Non-free osteoplasty of the mandible in maxillofacial gunshot wounds: mandibular reconstruction by compression–osteodistraction

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SUMMARY. We have treated 33 young men with medium to large (3–8 cm) bony and soft tissue defects of the lower third of the face caused by gunshot wounds. After debridement, collapsing the proximal segments for primary approximation of soft and hard tissues and a closed osteotomy of a small fragment of mandible, we used an original compression–distraction device, designed in 1982 and tested during 1983 (analogous devices were absent at that time) to reposition the mandible and cause callus to form (during distraction) between the fragment and to use the remaining stumps of bone to fill in the defect. The soft tissues were repaired at the same time. Twenty-eight of the patients presented within a few hours of injury, and the remaining five had old injuries. The only complications were in the group with old injuries where four patients developed abscesses that required drainage, but these did not interfere with the process of osteogenesis. All 33 patients had good functional and aesthetic results within 3–4.5 months.

The method allows a bloodless minimally traumatic procedure which can be carried out in one stage. The results compare very favourably with the classic methods of the treatment of mandibular gunshot injuries.

INTRODUCTION

Mandibular defects are notoriously difficult to treat. Transplantation has been widely used, but the choice of material (bone grafts, polymers, metals, or ceramics) remains controversial.1–6 Contrast microangiography after mandibular osteoplasty has shown that the formalized bone graft was either rejected or slowly revascularized and replaced by host bone. Combined biochemical and isotopic investigations have shown that the transplant remains metabolically inactive.7,8 Large, freeze-dried segments of homologous bone (which need supplementation by autologous bone chips) are eventually completely replaced by autologous bone.2,9 Embryonic bone is suitable for osteoplasty, but is not strong enough,10,11 and the process of transplantation and assimilation can be complicated by resorption or rejection.11

The technique of compression–distraction osteosynthesis that was first described by Ilizarov12,13 has revolutionized treatment of bony and soft tissue defects in trauma and orthopaedics. It is extremely effective in the treatment of fractures of the long bones, large bony defects, and traumatic osteomyelitis.14–17 Callus formed during gradual distraction has all the characteristics of an ideal transplant material that requires no mechanical stimulation, the main stimulator of bone growth being tension on the callus while the proximal fragments of bone are immobilized.

A fracture or osteotomy initiates the regeneration of bone. Skeletal growth factors (bone morphogenic proteins) are activated.18–21 These are non-collagenous proteins that regulate the process of repair.22,23 Primitive cells develop into preosteoblasts and then into osteoblasts under the influence of these growth factors.24,25 Distraction causes absorption of callus, and this results in the continuing activation of growth factors that cause pericapillary cells to transform into osteogenic cells.

There is some evidence that bone stem cells play a part in bone repair, and are also influenced by growth factors.26,27 and this might explain why the osteogenesis persists for several months until sufficient callus is formed.

Variations of this technique have been used in maxillofacial surgery for some years,28–36 particularly in the treatment of mandibular fractures without bony defects, for small defects after sequestrectomy, or for mandibular hypoplasia. However, we could find no reports of the technique being used for medium or large mandibular defects; the largest previously reported defect repaired was 3.75 cm.

We present here our modification of Ilizarov’s technique. We have adapted it specifically to deal with the anatomy of the mandible, and have used it to treat patients with gunshot injuries or defects from old injuries.37,38 Our method allows us to repair not only the bone, but also the muscles, nerves, blood vessels, skin, and mucosa so that we have a full-thickness repair of the defect.

PATIENTS AND METHODS

The principle of the method is a closed osteotomy (preparation of a small fragment) of one or both of the mandibular stumps after initiation of osteogenesis by short-term compression of the fragments at the osteotomy site. Regeneration of bone is continued by distraction of the callus until it is large enough to close the defect. The small fragment of bone that is osteotomized and transplanted is usually about 2.5–3 cm long, and as it is still connected to the surrounding
tissues it has a good blood supply and innervation, high regenerative potential, and is mobile.\textsuperscript{17}

We have treated 33 men, 20–35 years old. All had comminuted gunshot fractures of the mandible together with loss of surrounding soft tissue. The defects measured 3–8 cm (11–40\% of the length of the body of the mandible). Twenty-eight of the 33 had recent wounds, and the other five had defects (soft and hard tissue) of varying age. We divided the patients into two groups depending on the size of the defect and the mobility of the stumps, as they required two slightly different approaches.

