

A Free Vascularized Fibular Graft, Open Reduction and Internal Fixation for the Treatment of Non-Union after Middle-Third Clavicle Fractures: A Case Series

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Abstract

Background: Comminuted fractures of the clavicle with large bony defects, although rare, often result in multiple attempts at surgical management. We have used a free vascularized fibular bone graft, with Open Reduction and Internal Fixation (ORIF) as a reconstructive treatment option for the salvage of this complex condition after non-union.

Aim: The purpose of this study was to evaluate the clinical and radiological outcomes of seven patients who underwent this procedure.

Methods: Seven patients with middle-third clavicle non-union after previously failed ORIF were identified, five male and two female. A free vascularised fibula graft was harvested and fixated using a locking compression plate for the salvage of the clavicular bony defect. Their clinical and radiological outcomes were evaluated using plain radiographs, Range of Motion (ROM) testing and utilization of the Tang Score.

Results: Successful fracture union was achieved in all our patients, with an average time frame of 11 months (range 6 to 22). Three patients required secondary revision procedures due to implant failure. One patient required revision procedure due to a failed arterial microvascular anastomosis.

Conclusions: Using a free vascularized fibular bone graft and ORIF is a useful salvage option in the management of large bony defects/non-union after failed operative treatment of middle-third clavicle fractures.

Keywords: Clavicle fractures-non-union; Vascularized fibular graft

Introduction

Fractures of the clavicle account for 2.5-5% of all adult fractures [1,2]; middle third fracture morphology is found in 69 to 82% of these [3]. Usually these fractures can be treated conservatively and heal with a certain shortening. Radiographic union occurs in more than 95% of the cases [4-6]. Results from operative management however show fewer complications, a higher union rate and increased average DASH and Constant scores 1 year post operatively [7-9]. However, non union with bony defects after repeated efforts at surgical repair occasionally occurs and has been reported in the literature [10].

In these severe cases, using a free vascularized bone graft and ORIF can be considered as a useful salvage procedure. However, there are few reports in the literature dealing with this surgical technique due to the unclear side effects of fibula harvesting [10,11].

The purpose of this study was to evaluate the clinical and radiological results of seven patients who underwent clavicle reconstruction with the aforementioned technique.

Methods

Between 2013 and 2014, seven suitable patients were identified, five male and two female. The average age was 40 years (range 19-65). Exclusion criteria included peripheral vascular disease, previous deep vein thrombosis or other previous vascular pathology.

Radiological indications for operative intervention included parameters such as severe fracture displacement, over 2 cm of clavicular shortening and severe comminution. The clavicular length

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Table 1: Data of seven patients with free vascularized fibular graft, Open reduction and internal fixation for salvage for non-union after middle-third fractures of the clavicle.

Patient age	Female (1) Male (2)	Side	Surgical management	Bony defect after excision of fibrous soft tissue and bony sequester	Fixation of the fibula graft	Revision Operation	Bony Healing	Clinical evaluation at final follow up according to Tang
19y	2	left	ORIF and removal of the plate infect (infect)	5 cm	LC-DCP Synthes 8-hole plate	0	6 months	excellent
65y	1	right	ORIF and non-union	7.8 cm	Königsee Locking plate 10-hole	2x changing and refixation of the plate LC-DCP 124 cm + cancellous bone plastic	18 months	good
28y	2	left	3x ORIF and non-union (Fig 1-3)	6.6 cm	LC- DCP Synthes plate	0	6 months	excellent
55y	2	left	2x ORIF and non-union	5.2 cm	Königsee Locking plate 10-hole	1x changing plate LC-DCP 8-hole + cancellous bone plastic	22 months	fair
38y	1	right	2x ORIF and non-union	7 cm	LC-DCP Synthes plate	0	7 months	excellent
48y	2	left	2x ORIF and non-union	6 cm	LC-DCP Synthes plate	1x changing plate LC- DCP 8-hole + cancellous bone plastic	10 months	good
32y	2	right	2x ORIF and non-union	6.5 cm	LC-DCP Synthes plate	0	8 months	excellent

deficit was determined by comparison with the contralateral side. Patient-related parameters for operative intervention included level of shoulder function (ROM), pain and limitation of daily living, high workload /inability to work according to Tang classification [11]. Selected patients, who all had injured-free lower limb were informed about complications and morbidity from harvesting of the fibula.

