Immediate Loading of Dental Implants in the Edentulous Mandible: A Preliminary Case Report From an International Prospective Multicenter Study

CE 3

Abstract: ***The ability to predictably achieve long-term osseointegration in patients with compromised anatomical resources has been demonstrated numerous times in modern oral implantology. Recently, clinical attention has focused on new methods of reducing treatment time. One-stage surgical procedures and immediate loading of implants at the time of placement are two techniques that have demonstrated promising clinical results. A prospective clinical study of immediately splinting and loading a new, one-stage implant is currently in progress in the United States and France. An overview of the implant design and presentation of one case study from the University of Pittsburgh demonstrates how this promising technique is performed.***

Azfar A. Siddiqui, DMD, BDS, MSc
Assistant Professor
Prosthodontics

John Y.H. Ismail, DMD, PhD
Chairman
Prosthodontics

Steve Kukunas, DMD, MS
Assistant Professor
Prosthodontics

School of Dental Medicine
University of Pittsburgh
Pittsburgh, Pennsylvania

Learning Objectives:

After reading this article, the reader should be able to:

- explain the steps for placing and immediately loading four one-stage implants in the edentulous mandible with a bar overdenture restoration.
- discuss the rationale for developing different surgical protocols based on bone density.
- identify some of the research that supports the immediate loading concept.

Advances in implant designs, biomaterials, and surgical techniques have extended the benefits of root-form dental implants to many patients who were previously excluded as suitable candidates. Narrow, resorbed ridges, immediate extraction sites, and ridges with labial undercuts or convergent tooth roots can often be successfully treated with new, tapered implant designs.[1] For patients with poor bone quality, advances in hydroxyapatite (HA) coatings[2-3] and microtextured titanium surfaces[4-5] may offer improved prognoses of long-term implant success. One-stage surgical procedures have successfully eliminated second-stage surgery with excellent clinical results,[6-10] which thereby avoids the physical trauma and chair time of the uncovering procedure. A challenge that still confronts dentists and patients alike, however, is the traditional lag time between implant placement and prosthetic loading.

Originally, the Brånemark[a] surgical protocol[11] stipulated that dental implants were to be submerged beneath the soft tissue at the time of placement, and allowed to heal for a minimum of 3 months in the mandible and 6 months in the maxilla to achieve osseointegration.[11] Patients were also required to refrain from wearing a denture in the lowerjaw for 2 weeks after implant placement to facilitate soft tissue healing.[11] The denture was then relieved over the surgical area and relined with a soft material, which had to be replaced every 3 to 4 weeks.[11] A permanent reline with acrylic resin was only permitted at 5 weeks postoperative.[11] After the submerged healing period, a second surgery to uncover the implants was required, followed by 2 additional weeks of soft tissue healing before restorative procedures could begin.[11] It is not known how many patients may have been discouraged from selecting dental implant therapy as a result of the lag time between implant placement and delivery of the final prosthesis. Recent studies have documented the successful immediate loading of one-piece[12-14] and two-piece[15-17] implant designs. While some researchers caution that immediate loading of dental implants should be limited to the interforamina region of the symphysis in edentulous mandibles,[18] others report high clinical success rates of immediately loaded implants in partially edentulous cases, including the maxillary jaw.[19]

In 1999, a prospective 5-year clinical study of immediately splinting and loading four one-stage dental implants in the edentulous mandible was begun at

[a]Nobel Biocare, Inc., Yorba Linda, CA 92887; (800) 993-8100

Figure 1—AdVent™ dental implants feature an optional combination HA-coated and blasted surface.

the University of Pittsburgh, Boston University, and the University of Lyon, France. This preliminary case report from the ongoing study presents an overview of the new implant design used in the study, the technique used for immediate loading, and the results achieved in one case that has been monitored for 18 months of clinical follow-up.

