

# Fixed Rehabilitation of Severely Atrophic Jaws Using Immediately Loaded Basal Disk Implants After In Situ Bone Activation

Guillaume Odin, MD, PhD<sup>1</sup>  
 Carl E Misch, DDS, MDS<sup>2</sup>  
 Itzak Binderman, DDS, MDS<sup>3</sup>  
 Gerard Scortecchi, DDS, PhD<sup>4\*</sup>

Rehabilitation of severely atrophic jaws is facilitated when basal disk implants are used after activation of the future bony implant bed with a purpose-designed instrument (Osteotensor) 45 to 90 days before implant surgery. Fabrication of a highly rigid, screw-secured fixed prosthesis that acts as an external orthopedic fixator permits immediate functional loading. This protocol also represents a second chance for patients who have experienced complete implant loss and/or bone graft failure.

**Key Words:** *disk implant, atrophic jaw, bone activation, immediate loading protocol*

## INTRODUCTION

Implant placement in severely atrophic jaws (Figure 1) is especially challenging because of the poor quality and quantity of the future implant bed.<sup>1</sup> Calvarial or iliac bone grafts, mental nerve displacement, and sinus lift procedures are often used to overcome the initially unfavorable anatomical and mechanical conditions.<sup>2</sup> Despite acceptable success rates, these approaches involve unpredictable degrees of morbidity at the donor and/or recipient sites.<sup>3</sup> Furthermore, patients are sometimes reluctant to undergo such procedures.

This article describes an approach based on osteogenic activation of the future implant bed and full-flap surgery for basal implant installation. Using a novel flapless procedure, a series of microcracks are created in the bone by a purpose-designed

bone matrix Osteotensor 45 to 90 days before implant surgery. The cascade of biological responses includes recruitment of stem cells, both locally and at a distance, that participate in bone remodeling. Once the density of the recipient bone site is judged acceptable, the implants are installed and immediately loaded with a rigid, passive-fit, screw-secured prosthesis serving as an external fixator.

## MATERIALS AND METHODS

### *Rationale for bone activation*

Just as mechanical microtrauma of the periosteum induces subsequent repair,<sup>4</sup> surgical trauma of the cortical bone results in a burst of localized hard tissue remodeling.<sup>5-7</sup> The microcracks caused by penetration of the Osteotensor (Victory, Nice, France) induce the release of bone matrix growth factors (bone morphogenetic protein and insulin-like growth factor I, II, and beta)<sup>8</sup> that have a range of biologic properties. Osteoinductive proteins from the bone matrix recruit stem cells at a distance from the microcracks that participate in the bone remodeling process.<sup>7</sup> Complex interactions have

<sup>1</sup> Institut Universitaire de la Face et du Cou, Département de Chirurgie maxillo-faciale, Nice, France.

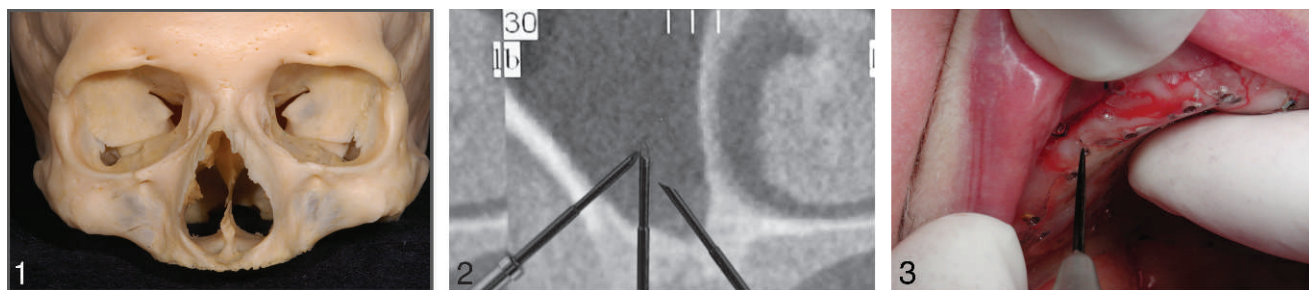
<sup>2</sup> Misch Implant Institute, Birmingham, Mich.

