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Reconstruction of residual mandibular defects by iliac crest bone graft in war-wounded Iraqi civilians, 2006–2011

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Abstract

Our aim was to assess the long-term results, complications, and factors associated with failure of mandibular reconstructions among wounded Iraqi civilians with mandibular defects. Success was measured by the quality of bony union, and assessed radiographically and by physical examination. Failures were defined as loss of most or all of the bone graft, or inability to control infection. During the 6-year period (2006–2011), 35 Iraqi patients (30 men and 5 women, mean age 33 years, range 15–57) had residual mandibular defects reconstructed by iliac crest bone grafts. The causes were bullets ($n = 29$), blasts ($n = 3$), and shrapnel ($n = 3$). The size of the defect was more than 5 cm in 19 cases. Along the mandible the defect was lateral ($n = 14$), central/lateral ($n = 5$), lateral/central/lateral in continuity ($n = 6$), and central in continuity ($n = 10$). The mean time from injury to operation was 548 days (range 45–3814). All but 2 patients had infected lesions on admission. Bony fixation was ensured by locking reconstruction plates ($n = 27$), non-locking reconstruction plates ($n = 6$), and miniplates ($n = 2$). Complications were associated with the reconstruction plate in 2 cases, and donor-site morbidity in 5. After a mean follow-up of 17 months (range 6–54), bony union was achieved in 28 (80%). The quality of the bone was adequate for dental implants in 23 cases (66%). Our results suggest that war-related mandibular defects can be reconstructed with non-vascularised bone grafts by multistage procedures with good results, provided that the soft tissues are in good condition, infection is controlled, and the method of fixation is appropriate. Further studies are needed to assess the role of vascularised free flaps in similar conditions.

Keywords: Mandibular defects; War-related trauma; Iraqi civilians; Reconstruction

Introduction

Surgical teams have been confronted with a large number of war-related injuries to civilians since the beginnging of the armed-conflict in Iraq in 2003. The face is particularly liable to injuries because it is unprotected or not padded by cloth. Many of the patients with such injuries have mandibular defects with subsequent residual complications, including obstruction of the airways, disturbances of eating, insufficient retention of saliva, impaired speech, and facial disfiguration. Alloplastic reconstruction is usually the treatment of choice for patients with mandibular defects. Although the outcome has been widely described for patients with malignant tumours,[1–3] few reports have focused on reconstruction of mandibular defects after war-related trauma.[4–6]

The purpose of this report was to describe the rate of successful bony union in wounded Iraqi civilians treated by mandibular reconstruction with non-vascularised bone grafts, and identify the factors associated with failure.

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Patients and methods

Injuries that require complex reconstructions are difficult in Iraq for technical, administrative, or security reasons.[7] In 2006, Médecins Sans Frontières initiated a surgical project within the Jordan Red Crescent Hospital in Amman, Jordan, to provide plastic, orthopaedic, and maxillofacial surgeons. Wounded Iraqi patients admitted between 2006 and 2010 with defects of the mandible and adjacent soft tissues that were reconstructed by iliac crest bone grafts in Amman were included in the study. Procedures were carried out by two experienced surgeons who had wide experience in war surgery.

We reviewed the charts retrospectively to identify patients' age, sex, mechanism of injury, size of bony defect and its position along the mandible, type of bony fixation, complications, and morbidity at the donor site. Time from injury to operation in Amman, duration of stay in hospital, number of operations required to achieve bony union, and duration of follow-up were also recorded. Success of mandibular reconstruction was measured by the quality of bony union, and was assessed radiographically and by physical examination. Failures were defined as loss of most or all of the bone graft, or inability to control infection.

Operative techniques

The wounded patients were first treated in Iraq by life-saving measures including tracheotomy, control of bleeding, closure of the wound, removal of bullets and fragments, fixation of the remaining mandibular segments either by intermaxillary fixation, Kirschner wires, external fixators or miniplates, reconstruction by bone graft and, occasionally, cover of soft tissues by local or regional flaps.

After the patients had arrived in Jordan, the first stage of treatment was exploration of the mandibular defects, removal of fixators or miniplates, and debridement of the wound and bone. Swabs from the deep soft tissues and bone were routinely taken for culture. A satisfactory occlusion was re-established using the remaining teeth (or the most anatomically proper position for the remaining mandibular segments) as a guide. Finally, the bony segments were fixed with reconstruction plates (locking or non-locking type, or miniplates) and the wounds were closed in layers (Fig. 1). If cultures grew pathogens, antibiotics were given parenterally for 2 weeks in the case of soft tissue infection, and for 6 weeks in the case of bone infection, according to the sensitivities.

