A Customized Distraction Device for Alveolar Ridge Augmentation and Alignment of Ankylosed Teeth

Pier Francesco Nocini, MD, DDS, MFS[1]/Daniele De Santis, MD, DDS, MFS[2]/
Francesca Ferrari, MD[2]/Gian Paolo Bertele, MD, DDS[3]

The purpose of this study was to develop an extraosseous, tooth-supported miniature intraoral device that could produce prosthetically driven bone distraction of small atrophic alveolar ridge segments. Extraosseous distraction requires that the distraction device be anchored to a dental implant previously placed into the ridge according to its anatomic axis. A distractor can also correct the position of implants placed in young patients before skeletal growth is completed. Similarly, it allows the alignment of ankylosed teeth not treatable by orthodontics. The device is made of (1) an engine consisting of an orthodontic micrometric screw; (2) a joint between the implant and the engine, ie, the ball attachment/o-ring system; and (3) an anchorage system to the oral cavity provided by an orthodontic appliance and a mini-implant for possible additional support. Surgery involves an osteotomy of the atrophic alveolar ridge segment, incorporating the implant, from the basal bone; afterward the device can be applied and distraction of the segment can be carried out. Distraction was successfully performed in 3 clinical cases: 2 bone-implant segments and 1 bone-ankylosed tooth segment. All cases were clinically uneventful. This mini-device for osteogenic distraction of small atrophic ridge segments can provide for accurate and precise ridge augmentation, as is required for ideal prosthetic rehabilitation. INT J ORAL MAXILLOFAC IMPLANTS 2004;19:133–144

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Bone distraction was first used for alveolar ridge augmentation in 1996 in in vivo trials by Block and coworkers[1] on mongrel dogs, while the first treatment in humans was performed by Chin and Toth.[2] Since then, this regeneration technique has proven to be a valid alternative to autogenous bone grafts and guided bone regeneration (GBR) in the preparation of a future implant site. The advantages of this new technique lie in its capacity for potentially unlimited and simultaneous regeneration of both bone and soft tissue and the absence of donor site morbidity. Furthermore, few complications occur when bone distraction is carried out in accordance with the proper surgical procedures.

Several researchers have contributed to the development of vertical ridge distraction osteogenesis by designing smaller and increasingly versatile intraoral distraction devices of both intra- and extraosseous types.[3–12] Parallel to this process has been the use of conventional endosseous implants to act as mini-distractors,[13–15] while a telescopic distraction device has been designed that remains in place to act as an implant at the end of the distraction process.[16] The most recent research on alveolar ridge distraction has tended toward 3-dimensional (3D) distraction[17] and distraction transport vector control,[18] as well as the use of distraction to solve preprosthetic problems, including any malposition of the implants.[19]

[1]Chairman of Oral and Maxillofacial Surgery, Faculty of Medicine, University of Verona, Italy.
[2]Dental and Maxillofacial Department, Faculty of Medicine, University of Verona, Italy.
[3]Chairman of Orthodontics, Faculty of Medicine, University of Verona, Italy.

Correspondence to: Prof Pier Francesco Nocini, Policlinico "G. B. Rossi," P. le L. A. Scuro, 10, 37134 Verona. Fax: +390-45-8202142. E-mail: pierfrancesco.nocini@univr.it

Figs 1a and 1b The distraction engine. *(Left)* The Super Micro screw (Leone), used in the first clinical case, and *(right)* the threaded tap screw from the First Class device (Leone), which was adopted in the second and third clinical cases.

In line with this development, the present study explored the possibility of performing a finely controlled 3D distraction of atrophic segments of the alveolar ridge, taking advantage of support from implants placed into it. Such a treatment plan can be applied after an appropriate implant is placed following the anatomic axis of the alveolar process (primary bone-driven implant placement) or using the support from implants that are not in an ideal position, for example, those placed in a young patient before skeletal development is complete (growth-related implant malposition).

The device that makes such remodeling of the ridge possible is a versatile, miniaturized, intraoral natural tooth/implant–supported unit built according to orthodontic and implant prosthetic concepts.[20] The device is well tolerated by the patient, and its use allows the atrophic segment, which is separated from the surrounding bone through osteotomy, to be moved in a very short time, thereby correcting the tissue and positional deficiencies. Concurrently, the implant can be placed in the most suitable position for subsequent prosthetic treatment without losing its osseointegration, as documented by other studies in the literature.[21,22] Thus, the morphologic and functional recovery of the ridge can be very precise; in addition, it takes much less time than conventional bone distraction (because the implant can already be used during the maturation of the regenerated tissue) and conventional regeneration techniques (autogenous bone grafts, GBR). With the same approach, it is also possible to solve problems of alveolar ridge underdevelopment caused by malposition of teeth with ankylosis of the periodontal ligament. The device allows for treatment similar to an orthodontic procedure that could not otherwise be performed: separation of the tooth from the rest of the ridge with sufficient surrounding bone without negative impact to the tooth structure.

MATERIALS AND METHODS

The distraction device is made by the laboratory assembly of components normally found in fields of clinical practice outside that of bone distraction. Some of the parts were adapted and a new element was made especially to make the device more versatile.