Implant Design and Surface Features

The AdVent™[,b] implant selected for this study features a tapered, intraosseous body with self-tapping, triple-lead threads, and a slightly fluted, 3-mm-long transmucosal neck designed to extend through the soft tissue from the time of placement (Figure 1). Manufactured in four intraosseous body lengths (8 mm, 10 mm, 13 mm, 16 mm) and two diameters (3.7 mm, 4.7 mm), the implants feature a common internal hexagonal prosthetic platform 4.5 mm in diameter. A low-profile surgical cover screw and a 2-mm-high neck extension for thick mucosa are also packaged with each implant. The neck extension component was not used in this case. During laboratory procedures, the surgical cover screw was threaded into the implant to prevent the ingress of debris and other contaminants.

A relatively smooth, machined titanium surface on the neck portion of the implant is designed to facilitate maintenance of oral hygiene. The intraosseous body portion of the implant is manufactured with a microtextured surface (MTX™[,b]) or a hybrid surface (Dual Transition™ Selective Surface™[,b]) that includes both microtexturing and HA coating. Microtexturing is a proprietary technology that blasts the implant with soluble HA particles, followed by a procedure to remove residual blasting particles that may become embedded in the implant's surface. For the hybrid surface option, HA coating is applied over a portion of the microtextured surface as a secondary surface treatment. The coating is restricted to the midsection of the intraosseous implant body, beginning 2 mm below the base of the machined neck, and extends to 3 mm above the apical end of the implant.

The implant system features two different surgical protocols that are selected according to bone density. Low-density bone characterized by loosely woven tissue and a thin cortical shell may not provide adequate threat engagement to immediately stabilize the implant. The soft bone surgical protocol is used to prepare a straight osteotomy that is slightly smaller than the actual diameter of the tapered implant. As the implant gradually seats into the receptor site, the widening diameter of the implant body is designed to increase mechanical stability at the crest of the ridge.

In dense bone where adequate thread engagement can be achieved, a tight mechanical interface at the crest of the ridge is not necessary to maximize initial stabilization. Therefore, the dense bone surgical protocol uses a double-cutting step drill to create a straight osteotomy with a smaller diameter apical end. As the implant seats into the osteotomy, the tapered apical end of the implant is designed to engage the narrow bottom of the receptor site and seat by self-tapping insertion.

In this study, implant selection was limited to the 3.7-mm diameter to maintain at least 10 mm of labial plate thickness, 1 mm of lingual plate thickness, and 3 mm of mesiodistal bone between each implant after preparation of the osteotomies. Implants were also limited to lengths of ≥ 10 mm, with the proviso that at least 2 mm of inferior cortical plate was retained. These limitations were designed to help ensure adequate thread engagement for immediate stabilization and bony support of the restoration. Each case in the study consists of four implants placed in the anterior mandible

[b]Sulzer Dental Inc., Carlsbad, CA 92008; (760) 929-4300

Figure 2—Clinical view of the patient's edentulous jaws.

Figure 3—Stone cast demonstrates the severe bone resorption pattern in the mandible.

Figure 4—New dentures were made and used for 2 weeks before implant surgery.

Figure 5—The cut-back surgical template provided access to the surgical field.

with cross-arch splinting for additional implant stability. Each case also consisted of two implants with HA-coated surfaces and two implants with microtextured surfaces, which will allow comparisons of clinical performance, marginal bone changes, and soft tissue response between the two surfaces.

Case Report

Patient Selection

The patient in this report was a 70-year-old man who presented with full edentulism in both jaws (Figure 2). Progressive bone loss in his edentulous lower jaw (Figure 3) compromised the fit and function of his complete denture prosthesis. The presurgical work-up consisted of an oral examination, health history, study cast evaluations, and various clinical and laboratory assessments. Tooth wear on the patient's existing denture required fabrication of a new prosthesis, which was placed into full function without complications 2 weeks before implant surgery (Figure 4).

