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The field of implant dentistry continues to grow globally as clinicians embrace the evolution of various endosseous implant technologies and the array of enhanced surgical and prosthetic products. The utilization of small diameter implants in limited osseous regions increases patients' ability to choose implants as a viable restorative option. Although small diameter implants have been indicated in the incisor region for the maxilla and mandible primarily, their usage should be considered in select posterior regions. These 2 case reports demonstrate the incorporation of small diameter implants to replace missing mandibular posterior teeth.

Key Words: *one-piece implants, immediate provisionalization, surface area, implant-protected occlusion*

INTRODUCTION

The discipline of implant dentistry has become a major aspect of clinical practices worldwide. As patients' interest and knowledge grow, their demands for an implant-retained prosthesis and other implant services will increase tremendously. The ability of the dentist to plan treatment using implant dentistry based on long-term success heavily relies on many factors, such as arch length and quantity of bone. Studies have led to the development of strict rules that govern the success of placement of endosseous implants for a predictable long-term prognosis.

Small diameter (1.8–3.0 mm diameter) implants have been widely accepted because they can be utilized in regions of the

mouth that are deficient in arch length, as well as alveolar width.^{1–3} Although small diameter single-stage implants have been indicated mainly for the maxillary lateral incisors and the mandibular incisor region, another clinical situation may warrant their application. Loss of maxillary and mandibular molars results in a mesial-distal dimension that may be insufficient in length for the placement of 2 conventional, standard size implants (3.75 mm diameter). In addition, a single large implant (4.7 mm or 6.0 mm diameter) may demonstrate limitations caused by existing osseous structures or with regard to established implant occlusal principles.

The incorporation of small diameter implants for oral reconstruction heightens the requirement for an applied understanding of implant occlusal principles. The reduced size of small diameter implants increases the level of stress under load to the crestal bone.^{4,5} This concept is consistent

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with the mathematical formula that stress is equal to force divided by area. Small diameter implants have reduced surface area compared with standard conventional implants. Therefore, when a force remains constant, overall stress to the crestal bone around small diameter implants will always be greater.⁶ It is the responsibility of the restorative dentist to minimize stress to the crestal bone to improve long-term success. The implant occlusal principles of prime importance are to develop a passive prosthesis with a reduced buccal-lingual dimension, direct the force of occlusion through the long axis of the abutments, and avoid eccentric interferences on the final prosthesis.

