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TECHNICAL NOTE

Free vascularised fibular graft in multi-operated patients for an aseptic non-union of the humerus with segmental defect: Surgical technique and results

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Summary In cases of non-union of the humerus with segmental bone defect, if a conventional treatment has failed, free fibular transfer should be considered as a reliable option to allow satisfactory bone union. We reported five cases of aseptic and multi-operated non-union of the humerus from trauma. In each case, a free fibular flap was performed after failure of a conventional treatment and bony union was demonstrable radiologically within six months. Some technical points such as harvesting of the fibula, humerus approach, fibula placement and fixation are highlighted in order to simplify the transfer and to standardise the technique.

Introduction

Humeral fracture account for approximately 5 and 8% of all fractures [1]. Conservative and surgical treatment of humeral fracture usually results in primary healing. Non-union is relatively common and can reach up to 12% in large series [2—4]. Most humeral non-unions are successfully treated by conventional methods such as compression plating, nailing and conventional bone grafting techniques. The use of these therapeutic options, alone or in combination, achieves bony union in 82% to 95% of patients [5]. When all these methods have failed in cases of multi-operated non-union of the humerus with risk factors [6,7] such as obesity, alcoholism, smoking, then humeral non-union becomes a real challenge for orthopaedic surgeon.

Free fibular transfer is a recognised technique of choice in long bone reconstruction in the upper extremity since its first description by Taylor et al. in 1974 [8]. Vascularised fibula flap has been reported following tumour resection, trauma, and osteomyelitis. The shape of the fibula gives it exceptional strength; the pedicle is reliable in calibre and reliable in location. Ilium, scapula, femur, rib and radius have been used successfully but the fibula has been found to be the most suitable for upper limb reconstruction [9].

In humeral fractures, after conventional treatment has failed, whether or not bone grafting has been attempted

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and even following multiple operations, free fibular transfer should be considered as a reliable option to promote satisfactory bone union.

We report the successful use of free fibular flap in five cases of aseptic and multi-operated non-union of the humerus. In each case, bone union was demonstrable radiologically within 6 months.

Materials and methods

This study retrospectively reviews five cases of aseptic non-union of the humerus treated with free fibula transfer after failure of conventional treatment. The flap was performed by senior surgeon in all cases. Five females with an average age of 60 years (range 54—65) were included. The average follow-up period was 14 months.

Fracture level of the humerus was mid-shaft in four cases and distal in one case. Primary treatment at the time of the fracture was surgical in all patients: intramedullary nail in one case and plate fixation in the four other cases. After primary treatment, each patient had undergone two prior procedures with bone grafting complicated by residual aseptic non-union. The mean length of bone defect was 8 cm (range 5—12 cm).

The fibular flaps were an average of 12 cm in length (range 10—15 cm). The mean operative time was 185 minutes. The fibular flap was affixed-affixed in one case and affixed-fitted in four cases. Distal non-union of the humerus was treated with a double-barred transplant fixed with a T-shape plate.

Bone union was assessed by standard radiography.

Surgical technique

A two-team approach is recommended, with one raising the fibular flap and the other preparing the humerus and the recipient vessels.

Under general anesthesia, the patient is positioned supine with the ipsilateral knee flexed. The operation is performed under tourniquet. A lateral approach as described by Gilbert [10] in 1979 is preferred to the Taylor postero-lateral approach.

A skin paddle is not usually necessary as skin cover is normally easy to achieve on the arm. No skin island was used in our study. The transplant is centered in the middle shaft. The pedicle is identified and distal osteotomies are performed with a Gigli saw. At least 7 cm of fibula was preserved both proximally and distally to reduce the risk nerve lesion and knee or ankle instability.

Traction on the fibular shaft and distal ligature of the pedicle allow a degree of fibular retraction, which facilitates dissection. The flap was raised from distal to proximal with a thin muscular cuff.

The dissection was performed as proximal as possible so that its length and diameter were optimised.

If the fibular was to be shortened prior to fixation, excising proximal bone effectively lengthens the available pedicle facilitating the anastamoses. Occasionally, a double-barrel flap (Fig. 1) is required in order to match the widths of the humerus and the fibula, this is achieved by performing

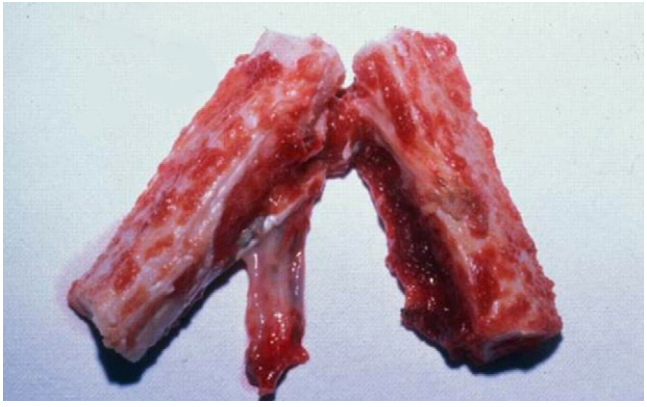

Figure 1 Double-barrel fibula transplant.

a transverse osteotomy of the fibula leaving the periosteum intact.

