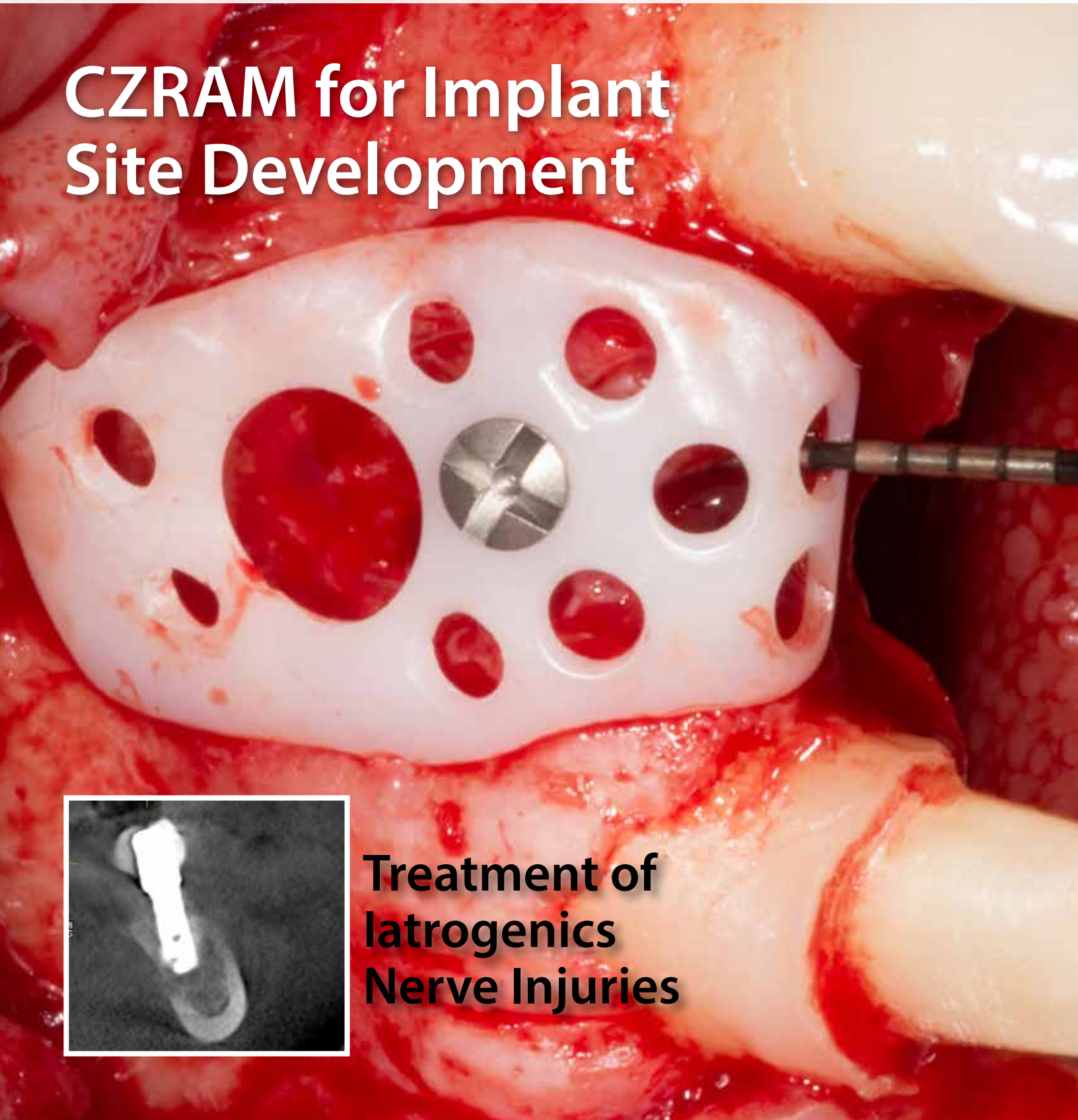


CZRAM for Implant Site Development



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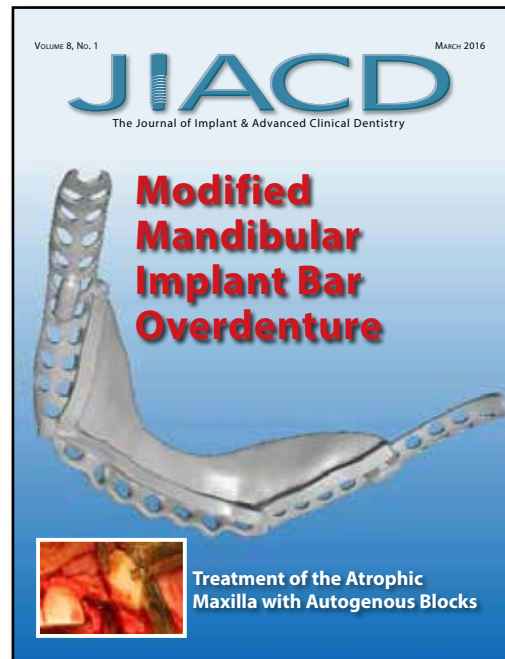
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Custom Zirconia Ridge Augmentation Matrix (CZRAM) for Implant Site Development: A Report of Two Cases

**Craig E. Hofferber, DDS¹ • J. Cameron Beck, DMD, MS²
Peter C. Liacouras, PhD³ • Matthew B.B. Miller, DDS, MS⁴**

Abstract

This is a report of two cases describing the use of custom zirconia ridge augmentation matrices (CZRAM) to effectively augment deficient alveolar ridges prior to dental implant placement. 3D computer-aided design (CAD) of customized zirconia rigid space maintenance devices was carried out using a baseline cone beam CT (CBCT) scan of the deficient ridges, and the devices were milled from partially-sintered zirconia blocks using a five-axis dental mill. The matrices were

surgically fixated and filled with particulate freeze-dried bone allograft. No complications or wound dehiscence were encountered during healing. Upon re-entry, both cases displayed complete bone fill to the intaglio surface of the matrix, allowing for the placement of dental implants. The customized nature of the CZRAM allows for predictable gains in alveolar ridge dimension, reduction of intraoperative time versus alternative approaches, and utilizes low-cost materials and equipment for fabrication.

KEY WORDS: 3D, CZRAM, GBR, customized, ridge augmentation, zirconia, bone graft

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INTRODUCTION

The atrophic alveolar ridge represents one of the most significant challenges in implant dentistry. Following tooth loss, alveolar bone resorption occurs due to the loss of blood supply to the buccal bone provided by the periodontal ligament and associated vasculature. The degree of this resorption has been reported to the extent of approximately half the horizontal ridge dimension within the first year following tooth loss.¹ Site preservation procedures have been developed and employed to minimize the degree of resorption that occurs,² however in many cases there is still insufficient alveolar bone to facilitate implant placement in an ideal restoratively-driven position.

A variety of ridge augmentation techniques are available to regenerate lost bone tissue, each with unique advantages and limitations.³ The limitations of traditional approaches such as autogenous block grafting (patient morbidity and graft resorption),⁴ allogenic block grafts (materials cost, graft resorption),^{4,5} and ridge split (technique sensitive, requirement for minimum cancellous bone volume)³ form the impetus for the development of more simple and efficient techniques that harness advances in technology. Guided bone regeneration (GBR) using titanium mesh has been shown to effectively regenerate deficient alveolar ridges, but high rates of wound dehiscence resulting in exposure of the mesh have been reported.⁶

In recent years, rapid prototyping techniques such as selective laser sintering and electron beam melting have been utilized along with CBCT imaging and computer aided design (CAD) to fabricate customized titanium frameworks for ridge augmentation.⁷⁻¹⁰ These patient-specific matrices are fixated to the edentulous site and act as rigid space-maintaining devices to facilitate ridge

augmentation. The customized nature of this technique has been shown to significantly reduce intraoperative time and reduce the rate of wound dehiscence when compared to commercially available titanium mesh.⁹ However, additive manufacturing of customized titanium matrices (via electron beam melting or selective laser sintering) requires costly machinery. The end-products of the electron beam melting process also have a rough surface¹¹ that requires additional time for polishing prior to implantation, adding to the difficulty and expense to produce these devices.

Malmström et al. recently described a similar approach to ridge augmentation using individualized, non-porous zirconia sheets.¹² Zirconia is an inert, biocompatible material with numerous applications in implant and restorative dentistry.^{13,14} Partially-sintered forms of zirconia can be precision-milled using a 5-axis dental milling machine and subsequently sintered to the specifications of computer-aided designs. The manufacturing workflow with this material represents a much more accessible approach than customized titanium meshes due to the ubiquity of 5-axis milling machines in commercial dental laboratories and the relative low cost and availability of zirconia. The present case report describes the Customized Zirconia Ridge Augmentation Matrix, or CZRAM: milled zirconia rigid space maintaining devices fabricated via CAD/CAM, with novel design features that enhance their ease of use during surgery.

DIGITAL AND MANUFACTURING METHODS

A 3D reconstruction of the alveolar ridge morphology was acquired in both cases by importing the CBCT images into Mimics (Materialise),



Figure 1a: Occlusal view of #8 at initial evaluation, revealing horizontal ridge deficiency in Case 1.

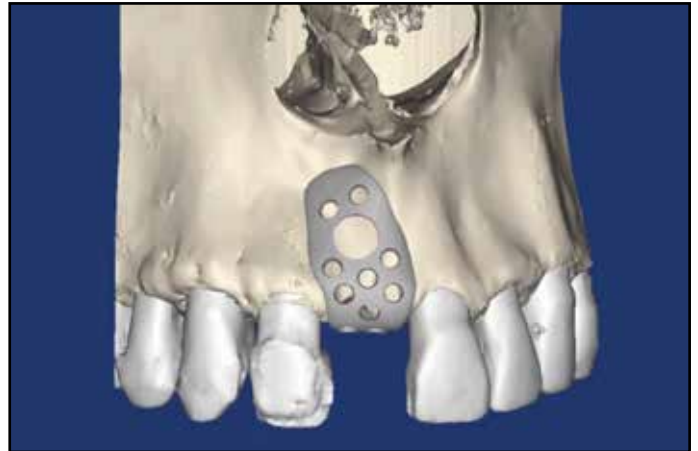


Figure 1b: Maxilla reconstruction and CZRAM design within CAD software.



Figure 1c: CZRAM after fabrication. Large 'bone loading port' (center) allows for bone graft placement. Smaller 'nutrient ports' were created across remainder of CZRAM surface; all are appropriately sized and countersunk to facilitate fixation screw placement.



Figure 1d: Intraoperative view of alveolar ridge defect at site #8. Corticotomies have been made in the region to be augmented.

thresholding for the osseous tissue, and exporting a stereolithography (STL) file. The STL of the mandible was manufactured on a multiple material jetting machine (Object Connex 500, Stratasys) to produce a physical 3D model. The digital maxilla/mandible STL file was then imported into Geomagic Freeform Modeling Plus

(3D Systems) and any surface imperfections due to the CBCT scan were digitally smoothed. This file was used primarily as a reference.

A separate, additional, digital body file was created on top of the existing ridge anatomy to represent a rough estimate of the desired post-augmentation dimensions of the alveo-

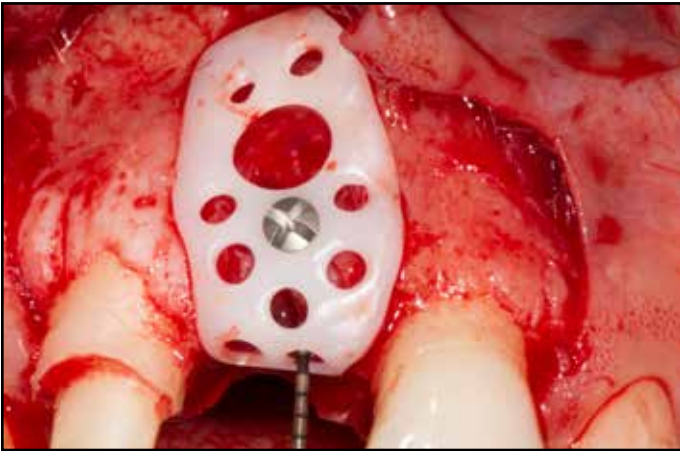


Figure 1e: CZRAM fitted in position with no adjustments necessary to achieve intimate fit. A single fixation screw was sufficient to completely immobilize the matrix. 3.5mm of vertical augmentation is planned.