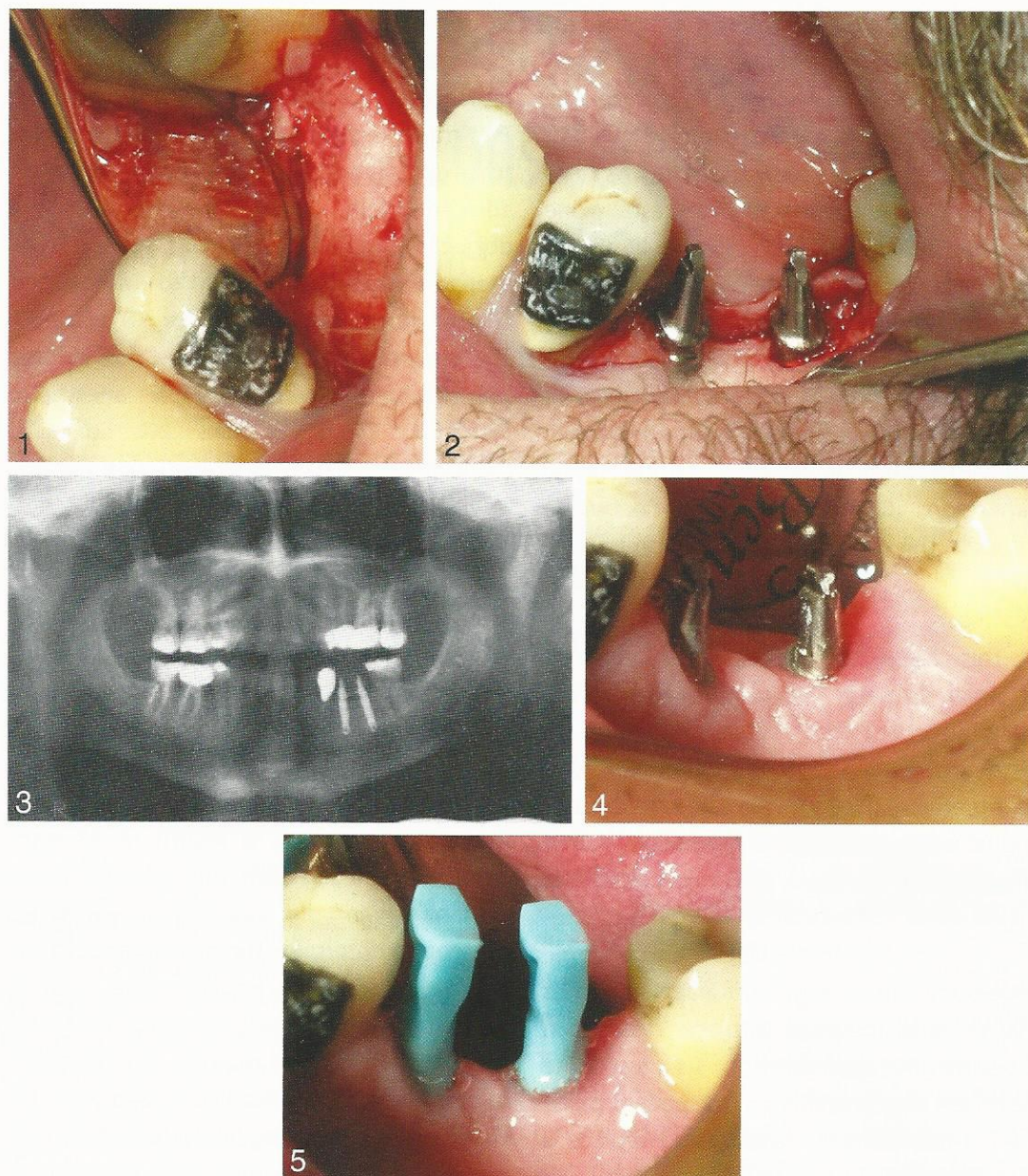
This case report illustrates the utilization of small diameter 1-piece implants in the mandibular posterior region.^{7,8} The mesial-distal arch length dimension between adjacent teeth measured 12 mm, and the buccal-lingual width measured 6 mm. The required length for 2 standard size implants in the mesial-distal dimension is 14 mm for long-term success.^{9,10} On the other hand, a single wide-body implant (eg, 4.7 mm) often creates a large mesial and distal cantilever, resulting in excessive gingival embrasures. As a result, the treatment plan presented to the patient called for 2 small diameter implants to replace a mandibular left first molar.

CASE REPORT I

A 46-year-old male with a negative medical history presented to the office with a missing mandibular left first molar (tooth #19). The clinical and radiographic evaluation indicated sufficient bone superior to the mandibular canal space but insufficient bone in the mesial-distal arch length for 2 conventional standard size implants (3.75 mm). The diagnostic model confirmed the intratooth space to be 12 mm. The treatment plan presented to the patient called for two

3.0-mm small diameter 1-piece implants (Zimmer Dental Inc, Carlsbad, Calif) for replacement of the mandibular first molar. This treatment plan allows 1.50 mm of bone to exist between the implant and its adjacent teeth,¹¹ and 3 mm between endosseous implants.^{11,12} The patient was prepped, draped, and asked to rinse with a chlorhexidine mouth rinse for 30 seconds. The patient was anesthetized via an infiltration technique with a local anesthetic consisting of 2 carpules 2% lidocaine (36 mg) with 1:100 000 epinephrine (36 µg) in the buccal and lingual mucosa. A full mucoperiosteal flap was raised using a #15C blade and periosteal elevator to expose the alveolar ridge (Figure 1). A surgical template was placed and initial osteotomy "dimples" were made with a #2 surgical long-shank round bur. Osteotomies were performed using the manufacturer's drill sequence, which included a 1.6-mm, a 2.3-mm and a final 2.8-mm drill to a length of 13 mm. Before implant selection, the 3.0-mm 1-piece implant "try-in" pin was used to assist the surgeon to determine the desired angulation of the endosseous implant. The 1-piece implants were placed manually with the more apically located margins placed in the buccal position and the flap closed with 4.0 Vicryl sutures (Ethicon, Somerville, NJ) (Figure 2). A panoramic radiograph was taken to evaluate the final positioning of the implants (Figure 3). The contour provisional copings were placed over the contoured 1-piece abutments, and a transitional acrylic crown was fabricated. The buccal-lingual dimension of the provisional restoration was reduced, and no occlusal contacts were established. The patient was given postoperative instructions and was scheduled for the restorative stage in 3 months.