Having raised the flap entirely, the tourniquet was released and the pedicle not divided until the recipient site and vessels were completely prepared.

Two surgical approaches were required for humeral approach. A long lateral approach has allowed identification of the radial nerve, excision of fibrous tissue decortication of the non-union and fibula placement.

A short medial approach has exposed the brachial artery and veins for the subsequent vascular anastomoses.

The fibular flap was placed in one of two principle ways in the recipient humerus (Fig. 2A, B, C).

In the ''affixed-affixed'' placement (Fig. 2A), a gutter in the humerus is custom made by decortication to receive the fibula which is placed within the gutter for fixation. This is particularly useful in a short bony defect.

The alternative, a ''fitted-fitted'' placement (Fig. 2B) inserts both ends of the fibular within the medullary cavity of the humerus. This is a particularly useful approach with a long bony defect. In this case, to facilitate the introduction, it is mandatory to remove the periosteum at both extremities.

If required, both approaches can be mixed (''affixed-fitted'' placement) (Fig. 2C) to obtain a gutter fixation at one end with the other end of the fibula inserted into the medullar cavity.

In all cases, iliac cancellous bone grafting is used at the junction between the transplant and the humerus.

For bony fixation, a long plate with three distal and three proximal auto-locked screws spanning the entire bone defect is recommended on the humerus. It is much more important to use an auto-locked screws plate because it allows the surgeon to leave the plate 3 or 4 mm proud from the fibula flap to avoid compressing its periosteum in order to preserve its peripheral vascularisation.

Two further screws secure the fibular flap, with great care taken not to damage the vascular pedicle. In one case, only the fibula was fixed in place.

Where there is a skin defect or in infected cases, an external fixator is recommended.

For distal humerus defects with a double-barrel fibular flap, a ''T-shaped'' plate was used.

Following bony fixation, the microvascular anastamoses are performed using an operating microscope. The peroneal

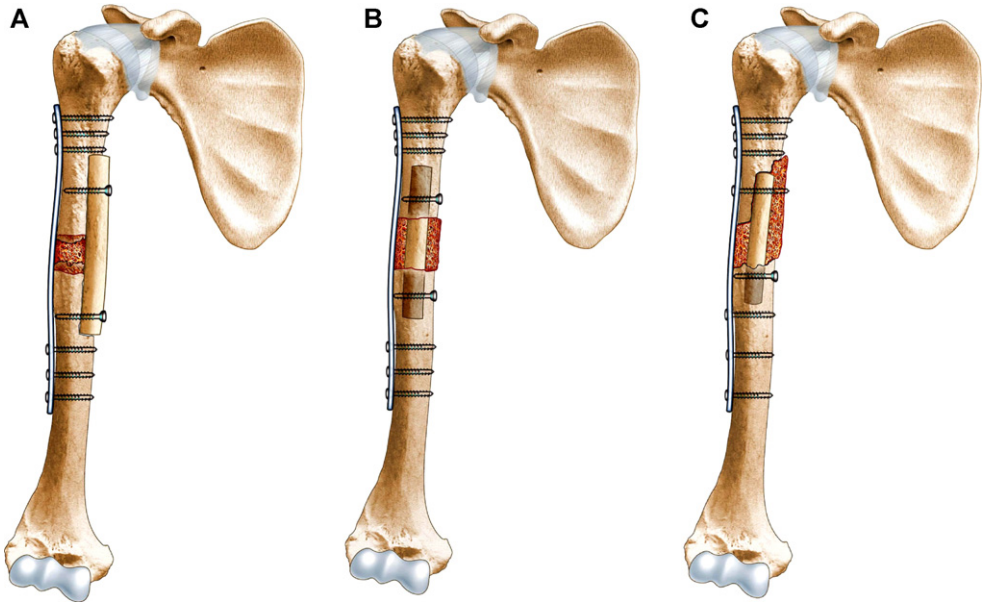

Figure 2 A. Affixed-affixed placement: a ''gutter'' is custom made in the proximal and distal humeral segment to receive the fibula. On the lateral aspect of the humerus, a plate bridges the non-union. B. Fitted-fitted placement: the ends of the fibula are shaped as a lead of a pencil and introduced into the intramedullary cavity. C. Affixed-fitted placement: one end is affixed and the other one is fitted.

vessels were anastomosed end to side to the brachial artery and vein in all cases. Care was taken to avoid compression of the pedicle under the biceps or brachialis muscles.

Results

No patient requires anastomosis revision. No complications were identified. No additional procedures were necessary.

