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11 A New Implant Architecture Designed for Extraction/Immediate Placement Protocols: The Fusion OS® Implant
Robert J. Miller, Ron Zokol, Dan Holzclaw, Jack Krauser, Antonio Sanz

Nabil E. Beaini, Michael R. Umaki
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A New Implant Architecture Designed for Extraction/Immediate Placement Protocols: The Fusion OS® Implant

Robert J. Miller, DDS, FACD1 • Ron Zokol, DMD, FACD2 • Dan Holtzclaw, DDS, MS3 • Jack Krauser, DMD4 • Antonio Sanz, DDS5

Abstract

Background: An increasing number of dental implants are being placed at the time of tooth extraction. Initial stability, primary stability, secondary stability, insertion torque, bone-to-implant contact, ISQ, and cumulative implant survival are measurements that have been developed in healed site protocols utilizing traditional implant designs. Unlike healed sites, extraction site defects often result in less than optimal bone-to-implant contact. This can result in lowered initial stability which may often have undesirable consequences when an implant is provisionalized or immediately loaded. An implant architecture has been designed to maximize initial stability in these compromised sites utilizing an advanced thread profile.

Methods: In a multi-center clinical trial, 99 patients were treated using this new design and clinical outcomes were then compared in both extraction and healed sites with the majority of these cases being single tooth placement.

Results: In the extraction/immediate placement group, 60 patients were treated with 86 implants. In this group, 3 implants failed to integrate (1 residual apical infection, 1 failure to obtain adequate initial stability, 1 fractured provisional) resulting in a 96.6% success rate. In the healed site placement group, 39 patients were treated with 58 implants for a 100% success rate. The total cumulative success rate was 98%.

Conclusion: When comparing extraction site defects and healed sites, this new implant design was highly successful regardless of the condition of the osteotomy and can be recommended for extraction site defects.

KEY WORDS: Dental implants, immediate placement, survival rate

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INTRODUCTION

For the greater part of the fifty year history of oral implantology, strategies have been built on the paradigm of placing endosseous implants in healed sites. Initial stability, primary stability, secondary stability, insertion torque, bone-to-implant contact, ISQ, and cumulative implant survival are measurements that have been developed in healed site protocols. However, with decreasing numbers of completely edentulous patients being treated, there is an increasing need to place implants at the time of tooth extraction.

Early surgical strategies required implants to be placed in healed osteotomies with prolonged unloaded healing times. These protocols were great equalizers with respect to widely divergent implant designs. Over the past decade, however, our discipline has seen a dramatic change with either earlier loading times or immediate loading. Unlike the healed site with a relatively balanced bone density and soft tissue coverage, extraction sites present additional challenges including implant positioning, initial stability, and levels of crestal bone.

Implant architecture and thread design in most implant systems have been based on engineering principles. These “engineering-driven” concepts have been studied in theoretical models, using finite element analysis and computer generated modeling to forecast what the anticipated behavior in the patient should be. Computer based models, however, are not powerful enough to represent the variability of implant sites from patient to patient. There is a limitation of clinical efficacy based on the conclusions as published in these studies. Therefore, if our paradigm is going to change from placement of implants in healed sites to one of immediate placement in extraction sites, models that reflect this new biologic imperative must be developed. This new architecture, known as “biologically-driven” implant design, is built not only on fifty years of our understanding of the interaction on implanted materials and living tissue, but also on our new respect for the short and long term consequences of placing implants in compromised sites.

Implants are manufactured using the same equipment used to produce industrial machine screws and screw type endosseous dental implants have employed thread architectures that are nearly identical to these engineering-driven examples. Whereas the guiding and retentive principles of these designs are valid in the solid model paradigm, biologic tissues may respond differently to threads of constant pitch and shape. In fact, constant pitch threads are only compressive on the coronal side after the device is fully seated. If we add to that a medium of varying density, remodeling of bone on the thread, and forces that are compressive, tensile, or shear, it has become clear that biologically sensitive strategies in implant design have generated renewed interest.

The first critical principle to understand is that turning a roughened implant through bone is an osteoreductive process. If we place a press-fit implant into an undersized osteotomy, we can achieve acceptable initial stability. However, if we turn that press-fit implant within that osteotomy, it soon becomes unstable because the roughened surface of the implant microfractures the bone interface. This not only reduces initial stability, but also increases the remodeling phase of bone. The net effect of this catabolic phase is to
reduce primary stability of the implant over the first 2-4 weeks, thereby jeopardizing potential success if any stress is applied in the early healing phase. Turning a roughened screw type implant through the osteotomy results in the same net effect.\textsuperscript{6} As a result of this decrease in early implant stability, it is now apparent that implants with standard V-shaped threads of constant pitch and shape have a reduced capacity to resist micromovement.\textsuperscript{7}

The second critical principle is stability as it is related to implant macroarchitecture. Parallel walled designs have given way to tapered forms that increase bone compression and insertion torque.\textsuperscript{8} However, not all tapered designs have the most desirable effects on bone during early healing. When a tapered implant is placed to position, it has significantly higher compressive force than a parallel walled design\textsuperscript{9}. This increased compression and insertion torque microfractures bone laterally from the implant/bone interface.\textsuperscript{10} This phenomenon can be even more pronounced in D3 and D4 bone sites where trabeculation is limited.

Bone microfracture potentiates the catabolic phase of bone during early implant healing and it is clear that a reduction of this type of activity is desirable to enhance early bone adaptation and integration. There is also a tendency, when an implant is placed in an extraction site, for the implant to migrate towards the defect side during delivery.\textsuperscript{11} Implant architecture that maintains axial positioning during placement should be employed in this type of osteotomy. These design changes can now be compared and critiqued.

Tapered implant designs use the body as a wedge in the implant osteotomy with threads being secondary. This results in an implant with a high ISQ value at seating.\textsuperscript{12} These implants can be placed partially into the osteotomy prior to engagement of the threads and, during initial implant placement, the torque value is low until more of the body comes into contact with the osteotomy walls. However, high torque values at final seating may result in compression remodeling of the bone interface or stripping of intra-thread bone in D3 and D4 ridges where trabeculation is limited.

\section*{Standard V-Shaped Thread}

The most common thread design, meant to guide the implant into the osteotomy, is the V shaped thread\textsuperscript{13} (Figure 1). This earliest thread design was adopted by the Branemark implant system. It is reported to have been copied from the standard \#6 wood screw which has 18 threads per inch. The thread shape emerges from the minor diameter of the implant at 30 degrees and returns in the body of the implant at the same 30 degrees creating a “V” shaped thread of 60 degrees. This design has been copied by many implant companies without consideration as to the effect it has on the bone interface. However, this represents the least functional design for protecting the implant in shear loading during the early healing phase. An implant utilizing this type of thread and placed in a site with a significant extraction defect has a markedly lower initial stability.

