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Vertical distraction of the severely resorbed edentulous mandible

A clinical, histological and electron microscopic study of 10 treated cases

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Abstract: The aim of this study was to evaluate the clinical and histomorphological results of distraction of the severely resorbed edentulous mandible. In a group of 10 edentulous patients suffering from insufficient retention of their mandibular denture related to a severely resorbed mandible, the anterior segment was augmented as a preimplant surgical procedure using the nonvoluminous Groningen Distraction Device (GDD). Two months after the last day of distraction, a bone biopsy was taken with a trephine, both distraction screws were replaced by endosseous implants and the guide screw was removed. The biopsies were examined by means of light microscopy (LM) and transmission electron microscopy (TEM). Radiographical and histomorphological examination of the biopsies revealed the presence of two cortical zones, one at each end of the biopsies, a poorly mineralized, fibrous interzone in the middle of the distraction gap, and two zones of mineralization between the central fibrous and the peripheral cortical zones. Formation of lamellar bone parallel to the distraction vector was clearly visible in the mineralization zone as well as signs of remodelling at the borderline between the native cortical bone and the generate. Clinical examination showed in all patients that the anterior segment distracted from the mandible body was sufficiently enlarged to enable insertion of endosseous implants with a length of at least 12 mm. One implant was lost during the healing phase, but was successfully replaced thereafter. Implant retained overdentures were fabricated 3 months after implantation. All patients have good function 11.2 ± 4.3 months after the end of treatment. From this study it is concluded that the GDD has proven to be a reliable tool for augmentation of the anterior segment of a severely resorbed edentulous mandible enabling osseointegration of endosseous load-bearing implants.

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The field of implant dentistry is dynamic and many clinicians are searching for rather simple preimplant surgical procedures that are less inconvenient to the patient and still possess the ability to create optimal circumstances for implant placement. Various augmentation techniques are currently in use to create sufficient bone volume for reliable insertion of endosseous implants in the case of severely resorbed mandibles (Stellingsma *et al.* 1998). Although these techniques have realized good results, the procedures require bone transplantation and may cause donor site morbidity (Kalk *et al.* 1996). Case studies have shown the potential applicability of distraction osteogenesis to create a sufficient bone volume for reliable insertion of endosseous implants (Chin & Toth 1996; Chin 1999; Hidding *et al.* 1999; Klein *et al.* 1999; Lazar *et al.* 1999; Gaggl *et al.* 2000). Distraction osteogenesis is a technique of gradual bone lengthening allowing for the natural healing mechanisms of the human body to generate new bone (Ilizarov 1988). The Groningen Group developed a nonvoluminous intraosseous distraction device to solve the problem of inadequate bone height for insertion of endosseous dental implants (Raghoebar *et al*. 2000). The advantages of the Groningen Distraction Device are its applicability in the case of a severely resorbed mandible (minimum height of 5 mm in the mandibular canine region), the adjustable distraction vector and the fact that the endosseous implants are inserted at the same spot from which the distraction screws have been removed.

Preliminary studies in animals have shown the very good quality of generated bone, with adequate potential for implant osseointegration (Block *et al*. 1996, 1998; Oda *et al*. 1999, 2000). To the best of our knowledge no studies in humans are available in the literature evaluating the formation of new bone induced by vertical distraction of the severely resorbed anterior mandible. Therefore the aim of this study was to evaluate both the clinical and histomorphological results of distraction of the severely resorbed edentulous mandible in humans.

Table 1. **Patient characteristics regarding bone height before distraction, planned increase in bone height by distraction (rate 1 mm/day), achieved increase in bone height by distraction at time of insertion of implants and time of follow up**

Patient	Initial bone height (mm)	Planned by distraction (mm)	Achieved by distraction (mm)	Follow up (months)
1	7	7	6	20
2	5	8	8	15
3	7	6	6	13
4	7	8	6	12
5	6	8	8	12
6	6	7	7	10
7	7	7	7	10
8	5	7	7	8
9	7	7	7	6
10	7	6	6	6

Patients and Methods

Patients

Ten patients (mean 60.6 years, range 50–73 years) participated in this study. The patients had been referred to the Department of Oral and Maxillofacial Surgery of the University Hospital Groningen by their dentist. The patients were suffering from reduced stability and insufficient retention of their mandibular denture and could not be treated with a conventional denture to the satisfaction of the patient. The patients had been edentulous in the mandible for 4–18 years and exhibited severely resorbed mandibles (Cawood class VI) (Cawood & Howell 1991). The mandibular height in the canine region ranged from 5 to 7 mm (Table 1). A routine intraoral and radiographical examination was carried out. The intraoral examination included an evaluation of the quality of the present set of dentures and the condition of the oral mucosa. For the radiographical examination a panoramic radiograph and a lateral cephalogram was made (Fig. 1A, B). Informed written consent was obtained from all patients.

Distraction equipment

The Groningen Distraction Device (GDD, Martin Medizin Technik, Tuttlingen, Germany) is an intraoral device consisting of two distraction screws, two extensions and one guide screw (Fig. 2A). The distraction screw (diameter 3.0 mm) has threads with a ridge to ridge distance of 0.5 mm. The caudal part of the distraction screws has a smooth surface (length 4 mm) and the top of the screws is hexagonal. The distraction screw can only be placed in the extensions from a caudal direction, because of the caudal part without threads. This prevents the possible risk of accidental loss of the distraction screws into the mouth and/or upper airway system (aspiration). The extension is fixed with titanium screws (diameter 1.5 mm, length 5 mm) on the top of the segmented cranial part of the anterior mandible. The guide screw has a threaded caudal part (length 3 mm, diameter 2 mm) for fixation in the caudal part of the mandible. Rotation of the distraction screws 'activates' the device (Fig. 2B). The result is elevation of the cranial bone segment (the transport disk) connected with the extensions to the distraction screws, while the distraction screws themselves keep their position in the caudal part of the mandible.