Two types of micrometric screws used in orthodontics were tried as a distraction engine. At the start of the research work, the Super Micro screw (Leone, Florence, Italy) was used, providing distraction of 0.7 mm per turn (Fig 1a), and later the threaded M2×2×15.9 tap screw from the First Class device was adopted (Leone) (Fig 1b). Several changes were made to the latter to improve its performance; in particular, a new and more accessible activation site was created in the head of the screw (Fig 2). At the other end, a threaded steel rod segment was screwed on to act as a distraction slider (Fig 2). The old activation site was made into a connection point for anchoring the device after removal of the cross holes (Fig 2). Lateral to the site, 0.7-mm steel wires were welded to run parallel to the screw and act as tracks and stabilizers for the threaded slider (Fig 2); rings made from a 0.7-mm-diameter steel rod were added for attachment to the tracks.

The joint between the distraction engine and the implant to be moved was formed by the ball attachment/O-ring system (Lifecore Biomedical, Chaska, MN), which is commonly used to retain implant-supported overdentures (Fig 3a). The O-ring's titanium ring was welded to the microscrew

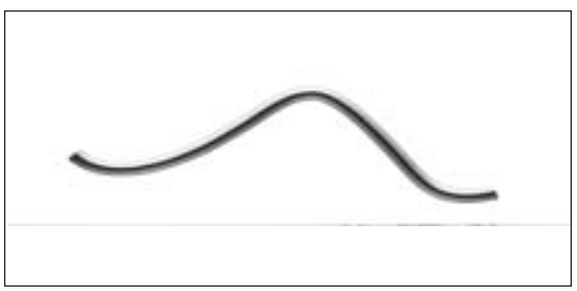
Fig 2 Changes were made to the threaded tap screw from the First Class device (Leone) to improve its performance. *(1)* a new and more accessible activation site was created in the head of the screw; *(2)* a threaded steel rod segment was screwed on to act as a distraction slider; *(3)* the old activation site was made into a connection point for anchoring the device; *(4)* steel wires (0.7 mm in diameter) were welded to run parallel to the screw and act as tracks and stabilizers for the threaded slider.

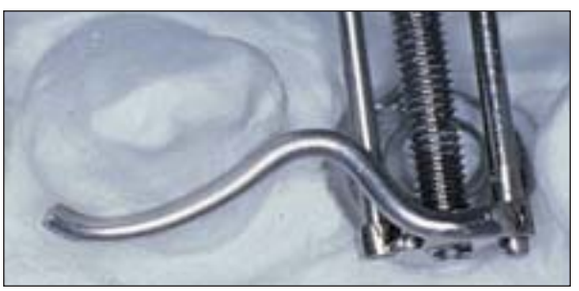
Figs 3a and 3b *(Left)* The joint between the distraction engine and the implant is represented by the ball attachment/O-ring system (Lifecore) for the outer hexagonal implant head. *(Right)* To obtain a universal joint, an O-ring abutment was also created with an inner hexagonal implant head (Loca Gold).

slider in the best indicated position for the clinical case. The procedure was carried out in an orthodontic laboratory on a master cast with an implant replica in it. To obtain a universal joint, an O-ring abutment was created with an inner hexagonal implant head (Loca Gold, Verona, Italy) (Fig 3b). The abutment, with a ball attachment, screws onto the implant, and the ring retainer is inserted into the implant with an orthodontic elastic inside it (Figs 4a to 4c). This produces a stable joint that is also hard-wearing and able to compensate for changes in the distraction transport vector up to ± 10 degrees where this is necessary to move the implant into its correct position. If a natural tooth requires repositioning, a mechanical chromium-cobalt arm of 0.9 mm diameter can be welded to the slider instead of the female part of the O-ring system and then ligated to a bracket that is glued to the tooth (Figs 5a and 5b).

The anchorage system to the oral cavity is very versatile and adapts easily to many kinds of abutments. Each case is planned individually on a working cast. With the help of an orthodontic appliance, both the adjacent teeth and any osseointegrated endosteal implants replacing missing teeth can be used for anchorage. When natural teeth provide adequate stability, an orthodontic support derived from the Crozat appliance and/or fixed orthodontic appliances can be used. When dental implants are used for anchorage, temporary abutments with brackets are made (Figs 6a and 6b). The Crozat appliance and orthodontic archwire were welded to the distraction engine. Where the anchorage abutments were inadequate and where the ridge adjacent to the tooth or implant to be moved was edentulous, an AISI 303 stainless steel mini-implant with a ball attachment (Loca Gold) was designed (Figs 7a and 7b). This is a small self-cutting screw, 10.8 mm

Figs 4a to 4c The device is built on the master cast with an implant replica in it. Note the welding *(top left)* between the O-ring's titanium ring *(right)* and the micro-screw slider in the best indicated position for the clinical case. The abutment, with a ball attachment, is screwed onto the implant replica *(bottom left)*.





Figs 5a and 5b The joint between the distraction engine and the tooth is a mechanical chromium-cobalt arm. *(Left)* 3D elaboration; *(right)* clinical view.