<sup>3</sup> School of Dental Medicine, Department of Bio-Engineering, Tel Aviv University, Tel Aviv, Israel.

<sup>4</sup> Private practice, Nice, France.

\* Corresponding author, e-mail: scortecchi@wanadoo.fr

DOI: 10.1563/AAID-JOI-D-10-00163



**FIGURES 1–3. FIGURE 1.** Extreme maxillary atrophy. Basal bone (human dry skull). **FIGURE 2.** Osteotensor in the sinus area. **FIGURE 3.** Transparent acrylic stent with impact markings. Osteotensor with diamond-like carbon coated tip.

been demonstrated between bone matrix tensions and signaling molecules (extracellular matrix, bone cells, cell nuclei). In addition to the existence of osteoregulation processes based on mechano-transduction,<sup>9,10</sup> osteotension triggers and regulates bone regeneration.<sup>11</sup> These observations, plus the findings of research in such fields as mechanobiology,<sup>12</sup> tensegrity,<sup>13</sup> corticotomy,<sup>14,15</sup> distraction osteogenesis,<sup>9,10,16</sup> and angiogenesis,<sup>17</sup> prompted the development of a specific instrument capable of producing calibrated microcracks without any local metal contamination or heat damage to tissues. Transparietal penetration of the instrument (Osteotensor) through the osteogenic compartments (periosteum, bone matrix, endosteum, vascular walls, bone marrow) instantly modifies the bone matrix tensions implicated in bone homeostasis.<sup>18,19</sup>

### **Osteotensor**

Bone perforation aimed at improving bone graft incorporation was originally performed using a variety of standard dental instruments (drills, burs, needles). The results were unpredictable, however, mainly because of heating, metallic pollution, and noncalibrated trauma. The purpose-designed Osteotensor is a specially calibrated, manual or rotary surgical steel instrument with a diamond-like carbon-coated tip. The procedure is performed without flap elevation so as to contain subperiosteal bleeding, avoid bacterial contamination, and maintain the peripheral blood supply. The size of each impact is no larger than the tip of a transfusion needle. When used in the sinus regions (Figure 2), the blood extravasates from the strongly irrigated connective tissue under the respiratory epithelial lining of the sinus cavities.

Each Osteotensor impact site is the point of

departure of accelerated reparative osteogenesis. Mineralization of the subperiosteal blood clot leads to formation of a bone callus after 45 days; this corresponds to the bone consolidation constantly observed for closed fractures without displacement.<sup>20</sup> Hyperdense type I sclerotic bone is “softened” into type II bone after 18 to 21 days, which marks the end of the post-trauma catabolic phase. This is the optimal moment for implant placement, distraction, or bone grafting on dense type I bone. Similarly, type IV bone can be “hardened” into type II bone after 45 to 90 days, depending on the severity of bone atrophy. When bone grafting is scheduled, the donor and recipient sites are both activated 18 to 21 days before surgery. The effects of bone activation do not last indefinitely, however. Vertical bone distraction, for example, should be performed after 18 to 21 days, which corresponds to the end of the catabolic phase, before the bone begins to consolidate.

### **Disk implants**

After bone matrix activation, extremely atrophic sectors are well managed with plate-form disk implants (Victory) ranging in length from 33 to 43 mm (width = 9 to 12 mm). The high fatigue strength of these solid titanium implants without any welds or added parts is particularly indicated for mechanically demanding situations (the canine and zygomatic sectors of the maxilla, the mandibular ramus). A specific titanium osteotome (“cutter”) is used to create a groove in the basal bone bed for lateral impaction of the implants. As intimate contact of the implant with the bone is essential, 2 to 5 titanium osteosynthesis screws (length = 4, 5, or 6 mm) are placed in eyelets on the implant base for added retention. The implant is then covered by autologous bone chips and/or biomaterial. For

maxillary rehabilitations, microthreaded root-form implants are usually installed in the tubero-ptyergoid sector for posterior anchorage. These implants all feature a flat emergence profile that allows 90° of freedom for prosthetic requirements.