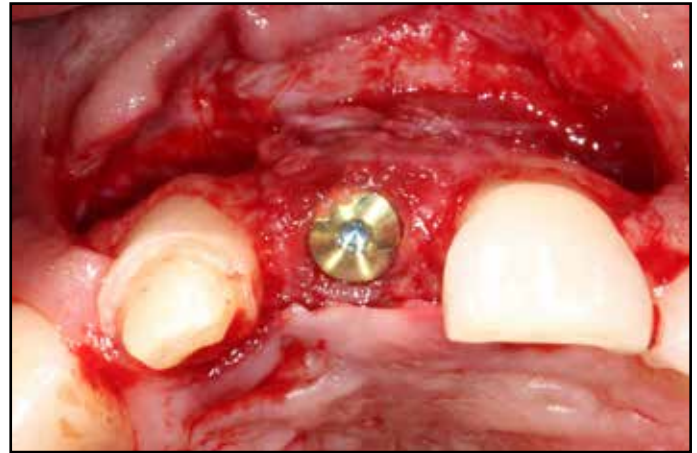


Figure 1f: Implant placed after CZRAM removal at re-entry six months following graft placement. Complete bone fill within confines of the CZRAM was observed at the time of removal.

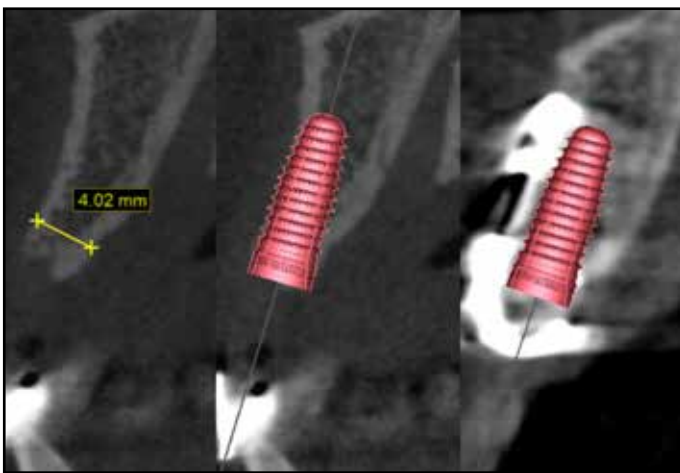


Figure 1g: Pre- (left) and post- (right) grafting CBCT with planned implant positions. Note the complete radiographic bone fill beneath CZRAM.



Figure 1h: Occlusal view following stage I implant surgery depicting provisional restoration in place (cantilever pontic at site #8). Correction of horizontal deficiency is apparent.

lar ridge. This augmentation was then digitally molded to produce the exact desired volume, shape, and contours of this 'ideal' ridge dimension based on the planned implant positions. This structure was then offset to the outside and used to create a solid surface file over the ideal augmented bone volume, representing the body

of the CZRAM. One or two larger "bone loading" ports, and numerous "nutrient" ports were added by subtracting cylindrical elements from the surface file. The bone loading ports were created in the surface to allow access for placement of graft material. Nutrient ports were created utilizing special cylinders with flared ends which

were subtracted from the surface throughout the CZRAM, each capable of accommodating placement of a 1.5mm diameter screw for fixation.

The final design was manufactured on a 5-axis laboratory mill (CORiTEC 350i, imesicore GmbH) from a partially-sintered substructure zirconia puck (Zenostar MO, Ivoclar Vivadent). The matrix was then sintered, and fit was verified on the 3D printed jaw model prior to sterilization with ethylene oxide.

CASE 1

A 38-year-old male presented with vertical and horizontal ridge deficiency secondary to loss of tooth #8, which had been avulsed due to trauma 20 years earlier (Figure 1a). His medical history was non-contributory, he took no medications, and was classified as an American Academy of Anesthesiology Physical Classification (ASA) 1. The prosthetic treatment plan included a dental implant at site #8 and a single unit implant-supported restoration. A CBCT scan of the site (Carestream 9500, Carestream Health) was obtained, and the implant position was planned in a restorative-driven position utilizing digital planning software (Blue Sky Plan, Blue Sky Bio). The amount of the required gain in horizontal and vertical ridge dimensions was determined and the CZRAM designed and fabricated according to the methods described earlier (Fig. 1b, c). After full thickness mucoperiosteal flap reflection, cortical perforations were made (Fig. 1d) and the CZRAM was positioned onto the defect. Intimate fit requiring no adjustments was immediately noted. A 7mm-length KLS Martin fixation screw was placed through one of the nutrient pores resulting in complete immobilization of the matrix

(Fig. 1e). Freeze-dried bone allograft (FDBA, LifeNet Health) was placed inside the framework through the large central loading port, and a collagen membrane was positioned (OsseoGuard, Zimmer Biomet) over the entire CZRAM. Tension-free primary closure was accomplished using 5-0 PTFE (CytoSurg, Salvin Dental Specialties) sutures. The site was provisionalized with a two-unit prosthesis with a cantilevered pontic, fabricated from poly(methyl methacrylate) (PMMA).

The patient was seen for post-operative follow-up at weeks 1, 2, 3, 4 and then monthly thereafter. At the 5-month post-operative visit, a second CBCT was obtained of the site to assess bone fill. Radiographic findings suggested complete bone fill beneath the matrix. At 6 months, the site was re-entered and the CZRAM was retrieved. Regenerated bone was observed up to the outer level of the mesh within the nutrient and loading ports. Upon removal of the matrix, a thin layer (less than 1mm in thickness) of soft tissue was observed between the intaglio surface of the matrix and the regenerated bone.

The dimensional increases of the alveolar ridge were approximately 3 mm in both the horizontal and vertical dimensions, which corresponds with the anticipated gain based on the design parameters of the matrix. Implant placement was performed in a two-stage approach with no additional bone augmentation required (Fig. 1f). Final insertion torque was measured at 45 Ncm. Second-stage surgery was performed two months later, and the implant was provisionalized with a cement-retained bis-acryl composite restoration. Three months later, a cement-retained metal-ceramic restoration on a custom titanium abutment was delivered (Fig. 1h).

CASE 2

A 36-year-old African-American female patient presented with partial edentulism and horizontal ridge deficiency at sites #28-31 (Fig. 2a). The prescribed prosthetic treatment plan was for three single-unit implant-supported restorations at sites #28-30.

A CBCT scan (Carestream 9500, Carestream Health) of the mandibular right quadrant was initiated, and preparations for guided implant surgical placement (Blue Sky Plan, Blue Sky Bio) were made. As in Case 1, the desired horizontal dimensional ridge augmentation was determined digitally and a CZRAM designed and milled (Fig. 2b) in the same manner discussed previously.

The surgical placement of the CZRAM involved reflection of a buccal full-thickness mucoperiosteal flap (Fig. 2c) and positioning of the matrix to the deficient ridge. The matrix was observed to have a precise and intimate fit requiring no adjustments and was stabilized with two 1.5 x 13 mm fixation screws (KLS Martin) placed through two of the matrix nutrient pores (Fig. 2d)

Enamel matrix derivative (Emdogain, Straumann) was first placed under the CZRAM, followed by a combination of FDBA and demineralized bone matrix putty (Acell, Keystone Dental) placed through the larger bone port orifices. A resorbable collagen membrane was trimmed and placed over the CZRAM (OsseoGuard, Zimmer Biomet). Tension-free primary flap closure was achieved.

Post-operative appointments were completed weekly for the first month, then monthly for seven months. Healing was uneventful and no exposure of the CZRAM occurred during the eight-month healing period.

A second surgery for matrix retrieval and

implant placement was completed eight months following CZRAM placement. Upon flap reflection, a periosteal tissue layer had covered most of the matrix and bone was observed to completely fill to the level of the intaglio surface (Fig. 2e). Approximately 3-4 mm of horizontal ridge regeneration was achieved as measured clinically with a UNC 15 probe (Hu-Friedy). The fixation screws and matrix were removed and two 4.3 x 13 mm implants (Nobel Replace, Nobel Biocare) were placed at sites #28 and 29, with an additional 5 x 13 mm implant placed at site #30 using a guided surgery technique (Fig. 2f). Good primary stability of the implants was achieved, a fixture-level impression was made, and cover screws were placed onto the implants for a two-stage approach. Second-stage surgery was subsequently performed and the implants were restored with individual screw-retained metal-ceramic restorations (Fig. 2h).

DISCUSSION

CAD/CAM customized ridge augmentation matrices are a viable modality in guided bone regenerative procedures. Literature has shown that custom matrices can be predictable, safe and efficient when used to facilitate implant-supported rehabilitation of the dentition.^{9,10} We have demonstrated that milled zirconia matrices can achieve the same excellent results as additively-manufactured custom titanium matrices.

Rigid space maintenance, a cornerstone of successful GBR,³ can be difficult to ensure when performing GBR with a membrane and particulate graft material. Bioabsorbable membranes, often favored by clinicians for their tissue compatibility and ease of use, lack inherent structural qualities to maintain defect space and prevent collapse of



Figure 2a: Pre-operative occlusal view of ridge deficiency in Case 2.



Figure 2b: CZRAM prior to placement. Design included five bone loading ports and numerous nutrient ports.

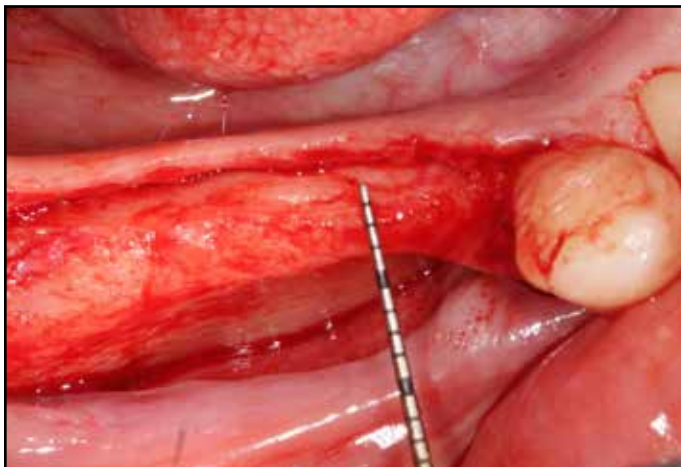


Figure 2c: View of alveolar ridge morphology following full thickness flap reflection.



Figure 2d: CZRAM fixated, graft materials in place (FDBA, DBM putty, and EMD).

graft materials, particularly when vertical augmentation is attempted.¹⁵ Rigid matrices like CZRAM, on the other hand, guarantee the preservation of space and wound stability over the entire area to be augmented throughout the healing process.

Another major advantage of customized ridge augmentation matrices is their precise, patient-specific design, which results in immediate inti-

mate fit within the defect and precludes the need for intraoperative manipulation. This advantage and its clinical implications were described in a study by Sumida et al. comparing commercially-available titanium mesh with customized, additively-manufactured titanium mesh.⁹ They reported a significant reduction of intraoperative time with customized mesh (75.38 vs. 111.9 min-



Figure 2e: Buccal view of re-entry at 8 months. Formation of mature bone up to the intaglio surface of the CZRAM can be observed.

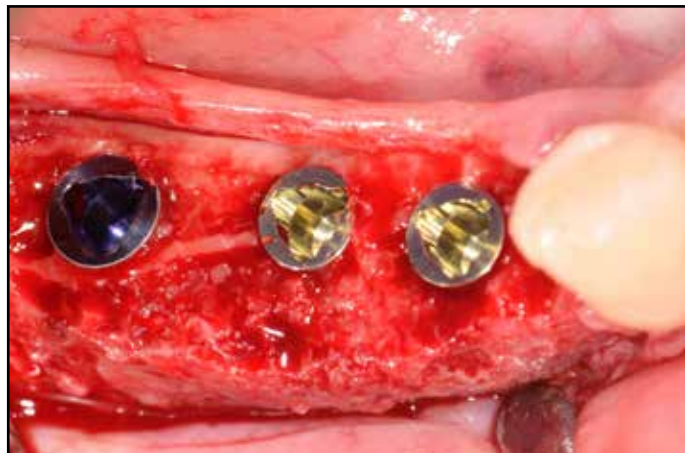


Figure 2f: Implant fixtures placed at sites #28, 29 and 30 according to restorative plan.

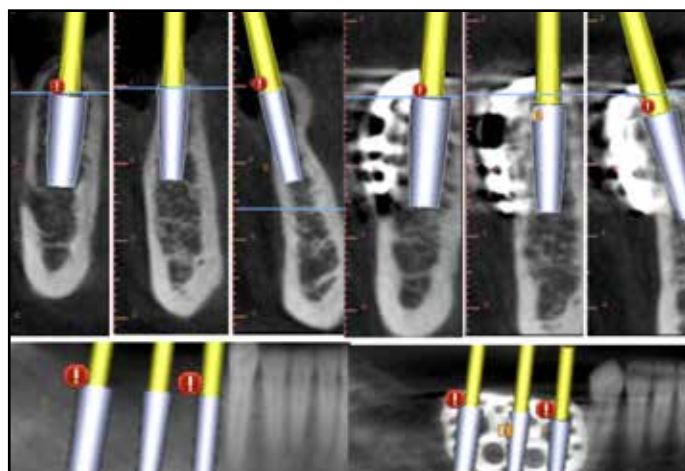


Figure 2g: Pre- (left) and post- (right) grafting CBCT with planned implant positions. Note the complete radiographic bone fill beneath CZRAM.



