*Journal of Cranio-Maxillofacial Surgery* (2005) **33**, 246–250

doi:10.1016/j.jcms.2005.02.007, available online at http://www.sciencedirect.com

# Case Report

## Distraction osteogenesis in the irradiated mandible. A case report

Gerry M. RAGHOEBAR, Johan JANSMA, Arjan VISSINK, Jan L.N. ROODENBURG

*Department of Oral and Maxillofacial Surgery, (Chairman: Prof. Dr. L. G.M. de Bont), University Medical Center Groningen and University of Groningen, The Netherlands*

*SUMMARY.* Background: **Distraction osteogenesis has been suggested as a relatively simple method of mandibular reconstruction following ablative head and neck surgery. Some authors report good results in irradiated patients while other authors report limitations with this group of patients.** Patient: **In a 72-year-old male an attempt was made to reconstruct the irradiated mandible using distraction osteogenesis.** Results: **Distraction osteogenesis only resulted in an enlarged soft tissue envelope, while there was no evidence of bone formation in the distraction gap.** Conclusion: **Based on this experience and a search of the literature, it is hypothesized that distraction osteogenesis is only a reliable reconstructive method in irradiated patients if the cumulative dose to the mandibular bone at the distraction site does not exceed a certain maximum still to be defined. © 2005 European Association for Cranio-Maxillofacial Surgery**

***Keywords:*** **distraction osteogenesis; head and neck cancer; radiotherapy; dental implants; reconstruction; Mandible**

## INTRODUCTION

Repair of mandibular defects following ablative head and neck surgery and radiotherapy is a great ongoing challenge. The treatment of first choice is primary reconstruction with free vascularized bone that can resist postoperative radiotherapy. Reconstruction plates or secondary reconstruction are second choice options if primary reconstruction is not possible or if a graft was lost.

Distraction osteogenesis has been proposed as an alternative method for secondary reconstruction aiming to replace bone. The concept of distraction osteogenesis was introduced by Ilizarov for the legs and has been used and further developed since his first report (*Ilizarov*, 1988). It has gained acceptance and has been widely used by orthopaedic surgeons. Recent studies have shown that distraction osteogenesis has the potential to play also an important role in craniofacial reconstruction, in the treatment of congenital craniofacial anomalies, and in reconstruction of the severely resorbed mandible (*Constantino* et al., 1990; *McCarthy* et al., 1992, 1999; *Raghoebar* et al., 2000; *Honig* et al., 2002).

Radiation treatment of head and neck cancers causes many oral sequelae (*Vissink* et al., 2003a, b). The radiation effects on soft and hard tissues, especially the loss of vascularity, directly interfere with oral rehabilitation of these patients including reconstructive surgery. Knowing these limitations, the clinical use of distraction osteogenesis in head and neck cancer patients has been limited by the unknown effects of distraction on irradiated bone. There are contradictory reports in the literature showing cases in which distraction of irradiated bone was successful and cases in which it was not (*Gantous* et al., 1994; *Hellner* and *Schmelzle*, 1994; *Sawaki* et al., 1997; *Holmes* et al., 2002; *Klesper* et al., 2002; *Muhonen* et al., 2002a, b; *Takahashi* et al., 2002; ). In this paper a case is presented in which distraction osteogenesis was applied unsuccessfully to reconstruct the mandible. The subsequent treatment to resolve this problem is described and the conditions allowing for distraction osteogenesis of irradiated bone are reviewed.

## CASE REPORT

A 69-year-old man presented with a cT4N2M0 squamous cell carcinoma in the floor of the mouth on the right side. The tumour had infiltrated the lower side of the tongue and the mandible. Due to extensive vascular disease, he was not considered to be a candidate for immediate reconstruction with a free microvascular graft. The tumour including part of the mandible were resected and a modified neck dissection was performed. The soft tissue was reconstructed with a pectoralis major flap. The mandibular continuity defect was stabilised by an A–O reconstruction plate (Fig. 1). Radiotherapy was started 6 weeks after surgery (2 Gy/day, 5 fractions/week, cumulative dose 60 Gy).