The second stage usually started six weeks after completion of the course of antibiotics. This included a new exploration of the mandibular defects, refreshment of the bony edges, and reconstruction of the defect using corticocancellous bony chips harvested from the hip and fixed to the reconstruction plate using bicortical screws (Fig. 2). When the amount of bone harvested from one side of the ilium was not enough to reconstruct the whole defect, the reconstruction procedure was completed using bone harvested from the other side of the ilium at least 4 months later (Fig. 3a).

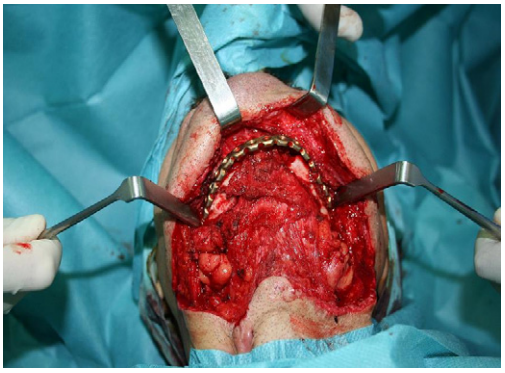

Fig. 1. Locking reconstruction plate in a 40-year-old patient who presented with an 8 cm defect after a bullet injury to the mandible.

The third stage started 4 months later with re-exploration of the mandible and removal of the reconstruction plate. If the bone was found to be satisfactory to support dental implants, the reconstruction procedure was finished (Fig. 3b). Results were considered unsatisfactory if the available bone was not sufficient for insertion of dental implants. In such cases, the reconstruction plates were removed and a new bone graft from the ilium was harvested to augment the existing bone using screws.

Statistical analysis

Data were analysed with the help of STATA (version 11, Stata Corporation, TX). Quantitative variables were expressed as mean (range). Categorical variables were given as number (%). The chi square test or Fisher's exact test was used when appropriate for testing the significance of differences between categorical variables. Student's *t* test or the Mann–Whitney *U* test was used when appropriate to assess the significance of differences between means. For biometric evaluation of risk factors of a postoperative complication being associated with the reconstruction plate, the factors were compared using the log rank test. The effect of several variables on the results of repair of a continuity defect was appraised using regression analysis to clarify multifactorial effects on the results of treatment. Probabilities of 0.05 or less were accepted as significant.

Results

During the 6-year period (2006–2011), 35 Iraqi patients (30 men and 5 women, mean age 33 years, range 15–57) had residual mandibular defects reconstructed with bone grafts from the iliac crest. Causes of injury were bullet, blast, and shrapnel in 29, 3, and 3 cases, respectively. The size of the bony defect was over 5 cm in 19 cases. The maxilla was involved in 6.

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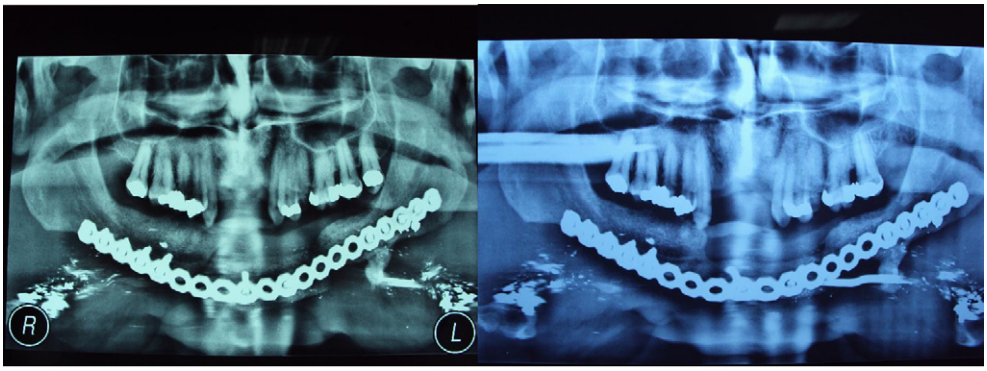

Fig. 2. (a) First stage reconstruction with chips of corticocancellous bone taken from the left anterior crest. (b) Healing of the graft after 4 months.