Radiological bony union was achieved in all patients at a mean time of 5 months. Hypertrophy of the fibula was noted at 12 months in all patients and no stress fracture of the grafted fibula was detected. There were no neurovascular complications in the upper limb and no donor site dysfunction.

Fig. 3 is a representative case.

Discussion

Numerous surgical options can be used to treat fracture-related humeral bone defects such as primary shortening,

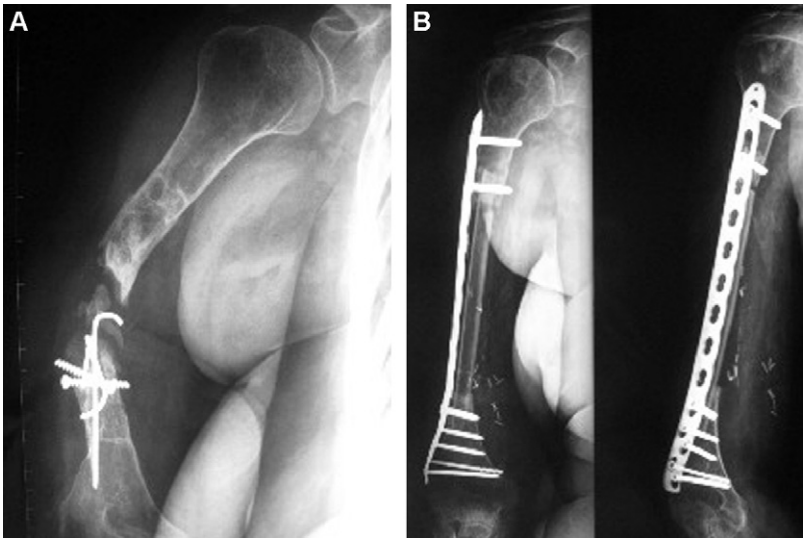

Figure 3 A. Non-union of the humerus after previous operation (3: Kirshner wires, Screws and plate). A bone defect (> 5 cm) with an atrophic non-union. B. Non-union was treated with success by a fibula vascularized transfer fitted proximally and distally. Fixation with a long plate putted externally. An iliac cancellous grafting around the non-union and the ends of the fibula was systematically used.

cancellous bone graft in one stage, cancellous bone graft in two stages [11,12] (after induced membrane), pedicle bone transfer [9,13] (free border of the scapula, 9th rib), periosteal free flap transfer [14] or bone morphogenetique protein [15—19].

Although non-vascularised bone grafting is effective in small bone defect with well-perfused soft tissues, they are less reliable when the gap defect is greater than 6 cm and when soft tissue vascularisation is poor. Indeed, blood support is essential to increase bone healing and to avoid infection. Moreover, vascularised bone graft provides higher biomechanical strength than non-vascularized techniques [20].

In the past two decades, vascularized fibula graft has become popular in treatment of humerus non-union. The fibula flap is easy to harvest for a microsurgery-trained operator. The pedicle is long and large and the anatomy is consistent. Donor site morbidity if present is usually minor in nature. Many studies [21—25] have reported the success of this procedure. Jupiter [21] reported the fibula flap in four obese patients who had atrophic synovial non-union of the humeral shaft. Healing was obtained at an average follow-up of twenty-seven months. Wright et al. [22] used an intramedullary fibular bone graft and a compression plate in nine humeral non-unions. Eight of the nine fractures united at an average of 3.5 months. Muramatsu et al. [5] reported nine patients with recalcitrant non-union of the humerus reconstructed by a vascularised fibula; the mean time for healing was 6 months. More recently, Beredjiklian [23] reported the use of vascularised fibula in distal non-union of the humerus in five cases with an average age of 48 years. Four of the five patients had clinical and radiographic union at 4.5 months.

Adani et al. [24] treated 13 patients, with an average length of humeral defect of 10.5 cm. Nine patients healed primarily, three required additional bone grafting, and 1 had a second fibular transplant. The mean period to radiographic bone union was 6 months.

In 2009, Chhabra et al. [25] reviewed 13 cases of chronic non-union of the humerus resulting from trauma or osteomyelitis treated with vascularised fibula transfer after failure of conventional treatment. Healing was obtained in 92% of patients in a mean time of 18 months.

Vascularised fibular grafting offers the patient a great deal of benefit and also complications such as infection, recurrent non-union transient palsy of the radial nerve occur in only 7% to 10% of cases [26]. Stress fracture is a more common event (10 to 15%) [24].

Conclusion

According to our experience and to the review of the literature, free vascularised fibula transfer is an efficient technique for exceptional cases of multi-operated and aseptic resistant non-union with bone defect of the humerus.

The salvage procedure can be used in the elderly patient, even in small bone defects when traditional option has failed. This technique comes into competition with induced membrane technique.

This significantly invasive procedure is not without risk but remains acceptable in salvage situation with a standardised procedure and experienced surgeon.

Disclosure of interest

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

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