Six months after radiotherapy, an infected osteoradionecrois developed in the region of the plate with dehiscence of skin and mucosa. The patient was

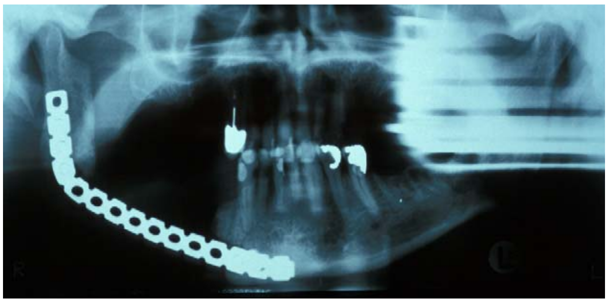

**Fig. 1** – A 69-year-old man treated for a T4N2M0 squamous cell carcinoma in the floor of the mouth. The mandibular continuity defect was bridged by an A–O reconstruction plate.

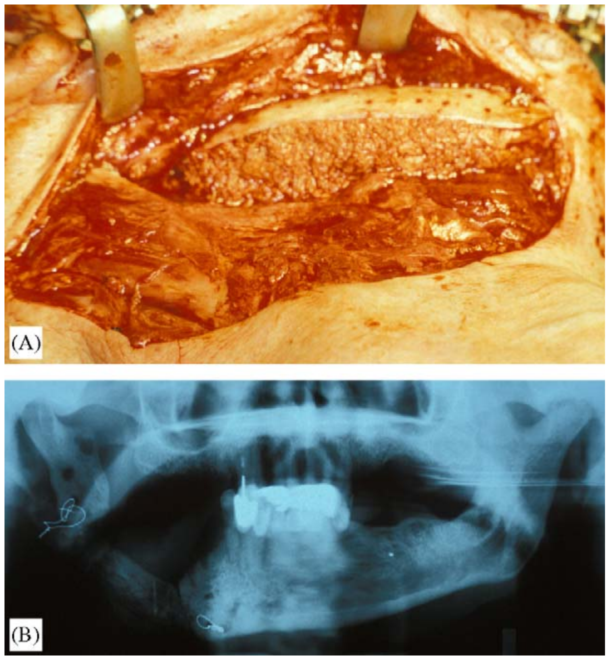

**Fig. 2** – (A) Intraoperative view showing reconstruction of the mandible with autogenous posterior iliac crest bone and split allogeneic rib as a scaffold. (B) Postoperative panoramic radiograph.

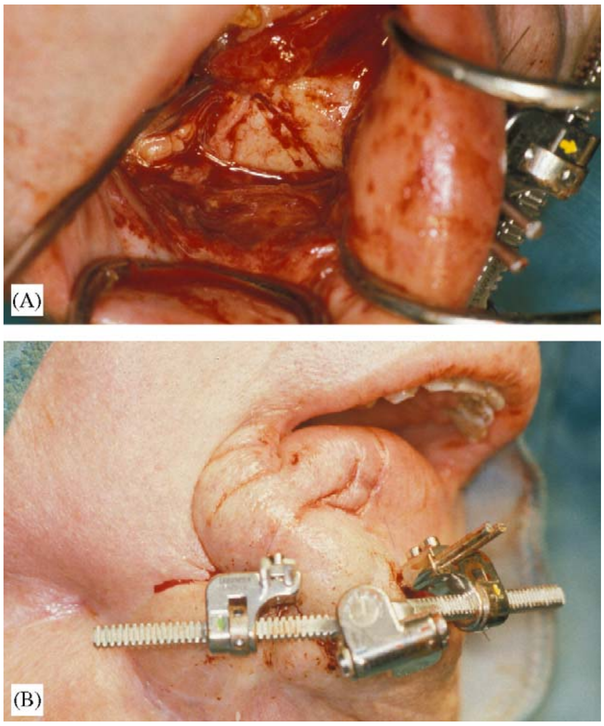

**Fig. 3** – (A) Intraoperative view of osteotomy in the native bone. (B) Extraoral view after insertion of the distraction device.