\section*{Buttress or Reverse Buttress Threads}

The buttress thread, whether in the standard orientation or reverse buttress design, is an architecture designed to reduce stress concentration at the implant/bone interface (Figure 2). The screw stress concentration for various thread profiles can be measured photoelastically. Square buttress (nearly zero flank angle), trapezoidal (15-deg flank angle), and triangular (30-deg flank angle) thread forms have been compared with regard...
to stress concentration. Utilizing photoelastic analysis, the buttress thread is stronger than the triangular thread design. While the trapezoidal contour behaves better than standard ISO V-shaped triangular threads, there is roughly a 20-percent increase in the stress concentration factor of the trapezoidal thread when compared to square buttress thread when compared to trapezoidal. However, this thread design maximizes the percentage of intra-thread bone, reducing the possibility of stripping during implant placement and maintaining collateral microvascularity.

Square Buttress Thread
The square buttress design, also known as a power thread, is the most resistant to movement during shear forces (Figure 3). The square buttress thread is designed to transition crestal loading into as much compression of bone as reasonably possible. The major concern with this implant is the strength of the bone at the point where the threads merge with the crestal zone. The angulation is close to 90 degrees and this results in a substantial decrease in intra-thread bone. The narrow intra-thread space creates

Figure 1: A standard V-shaped thread used on the majority of implant designs.

Figure 2: The buttress thread in the most common orientation with the flat on the apical side.
small islands of unsupported bone that may result in increased bone turnover or crestal bone loss.

**Variable Depth Thread**
Changing the medio-lateral depth of the thread from apical to coronal areas is a strategy to compensate for the osteoreductive phenomenon. When compact bone is stripped from the implant/bone interface, the increasing thread profile maintains constant bone compression. However, the depth of the thread is almost non-existent in either the apical or coronal third of some implant systems. These implants resemble more of a press-fit design either apically or coronally and lack the initial stability of a more aggressive thread design.

**Variable Geometry Thread**
This design employs a thread of varying apico-coronal and medio-lateral shape to maintain constant bone compression by counterbalancing osteoreduction. The concept of radial compression threading (US Patent #6997711, EU Patent #1578299), as embodied in the Fusion OS® architecture, is designed to meet the biologi-
cal imperative while satisfying the requirements for greatest initial stability for early or immediate load. The most apical threads are buttress which allow high directional tracking while maintaining the highest quantity of intra-thread bone in the zone where bone is generally less dense. The thread changes radially to maintain appropriate osteocompression during seating of the implant. The thread design ends as a square buttress to resist micromotion in early and immediate load. This design addresses the engineering requirements for the highest initial stability of the implant while maintaining the viability of peri-implant bone. These are critical parameters in a biologically sensitive implant architecture. The thread design acts to resist micromotion by keeping the vector of force in an apical and lateral direction. The radial compression design does not form a complete square buttress until the final thread, maintaining more intra-thread bone and keeping the implant seated within the osteotomy. Bone compression is maintained on the apical side of the thread where it can counteract compressive forces while minimizing micromotion. Additionally, the development of a flatter thread architecture in the coronal area of the implant resists shear stresses dramatically better than V-shaped geometry.

Figure 5: Fusion OS® implant demonstrating radial compression threads, a modified taper body, and novel neck design for bone ingrowth.

Figure 6: Pre-Op view of fractured maxillary left central incisor.
Self-Cutting Design
The Fusion OS® thread design also employs an embedded helical tap. Unlike traditional vented implants, there is almost no loss of implant surface area in the apical area. This is critical in extraction sites where only the apical portion of the implant is seated in bone. In addition, these cutting features will efficiently cut through and gently compress the intra-thread bone, creating additional points of stability, especially in bone of compromised density.

Insertion Torque
Another parameter that has a direct effect on bone integrity is the force with which an implant is placed into the osteotomy, also known as insertion torque. It was generally believed that the higher the insertion torque, the greater the stability of the implant at the time of placement. This was, however, an empirical observation based on solid model forecasting. In reality, high compressive force generated by excessive insertion torque is actually damaging to the bone interface and results in lowered initial

Figure 7: Pre-op radiograph of a non-restorable left maxillary incisor.

Figure 8: Immediate post-op radiograph showing that only the apical half of the implant is engaged in bone.
stability.\(^\text{17}\) Clinical research studies suggest that insertion torques of less than 50 Newton centimeters are more physiologic and minimize bone microfracture.\(^\text{18}\) The Fusion OS\(^\text{®}\) implant generates 35-45 Ncm of torque throughout the seating process until almost fully seated. A torque wrench is then used to complete the seating protocol.

**Modified Taper Architecture**

While initial stability of the implant body is important in extraction/immediate implant placement, immediate loading adds another area of concern. The macroarchitecture of the implant body contributes to force transfer to the contacting bone interface. In studies of different degrees of implant taper, it has been found that a moderately tapered implant body has optimal force transfer.\(^\text{19}\) The Fusion OS\(^\text{®}\) implant is designed with a modified continuous taper. This architecture, when compared to the majority of more aggressively tapered implant designs, significantly lowers bone compression and insertion torque throughout the seating process, thereby reducing bone microfracture and enhancing primary stability.

**Fusion OS\(^\text{®}\) Clinical Trial**

A multi-center study was conducted to compare survival rates of the Fusion OS\(^\text{®}\) implant in healed and extraction/immediate placement sites. A total of 99 patients were treated in five clinical locations with 144 implants. All implants were identical in diameter (4.75 mm) to reduce variability between clinicians and surgical sites (Figures 6-12).

In the extraction/immediate placement group, 60 patients were treated with 86 implants. In this group, 3 implants failed to integrate (1 residual apical infection, 1 failure to obtain adequate initial stability, 1 fractured provisional) and were included in the study despite not meeting the protocol criteria. These implants were successfully replaced. This relates to a 96.6% success rate in total. It should be noted that none of the failures were related to implant design, but rather failure to meet the requirements for initial stability or healing. For the implants that met the study criteria, there was 100% success.

In the healed site placement group,
39 patients were treated with 58 implants. Each of the clinicians reported that all of the implants in this part of the study integrated successfully for a 100% success rate. Additionally, all clinicians reported outstanding initial stability.

If we combine all implants placed in the study, the total cumulative success rate in 99 patients was 98%. One additional observable benefit of the Fusion OS® implant, as reported by each of the participating clinicians, is net bone growth at crest often seen during the integration process extending out to the post-reconstructive phase. This may be related the combination of architecture at the neck region, the calcium phosphate surface, lowered insertion torque, and the medialized low micro-leakage abutment attachment. Further studies are needed to validate this effect and to understand how the Fusion OS® implant architecture may contribute to this type of crestal bone growth.

Insertion torque values averaged 35-45 Ncm, depending on site characteristics and bone density. In a majority of the sites, bone density was reported to be D3. The Fusion OS® implant does not appear to require the same levels of insertion torque as do other implant systems. All clinicians in this clinical trial reported excellent initial stability and, in even more dense bone, the implants were delivered effortlessly into the osteotomies. In extraction sites with immediate implant placement, initial stability was impressive, especially when the implant was provisionalized at the time of surgery.