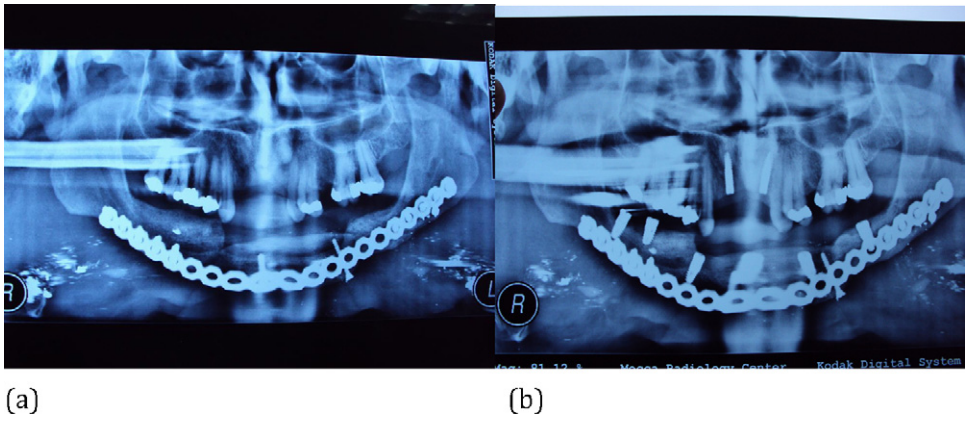

Fig. 3. (a) Additional augmentation of the bone graft by a new graft harvested from the other side of the ilium. (b) Well-healed bone with rehabilitation of the mandible by dental implants.

The position along the mandible was lateral ($n = 14$), lateral/lateral ($n = 3$), central/lateral ($n = 7$), lateral/central/lateral in continuity ($n = 6$) and central in continuity defect ($n = 5$). The mean time from injury to operation was 824 days (range 45–3814). All but 2 patients had infected lesions on admission. The patients had several procedures in Iraq, including non-vascularised bone graft ($n = 11$) and vascularised soft tissue flap ($n = 1$). In Amman the mean number of reconstructive procedures was 3 (range 1–8). Bony fixation was ensured by locking reconstruction plates ($n = 27$), non-locking reconstruction plates ($n = 6$), and miniplates ($n = 2$). Details of patients on admission, and of their injuries and management according to outcome, are shown in Table 1. Two patients had a single operation during which bone was grafted at the same time as fixation plates were placed. Those patients were subsequently lost to follow-up. Two patients whose initial bone grafts failed required vascularised bone grafts. One patient had sufficient bone from the graft at the time that the plate was removed, and one did not have the plate removed as he was not fit for general anaesthesia although the bone graft was successful in terms of height and union.

Bacteriological data were complete for 20 of the 33 infected patients (61%); 8 (40%) grew one bacterium, and 12 (60%) more than one. Bacteria were resistant to multiple drugs in 10 cases. Bacterial species are shown in Table 2.

After a mean follow-up of 17 months (range 6–54), bony union was achieved in 28 patients (80%). The quality of bone was satisfactory for dental implants in 23 (66%). Three patients in whom grafts failed had complete loss of the bone graft and 4 had partial loss. Neither the anatomical site of the defect, nor sex, diabetes, smoking, time from injury to operation, mechanism of injury, size of defect, type of fixation, or number of operations significantly increased the risk of failure.

Complications were associated with the reconstruction plate in 2 cases, including extraoral and intraoral exposure in one and fracture in the other. Five patients developed seromas at the donor site.

Discussion

Autogenous bone grafts taken from the ilium are a reliable means of reconstruction of mandibular defects after high

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Table 1
Characteristics of patients with mandibular defect according to the outcome, Amman 2006–2011. Data are no. of patients except where otherwise stated.

	Total ($n=35$)	Success ($n=28$)	Failure ($n=7$)	P value
Sex				0.22
Male	30	25	5	
Female	5	3	2	
Mean (range) age (years)	33 (15–57)	37 (15–56)	31 (15–57)	0.13
Nature of the osseous defect				0.74
Lateral	14	3	11	
Central/lateral	7	2	5	
Lateral/central/lateral	6	1	5	
Central	5	0	5	
Maxilla involved	6	5	1	0.32
Four or more operations needed	14	10	4	0.56
Cause of injury				0.46
Bullet	29	20	9	
Missile	3	2	1	
Blast	3	1	2	
Mean (range) number of days from injury to admission	824 (45–3814)	743 (45–1674)	1037 (78–3814)	0.15
Diabetes	3	3	0	0.36
Smoking	12	11	1	0.25
Graft performed in Iraq	12	9	3	0.59
Size of defect > 5 cm	19	14	5	0.31
Infection at admission	33	26	7	0.47
Type of fixation				0.42
Locking reconstruction plates	27	22	5	
Non-locking reconstruction plates	6	4	2	
Miniplates	2	2	0	

