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TECHNICAL NOTE

Free vascularized fibular graft as a salvage procedure for large clavicular defect: A two cases report

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KEYWORDS

Clavicle;
Non-union;
Vascularized fibula
graft;
Reconstruction;
Cleidectomy

Summary The gold standard technique for treating clavicle non-union is based on cortico-cancellous bone graft harvested from the iliac crest and fixed with a plate. In cases of large clavicular defects, this surgical procedure becomes ineffective and only reconstruction using vascularized bone grafts can be considered. Nevertheless, there are few reports in the literature dealing with this procedure and surgical technique remains unclear. We expose here a technique and results of free vascularized fibular graft for two patients with large clavicular defects.

Levels of evidence: Level IV, technical note.

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Introduction

With regard to the high union rate of nearly 95%, most authors do not recommend surgical treatment for fractures of the middle third of the clavicle [1,2]. However, a few patients evolve to symptomatic non-union, especially when displacement is marked [3,4]. In these situations, surgical treatment, consisting in autologous bone graft associated with a plate fixation, becomes necessary [5,6]. Unfortunately, a few patients never heal [7] despite repeated autologous bone grafts, resulting in significant bone loss.

In these cases, reconstructive procedure using a free vascularised fibular graft can be performed. Nevertheless, there are few reports in the literature dealing with this procedure and surgical technique remains unclear. We describe here technical points and results for 2 patients.

Technique

The patients were positioned in a beach chair position with a cushion placed behind the scapula and the ipsilateral hip.

Recipient site preparation

The surgeon stood over the patient's shoulder. A straight incision just above to the clavicle was made. The surgical

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approach went through the platysma muscle while preserving the branches of the superficial cervical plexus. The external jugular vein was identified at the anterior surface of the sternocleidomastoid muscle. The omohyoid muscle was sacrificed and the lateral part of the sternocleidomastoid muscle was incised. The superficial transverse cervical artery was identified just behind this muscle in front of the anterior scalene muscle under microscopic control. It was prepared for the anastomosis as well as a branch of the external jugular system. The middle third of the clavicle was then released from pectoralis major and subclavius muscles insertions. After excision of fibrous soft tissue and bony sequestrum, the clavicle was sawed as necessary to expose a healthy bleeding bone (Fig. 1). The intramedullary canal of each fragment was permeabilized with a 3.5 mm drill.

Fibula harvesting

The fibula was harvested from the ipsilateral leg. The technique is already well described in the literature [8–10].

Positioning, fixation and revascularization

The fibula flap was osteotomized and sculptured to fit perfectly the gap between the two clavicular stumps. It was then fixed with a contoured 3.5 mm dynamic compression locking plate with 3 screws in each part of the clavicle. The fibula was fixed with only 2 monocortical screws in order to not damage the intramedullary vascularization. Termino-terminal anastomoses were made using a 9.0 nylon wire after perfusion of heparinized serum in the vessels. Graft extremity medullar bleeding was checked after releasing the vascular clamps. Additional cancellous bone harvested from the iliac crest or the proximal tibial metaphysis filled the graft junctions (Fig. 2). A suction drainage was placed in contact with bone grafting. The subcutaneous tissue and skin were finally closed.

Postoperative management

The patients were kept on continuous systemic heparinization for 1 week with a cephalin level ranging from 2 to 3 times the control level. An immobilization was placed on the affected shoulder for 2 months. Forward flexion and lateral elevation were allowed only when bone union was noted on X-rays.

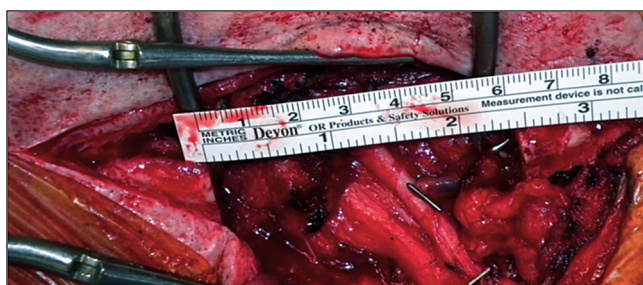


Figure 1 Operative view after excision of fibrous soft tissue and bony sequestrum. The subclavicular artery and brachial plexus are well viewing.

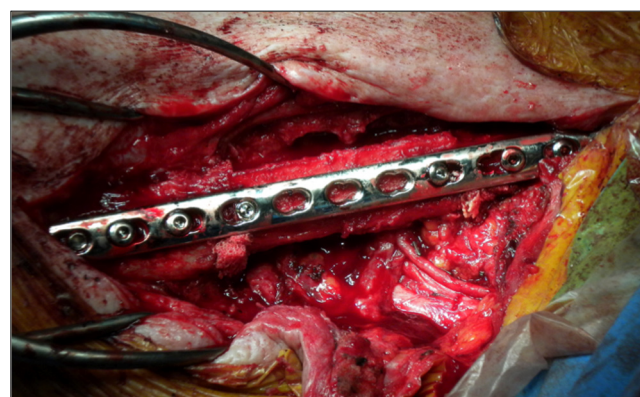


Figure 2 Internal fixation of the fibula in addition with cancellous graft harvested from de homolateral iliac crest. The anastomosis was sutured above the graft.