prescribed to broad-spectrum antibiotics and hyperbaric oxygen therapy (30 sessions). The screws of the reconstruction plate were loose and the reconstruction plate had to be removed. After local debridement, postoperative hyperbaric oxygen was administered (10 further sessions) to promote revascularization. During follow-up, the skin and mucosa healed. There followed a gradual shift of the chin to the right side. Eighteen months later the patient was scheduled for reconstruction of the mandible with free iliac crest bone and a freeze-dried rib as scaffold to improve his appearance and to restore continuity.

The mandible was approached using an extraoral incision. A freeze-dried allogeneic rib (Maimi Tissue Bank, USA) was reconstituted in sterile saline. During the procedure for harvesting bone from the posterior iliac crest, the rib was prepared for use as a scaffold by splitting it longitudinally with a thin saw and removing the cancellous bone with a rotating bur. The halves of the rib were used as a lingual and buccal crib and were fixed to the alveolar crest of the proximal and distal end of the mandible. The cancellous bone from the posterior iliac crest was condensed between the rib segments (Fig. 2). The mandible was stabilized by external pin fixation. Unfortunately, it was not possible to reposition the chin fully to its original position because of the presence of abundant scar tissue. After wound closure an acrylic bar was constructed connecting the pins for external fixation. Healing was encouraged by 10 additional hyperbaric oxygen sessions.

Prosthetic rehabilitation could not be performed to the satisfaction of the patient as there still was residual mandibular distortion. To solve this problem, the patient was scheduled for distraction osteogenesis. Starting the day before surgery, the patient was prescribed broad-spectrum antibiotics. Using an intraoral approach, an osteotomy was made with a microsaw in the irradiated native bone of the mandible and the distraction device (Multiguide, Howmedica Leibinger GmbH, Freiburg, Germany) was installed (Fig. 3). Review of the radiotherapy records revealed that the cumulative dose to the mandibular bone at the distraction site was 60 Gy. To support healing and formation of new tissue, the patient was treated again with hyperbaric oxygen (10 sessions) starting 3 days postoperatively. After a latency period of 7 days, the device was activated at a

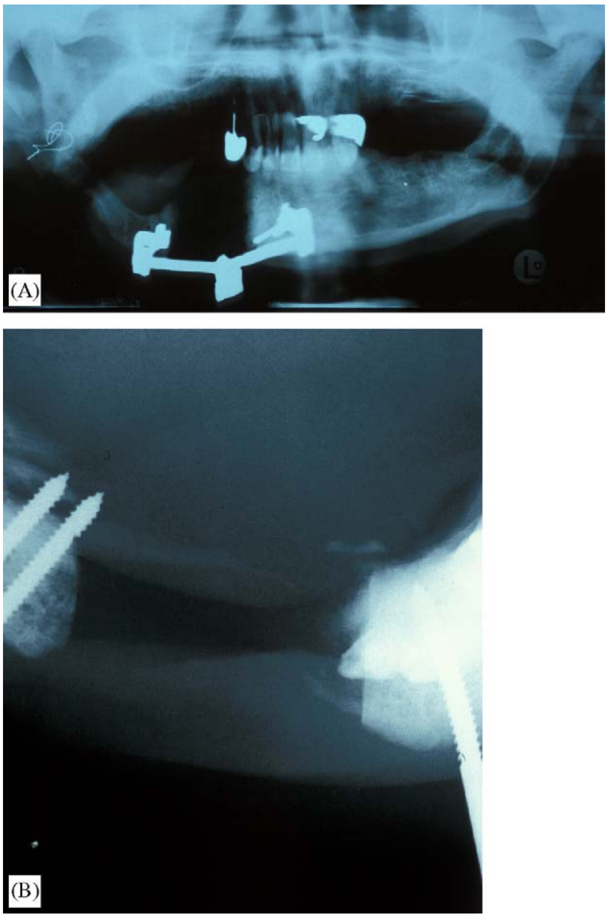


**Fig. 4** – (A) Panoramic radiograph taken at the end of distraction. The gap is clearly visible as well as the chin repositioned to the contralateral side. (B) Occlusal radiograph revealing absence of bone in the distraction gap.