In order to salvage the bony defect after previous failed operative treatment, a free vascularised fibula graft was harvested from the contralateral side and fixated to the recipient site using a Limited bone Contact - Dynamic Compression Plate (LC-DCP). The defects had an average length of 6.3 cm (range 5.0-7.8cm). In 4 cases the left side was involved and in 3 cases the right side (Table 1).

Surgical technique

Surgery was performed under general anaesthesia with supine positioning of the patient. The pelvis was elevated on the right side to keep the donor leg in a neutral position.

A single shot of intravenous antibiotics was administrated preoperatively. As all patient's had previous surgery at the clavicle the old scars were excised. The clavicular part of the sternocleidomastoid muscle was detached and the omohyoid muscle was identified at the lateral border, guiding the preparation into the supraclavicular triangle. The superficial branch of transverse cervical artery and two veins of adequate caliber were prepared for microsurgical anastomosis. The pectoralis major and subclavius muscles were released from their insertion on the middle third of the clavicle. After excision of fibrous soft tissue and bony sequestrum, bony debridement was carried out with a saw back to healthy clavicle bone. The free fibula graft was harvested from the contralateral side as a vascularized osseous flap, according to the Wei et al technique [12].

The fibula was osteotomized 3-4 cm longer than the lengths of the bony defect of the clavicle. Graft sculpturing was carried out to fit the gap between the two clavicular stumps with preservation of the peroneal vessels. This was carried out to restore normal clavicular length, as measured from the contralateral side.

The clavicle was then reconstructed with a contoured 3.5 mm low-contact dynamic compression plate (LC-DCP-Synthes in five

cases and Königsee eight-hole plate in two cases). Three screws were inserted bicortically into each part of the native clavicle. The fibula graft in between was fixed with monocortical screws.

Microvascular termino-terminal anastomoses of the prepared superficial branch of transverse cervical artery with the fibular artery and the two concomitant veins was performed under microscope. 8.0 nylon wire interrupted stitches were used. Arterial inflow and venous outflow to the fibular graft was checked and the subcutaneous tissue and skin were subsequently closed.

The patients were kept on prophylactic dose low molecular weight heparinisation with respect to the immobilisation of the donor leg in a walking cast for 6 weeks. To immobilise the clavicle the shoulder was placed on a custom designed abduction pillow for 12 weeks. During that period patients were allowed to perform body hygiene and dress in maximum 90° of shoulder elevation in a cubita bent position. After 12 weeks they were allowed to perform non weight bearing movement of the arm up to 90° of shoulder anteversion and abduction. Once bony consolidation of the clavicle was achieved on X-ray or CT scan, patients were allowed free movement of the shoulder and participation in weight bearing activities again.

The final follow up evaluation consisted of clinical evaluation according to the Tang classification [11] and radiological assessment of union.

Results

Prior to surgery the clavicular deficit was calculated by comparison with the contralateral clavicle with an average of 2.2 cm (range 2.0-3.8 cm). The ROM of the shoulder was limited in abduction and anteversion with an average of 90°. The preoperative clinical evaluation according to the Tang score [10] showed poor results in all patients. The length of the harvested fibula was in average 11 cm (range 8.5-15.0 cm), keeping the fibular head and a minimum of 7 cm of the distal part of the fibula in place to prevent knee or ankle instability. In restoring the clavicle to symmetrical length, the free vascularised fibular ended up with an average of 6.3 cm (range 5.0-7.8 cm).

All procedures were performed without intra-operative



Figure 1: Non-union of middle third clavicle fractures after three ORIF operations-with plate *in situ*.