Operative cases

Case 1

Seven years after a left midshaft clavicle fracture, a patient of 53 years presented with paraesthesia of his left medial three fingers. In his medical history, he reported a Hodgkin's disease treated with radiotherapy and chemotherapy at the age of 25. Clinical examination retrieved a claw hand affecting the middle, ring and little fingers. A positive Tinel sign in the supraclavicular region and a discriminative sensory loss was noted on these fingers. Magnetic resonance imaging showed narrowing of the thoracic outlet related to a malunion of the clavicle.

The patient underwent surgical correction of this deformity with open reduction and internal fixation. One year later, there was no neurological impairment but the patient still complained of shoulder pain. X-rays showed non-union of the clavicle. Consequently, a cancellous bone graft harvested from the iliac crest and fixation with a locking plate was performed. This one was replaced a month and a half later due to early failure. The new plate was removed one month later, considering the appearance of signs of local infection. During this procedure, no purulent effusion was noted and a new fixation was carried out.

Eight months later, the skin was still unhealed. The X-ray showed no bone fusion. During the sixth operation for removing all hardware material, the presence of *Staphylococcus aureus* was identified. Eleven months later, after a suitable antibiotic treatment, there were no sign of inflammation. The patient again reported numbness in the fingers without objective signs. The Constant score was 48 points. A CT scan showed a major bone loss (Fig. 3).

The gap between clavicular stumps was measured at 6.5 cm after excision of bony sequestra during the free vascularized fibula transfer.

Four months later, follow-up radiographs demonstrated complete bone union on both sides of the graft (Fig. 4).

At 20 months follow-up, he had neither pain nor sign of infection. The Constant shoulder score was 96 points. The patient returned to muscle-building exercises.

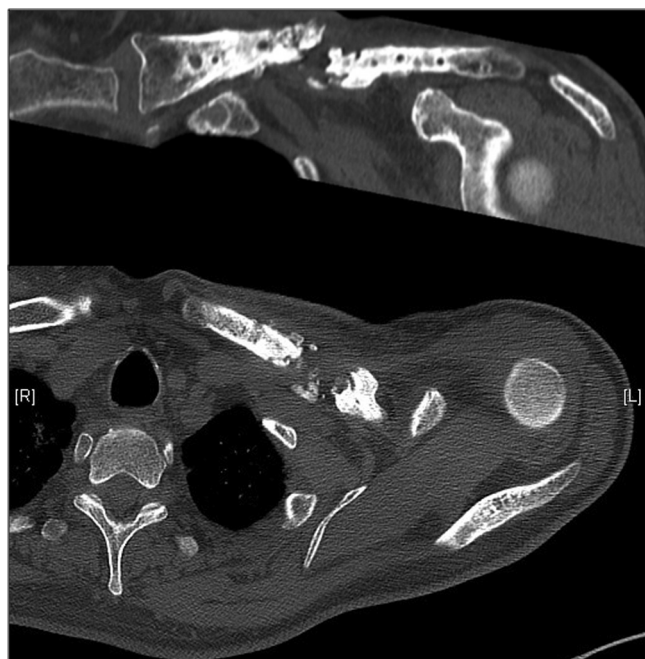


Figure 3 Large bone defect of the left clavicle of the first patient. The residual bone is sclerotic. Medical history of the patient retrieved irradiation and long history of infection.

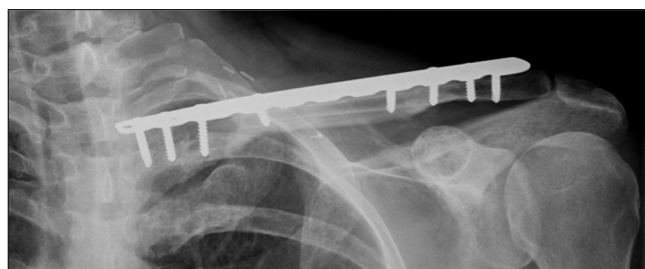


Figure 4 Final X-ray of the first patient.

Case 2

A 48-year-old woman consulted 21 months after a midshaft fracture of the right clavicle. An open reduction and internal fixation with a dynamic compression plate was carried out three months later because of a painful evolution and the absence of fusion on X-rays. Fixation failure occurred two months later and required a new plate fixation associated with a cortico-cancellous graft. After another fixation failure, a new osteosynthesis five months later with local implantation of bone morphogenetic protein 7 (Osigraft®) was performed. The patient consulted for chronic pain without union on X-rays (Fig. 5). Shoulder evaluation with the Constant score was at 45 points.

