



Treatment of non-union of forearm bones with a free vascularised cortico-periosteal flap from the medial femoral condyle

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We report 6 cases of recalcitrant non-union of forearm bones treated with a free vascularized thin corticoperiosteal graft harvested from the medial condyle of the femur. All non-unions healed. In one 58-year-old patient a fracture of the femur occurred.

Keywords : forearm bones ; nonunion ; free vascularized osteoperiosteal flap.

morbidity. Sakai *et al* in 1991 (4) described a cortico-periosteal flap from the medial condyle of the distal femur for difficult non-unions. Recently several authors have reported their initial results (1-3). The purpose of our study is to report our results with this technique in six cases of recalcitrant non-unions of the forearm following internal fixation, and to add these to the existing literature.

INTRODUCTION

Cornerstones for a successful treatment of non-unions of the forearm bones are resection of the pseudarthrosis, grafting and rigid fixation. This will achieve union in most cases. However, failures do occur and can even be predicted : hypo-vascularity of the field (particularly vascularity-at-risk of parts of bones), multiple prior operations and prior infection. In these cases vascularised bone grafts offer several benefits. They bring in new living osteocytes and osteoblasts with their blood supply to the non-union site. Incorporation of the graft is faster and more secure since it relies on simple fracture healing processes rather than on creeping substitution.

For major defects the vascularised fibula is the gold standard but in smaller defects (less than 5 cm) this may be not necessary. Several potential donor sites are known : the iliac crest, the radius, the scapula and the ribs. They are all associated with extensive dissection and important donor site

PATIENTS AND METHODS

Patients

We treated six difficult non-unions of the forearm, in two male and four female patients. Their mean age was 44 years (range 27 to 58 y). In two cases the non-unions occurred following osteotomy of the ulna. In one patient a Sauvé Karpandji procedure was undone, in order to allow for implantation of a distal ulnar head prosthesis in a second stage. The other case was a non-union which developed following refracture of an ulnar shortening osteotomy, following hardware removal. Two non-unions resulted from an open and infected fracture. One patient had a recurrent fracture (4 interventions) of the

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Table I. — Summary of patients' details

Gender/age	History	Side/bone	N°	Delay of definitive surgery (in months)	Time to solid union (in weeks)
M 48	Open fx ; ORIF, atrophic nonunion	Rt ulna	1	8	8
F 51	Shortening osteotomy, Hardware removal, recurrent fx, Sarmiento, non-union	Lt ulna	2	8	9
F 58	Recurrent fx, ORIF, Re-do ORIF, fx plate, atrophic non-union	Lt radius	4	6	14
F 27	Open fx, infection, 3x ORIF, atrophic non-union	Lt ulna	3	9	8
F 33	Open fx, ORIF, infection, ExFix, non-union	Lt radius	5	17	17
M 49	Failed Sauve Kapandji. Reconstruction of the distal ulna in preparation for an ulnar head prosthesis	Lt ulna	2	24	8

radius with development of an atrophic non-union. One patient had an technically defective osteosynthesis of the proximal ulna which resulted in an atrophic non-union (table I).

No patient had a draining wound or a fistula at the time of the vascularized graft. There were 5 atrophic non-unions. The mean time from fracture/osteotomy to the vascularized grafting procedure was 12 months (range : 6-24 months). The mean number of previous procedures was 2.8 (range : 1-5). In one case the vascularized graft was combined with a conventional cortico-cancellous graft from the iliac crest (case 5).

Surgical technique

After resection of the pseudarthrosis, reduction and rigid fixation of the bones, the bone defect is obvious. The radial or ulnar artery, depending on the localisation of the non-union, is dissected and isolated over a length of 4 to 6 cm, sufficient to perform an end-to-side vascular anastomosis. A subcutaneous vein is also prepared.