Figure 2h: Individual screw-retained metal-ceramic restorations at sites #28-30.

utes), and attributed this reduction to the lack of need to trim and adapt customized mesh to the defects intraoperatively. This intimate defect fit also contributed to their ability to fixate the customized mesh with fewer fixation screws than the trimmed, stock titanium mesh. In the present study, both CZRAMs were found to fit intimately to the defects, without ambiguity regarding their

intended fixation position. The specificity of the fit of the matrix ensures that the desired gain in bone occurs in the exact site where it is needed to support the planned implant placement. Also, the precise fit allows for the minimum amount of material to be used, which lessens the size and scope of the surgery required to achieve the desired augmentation. This, in turn, can decrease the risk

of morbidity to the patient and supports a minimally invasive approach to ridge augmentation.

The use of zirconia for fabrication of customized ridge augmentation matrices confers several distinct advantages over the use of titanium. Titanium matrices fabricated through additive methods such as electron beam melting or selective laser sintering require expensive machinery which limits their widespread applicability. Most practitioners or dental labs do not have access to these machines. However, zirconia can be milled to precise specifications from a partially-sintered green body or puck utilizing a standard 5-axis laboratory mill. These mills are common in dental laboratories, and therefore manufacturing protocols involving their use are more widely accessible than those for the aforementioned additive titanium processes. Also, following fabrication, the titanium matrices have a very rough surface that requires polishing before they can be implanted into the patient. This requires additional time and can inadvertently induce changes to the matrix from the original design due to over-polishing or manipulation. In contrast, after milling, the zirconia framework is sintered and the resultant surface is smooth and glass-like, requiring no additional polishing, and this ensures the design specifications are perfectly maintained.

As mentioned in a pilot study utilizing ceramic sheets,¹² the soft tissue response to zirconia appears to be excellent. Neither CZRAM in this report became exposed to the oral cavity through tissue fenestration during the prolonged healing period. Upon removal, the mucoperiosteal flap was easily reflected from the zirconia surface, facilitating removal of the matrix. This is in sharp contrast with the authors' experience using custom titanium matrices fabri-

cated via electron beam melting where despite substantial post-fabrication polishing, surface irregularities seem to result in a robust physical attachment to the overlying soft tissue requiring sharp dissection of the tissue during removal. The result we observed was less post-operative swelling and a shorter course of healing following the removal of the zirconia matrices.

CBCT radiographs obtained one month prior to removal of both CZRAMs in this report suggested complete bone fill to the intaglio surface of the matrices (Figs. 1g & 2g). Clinically, a soft tissue layer with consistency similar to periosteum was noted immediately subjacent to the CZRAM and overlying the regenerated bone upon re-entry. This finding has been reported previously with the use of both custom titanium and zirconia matrices/sheets.^{10,12} While no histologic assessment of newly formed tissues was performed in the two cases in this report, the soft tissue layer forming beneath zirconia sheets used for GBR has previously been shown histologically to consist of connective tissue devoid of inflammatory infiltrate, and was considered to represent newly formed periosteum.¹² The major advantage of the CAD/CAM customized ridge augmentation approach is that a pre-determined, specific amount of bone gain can be achieved that is directly congruous with the requirements of the final implant prosthetic plans. Indeed, both CZRAM cases in this report resulted in bone fill that represented 100% of the clinically anticipated gain based on the CZRAM design.

CONCLUSIONS

Customized ridge augmentation matrices reduce intraoperative time, allow for intimate and precise fit to hard tissue defects and less complicated fixation intra-operatively, and allow

clinicians to precisely control the degree and location of ridge augmentation performed. Zirconia appears to be a safe and effective material to serve as the substrate for these matrices, with several advantages over titanium alloys. Particularly, the ability to manufacture CZRAM using 5-axis dental milling machines represents a major advantage in terms of accessibility to the average clinician. Prospective studies evaluating the volumetric bone gains and clinical out-

comes in larger patient populations are needed to further support the observations of consistent bone regeneration and enhanced soft tissue interactions compared with other materials. ●

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Disclosure

The authors report no conflicts of interest with anything mentioned in this article. The contents of this article are the opinions of the authors and do not reflect the opinions of the United States Department of Defense, the United States Navy, nor the United States Navy Post-Graduate Dental School.

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Repair of Dental Implant Induced Inferior Alveolar Nerve Injuries with Dehydrated Human Amnion-Chorion Membranes: A Case Series

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Abstract



Dental implant treatment has become a common treatment modality for the replacement of missing teeth. As the number of implants placed annually continues to increase, so too has the incidence of iatrogenic nerve damage secondary to implant placement. Over the past decade, a handful of conservative protocols have been proposed for the treatment of neural maladies following the placement of dental implants with varying degrees of success. Recent advances in biologic growth factor technology have introduced products that may serve as adjuncts in the treatment of neural injury. Medical literature has documented a vari-

ety of cases in which placentally derived amnion-chorion membranes were used for the treatment of neural issues with promising results. The aim of the current paper is to document a treatment protocol used by the author for the treatment of iatrogenic neural maladies secondary to the placement of dental implants. A series of 5 cases are presented in which the author utilized amnion-chorion membranes as an adjunct for treatment of damaged inferior alveolar nerves. In all cases, significant improvement was documented. While these results are encouraging, case controlled studies with larger patient populations are needed to verify these results.

KEY WORDS: Dental implants, nerve injury, amnion, chorion, iatrogenic

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INTRODUCTION

As more dental implants are placed by an ever-increasing number of practitioners with varying degrees of skill and experience, it is inevitable that the number of complications associated with implant treatment will rise. This is just as true today as it was more than 20 years ago when Worthington predicted the same.¹ One of the most common and serious complications of dental implant treatment is iatrogenic damage to the mandibular branch of the trigeminal nerve. The incidence of nerve injury following dental implant treatment is extremely variable with reports ranging anywhere from 0-44%.²⁻⁵ Furthermore, the degree of nerve injury following dental implant treatment is likewise highly variable.²⁻⁵ Treatment of neural injury following dental implant placement remains a challenge, evidenced by the fact that few published studies have defined standardized treatment protocols for the majority of dentists that do not specialize in nerve repair.⁶⁻¹²

Over the past decade, a plethora of published articles have documented the efficacy of various growth factors in surgical dentistry.¹³⁻¹⁶ Some of these growth factors, such as placental allografts, have been utilized in medical studies for nerve repairs and adjuncts to reduce the incidence of neural injury following various surgical procedures.¹⁷⁻²⁶ To date, no known dental studies have documented the use of growth factors for the treatment of nerve injuries sustained during the course of dental implant treatment. Accordingly, the purpose of the current case series is to document cases in which placental growth factors were incorporated into a systematic protocol for the treatment of iatrogenic neural injuries following the placement of dental implants.

METHODS

Based on studies documenting the use of placental derived growth factors for the treatment of non-dental, medically based neural maladies, a protocol was initiated in the private practice of the author for the treatment of iatrogenic nerve injuries related to the placement of dental implants. Upon presentation of such injuries, the following treatment was enacted (Table 1): 1) mapping of neural deficits with commonly used subjective methods²⁷ including pin prick test²⁸ and direction of movement test^{9,28} 2) removal of the suspected offending item if possible (ie. Dental implant penetrating or in close proximity to the mandibular canal)²⁹ 3) irrigation of the implant osteotomy with 4mg/ml Dexamethasone solution^{9,10,21} 4) placental derived amnion-chorion membrane (BioXclude, Snoasis Medical, Denver, Colorado, USA) soaked in 4mg/ml Dexamethasone solution²¹ for 2 minutes and placed into the implant osteotomy directly upon the site of the suspected neural injury¹⁷⁻²⁶ 5) collagen tape soaked in 4mg/ml Dexamethasone solution placed on top of the amnion-chorion membrane 6) bone allograft (Maxxeus, Community Tissue Services, Dayton, Ohio, USA) hydrated with normal saline placed on top of the collagen tape 7) dry amnion-chorion membrane placed on top of the bone allograft and left exposed to the oral environment. The external layer of amnion-chorion allograft is then hydrated with blood or saline and tucked under the adjacent gingival tissue in a fashion similar to previously published studies in which this material was used for extraction site preservation³⁰ 8) post-operative narcotics as needed; 9) post-operative large dose non-steroidal anti-inflammatory drug (NSAID) (800mg Ibuprofen, three times orally per day for 10

Table 1: Amnion-Chorion Protocol

1. Pre-surgical subjective nerve mapping of affected sites.
2. Repositioning or removal of any irritant in close approximation to the neurovascular bundle.
3. Rinse osteotomy and affected nerve with 4mg/ml dexamethasone solution.
4. Place dexamethasone hydrated amnion-chorion membrane into osteotomy down to the level of the affected nerve.
5. Place collagen tape soaked in dexamethasone over amnion-chorion membrane.
6. Place bone allograft hydrated with saline into osteotomy over collagen tape.
7. Place dry amnion-chorion membrane over bone allograft.
8. Place patient on post-surgical systemic antibiotics (Medrol dose pack).
9. Place patient on post-surgical NSAIDs (800mg ibuprofen, TID).
10. Place patient on post-surgical narcotics as needed.
11. Place patient on post-surgical antibiotics.
12. Cryotherapy ice applied to surgical site.
13. Post-surgical subjective nerve mapping of affected sites.

days)^{9,11} 10) post-operative tapering Medrol systemic corticosteroid dose pack^{9,11} 11) post-operative systemic antibiotics taken orally 12) ice pack application to the surgical site intensely for the first 24 hours after surgery and then episodically for the next 3 days⁹ 13) follow-up visits performed at 10 days, 30 days, 60 days, 90 days, 180 days, and yearly. At each follow-up visit, the aforementioned neurosensory tests and mapping were repeated and recorded. When applicable, dental implants were replaced at the sites of the prior neural injury or in other sites as indicated by the patients' treatment plans.

RESULTS

From 2011 to 2015, a total of 5 patients presented to the private office of the author with chief complaints of iatrogenic nerve injury following the placement of dental implants at other offices. The average length of time from injury to treatment was 6.25 years (range 1 – 16 years). Cumulatively, a total of 9 iatrogenically placed dental implants were removed and their corresponding osteotomy sites treated with the amnion-chorion protocol. Nine of the ten dental implants partially penetrated or compressed the mandibular canal while one of the dental implants penetrated the



Figure 1: Panoramic radiograph of iatrogenically placed implants at sites 18, 19, 20.

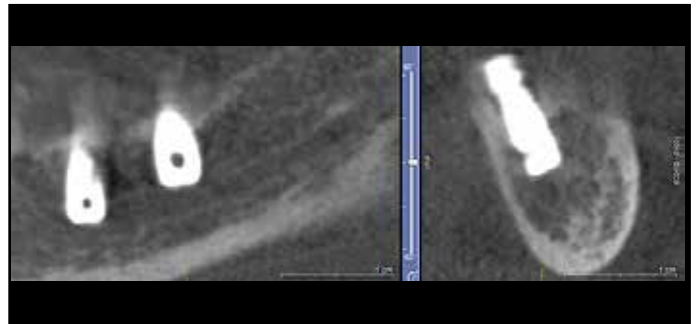


Figure 2: Radiographic image of iatrogenically placed implant at site 18.



Figure 3: Radiographic image of iatrogenically placed implant at site 19.

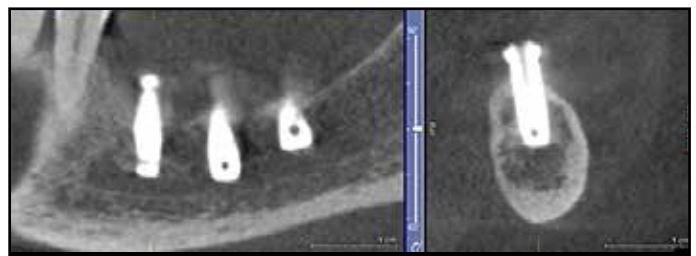


Figure 4: Radiographic image of iatrogenically placed implant at site 20.



Figure 5: Iatrogenically placed dental implants removed and injured left inferior alveolar nerve treated with amnion-chorion protocol.

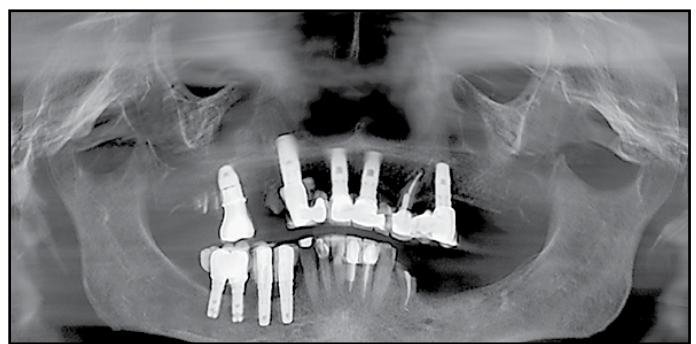


Figure 6: Panoramic radiograph of iatrogenically placed implants at sites 28, 29, 30

mental foramen (Figures 1-13). Following dental implant removal and treatment, three of the five patients were treated with the All-On-4™ style dental implant protocol and two patients had the offending implants replaced in the same exact spot with a shorter implant. During follow up

appointments now extending up to 7 years post-treatment, each patient has reported significant and sustained improvement in their neurosensory recovery. With each patient, the most notable and appreciable neurosensory improvements occurred in the first 180 days after treatment.