**CONCLUSION**

The conclusion reached by all of the participating clinicians was that the Fusion OS® implant is a highly reliable product to use for immediate placement following tooth extraction.

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The authors report no conflicts of interest with anything mentioned in this article.

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Nabil E. Beaini, DDS¹ • Michael R. Umaki, DDS²

Abstract

Mandibular ridge reconstruction presents various challenges to surgeons. Obviously, the presence of the inferior alveolar canal complicates implant placement in the posterior mandibular areas. In addition, skeletal deformities, namely resorption, occur as a result of loss of mandibular posterior teeth. Various techniques have been proposed in order to augment the posterior mandibular segments, including the ramus and/or chin autogenous block bone graft approach guided bone regeneration or a split ridge osteotomy. Misch, Pikos and Block et al., have reported ramus and chin autogenous block bone grafts to be predictable in augmenting the posterior edentulous mandibular alveolar ridge, both in horizontal and vertical dimensions. However, such procedures are technique sensitive with the success highly dependent on the fixation and immobility of the block segment. Using a bone autograft and a protective barrier, Buser et al. reported on a technique for local augmentation of deficient ridges. The authors stated that space maintenance and primary closure were critical determinants of success for such procedures. Scipioni et al. introduced the ridge split osteotomy as an alternative method which allows for conservation of the cortical plate, determined to be crucial to the success of implant placement. The ridge split osteotomy technique requires careful planning. The initial osteotomy must result in a buccal residual ridge width of 3 mm and lingual cortical plate of no less than 1 mm prior to displacement of the facial cortical bone. Violation of anatomical structures such as inferior alveolar nerve and mental foramen are additional considerations. The main challenge with the split ridge osteotomy is the potential risk for fracture and displacement of the facial cortical bone. This case report presents the technique and instrumentation to perform a piezoelectric hinge assisted alveolar ridge split osteotomy followed by placement of a two dental implants.

KEY WORDS: Mandibular ridge split, bone augmentation, dental implants

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INTRODUCTION
Mandibular ridge reconstruction presents various challenges to surgeons. Obviously, the presence of the inferior alveolar canal complicates implant placement in the posterior mandibular areas. In addition, skeletal deformities, namely resorption, occur as a result of loss of mandibular posterior teeth. Various techniques have been proposed in order to augment the posterior mandibular segments, including the ramus and/or chin autogenous bone graft approach, guided bone regeneration or a split ridge osteotomy. Misch, Pikos and Block et al., have reported ramus and chin autogenous bone grafts to be predictable in augmenting the posterior edentulous mandibular alveolar ridge, both in horizontal and vertical dimensions. However, such procedures are technique sensitive with the success highly dependent on the fixation and immobility of the block segment. Using a bone autograft and a protective barrier, Buser et al. reported on a technique for local augmentation of deficient ridges. The authors stated that space maintenance and primary closure were critical determinants of success for such procedures. Scipioni et al. introduced the ridge split osteotomy as an alternative method which allows for conservation of the cortical plate, determined to be crucial to the success of implant placement. The ridge split osteotomy technique requires careful planning. The initial osteotomy must result in a buccal residual ridge width of 3 mm and lingual cortical plate of no less than 1 mm prior to displacement of the facial cortical bone. Violation of anatomical structures such as inferior alveolar nerve and mental foramen are additional considerations. The main challenge with the split ridge osteotomy is the potential risk for fracture and displacement of the facial cortical bone.

This case report presents the technique and instrumentation to perform a piezolectric hinge assisted alveolar ridge split osteotomy followed by placement of two dental implants.

CASE REPORT AND SURGICAL TECHNIQUE
A healthy 64 year-old female presented to the Graduate Periodontics Clinic at the University of Missouri Kansas City for implant placement. The patient had a fixed partial denture extending from
teeth #28 to #31 that replaced missing teeth #29 and #30. Teeth #29 and #30 had been missing for over ten years. Tooth #31 exhibited recurrent caries extending into the furcal area and a periapical radiolucency involving the mesial root. The patient’s medical history was unremarkable.

A panoramic and a periapical radiograph confirmed our findings (Figs. 1 & 2). Clinically, the edentulous ridge presented as a Seibert\textsuperscript{16} Class I (horizontally deficient). The treatment plan included sectioning the fixed denture, extraction of #31, reconstruction of the resorbed ridge prior to placement of two implants. The two implants were intended to support a fixed prosthesis extending from tooth #29 to tooth #31. Following a detailed explanation, the patient signed an informed consent for the necessary surgery and restorations and possible publication of a case report, including photographs and radiographs.

Three carpules of 2\% Lidocaine with 1:100,000 epinephrine and one carpule of 0.5 \% Marcaine with 1:200,000 epinephrine were administrated to obtain a field block of the inferior alveolar, local buccal and mental nerves. The fixed partial denture was sectioned (Fig. 3) distal of teeth #28 and #31 and delivered without complications. A full-thickness mucoperiosteal flap was reflected, exposing the edentulous bony ridge and confirming the underlying bone deformity (Seibert Class I). The ridge presented a horizontal dimension of 3 mm in the premolar region and 5 mm in the tooth #30 area. Following exposure of the edentulous ridge, the mylohyoid muscle was carefully dissected and released, thereby allowing passive displacement of the lingual flap (Fig. 4). The mental foramen and inferior alveolar canals were identified to prevent inadvertent violation of their nerve and vascular tissues during the osteotomy procedure. Using a NSK VarioSurg\textsuperscript{®} piezo-electric unit (NSK, America Corp, Schaumberg, IL) fitted with an SG2R titanium nitride coated 0.5 mm blade and copious amounts of sterile water, a midline crestal ridge osteotomy was performed, cutting 10 mm into the alveolus.\textsuperscript{17} This initial cut started within the mesial aspect of the extraction socket of tooth #31 and extend to within 2 mm of the distal aspect of tooth #28 (Fig. 5). Starting at the most mesial extension of the midline crestal ridge incision, using an SG1 blade, a 10 mm vertical cut was extended apically. This cut passed...
through the facial cortical bone. A distal vertical cut was not necessary as the extraction socket allowed facial displacement of the facial cortical bone. Apically, 10 mm from the alveolar crest, the facial cortical bone was weakened by placing a horizontal cut with a #2 round bur. This bur cut penetrated to a depth of approximately 1.5 mm such that the facial cortical bone was not free but was flexible. Using bone spreaders and osteotomes, the facial cortical bone was gently moved facially. Puros allograft®, hydrated in sterile water, was used to preserve the socket of tooth #31 and fill the space created within the alveolar ridge. The grafted area was then covered with Puros Copios® Pericardium membrane (Zimmer Dental, Carlsbad, CA). Primary closure was attained using Vicryl™ 4-0 sutures (Ethicon, Inc, Somerville, NJ) using a horizontal mattress suture, two interrupted sutures and a continuous interlocking suture (Fig. 6). The patient was prescribed Amoxicillin 875 mg, b.i.d. for 7 days, a Medrol dose pack, Vicodin 5/500, and a 0.12% chlorhexidine rinse. The patient was given written and oral instructions and seen at 10 days, 1 month, and 3 months post-surgery (Fig. 8).