Implant Placement

Since the patient's new denture would be used as the final restoration, an acrylic duplicate was made of it to function as a surgical template for placing the dental implants in optimal locations relative to the prosthesis (Figure 5). A regimen of antibiotic coverage was prescribed, which the patient was instructed to commence 24 hours before surgery. On the day of surgery, the patient was prepared for an aseptic procedure and anesthetized by local infiltration. A midcrestal incision and two release incisions were made and the soft tissue was elevated to expose the underlying alveolar process. After flattening the ridge to provide at least 1 mm of bone on the facial and lingual surfaces after preparation of the implant osteotomies, the surgical template was placed into the patient's mouth, and the osteotomies were prepared by sequential cutting with internally irrigated drills in a slow-speed, high-torque handpiece. In the present case, the dense bone surgical protocol was successfully used to place the implants (Figure 6).

Fabricating the Working Cast

Indirect transfers were threaded into the implants (Figure 7), after which the soft tissue was sutured around the necks of the implants with 4-0 vicryl sutures[e]. After trimming the loose ends, each suture was coated with petro-

[e]Ethicon, Inc. Somerville, NJ 08876; (800) 255-2500

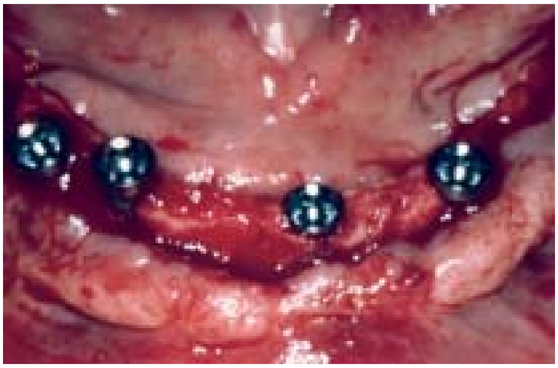

Figure 6—The surgical placement of four transmucosal implants.

Figure 7—Indirect transfers were threaded into the implants.

Figure 8—A full-arch, elastomeric impression was made over the implants and transfers.

leum jelly to facilitate the impression procedure. A full-arch impression was made with an elastomeric material (Figure 8). Once the impression material set, the tray was removed from the patient's mouth. The transfers were unthreaded from the implants, and replaced by the surgical cover screws to maintain hygiene during bar fabrication (Figure 9). Each transfer was attached to a replica of the implant and reinserted into its corresponding impression hole (Figure 10). The impression was poured in dental stone, then separated after setting (Figure 11). Each of the indirect transfer components was unthreaded from the working cast.

Fabricating the Overdenture Bar

A 3-mm-high gold coping and fixation screw assembly was attached to each implant replica in the working cast (Figure 12) and tightened to 20 Ncm with a 1.25-mm diameter hexagonal wrench tool and torque wrench. Round gold bars were cut to the appropriate lengths and shaped to fit between the gold cylinders. Each bar segment was luted to the gold cylinders with autopolymerizing acrylic (Figure 13). The joints of the bar pattern were reinforced by overbulking with autopolymerizing acrylic and wax to provide additional space for soldering after investment and burnout.

When the bar pattern was completed, the fixation screws were unthreaded with the wrench tool. The bar pattern was carefully removed from the working cast and invested in a silica-bonded soldering investment material, which was allowed to flow through the gold cylinders and over the metal bars. After setting, the investment was trimmed and shaped around the joints to allow for the free flow of heat and soldering material. Standard laboratory procedures were used for burnout of the residual autopolymerizing acrylic and wax. The round bar segments were then soldered to the gold cylinders. After bench-cooling, the soldered bar was divested, the soldered joints were finished, and the bar was polished.

Verifying a Passive Fit

The surgical cover screws were removed and the bar was seated on the implants. The one-screw or "Sheffield fitting test"[20] was used to determine if the bar achieved a passive fit on the implants. A distal gold cylinder incorporated within the bar was attached to its corresponding implant with a fixation screw. The bar was then visually inspected to verify that no discernable gaps were present between the remaining gold cylinders and the implants. This procedure was repeated in succession with each remaining gold cylinder and the passive fit of the bar was verified (Figure 14). If a gap had been present between the bar and any of the implants, the bar would have to be corrected by sectioning and resoldering.