Surgical protocol

The patients are operated under general anaesthesia. The mandibular ridge between the mental foraminae is exposed by an interforaminal incision in the buccal fold and raising of a full thickness mucoperiostal flap. The mental foraminae are carefully localized. In the correct sagittal relation to the opposing occlusion a vertical hole is made in the midline with a bur, just perforating the basal bone. A direction indicator is placed in the hole. The holes for the distraction screws are prepared 1 cm to the left and right side of the midline. Care has to be taken not to perforate the basal cortical bone. These paramedian distraction holes are widened using a standarized bur. Preparation is carried out at high speed, ca. 2000 r.p.m., and profuse irrigation with sterile saline is mandatory to prevent overheating of the bone. All sites (distraction screws and guide screw) should be parallel with one another. The distraction screws are positioned and the holes for fixation of the extensions are drilled. Subsequently, all screws are temporarily removed. Lateral of both paramedian holes, but anteriorly of the mental foraminae (minimum distance between saw-cut and mental foramen is 5 mm), vertical cuts are made in the upper third of the mandibular bone with an oscillating saw. These saw-cuts are horizontally connected with an oscillating saw. After all saw-cuts are made, the mobility of the anterior segment is tested. The survival of the transport disk is dependent on the preservation of the lingual mucoperiostal flap. In the midline the Martin® guide self-tapping screw (Martin GmbH & Co., KG Tüttlingen, Germany) is inserted through a small incision in the mucosa, and the mobility of the transport disk is checked again. Subsequently, two Martin® distraction screws (Martin), mounted in the extensions, are inserted in the paramedian holes through a small incision in the mucosa. Each extension is fixed. The mobility of the transport disk is checked for the last time by rotating the device to its maximum. Care is taken to preserve the soft tissue pedicle on the lingual surface. The

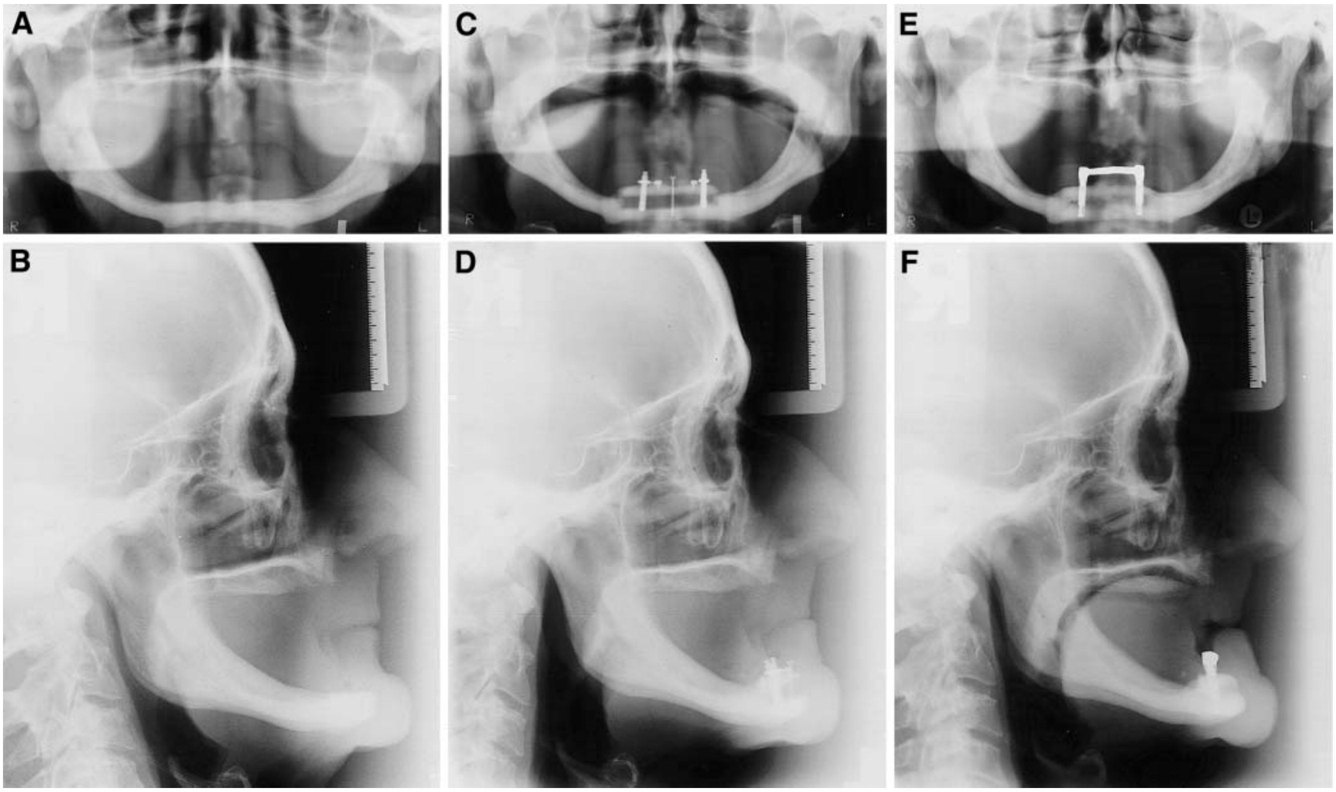

Fig. 1. A 68-year-old man with a severely resorbed mandible. The height of the mandible in the canine region is 6 mm. (A) Panoramic radiograph of the extremely resorbed mandible. (B) Lateral cephalogram of the extremely resorbed mandible. (C) Panoramic radiograph 8 weeks after the distraction period showing the gain in bone height. (D) Lateral cephalogram of the same patient 8 weeks after the distraction period. (E) Panoramic radiograph 12 months after delivery of the prosthesis still showing a slight radiolucent structure in the distraction area. (F) Lateral cephalogram 12 months after delivery of the prosthesis.

wound is closed in layers. The patient is not allowed to wear a mandibular denture during the period the distraction device is in place.

