

# Distraction Osteogenesis for Ridge Augmentation: Prevention and Treatment of Complications. Thirty Case Reports



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*Distraction osteogenesis (DO) is the latest addition to the variety of alveolar ridge augmentation procedures used to increase the volume of bone prior to implant placement. Thirty DO procedures were performed in 30 patients using 17 intraosseous and 13 extraosseous devices to augment deficient alveolar ridges. Fifty-five implants placed in the distracted bone were followed for a period of 34 to 60 months after loading. Five implants failed, for a 90.9% success rate. Vertical augmentation ranged from 3.5 to 13.0 mm (average, 7.8 mm). At least one complication was encountered, requiring additional hard or soft tissue surgery, in each of the 30 reported cases. This paper reviews complications encountered in the DO-treated patients, suggesting solutions and measures to prevent these problems. (Int J Periodontics Restorative Dent 2008;28:337–345.)*

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Various ridge augmentation procedures have been documented as predictable means of establishing new vital bone for implant placement.<sup>1–4</sup> A variety of procedures, including guided bone regeneration (GBR) (with and without the addition of particulate bone), autogenous block grafts from the ramus or symphysis, and allograft blocks, have been used to increase bone volume prior to implant placement.<sup>5–7</sup> The latest addition to the various ridge augmentation techniques is distraction osteogenesis (DO). DO is defined as a surgical process that involves the gradual, controlled displacement of a surgical fracture that results in simultaneous enlargement of the volume of bone and soft tissue.

The use of DO for long bone defects (to increase the length of the femur) dates back to the work of Codivilla.<sup>8</sup> Ilizarov, a Russian orthopedic surgeon, and coworkers described the biologic basis for healing with a surgical distraction device,<sup>9</sup> and a number of successful case reports were subsequently presented in the orthopedic literature.<sup>10</sup> In 1973, Snyder et al<sup>11</sup> used a surgical device for the osseous

distraction of a dog mandible, and since then several authors have used this technique in other mandibular animal models.<sup>12,13</sup> Ilizarov suggested the use of DO to correct maxillofacial deformities,<sup>14</sup> and DO was later used by Karp et al in oral surgery.<sup>15</sup> Nishimura et al reported the use of DO for ridge augmentation,<sup>16</sup> while McCarthy et al<sup>17</sup> reported on four cases of unilateral mandibular hypoplasia that were treated using a miniaturized Hoffman device. Different DO devices for treating alveolar ridge deformities in animal and human studies were subsequently described by other authors.<sup>18–32</sup>

For the last decade, DO has been used intraorally to create bone for implant placement. In 1996, Block et al<sup>22</sup> and Chin and Toth<sup>23</sup> reported on the use of DO for site development prior to implant placement. Implants have been placed in this new bone with short-term and long-term success rates that are similar to those seen for implants placed in ridges augmented with GBR procedures.<sup>3,4</sup> In fact, one study concluded that “the overriding question of whether or not alveolar distraction osteogenesis can provide better results than conventional augmentation techniques was judged affirmatively, though the risk of the surgical procedure may possibly be somewhat greater than conventional grafting procedures.”<sup>33</sup> That study reported that the 5-year clinical success of implants placed in bone augmented by DO was 90.4%. Another study elaborated on three areas of minor complications arising during seven mandibular distraction procedures.<sup>34</sup> These included intraoperative compli-

cations (ie, fracture of the transport segment), complications during distraction (ie, incorrect direction of distraction), and postdistraction complications (ie, bone formation defects).

A published review of the DO procedure described different types of intraosseous and extraosseous devices and a combination device.<sup>35</sup> This review also discussed several potential complications with the various devices. The purpose of the present article is to document the success rate and problems relative to 30 DO procedures performed using intraosseous or extraosseous devices and to discuss the occurrence, prevention, and treatment of these potential complications.