Processing the Denture Clips

The bar fixation screws were tightened to 20 Ncm of torque. Adequate clearance was created in the denture base to accommodate the bar and

Figure 9—Surgical cover screws were threaded into the implants until delivery of the prosthesis.

Figure 10—The indirect transfer were attached to implant replicas and reinserted into the impression.

Figure 11—The working cast contained replicas of the patient's AdVent™ implants.

Figure 12—Gold cylinders were attached to the implant replicas in the working cast.

implants without contact when the denture was seated over them and placed into occlusion with the opposing denture. After removing the denture from the mouth, block-out wax was used to eliminate the voids beneath the bar. A gold denture clip was fastened to the bar, the denture was reseated over the assembly, and the occlusion was rechecked to verify that the clip did not interfere with the full, contact-free seating of the denture. The denture was removed from the mouth and a small amount of autopolymerizing acrylic was placed into the dry, relieved area of the denture base. After reseating the denture over the bar and clip, the patient was instructed to bite lightly in centric occlusion. When the autopolymerizing acrylic set, the denture was removed from the patient's mouth and final adjustments were made to the prosthesis. Voids around the processed clip were occluded with additional autopolymerizing acrylic (Figure 15). The block-out material was removed from the bar and the denture was reseated.

Completion of the Case and Follow-up

The fit and function of the prosthesis were clinically evaluated. Oral hygiene and postoperative home care instructions were provided, and the patient was dismissed. The patient was recalled for an evaluation of healing 7 days later. Oral hygiene and home-care instructions were reinforced, and the patient was dismissed. After 3 months, the patient was recalled for manual testing to verify the presence of clinical osseointegration. Oral hygiene instructions were repeated, and the patient was dismissed until the first prophylaxsis appointment.

Discussion

All of the implants in this report successfully osseointegrated under immediate loading conditions, and healing was uneventful. The entire restorative procedure took approximately 2 $^{1}/_{2}$ hours after completion of the surgery, including time for fabrication of the gold bar superstructure in the laboratory, and the patient left with a fully functioning, implant-supported overdenture restoration. No complications or discernable changes in marginal bone height were radiographically evident at the 18-month follow-up appointment (Figure 16), and the patient expressed great satisfaction with the results.

Modern implant dentistry stems from the 19th century, when implants ranged from one-piece, transmucosal designs that were loaded

Figure 13—The bar pattern was formed by connecting the gold cylinders with gold bar segments.

Figure 14—The finished gold bar provided a passive fit on the implants in the patient's mouth.

from the time of placement, to two-piece root-and-crown analogs that were loaded after a brief healing period of no more than 6 weeks.[21] The long-term results of these early designs were highly variable and unpredictable because of a lack of appropriate biomaterials.[22] An immediately loaded porcelain-and-lead implant introduced in 1886, for example, remained in function for 27 years, despite the inherent toxicity of the metal.[21] The popularity of one-stage implants continued into the 20th century, with various designs introduced by Formiggini, Chercheve, Linkow, and others.[23]

Immediate loading of one-stage dental implants continues to generate clinical interest. One concern in using the protocol, however, is that implant micromovement during early postinsertion healing will hamper bone regeneration, prevent osseointegration, or will result in the interposition of fibrous tissue between the implant and the walls of the receptor site. Thread engagement, friction fit, or a combination of both are methods used by root-form dental implants to achieve initial stabilization. Engaging dense, compact quality 1 or 2 bone with implant threads is another technique for achieving immediate implant stabilization.

It has been postulated that a gentle surgical technique and splinting of implants may sufficiently shield the bone-implant interface from functional overload and prevent micromovement from exceeding the allowable limits for successful osseointegration.[12] This theory is supported by the extremely high success rates achieved with splinted implants loaded early in primates[24] and loaded immediately in humans.[25] However, even higher success rates have been reported for nonsplinted crowns placed in the anterior maxilla,[26] which suggests that other methods of implant stabilization may be as effective as splinting in the prevention of implant micromovement.

