minimal bone loss. For case 2 (shown in Fig. 8) final crown was placed with ideal crestal bone height as mentioned above. The bone loss at two years after placement of the permanent crown in tooth 8 was due to distal wall contact pressure at time of cementing the final crown, creating a strained environment after loading at the permanent restoration. It is determined that the dental fossa in conjunction with the micro rings permits 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 a result.

6. CONCLUSION

The design of the crestal micro rings/threads with a certain minimum depth, platform switching design along with the semi rounded rings in the middle – the dental fossa in the implant 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 towards predictable long-term bone preservation and internal stress outcome.

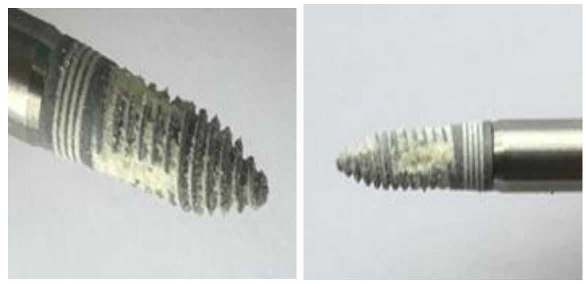


Figure 9. Osseointegration on different zones of ESi

REFERENCES

1. Smeets, Ralf, Bernd Stadlinger, Frank Schwarz, Benedicta Beck-Broichsitter, Ole Jung, Clarissa Precht, Frank Kloss, Alexander Gröbe, Max Heiland, and Tobias Ebker. "Impact of Dental Implant Surface Modifications on Osseo integration." Biomed Research International. Hindawi Publishing Corporation, 2016. Web. 07 Dec. 2016.

2. Misch, Carl E. Contemporary Implant Dentistry. St. Louis: Mosby, 2007. 77-79. Print.

a. CE, Suzuki JB, Misch-Dietsh FD et al: A positive correlation between occlusal trauma and peril-implant bone loss: Literature support, Implant Dent 14: 108-114, 2005.

b. Glossary of Prosthodontics Terms, end 7,1 Prosthetic Dent 81:1-141, 1999.

c. Lang NP, Wilson TG, Colbert EF: Biological complications with dental implants: their prevention, diagnosis and treatment. Clan Oral Implants Res 11 (supple): 146-15,2000.

d. Tonetti MS, Schmid J : Pathogenesis of implant failures, Periodontology 2000 4: 127-138, 1994.

e. Heitz-Mayfield LJ, Schmid B, Weigel C et al: Does excessive occlusal load affect Osseo integration? An experimental study in the dog, Cin Oral Impl Res 15.259-268, 2004.

f. Misch CE: Early crestal bone loss etiology and its effect on treatment planning for implants, Dental Learning Systems Co, Inc, Postgrad Dent 2:3-17, 1995.

g. Rosenberg ES, Torosian JP, Slots J: Microbial differences in 2 clinically distint types of failures of Osseo integrated implants, Class Oral Implants Res 2:135-144.1991.

h. Karolyi M: Beobachtungen uber Pyorrhea alveolaris, Ostterenorichisch-Ungarische viertel jahresschrift fur Zahnherilkunde 17:279, 1991.