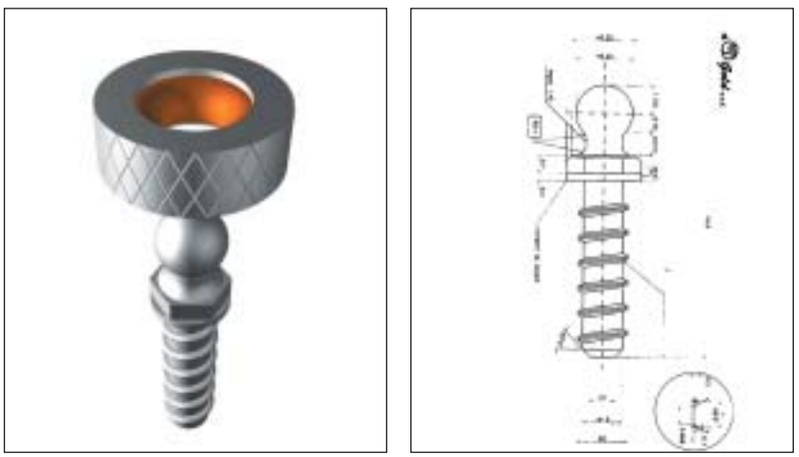
Figs 6a and 6b The device's anchorage system. When teeth provide adequate stability, they can be used as orthodontic support. When dental implants are used for anchorage, temporary abutments with brackets were made *(above)* or a combination of the two was employed *(right)*.

in total length; the endosseous portion was 7.0 mm long and 2.0 mm in diameter, including the threads. The mini-implant can be placed easily using quick and extremely conservative surgery and can be immediately loaded. Device anchorage to such a new abutment is made possible by simply providing the device with the female retainer that inserts into the mini-implant ball attachment. Anchorage of the mini-implant can be strengthened by attachment both to teeth or implants at the same time.

Clinical conditions dictate the particular assembly of components; the connections are carried out on a working cast in an orthodontic laboratory by laser welding with 0.12-inch steel wire.

Case 1

A 52-year-old man presented with Cawood Class 4 bone atrophy at the maxillary left lateral incisor. The severely impaired tooth was extracted. It was decided to replace the tooth with a 13-mm-long,



Figs 7a and 7b The mini-implant with ball attachment (Loca Gold) was used where the anchorage abutments were inadequate. *(Left)* 3D elaboration; *(right)* technical drawing of the mini-implant.

4.2-mm-diameter Sustain implant (Lifecore Biomedical) without first regenerating the bone defect with conventional augmentation methods such as GBR, bone grafts, or bone substitutes. The implant was placed inside the ridge following the anatomic axis, and because of the anatomic characteristics of the defect related to the centripetal resorption of the alveolar process in the maxilla, the implant occupied a position that was too buccal compared to the other teeth (Figs 8a and 8b). The treatment plan was thus based on separating the implant with its supporting bone from the surrounding ridge so that it could be moved to the new position using the aforementioned device, at the same time correcting the morphologic defect of the ridge.

The distraction transport process involved the use of an unmodified 0.7-mm-per-turn Super Micro screw (Leone). The screw anchorage system was planned and built on a working cast in the orthodontic laboratory according to the construction principles of the Crozat appliance: Occlusal support clasps were fitted to the dental abutments and the system was connected to the microscrew by one of its 2 sliders using an adjustable, dual-steel-wire cradle. To the other slider was welded the O-ring's titanium ring for connection to the O-ring abutment screwed to the implant. After assembly, the technician simulated the distraction process by separating the portion corresponding to the harvested bone from the remaining plaster cast, interposing a layer of hot wax. The distraction device was fitted into the patient's mouth to check its fit and then removed.

This was followed by the surgical stage. Surgery was carried out under local regional block anesthesia with mepivacaine hydrochloride (Optocain; Molteni Dental, Firenze, Italy); for additional comfort, the conscious patient was also lightly sedated with 5 mg of intravenous diazepam. After screwing a regular diameter O-ring abutment to the implant, a full-thickness flap was elevated buccally to expose the buccal aspect of the cortical alveolar bone, the implant head, and the coronal portion of the roots of the maxillary left central incisor and the maxillary left canine. With the flap raised, the osteotomy line was marked with a pencil. The osteotomy was performed to interfere as little as possible with the supporting tissue of neighboring teeth. Two vertical cuts and 1 horizontal cut into the buccal cortical and cancellous bone were made with a micro-oscillating saw (Medicon, Tuttlingen, Germany), while the palatal corticotomy was performed using a bone osteotome (Medicon) to spare the palatal periosteum. It was felt that this was essential for the maintenance of the bone block vitality and for the future fibrous callus formation. The device was then put in place and attached to the dentition by means of light-curing composite at 4 abutments (Figs 8c and 8d).