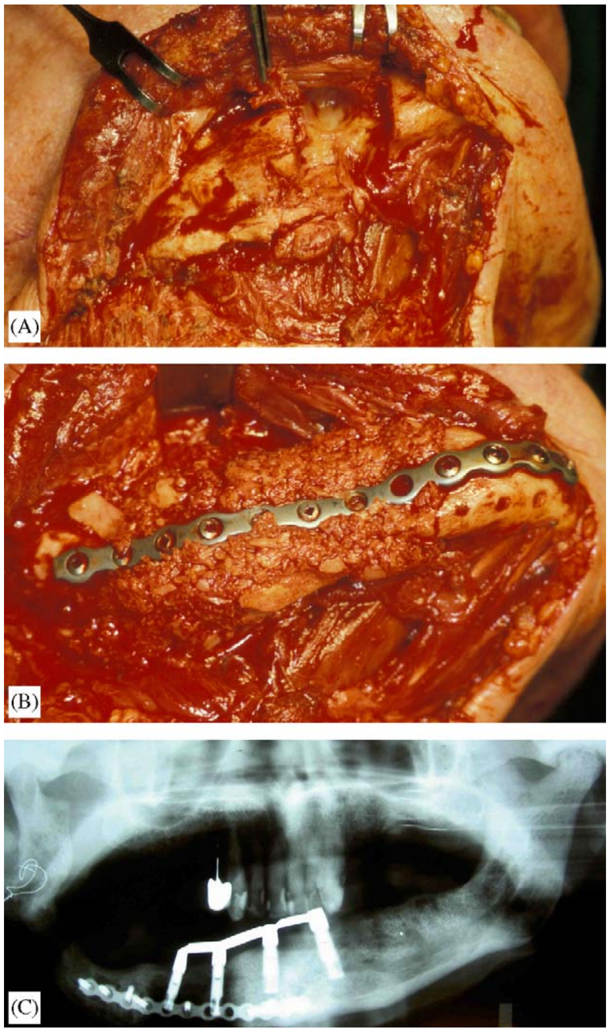


**Fig. 5** – (A) On surgical exposure no bone to be found in the distraction gap. (B) The distraction gap was filled with autogenous bone and bridged with a 2.3 mm reconstruction plate. (C) Panoramic radiograph 1 year after fabrication of the prosthetic construction on four endosseous dental implants.

rate of 0.5 mm/day for 62 consecutive days. Clinically, the appearance of the patient improved significantly. No mucosal reactions, dehiscence or infection were observed during the distraction. Occlusal radiographs were taken at the start and 4 and 8 weeks after distraction. Radiographically there was no sign of bone formation (Fig. 4). The distraction area was surgically exposed and no bone was found in the distraction gap. The distraction procedure had only expanded the soft tissue envelope between the two bone stumps (Fig. 5A). During the same surgical procedure, the distraction device was removed and a bone graft from the anterior iliac crest was transplanted into the distraction gap. A reconstruction plate was used to stabilize the graft and mandible (Fig. 5B). Healing was uneventful.

Radiographic examination 6 months after surgery demonstrated satisfactory bone remodelling. This was considered as a proper basis for further prosthetic treatment with an implant supported overdenture. The remaining decayed teeth in the mandible were removed, again under broad spectrum antibiotic cover. Three months later, four dental implants (Brånemark, Nobel Biocare, Göteborg, Sweden) were inserted. No complications occurred. After the healing period of 6 months, the patient received a mandibular overdenture retained by a round bar and clip attachments (Fig. 5C).