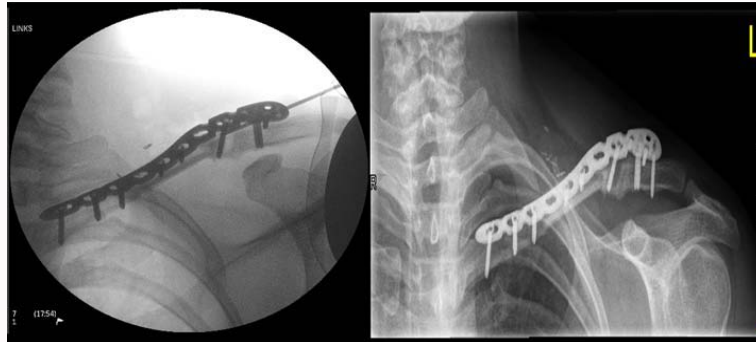


Figure 2: Intraoperative view of ORIF between the two clavicular stumps with a vascularized free fibula (6.6 cm) and at final evaluation.

complications. In one case bleeding in the immediate postsurgical period required acute revision of the arterial anastomosis. 3 patient’s required secondary revision procedures to replace broken plates or iliac bone grafting. Bony consolidation of the clavicle was achieved in all cases with the vital fibular graft *in situ*.

At final follow-up, on average 31 months post-op (range 22-54), clinical evaluation according the Tang score showed four excellent cases, two good cases, and in one case a fair result. Bone healing was successful in all patients in an average of 11 months (range 6-22).

There was no apparent post-operative evidence of knee or ankle instability. All patients had some mild paraesthesia symptoms in the donor leg, weakness of the long toe flexors and extensors and some discomfort on walking. Two patients had no significant complaints relating to their daily routine. Five patients had complaints mainly related with sport activities.

Discussion

Non union and large bony defects, although rare, often result from multiple failed attempts at operative treatment after middle third clavicle fractures [9]. En-bloc resection of the clavicle non-union causes significant, intractable pain and weakness of the whole upper limb.

A significantly decreased ROM in the shoulder girdle has also been documented [13]. In any case, our experiences with instability in the shoulder girdle, has been less than favourable.

Accordingly, all our patient’s presented with poor shoulder function prior to surgery. Restoration of a normal sterno-acromial distance, and union of the clavicle are recognized as vital principles in restoring normal shoulder function [15,16].

The use of vascularised bone grafting for clavicle non union has been described by Nathan G. et al [10] and provides the best possibility to restore a large bony defect and correct shoulder girdle



Figure 3: 12.5 cm free vascularized fibula graft harvested from the contralateral side.

function. In our series to ensure union of the fibula graft the shoulder girdle was immobilised and placed on a custom designed abduction pillow for 12 weeks. The shortest time for union of the fibula graft was 6 months. In any case, our experiences with vascularized fibula grafting for reconstruction in the upper (exclusively clavicle) and lower limb showed average shortest time for ingrown of 3.4 to 6.7 months depending on the age of the patient. This is comparable with the results for the clavicle [17].

In all cases we achieved the targeted goal of painless motion of the upper limb and return to activities of daily living without any immediate discomfort. Patients age seems to play a role, as all of our patients under 40 years achieved excellent results, while the patients above this age achieved only good or fair results in the Tang test.

Graft harvest requires surgery on a normal healthy leg. In a series of three patients, Nathan G. et al [10] showed that they do

not necessarily see long term donor site morbidity. Lee EH et al [14] showed in a series of 10 patients, definite differences in gait cycle, which could be attributed to weakness of the deep musculatures, which had lost its normal anatomical origin. The change in load transmission through the fibula seems to also have an effect on this. At final follow up all our patients had symptoms in the donor leg, such as paraesthesia/weakness of the long toe flexors/extensors and discomfort on walking especially during sport activities, but none of them were really handicapped by these problems.

Conclusion

Although the indications for treating clavicle non-union with a free vascularized fibula transfer and ORIF are rare, we believe that this is a reliable and safe reconstructive technique for the treatment of bony defects/non-union, when other methods have failed. Resection of the fibula has an associated morbidity, and a thorough and thoughtful informed consent discussion with the patient is key.

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