The patients receive broad-spectrum antibiotics for 48 h, starting intravenously prior to the surgical procedure. Five days after insertion of the GDD, distraction is started (1 mm/day). The screws are rotated two revolutions per day. Each revolution represents 0.5 mm cranial movement of the transport disk (Fig. 2B). Vertical transport of the transport disk elevates the ridge crest by enlarging the space within the horizontal osteotomy. The space beneath the elevated segment forms the regeneration chamber.

Two months after the last day of distraction, the distraction screws were removed under local anaesthesia. ITI Bonefit implants® (Straumann AG, Waldenburg, Switzerland) ($n = 6$ patients, 12 implants), Brånemark implants® (Nobel Biocare AB, Gothenburg, Sweden) ($n = 4$ patients, 8 implants) were used (Fig. 1C, D). The implants were inserted in the paramedian holes after widening these holes to the required dimensions using the standard burs for the implant system chosen. Finally, the median guide screw is removed. Twelve weeks after implantation, the prosthetic treatment was started. Our patients received new maxillary, conventional prostheses and implant-retained mandibular overdentures. The overdentures were retained by a Dolder bar with clip attachments.

Clinical and radiographic examination

The following clinical parameters were evaluated:

- inflammation around the screws;
- loss of distraction screws;
- loss of implants, and;
- sensory changes of lip and chin.

The height of the augmented part of the mandible was measured on panoramic radiographs. The radiograph made before the surgical procedure was compared with radiographs made before insertion of the implants and during the follow-up to detect possible bone resorption. The mean follow-up after delivery of the prosthesis was 11.2 ± 4.3 months (Table 1).

Histological and electron microscopic examination

In all patients a through biopsy of the distraction area (including the top and basal bone) was taken with a trephine bur (Ø 2 mm) 2 months after the last day of distraction (Fig. 3A). All biopsies were taken with copious irrigation with sterile saline. A standardized radiograph was made prior to histological processing of all biopsies (Fig. 3B).

Light microscopy (LM)

Immediately after the biopsies were taken, they were fixed in 2% glutaraldehyde in 0.1 M sodium cacodylate buffer, pH 7.4, at 4°C for at least 2 days. After rinsing in 0.1 M sodium cacodylate buffer, the samples were dehydrated in a graded concentration of ethanol and embedded in glycolmethacrylate. Sections 2 μm thick were obtained using a Jung 1140 autocut microtome with a D-hard metal knife (Shandon, Life Sciences International Ltd, Cheshire,

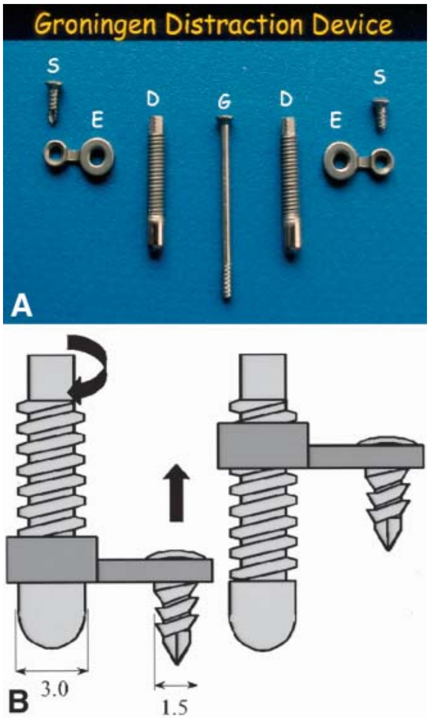

Fig. 2. The Groningen Distraction Device (GDD). (A) The distraction device consists of two distraction screws (D), two extensions (E), two 1.5 mm titanium screws (S) for fixation of the distraction screws via the extensions to the segmented cranial part of the anterior mandible, and one guide screw (G). (B) Rotation of the distraction screws results in elevation of the cranial bone segment connected with the extensions to the distraction screws.

England). The sections were mounted on glass and stained with toluidine blue and alkaline fuchsin (Merck, Darmstadt, Germany).

Transmission electron microscopy (TEM)

After harvesting, the samples were dissected into smaller samples (approximately 2×2×2 mm) and subsequently fixed as described for LM. After rinsing thoroughly with buffer, the samples were additionally fixed with 1% OsO_4 and 1% $K_4Fe(CN)_6$ in 0.1 M sodium cacodylate buffer for 2 h. The samples were then dehydrated in a graded series of ethanol followed by propylene-oxide and embedded in Epon 812. Sections with a thickness of 60 nm were obtained by cutting with an Reichert OMU4 ultramicrotome (Reichert AG, Vienna, Austria), using a diamond knife. The sections were stained with uranyl acetate and lead citrate and examined with a Philips CM-100 transmission electron microscope (Philips, Eindhoven, the Netherlands) operated at 60 kV.