Some researchers have stated that the increasing diameter of tapered implants results in compression of the interfacial bone, which produces a higher insertion torque and greater mechanical retention than nontapered implant designs.[27] While actual bone compression with tapered implants has not yet been adequately demonstrated in clinical studies, it is reasonable to assume that the higher torque reported[27] with tapered implants is indicative of very close interfacial contact between the increasing diameter of the implant body and the walls of the receptor site. It has also been theorized[1] that tapered implants dissipate forces into the surrounding bone more uniformly than parallel-walled implants and are associated with more uniform compaction of bone in adjacent osteotomy walls. These claims, together with the effects of marginal bone changes under long-term functional loading, are yet to be documented by long-term, prospective clinical studies.

Implant threads are designed to maximize initial contact, achieve initial stability, enlarge the implant's surface area, and dissipate interfacial stress.[28] The threads of screw-type implants can range from the pretapping variety, which requires the use of a bone tap before implant placement, to self-tapping designs, which cut directly into the bone as the implant is threaded into place. Prolonged tightening of the bone by pretapping followed by screwing an implant into place has been postulated to create stress concentrations at the crest of the ridge, which can reportedly contribute to a loss of marginal bone.[29] Satomi and colleagues[29] recommend self-tapping insertion of the implant instead

Figure 15—A retentive clip processed into the denture base attached to the bar when the prosthesis was placed into the patient's mouth.

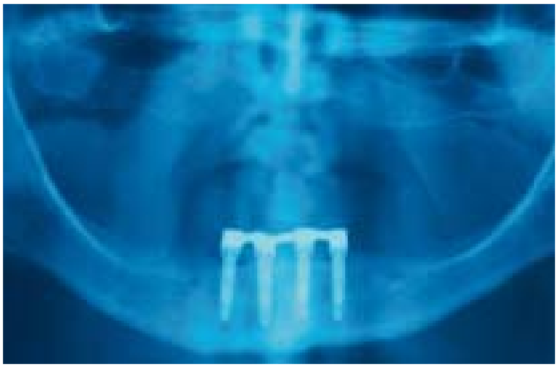

Figure 16—Panoramic radiograph taken at 18 months.

of pretapping the surgical site to avoid excessive stress concentrations in the hard tissue.

In a study of maxillofacial fixation screws, Bähr and Lessing[30] report that pretapped screws require more bone remodeling to osseointegrate than self-tapping screws, and conclude that the higher friction between the bone and self-tapping screws results in a greater degree of anchorage. This finding is reaffirmed by Cook and coworkers,[31] who report that the more intimate the initial fit between the implant and the walls of the receptor site, the greater the percentage of bone apposition to the implant surface after healing. Self-tapping insertion of screw-type implants has also been reported to reduce surgical time by as much as 3 minutes per implant,[32] which may shorten clinical chair time. Sykaras and colleagues[28] report that double-threaded or triple-threaded implants are faster to thread into the osteotomy site, generate less heat on placement, provide increased initial stability, and require more torque for placement (and thus tighter contact with bone). The ability of a dental implant to distribute the stresses of occlusion is determined, in part, by the amount of bone-to-metal interface achieved by the implant.[33] Recent studies on implant surfaces have shown that roughening the surface by grit blasting,[7,8] increases the amount of bone-to-implant apposition, and that coating with titanium plasma spray (TPS)[34] or HA[35] increases removal torque values. Conversely, the health of soft tissue is more readily maintained if the portion of the implant emerging from the bone has a relatively smooth surface.[36]

Wennerberg and colleagues[37] observed that surface topography varied among 13 commercially available implant systems. In an animal study comparing bone-to-metal contact between machined titanium and surfaces roughened by blasting with small-grit (25 µm), medium-grit (75 µm), and large-grit (250 µm) particles of $A1_2O_3$, they reported that the medium-grit particles achieved the highest degree of bone-to-metal contact.[38] This may suggest that uncoated implant surfaces grit-blasted with medium-sized particles in the diameter range of 75 mm may provide an optimum range of surface roughness for bone apposition. More research is needed in this area before any definitive conclusions can be drawn.