Figure 7: Radiographic image of iatrogenically placed implant at site 28.

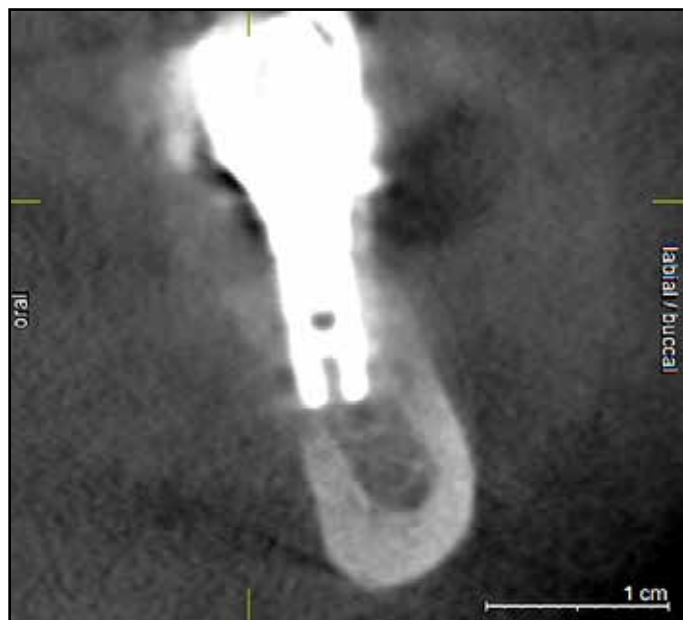


Figure 8: Radiographic image of iatrogenically placed implant at site 29.



Figure 9: Radiographic image of iatrogenically placed implant at site 30.

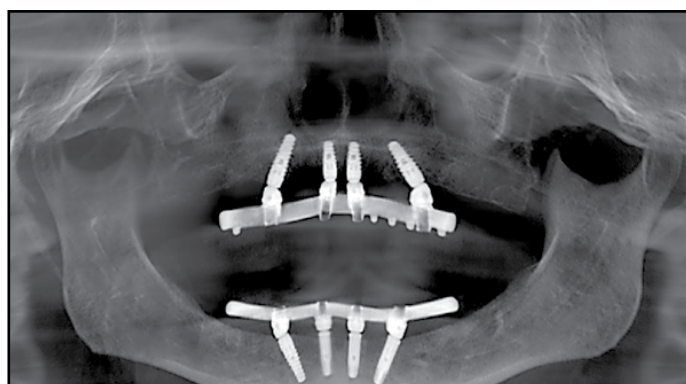


Figure 10: Iatrogenically placed dental implants removed and injured right inferior alveolar nerve treated with amnion-chorion protocol.

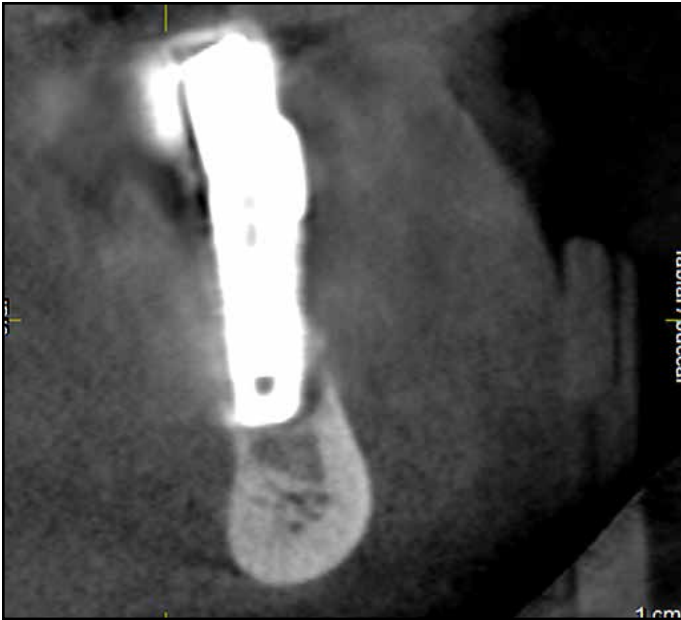


Figure 11: Iatrogenically placed dental implant penetrating mental foramen.

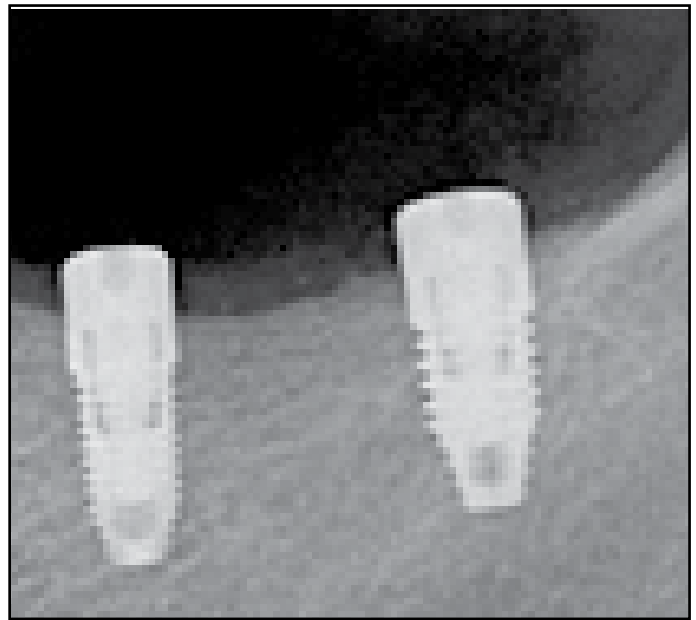


Figure 12: Iatrogenically placed dental implant (right) penetrating mandibular canal.



Figure 13: Radiographic image of iatrogenically placed implant at site 30.

Over follow-up periods ranging from 3 to 7 years, no patients have reported any regression in the improvements attained following treatment of their neural maladies. Furthermore, at no point during treatment or follow-up did any patient report any worsening of their neurosensory symptoms.

DISCUSSION

Neurosensory disturbances following the placement of dental implants are common with up to 73% of dentists encountering such issues in during the course of their practice.⁹ The inferior alveolar nerve consistently ranks as the nerve most commonly affected by the placement of dental implants with rates of altered sensation reaching as high as 43.5%.³¹ Accordingly, iatrogenic damage to the inferior alveolar nerve following the placement of dental implants is one of the most common dental malpractice claims.³² Neurosensory disturbances of the inferior alveolar nerve

Table 2: Misch and Resnik⁹ Treatment Protocol

1. Pre-surgical subjective nerve mapping of affected sites.
2. Repositioning or removal of any irritant in close approximation to the neurovascular bundle.
3. Topical application of 4mg/ml dexamethasone solution.
4. No bone graft materials placed into osteotomy site.
5. Cryotherapy ice applied to surgical site for one week.
6. Place patient on 6-day post-surgical regimen of oral dexamethasone.
7. Place patient on post-surgical NSAIDs (600-800mg, TID for up to 3 weeks).
8. Post-surgical subjective nerve mapping of affected sites.

range from transient to permanent with varying degrees of intensity depending on the etiology of the cause. Temporary and lower grades of neural disturbances are sometimes seen with non-iatrogenic post-surgical healing. Post-surgical bleeding, edema, and/or hematoma occasionally cause nerve compression resulting in paresthesia that typically resolves spontaneously over time.³³ A 2016 meta-analysis of the incidence of altered nerve sensation after mandibular dental implant surgery indicated that up to 91% of patients would return to “normal sensation” within one year of surgery when damage to the inferior alveolar nerve was non-catastrophic.³³ Over the past decade, a handful of protocols have been proposed to treat and conservatively manage neurosensory disturbances following dental implant treatment. In 2010, Misch and Resnick⁹ proposed treating mandibular neurosensory impairment with a combination of implant removal, irritant removal, topical steroid application, systemic corticoste-

roids, NSAIDs, and cryotherapy (Table 2). In 2011, Juodzbaly et al.¹¹ proposed the IANIDIS protocol for dental implant related impairment of the inferior alveolar nerve. The IANIDIS protocol incorporated implant and irritant removal, topical steroid application, systemic corticosteroids, NSAIDs, diuretics, vasodilators, antihistamines, and B-group vitamins (Table 3). In 2013, Kim et al.¹² proposed a conservative treatment protocol (Table 4) for management of dental implant induced inferior alveolar nerve injury that included implant and irritant removal, systemic corticosteroids, vitamin B-12, anti-convulsants, low dose NSAIDs, and heat therapy. Of these treatments, the IANIDIS protocol showed neurosensory improvement in all patients after 3 months while the protocol of Kim et al. showed no improvement in nearly 70% of treated patients. One significant difference of note between the Kim et al. and IANIDIS study of Juodzbaly et al. is the time elapsed between inferior alveolar nerve injury

Table 3: IANIDIS¹¹ Treatment Protocol

1. Confirmation of injury with patient.
2. Identify related risk factors.
3. Identify likely etiologic risk factors.
4. Pre-surgical subjective nerve mapping of affected sites.
5. Repositioning or removal of any irritant in close approximation to the neurovascular bundle.
6. Topical application of 4mg/ml dexamethasone solution.
7. Place patient on post-surgical NSAIDs (400-800mg, TID for 1-3 weeks).
8. Place patient on 6-day post-surgical regimen of oral dexamethasone.
9. Place patient on post-surgical diuretics for 5 days.
10. Place patient on post-surgical vasodilators for 10 days.
11. Place patient on post-surgical antihistaminic drugs.
12. Place patient on post-surgical B-group vitamins.
13. Post-surgical subjective nerve mapping of affected sites.

and neural treatment initiation. While all but one patient in the IANIDIS study were treated within 10-52 hours of neural injury, the mean interval between nerve injury and treatment in the Kim et al. study was 10.91 months. This significant difference in time between neural injury and treatment initiation is a possible reason for the vastly different outcomes between these two studies. The work of Khawaju and Renton³⁴ may support this statement as their study suggested that early treatment within 36 hours of dental implant related neural injury could greatly minimize post-surgical neuropathy.

While mild neurological deficits of the inferior alveolar nerve may occur secondary to iat-

rogenic placement of dental implants, more severe neurological complications may occur as well. Most cases of advanced neuropathy following the placement of dental implants tend to be iatrogenic in nature and are rarely seen with non-iatrogenic placement of dental implants. In some cases, overpreparation of the implant osteotomy may lead to drill penetration into the mandibular canal.^{35,36} Juodzbalys et al.¹⁰ described 5 degrees of implant drill penetration into the mandibular canal that could result in varying severity of damage to the inferior alveolar nerve. It is important to note that dental implant drills are often longer than their corresponding depth markings and may

Table 4: Kim et al.¹² Treatment Protocol

1. Pre-surgical subjective nerve mapping of affected sites.
2. Repositioning or removal of any irritant in close approximation to the neurovascular bundle.
3. Place patient on post-surgical Prednisolone prescription for 7 days.
4. Place patient on post-surgical NSAIDS (“aspirin” TID).
5. Place patient on post-surgical B-group vitamins.
6. Place patient on post-surgical Neurontin TID.
7. Place patient on post-surgical narcotics as needed.

mislead inexperienced dental implant surgeons to overprepare dental implant osteotomies to excessive depths.³⁷ Just as overpreparation of the implant osteotomy can damage the inferior alveolar nerve, placement of the actual implant fixture into the mandibular canal can do the same. Six degrees of dental implant penetration into the mandibular canal have been noted.¹⁰ In cases where dental implants penetrate the mandibular canal, removal of the fixture is advocated.^{34,37,38} Neurosensory deficits of the inferior alveolar nerve will vary depending on the amount of drill or implant penetration into the mandibular canal. While it does happen in cases of gross negligence, complete drill or implant transection of the inferior alveolar nerve is rarely seen due to clinicians following standard peri-operative dental implant protocols of acquiring and analyzing both pre-operative and intra-operative radiographic measurements relative to the mandibular canal. In the rare cases of known complete nerve transection, immediate referral to a nerve repair specialist is recommended as conservative treatment of such

injuries has minimal positive effect.⁹ Because the majority of implant surgeons follow standard peri-operative treatment protocols, if iatrogenic complications arise, they tend to be related to partial penetration or near penetration into the mandibular canal. Partial or near penetration into the mandibular canal may occur due to drill slippage, varying degrees of bone density coronal to the mandibular canal, improper radiographic angulations, and patient movement.^{35,36} Such penetration injuries may result in a variety of possible injuries including complete resection, crushing, stretching, or entrapment injuries to the inferior alveolar nerve.⁹ Because the nerve fibers are not completely severed in such scenarios, conduction capability remains and less invasive treatment remains an option. When initiated early, typically within 36 hours of injury, prognosis is generally good. In a systematic review and meta-analysis of altered sensation following mandibular dental implant surgery, Lin et al. noted that 91% of affected patients regained “normal sensation” one year after treatment

while only 3% of affected patients reported continued altered sensation.³³ Gregg et al. noted that 8% of patients with dental implant related inferior alveolar nerve damage had permanent neurosensory deficits.⁴ Juodzbaly et al. noted that “all patients were successfully treated” for implant induced neural impairment with the IANIDIS protocol.¹¹ However, careful analysis of the data in the Juodzbaly et al. article reveals that 8 of the 16 patients in the study “completely healed”, 7 of the 16 patients had moderate sensory alteration, and 1 of the 16 patients continued to have severe sensory alteration after treatment. Casual skimming of this article or just reading the abstract may lead one to believe that this treatment protocol cured all affected patients as the article states that all patients in the study “were successfully treated with the IANIDIS protocol.” In reality, while all patients in the study did show improvement, only 50% of the patients fully recovered neurosensory function. It is important to note that the remaining 50% of patients treated for iatrogenic dental implant damage to the inferior alveolar nerve retained some degree of neurosensory impairment after treatment. These findings are actually in line with the findings of Kim et al. who noted that 70% of patients with inferior alveolar nerve damage showed no improvement with non-surgical neural treatment.¹²