POST-TREATMENT RESULTS

Following a 4-month healing period, the site was re-entered and measurements were taken. The initial measurement of a 3 mm in the premolar area increased to 8 mm and that in the molar area (#30) doubled to 10 mm (Figs. 7 & 8). Osteotomies were prepared to receive two screw-form implants. RP Nobel Replace Select® implants were placed in sites corresponding to teeth #29 and #31, 4.3 mm and 5.0 mm diameters, respectively (Nobel Biocare USA, LLC, Yorba Linda, CA). Type II bone density was evident when placing the implants.

CONCLUSION

This single case report demonstrates that the techniques presented by Scipioni et al.11,12 and Holtzclaw et al.15 are viable approaches. The technique allows for substantial gains in horizontal dimension of the edentulous posterior mandibular alveolar ridge without morbidity to a secondary site. Maintaining the original cortical bone plate and the increase in the lateral dimension allowed for adequate placement of implants.
Figure 7: Re-entry, 4 months post healing.

Figure 8: Width of the reconstructed ridge.

Figure 9: Implants in place.

Figure 10: Periapical radiograph after implant placement.

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Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

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1. Data on file at Exactech.
**Background:** This article describes a case of horizontal alveolar ridge defect augmented with mental bone block harvested using Ultrasonic bone surgery (USBS). Platelet rich plasma (PRP) and platelet poor plasma (PPP) membrane were used as a source of biologic mediators.

**Methods:** Prior to implant placement, the horizontal defect in anterior maxilla was augmented with mental bone block obtained using USBS and overcorrected using bovine derived xenograft with PRP which helps in early graft consolidation. Supernatant PPP was also utilized to form autologous fibrin glue, thus deriving maximum benefits from the patient’s blood.

**Results:** After 6 months, upon exposure, it was observed that the block graft was integrated with the alveolar ridge resulting in increased ridge width. This was confirmed on DentaScan and 3D reconstruction images. Implants were placed and restored with satisfactory outcome.

**Conclusion:** Ultrasonic bone surgery is a fast, precise and simple technique for block graft harvesting. Predictable reconstruction of alveolar ridge defects can be obtained by using intra oral autogenous membranous bone block and use of autologous PRP as a source of growth factors facilitates early graft consolidation. PPP membrane can be used for graft containment and to promote soft tissue healing.

**KEY WORDS:** Alveolar ridge augmentation, autogenous block graft, dental implants, platelet rich plasma
INTRODUCTION
Localized alveolar ridge defects can be predictably augmented using autogenous block grafts. Significant alveolar bone resorption can occur shortly after dental extractions. In non-grafted sites, more than 20% of the buccal plate is lost after 90 days\textsuperscript{1} and up to 4mm of vertical height can be lost in the first year.\textsuperscript{2} Various onlay grafts have been used for placement and successful integration of endosseous implants like autogenous bone, allografts, xenografts and alloplastic materials. However, autogenous bone is considered to be the gold standard for grafting hard tissue defects. The use of intraoral donor sites like the mandibular symphysis and ramus (membranous bone) has several advantages over extraoral sites like iliac crest & tibial plateau (endochondral bone). Studies have revealed that membranous bone grafts retained greater than 80% of their original volume whereas iliac bone showed 65% to 88% resorption.\textsuperscript{3,4} Mandibular symphysis and ramus bone undergo less resorption because of thick cortical layers and their rigid structure. Other advantages include conventional intraoral access, reduced surgical time and no cutaneous scars.\textsuperscript{5}

Until recently, rotary instruments were used for autogenous block graft harvesting. However, accessing a bone harvesting site with a bur or oscillating saw is a delicate procedure that requires great technical skill. Further, this approach is slow, requiring more surgical time. Ultrasonic bone surgery (USBS) represents an alternative technique to perform precise bone surgery. The principle of USBS is to induce energetic microvibrations to a metallic saw of a given design. The vibration frequency ranges from 20 to 32 KHz, well above the audible spectrum. The vibrations are generated by a piezoelectric transducer. When ultrasonic saws are used to cut hard tissues, soft tissues like the Schneiderian membrane, vessels and nerves are preserved from injury because they vibrate with the tip.\textsuperscript{6} This makes USBS very useful and a simpler alternative for bone surgery.

Recent research has focused on applying native growth factors to graft materials to enhance osteogenesis, increase vascularization and shorten healing time for bone maturation. A high concentrated source of platelets in the form of platelet rich plasma (PRP) has been used for this purpose. Platelets produce and release multiple growth and differentiation factors that are critical for the stimulation and regulation of wound healing, including platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β), and vascular endothelial growth factor (VEGF).\textsuperscript{7} Marx et al\textsuperscript{8} demonstrated in their clinical studies with mandibular reconstruction that the addition of PRP resulted in early graft consolidation and mineralization in half the time compared to graft without the addition of PRP. Bone healing was accelerated approximately two times that of autogenous bone grafts without PRP. PRP offers many advantages: It decreases the frequency of intraoperative and postoperative bleeding at the donor and the recipient sites, facilitates rapid soft-tissue healing, aids in the initial stability of the grafted tissue at the recipient site (as a result of its cohesive and adhesive nature), may promote rapid vascularization of the healing tissue by delivering growth factors and, in combination with bone replacement materials, induces regeneration.\textsuperscript{9} A byproduct of platelet-rich plasma production is platelet-poor plasma, which, when activated in a similar manner as
platelet-rich plasma, can be used as a haemostatic agent. PRP can be prepared in an in-office environment using a tabletop centrifuge using 10 ml of patient’s blood. One vial of 10 ml of venous blood is withdrawn from the antecubital region with a 10 ml syringe and transferred to a container containing 1.4 ml anticoagulant (Citrate phosphate dextrose solution). It is then centrifuged for 10 minutes at 1300 rpm. The result is a separation of whole blood into a lower red blood cell (RBC) region and upper straw-colored plasma region. There is relatively high concentration of platelets found in the boundary layer between these two regions. The upper straw colored plasma layer (platelet poor plasma : PPP) and 1-2 mm of the top part of the RBC layer is aspirated and transferred into another container and again centrifuged for 10 minutes at 2000 rpm. This results in an upper portion of clear yellow supernatant PPP and the bottom red tinged layer consisting of highly concentrated PRP. The upper clear layer is aspirated until 1.5 ml of serum is left. The contents of the tube is mixed well and transferred into a sterile container. At the time of the application, the PRP is combined with an equal volume of a sterile saline solution containing 10% calcium chloride and 100 U/ml of sterile bovine thrombin. This results in formation of a sticky gel that is relatively easy to apply to the surgical defects.