## DISCUSSION

Choices for mandibular reconstruction after ablative cancer treatment include free vascularized flaps such as fibula, iliac crest, radial forearm and scapula. The success of each flap is related to many factors including the experience of the surgeon, complexity of the defect, and choice and quality of recipient vessels. The attraction of applying the distraction technique for secondary mandibular reconstruction after ablative surgery for oral malignancies is its lack of donor site morbidity and its ability to increase the overlying soft tissues histiogenesis (*Holmes* et al., 2002; *Takahaski* et al., 2002). Although distraction osteogenesis is a promising method for mandibular reconstruction, it has certain limitations as shown in this case.

In non-irradiated subjects distraction osteogenesis has developed into a reliable method. In irradiated subjects, the situation is different. Some animal studies have shown that distraction osteogenesis probably also can be applied in irradiated bone. *Gantous* et al. (1994) tried to simulate the clinical situation occurring with reconstruction of the human mandible following resection and radiation for head and neck cancer. Histology confirmed complete bone regeneration in four out of five animals, 7 weeks after the completion of distraction. In another animal study, *Muhonen* et al. (2002a) radiated the mandible of 13 rabbits. Seven of the 13 irradiated rabbits were treated with hyperbaric oxygen as well. The authors concluded that despite delayed bone formation, distraction osteogenesis can be applied after radiotherapy and hyperbaric oxygen had a beneficial effect on bone quality of a previously irradiated mandible.

In agreement with the results from animal studies beneficial effects of distraction osteogenesis have also been described in men. *Sawaki* et al. (1997) reported satisfactory bone formation after longitudinal distraction of a mandibular defect in a patient who preoperatively had received 30 Gy to the surgical site. *Klesper* et al. (2002) reported the possibility of vertical distraction of fibula transplants in head and neck cancer patients. All the patients had either been irradiated with doses of 39.6 Gy prior to tumour resection and reconstruction in patients suffering from squamous cell carcinoma ($n = 8$) or 54.9 Gy (in one patient with Ewing's sarcoma). By contrast, *Holmes* et al. (2002) reported two unfortunate cases of distraction in irradiated patients of which the radiation data were available in only one. That patient had received a cumulative dose of 60 Gy to the surgical site. Our patient also received a cumulative dose of 60 Gy to the distraction site and formation of new bone was unsatisfactory. It seems that there may be a threshold above which distraction osteogenesis becomes troublesome.

Fortunately for our patient, the distraction process had resulted in a well-defined new soft tissue pocket, and repositioned the original part of the mandible into a better relationship with the maxilla and a better facial appearance. The pocket facilitated bone grafting (*Yonehara* et al., 1999). Soft tissue expansion has been described in relation to mandibular reconstruction using distraction, and its use should not be undervalued. This method is effective in patients with scarring after radiotherapy and infection. The main advantage is that space is created without insertion of a soft tissue flap.

There is a great need for studies defining the threshold dose above which distraction osteogenesis should be discouraged, a cumulative dose which may be of the order of 50 Gy. This suggested that the threshold may also probably be modified by applying hyperbaric oxygen.

## CONCLUSION

From this report, it is concluded that distraction osteogenesis in an irradiated mandible is not a treatment modality with a predictable outcome for new bone formation in patients having had local radiotherapy. In this case, no new bone was formed, although the formation of new soft tissue can still be considered as an advantage of the distraction technique, since it may serve as a suitable graft bed for reconstruction with free bone.