When treating implant induced neural injuries, published literature suggests that time is of the essence for improved chances of recovery. Khawaja and Renton³⁴ suggests a magic window of 36 hours post dental implant nerve injury while Juodzbaly et al.¹¹ showed benefits when treating patients within 52 hours of injury. Kim et al.¹² treated patients nearly 11 months

after dental implant induced nerve injury and noted that only 16.4% of these patients experienced improved neurosensory outcomes. The patients treated in the current case series had an average of 6.25 years elapsed from the time of iatrogenic dental implant injury to presentation for treatment. Although the patient population in the current report is very small, it is interesting to note that all patients treated with the amnion-chorion protocol experienced significant improvement in neurosensory outcomes despite the very long interval between nerve damage and nerve treatment. The amnion-chorion protocol utilized for the treatment of these patients is based on the protocols initially proposed by Misch⁹ and Juodzbaly et al.¹¹ The concepts of irritant removal, localized and systemic anti-inflammatory treatment, and cryotherapy are retained with the addition of localized application of placental growth factor.

Placental growth factor was specifically chosen for this protocol based on published medical studies that have shown positive results when the material was used for nerve repair. Animal studies involving the complete transection of sciatic nerves have shown dramatic improvements in physical, electrophysiological, and histologic assessments when amnion membranes were applied to the damaged nerve.²¹⁻²⁶ Sadraie et al. found that physical movement was dramatically improved by 8 weeks in limbs of damaged nerves that were treated with amnion and steroid application.²¹ These results were consistent with multiple other studies that found similar physical improvements within 2-12 weeks of neural treatment.^{23,24,26} Concerning electrophysical results, numerous studies show improved neural conduction amplitudes 8-12

weeks after amnion treatment.^{26,39,40} Finally, multiple studies show histologic improvements in damaged nerves treated with amnion. Meng et al., Zhang et al. Mohammadi et al., and Sari et al. all found significantly increased numbers of myelinated axons, less inter-axonal fibrosis, improved axonal diameters, improved myelin thickness, and improved neurite densities when damaged nerves were treated with amnion.^{24-26,40,41}

The encouraging results of these animal studies for amniotic neural treatment have been tested and confirmed in human subjects. Utilization of amnion membranes has been used in a number of studies evaluating prostatectomy treatment. In a 2015 case controlled study by Patel et al.,¹⁸ dehydrated human amnion-chorion allograft was wrapped around the neurovascular bundle during robot assisted radical prostatectomy. Traditionally, radical prostatectomy has been associated with long convalescent periods due to incontinence and impotence caused by inflammatory responses secondary to traction of the neurovascular bundle.^{19,20} In this study, patients treated with amnion-chorion had faster returns to continence and potency compared to conventionally treated patients. A 2017 study by Pinies et al.¹⁷ also evaluated the use of dehydrated human amnion-chorion allograft in the treatment of robot assisted radical prostatectomy. This study with a large experimental 235 patient population, was compared to a control group of 705 patients. While the controlled patients received traditional treatment, the experimental group had amnion-chorion grafts applied to the neurovascular bundle at the time of surgery. Measures of potency, the ability to achieve and maintain erections firm enough for sexual intercourse,

were significantly lower in the experimental group. While both of these studies showed significant benefits with the use of amnion-chorion membranes, neither study showed any detrimental effects with use of the material.

In the present study, multiple patients with longstanding damage to the inferior alveolar nerve were treated with minimally invasive protocols that employed the benefits of amniotic membranes. Following removal of the suspected irritants, the damaged nerves were treated with a combination of anti-inflammatory medications and amniotic membranes. In all cases, patients experienced significant improvements in neurosensory function. Multiple studies indicate that treatment of damaged inferior alveolar nerves should occur within 36-52 hours to provide the best chance of recovery and that minimal improvement may be achieved with long-standing nerve damage.^{11,34,42,43} The patients in this report had nerve damage of an average of 6.25 years duration prior to the initiation of neural treatment. How then, did these patients experience improvements to neurological function? Prior studies involving irritant removal and anti-inflammatory treatment have found minimal improvement to neurosensory deficits when the damage was long-standing.¹² The current study, however, found results that differed from these findings. The most significant variable between the protocol in this paper and those previously published is the addition of amnion-chorion placental based growth factors. Was it the addition of amnion-chorion that allowed for the improved neurosensory results for the patients presented in this report? As this is simply a retrospective observational report and not a prospective case-controlled

study, it is impossible to say. However, the documented benefits of amniotic membranes for the treatment of nerve damage in multiple other studies and the promising findings of the current paper suggest that this is a strong possibility.

The mechanisms by which amniotic membranes possibly aid neural recovery is multifaceted. Inflammatory reduction is one of the initial ways that amnion may aid neural recovery. The anti-inflammatory effects of placental membranes are well documented. Solomon et al.⁴² cultured human corneal limbal epithelial cells on either freshly frozen and thawed human amniotic membrane or tissue culture plastic. These cells were plated on amnion tissue and assayed for the expression of inflammatory cytokines. The cultures demonstrated that cryopreserved amnion directly suppressed the expression of pro-inflammatory cytokines at the protein and mRNA levels. In another study of transepithelial photorefractory keratectomies in rabbits, the application of fresh amnion showed a significant reduction in the number of leukocytes and less keratocyte death compared to controls, demonstrating the anti-inflammatory effects of amnion.⁴³ When studying the effects of amniotic membrane on corneal wounds in rabbits via histopathologic, proteinase assay, and zymography, Kim and colleagues⁴⁴ reported decreased polymorphonuclear leukocyte (PMN) infiltration, decreased macrophage chemotaxis, and inhibited proteinase activity at treated sites. In reviewing the use of amniotic grafts for ocular surface reconstruction, Tseng⁴⁵ noted the anti-inflammatory effects of the graft as did Güell et al.⁴⁶ in their treatment of symptomatic bulbous keratopathy. Koob and colleagues have performed multiple studies evaluating amniotic

tissues such as dHACM for anti-inflammatory modulators via enzyme linked immunosorbent assays (ELISA) with significant findings.^{47,48} These numerous studies demonstrate the significant anti-inflammatory effects of placental membranes. So how do these help with neural damage? Upon being injured, the inflammatory response often induces conduction blocks in affected nerves causing temporary paresthesia. Continued or excessive edema may eventually lead to segmented demyelination of affected neural sheaths and axonal damage, resulting in longer bouts of neurosensory deficits.⁴⁹ Certain inflammatory factors such as phospholipase are thought to be involved in the process of myelin degeneration.⁴¹ Inhibition of phospholipase and other inflammatory factors is the reason for localized and systemic administration of corticosteroids following neural injury.^{9-11,21} The addition of amniotic membranes to the sites of neural injury add to the anti-inflammatory effect.

In cases of injury without complete nerve transection, as was the case with the patients in this report, impaired neural transmissions may result in sensory disturbances. If the extraneural tissues are damaged, placental allograft tissues may act as a substrate for axon growth.⁴⁹ Multiple studies have shown amnion may be used as a peripheral nerve conduit and aid neural regeneration.⁵⁰⁻⁵³ The histomorphometric studies amnion treated transected nerves in rats have shown robust axonal healing compared to non-amnion treated sites.²¹⁻²⁶ Upon removal of the source of irritation, placing amniotic membranes at the site of damage to the inferior alveolar nerve may indeed follow these same patterns and aid in the healing of damaged neural tissue.

CONCLUSION

As more dental implants are placed by dentists with varying levels of training, skill, and experience, the risk of iatrogenic damage to adjacent nerves such as the inferior alveolar nerve remains a concern. The application of growth factors such as amnion-chorion to existing conservative protocols provides a minimally invasive option for the treatment of nerve damage. The promising results of the current report, in addition to the positive results of previously published animal and human studies in medical literature, provide basis for further exploration of the use of placental tissues for repair of nerve damage secondary to the placement of dental implants. Case controlled animal studies with physical, electrophysical, and histomorphometric analysis would provide valuable insight into the use of this material for the treatment of dental implant induced neural injuries. ●

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Disclosure

Dr. Holtzclaw has a financial interest in Snoasis medical and serves as a clinical advisor for the company.

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Full Mouth Rehabilitation with Immediate Implants and Fixed Prosthetics: A Surgeons' Prospect and Critical Review

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Sahitya. C, BDS • Nirosha Shetty, BDS

Abstract



Dental implants have become the preferable choice of restoring the missing teeth for the patient, which made the dental professionals look for the best implant systems, advanced research, and techniques for constant improve in the quality of patients life. Dental implants can be placed immedi-

ately after the extraction – “Immediate implants” or can be placed after complete healing of the extraction site – Delayed Implants. This article is about the author’s experience with full mouth immediate implants and explained the critical factors that influenced the outcome.

KEY WORDS: Dental implants, prosthetics, oral surgery, immediate placement, treatment planning, case report

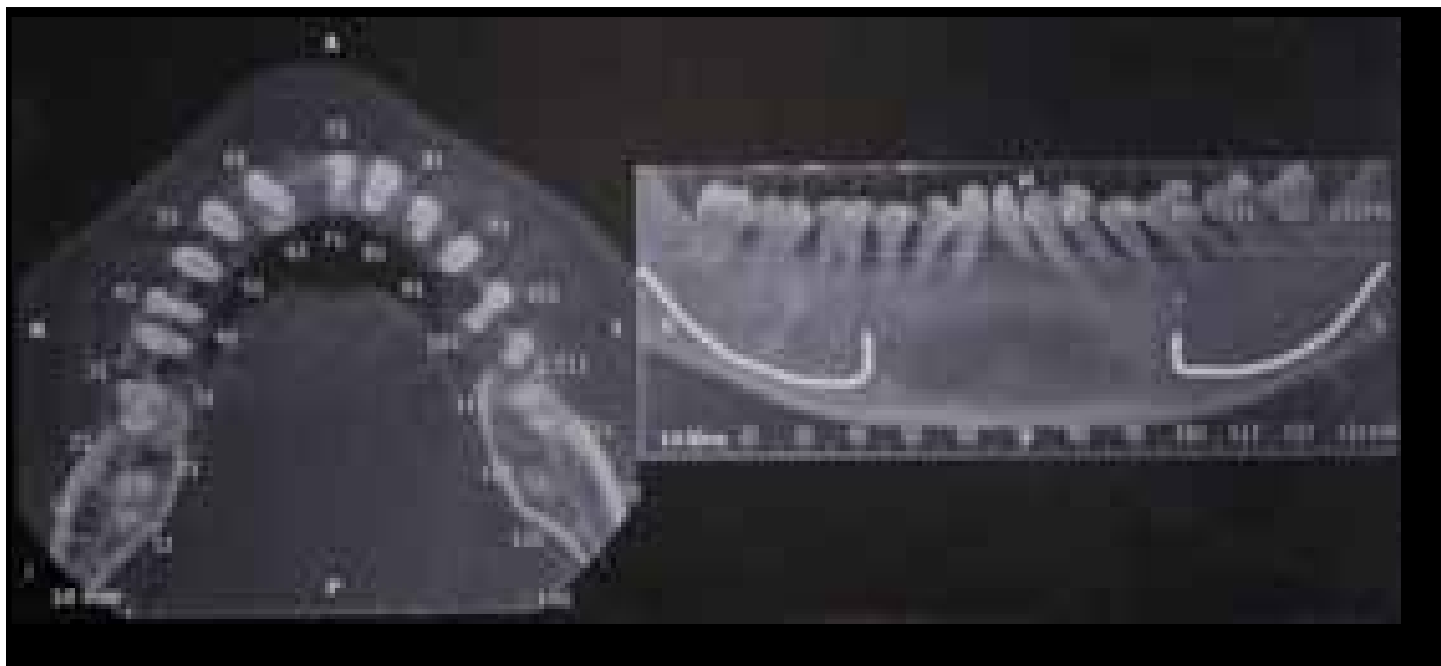


Figure 1: Pre-surgical radiographic image.