The purpose of this case study was to evaluate the effectiveness of using ultrasonic bone surgery device to harvest intraoral cortical bone graft coupled with PRP and using PPP as barrier to augment alveolar ridge defect for implant placement.

**CASE REPORT**

A 26 year old woman presented for dental implant treatment. She reported a history of trauma 3 years previously which resulted in loss of teeth numbers #8, #9 and #10. The patient’s medical history was not contributory. Clinical examination revealed loss of the labial cortical plate leading to an unaesthetic facial profile. Subsequent radiographic imaging using dentascan showed a narrow alveolar ridge, however adequate height was present for implant placement (Fig. 1). On the basis of diagnostic findings and after prosthodontic consultation, the
patient was scheduled for alveolar ridge augmentation using an autogenous bone block harvested from the mandibular symphysis using USBS.

Recipient Bed Preparation
The recipient site was anaesthetized using 2% lidocaine with 1:100,000 epinephrine given as infiltration. The maxillary ridge was accessed using a horizontal incision 2 mm palatal to the crest to ensure better holding of suture by thick palatal tissues. Vertical releasing incisions were made one tooth away from the defect on either side. A full thickness mucoperiosteal flap was raised till the anterior nasal spine to obtain adequate release for passive primary closure. Perforation of the cortical plate is recommended to allow faster revascularization of the graft.12 This was done after graft was harvested and tried in the defect (Figs. 2, 3).

Donor Site Preparation and Graft Harvesting
After adequate anesthesia by infiltration, an incision was made in the attached mucosa, 0.5 mm above the mucogingival junction (from left to right first premolar) from canine to canine region. A full thickness mucoperiosteal flap was reflected to the inferior border, which resulted in a de-gloving
of the anterior mandible and allowed for good visualization of the entire symphysis. It is important not to encroach within 5 mm of the apices of the incisor and canine teeth and the mental neurovascular foramina. The inferior osteotomy was made no closer than 4 mm from the inferior border. A template was used to identify and locate the shape and location of graft site. The block graft was harvested using the UBS device (Italia Medica, Milan, Italy). The UBS works in the 20-32 KHz range and the maximum ultra-sonic power is 90W. The UBS tips are made of titanium alloy. To open the bony window, a round O 2.8 mm tip was used. To harvest bone from the chin, angled and straight saw-shaped tips were implemented (Fig. 4). The graft was placed in normal saline before contouring and fixation. The donor site was then packed with gauze soaked in platelet-poor plasma. The harvest site was packed with gelatin sponge to decrease the dead space and prevent a hematoma. The incision was sutured with 4-0 silk suture.

**Graft Adaptation and Fixation**

The block graft was manipulated to accurately fit the defect. The edges of the graft must be
1mm away from the adjacent roots. Fixation requires lagging the graft to the recipient site with multiple screws. This means that the outer hole in the graft must be larger than the hole in recipient site, allowing compression of the graft, resulting in rapid primary bone healing with less resorption. The key is to have a passive fit without any gap or rocking. Otherwise, the graft will delaminate at the time of reentry due to poor integration and a fibrous union in the space between the graft and the host bone (Fig. 5).

The defect was filled and overcorrected with particulate bovine xenograft (Bio-Oss® Spongiosa small granules - 0.25-1mm, Geistlich Pharma AG, Switzerland) mixed with autologous PRP. In addition to restoring hard tissue defect, the particulate bone preserves and augments the lost soft tissue architecture (Fig. 6).

The grafted site was covered with a platelet poor plasma membrane. The membrane was obtained from the same blood sample and activated in the same way as platelet rich plasma. Supernatent fibrin rich acellular plasma forms autologous fibrin glue on activation. It helps in hemostasis and functions as a barrier, especially helps in graft containment (Figs. 7, 8). Soft tissue closure should be passive. To achieve this, a periosteal releasing incision was made along the base of the entire flap. Multiple interrupted non resorbable sutures were placed to achieve primary closure over the entire surgical site (Fig. 9).

Post operatively, the patient was placed on a soft diet and the prosthesis was adjusted to avoid impingement on grafted site. The patient was placed on postoperative antibiotic (penicillin 500 mg thrice a day for seven days) and a chlorhexidine mouth rinse for 2 weeks.
RESULTS
After 6 months, the grafted site was uncovered and screws removed. The block graft was stable and integrated with the alveolar ridge resulting in increase in the ridge width along with the restoration of lost labial plate. Three implants were placed at #8, #9 and #10 positions with 1 mm of bone on both labial and palatal sides of the implants (Hi Tec tapered titanium thread 3.75 X 13 mm, Hi Tec Implants, Israel) (Figs 10, 11). The implants were successfully loaded after 3 months with satisfactory aesthetic and functional outcomes (Fig. 12).

Comparison of Dentascan
A comparison of preoperative and postoperative Dentascans, taken after 6 months, showed successful alveolar bone augmentation. The block graft was integrated with the alveolar ridge which can be appreciated by the absence of any radiolucency between the block graft and the residual ridge (Figs. 13, 14). On comparison, the increase in ridge width is as follows: #8 (1.1 mm), #9 (1.0 mm) and #10 (1.1 mm). The same can be appreciated very well on 3-D, reconstruction images (Figs. 15, 16).

DISCUSSION
Alveolar ridge augmentation using autologous block grafts is a predictable method for enhancing deficient alveolar ridge before implant placement. The intraoral block graft is the preferred choice over extraoral sites due to increased resorption, high cost and increased morbidity of the latter. Autogenous block grafts harvested from the mandibular symphysis or ramus undergo less resorption because of thick cortical layer and rigid structure. Ultrasonic bone surgery (USBS) was recently introduced as a technique for graft harvesting. USBS offers the following advantages over rotary instrumentation: 1) a clean and blood free surgical field because of cavitation and collapsing action of the ultrasound on blood vessels; 2) better visual access to the surgical area; 3) easier access to bone harvesting sites with no risk of injury to surrounding neurovascular bundles and soft tissues.
Platelet-rich plasma (PRP) is an autologous concentration of platelets in concentrated plasma, which is extensively used to promote soft and hard tissue healing. The use of PRP facilitated the clinical handling of graft material. An added benefit of PRP is its ability to form a biologic gel that may provide graft containment, clot stability, and function as an adhesive. An autologous material that possesses a high concentration of biologic mediators improves the rate of wound healing without the cost of additional materials.

Review of current published data of in vitro studies support the use of platelet concentrates, however, literature on humal clinical trials is inconclusive to determine platelet concentrate benefits for oral and maxillo-facial studies. Among various platelet concentrates, L-PRF (Leukocyte- and Platelet-Rich Fibrin) clot has emerged as a front runner because L-PRF clots slowly release significantly larger amount of growth factors (TGF 1, PDGF-AB, VEGF) over 7 days in culture medium. Although clinical data is minimal at this time, researchers have advocated use of PRF for varied regenerative procedures, including sinus augmentation, ridge augmentation and peri-implantitis. However, use of PRF to mix with the bone graft and also to obtain membranes would require 20-30 ml of patient's blood to obtain the desired number of PRF clots. This could be avoided in the present case as PRP was mixed with the bovine graft and supernatant PPP was utilized to form membrane to cover the grafted site. Marx et al. have shown 40% decrease in the healing time of autogenous bone grafts when PRP was incorporated into the site. Their results along with the case series by Kassolis JD et al. suggest that the use of PRP may allow for earlier implant placement and/or loading.