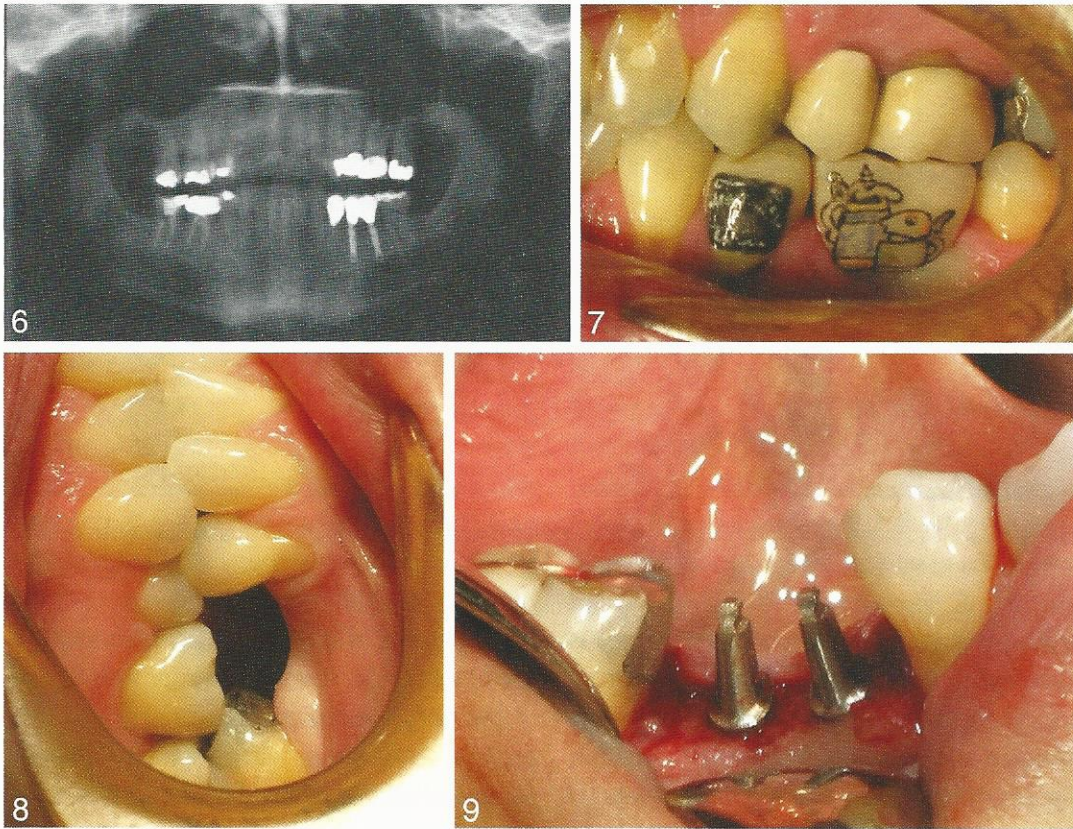
The restorative stage was initiated 3 months postsurgery and was based on a conventional surgical healing period for the posterior mandible. The transitional restora-



FIGURES 1-5. **FIGURE 1.** Full mucoperiosteal flap reflected. **FIGURE 2.** Two 3.0 × 13-mm 1-piece implants. **FIGURE 3.** Panoramic radiograph: postimplant placement. **FIGURE 4.** Two 3.0 × 13-mm 1-piece implants 3 months postsurgery. **FIGURE 5.** Contour impression caps.

tion was removed with a GC pliers, and the abutment and gingival sulci were cleared of all debris (Figure 4). The contour impression caps were placed onto the 3.0-mm implant abutments, and a vinyl polysiloxane impression (Imprint III, 3M ESPE, St Paul, Minn) was made and allowed to set for 3 minutes (Figure 5). An opposing model, maxillary-mandibular occlusal relationship and shade were taken to complete the impression-

stage component. The case was sent to a commercial laboratory with the contour waxing copings and abutment analogs. The commercial dental laboratory (Gardali Dental Laboratory, Utica, NY) placed the analogs into the impression caps and poured a working model. The dental technician created a coping pattern using routine crown and bridge procedures and invested and casted a 2-unit-high noble ceramic alloy. The casting



FIGURES 6-9. **FIGURE 6.** Final prosthesis: panoramic radiograph. **FIGURE 7.** Two-unit porcelain fused to metal-fixed prosthesis. **FIGURE 8.** Preoperative view (mesial-distal dimension: 12 mm; buccal-lingual: 5 mm), centric occlusion. **FIGURE 9.** Two 3.0 × 11.5-mm 1-piece implants.

was polished and returned to the clinician for a prosthetic metal try-in.