### **Clinical case report**

A 74-year-old woman consulted in 2005 for fixed rehabilitation of her extremely atrophic edentulous maxilla. She had previously refused an iliac crest bone-grafting procedure. After initial workup and analysis of the computerized tomography (CT) scan and corresponding stereolithographic model (Materialise Dental, Chatillon, France), the implant-prosthetic project was prepared using simulation software (SimPlant, Materialise Dental, Leuven, Belgium) containing the library of basal disk implants. The study models were placed in occlusion, and a rigid transparent stent was prepared. The impact sites for bone activation were marked on this stent. A new set of removable complete maxillary trial dentures that satisfied the patient's esthetic requests and a surgical guide were also fabricated.

Bone matrix activation was performed as a flapless procedure after oral administration of 3 g amoxicillin, followed 20 minutes later by antiseptics of the operative field (2% chlorhexidine, 10% povidone-iodine). A topical anesthetic was then applied over the entire region. A local anesthetic containing adrenaline (1:200 000) was slowly injected using a 0.30 mm diameter, silicone-coated beveled-edge needle, stopping at the bone level. The impact stent was then inserted in the mouth and checked for correct fit and stability. Osteotensors were next applied through the impact perforations in the stent (Figure 3). A manual instrument was always used first. As soon as resistance to penetration was encountered, a switch was made to a rotary Osteotensor (20 000 rpm under copious irrigation). The type IV bone identified on the CT scan was confirmed during passage of the manual Osteotensors.

Forty-five days later, the same impact stent was used to check the maxillary bone status. The manual Osteotensor could no longer penetrate 23 of the 42 initial impact sites. Bone density at the remaining 19 sites was clearly improved, but manual penetration remained possible. After another 45-day waiting period, the patient returned

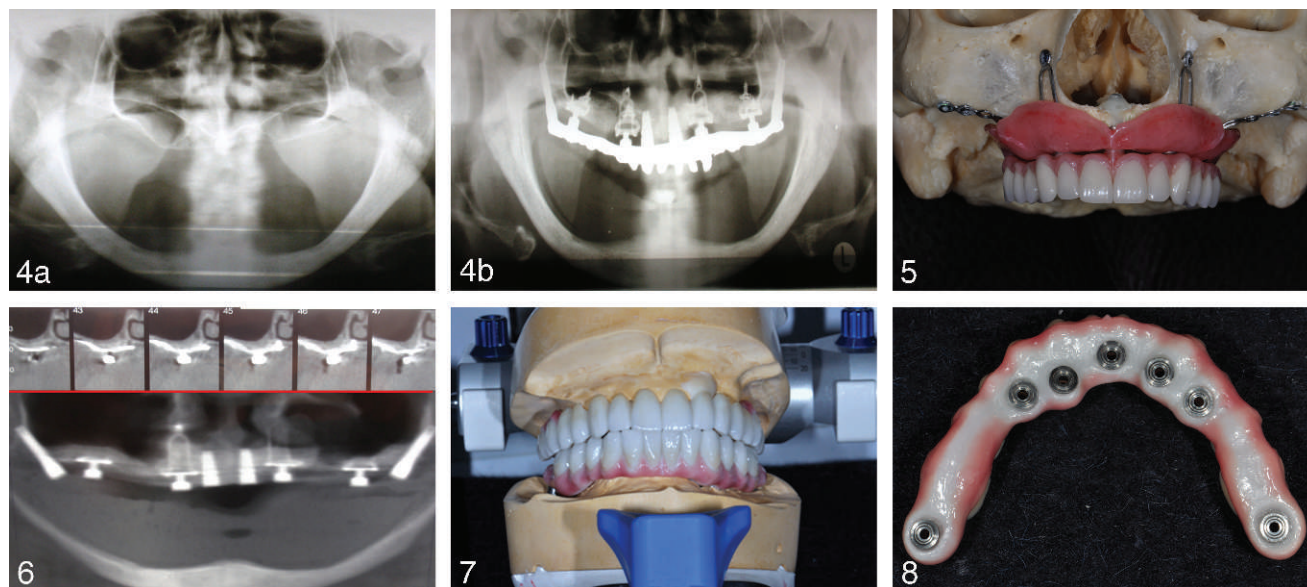
for a second check, at which time none of the impact sites could be penetrated with a manual Osteotensor. The initially unpredictable type IV bone of the atrophic maxilla had been transformed into "safer to operate" type II bone. It was then decided to proceed with implant surgery. A full-thickness flap was elevated and 8 titanium implants were installed in the now-optimized maxillary bone: 2 microthreaded, root-form cylindrical implants in the pterygoid region, 2 basal disk implants in the zygoma region, 2 basal disk implants in the maxillary canine pillars, and 2 cylindro-conical microthreaded implants (Fractal, Victory) that were combined with a crestal nasal floor elevation procedure. Biomaterial (Interpore 200, Interpore Orthopaedics, Irvine Calif) covered by autologous platelet-rich fibrin membranes<sup>21</sup> was used to augment the bone volume for cosmetic purposes. A pick-up impression was taken in the operating room immediately after suturing. Forty-eight hours later, the implants were functionally loading with a highly rigid, screw-retained fixed transitional prosthesis (Figure 4). The resin teeth were supported by a one-piece chromium-cobalt framework into which machined titanium copings had been glued (Figure 5). These cylinders guarantee a passive fit and prevent shearing forces at the implant interface. The postoperative course was uneventful; the patient rapidly regained normal mastication and speech and was fully satisfied with the esthetic outcome.