The graft is now harvested. The hip and knee are flexed and the leg is externally rotated. A tourniquet is inflated after elevation of the leg and without Esmarch exsanguination. A straight medial incision runs proximally for 10 to 12 cm from the medial edge of the proximal pole of the patella. After incision of the fascia along the medial border of vastus medialis, this muscle is retracted anteriorly. The vessels can now clearly be seen (fig 1). Distally the artery lies in close proximity to

the medial condyle, where several thin branches appear. The connection with the superomedial genicular artery is clamped. The descending genicular artery can be dissected with the accompanying vein in a retrograde fashion up to its origin from the femoral artery at the level of Hunter's canal. A thin corticoperiosteal graft is delineated on the medial condyle and is harvested with its feeding vessels using a small osteotome. The pedicle is about 5 to 7 cm long and the diameter of the artery is large enough to comfortably perform the anastomosis. The procurement is straightforward and can easily be done in 45 to 60 minutes.

The graft is moulded over the non-union site of the forearm and is fixed with stitches. The microvascular anastomoses are made. The donor site is closed and immediate mobilisation and weight bearing is allowed. No casts or braces were applied in our patients.

RESULTS

All non-unions went on to bone union. The typical case histories are summarised in table I and figures 2 and 3. The average time to union was 11 weeks (range : 8 to 17 weeks).

Secondary procedures were necessary in 4 cases. The hardware was removed in three patients. One patient complained of persisting knee pain. She suffered from severe osteoporosis, and she had undergone total knee arthroplasty on the contralateral



Fig. 1. — Intra-operative views of the donor side (→ = descending geniculate artery).

knee. The donor knee had suffered a tibial plateau fracture with fixation material still present. She was the oldest patient of the cohort (58 years). Three weeks after the procedure she was admitted with an insufficiency fracture through the donor site.

The patient with the failed Sauvé Kapandji had good reconstruction of the distal ulna. The major complaints of painful instability were under control and he denied further procedures (fig 4).

DISCUSSION

The concept of a vascularised osteoperiosteal flap was introduced in 1991 by Sakai *et al* (4). They proposed the medial condyle of the femur as a



Fig. 2a. — Open fracture of the distal ulna with infection after the first ORIF. Several consecutive surgeries resulted in an atrophic non-union.



Fig. 2b. — Solid bony healing

potential donor site. The blood supply has been studied. The descending genicular artery – a direct branch of the femoral artery – runs along the



a

Fig. 3a. — Non-union of the distal radius after ORIF, infection, prolonged casting and external fixator.



b

Fig. 3b. — Solid healing with a combined vascularized cortico-periosteal graft and a corticocancellous graft.



a



b

Fig. 4. — Reconstruction of the distal ulna after a failed Sauvé Kapandji procedure
(a) : preoperative ; (b) : after healing of the reconstructed distal ulna.

posteromedial side of the femur, from Hunter's canal down to the medial condyle and provides the vascularisation of the periosteum and bone of the medial condyle. There is a constant communication with the superomedial genicular artery. The anatomy is quite constant and the morbidity resulting from graft procurement is minimal. The periosteum has a high capacity for osteogenesis. Former attempts to harvest the periosteum alone without the underlying cortical bone resulted in poor outcome, probably because harvesting itself damaged the deepest layer of the periosteum, where most osteoblasts can be found.

Sakai *et al* (4) used this technique in 6 cases in the upper limb ; all achieved bone healing. Only recently were results reported from other centers. Del Pinal *et al* (2) published 6 cases, all of which healed. Choudry *et al* (1) reported 13 cases, of which 9 were free flaps in the upper and lower limb ; 9 healed, two did not, one flap failed and ended into a below-knee amputation. The four cases of Kaminski *et al* (3) all healed. Del Pinal *et al* (2) recorded one donor site problem : a large haematoma with secondary infection and prolonged rehabilitation. Choudry *et al* (1) reported 3 cases of seroma at the donor site, all treated conservatively without long-term morbidity.

The outcome with this graft is very positive ; bone healing occurs rapidly in this and other series. The possibility of donor site morbidity has to be kept in mind, as the supracondylar fracture observed in our series was severe enough to impose weight-bearing restriction. In osteoporotic patients, a period of protected weight bearing is recommended.

The donor side morbidity in other cases was minimal and procurement was better tolerated than at the iliac crest. The procedure in itself is not very time consuming and does not involve additional costs to the patient or the community.

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