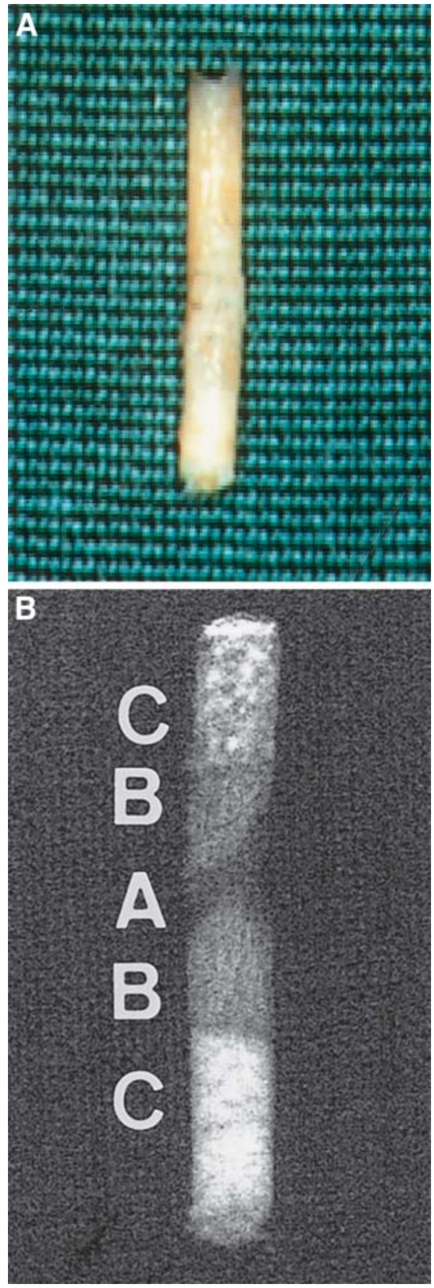

Fig. 3. (A) Bone biopsy after it has been removed from the trephine drill. (B) Radiograph of a biopsy showing the fibrous interzone in the middle of the distraction gap (a), two zones of mineralization (b) and the zone with the native cortical bone (c).

Results

Clinical results

Notwithstanding the rather low mandibular bone height at the time of surgery (5–7 mm in the canine region, Table 1), all surgical procedures were performed without complications. Wound healing was uneventful and no problems were observed during the distraction period other than one case of wound dehiscence that had developed 3 days after surgery. This patient was put on a regimen of rinsing with a chlorhexidine mouthrinse 4 times daily. The dehiscence healed within a couple of days. None of the patients experienced subjective or objective signs of a disturbed sensitivity of the lip or chin region post surgery. In two patients the distraction screws used were longer than was necessary for the aimed increase in bone height, which resulted in a slight loss of distraction height due to backwards rotation of the distraction screws (the patients were urged to play with the intraorally extending part of the distraction screws).

The increase in bone volume (Table 1) was sufficient to insert implants with a length of at least 12 mm in the interforaminal region. The length of the implants used was 12 mm ($n=8$), 13 mm ($n=8$), and 14 mm ($n=4$). During the osseointegration period, one ITI implant was lost. This occurred in the patient in whom both the wound dehiscence had occurred and the distraction screw had extended for a couple of millimeters through the oral mucosa during the consolidation phase. After a healing period of 2 months, a new ITI implant was inserted, which became osseointegrated.

Radiographic results

Radiographically, there was no evidence of resorption of the cranial bone segment, although the distraction zone still had a somewhat radiolucent appearance 1 year after distraction (Fig. 1E, F).

Radiographic examination of all biopsies was indicative for the generation of at least some mineralized tissue in the distraction area (Fig. 3B). When combining the radiographical data with the histological data (see below), five zones can be distinguished: two cortical zones, one at each end, a poorly mineralized, radiolucent, fibrous interzone in the middle of the distraction gap, and two zones of mineralization between the central fibrous and peripheral cortical zones.

Histomorphologic results

The histomorphological results of all 10 biopsies were consistent. At the time of implant insertion, the tissue between the lingual and facial cortex formed during the distraction period was bone hard and covered with healthy looking soft tissue along the ridge and around the distraction and guide screws. The soft tissue lining that had been increased by the distraction process, was intact and clinically resembled the original tissue.

Light microscopic evaluation of all specimens confirmed the radiographic assumption that new bone had formed in the distraction gap (Figs 3, 4, 5 and 6). In general, intramembranous ossification of bony trabeculae was present in both mineralization zones. The trabeculae showed an orientation parallel to the distraction vector (Figs 4E and 5C). Further analysis revealed that the generated bone consisted largely of vital lamellar bone, some woven bone and a cell-rich fibrous interzone in the centre of the distraction gap (Fig. 4). The bone contained clearly distinguishable osteocytes within normal appearing osteocyte lacunae, indicative for vital bone tissue (Figs 4E, 5C and 6B). Many trabeculae demonstrated active bone formation with plump osteoblasts and a layer of osteoid (Fig. 4). Newly formed, vertically orientated osteons were observed in a large part of the generated bone. The fibrous interzone consisted of highly organized, longitudinally oriented, parallel bundles of collagen with spindle-shaped fibroblasts (Figs 4B and 6A) and undifferentiated mesenchymal cells located throughout the matrix. At the peripheries of this fibrous interzone, there are two zones with longitudinally oriented, cylindrical primary osteons, which are covered by a layer of osteoblasts (Fig. 4C, D). Throughout the mineralization zone, spots with a mineralized matrix can be observed (Fig. 6C). At certain spots the borderline between the generate and the native cortical bone is still visible (Fig. 5A), while at other spots, signs of remodelling are obvious (Figs 4A, 5B and 6D).