Conclusion

The observations in this report raise hope that AdVent™ implants immediately splinted and loaded with bar-supported overdenture restorations in the edentulous mandible may offer a promising alternative to traditional overdenture treatment. Data from the current study and other long-term, prospective studies with a larger patient population, are needed before definitive conclusions can be made.

Acknowledgments

The authors thank Robert Riley, CDT, Bob Vanard, CDT, and Michael D. Henry, MA, for their sterling assistance in researching, writing, and editing this article.

Disclosure

This study was supported by a grant from Sulzer Dental, Inc.

References

1. Callan DP, Hahn J, Hebel K, et al: Retrospective multicenter study of an anodized, tapered, diminishing thread implant: success rate at exposure. *Implant Dent* 9(4):329-335, 2000.
2. Burgess AV, Story BJ, La D, et al: Highly crystalline MP-1 hydroxyapatite coating. Part I: In vitro characterization

and comparison to other plasma-sprayed hydroxyapatite coatings. *Clin Oral Implants Res* 10(4):245-256, 1999.

3. Burgess AV, Story BJ, Wager WR, et al: Highly crystalline MP-1 hydroxyapatite coating. Part II: In vivo performance on endosseous root implants in dogs. *Clin Oral Implants Res* 10(4):257-266, 1999.
4. Wennerberg A, Ektessabi A, Albrektsson T, et al: A 1-year follow-up of implants of differing surface roughness placed in rabbit bone. *Int J Oral Maxillofac Implants* 12(4):486-494, 1997.
5. Trisi P, Rao W, Rabaudi A: A histometric comparison of smooth and rough titanium implants in human low-density jawbone. *Int J Oral Maxillofac Implants* 14(5):689-698, 1999.
6. Bernard JP, Belser UC, Marinet JP, et al: Osseointegration of Brånemark fixtures using a single-step operating technique. A preliminary prospective one-year study in the edentulous mandible. *Clin Oral Implants Res* 6(2):122-129, 1995.
7. Collaert B, De Bruyn H: Comparison of Brånemark fixture integration and short-term survival using one-stage or two-stage surgery in completely and partially edentulous mandibles. *Clin Oral Implants Res* 9(2):131-135, 1998.
8. Ericsson I, Randow K, Nilner K, et al: Some clinical and radiographical features of submerged and non-submerged titanium implants. A 5-year follow-up study. *Clin Oral Implants Res* 8(5):422-426,1997.
9. Kohal RJ, De LaRosa M, Patrick D, et al: Clinical and histologic evaluation of submerged and nonsubmerged hydroxyapatite-coated implants: a preliminary study in dogs. *Int J Oral Maxillofac Implants* 14(6):824-834, 1999.
10. Becker W, Becker BE, Israelson H, et al: One-step surgical placement of Brånemark implants: a prospective multicenter clinical study. *Int J Oral Maxillofac Implants* 12(4):454-462, 1997.
11. Adell R, Lekholm U, Brånemark PI: Surgical procedures In: Brånemark PI, Zarb GA, Albrektsson T (eds.): *Tissue-Integrated Prostheses. Osseointegration in Clinical Dentistry*. Chicago, Quintessence Pub Co, Inc, pp 211-232, 1995.
12. Ledermann PD, Schenk RK, Buser D: Long-lasting osseointegration of immediately loaded, bar-connected TPS screws after 12 years of function: A histologic case report of a 95-year-old patient. *Int J Periodontics Restorative Dent* 18(6):553-563, 1998.
13. Levine RA, Rose L, Salama H: Immediate loading of root-form implants: two case reports 3 years after loading. *Int J Periodontics Restorative Dent* 18(4):333-343, 1998.
14. Gatti C, Haefliger W, Chiapasco M: Implant-retained mandibular overdentures with immediate loading: a prospective study of ITI implants. *Int J Oral Maxillofac Implants* 15(3):383-388, 2000.
15. Tarnow DP, Emtiaz S, Classi A: Immediate loading of threaded implants at stage 1 surgery in edentulous arches: ten consecutive case reports with 1- to 5-year data. *Int J Oral Maxillofac Implants* 12(3):319-324, 1997.