velocity or explosive war-related injuries. To our knowledge this is the first study that has assessed the outcome of delayed reconstruction of residual mandibular defects by iliac crest bone graft after such trauma. In only 4 patients was there total failure of grafting, while 3 developed partial loss of the grafted bone. Morbidity was acceptable in all the patients treated, with limited postoperative pain at both donor and recipient sites. Our overall success rate of 80% for bony union is in line with reports of the use of non-vascularised bone grafts for reconstruction after resection of mandibular tumours. For example, van Gemert et al. reported 76%,[8] Pogrel et al., 76%,[9] Foster et al., 75%,[10] and Tidstrom et al., 100%.[11] The width and height of the grafts were sufficient to receive implants in most patients. In the near future we will assess the occlusal rehabilitation through the creation of an adequate support for the phases after placement of implants and implant-supported prosthetic restorations in those patients.

The procedures were particularly challenging because wounds were infected and the losses of bone and soft tissue were severe. The "3-steps" approach allowed a limited number of operations: only 7 patients had more than 4. Our standard protocol of antibiotics seemed to be efficient, as all infections present on admission were controlled, despite several highly resistant pathogens. Such highly resistant bacteria are common problems in the treatment of war-related trauma.[12]

Table 2
Bacterial species grown in culture.

Bacteria isolated	Number (%) of cultures
Staphylococcus aureus	8 (22)
Acinetobacter baumannii	5 (13)
Pseudomonas aeruginosa	5 (13)
Proteus mirabilis	4 (11)
Streptococcus viridans	4 (11)
Klebsiella pneumoniae	3 (8)
Other	8 (22)

Interestingly, the extent of the defect did not limit our use of non-vascularised bone grafts, probably because defects were reconstructed in several stages. Our results suggest that reconstructions with such grafts can also be successful for post-traumatic mandibular defects that exceed 5 cm in size, contrary to findings reported among patients with mandibular defects caused by tumours who were given radiotherapy postoperatively.[9]

There were no obvious factors that predicted failure of the reconstruction. In particular, the mechanism of injury was not associated with failure, and this prevented us from developing an algorithm to guide the choice of the most appropriate surgical technique according to type of injury. One potential explanation for failure of the procedure might be that the quality and quantity of soft tissues surrounding the graft were inadequate. Indeed, most of these patients had had multiple reconstructive procedures in Iraq before being admitted in our programme, and these had left scars and poor quality soft tissue coverage with compromised blood supply over the reconstructed area, irrespective of the extent of the defect.

Although most of the patients were healthy and under 50 years of age, several factors, including soft tissue loss

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and infection, may have compromised the vascularity of the recipient site. It is likely that reconstruction with free revascularised flaps would have been the treatment of choice in our failed cases. Free flaps, thanks to their vascular pedicle that guarantees immediate blood supply to the transplanted bone, can survive in an unfavourable, hypovascularised environment. Although rare in our series, intraoral wound dehiscence may also result in failure of the graft as a result of use of the intraoral approach and contamination of the wound with oral micro-organisms. The amount of soft tissue loss and the suspicion of occult infection should influence the choice of surgical interventions.

Segmental resection of the anterior mandible causes the muscles of the floor of the mouth and tongue to lose their insertion to the mandible. This may cause exposure of the palate and failure in anterior alloplastic mandibular reconstruction as a result of the limitations of a non-vascularised bone graft. Unlike other authors,[8,10] we were unable to find any correlation between the anatomical site of the defect and failure or complications associated with reconstruction plates.

Surprisingly, our study failed to show that smoking had any effect on the success of the graft in mandibular reconstruction. We know that cigarette smoking adversely affects both wound healing and the success of implant-related grafting.[13] Several studies have reported that failure of a graft is associated with smoking.[8,14] However, whether smoking influences the development of complications and the success rate may depend on the volume of the autogenous bone graft. Another potential explanation for this lack of association may be the multistage approach, which compensates for any bony resorption after the first reconstructive procedure. Above all, the limited number of patients included in this study may have defied any statistical test to detect significant differences between patients with successful procedures and those in whom the procedure failed. The quantitative conclusions about 28 of 35 patients successfully operated on must therefore be interpreted cautiously. Further studies are needed to assess the use of, and indications for, vascularised free flaps under similar circumstances.

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