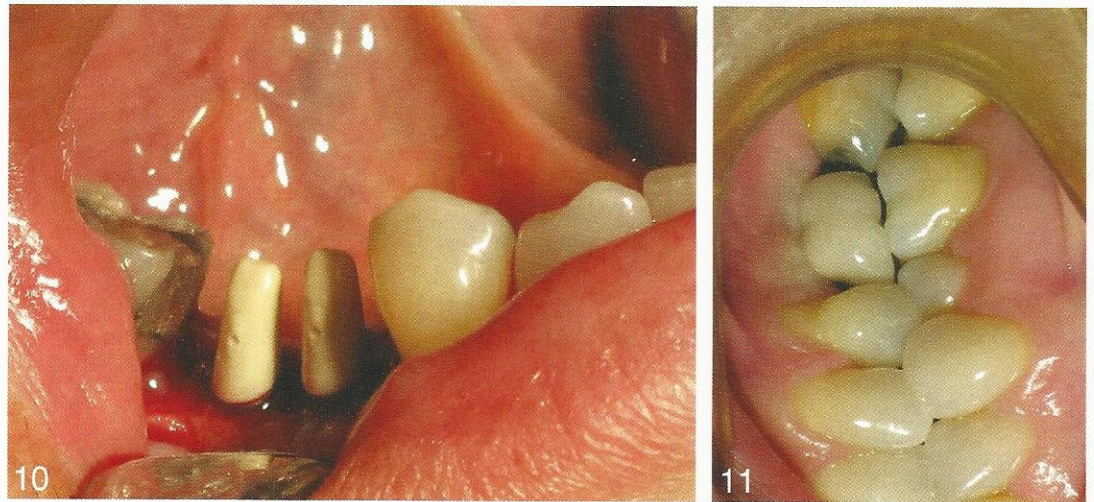
The provisional restoration removal was followed by a try-in of the 2-unit metal framework. Occlusal clearance was verified and shade was confirmed before porcelain application. One week later, the final porcelain fused to the metal crown was placed with zinc phosphate cement (Fleck's Cement, Mizzy, Cherry Hill, NJ) (Figures 6 and 7). The patient was given oral hygiene instructions before discharge.

CASE REPORT II

A 47-year-old female taking levothyroxine for hypothyroidism presented to our office for an implant evaluation concerning tooth site #30, the mandibular right first molar. After an evaluation and consultation appointment, the patient decided to receive endosseous

implant therapy. Radiographic evaluation demonstrated sufficient bone quantity to place endosseous implants, without violation of the inferior alveolar nerve (IAN). A clinical evaluation and diagnostic model verified the intratooth distance at 12 mm and the buccal-lingual distance at 5 mm (Figure 8). As a result, two 1-piece 3.0-mm-diameter implants (Zimmer Dental) with a splinted 2-unit fixed prosthesis were recommended to replace the mandibular right second premolar and the first molar.

The patient rinsed with a chlorhexidine mouthwash for 30 seconds and was prepped and draped. The patient was anesthetized with 3 carpules of 2% lidocaine (54 mg) with 1:100 000 epinephrine (54 µg). A midcrestal incision was made with #15C and #12 blades at midcrest, and a full-thickness mucoperiosteal flap was reflected with a periosteal elevator to expose the alveolar ridge. A



FIGURES 10 AND 11. **FIGURE 10.** Two-unit porcelain-fused-to-metal (PFM) bridge, occlusal view (intraorally). **FIGURE 11.** Two-unit PFM bridge, centric occlusion.