Autologous fibrin glue obtained by activation of supernatant PPP is known to promote hemostasis and assists in soft tissue healing. PPP has antimicrobial activity at par with PRP which is useful for wound healing. Both PRP and PPP stimulated human gingival fibroblasts suggesting that both platelet-derived fractions may exert a positive effect on gingival repair.
An experimental study\textsuperscript{22} to compare the effects of PRP, PRF, and PPP showed that PPP is an effective material for the preservation of sockets with buccal dehiscence and it plays a significant role in the presence of few osteogenic cells. Therefore, in present case, maximum benefits of blood constituents could be obtained from 10 ml of patient’s blood with use of both PRP and PPP which augmented the procedure of ridge augmentation with mental block graft.

**CONCLUSION**

The autogenous intraoral block graft is a predictable method to correct alveolar ridge defect before implant placement. Use of USBS simplified the bone harvesting procedure. Autologous PRP is a rich source of growth factors which helps in early graft consolidation and, PPP membrane acts as a barrier for the containment of particulate graft material and assists in soft tissue healing. Optimized aesthetics and function will be obtained using autologous bone block and PRP.

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\section*{Disclosure}
The authors report no conflicts of interest with anything mentioned in this article.

\section*{References}
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Background: The purpose of this study was to evaluate the clinical and radiographic outcomes of one-piece zirconia implants after 18 months follow up period.

Methods: A total of 10 one piece zirconia implants were inserted into anterior maxillary region in 10 participants. The clinical and radiographic outcomes were evaluated during 18 months follow up period. Gingival index (GI), Plaque index (PI), Probing pocket depth (PD) values, and marginal bone loss were measured.

Results: PI values after 3, 6, 7, 12, and 18 months were; 0.65 ± 0.04, 0.56 ± 0.07, 0.56 ± 0.07, 0.43 ± 0.06, and 0.37 ± 0.94, respectively. Assessment of GI and PD after 3, 6, 7, 12, and 18 months revealed 0.50 ± 0.06, 0.47 ± 0.06, 0.43 ± 0.06, 0.43 ± 0.06, 0.31 ± 0.10, and 3.1 ± 0.41, 2.21 ± 0.16, 2.25 ± 0.16, 2.31 ± 0.17, and 2.37 ± 0.15, respectively. Two implants were lost within 3 months after placement. Bone loss was 0.96 ± 0.08 mm and statistically different between the follow up periods (p<0.01).

Conclusions: Periimplant soft tissue parameters demonstrated promising results but marginal bone loss is higher than expected and long term clinical studies are needed to recommend one piece zirconia implants for clinical use.

KEY WORDS: Dental implants, zirconia, prosthetics, bone, healing

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INTRODUCTION

To achieve esthetic success with implant-supported prosthetics, restorations, abutments, and implants should be in harmony with color, shape, and surface structure of the adjacent dentition.\(^1,2\) In addition, preservation of the peri-implant mucosa may be another important factor for creation of harmonious soft tissue contours.\(^3\)\(^-\)\(^5\) The area which is seen when the patient smiles is referred to as the esthetic zone and maxillary teeth are closely associated with this area.\(^6\) However, it is very difficult to achieve esthetic appearance in this region with titanium implants.\(^5\) Esthetic outcomes of restorations supported by titanium implants may be impaired when the grey color of the implant shines through the mucosa or the implant head becomes visible because of soft tissue recession. Furthermore, increased concentrations of titanium particles or possible corrosive products have been detected in adjacent tissues or in regional lymph nodes, but these clinical findings are not yet clear.\(^7\)\(^-\)\(^11\)

Zirconia has been suggested as an implant base material due to its high fracture strength, minimal thermal conductivity, chemical inertness, natural tooth like color, and low affinity to bacterial colonization.\(^7\)\(^-\)\(^18\) Furthermore, its osseointegration capacity and biocompatibility has been shown in the animal investigations.\(^16\)\(^,\)\(^19\)\(^-\)\(^24\) In vitro studies have demonstrated that zirconia can withstand to functional long term loads but preparation of the material can decrease mechanical properties.\(^17\)\(^,\)\(^25\)\(^,\)\(^26\)

Zirconia implants have been produced and marketed in recent years due to product development and improvements in ceramic materials. Their minimum requirements as a dental implant material are summarized in standart ISO 13356.\(^27\) Zirconia implants can be manufactured in 1-piece or 2-piece designs. Both designs are available in the market but most of the zirconia implant systems are of the 1-piece design. One-piece designs incorporate the transmucosal abutment as an integral part of the implant. Manipulation of the periimplant soft tissue after initial healing can be avoided with 1-piece implant design which can be restored with an interim restoration at placement, allowing the mucosal epithelium and the connective tissue adhesion.\(^28\) The preparable abutment creates an individualized profile which follows the contour of gingival margin.\(^29\)

To achieve expected esthetic result with 1-piece implants, implants must be placed in an ideal position. The bone height and width must be sufficient for insertion of 1-piece implants because augmentation procedures or grafting can not be used with 1-piece zirconia implants.\(^7\) One-piece implants can be immediately restorated with an interim fixed prosthesis. The interim prosthesis must be placed out of occlusion during the osseointegration period\(^16\) because premature loading of the implant may lead to fibrous encapsulation and possible clinical failure.\(^30\) It is very important to avoid deflective occlusal contacts in centric relation, lateral, and protrusive excursions. The interim prosthesis must not be removed before 3 months and patients must be instructed not to chew on the implants during osseointegration period.\(^16\)

Immediate loading is a treatment intended to reduce the period between implant surgery and prosthetic rehabilitation.\(^31\)\(^,\)\(^32\) The treatment success with immediately loaded implants may be influenced by primary stability of implants, bone quality and quantity, macro and micromovements of implant, implant characteristics, and general conditions of patients.\(^33\) Positive clinical outcomes including osseointegration and...
successful clinical reports have been presented for zirconia implants but long term clinical data related with zirconia implants is very limited. Some retrospective clinical studies have been reported. The purpose of this study is to evaluate clinical and radiographic outcomes of immediately loaded 1-piece zirconia implants after 18 months follow up period.

MATERIAL AND METHODS
This study included 10 participants between 17 and 56 years old who were in need of single tooth restorations in maxillary anterior region and referred to Gazi University Faculty of Dentistry. The ethics committee of the Gazi University Faculty of Dentistry approved the investigation and this study was performed in compliance with the Declaration of Helsinki. All participants were volunteered for the study and signed a written informed consent form before their treatment.