Six months later, the transitional prosthesis was retrieved. All implants were assessed individually, both clinically and radiographically (Figure 6). After another 6-month period, a new impression was taken using the existing fixed prosthesis to transfer the implant positions, emergence profiles, occlusion, and cosmetics. Three weeks later, a screw-secured, all-zirconium fixed prosthesis was fabricated (Figures 7 and 8).

### **RESULTS**

Regular checkups for maintenance and verification of the occlusion were performed every 3 months the first year, then once a year. After 2 years of function, the newly regenerated bone had remodeled into functional bone with trabeculae oriented perpendicular to the bone-implant interface.<sup>22</sup> After 2 years, CT imaging revealed that all implants were radiographically and clinically osseointegrated.





**FIGURES 4–8.** **FIGURE 4.** Severely atrophic maxilla before and after implant placement and immediate installation of a rigid, screw-secured fixed prosthesis (4 disk implants, 2 root-form implants, 2 microthreaded pterygoid implants). **FIGURE 5.** Four disk implants screw-secured onto the canine pillars and the zygomatic processes. The screw-secured transitional fixed prosthesis acts like an external orthopedic fixator. (Human dry skull). **FIGURE 6.** The fixed appliance was retrieved after 6 months of function. The computerized tomography scan reveals the bone growth around the titanium implants after osteogenic activation of the implant sites with bone matrix osteotensors. The sinuses appear healthier than they did initially. All implants were checked individually; none were painful or mobile, and the gingiva appeared healthy. **FIGURE 7.** The final full-zirconium rehabilitation can be fabricated after 12 months of function with a transitional prosthesis. **FIGURE 8.** Full-zirconium prosthesis (tissue/implant interface view). The machined titanium copings glued into the frame guarantee a totally passive fit and reduce shear and wear at the implant/zirconium interface.

Bone gain in the highly atrophic sectors that had undergone bone matrix activation ranged from 2 to 6 mm. The gingival tissues around each implant appeared healthy (no bleeding or inflammation).