The first group comprised seven patients with mandibular defects 3–4 cm long. The indication for osteoplasty was that the mandibular ends could be closely approximated by the compression–distraction device. In some cases, however, there was no possibility of rapid knitting, and in others the mandibular ends were almost, but not quite, in contact with each other (Fig. 1).

The second group (n=26) had defects 4–8 cm long on the lateral side of the mandible. In these cases we were able only to approximate the mandibular ends and reduce the size of the defect (Fig. 2).

The site of the proposed closed osteotomy (small fragment) was marked on the skin, while the gunshot wound was being debrided. Two to four threaded screws were then inserted into each section of the mandible by drilling, and two to three threaded screws were drilled into what was to be the ‘small fragment’. The pins were united in groups by plates, which were transformed into a unified hard mobile system by means of a threaded arch bar (Figs 1 & 2). The device was designed to approximate the mandibular ends towards each other and although temporarily disturbing the occlusion, would reduce the size of the defect. As a result of this approximation, the soft tissue

![Fig. 1 – Diagram of the non-free osteoplasty of the mandible used for the first group (A) the mandibular ends are fixed by the compression device, the site of the future osteotomy is marked with a dotted line, arrows show the direction of the mandibular ends; (B) the mandibular ends are approximated and the osteotomy created; (C) final result after restoration of the shape of the mandible, the defect is filled by immature callus.](image1)

![Fig. 2 – Diagram of the osteoplasty used, for the second group: (A) the mandibular ends are fixed by the compression device and an osteotomy is created on the larger mandibular stumps to make a small mobile bone fragment; the arrow shows the direction of the mobile fragment; (B) final result after the two fragments have joined up; the defect is filled by immature callus.](image2)
Fig. 3 – (A) The small entrance wound is situated on the chin (below right retractor – arrow) and large lacerated exit wound on the left side of the the face; (B) occiptomental radiograph showing bursting fracture of the mandibular body along 1234567; (C) the patient’s face deformed after the mandibular stumps have been shifted towards the defect; (D) disturbance of dental occlusion: the right lower canine is situated opposite the left first upper incisor and the right lower premolar is between the right upper incisors; (E) the right lower canine is left in the same place and the right second premolar is shifted backwards together with the large mandibular stump as the distance between these teeth increases; (F) occiptomental radiograph shows the normal positions of the large mandibular stumps, the small mobile fragment has moved towards the left side and the defect at the osteotomy site is filled with immature callus; (G) the right lower canine and both incisors are in contact with the left upper premolars and molar, the right lower second premolar is in its normal position, between the lower teeth mentioned above, there is a considerable amount of gum formed by immature callus; (H) the same patient with removable denture; (I) occipito-mental radiograph showing the restored shape, size and continuity of the mandible, and well mineralized callus is seen at the site of the former mandibular defect.
defects in the fresh wounds were reduced and we were always able to suture the mucous membrane and separate the oral cavity from the external wound despite substantial debridement of the wound edges. This is important in the prevention of infection.

We then removed from the ends of the stumps, with either burs, tooth cutters, or a disc saw, 2–3 mm of dead bone and any bone with reduced regenerative capacity. Not only did this allow access to live bone containing growth factors, but removal of dead tissue helped healing, prevented infection and the development of gunshot osteomyelitis.

In both groups, the closed osteotomy (preparation of the small segment) was completed with a wire saw, through a small incision in the submandibular region. The primary defect was then compressed with the compressive–distractive device, and the external gunshot wound repaired. The period of compression lasted for 10 days, after which we started the distraction. The ‘small fragment’ was separated at a rate of 1 mm/day by adjusting the device every 5–6 hours. We chose this rate because an osteon grows at a rate of 1 mm/day during regeneration. The fragment was displaced along the curved threaded bar (which had been shaped during the operation by the surgeon to correspond with the patient’s face) towards the defect. In bending the bar, the surgeon had programmed the future curvature of the body of the mandible.