A total of 10 WhiteSKY (Bredent Medical, Senden, Germany) 1-piece zirconia implants (3.5 mm in diameter and 11.5 mm in length) were inserted into 10 participants (1 woman, 9 man). The metal free high strength zirconium dioxide implants are hot isostatic pressed, have conical implant body with a cylindrical, self cutting double thread and sandblasted surface with a roughness of $\text{Sa} = 1.17 \, \mu \text{m} (\pm 0.15)$. Smokers, bruxers, participants had general contraindications against implant treatment, and need for tooth replacement more than 1 in the maxillary anterior region were excluded from the study.

The implants were placed according to the instructions of the manufacturer for WhiteSKY implants by the same surgeon. Surgical procedures were performed under local anesthesia. After full thickness flaps were elevated labially and lingually to expose the alveolar bone, drill-
ing sequences were performed according to instruction of manufacturer using drill diameters available to achieve accurate implant positioning. Each implant was placed using a 1-stage surgical protocol and 30 Ncm of torque was performed with torque ratchet (Figures 1, 2). Participants were then instructed in postoperative home-care maintenance procedures and not touching the surgical area with toothbrush for ten days. The participants were seen after 10 days from the surgery and sutures were removed. The abutments were prepared in
participants who were in need of adjustment of the angulation of the abutment. During the osseointegration period, the participants were provided fixed interim restorations (Figure 3). The interim prosthesis were made out of occlusion and cemented with provisional cement (Cavex temporary cement; Cavex, Haarlem, Netherlands). The interim prosthesis were left in place for 3 months as recommended.

Six months after the surgery, panoramic, and periapical radiographs were obtained and examined for bone implant osseointegration. An elastomeric impression material (Zeta Plus, Zhemlack, Badia Polesine, Italy) was used to take the impressions. Zirconia based ceramic restorations (Lava, 3M ESPE, Seefeld, Germany) were made (Figure 4) and cemented onto the abutment with resin cement (Panavia TC, Kuraray, Osaka, Japan). Excess cement was removed after prosthesis placement. The restorations were left out of occlusion and contacts in lateral excursions were avoided.

The clinical examinations at baseline and follow up periods of 3, 6, 7, 12, and 18 months included Plaque Index (PI), Gingival Index (GI), and Probing Pocket Depth (PD) (Figure 5). All scores were measured using a plastic periodontal probe (Hawe Click-Probe, Kerr Hawe, Bioggio, Switzerland) on the mesial, distal, buccal, and lingual sides of the each implant (the mean of all 4 measurements were used) (Figure 6). PI scores were recorded according to Silness and Löe and GI scores were recorded according to Löe and Silness.

For the radiographic measurements, at the presurgery visit, a radiographic stent was constructed on the film holder in order to standardize periapical radiographs and a silicone occlusion block used to ensure accurate repositioning at each visit (Figure 7). Marginal bone loss was measured with standardized periapical radiographs. The periapical radiographs were obtained with long cone paralleling technique with using a cone paralleling film holder. The known distance between the implant shoulder and implant apex were used for calculating the magnification. The bone
loss measured from the crestal bone margin to bone-implant contact on the mesial and distal aspects and a mean value was used. Intraoral radiographs were obtained immediately after the surgery and 1, 3, 6, 7, 12, and 18 months follow up periods and were examined (Figures 8-11). In one participant, a bone grafting procedure was necessary. This particular participant was excluded from the bone loss measurements.

Implant data were analyzed by one factor repeated measures ANOVA and Bonferroni posthoc tests. The results are expressed as the number of observations (n) and the mean ± standard error of the mean. The alpha level was set at %5. Data analyses were performed with SPSS software (Statistical Package for the Social Sciences, version 18.0; SPSS, Inc., Chicago, Ill).

**RESULTS**

Two implants failed before the prosthetic restoration during the osseointegration period, and in one participant crestal bone resorption was observed so graft was applied to resorption area. The grafted participant was excluded from the radiographic assessments.

The mean PI, GI, and PD values (the mean of mesial, distal, buccal, and palatinal measurements were used) are summarized in Table 1. PI values after 3, 6, 7, 12, and 18 months were: 0.65 ± 0.04, 0.56 ± 0.07, 0.56 ± 0.07, 0.43 ± 0.06, and 0.37 ± 0.94, respectively. The PI values were statistically different between the follow up periods (p < 0.01). The highest PI values were observed after 18 months and the lowest PI values were observed after 3 months.
GI values after 3, 6, 7, 12, and 18 months were: 0.50 ± 0.06, 0.47 ± 0.06, 0.43 ± 0.06, 0.43 ± 0.06, 0.31 ± 0.10 respectively, and PD values after 3, 6, 7, 12, and 18 months were 2.31 ± 0.41, 2.21 ± 0.16, 2.25 ± 0.16, 2.31 ± 0.17, and 2.37 ± 0.15 respectively. GI and PD values were not different significantly between the follow up periods (p > 0.05). The lowest GI values were after 18 months and the highest were after 3 months. The lowest PD values were after 6 months and the highest values observed after 18 months.

Marginal bone loss values around the 1-piece zirconia implants after 18 months are summarized in Table 2. Bone loss was statistically different between the follow up periods (p < 0.01). The bone loss values after 1 month and 3 months, 12 months, and 18 months were not statistically different from each other (p > 0.01). Consequently, 7 participants followed for 18 months and mean bone loss was 0.96 ± 0.08 mm. Implant, abutment, and superstructure fracture or prosthetic complications were not observed during the follow up period.

**DISCUSSION**

Zirconia implant supported restorations are a relatively new treatment option in clinical applications. The same success criteria which are valid for titanium implants have to be applied to zirconia implants to determine their advantages and disadvantages. In the present study, PI, GI, PD, and marginal bone loss were examined after 18 months function of immediate loaded 1-piece zirconia implants. PI values were decreased signifi-

![Figure 10: Periapical radiograph after 12 months.](image1)

![Figure 11: Periapical radiograph after 18 months.](image2)
Table 1: PI, GI, and PD Measurements After Follow Up Periods

<table>
<thead>
<tr>
<th>Follow-up Period Mean (±SE)</th>
<th>PI</th>
<th>GI</th>
<th>PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 months</td>
<td>0.65 ± 0.04 A</td>
<td>0.50 ± 0.06 a</td>
<td>2.31 ± 0.41 b</td>
</tr>
<tr>
<td>6 months</td>
<td>0.56 ± 0.07 AB</td>
<td>0.47 ± 0.06 a</td>
<td>2.21 ± 0.16 b</td>
</tr>
<tr>
<td>7 months</td>
<td>0.56 ± 0.07 AB</td>
<td>0.43 ± 0.06 a</td>
<td>2.25 ± 0.16 b</td>
</tr>
<tr>
<td>12 months</td>
<td>0.43 ± 0.06 BC</td>
<td>0.43 ± 0.06 a</td>
<td>2.31 ± 0.17 b</td>
</tr>
<tr>
<td>18 months</td>
<td>0.37 ± 0.94 c</td>
<td>0.31 ± 0.10 a</td>
<td>2.37 ± 0.15 b</td>
</tr>
</tbody>
</table>

Same characters (vertically) indicate that plaque index value were not statistically significantly different between the follow up periods (p < 0.01).