INTRODUCTION

In recent years, dental implants have proven to be a popular choice for patients compared to traditional conventional prosthetics. Literature shows adequate evidence of successful immediate implant function for single or full mouth prosthetics, provided patients are carefully assessed and planned.¹⁻³ The surgeon's role is crucial for successful osseointegration of dental implants. However, the surgeon must be visionary and think critically for successful prosthetic outcomes.

CASE REPORT

The present article presents a 40 year old female, with no medical problems, who we diagnosed with chronic generalized periodontitis after observation of grade 2 to 3 mobility of the remaining dentition and significant bone loss in both arches. With all aseptic precautions, the patient was planned for full mouth extraction, alveo-

plasty and immediate implant placement under local anaesthesia. After removal of the remaining diseased teeth, the sockets were well irrigated with Betadine and saline. Optimal implant length and diameter were selected with the help of 3D CBCT implant planning (Figures 1, 2). Maxillary implants (Standard Mydril plus Equinox implant system) were placed first followed by mandibular implants. Eight implants in each arch were placed just below the crestal level and no bone grafts were required. Gingival tissue was then trimmed and primarily closed with sutures. Secondary surgery was planned after four months of healing followed by the fixed prosthesis. Interim dentures were given to the patient until the final prostheses were delivered. Custom abutments were used to orient the prostheses with implant angulation (Figure 3). All the steps of prosthetic phase (i.e., closed tray fixture level impressions, verification jig, jaw relations, bite

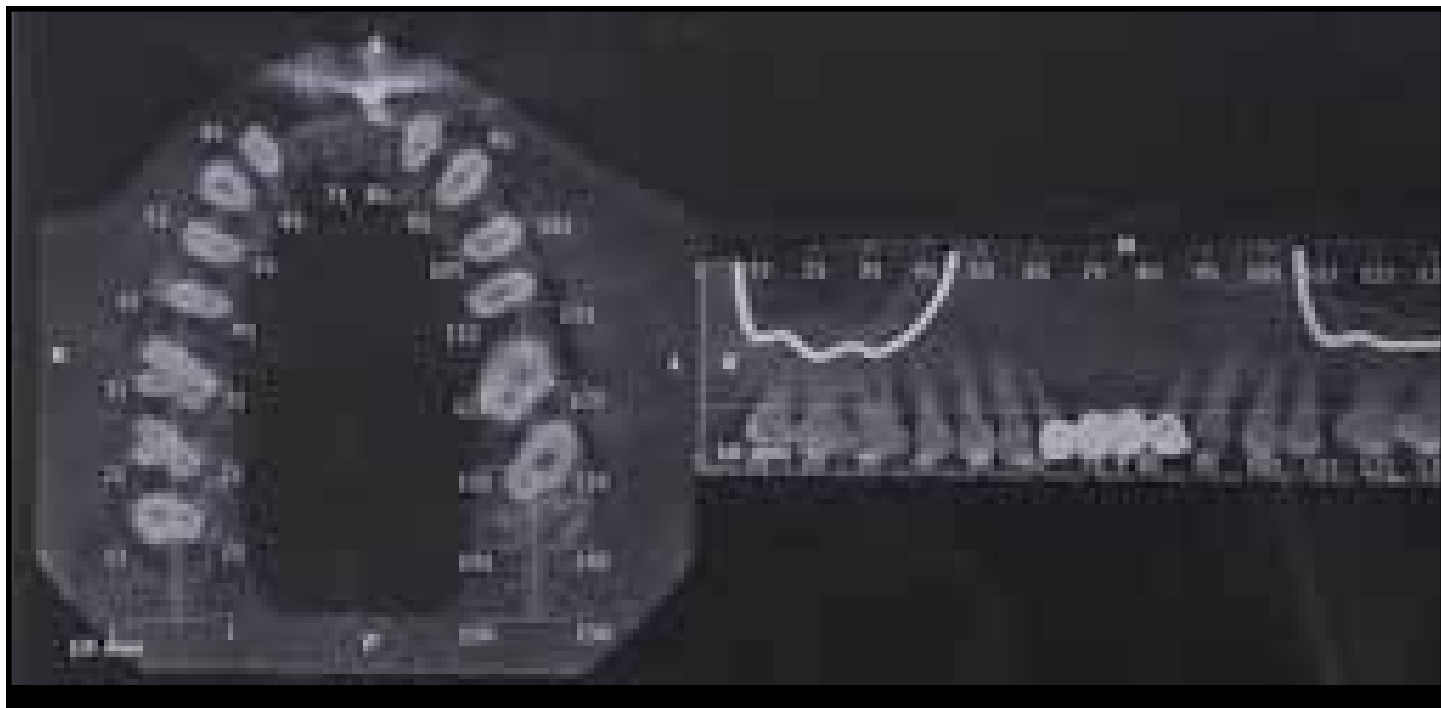


Figure 2: Pre-surgical radiographic image.



Figure 3: Intra-oral image of dental implant abutments in place.



Figure 4: Post-surgical radiographic image.

registration followed by metal and bisque try-in, etc.) were accomplished before the delivery of the laser porcelain fused to metal cement retained implant supported fixed prosthesis (Figures 4, 5).

DISCUSSION

Full mouth immediate implants can be a challenge for the surgeon and prosthetic outcomes must always be considered. Critical factors that a surgeon needs



Figure 5: Final implant supported fixed prostheses.

to consider at different stages of immediate full mouth implants include the following:

Patient Evaluation

Review the patient medical history and look for any limitations and necessary precautions to take during surgery. Evaluate the radiographs. Look for quality of bone and periapical lesions or any pathology. Discuss and document patient expectations and clearly explain to the patient about the choice of prosthesis and total estimated cost. Other important aspects we need to consider are motivation and preparation of the patient mentally for a long surgical procedure, possible additional appointments that may be necessary, and possible complications. The patient must be educated about the importance of oral hygiene methods, implant maintenance and follow up during the initial visits. Detailed informed consent must be taken.

Treatment planning

3-dimensional cone beam computed tomography (3D CBCT) scans help in treatment planning. Various advantages of the scan include in-depth analysis of bone density and volume,

anatomical landmarks and implant selection. Surgical guides can be constructed with help of the CBCT scan and diagnostic casts that can be made using 3D printing technology. Surgical template preparation is an important consideration for selecting the position as well as proper alignment of implants. Preoperative estimation of buccal cortical height, thickness and the position of the implant relatively is an important factor determines the success of immediate implants. We have experienced the consequences of improper treatment planning resulted in an expense of time, energy, and money of the clinician as well as the need for additional appointments for the patient.⁴ It is better to have a case discussion coordinating the surgeon, prosthodontist and laboratory person before appointment for surgery.

Intraoperative factors

In the present case, as in all cases, time management and patient comfort are a concern. Atraumatic extraction preventing damage to adjacent bone is always desired. Following tooth removal, careful elimination of granulation tissue is paramount for future implant success. After tooth removal and prior to implant placement, measuring the 3D CBCT scan and the length of the extracted roots help in estimating the depth of pilot drill. In the present case, it took three hours for extraction, followed by implant placement and primary closure. The surgery could have been faster and implant placement more accurate if surgical guides was used. Mean insertion torque value for the implants was 45 Ncm. A minimum torque limit of at least 20Ncm is required for the immediate implants to survive.^{6,7,8} It is essential to check the implant stability coefficient (ISQ) to decrease the chances of implant failure. In cases of inadequate

bone thickness, guided bone regeneration (GBR) with bone graft and membrane may result in a better outlook of the bone morphology and implant to crest relation by the end of surgery. Implants placed below the bone crest may require minor alveoplasty around the platforms to allow for complete abutment seating without impinging on the bone. Observe for any active bleeding, hematoma formation, especially in sublingual region during and after surgery. Post-surgical antibiotics are often a good consideration. In the present case, a dose of Dexamethasone 4mg was administered immediately after surgery and postoperative oral antibiotics and analgesics (NSAIDs) were advised for five days. It is advisable to take a radiograph, preferably a CBCT scan, immediately after surgery to verify the implant bone relation.

Prosthetic Phase

Proper alignment of implants greatly influences the prosthetic phase. In the present case, we have observed the failure of two implants out of sixteen, which was due to be improper alignment of implants with thin buccal plate and lack of primary stability. Custom abutments were made to attain alignment of abutments and ridge parallelism. Starting from implant placement until the abutment and crown fixation (screw retained implants), we need to be very cautious about applied torque, always adhering to manufacturers' recommended values. The clinician must be thorough with all attachments and mechanics of the implant system they are using. The limitations in torque levels of abutment and prosthetic screws for different implant systems must be followed. Limit the number of times the abutment screw is loosened and tightened. We recommend limiting multi-unit abutment screw removal to no more

than five times prior to screw replacement. In the present case, we encountered screw breakdown of the mandibular posterior implant and could not retrieve smoothly because of lack of expertise. However, we managed by making a post to retain the abutment for the implant. We have to accept that this is an extra cost of time and money to the clinician and an increase in the number of appointments for the patient. Fabrication of implant supported prostheses is challenging clinically as well as technically. Careful attention is required during every step of fabrication including maintaining rapport between clinician and the technical team.

CONCLUSION

Immediate implants can be a successful treatment option in full mouth rehabilitation. Proper planning, in depth knowledge of anatomy and biomechanics of the desired implant system is very important. Complications do occur. We should learn from them and challenge ourselves to achieve better outcomes. ●

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Disclosure

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

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Extra-Short Implants for Rehabilitation of Atrophic Ridges: A Retrospective Study with up to 5 Years of Follow-Up

Dr. Luis Eduardo Benevides de Moraes¹

Dr. Nathalia Benevides de Moraes² • Dr. Eduardo José de Moraes³

Abstract

BACKGROUND: The bone augmentation techniques suggested by literature including onlay bone grafts, guided bone regeneration (GBR), maxillary sinus elevation and distraction osteogenesis (DO) have been proved effective in regaining bone volume. However these approach techniques can present multiple complications and morbidity after surgery, with prolonged treatment duration and extra costs. Short implants could be a simpler, cheaper and faster alternative than augmentation procedures, if they can be shown to result in similar success rates. Recently the use of extra-short implants (6 mm) has been reported with good outcomes⁵⁻⁸ and promising results have been published in comparison with alveolar bone augmentation techniques. The aim of this clinical retrospective study was to evaluate the survival rate of extra-short implants in different clinical situations with a minimum follow-up 12 months.

MATERIALS AND METHODS: Extra-short implants with 6.0 mm height were placed in patients of authors clinic to restore by mul-

tiple partial or total prostheses in the anterior and posterior regions of maxilla and mandible areas affected by high bone resorption.

RESULTS: Between February 2009 to October 2013 a total of 302 implants were placed in 98 patients (67 women and 31 men) with mean age of 68 years (range: 54–82 years). The total of 302 implants were placed and distributed in the anterior region (12 %) and posterior region (88 %) of maxilla and mandible. Two hundred and eighty-eight implants were restored by multiple partial and total prostheses (96.8%). These 288 implants, 8 (2.8 %) were submitted to immediate loading and 280 rehabilitated after a period of 4 and 6 months. After 1-5 year follow-up, 288 implants are in function and 14 implants have been lost, achieving a survival rate of 95.4 %.

CONCLUSION: The results of this study suggested that extra-short implants presented a good survival rate and therefore should be regarded as a predictable solution for the rehabilitation of highly resorbed mandible and maxilla.

KEY WORDS: Dental implants, short implants, success rate

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INTRODUCTION

Rehabilitation of total and partially edentulous patients with removable dentures can be an unsatisfactory treatment option, creating discomfort and affecting ability to eat and speak.¹ An implant-supported prosthesis could be the ideal option, although alveolar resorption can result in the insufficient bone volume. Therefore, reduced alveolar bone height due to post-extraction atrophy and maxillary sinus pneumatization becomes a major challenge, especially in posterior regions. The insufficient residual bone height not only limits the application of implant therapy, but also increases the probability of invasive damage to some anatomical structures, such as maxillary sinus and nasal cavity.²⁻⁴

The bone augmentation techniques suggested by literature, including onlay bone grafts, guided bone regeneration (GBR),⁵⁻⁶ maxillary sinus elevation,⁷⁻⁸ and distraction osteogenesis⁹ have been proven effective in regaining bone volume. However these approaches can present multiple complications and morbidity after surgery, with prolonged treatment duration and extra costs.⁴

A bone height of 10–12 mm is generally considered to be the minimal amount of bone required to place implants of “sufficient” length, 9–11mm long, which are most likely to generate good long-term results.³ Short implants could be a simpler, cheaper and faster alternative than augmentation procedures, if they can be shown to result in similar success rates.⁴

The definition of “short” implants is controversial because some authors consider “short” those implants with a length within the range of 9 –10 mm whereas other authors

consider “short” those implants with an intra-bony design.³ Recently, the use of extra-short implants (6 mm) has been reported with good outcomes⁵⁻⁸ and promising results have been published in comparison with alveolar bone augmentation techniques.^{10,11} On the other hand some clinical follow up of short implants have been discussed and controversial results have been reported, with some studies presenting failures frequently.¹²⁻¹⁵ Other authors found increased failure rates for short implants, suggesting that short implants still presented inadequate survival rates.¹⁶⁻²⁰ Although the use of extra-short implants is tempting, it should only be undertaken if adequate evidence is available to support the hypothesis that modality of implant treatment results at least equal to those achieved with conventional implants.²¹ The purpose of this retrospective study was to assess the survival of extra-short implants in the treatment of severe atrophic ridges in function over time.