surgical template was placed and 2 osseous "dimples" were made with a #4 long-shank surgical bur. The implant drill sequence consisted of 1.6 mm, 2.3 mm, and 2.8 mm to a depth of 11.5 mm. Utilization of parallel pins and radiographs was essential to establish the future path of insertion of the final prosthesis, and to confirm the proximity of the IAN. To determine the ideal implant selection, straight and angled 3.0-mm 1-piece try-in replicas were placed in the final osteotomies. Placement of the 2 straight 3.0-mm 1-piece-diameter implants was achieved by using the hand seating tool to final depth and orientation (Figure 9). Two temporary copings were inserted over the precontoured abutments and served as the substructure for the provisional restoration (Figure 10). A 1-unit provisional restoration reduced in a buccal-lingual dimension was made with self-curing acrylic and was polished. The implant-protected occlusion established on the transitional prosthesis had no contact in centric occlusion, lateral excursion, and protrusion. The restoration was cemented with temporary cement (TempBond NE, Kerr Corporation, Orange, Calif), and a panoramic radiograph was taken to confirm appropriate fixture placement. The surgical flap was closed using two 4.0

Vicryl sutures in an interrupted manner. The patient was discharged after postoperative instructions were given.

The restorative stage was initiated 5 months postimplant placement. The transitional prosthesis was removed and soft tissue examined. Contour impression caps were placed onto the 3.0-mm 1-piece abutments, and a periapical radiograph was taken to confirm complete seating. A vinyl polysiloxane impression material was utilized to capture the orientation and angulation of the implants. An opposing arch impression, maxillomandibular occlusal relationship, and shade were obtained. The final 2-unit fixed porcelain fused to the metal prosthesis was evaluated in all excursive movements and in centric occlusion (Figure 11). The final prosthesis was cemented with permanent zinc phosphate cement (Fleck's Cement, Mizzy), and a periapical radiograph was taken (Figure 3).

DISCUSSION

The utilization of small diameter implants has become more widespread because of the demand for endosseous implants in a wide range of osseous dimensions. Although bone-grafting procedures can idealize the

width of the alveolar ridge, many patients decline because of the additional time, cost, and morbidity. Additionally, bone-grafting procedures do not resolve the issue of length in the mesial-distal dimension. As a result, small diameter implants are being used as an alternative diameter choice to gain case acceptance.¹³ The main advantages of this type of endosseous implant are its size, 1-piece design, and precontoured abutment, as well as the ease of the restorative phase.¹⁴

The 1-piece design of small diameter implants (1.8–3.0 mm diameter) provides strength to the implant while allowing biological width development to occur at fixture placement. Predictability in strength of the implant is largely due to the lack of an abutment-fixture connection (micro-gap) and retention screw commonly found in the 2-stage design. Small diameter 2-piece implants demonstrated higher failure rates caused by small diameter screws, screw loosening, and fracture. As a result, this implant design elicited low success rates and its fabrication and use were diminished by most implant manufacturers and conscientious clinicians. Moreover, research has demonstrated that the 2-piece implant design with its abutment fixture connection (micro-gap) harbors pathogenic microorganisms that can cause peri-implantitis. Microbial pathogens have been indicated as a causative factor of crestal bone loss around dental implants.¹⁵ Finally, studies have demonstrated that limiting prosthetic component part disconnections from the implant body minimizes the amount of gingival recession and dental papilla shrinkage that occurs.¹⁶

Alternative surgical approaches to idealize ridge width for incorporating standard size implants (3.75 mm) include block onlay grafting, ridge expansion, and/or alveoloplasty. The surgical process of block onlay grafting leads to additional surgeries, as well as increased treatment time and costs and

morbidity. Additionally, a secondary donor site is required, which involves risks of infection and parasthesia.¹⁷ The surgical concept of ridge expansion is possible in the maxilla but is limited in the mandible.¹⁸ Alveoplasty can widen the crest of the ridge but often is not an option in the mandible because of the proximity of the superior aspect of the inferior alveolar nerve and the density of the bone. All of these surgical approaches can be utilized to maximize the width of the alveolar ridge for accommodation of standard size implants (3.75 mm) or small diameter implants (1.8–3.0 mm). However, these surgical approaches do not resolve diminished arch length in the mesial-distal dimension. This clinical issue can be addressed only by orthodontics, by extraction of teeth, or by incorporation of small diameter implants.

Research has established the osseous dimensions required for long-term implant success.^{11,12} Treatment plans must be designed to incorporate the best implant modality for the ideal final prosthesis for the patient. Esposito and associates have stated that a minimum of 1.5 mm of space is required between a tooth and an adjacent implant surface.¹¹ Elian and colleagues demonstrated that 3 mm of bone is needed between 2 adjacent implants for success.¹² The cases presented in this paper demonstrate that 12 mm of mesial-distal dimension allows ideal spacing for 2 small diameter implants for predictable results in the mandibular first molar region.