At the time of surgery, the bone loss was measured at 5.5 cm.

Two month after this reconstructive surgery, there was a delayed union at the junction between the medial part of the clavicle and the fibula. While performing an additional cancellous graft, it was observed that the callus bridged the fracture on the superior part of this area. At 12 months follow-up, the patient complaint only of soft tissue conflict



Figure 5 Clavicular non-union of the second patient.

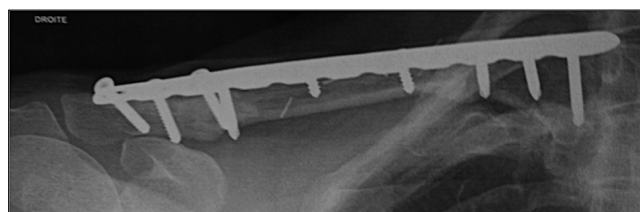


Figure 6 Final X-ray of the second patient.

with the plate. The Constant shoulder score reached to 90 points. The clavicle was fused (Fig. 6).

Discussion

Since its introduction by Taylor et al. [11], the microvascular free fibula transfer has become a gold standard for reconstruction of larges osseous defects [12,13]. Only a few cases have been described for clavicular non-union. In 1990, the first three cases were reported by Monberger et al. [14] with excellent results. Erdmann et al. [15] reported also bone union for 2 patients with chronic osteitis after clavicle fracture and failure of several surgeries. Our first patient had also bone infection in addition to bone radiation damage. In this context, bone fusion is rarely achieved with a simple conventional graft. The most important study dealing with this reconstructive procedure was reported by Krishnan et al. [16] who presented results for 8 patients. Unfortunately, neither functional outcome nor rate of bone fusion was mentioned.

This treatment is always sufficient to fill large bone defects of the clavicle. Indeed, the whole fibula can be harvested excepted to its distal and proximal ends. At this stage, the key point is to take away the bone with its middle part, so, the entry point of the peroneal artery is preserved. In both cases, we added cancellous graft to fill the junction between the fibula and the clavicle. Although the fibula provides the quantity of bone needed, we hypothesize that this additional graft will decrease the risk of non-union. We did not use osteocutaneous flaps. Even if this technique allows monitoring of the graft, it complicates the harvesting process and increases it length. In our experience, a free fibula graft is harvested in 45 min. Moreover, the large diameter of the vessels allows a safe anastomose. In the same way, we did not use osteomuscular flap in cases of infection. In these cases, we preferred to control the infection before

performing a classic free fibular flap. If antibiotic treatment is not effective, we prefer to carry out a cleidectomy. Finally, we always used the superficial transverse cervical artery and a branch of the external jugular system for anastomosis. It is also possible to connect the peroneal vessels with the acromiothoracic artery and the cephalic vein [17]. The choice must be made during the surgical procedure. It is based on the anatomical features of the patient and on the location of the entry point of the peroneal artery on the fibula.

Other free vascularized grafts could be used for reconstruction of these large bone defects. Fuch et al. [18] recommend free vascularized corticoperiosteal bone graft harvested from the medial femoral condyle. They report results on one patient with osteitis of the clavicle and two patients with non-union after fracture of an osteodionecrosis bone. All of them recovered normal shoulder function. We do not have experience of this procedure. It seems that indications are probably similar. However, we think that it could be difficult to fill large defects as encountered in both of our patients. We also think that the fibula has a closer anatomical shape and structure to clavicle compared to a femoral condyle.

The others clavicular reconstruction possibilities are the induced membrane technique [19] or a pedicled flap based on the thoracodorsal system with a rib [20].

A radical alternative procedure is a cleidectomy. Currently, it is mainly used for tumoral diseases [21,22] as well as for the thoracic outlet syndrome [23]. Concerning clavicular non-union, this procedure has not yet shown its value. The clavicle has a stabilization function for the scapula through the coracoclavicular ligaments and represents the only rigid link to axial skeleton [24]. Functional implications of this surgery are obvious for Rockwood and Wirth who recommend preserving the clavicle if possible [25]. Wessel and Schaap [26] report results for 6 patients who underwent cleidectomy. The three post-traumatic cases had poor results on Constant shoulder score because of persistent pain. For other authors, the lack of clavicle does not impair the proper functioning of the shoulder [21,22,27,28]. A mean Constant score of 95 was also reported by Oheim et al. [28] for 5 cases of osteitis. Much in the same way, Krishnan et al. [29] emphasized the good functional outcomes in a group of six patients. However, they also pointed out that this procedure is associated with a high complication rate.

To our knowledge, nobody has ever compared the results of cleidectomy and a vascularized bone graft for large clavicular defects. We preferred a reconstructive approach to avoid destabilizing the shoulder. We also believe that the cosmetic result is improved after completing this surgical procedure.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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