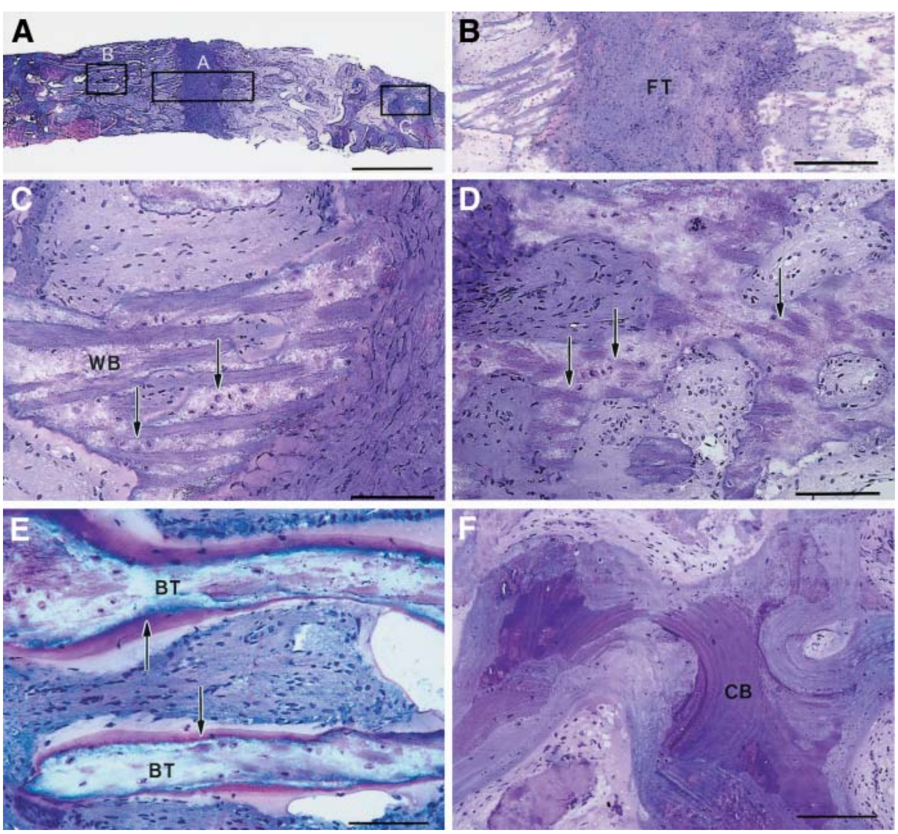

Fig. 4. Histological section through a biopsy taken from the distraction area showing intramembranous ossification of bony trabeculae. The trabeculae are oriented parallel to the distraction vector (toluidin blue and alkaline fuchsin stain). (A) Overview of a bone biopsy. Two zones with native cortical bone (area C), two mineralization zones (area B) and the fibrous interzone (area A) are clearly visible. Bar = 2 mm. (B) Detail of area A showing the presence of fibrous tissue (FT) in the center of the gap. Bar = 100 μm. (C) Detail of the periphery of area A (left side) showing ossification of newly formed bone tissue. Osteoblasts are present on the surface of the woven bone (WB). Osteocytes are visible within the mineralized areas (arrows). Bar = 58 μm. (D) Detail of the periphery of area A (right side) also showing ossification (arrows) of newly formed bone tissue. Bar = 58 μm. (E) Detail of area B showing ossification (arrows) of newly formed bony trabeculae (BT) oriented parallel to the distraction vector. Bar = 50 μm. (F) Detail of area C showing mature compact cortical bone (CB). Bar = 70 μm.

Discussion

Distraction osteogenesis is generation of new bone and soft tissues as a result of slow application of force to a bone gap. Initially, the bone gap is occupied by fibrous connective tissue of which the collagen fibres are arranged parallel to the distraction vector. If adequate stability is maintained within the generate, direct ossification of the collagen bundles is the next step. Too much movement guides the healing process into the formation of cartilage and fibrous tissue, which prevents bone mineralization.

The bone generate between both zones of native cortical bone is oriented along the distraction vector and can be divided into three parts: two areas with increased density adjacent to the original bone segments and a radiolucent middle zone (Samchukov *et al.* 1999). Histologically, the gap between the distracted bone segments is first occupied by fibrous tissue. The collagen fibres connect both original bone surfaces. The newly formed trabecular bone originates from both original bony walls and progress towards the centre of the distraction generate. In the adjacent areas, the trabeculae undergo resorption and remodel to cortical bone. Signs of bone bridging of the distraction gap are present early on. Yamamoto *et al.* (1997) observed this phenomenon already 4 weeks after the end of distraction in his dog model. In our human study, we observed significant bone formation at our 8-week evaluation. Furthermore, in our study the maturation of bone in the distraction area takes over 1 year before the same density is reached as the original bone. This observation is in agreement with data of Samchukov *et al.* (1999). In a dog study, at 52 weeks after distraction, it has been shown that the thickness of the cortical bone in the distraction zone is slightly thinner than that of native cortical bone (Oda *et al.* 1999).