The Table summarizes the results obtained using this same protocol for 36 patients (291 implants) treated from 2005 to June 2010. Only one patient was lost to follow-up. Two implants but none of the prostheses were lost. Of the 36 patients, 29 were highly satisfied by the outcome and 5 were satisfied. One patient was not satisfied, and the entire transitional fixed prosthesis was redone. This last patient suffered from psychological problems, and it was decided to maintain the transitional

screw-secured prosthesis and not fabricate the final all-zirconium restoration until complete satisfaction was achieved.

### DISCUSSION

Implantology is a nonurgent therapy that allows time for presurgery bone preparation. This is particularly important for patients with severe maxillary atrophy for whom maximum precautions must be taken. In contrast to bone activation techniques based on undulatory and/or vibratory phenomena (shockwave units, electromagnetic fields, piezotome apparatus, and lasers), Osteoten-

TABLE						
Number of patients treated per year						
	2005	2006	2007	2008	2009	2010
	Maxilla/Mandible	Maxilla/Mandible	Maxilla/Mandible	Maxilla/Mandible	Maxilla/Mandible	Maxilla/Mandible
Women	4/2	3/1	4/0	3/1	4/2	2/1
Men	1/0	2/0	1/0	1/1	1/1	1/0
Total	7	6	5	6	8	4

sors belong to the category of matrix mechanotensors. As with all types of mechanical osteotomy, the induced post-trauma neoangiogenesis and recruitment of progenitor cells both in situ and at a distance promote accelerated natural bone regeneration with formation of a bone callus.

Osteotensor application is indicated whenever imaging studies reveal bone of inadequate quality, whether fragile type IV bone or hyperdense type I bone. Similarly, osteogenic preparation is helpful when bone grafting, a sinus elevation procedure, or bone distraction is planned. Bone matrix activation by Osteotensors should be reserved for healthy patients without any local and/or general pathologies that may affect the bone tissue. As little or no bleeding occurs during this entirely flapless procedure, patients do not have to cease taking anticoagulation medication such as aspirin. Contraindications include buccodental infections, maxillary sinusitis, heavy smoking, alcoholism, substance abuse, insufficient oral hygiene, treatment by bisphosphonates, ongoing radiotherapy and/or chemotherapy, plus all of the temporary and/or absolute physical and/or psychological contraindications of buccodental surgery.

The Osteotensor can also be used to verify the initial bone density of intended implant sites. Combined with a robotic navigation system, it can be used both as a bone surface probe and a transmatrix depth gauge.

In this clinical report, 2 successive Osteotensor sessions were required to obtain satisfactory bone conditions for the installation of implants that could be functionally loaded with a fixed prosthesis within 48 hours. This is the minimum time required by the dental laboratory to fabricate a screw-retained prosthesis with a highly rigid chromium-cobalt framework with machined titanium cylinder connectors and resin teeth.

Although osteogenic preparation plays a central role in modifying the quality of the bone at intended implant recipient beds, the immediate and final screw-secured prostheses also transmit physiological stress to the bone matrix. These solid monoblock appliances are the equivalent of external orthopedic fixators. They maintain the absolute initial stability at the bone/implant interface during function required for adequate physiological bone remodeling over time around the implants. This prevents the continuous bone loss observed when

removable dentures are worn. An accurate and passive fit between the implant/prosthesis interface is thus essential, regardless of implant angulation.

Use of a pick-up impression technique, implants with a flat emergence profile, and machined titanium cylinders that are glued (Attachment Bond, Kulzer, Germany) into a cast or machined metal framework (chromium-cobalt/titanium) makes it possible to achieve this goal. The framework of the immediate transitional prosthesis must be extremely rigid and strong. Chromium-cobalt alloy frameworks with an L-shaped profile avoid the problems of cracking and breakage seen with resin frameworks that can be detrimental to both implants and the recipient bone. Resin teeth absorb potentially dangerous shocks and vibrations during the initial healing period. This is especially important when treating atrophic jaws.