After insertion of the O-ring's female retainer onto the ball attachment, the distractor was activated during surgery with a small wrench to ensure the completeness of the osteotomy and the correctness of the distraction transport vector. The screw was then returned to its initial position, and the flap was repositioned and carefully sutured (Fig 8e). The patient was given preventive antibiotic coverage using amoxycillin (1 g tablet orally every 8 hours for 5 days). After a latency period of 5 days, the screw was activated (1 1/2 turns per day). This resulted in a palatal implant movement of 1.05 mm/day; at the same time, the resilience of the O-ring/ball attachment allowed a distraction transport vector angular change of ± 10 degrees. After 9 days, the implant and the alveolar ridge had attained the optimal position planned at the start of treatment (Fig 8f). A temporary prosthesis was then placed to make sure that the distracted tissue was allowed rigid fixation

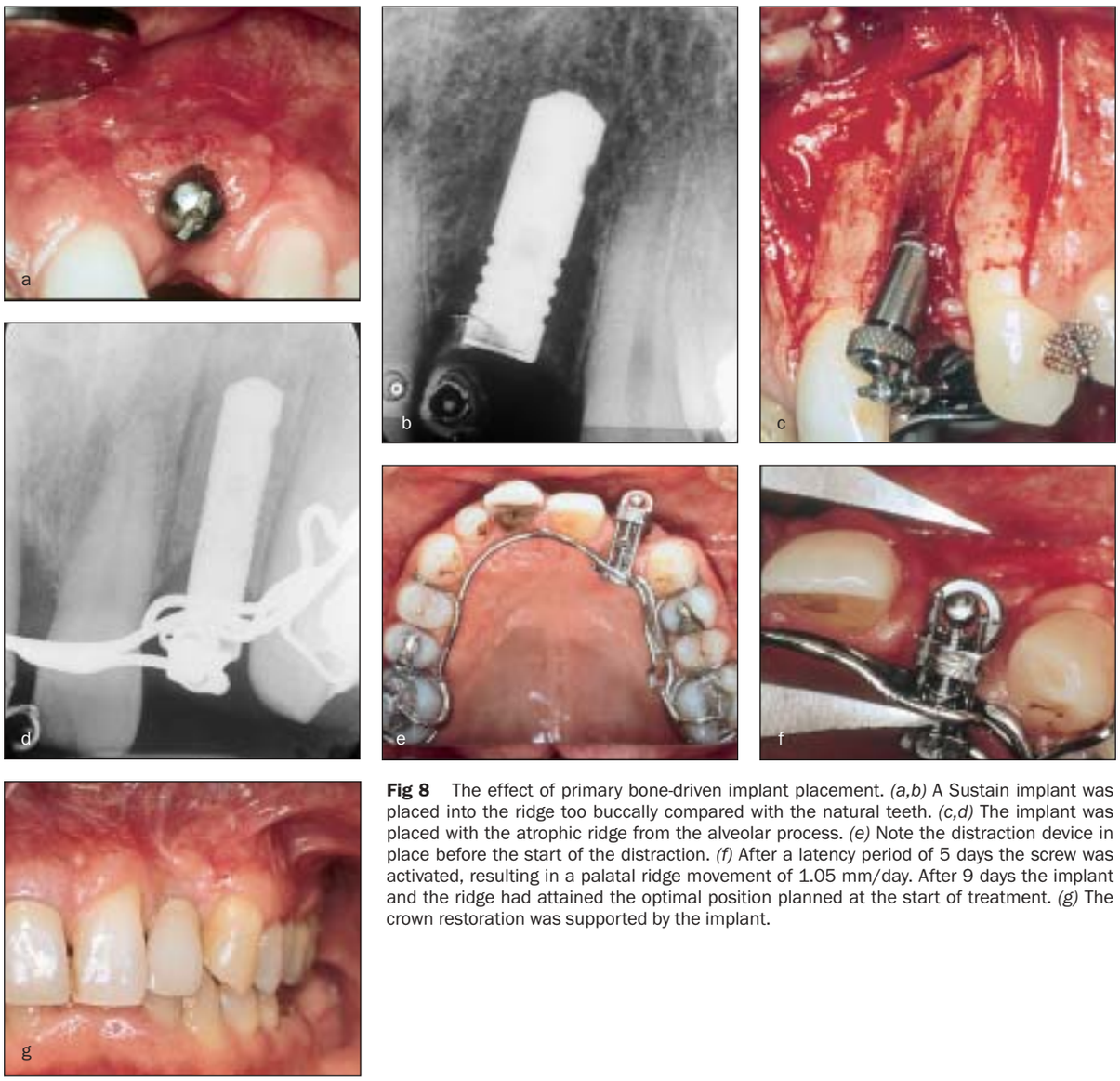


Fig 8 The effect of primary bone-driven implant placement. *(a,b)* A Sustain implant was placed into the ridge too buccally compared with the natural teeth. *(c,d)* The implant was placed with the atrophic ridge from the alveolar process. *(e)* Note the distraction device in place before the start of the distraction. *(f)* After a latency period of 5 days the screw was activated, resulting in a palatal ridge movement of 1.05 mm/day. After 9 days the implant and the ridge had attained the optimal position planned at the start of treatment. *(g)* The crown restoration was supported by the implant.

for 3 months, which was necessary for its maturation. The definitive prosthesis was then fabricated (Fig 8g).

Case 2

The 19-year-old female patient had undergone mandibular bone resection in the left premolar and molar region for an ameloblastic fibroma during childhood. She was subsequently treated for the resulting severe bone atrophy by alveolar distraction with the Verona device,[22] another author-designed intraoral distractor. After the consolidation period, when the device was removed, the anterior section of the newly formed alveolar ridge showed excessive lingual tilting caused by the traction exerted by the soft tissues on the distracted segments. The decision was made to place 3 Sustain implants (Lifecore Biomedical) in the regenerated bone. The most mesial of these, an implant 3.4 mm in diameter and 13 mm in length, was placed taking into account the anatomic axis (Figs 9a and 9b). It was subsequently used to improve the alveolar profile using the distraction device. At the end of the treatment, it served as the prosthetic rehabilitation unit. On this occasion, the distraction screw chosen was the threaded rod in the First Class device (Leone), with the alterations previously indicated, since the authors decided that the device would thus be rendered even more versatile.