In our patients, we waited 5 days before initiation of distraction and used a rate of distraction of 1 mm/day, which worked

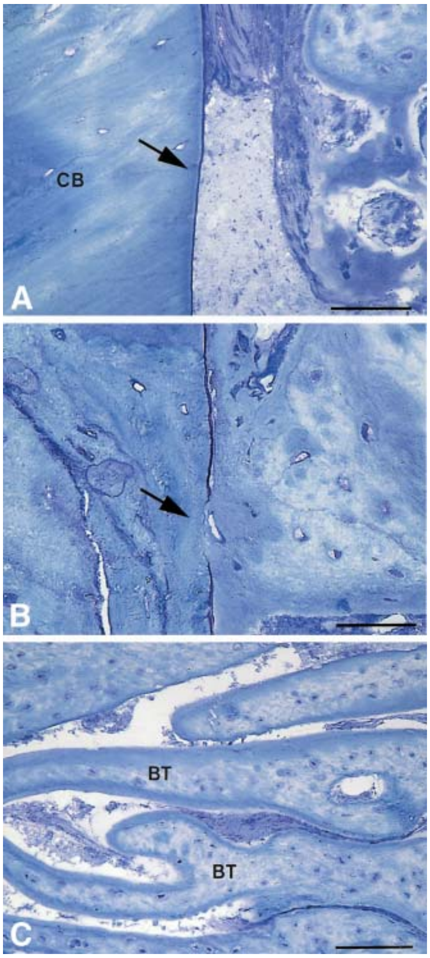

Fig. 5. (A) Detail of the osteotomy area showing a smooth border line (arrow) between the native cortical bone (CB) and the generate (toluidine blue stain). Bar = 44 μm. (B) Detail of the osteotomy showing remodelling (arrow) at the border between the native cortical bone and the generate (toluidine blue stain). Bar = 44 μm. (C) Detail of the mineralization zone showing ossification of newly formed bony trabeculae (BT) oriented parallel to the distraction vector (toluidine blue stain). Bar = 50 μm.

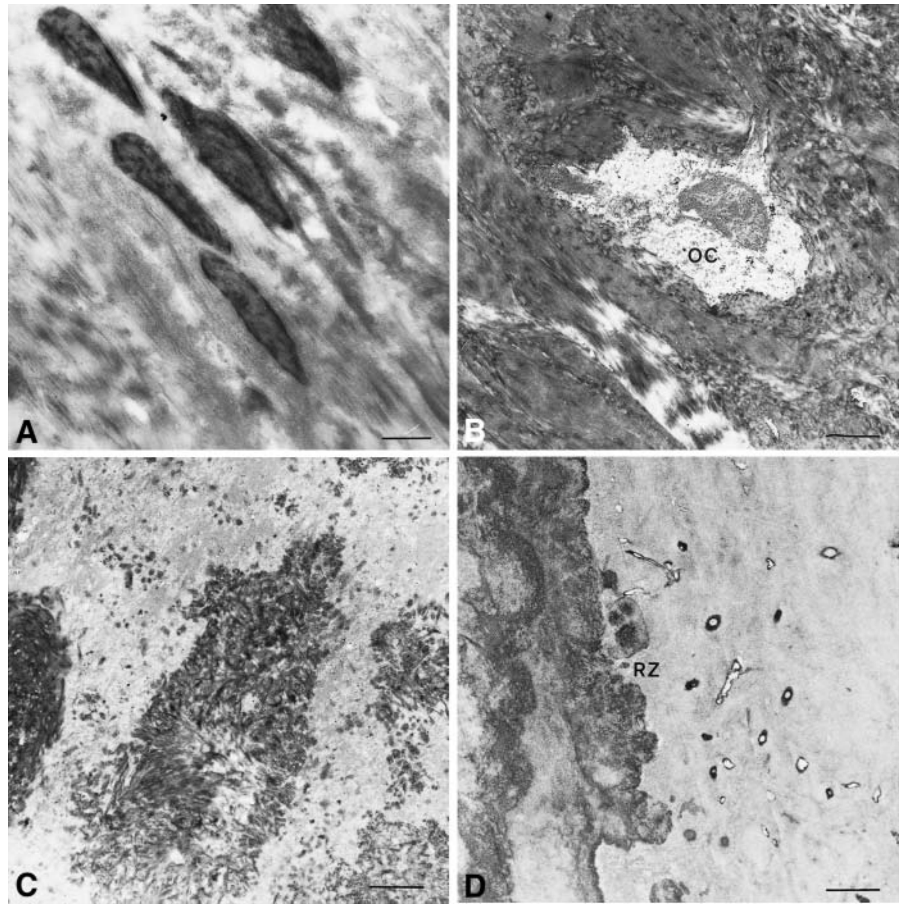

Fig. 6. (A) TEM image showing the presence of fibroblasts in fibrous interzone. The cells are surrounded by collagen fibres. Bar = 0.17 μm. (B) TEM image showing an osteocyte (OC) in the distraction area. The mineralized matrix is black owing to the electron scattering of the apatite crystalls. Bar = 0.15 μm. (C) TEM image of the mineralization zone showing the mineralized matrix with apatite crystals. Bar = 0.15 μm. (D) TEM image of the borderline between generated bone and native cortical bone showing remodelling of this area (RZ). Bar = 0.15 μm.

well. The optimum rate of distraction is one that allows for lengthening with bone formation and a proper soft tissue response. If the distraction rate is too rapid, nonunion will occur, and if it is too slow, premature union will happen (Davies *et al.* 1998). The rate of distraction and length of latency before onset of distraction needs further study. Thus far, a continuous rhythm of distraction is thought to be ideal, with lengthening of approximately 1 mm a day (Chin & Toth 1996; Block *et al.* 1998).