In the five patients with old defects the scar between the stumps was compressed during distraction by the small fragment. In four of the five cases this caused an abscess that had to be drained, but the inflammation did not spread to the bone. In each case there was room for direct contact between the mandibular end and the ‘small fragment’ and it was possible to trim the end surfaces through the wound to enable primary repair.
By the end of the 10-day period of compression, the soft tissue injury had usually healed, and during the distraction of the callus the soft tissues were also being stretched. This slow stretching stimulated growth and repair of muscles, vessels, mucosa, skin, and nerves and progressed at the same time as osteogenesis.

When direct contact had been made between the small fragment and the opposite mandibular end we trimmed and freshened the compressed ends to obtain the maximum contact. The ends were then compressed again. By now, immature callus had started to ripen, and could be palpated inside the mouth. Depending on the size of the defect this would take from 1.5–2.5 months to mature.

Three to four weeks after direct contact between the small fragment and the opposite mandibular end had been achieved, the patient was given a removable denture to wear. This improved speech, mastication, and accelerated reconstruction and mineralization of the callus. The compression–distraction device was removed after the arch bar had been taken off and the callus had been examined manually to make sure that it was stable.

RESULTS

All 33 patients had good functional and aesthetic results. There were no complications, except for the four abscesses that developed in four of the five results. There were no complications, except for the four abscesses that developed in four of the five results. The duration of treatment ranged from 1.5–2.5 months to mature.

DISCUSSION

Only if the recipient bed is healthy will a free osteoplasty (bone graft) succeed. However, gunshot wounds to the face usually result in both soft and hard tissue defects. Restoration of the mandibular defect also requires a repair of the soft tissue loss. The soft tissue bed must be healthy if it is to take a future bone transplant. Usually in such cases a pedicled, musculocutaneous or free flap is used to restore the soft tissues and repair usually requires several operations, which take a long time and often give poor aesthetic results. A few months later, a graft made of autologous or allogeneic bone, ceramic, metal or plastic will need to be inserted but nobody can predict the success of the graft. It may result in assimilation, resorption or rejection. There are many causes for resorption or rejection, and it is not possible to eliminate them all.

The non-free osteoplasty of the mandible has many advantages. During compression, the desmogenous callus formation resembles bony embryogenesis, and is replaced by osteogenic tissue when distraction begins. The angiogenic callus that extends from the end of the small fragment has a good capillary blood supply and causes no immunological reaction. The new bone that forms during distraction may be grown to any size, forms easily, and quickly matures into organotypical bone. It can be bent by the preformed arch bar (prepared by the surgeon in theatre) to the mandibular shape required. This technique compares favourably with bone grafts and alloplastic implants because it is not subject to resorption or rejection.

Compression–distraction osteoplasty not only restores the mandible but during distraction the soft tissue is also repaired, which means that a bloodless restoration of the lower third of the fact is possible in one stage.

It is always difficult to place a denture after bone-grafting, because the bone graft does not contain teeth. The mobilized and displaced small fragment, however, does have teeth and moves them into the defect, so it is relatively easy to fix a denture to them. Unlike bone-grafting, when we have no control over the processes of healing, we can easily regulate the degree of compression, distraction, and fixation.
Compression can accelerate callus formation and is used in two ways in this technique. When the small segment’ prepared reached the opposite mandibular end, the new union (primary site) is compressed for ten days with the compressive–distractive device causing an activation of osteogenesis. Ten days later, distraction is commenced at this site by displacing the small fragment backwards for a 6–7 day period. This allows compression of the regenerated bone and speeds up maturation of the previously formed callus and allows some further distraction at the primary site.

CONCLUSION

Mandibular bony and soft tissue reconstruction can be achieved by non-free osteoplastic with the help of this compressive–distractive device. This method avoids the need for multiple extensive operative procedures on both soft and bony tissues. It does not require a bone graft or an implant with their unpredictable outcome (assimilation, resorption, rejection). The method of non-free osteoplasty compares very favourably with the classic methods of mandibular reconstruction. It is a relatively atraumatic, bloodless procedure, secures substitution of the combined soft and hard tissue defect in one stage and decreases the duration of treatment three- to four-fold.

References

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