16. Schnitman PA, Wohrle PS, Rubenstein JE, et al: Ten-year results for Brånemark implants immediately loaded with fixed prostheses at implant placement. *Int J Oral Maxillofac Implants* 12(4):495-503, 1997.
17. Balshi TJ, Wolfinger GJ: Immediate loading of Brånemark implants in edentulous mandibles: a preliminary report. *Implant Dent* 6(2):83-88, 1997.
18. Ericsson I, Randow K, Nilner K, et al: Early functional loading of Brånemark dental implants: 5-year clinical follow-up study. *Clin Implant Den Relat Res* 2(2):70-77, 2000.
19. Kupeyan HK, May KB: Implant and provisional crown placement: a one stage protocol. *Implant Dent* 7(3):213-219, 1998.
20. White CE: *Osseointegrated Dental Technology*. Chicago: Quintessence, pp 95-129, 1993.
21. Ring ME: A thousand years of dental implants: a definitive history—Part 1. *Compend Contin Educ Dent* 16(10):1060-1069, 1995.
22. Luckey HA and Kubli Jr F (eds.): *Titanium Alloys in Surgical Implants*. Philadelphia, American Society for Testing and Materials, pp 1-3, 1983.
23. Ring ME: A thousand years of dental implants: a definitive history—Part 2. *Compend Contin Educ Dent* 16(11):1132-1136, 1995.
24. Piatelli A, Corigliano M, Scarano A, et al: Bone reactions to early occlusal loading of two-stage titanium-plasma sprayed implants: a pilot study in monkeys. *Int J Periodontics Restorative Dent* 17(2):163-169, 1997.
25. Brånemark PI, Engstrand P, Öhrnell LO, et al: Brånemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. *Clin Impl Dent Relat Res* l(l):2-16, 1999.
26. Wöhrle PS: Single-tooth replacement in the aesthetic zone with immediate provisionalization: fourteen consecutive case reports. *Pract Periodontics Aesthet Dent* 10(9):1107-1114, 1998.
27. O'Sullivan D, Sennerby L, Meredith N: Measurements comparing the initial stability of five designs of dental implants: a human cadaver study. *Clin Implant Dent Relat Res* 2(2):85-92, 2000.
28. Sykaras N, Iacopino AM, Marker VA, et al: Implant materials, designs, and surface topographies: their effect on osseointegration. A literature review. *Int J Oral Maxillofac Implants* 15(5):675-690, 2000.
29. Satomi K, Akagawa Y, Nikai H, et al: Bone-implant interface structures after nontapping and tapping insertion of screw-type titanium alloy endosseous implants. *J Prosthet Dent* 59(3):339-342, 1988.
30. Bähr W, Lessing R: The response of midfacial bone in sheep to loaded osteosynthesis screws in pretapped and nontapped implant sites. *J Oral Maxillofac Surg* 50(12):1289-1294,1992.
31. Cook SD, Salkeld SL, Gaisser DM, et al: The effect of surface macrotexture on the mechanical and histologic characteristics of hydroxylapatite, coated dental implants. *J Oral Implantol* 19(4):288-294,1993.
32. Friberg B, Grondahl K, Lekholm U: A new self-tapping Brånemark implant: clinical and radiographic evaluation. *Int J Oral Maxillofac Implants* 7(l):80-85, 1992.
33. Siegele D, Soltesz U: Numerical investigations of the influence of implant shape on stress distribution in the jaw bone. *Int J Oral Maxillofac Implants* 4(4):333-340, 1989.
34. Carr AB, Beals DW, Lawsen PE: Reverse-torque failure of screw-shaped implants in baboons after 6 months of healing. *Int J Oral Maxillofac Implants* 12(5):598-603, 1997.
35. Carr AB, Larsen PE, Papazoglou. E, et al: Reverse torque failure of screw-shaped implants in baboons: baseline data for abutment torque application. *Int J Oral Maxillofac Implants* 10(2):167-174, 1995.
36. Rimondini L, Fare S, Brambilla E, et al: The effect of surface roughness on early in vivo plaque colonization on titanium. *J Periodontol* 68(6):556-562, 1997.
37. Wennerberg A, Albrektsson T, Andersson B: Design and surface characteristics of 13 commercially available oral implant systems. *Int J Oral Maxillofac Implants* 8(6):622-633, 1993.
38. Wennerberg A, Hallgren C, Johansson C, et al: A histomorphometric evaluation of screw-shaped implants each prepared with two surface roughnesses. *Clin Oral Implants Res* 9(1):11-19, 1998.