Use of 1 implant per root has been recommended as the appropriate treatment plan for implant mandibular molar replacement.^{19,20} However, the osseous quantitative requirements preclude the use of conventional standard size implants (3.75 mm) in many clinical situations. Small diameter implants allow for successful placement with adequate osseous support. The 2-implant concept to replace a single molar allows for

an enhanced prognosis by increasing implant surface area by splinting. Also, it eliminates the complication of abutment screw loosening by reducing detrimental rotational movements such as wobble or tipping. In addition, it reduces the size of the gingival embrasures often present when a single implant replaces a mandibular first molar. This clinical problem often becomes the patient's chief complaint after final restoration placement.

The precontoured titanium (Ti) abutment that is part of the 1-piece endosseous implant delivers ideal esthetics and reduces the need for preparation. The precontoured Ti abutment has a natural emergence profile as it moves apically-coronally. The abutment finish line or final restorative margin is .50 mm larger in diameter than the size of the implant measured at the alveolar crest. This design and the nature of Ti alloy promote soft tissue opposition and maximize esthetics by mimicking the natural tooth it replaces.^{21,22} In addition, the abutment is precontoured to reduce or dramatically lessen the need for preparation during the restorative stage. This feature simplifies the impression stage for the restorative phase. More important, it allows soft tissue stability by decreasing the number of soft tissue surgical procedures.¹⁶

Although the utilization of a provisional restoration in the molar region is not required, it is advised because the abutments are sharp to the tongue and oral mucosa. The provisional restoration is splinted together via the restorative material to comply with implant occlusal principles.²³ Adjacent implants can be splinted together only when fixtures are placed in parallel. It is critical that the surgeon is cognizant of this principle when placing 1-stage implants, thereby allowing the restorative dentist to design the final restoration as a single-unit crown supported by 2 endosseous implants.

The provisional restoration should be designed to comply with implant occlusal

principles, thereby protecting the osseointegrative process.²³ The transitional restoration should be splinted together to increase surface area, thereby reducing stress to the crestal bone. The buccal-lingual dimension of the restoration should be reduced to minimize detrimental eccentric interferences. The occlusion on the provisional restoration should be zero in centric occlusion, lateral excursion, and protrusive movement. The temporary restoration must be highly polished to prevent plaque accumulation. The manufacturer's provisional copings fit precisely but passively, allowing a temporary cement (eg, TempBond NE) to adequately retain the prosthesis. The traditional time for osseointegration in the mandible is 3 months before the restorative phase.²⁴

Following removal of the provisional restoration, a contour impression cap is placed onto the abutments, and an impression material can be used to transfer the implant orientation and position to the dental laboratory. The clinician can elect to place the gingival retraction cord into the gingival sulcus and take an impression by traditional means. The certified dental technician will utilize the contour waxing coping to fabricate the final splinted restoration. The buccal-lingual dimension of the final ceramic restoration should be reduced to mimic the size of a mandibular premolar and should be highly polished and passive. The final restoration is designed in accordance with implant occlusal principles, including no contact during centric occlusion, lateral excursion, or protrusion; a point contact should be designed during maximum occlusal contact (clenching).^{25,26} The patient should be reevaluated in 2 weeks to assess the occlusion.

CONCLUSION

The field of oral implantology has become a widely accepted area of interest in dentistry. The role of the dentist is to recommend

treatment that is supported by research and leads to reduced treatment times, risks, and costs to patients. Small diameter implants have become a viable alternative to standard conventional implants in a large number of clinical situations. The mandibular posterior regions of the mouth may present an opportunity to incorporate these types of implants to reduce surgeries, morbidity, and treatment time. Additionally, small diameter implants can increase the long-term prognosis of the prosthesis by increasing surface area and reducing screw loosening. The precontoured abutment and impression copings make the restorative stage simple and effective for the experienced or novice practitioner. It is critical that the clinician design the prosthesis in accordance with implant occlusal principles to maximize long-term success. Although small diameter implants have been utilized in many mandibular clinical areas, additional long-term studies focused on maxillary and/or mandibular posterior regions of the mouth will lead to greater acceptance by clinicians.

ABBREVIATIONS

IAN: inferior alveolar nerve
PFM: porcelain-fused-to-metal
Ti: titanium

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