## Method and materials

Since 1999 at New York University Dental Center Department of Periodontology and Implant Dentistry, and in the private practices of the authors, 30 patients have been treated with 30 DO procedures using 17 intraosseous devices (IDs) (Lead Stryker, Leibinger) and 13 extraosseous devices (EDs) (Track Plus System, KLS Martin) to augment deficient alveolar ridges prior to implant placement (Figs 1a to 1f). Procedures followed standard distraction techniques,<sup>35,36</sup> albeit with several modifications, when these devices were used for distraction of the transport segments. Distraction of the segments was performed at a rate of 0.4 to 1.2 mm per day. A 0.4-mm or 0.6-mm distraction rate was used for the first 3 days, followed by a rate of 1.2 mm per day in all cases treated. The consolidation time (healing time

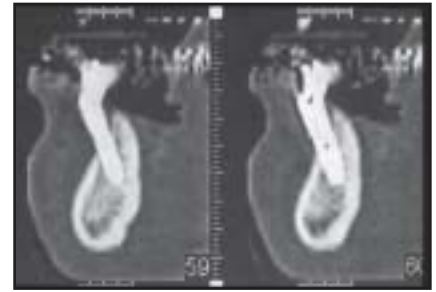
with the device in situ, with no movement following active distraction) prior to device removal and implant placement was 9 to 12 weeks in all cases.

In three patients using the ID and in 13 patients using the ED, two modifications designed by one of the authors were made to the standard distractor appliance. Metal wedges were placed and attached with absorbable sutures, lingual to the transport and base plates, to change the buccal vector of the distractor (Fig 2). An additional modification included the use of a horizontal distractor appliance devised by the same author that employed a palatal expansion device<sup>37</sup> (Fig 3). This device was worn as a guide and to prevent lingual relapse. It was activated every other day during the vertical distraction (which was activated 0.4 mm on alternate days). This appliance allowed for improved buccal vectors while avoiding the application of lateral forces to the central distractor screw.

To determine the amount of vertical augmentation achieved with the ED, measurements were made from one screw hole in the transport plate to a corresponding screw hole in the base plate (Fig 1c). This distance was calculated at the time of distractor placement and again at the time of removal (Fig 1e). The vertical augmentation was calculated by subtracting the distance at the time of distractor removal from the measurement at time of distractor placement. In patients in whom the ID was used, measurements from the screw hole in the base plate to the screw hole in the transport plate were calculated at the time of distractor placement and sub-



**Fig 1a** (left) Preoperative view of a ridge defect with a malposed implant in the mandibular incisor area.



**Fig 1b** (right) Axial computerized tomographic scans of the malposed and unre-storable implant.



**Fig 1c** (left) Extrasosseous distractor with transport plate secured to the mobile segment, with screw holes 5 mm apart.



**Fig 1d** (right) Distractor at the time of removal.



**Fig 1e** (left) New bone formed following distraction. The screw holes are now 16 mm apart, documenting 11 mm of vertical augmentation.



**Fig 1f** (right) Final four-unit restoration following DO, removal of malposed implant, and placement of two implants in the lateral incisor areas.



**Fig 2** (left) Extrasosseous distractor with metal wedges attached to distraction microplates to change the guidance vector.



**Fig 3** (right) Placement of a horizontal distractor appliance designed by one of the authors to move the segment buccally following vertical distraction. Distraction is performed at a rate of 0.25 mm per day.

tracted from the same measurements obtained at the time of distractor removal.

Fifty-five implants were placed in the distracted ridges and followed for a period of 34 to 60 months after loading. Of these, seven had machined

surfaces and 48 were rough-surfaced implants. The implants were manufactured by four different companies (Endopore Innova, ITI Straumann, Nobel Biocare, and Implant Innovations). Any and all complications were documented and recorded.

Implant success was defined following the criteria described by Albrektsson et al.<sup>37</sup> Failure was defined as any implant that did not follow these criteria, usually showing mobility at the time of removal.

**Table 1** Complications encountered with the distraction osteogenesis procedure (listed according to incidence)

Type of complication	No. of cases
Need for additional surgery	30/30 soft tissue grafts, 18/30 hard tissue grafts
Guidance problems	
1. Failure to achieve buccal augmentation	22/30
2. Palatal movement of the transport segment	22/30
Soft tissue complications	
1. Diminished vestibule	13/30 (all ED)
2. Flap dehiscence	4/30 (all ED)
Compromised esthetic result	12/30
Temporization difficulties	3/30
Distractor instability	2/30
Infection	2/30
Resorption of transport segment	Full 1/30, partial 8/30 (all ID)

ED = extraosseous distractor; ID = intraosseous distractor.