In the two patients who lost some of the obtained distraction height during the consolidation period, the distraction screws extended through the oral mucosa for up to 8 mm. This encouraged the patients to play with the intraorally extending part of the distraction screw. This resulted in a rotating backwards of the distraction screw. In extreme cases this even may lead to mobility of the distraction screw and an compromised implantation site. To prevent this phenomenon, distraction screws have to be chosen with a length just sufficient to obtain the needed increase in bone height. When such screws are used, the distraction screws are extending into the oral cavity for a maximum of 1–2 mm at the end of the distraction period, and ideally they are at the level of the oral mucosa. This was the case in the other patients.

Distraction osteogenesis has the potential for almost unlimited new bone formation. Because of early mineralization, dental implants can be inserted into the new bone 2 months after completion of distraction. Advantages of callus distraction in edentulous jaws are no need for bone harvesting; avoidance of donor site morbidity; vital bone in the distraction area and gain of soft tissue. We feel that the implants probably can be inserted already 4 weeks after the last day of distraction because the osseointegration time for the implants is 3 months. This results in a stabilization period of 4 months before loading the bone. A further advantage of our device is that the incision is short in length and minimal dissection of the periosteum is applied at insertion of the implants. This ensures good blood supply to the osteotomy site and promotes healing. The implants are placed bicortically and will therefore stabilize the transport disk to the native mandible. A further advantage of distraction osteogenesis is that less bone resorption is expected as well as less morbidity problems when compared to a sandwich osteotomy (Lazar *et al.* 1999).

Not unlike all surgical techniques, distraction osteogenesis also has some disadvantages. The need for absolute compliance of the patient and the family is of utmost importance (for daily rotation of the distraction screws at home), and close and frequent follow-up is obvious. The patient cannot wear his/her mandibular prosthesis. Possible complications of the distraction procedure are fracture of the mandible, wound dehiscence and nerve disturbance (Gaggl *et al.* 2000). Other complications might occur like osteomyelitis, lack of bone formation and bone resorption of the superior segment (Oda *et al.* 1999). The last two complications may be due to the severely resorbed mandible with its poor blood supply. This has not occurred in our cases thus far.

The insertion of two 12 mm implants in the mandible seem to be sufficient for the overdenture treatment (Batenburg *et al.* 1998). There is no need for further augmentation of the mandible. If fixed bridges are to be made, a minimum of four implants is needed. Proper planning of the spot of the hole for the distraction screws is obligatory when four or more implants are needed. There must be a minimal bone height of 5 mm in the canine region to create a transport disk of 2 mm thickness to avoid fractures of the bone. For fixation of the distraction screws at least 2 mm is necessary.

This study encourages further investigation of the use of distraction osteogenesis for augmentation of the mandible, and potentially of the maxilla, in larger series of patients. It is still unknown whether the bone formed by the distraction procedure will be able to withstand masticatory forces transmitted through implants in the long term. Thus, long-term results of the implants and a comparison of the distraction method with other techniques like insertion of short implants, augmentation in combination with insertion of implants or placement of a transmandibular implant must be obtained to determine the ultimate treatment of choice for severely resorbed mandibles or the ultimate approach for the various clinical situations, applying the best treatment modality amongst the approaches available for that particular case.

Résumé

Le but de cette étude a été d'évaluer les résultats cliniques et histomorphométriques de distraction de la mandibule édentée sévèrement résorbée. Dans un groupe de dix patients édentés souffrant de rétention insuffisante de leur prothèse inférieure suite à une résorption très poussée de leur mandibule, le segment antérieur a été épaissi par un processus chirurgical pré-implantaire en utilisant le Groningen Distraction Device (GDD) nonvolumineux. Deux mois après le dernier jour de la distraction une biopsie osseuse a été prélevée à l'aide d'un trépan, les deux vis de distraction ont été remplacées par des implants endo-osseux et la vis de guidage a été enlevée. Les biopsies ont été examinées par microscope optique et électronique à transmisssion. L'examen radiologique et histomorphométrique des biopsies prélevées a révélé la présence de deux zones corticales, une à chaque extrémité des biopsies, une interzone fibreuse et pauvrement minéralisée dans le milieu de l'espace de distraction et deux zones de minéralisation entre les zones centrale fibreuse et corticales périphériques. La formation d'os lamellaire parallèle au vecteur de distraction était clairement visible dans la zone minéralisée ainsi que des signes de remodelage dans la zone de l'os cortical original et le régénéré. L'examen clinique a montré que chez tous les patients ce segment antérieur avait du corps de la mandibule suffisamment été élargi pour permettre l'insertion d'implants endo-osseux d'une longueur minimum de 12 mm. Un implant a été perdu durant la phase de guérison et a été remplacé avec succès par la suite. Des prothèses amovibles sur implants ont été fabriquées trois mois après l'insertion de ces derniers. Tous les patients avaient une mise en fonction parfaite observée 11,2 ± 4,3 mois après la fin du traitement. Le GDD a prouvé son efficacité lors de l'épaississement du segment antérieur de mandibules édentées et résorbées sévèrement permettant l'ostéointégration d'implant endo-osseux devant servir d'ancrage à des prothèses.