In accordance with protocol, anchorage was planned on the working cast from an elastomeric impression containing the implant pickup impression copings; the laboratory was thus presented with

the clinical picture in detail. The chosen abutments were the 2 most distal implants, which were restored with a temporary acrylic resin denture incorporating a metal arm, and the natural dentition, which was fitted with conventional brackets and full-size orthodontic wire. The passive fit of the provisional out-of-occlusion prosthesis was checked in the patient's mouth; the metal arm and orthodontic archwire were then welded to the original screw activation site with the screw in line with the required displacement vector. The O-ring's titanium ring was welded to the distraction expander's slider in relation to the O-ring abutment position, and finally the technician simulated movement on the plaster cast to ensure that the vector was correct.

The same surgical criteria were followed as in the previous case. A buccal mucoperiosteal flap was elevated after block anesthesia and infiltration of the mandibular alveolar and lingual nerves and mucosal infiltration of 3.6 mL of Optocain in the mandibular left first premolar area. The bone block containing the implant was freed using the osteotomy technique described above (Figs 9c and 9d), and the device was delivered, fitting the provisional prosthesis to the distal implants and ligating the orthodontic archwire to the brackets secured on the teeth. Once the O-ring's retainer was inserted into the ball attachment of the small-diameter abutment screwed to the lingually displaced implant, the distractor was activated using a small screwdriver. After checking that the osteotomy was complete, the screw was returned to its initial position, and the flap was repositioned and carefully sutured (Fig 9e).

It is imperative that the soft tissue incisions are well removed from the areas where the corticotomy is carried out, so that the bone segment is adequately protected from infections and so that the distraction gap receives adequate blood supply. The patient was given prophylactic antibiotic treatment using amoxicillin (1 g orally every 8 hours for 5 days). After a latency period of 5 days, the screw was activated (1½ turns per day), resulting in buccal movement of 0.6 mm/day of the slider connected to the implant. At the same time, the resilient O-ring/ball attachment joint allowed angular changes in the transport vector of up to ± 10 degrees. After 7 days the implant and ridge position was fully corrected (Fig 9f), and the 3 implants were restored with a provisional prosthesis for the 3 months of bone callus consolidation (Fig 9g). The degree of mineralization of the tissue filling the distraction gap was documented radiographically at the end of consolidation period (Fig 9h).