## Results

Five of the 55 implants that were placed failed, for a 90.9% success rate. Vertical augmentation in the 30 patients ranged from 3.5 to 13.0 mm (average, 7.8 mm). Implant failures in the present study correlated closely with resorption of the transport segment of the distracted bone. Four of the five implant failures occurred in sites where the transport bone underwent moderate to severe resorption. The other implant failure occurred as a result of infection at the surgical site. Of the five failed implants, two had smooth surfaces and three had rough surfaces.

Complications encountered in the 30 DO procedures are listed in Table 1 in order of frequency of occurrence and were classified into eight categories. The need for additional surgery

occurred in all 30 patients, and soft tissue grafts were required to reestablish an adequate vestibule or provide necessary keratinized tissue prior to implant placement. Additional hard tissue augmentation using GBR or block grafts was required in 18 of the 30 patients. Failure to achieve the desired buccal augmentation occurred in 22 of 30 cases. This was caused by segment guidance problems related to the buccal vector of movement. In 8 of 30 cases, a less-than-ideal esthetic result was reported. Other complications occurred to a minor degree.

## Discussion

Success rates of implants placed in distracted bone may be somewhat lower than those of implants placed in bone

augmented via GBR. However, comparisons of implant survival rates between reports that used different ridge augmentation procedures should be made with caution because of the many variables involved. Buser et al reported a 5-year success rate of 98.3% of 66 implants placed in bone that had been previously augmented with autografts and nonresorbable barrier membranes.<sup>4</sup> A literature review in the same article documented survival rates that ranged from 92.6% to 100% with implants placed in ridges augmented with membrane barriers combined with allografts, xenografts, or autografts. Two separate studies of implants placed in ridges augmented with autogenous block grafts reported implant success rates of 98.3%<sup>38</sup> (followed for 0 to 77 months) and 81.2%<sup>39</sup> (followed for 3 years).

Although short-term data of implants placed in distracted bone reported no failures,<sup>40</sup> a prospective study reported a 90.4% success rate after 5 years of follow-up.<sup>33</sup> The results of the present investigation documented a similar implant success rate (90.9%).

DO has proven to be a predictable method for vertical ridge augmentation.<sup>24–27,30,33,35,40</sup> Two recent prospective studies documented average vertical gains following DO of 6.5 mm (range, 3 to 15 mm)<sup>33</sup> and 7 mm (range, 5 to 9 mm).<sup>40</sup> A case report used DO to treat an atrophied alveolar ridge in the anterior mandible of a 30-year-old woman and reported that “a vertical augmentation of 7 mm had been achieved.”<sup>32</sup> Our results were similar to those of other authors, in that we achieved an average of 7.8 mm of vertical augmentation, with a range of 3.5 to 13.0 mm. These measurements should be viewed in light of the potential for the DO technique to achieve vertical augmentation. For example, some patients required only 4 to 5 mm of augmentation. Therefore, when this amount of augmentation was achieved, the movement was ended. However, the greater potential of DO to achieve vertical augmentation is significant compared to ridge augmentation procedures using GBR, which seem to be limited to approximately 4 mm of vertical augmentation.<sup>41</sup>

### *Guidance problems*

One of the complications observed in the present study was the limited buccal augmentation achieved by DO

because of an inadequate buccal vector. One study<sup>33</sup> reported an average of  $\leq 2$  mm of horizontal augmentation following DO in 30 patients. That study reported a range of 10 mm of buccal positioning to 4 mm of lingual positioning in horizontal augmentation procedures. In the same study, 11 segments moved palatally and 5 segments healed in a neutral position. Thus, additional surgery (bone grafting or soft tissue augmentation) was necessary in the 30 patients reported. We have presented a possible solution for this vector problem in a horizontal distractor that can aid in the attainment of the desired buccal augmentation. Care must be taken when using two different vectors not to move the segment too rapidly, which may result in nonunion. More documentation is necessary to determine the ideal rate and timing of the use of two vector distractions.