The transitional prosthesis allows evaluation of masticatory function, occlusion, speech, esthetics, and the embrasures required for adequate maintenance. The final prosthesis is not fabricated until rehabilitation of the patient's mouth is completely under control. This can take 6 months to 1 year, depending on the initial clinical situation. The material selected for the final prosthesis (composite resin, ceramic, zirconium) must take into account the specific clinical characteristics of each individual (bruxism, bite force, presence of fixed opposing teeth).

The reproducible clinical results obtained with osteogenic activation by bone matrix osteotensors before implant surgery for patients with severe jaw atrophy allow routine use of this approach before bone grafting procedures and/or implant installation (root-form and/or disk implants).

#### ABBREVIATION

CT: computerized tomography

#### REFERENCES

1. Scortecchi G, Misch CE, Benner KU. *Implants and Restorative Dentistry*. London, UK: Martin Dunitz; 2001:79–85.
2. Misch CE, Qu Z, Bidez MW. Mechanical properties of trabecular bone in the human mandible. Implications of dental implant planning and surgical placement. *J Oral Maxillofac Surg*. 1999;57:700–706.
3. Misch CE. *Contemporary Implant Dentistry*. St Louis, Mo: Mosby Elsevier; 2008:1034–1035.

4. Wilderman MN. Repair after a periosteal retention procedure. *J Periodontol.* 1963;34:487–503.
5. Frost HM. The biology of fracture healing: an overview for clinicians. Part I. *Clin Orthop.* 1989;248:283–293.
6. Axhausen W. The osteogenic phases of regeneration of bone: a historical and experimental study. *J Bone Joint Surg Am.* 1956;38:593–600.
7. Wolff J. *The Law of Bone Remodeling.* Berlin, Germany: Springer; 1986 [translation of the 1892 German edition].
8. Urist MR. Bone formation by autoinduction. *Science.* 1965;150:893–899.
9. Robling AG, Burr DB, Turner CH. Skeletal loading in animals. *J Musculoskelet Neuron Interact.* 2001;1:249–262.
10. Morgan EF, Longaker M, Carter DR. Relationships between tissue dilatation and differentiation in distraction osteogenesis. *Matrix Biol.* 2006;25:94–103.
11. Binderman I, Zor U, Kaye AM, Shisushoni Z, Harell A, Somjen D. The transduction of mechanical force into biochemical events in bone cells may involve activation of phospholipidase A2. *Calcif Tissue Int.* 1988;42:261–266.
12. Ingber DE. Mechanobiology and diseases of mechanotransduction. Review. *Ann Med.* 2003;35:564–577.
13. Ingber DE. Tensegrity: the architectural basis of cellular mechanotransduction. *Ann Rev Physiol.* 1997;59:575–599.
14. Suya H. Corticotomy in orthodontics. In: Hosl E, Baldauf A, eds. *Mechanical and Biological Basics in Orthodontic Therapy.* Heidelberg, Germany: Hütlig Buch; 1991:207–226.
15. Sebaoun JD, Kantarci A, Turner JW, et al. Modeling of trabecular bone and lamina dura following selective alveolar decortication in rats. *J Periodontol.* 2008;79:1679–1688.
16. Ilizarov GA. The tension stress effect on the genesis and the growth of tissues. Part II. The influence of the rate and frequency of distraction. *Clin Orthopaed Rel Res.* 1989b;239:263–285.
17. Marx JL. Angiogenesis research comes of age. *Science.* 1987;237:23–24.
18. Doglioli P, Scortecci G. Characterization of endosteal osteoblasts isolated from human maxilla and mandible: an experimental system for biocompatibility tests. *Cytotechnology.* 1991;7:39–48.
19. Frost MH. The biology of fracture healing: an overview for clinicians. Part II. *Clin Orthop.* 1989;248:294–309.
20. Spiessl B. *Internal Fixation of the Mandible: A Manual of AO/ASIF Principles.* New York, NY: Springer-Verlag; 1989: 68.
21. Choukroun J, Diss A, Simonpieri A, et al. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part IV: clinical effects on tissue healing. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101:e56–e60.
22. Branemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg.* 1977;16(suppl):1–132.