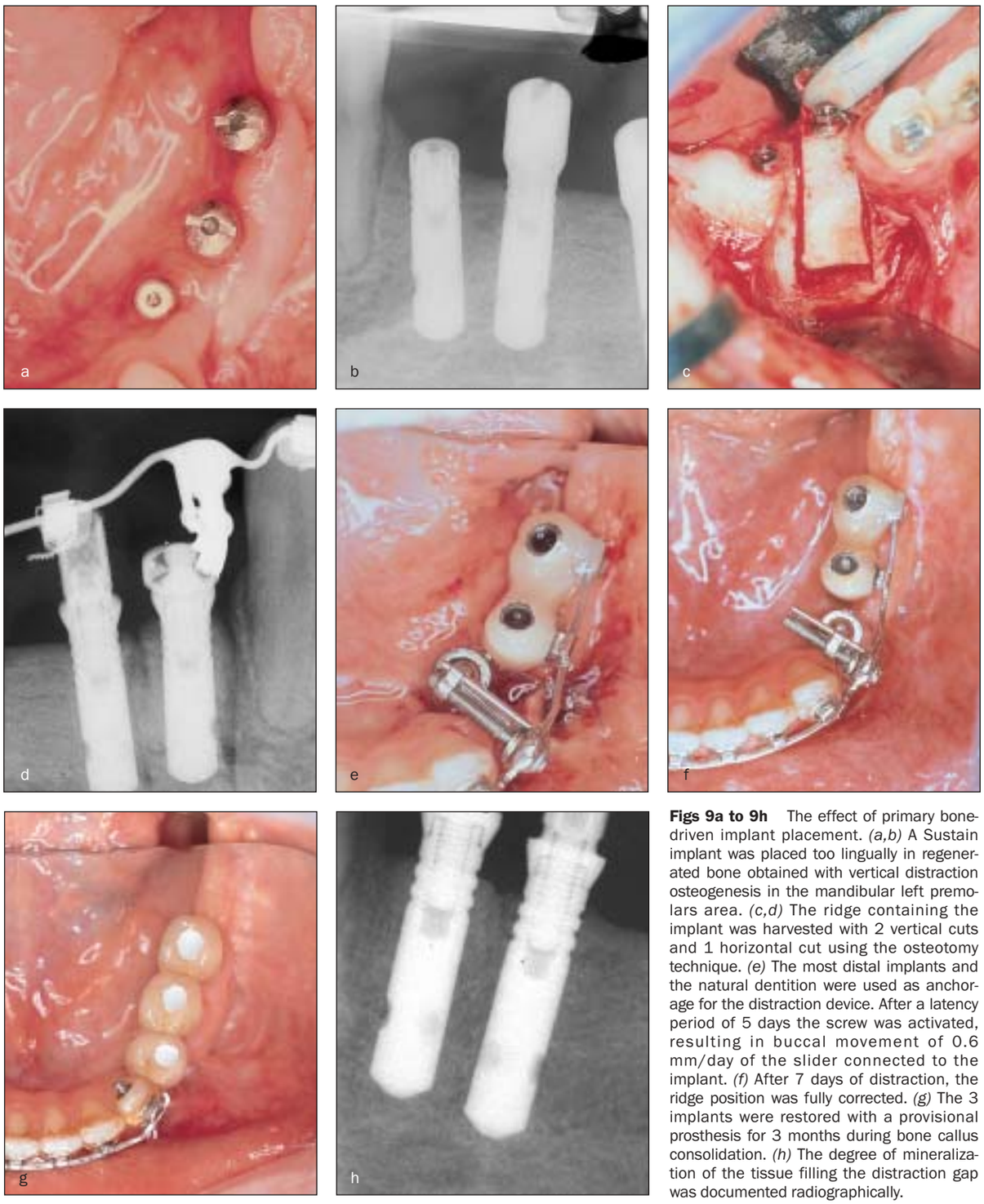
Case 3

A 58-year-old man who wore a maxillary removable partial denture required realignment of the maxillary left canine, which was markedly tilted palatally and clinically ankylosed (Figs 10a and 10b). As well as compromising the appearance of the patient's smile, the dental malposition had caused malocclusion, with a left lateral displacement of the mandible. Since the ankylosis of the involved tooth made the effectiveness of conventional orthodontic therapy doubtful, use of the distraction device, according to the same criteria adopted with the previously described implants, seemed to be indicated.

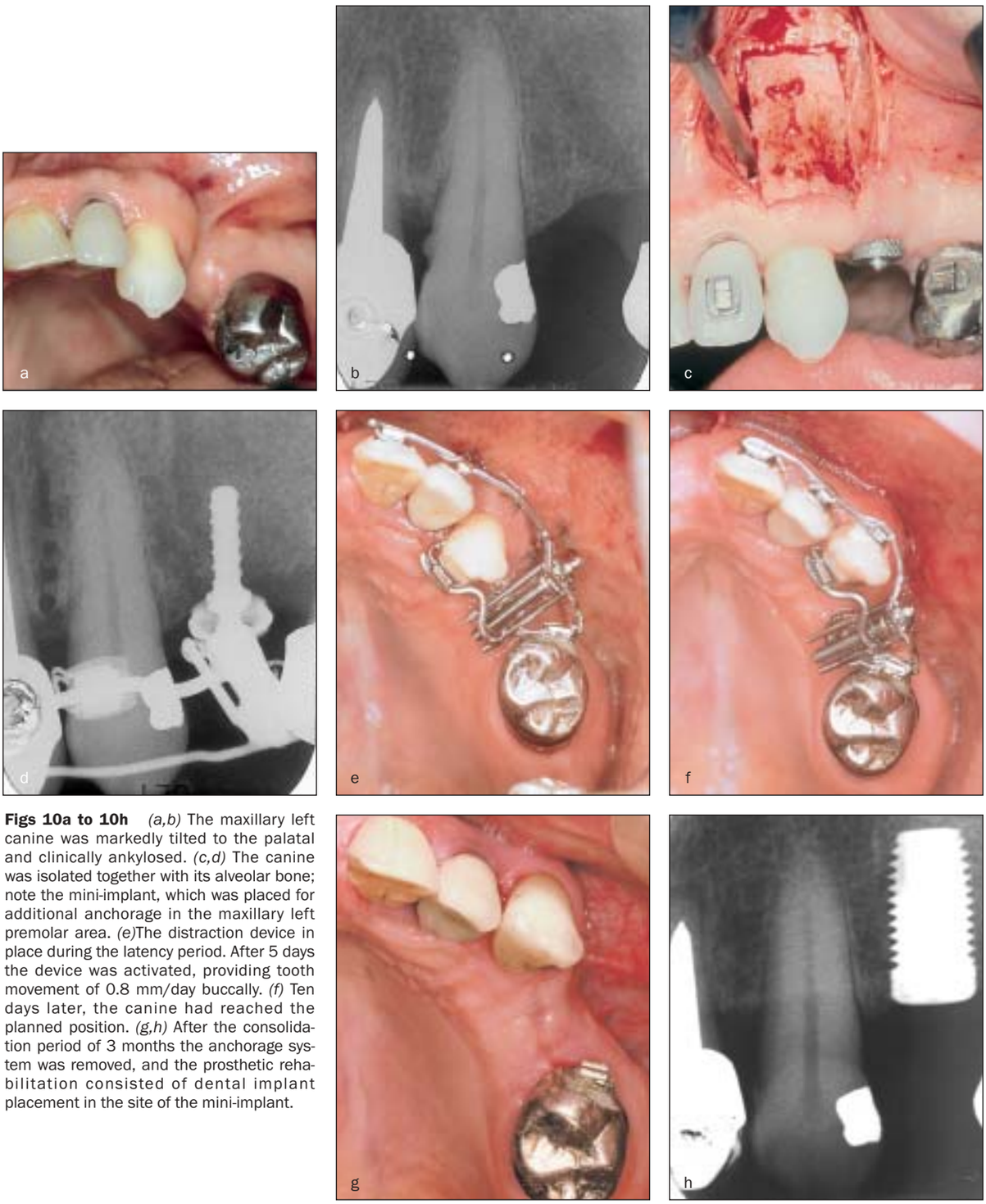
The choice of distraction expander was once again a modified male threaded screw from the First Class device (Leone). In place of the O-ring's titanium ring, which no longer served as a joint, a mechanical arm obtained from casting together several 0.9-mm chromium-cobalt orthodontic wires was welded to the slider. The purpose of the arm was to transmit the force and direction of the distraction to the tooth and stabilize it during the latency period; for this reason the arm itself was bound to a bracket applied to the tooth's palatal surface. The fact that a number of teeth were missing had to be considered when planning the anchorage sites, and again the working cast of the arch was used in the planning process.