Gingival index and probing depth values were not statistically different between the follow up periods (p > 0.05).

Significantly after follow up period (p < 0.01). PI values are directly related with the ability of participants performing oral hygine procedures. Dental plaque is one of the main factors of gingival disease. GI values decreased after 18 months but the difference was not statistically significant (p > 0.05). The decrease in GI values may be a result of decrease in PI values which was affected by dental care. Also, PD values were not different significantly between the follow up periods (p > 0.05).

Bone loss around implants is an important factor to evaluate the clinical success of the implants. In the present study, clinical assessments of zirconia implants were promising, but radiographic examinations showed that marginal bone loss was 0.96 ± 0.08 mm after 18 months. The bone loss was higher than 0.2 mm which was reported as an implant success criteria after 1 year by Smith and Zarb. However, it is not clear that bone loss was affected by implant material, macro and micro design of the implants, surgical technique or loading during osseointegration period. A number of factors such as indication, implant insertion and angulation, prosthetic design are important to achieve successful esthetic and functional results with 1- piece zirconia implants. But clinical reports demonstrated good results for using zirconia implants in the esthetic regions.

Oliva et al, Sierraalta et al, Aydin et al, presented esthetic rehabilitations of the missing maxillary incisors with 1-piece zirconia implants. After the follow up periods, no complications were observed, implants were stable, gingival tissues were healthy, and the patients were satisfied with their prostheses. It was concluded that zirconia implants regarded the...
Table 2: Bone Loss Measurements After Follow Up Periods

<table>
<thead>
<tr>
<th>Follow Up Periods (Mean (±SE))</th>
<th>Bone Loss (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>0.23 (± 0.02)</td>
</tr>
<tr>
<td>3 months</td>
<td>0.35 (± 0.03)</td>
</tr>
<tr>
<td>6 months</td>
<td>0.60 (± 0.05)</td>
</tr>
<tr>
<td>7 months</td>
<td>0.66 (± 0.04)</td>
</tr>
<tr>
<td>12 months</td>
<td>0.82 (± 0.07)</td>
</tr>
<tr>
<td>18 months</td>
<td>0.96 (± 0.08)</td>
</tr>
</tbody>
</table>

Bold italic characters (vertically) indicate that bone loss were not statistically significantly different between follow up periods (p < 0.01).

patient’s esthetic expectations. And also, zirconia implants can be an alternative treatment option in metal allergenic patients.35

The data with long term usage and complications of zirconia implants is very limited. Available clinical results of zirconia implants include 5 year follow up period. Blashcke and Volz,37 investigated soft and hard tissue response to zirconia implants for a 2 to 5 year period and reported that 98 % of 66 inserted zirconia implants showed good osseointegration. Oliva et al.38 evaluated the 1 year follow up 100 zirconia implants and compared the 2 different roughed surfaces. Implants in group 1 were mechanically roughed and in group 2 were bioactive ceramic coated. The study included 36 patients and success rate after 1 year follow up period was 98 %. In another investigation, Oliva et al16 investigated the 5 year success rate of 831 consecutively placed zirconia implants. Three different roughed surfaces (uncoated, coated, and acid etched) were evaluated in this investigation. The overall implant success rate after 5 years follow up period was 95%. And the success rate of acid etched surface group was significantly better than the others. A total of 42 implants failed; 29 were in smokers, 8 implants were in grafted areas, and 9 were placed with sinus elevation procedures. Failure rates were lower at anterior regions than posterior regions. In this study, 8 implants were survived and 2 were lost during the osseointegration period.

Gahlert et al.39 investigated the failure analysis of fractured zirconia implants. A total of 170 implants (Z-Look3, Z-Systems AG, Konstanz, Germany) were inserted in 79 participants. Implants were inserted in 3 different diameters of 3.25, 4, and 5 mm. 13 of the 170 implants failed due to fracture after prosthetic function within the period of 38 months (median). The participants’ histories were used to compare and identify the reasons for the fractured implants. Twelve of 13 fractured implant had been in reduced diame-
ter (3.25 mm), 1 had a diameter of 4 mm. The cracks were located at the level of the first turn of the thread in 10 of 13 investigated implants. It was indicated that those implants had been osseointegrated. The authors concluded that reduced diameter implants could not be recommended for clinical use. The implants were 3.5 mm diameter in this study and no implant fractures were observed during the follow up period. Payer et al.\textsuperscript{40} and Kohal et al.\textsuperscript{41} evaluated periimplant marginal bone level and plaque index in similar investigations and resembling results were observed. Payer et al.\textsuperscript{40} evaluated clinical and radiographic outcomes of immediately placed 1-piece zirconia implants (WhiteSKY). A total of 20 implants were inserted to 20 participants. Periimplant marginal bone level, plaque index, bleeding on probing values, periotest, pink aesthetic scores, and clinical success were evaluated after 24 months clinical function. A 95% success and survival rate were reported. Observed bone loss was 1.29 mm after 24 months follow up period. The plaque index values were decreased during the follow up periods. Also in this study, similar to Payer et al.\textsuperscript{40}, the PI values were decreased during the follow up periods however the values were statistically different between the 3, 12, and 18 months follow up periods (p < 0.01). The lowest GI values were observed after 18 months however the difference in the values were not statistically significant between the follow up periods (p > 0.05). Kohal et al.\textsuperscript{41} investigated the clinical and radiographic outcomes of Zi Unite (Nobel Biocare, Gothenburg, Sweden) 1-piece zirconia implants after 1 year follow-up. The values of the clinical parameters (probing depth, clinical attachment level, bleeding index, and plaque index) decreased over 1 year. The marginal bone loss measured after implant insertion and after 1 year follow up period. The marginal bone loss was 1.31 mm and the survival rate was 95.4%. Also in the present study, the PI and GI values decreased during the 3, 6, 7, 12, and 18 months follow up periods. PD values were not different significantly between the follow up periods (p > 0.05). The observed marginal bone loss was 0.96 ± 0.08 mm after 18 months.

When planning and insertion of the implants are accurate, indicated patients can be successfully treated with 1-piece zirconia implants. This study demonstrated only the results of PI, GI, PD, and bone loss after 18 months for limited number of participants. Long term examinations of 1-piece zirconia implants in higher number of participants must be performed to establish their clinical performance and success.

**CONCLUSIONS**

Periimplant soft tissue parameters demonstrated promising results in the present study, but marginal bone loss was higher than expected (0.96 ± 0.08 mm) and long term clinical studies are needed to recommend 1-piece zirconia implants for clinical use.

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