In the final eight patients treated in the present study, the buccal augmentation was significantly improved over the previous 22 cases. Each of these cases used metal buccal wedges to change the distraction vector and a horizontal distractor in conjunction with the vertical augmentation to achieve satisfactory buccal movement of the transport segment. Moreover, the concept of “overdistraction” was employed in an attempt to solve the problem recently identified with two adjacent implants in the esthetic zone.<sup>42–44</sup> These papers documented a deficiency of the interimplant papillae caused by the limitation of soft tissue height (average 3.4 mm) coronal to the intercrestal bone between two adjacent implants. Overdistraction of

the tissue in this area may compensate for the soft tissue limitation and improve the esthetic result.

### *Soft tissue complications (diminished vestibule)*

A diminished vestibule is often encountered as a result of the initial incision in the alveolar mucosa and the advancement of the flap to obtain complete flap coverage over the distraction apparatus. This problem occurred in all 13 patients with the ED and in five patients with the ID. In the patients who used the ID, the initial vertical gap of approximately 4 mm caused by the interposition of the base and transport plates requires advancement of the flap to gain primary closure. In patients with the ED, a diminished vestibule is even more common, since there is a greater bulk of material to cover with the flap. This problem can be treated with a connective tissue graft placed at the time of or shortly after removal of the distraction apparatus (Fig 4).

### *Soft tissue complications (flap dehiscence)*

Flap dehiscence at the distractor plates occurred in four patients with the ED. These dehiscence defects appeared at 2, 4, 4, and 8 weeks following active distraction (Fig 5). The patients were instructed to clean the exposed plates with a cotton swab saturated with 0.12% chlorhexidine three times per day and use warm saline rinses three or four times a day until the distraction



**Fig 4 (left)** A connective tissue graft of palatal mucosa is placed on the buccal aspect of the augmented ridge to reestablish the vestibule following removal of the distractor.

**Fig 5 (right)** Soft tissue dehiscence occurred with an ED at 4 weeks after initiation of distraction.



devices were removed. There were no cases of infection or instances where the distraction device had to be removed earlier than planned. In one patient, a bony dehiscence was noted during distraction with the ID (Fig 6). The etiology of this was related to the fact that irregular and sharp bony edges are often created when the vertical cuts are made during the osteotomy. Because during the standard DO procedure, tissue is reflected up to but not over the alveolar crest, these sharp edges often remain undetected until they become visible through the crestal tissue. Treatment of this complication involves immediate osteoplasty of the exposed bony segment. Prevention is accomplished by performing this osteoplasty during surgery to place the distractor, following the vertical osteotomy cuts. The steeper the angle of the vertical defect, the greater the likelihood that this problem will occur.

### *Compromised esthetic results*

One of the major indications of the DO procedure is to reconstruct hard and soft tissue in the anterior areas of the maxilla and mandible to enable fabrication of an esthetic implant-supported fixed restoration. Unfortunately, this is often difficult to accomplish. In fact, Jensen et al,<sup>33</sup> in discussing the esthetics of restorations placed following DO, reported that none of his 30 distracted cases showed superlative esthetic results with implant-supported restorations. In the present study, following the additional hard or soft tissue surgery that was necessary in all 30 DO cases to improve augmentation and esthetics, only 8 of 30 patients treated felt that the esthetic results were unacceptable. Since all DO-treated cases required additional surgery, the clinician using this modality should be familiar with auxiliary methods of ridge augmentation, including soft and hard tissue grafts and GBR, to achieve the excellent esthetic results that have until now been rare with DO procedures alone.

### *Temporization difficulties*

Temporization during DO requires acceptable esthetics, easy access (for the operator) to the distraction screw, and prevention of occlusal forces on the transport segment. Whenever possible the patient is asked to function without a provisional appliance for 10 to 14 days postsurgery. In some cases this is not possible. The provisional appliance of choice uses orthodontic brackets and an archwire to which the pontics are attached coronal to the segment being distracted. During the consolidation period, an acrylic resin-bonded splint may be fabricated. Intraosseous DO devices require that a hole be made in the splint to allow positioning of the splint over the distraction screws (Fig 7).