In addition to the tooth to be repositioned, only the maxillary right canine, the maxillary left central and lateral incisors, and the maxillary left first molar were present; the edentulism was treated with a removable partial prosthesis. Double anchorage was considered necessary to make the device stable: the right canine, the left central and lateral incisors, and the left first molar were banded and held together by orthodontic wire, with additional anchorage provided by a mini-implant with a stainless steel ball attachment (Loca Gold). This placement was planned in the maxillary left premolar area to make up for the absence of the 2 premolars. Changes were therefore made to the removable partial denture to enable the patient to wear it throughout the treatment period. At the same time, a bite plate was fabricated in the laboratory for adaptation to the mandibular arch; this was separated from the maxillary arch to allow the canine, during distraction, to pass over the mandibular left canine. When displacement was complete, the bite plate would also protect the tooth from occlusal loading and guide function during the consolidation period.

Placement of the mini-implant was carried out under local anesthesia. A full-thickness ridge incision was made, 2 buccal and palatal flaps were elevated, and the implant site was prepared with an



Figs 9a to 9h The effect of primary bone-driven implant placement. *(a,b)* A Sustain implant was placed too lingually in regenerated bone obtained with vertical distraction osteogenesis in the mandibular left premolars area. *(c,d)* The ridge containing the implant was harvested with 2 vertical cuts and 1 horizontal cut using the osteotomy technique. *(e)* The most distal implants and the natural dentition were used as anchorage for the distraction device. After a latency period of 5 days the screw was activated, resulting in buccal movement of 0.6 mm/day of the slider connected to the implant. *(f)* After 7 days of distraction, the ridge position was fully corrected. *(g)* The 3 implants were restored with a provisional prosthesis for 3 months during bone callus consolidation. *(h)* The degree of mineralization of the tissue filling the distraction gap was documented radiographically.



Figs 10a to 10h *(a,b)* The maxillary left canine was markedly tilted to the palatal and clinically ankylosed. *(c,d)* The canine was isolated together with its alveolar bone; note the mini-implant, which was placed for additional anchorage in the maxillary left premolar area. *(e)*The distraction device in place during the latency period. After 5 days the device was activated, providing tooth movement of 0.8 mm/day buccally. *(f)* Ten days later, the canine had reached the planned position. *(g,h)* After the consolidation period of 3 months the anchorage system was removed, and the prosthetic rehabilitation consisted of dental implant placement in the site of the mini-implant.

externally irrigated, 1.5-mm-diameter twist pilot bur. After placement of the self-tapping implant into the bone using a manual rotary head screwdriver fitted to the ball attachment, the flaps were repositioned and sutured. An elastomeric impression was then made of the maxillary arch for the purpose of master cast fabrication. The technician assembled the various device components on this cast in the laboratory, and a simulation of distraction was carried out by carving the block out of the plaster cast and placing a layer of hot wax in between.

After approximately 10 days, when the soft tissue around the miniature implant had healed, the delicate step of moving the ankylosed tooth from the alveolar bone was initiated. Surgery was carried out under local regional block anesthesia of the posterior superior alveolar, infraorbital, nasopalatine, and greater palatine nerves, with mucosal infiltration at the maxillary left canine using 5.4 mL of Optocain 2% mepivacaine 2% with adrenaline 1:100,000). The patient was also sedated with 5 mg of intravenous diazepam. A full-thickness flap was elevated in the vestibular alveolar mucosa of the canine. It was decided to carry out a horizontal paramarginal incision so as to spare the tooth's superficial periodontium; the 2 vertical releasing incisions reached as far as the top of the fornix. An osteotomy guide mark was made beneath the raised flap, and the canine was isolated together with an adequate thickness of surrounding bone, while care was taken to avoid damage to the supporting tissue of the maxillary left lateral incisor (Figs 10c and 10d). The distraction device was then placed: the O-ring was inserted into the miniature implant's ball attachment and the orthodontic archwire was ligated to the brackets previously positioned on the maxillary left central and lateral incisors and the maxillary left first molar. After activation of the distractor with the specially designed hexagonal wrench for the purpose of checking mobility of the bone block, the screw was returned to its initial position and the flap was repositioned and carefully sutured (Fig 10e). The device occupied the edentulous maxillary left premolar area, so that the patient could wear his suitably modified removable partial denture immediately after surgery. The patient was given prophylactic antibiotic coverage with amoxicillin (1 g orally every 8 hours for 5 days).