MATERIALS AND METHODS

Patients

The patients of the author’s clinic chosen for treatment with extra-short implants were referred for partial and total implant rehabilitation of the maxilla and mandible. All patients had been advised about their alveolar ridge conditions and the reason that extra-short implants were the treatment option proposed. All sites had sufficient alveolar ridge width to receive implants at least 3.75 mm in diameter.



Figure 1: Aspects of implant design with measures.

Exclusion Criteria

1. The patient was not able to give his/her informed consent to participate.
2. Health conditions that did not permit the surgical procedure.
3. Patients with systemic contraindications to surgery.
4. Uncontrolled diabetes.
5. Patients who were treated with bisphosphonates in a long-term period.
6. Patients with abuse of alcohol or drugs.
7. Patient health or psychiatric problems.
8. Irradiated patients.

Implant System

All implants used were extra-short thread implants (P-I Brånemark Philosophy –SIC Invent Group – Switzerland) with a length of 6 mm. They were provided by manufactured purchased and bought from the commercial distributor by the clinician. These implants with surface versions nano and micro nano, are available in diameters of 3.75, 4.0 or 5.0 mm for regular-platform implants (platform diameter: 4,1 mm) or 5.0 mm for wide-platform implants (platform diameter:



Figure 2: Implant before placement.

5.1 mm). They were machined from grade 4 titanium with a parallel design, intrabony designed length of 5.3 mm and a standard 0.7-mm-high external-hex connection (Figures 1 and 2).

Treatment Planning

Prior to surgery in addition to clinical examination, intraoral radiography, panoramic radiography, and computerized tomography scans (Figures 3-5) were taken for the preoperative evaluation of the implant site. The results of this evaluation were used for planning the extra-short implant length (6 mm long) to be used for the rehabilitation of edentulous sites with 7 to 9 mm of available bone. All patients were identified, individual charts were recorded with age, date of implant placement, medical history, region of implant placement, additional surgical procedures, implants dimension and type of prostheses.

Surgical and Prosthetic Procedures

Local anesthesia was achieved using lidocaine 2% with 1:100.000 epinephrine (DFL, Rio de Janeiro, Brazil). A supracrestal (delayed sites) or sulcus incision (extraction sites) connected

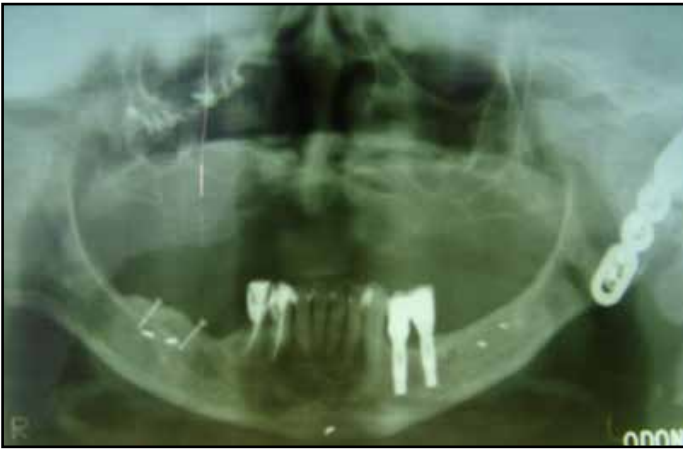


Figure 3: Pre-surgical radiograph.

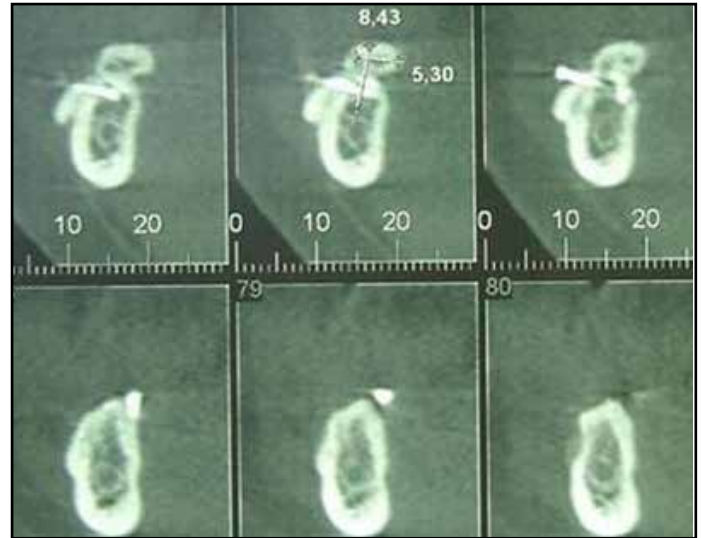


Figure 4: CT Cone Beam.

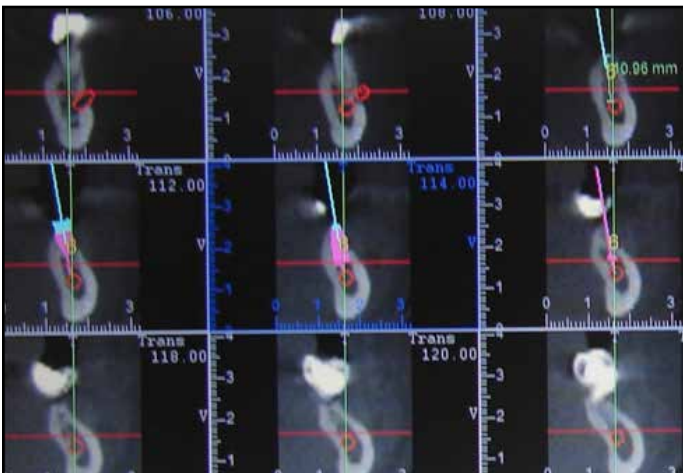


Figure 5: Virtual Planning Dental Slice Software.

to a vertical releasing distal or mesial were performed followed a mucoperiosteal flap. Site preparation and implant placement were performed with drill sequences and surgical protocol recommended by the manufacturer (Figures 5, 6). In cases of dehiscences, fenestrations, and gaps between implant and alveolar walls at this operation, biomaterial (Bio Oss, Geistlich, Wolhusen, Switzerland) or autogenous bone chips were grafted to the defects. Primary closure of the wound was achieved with 5-0 mononylon sutures, and Rehrman-plasty²² (periosteal

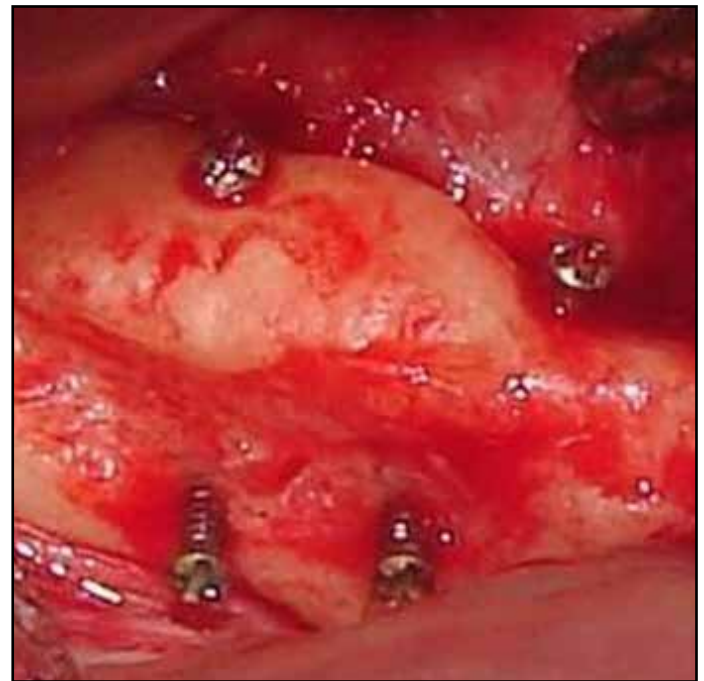


Figure 6: Surgical access in grafted atrophic mandible (posterior region).

incision) was used as the routine technique to seal the extraction after implant placement.

In association with implant surgery, Amoxicillin tablets (500 mg 3 times daily for 7 days)

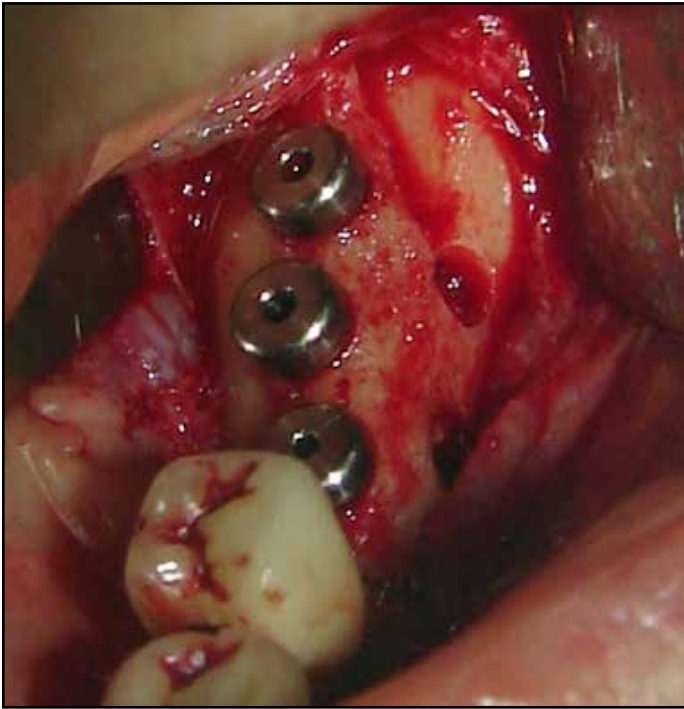


Figure 7: Extra-short implants placed after micro-screw removal using a trephine drill.

were systemically administered, and pain control was achieved by Tenoxycan tablets (20 mg 2 times daily for 3 days). Medication was started 1 hour before surgery and penicillin or cephalosporin-sensitive patients were medicated with clindamycin. The patients rinsed their mouths with chlorhexidine digluconate 0.1% solution for 1 minute twice a day for 7 days following implant surgery. All implants were placed by the same surgeon and sutures were removed after one week after surgery. The patients were then seen once a week for the next 3 weeks for prophylaxis, instruction in oral hygiene, and monitoring of the healing process. During this time was recommended to patients not to use removable provisional partial dentures to avoid traumatizing the treated area. After a period of 4 months to mandible and 6 months to maxilla, second-stage



Figure 8: Final radiograph with prosthetic rehabilitation.

surgery was performed for implants exposure and periapical radiograph were obtained to document healing status. In the second stage the apically repositioned flap was used at healing abutment connection or intermediary abutment placement. The osseointegration was confirmed according Albretksson et al.²³ and Buser et al.²⁴ success criteria. Reverse torque test (10 Ncm) was also performed that is an indicator of clinical stability and percussion over the abutment.²⁵ The complementary prosthetic components were used for a fixed prosthetic restoration manufacturing.

All the patients were rehabilitated with fixed and screwed prostheses, with micro-unit abutments were used in the multiple implants rehabilitation, and the minimum follow-up was 12 months after prosthesis installation.

Post-Surgical Follow-Up

The patients were recalled for radiographic and clinical examinations every 6–12 months. During each visit, the clinical assessment of implants, prostheses and perimplant tissues were respectively conducted by a surgeon and a prosth-

Table 1: Distribution of Implants According to Location.

Size	Mandible	Maxilla	Total
First Premolar	8		8 (2.6%)
Second Premolar	40	4	44 (14.6%)
First Molar	86	2	88 (29.1%)
Second Molar	120	7	127 (42.1%)
Anterior	5	30	35 (11.6%)
Total	259	43	302 (100%)
Failure	4	10	14 (4.6%)

odontist, who were not involved in the treatment of the patients. Panoramic and periapical radiography were taken to evaluate the bone level and peri-implant radiolucency. For the patients experiencing implant loss or other complications, data related to the causes were collected.