Zusammenfassung

Das Ziel der Studie war es, die klinischen und histomorphometrischen Resultate der Distraktion von stark resorbierten zahnlosen Unterkiefern auszuwerten.
Bei einer Gruppe von 10 zahnlosen Patienten, welche einen ungenügenden Halt der UK-Prohtese aufgrund eines stark resorbierten Unterkiefers beklagten, wurde vor einer Implantation das anteriore Segment mit dem nichtvoluminösen Groningen Distraktionsapparat (GDD) augmentiert. Zwei Monate nach dem letzten Tag der Distraktion wurden mit einer Hohlfräse Biopsien gewonnen. beide Distraktionsschrauben wurden durch enosslae Implantate ersetzt und die führungsschraube wurde entfernt. Die Biopsien wurden im Lichtmikorskop (LM) und unter dem Transmissionselektronenmikroskop (TEM) untersucht.
Radiologische und histomorphometrische Untersuchungen der Biopsien zeigten, dass zwei kortikale Zonen vorhanden waren, eine an jedem Ende der Biopsien. In der Mitte der Distraktionslücke befand sich eine schwach mineralisierte, fibröse Zwischenzone und zwischen der zentralen fibrösen und den peripheren kortikalen Zonen befanden sich zwei Mineralisationsfronten. Die Formation von lamellärem Knochen parallel zum Distraktionvektor konnte in der Mineralisationszone deutlich gesehen werden. Zudem bestanden Anzeichen von Umbauvorgängen im Bereich der Grenze zwischen dem nativen kortikalen Knochen und dem Regenerat. Die klinische Untersuchung zeigte bei allen Patienten, dass die anterioren Segmente, welche vom Mandibularkörper distrahiert wurden, genügend verbreitert werden konnten und die Eingliederung von enosslalen Implantaten einer Länge von mindestens 12 mm erlaubten. Während der einheilphase ging ein Implantat verloren, es konnte aber erfolgreich ersetzt werden. Die implantatgetragenen Hybridprothesen wurden 3 Monate nach der Implantation angefertigt. Bei der Nchkontrolle 11.2 ± 4.3 Monate nach Behandlungsabschluss bestanden keine funktionellen probleme.
Aus dieser Studie wird die Schlussfolgerung gezogen, dass sich die GDD als verlässliches Werkzeug zur Augmentation des anterioren Segments von stark resorbierten zahnlosen Unterkiefern erwiesen hat. Dadurch wird eine Osseointegration von enossalen belastbaren Implantaten ermöglicht.

Resumen

La intención de este estudio fue evaluar los resultados clínicos e histomorfológicos de la distracción de la mandíbula edéntula severamente reabsorbida. Se aumentó el segmento anterior como procedimiento quirúrgico preimplante usando el poco voluminoso Dispositivo de Distracción Groningen (GDD) en un grupo de 10 pacientes edéntulos que padecían de insuficiente retención de su dentadura inferior relacionada con una mandíbula severamente reabsorbida. Se tomó una biopsia con un trépano dos meses después del ultimo día de la distracción, se retiraron ambos tornillos de distracción reemplazándose por implantes endoóseos retirándose la guía quirúrgica. Las biopsias se examinaron por medio de microscopía óptica (LM) y microscopía electrónica de transmisión (TEM). El examen radiográfico e histomorfométrico de las biopsias revelaron la presencia de dos zonas corticales, una a cada extremo de las biopsias, una interzona pobremente mineralizada, fibrosa en la mitad del hueco de distracción, y dos zonas de mineralización entre las zonas fibrosa central y cortical periférica. La formación de hueso lamelar paralelo al vector de distracción fue claramente visible en la zona de mineralización al igual que signos de remodelado en el borde entre el hueso nativo cortical y el generado. Los exámenes clínicos mostraron en todos los pacientes que el segmento anterior distraído del cuerpo mandibular fue suficiente alargado para permitir la inserción de implantes endoóseos con una longitud de al menos 12 mm. Un implante se perdió durante la fase de cicatrización, pero fue sustituido con éxito por otro posteriormente. Las sobredentaduras retenidas por implantes se fabricaron 3 meses tras la implantación. Todos los pacientes funcionaban bien tal como se observó 11.2 ± 4.3 meses tras el final del tratamiento. De este estudio se concluye que el GDD ha demostrado ser un instrumento fiable para el aumento del segmento anterior de una mandíbula edéntula severamente reabsorbida permitiendo la osteointegración de implantes endoóseos que permiten carga.

要旨

本研究の目的は、重篤な吸収を呈した無歯顎下顎の骨延長術の結果を、臨床的及び組織形態学的に評価することであった。顎骨の重篤な吸収のために下顎総義歯の安定性が損なわれている１０名の無歯顎患者において、インプラント埋入の前処置として、小型の Gronigen Distraction Device (GDD) を用いて前歯部の骨を増多した。延長術の終了２ヶ月後に、骨の生検標本をトレファンで採取し、延長装置のスクリューを骨内インプラントに置換し、ガイド・スクリューを抜去した。生検標本は光学顕微鏡（ＬＭ）と透過電子顕微鏡（ＴＥＭ）で検査した。

生検標本のレントゲン像及び組織形態学的検査は、生検標本の両端各々に皮質骨ゾーンが存在することを示し、延長した間隙の中央部分は余り石灰化していない、繊維性の中間ゾーンとなっており、中央の繊維性ゾーンと末端の皮質骨ゾーンの間に石灰化したゾーンがあった。石灰化したゾーンでは、延長方向に平行な層状骨の形成が明らかに認められ、元の皮質骨と新生骨の間の境界線では骨改造の兆候が認められた。臨床検査は、全ての患者において、下顎骨体部から延長術を施した前歯部は十分に増多され、少なくとも長さ１２ｍｍの骨内インプラントが埋入できることを示した。インプラント１本が治癒期間中に失われたが、その後成功裏に置換された。インプラント義歯は、インプラント埋入３ヵ月後に製作した。治療終了後１１．２±４．３ヶ月の追跡調査中、全ての患者は良好に機能していた。

本研究の結論として、ＧＤＤは重篤な吸収をきたした無歯顎下顎の前歯部において、骨内インプラントの骨性統合を可能にする信頼性の高いツールである事が証明された。

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