After a latency period of 5 days, the distractor was activated by 2 turns of the screw per day, which moved the tooth 0.8 mm/day in a buccal direction. This rate of distraction was employed for a period of 10 days, by which time the canine had reached the planned position (Fig 10f). The mucogingival tissue showed no clinical signs of inflammation and the surgical wound had completely healed. The bite plate had allowed the opposing canine to be overtaken without interference and the malocclusion was corrected, with the mandible moving into its proper natural position. The bite plate was then removed, the distractor was removed from its anchoring pillars, and the canine was connected to the remaining teeth by a buccally placed orthodontic archwire. The patient was thus relieved of any discomfort that may have resulted from the small distraction device during the consolidation period of 3 months. The prosthetic rehabilitation consisted of placement of a dental implant in the site of the mini-implant (Figs 10g and 10h). Removal of the mini-implant was accomplished by means of counterclockwise unscrewing before implant drilling.

RESULTS

Osteodistraction and tooth repositioning were successfully carried out in all 3 patients. At the end of treatment in the first 2 patients, the implant positioning was ideal for prosthetic rehabilitation, while in the third patient the tooth was realigned with the dental arch and the malocclusion was resolved. The mean distraction period was 9 days (range, 7 to 10 days). The first bone/implant segment was moved 9.5 mm in a palatal direction, the second was buccally displaced by 4.2 mm, and the ankylosed canine was moved 8 mm in a buccal direction. At the end of the consolidation period of 3 months, the bone blocks showed no mobility on palpation or signs of inflammation of the overlying mucosa. The implants showed no loss of osseointegration. Osstell resonance frequency testing analysis (Osstell/Integration Diagnostics, Sävedalen, Sweden) gave implant stability quotient values of 72 in the first patient and 68 in the second patient, and the periimplant bone underwent no resorption. No pathology of any kind was found in the canine periodontal tissue, and Periotest values (Siemens, Erlangen, Germany) of –1 were noted. During the clinical follow-up period, none of the patients had wound dehiscences and the treatment was tolerated well. The patients did not complain of any discomfort during the distraction procedure. Follow-up intraoral and panoramic radiographs showed the first signs of fibrous callus calcification at 4 weeks after the end of distraction, with the gap disappearing by 3 months. No problems of device detachment were encountered.

DISCUSSION

When rehabilitating an edentulous patient with implants, the clinician is often faced with a bone site whose anatomic characteristics have been dramatically changed by atrophy. Without regeneration of the alveolar process through autogenous grafting, GBR, or bone distraction before implant placement, it is impossible to subsequently provide prosthetic rehabilitation that is esthetically acceptable as well as functionally and biomechanically appropriate. This is related to the fact that positioning of the implants is inevitably affected by the changed shape of the resorbed site. Although each of the 3 conventional regeneration methods previously mentioned has precise indications and a high success rate, in many cases they do not guarantee an accurate 3D reconstruction of the alveolar ridge for the purposes of implant placement. This type of morphologic correction can be adopted in the event of alveolar process underdevelopment caused by the placement of implants in young patients whose skeletal development is not yet complete.

In the authors' view, the solution to these problems can be found in the application of 3D bone distraction to atrophic segments using, as a point of connection and reference, an implant previously placed following the anatomic axis. The implant and osteotomized bone block can then be repositioned based on prosthetic criteria. This is made possible by the device and method described here, which are based on widely accepted orthodontic, implant dentistry, and bone distraction concepts. By introducing small changes to the device and to the surgical procedure itself, the clinician can also reposition small ridge segments containing malpositioned teeth that cannot be moved orthodontically because of ankylosis. The solution suggested obviates the need to extract these teeth by restoring their function. At the same time, it solves the problems of malocclusion that have resulted from their incorrect position.

The results of this clinical experience were excellent; both the implants and the natural tooth were precisely realigned in a short time with no disturbance of their tissues or those of adjacent teeth. After the consolidation stage, the bone blocks showed no mobility on palpation and radiographs revealed the distraction gap to be fully mineralized. The treatment was well tolerated by all the patients, and the daily activation of the distractor was not a source of discomfort. The distraction device met all the requirements of a versatile and effective miniature distractor.

The following advantages to this treatment modality were found:

1. Subtle movement was possible with the use of a micrometric screw acting as a distractor.
2. Vectorial precision was accomplished as a result of customized assembly of device components on a case-by-case basis using the working cast.
3. Simple activation was possible as a result of the suitable modifications made to components.
4. System rigidity was achieved by planning anchorage that was suited to the individual clinical conditions.
5. The device was also useful for fixation of the bone block during the consolidation stage.
6. The device was easy to remove because of the purely extraosseous tooth/implant support. No invasive revision surgery was necessary for removal of the distractor, and scarring resulting from protrusion of the device was also avoided. The mini-implant, which provided additional support, was removed simply by unscrewing it from the bone.

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