RESULTS

Summaries of implants locations, types of prostheses placed and time in function at the time of data collection for this report are presented in Tables 1, 2 and 3. Between February 2009 and October 2013, there were 98 patients (67 women 31 men) with a mean age of 68 years (range 54–82 years) who were submitted to implant surgery. A total of 302 implants were placed to restore with multiple teeth. All implants length used were, 6-mm-long and respect to implant diameter used were, 3.75 mm, 4.0 mm and 5.0 mm in 94 % (n=285), 1% (n=2) and 5% (n=15) of sites respectively. Two hundred fifteen implants were used to replace

molar teeth, fifty-two implants to replace premolar teeth and thirty-five implants in anterior mandible or maxilla region. Two hundred fifty-four implants (84.1%) were placed in mandible posterior region (Figures 6-8), thirteen implants (4.3%) were placed in maxilla posterior region, thirty implants (10%) in maxilla anterior region and five implants (1.6%) in mandible anterior region (Table 1). In 6% (n=18) of the implants were placed in fresh sockets post exodontias sites grafted with bio-material and 1.7 % (n=5) of the implants associated to guided bone regeneration technique and 2.3% (n=7) of the implants inserted in bone augmented sites. In the others 90% of sites bone grafting was not required for implant placement. In four patients with severe bone atrophy extra-short were splinted to zygomatic implants (Figures 9-12). All 288 implants (100%) were restored with fixed prosthesis. Fifteen implants (5%) were located and restored in the cantilever of total fixed prosthesis and 10 implants (3.3%) were

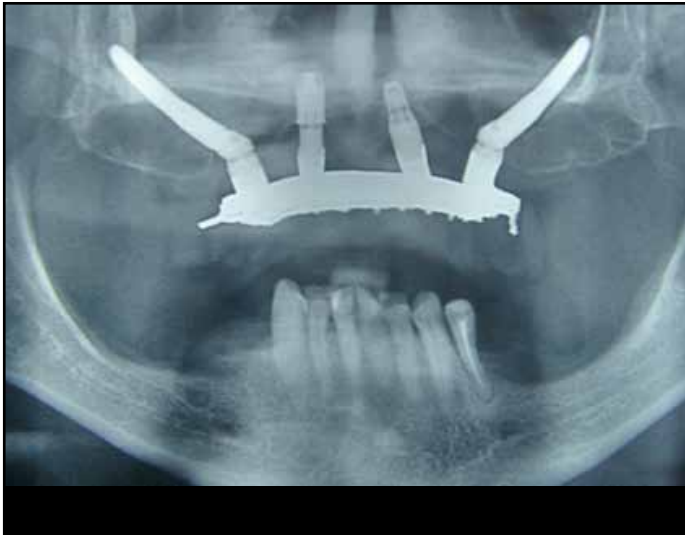


Figure 9: Radiograph exam with short implants and zygomatic implants in maxilla.



Figure 10: Radiograph exam with extra-short implants in the mandible.



Figure 11: Occlusal view of prostheses.



Figure 12: Final Rehabilitation of maxilla and mandible posterior region.

submitted to immediate loading (Figures 13, 14).

No surgical or prosthetic complications associated with implant placement were observed. A total of 288 implants were followed up for at least 1 year, 124 implants were followed up at least 2 years, 66 implants at least 3 years, 72 implants had a follow-up period longer than 4 years, and 26 implants longer than 5 years (Table 2). Fourteen implants (4.6 %) placed in eight patients, were lost: 10 in the maxilla and 4 in the man-

dible. In the group of lost implants, ten implants were with diameter of 3.75 mm (4 in mandible, 6 in maxilla) and four implants with diameter of 5.0 mm all of them in the maxilla. Eleven implants presented mobility during healing period and had been removed. The other three lost implants presented mobility after had been submitted to functional load using fixed provisional prostheses. One lost implant was placed in mandible, in post extraction sites associated to biomaterial graft.

Four implants placed in three patients that used removable provisional prosthe-



Figure 13: Extra-short implants associated to zygomatic implants and submitted to immediate loading.

ses in maxilla were removed during healing period. Two lost implants placed in the mandible posterior region in a patient with malocclusion, which presented mobility after the use of fixed provisional prostheses were removed.

The 14 failed implants in the total of 302 placed, resulted in an overall success rate of 95%. The characteristics of the failed implants are provided in Table 3.

DISCUSSION

The bone augmentation techniques suggested by the literature are considered as predictable alternatives for treatment of edentulous atrophic ridges.⁵⁻⁹ However, the use of short implants has been presented by some authors as an interesting option of treatment.¹⁶⁻²⁰ Renouard and Nisand¹¹ discussed some controversial aspects in a literature review of articles in a study about relationship between length and diameter of implants, dividing the articles in four main sub-groups. In three groups were not clearly confirmed the short implant success rate. Although, the group IV focused specifically on short implants presenting similar outcomes to those reported for

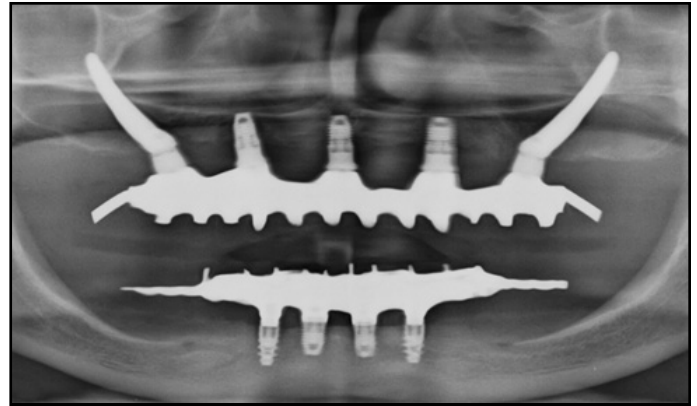


Figure 14: Control radiograph of final prostheses rehabilitation after 12 months.

longer implants, with survival rates of 88–100%.

Friberg et al.²⁶ reported in a retrospective clinical study a survival rate of 92.3% with a long-term follow-up of short implants. Many authors^{1,2,21,26} confirmed that short and extra-short implants constitute a reliable and predictable solution in severely atrophic arches. Other authors^{10,16,27} reported on the performance of 6-mm-long implant of 94% to 97% of survival rate

Tawill and Younan²⁸ indicated that the preparation of the surgical site was altered to ensure greater primary stability in sites of poor bone density. Lai⁴ emphasized that the low density and poor quality of the bone in implant sites may cause the short implant failure. The authors^{4,11,29} confirmed that the low bone density in the edentulous site was a risk factor for short implant failure. Therefore, the replacement of short implant in type IV bone should be considered carefully. Other publications^{27,30,31} presented similar survival rates of short implants compared with longer implants placed in posterior region of mandible, confirming the predictability of bone density for the success of short implants

Analyzing the results of the present study it

Table 2: Distribution of Implants According to Time in Function.

Follow-up (Mo)	No of Patients	No of Implants
12 to 23	16	55
24 to 35	29	69
36 to 47	23	66
48 to 59	22	72
60+	8	26
Total	98	288

is possible to observe some similarities with outcomes cited in the literature. The survival rate of extra-short implants in this study was 95% that was similar with the results reported by many authors.^{2,10,16,21,27} Other authors^{4,11,29,30,31} emphasized the difficulty to ensure a primary stability in sites with poor bone quality suggesting a modification in the surgical site preparation and considered a risk factor of implant failure. The present clinical study corroborated these authors achieving a failure rate of 4.6%, with a higher tendency of 3.3% in the maxilla compared with 1% in the mandible, probably as a result of the softer maxillary bone.

An important aspect to be considered as a risk failure factor was the overload during the healing period by the use of provisional removable prostheses and after second stage using provisional fixed prostheses. In 78% of lost implants the causes of failure occurred in healing period and 21% after loading. In 50% the mobility was observed during second stage surgery, in 28% the use of removable provisional prostheses caused overloading and 21% after healing period

when implants were submitted to occlusal loading with fixed provisional prostheses. However the relationship between primary stability of lost implants and patients using of removable prostheses was not analyzed. Therefore the relevance of this aspect would be considered, because was a risk failure factor detected in this study.

CONCLUSIONS

Within the limits of this retrospective clinical study, it can be concluded that extra-short implants with a length of 6 mm presented survival rates comparable with longer implants. The use of extra-short implants combined or not with regular length implants in fixed prosthesis is a recommendable option. Aspects as primary stability, bone density and the use of provisional removable prosthesis during healing period are relevant risks factors for failure that influences treatment success. ●

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Table 3: Region and Characteristics of Implant Failure.

Implant	Site	Bone Graft?	Implant Size (mm)	Time Loss	Prosthesis	Reason	Notes
1	15	No	5.0 x 6mm	Second stage			
2	16	No	5.0 x 6mm	Second stage			
3	13	No	3.75 x 6mm	3 mo after loading	Fixed Prosthesis	Overload	
4	12	No	5.0 x 6mm	Second stage		Overload by removable provisional	
5	45	Yes	3.75 x 6mm	4 mo after loading	Fixed Prosthesis	Overload	Malocclusion
6	47	No	3.75 x 6mm	4 mo after loading	Fixed Prosthesis	Overload	Malocclusion
7	23	No	3.75 x 6mm	Second stage		Overload by removable provisional	Patient Diabetic and HIV
8	12	No	3.75 x 6mm	Second stage		Overload by removable provisional	Patient Diabetic and HIV
9	13	No	3.75 x 6mm	Second stage		Overload by removable provisional	Patient Diabetic and HIV
10	25	No	3.75 x 6mm	Second stage			
11	26	No	3.75 x 6mm	Second stage			
12	37	No	3.75 x 6mm	Second stage			
13	45	No	3.75 x 6mm	Second stage			
14	17	No	5.0 x 6mm	Second stage			

Disclosure

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Leveraging the Dental Hygienist to Promote the Periodontal Practice

Nafiseh Soolari, RDH, BA¹ • Soulayman Diallo, MS² • Ahmad Soolari, DMD, MS³

Abstract

Periodontal referral is declining, and a dental office must market itself to alert potential patients to its existence. Offering a free cleaning to new patients is a marketing tool that pays long-term dividends in return visits for dental hygiene or periodontal surgery. The number of active dental hygiene patients is a measure of the practice's financial health,

as this service accounts for 40-60% of the office's income. A strong dental hygiene program, therefore, is essential for practice-building, and must convey an image of the practice as trustworthy and caring. The following article focuses on how to leverage the dental hygienist to promote the modern periodontal practice.

KEY WORDS: Dental hygiene, periodontics, practice management

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Periodontal referral is declining, and a dental office must market itself to alert potential patients to its existence. Offering a free cleaning to new patients is a marketing tool that pays long-term dividends in return visits for dental hygiene or periodontal surgery. The number of active dental hygiene patients is a measure of the practice's financial health,^{1,2} as this service

accounts for 40–60% of the office's income.³ A strong dental hygiene program, therefore, is essential for practice-building, and must convey an image of the practice as trustworthy and caring. The practice should work with patients to help them derive maximum benefits from their insurance coverage, and go the extra mile to offer extended hours on evenings and weekends for the patients'

convenience. The hygiene appointment is also an opportunity for patient education, in a relaxed atmosphere in which the patient is more likely to be open to suggestions on lifestyle changes such as diet modification and smoking cessation, and is more likely to commit to self-care.

Patients want to trust their hygienist and office staff, and to have confidence that their work would produce positive results. Subjective and objective factors both play into the patient's perceptions of office visits, and differ markedly between the dental hygiene visit and the periodontal surgery visit. The patient typically looks forward to the dental hygiene visit and keeps the appointment, with minimal stress and high satisfaction with the results. The patient may form a social bond with the hygienist and office staff over return visits, and is likely to comply with post-treatment instructions and behavioral changes suggested by the hygienist. In contrast, the prospect of periodontal surgery does not elicit anticipation in the patient, who dreads the upcoming appointment with its perceived stress and pain, and may consequently defer or cancel it. Unlike the preventive hygiene appointment, periodontal surgery is corrective and occasional; its infrequency may preclude the patient from forming a long-term bond with the surgeon, and the associated discomfort is less likely to lead to post-treatment compliance and recommended lifestyle changes. Periodontal surgery is typically followed by a return visit to assess the results, remove sutures, and sometimes perform a second procedure; this adds to the patient's stress and feelings of dread.

Objective factors include financial concerns, namely the cost of treatments and insurance coverage. While the fees for dental hygiene cleanings are modest and manageable, and many insurance

policies cover them, periodontal surgery costs more and requires the patient to plan, while certain procedures may not be covered adequately by the carrier, adding to the patient's stress and inclination to defer the procedure indefinitely. The physical and medical aspects involved in the office visit also differ: Post-treatment discomfort is minimal or non-existent after the hygiene visit, while periodontal surgery often involves bleeding, pain, swelling, and sutures, and may require medications for days after the procedure. While complications from the dental hygiene visits are unlikely, they do occur occasionally following periodontal surgery, along with sensitivity.

The success of a dental practice rests on patients' acceptance of treatment plans,^{1,2} and this acceptance is anchored in the patients' trust, which is built on their perceptions of the staff and the office. For this reason, the hygiene appointments are practice-builders, one cleaning at a time, for the mutual benefit of patients, hygienists, and periodontists. ●

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Disclosure

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

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