## References


Constantino PD, Shybut G, Friedman CD, Pelzer HJ, Masini M, Shindo ML, Sisson GA: Segmental mandibular regeneration by distraction osteogenesis An experimental study. Arch Otolaryngol Head Neck Surg 116: 535–545, 1990

Gantous A, Phillips JH, Catton P, Holmberg D: Distraction osteogenesis in irradiated canine mandible. Plast Reconstr Surg 93: 164–168, 1994

Hellner D, Schmelzle R: Sekundäre Unterkieferrekonstruktion in bestrahlten Gebiet durch mikrovaskuläre Knochentransplantate und Kallusdistraction. In: Rahmanzadeh R, Scheller EE (Eds.), Alloplastische Verfahren und mikrovaskuläre Maßnahmen. Einhorn Presse-Verlag, Reinbek, pp. 462–465, 1994

Holmes SB, Lloyd T, Coghlan KM, Newman L: Distraction osteogenesis of the mandible in the previously irradiated patient. J Oral Maxillofac Surg 60: 305–309, 2002

Honig JF, Grohmann UA, Merten HA: Mandibular distraction osteogenesis for lengthening the mandibule to correct a malocclusion: a more than 70-year-old German concept in craniofacial surgery. J Craniofac Surg 13: 96–98, 2002

Ilizarov GA: The principles of the Ilizarov method. Bull Hosp Joint Dis Orthop Inst 48: 1–11, 1998

Klesper B, Lazar F, Sießberger M, Hidding J, Zöller JE: Vertical distraction osteogenesis of fibula transplants for mandibular reconstruction. A preliminary study. J Cranio-Maxillofac Surg 30: 280–285, 2002

McCarthy JG, Stelnicki EJ, Grayson BH: Distraction osteogenesis of the mandible: a ten-year experience. Semin Orthod 5: 3–8, 1999

McCarthy JG, Schrieber J, Karb N, Thorne CH, Grayson BH: Length ening the human mandible by gradual distraction. Plast Reconstr Surg 89: 1–8, 1992

Muhonen A, Muhonen J, Lindholm TC, Minn H, Klossner J, Kulmala J, Happonen RP: Osteodistraction of a previously irradiated mandible with or without adjunctive hyperbaric oxygenation: an experimental study in rabbits. Int J Oral Maxillofac Surg 31: 519–524, 2002a

Muhonen A, Muhonen J, Minn H, Kulmala J, Klossner J, Teras M, Knuuti J, Happonen RP: The effects of irradiation and hyperbaric oxygen on bone formation during rabbit mandibular distraction. Arch Oral Biol 47: 701–707, 2000b

Raghoebar GM, Heydenrijk K, Vissink A: Vertical distraction of the severely resorbed mandible. The Groningen Distraction Device. Int J Oral Maxillofac Surg, 29: 416–420, 2000

Sawaki Y, Hagino H, Yamamoto H, Ueda M: Trifocal distraction osteogenesis for segmental mandibular defect: a technical innovation. J CranioMaxillofac Surg 25: 310–315, 1997

Takahashi T, Fukuda M, Aiba T, Funaki K, Ohnuki T, Kondoh T: Distraction osteogenesis for reconstruction after mandibular segmental resection. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 93: 21–26, 2002
Vissink A, Burlage FR, Spijkervet FKL, Jansma J, Coppes RP: Prevention and treatment of the consequences of head and neck radiotherapy. Crit Rev Oral Med 14: 213–225, 2003a
Vissink A, Jansma J, Spijkervet FKL, Burlage FR, Coppes RP: Oral sequelae of head and neck radiotherapy. Crit Rev Oral Med 14: 199–212, 2003b
Yonehara Y, Takato T, Matsumoto S, Nakatsuka T: Distraction of scarred soft tissue before secondary bone grafting. Int J Oral Maxillofac Surg 28: 347–348, 1999

**Dr. G.M. RAGHOEBAR**
Department of Oral and Maxillofacial Surgery,
University Medical Center Groningen and
University of Groningen,
P.O. Box 30.001, 9700 RB Groningen,
The Netherlands.

Tel.: +31 50 3613840 Fax: +31 50 3611136.
E-mail: g.m.raghoebar@kchir.azg.nl

Paper received 11 November 2003
Accepted 22 February 2005