**Fig 6** (left) Clinical view of bony spicule caused by the sharp bony edge following vertical osteotomy.



**Fig 7** (right) Removable provisional appliance with provision made for access for the distractor rod of the ID.

### *Distractor instability*

Instability of the distraction device was a problem in 2 of the 30 cases performed. Both of these occurred with the intraosseous systems. This did not, however, compromise the success of the four implants placed in the distracted bone. In all other cases, the transport and base plates were well fixated with 10- to 12-mm-long screws. In patients who received EDs, the base plate with the added vertical straight chain "tailpiece" increased stability of the distractor screw, thus preventing this problem.

### *Infection*

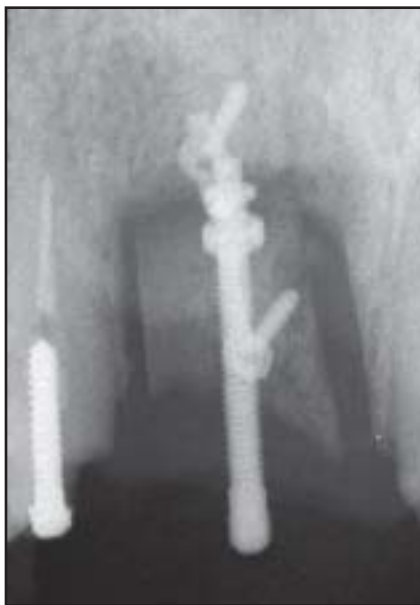
Infection occurred in 2 of the 30 distraction procedures. Both of these complications occurred in patients with IDs. In these two cases of infection, partial resorption of the transport segment took place. Chlorhexidine 0.12% rinses and systemic antibiotic coverage resulted in resolution of the infection in both cases. Prevention of infection was

accomplished by premedicating all patients with 2 g amoxicillin (or 600 mg clindamycin for those with penicillin allergy) 1 hour prior to surgery and continuing with 500 mg of amoxicillin three times daily or 300 mg of clindamycin four times daily for 10 to 14 days postsurgery. All patients were prescribed a 0.12% chlorhexidine gluconate mouthwash to use twice a day on the day prior to surgery, immediately before the procedure, and continuing twice a day beginning 24 hours following surgery for 1 month postsurgery.

### *Resorption of transport segment*

Resorption of the transport segment can be minimized by keeping the crestal and lingual soft tissues intact during both the osteotomy procedure and the distraction period. These tissues stabilize the transport segment and provide vascular supply to the healing tissue. In the present study, complete resorption of the distracted bone

occurred in one patient. Partial resorption occurred in eight patients. All but one of these patients used the ID. In the ID patient, complete resorption occurred following successful vertical distraction when an attempt was made to move the transport segment buccally with orthodontic elastics attached to the central distractor screw. The distractor moved buccally, but the segment resorbed. This was the result of the application of buccal forces to the distractor screw, which was not integrated with the transport plate (Fig 8). In all subsequent cases, no additional force was applied to the distractor other than that indicated for a vertical activation of 1.2 mm per day. Researchers have noted that the magnitude of distraction is more important than the frequency of distraction in producing an improved regenerative result.<sup>45</sup> In the other 21 patients, the transport segment remained vital, did not resorb, and was moved vertically with success.



**Fig 8** Resorption of a transport segment caused by horizontal forces that were placed on the distractor rod in an attempt to move the segment buccally.

## Conclusions

Distraction osteogenesis is a predictable method of treating alveolar ridge deformities prior to implant placement. In this study, significant vertical augmentation was achieved. However, the clinician must be aware of the limitations and potential complications of this procedure. The solutions suggested in this paper to prevent these problems may make this modality more acceptable to a larger percentage of surgeons performing ridge augmentation procedures. Moreover, the clinician should be familiar with other methods of augmentation (guided bone regeneration, block grafts, soft tissue grafts), which are usually necessary in conjunction with distraction osteogenesis augmentation to achieve the desired functional and esthetic results.

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