Quiz 3

1. **In which three areas have advancements extended the benefits of root-form dental implants to many patients who were previously excluded?**
   a. Stronger titanium, antibiotics, chemotherapeutics
   b. Implant designs, biomaterials, surgical techniques
   c. Improved tolerances, chemotherapeutics, antibiotics
   d. Stronger antibiotics, designs, biomaterials

2. **Some researchers caution that immediate loading of dental implants should be limited to the:**
   a. intercanine region of the maxilla.
   b. intermolar region of the posterior mandible.
   c. interforamina region of the mandible.
   d. intermolar region of the maxilla.

3. **In the soft bone surgical protocol, the widening diameter of the implant body is designed to increase mechanical stability at the:**
   a. crest of the ridge.
   b. apical region.
   c. medullar region.
   d. lingual region.

4. **The joints of the bar pattern were further reinforced by overbulking with additional autopolymerizing acrylic and wax to:**
   a. compensate for inadequate bar length.
   b. provide more room for soldering.
   c. facilitate clip attachment.
   d. add strength to the bar.

5. **If a gap had been present between the bar and any of the other implants, the bar would have to be corrected by:**
   a. carefully screwing the bar into place.
   b. using fewer screws to retain the bar.
   c. repolishing the bar.
   d. sectioning and resoldering the bar.

6. **The bar fixation screws tightened to what torque?**
   a. 20 Ncm
   b. 25 Ncm
   c. 30 Ncm
   d. 35 Ncm

7. **The patient was recalled for manual testing to verify the presence of clinical osseointegration after:**
   a. 1 year.
   b. 6 months.
   c. 3 months.
   d. 1 month.

8. **What are methods used by root-form dental implants to achieve initial stabilization?**
   a. Thread engagement
   b. Friction fit
   c. Combination of both thread engagement and friction fit
   d. all of the above

9. **It has also been theorized that which implants dissipate forces into the surrounding bone more uniformly?**
   a. Parallel-walled
   b. Smooth-walled
   c. Tapered
   d. Coated

10. **Uncoated implant surfaces grit-blasted with medium-size particles in the diameter range of 75 µm may provide an optimum range of surface roughness for:**
    a. thread sharpness.
    b. soft tissue apposition.
    c. oral hygiene.
    d. bone apposition.

This article provides 1 hour of CE credit from Dental Learning Systems, in association with the University of Southern California School of Dentistry and the University of Pennsylvania School of Dental Medicine, representatives of which have reviewed the articles in this issue for acceptance. Record your answers on the enclosed answer sheet or submit them on a separate sheet of paper. You may also phone your answers in to (888) 596-4605, or fax them to (703) 404-1801. Be sure to include your name, address, phone number, and social security number.