The use of a vascularised periosteal patch onlay graft in the management of nonunion of the proximal scaphoid

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We describe the use of a vascularised periosteal patch onlay graft based on the 1,2 intercompartmental supraretinacular artery in the management of 11 patients (ten men, one woman) with chronic nonunion involving the proximal third of the scaphoid. The mean age of the patients was 31 years (21 to 45) with the dominant hand affected in eight. Six of the patients were smokers and three had undergone previous surgery to the scaphoid. All of the proximal fragments were avascular. The presence of union was assessed using longitudinal axis CT.

Only three patients progressed to union of the scaphoid and four required a salvage operation for a symptomatic nonunion. The remaining four patients with a persistent nonunion are asymptomatic with low pain scores, good grip strength and a functional range of wrist movement.

Although this technique has potential technical advantages over vascularised pedicled bone grafting, the rate of union has been disappointing and we do not recommend it as a method of treatment.

The combined presence of nonunion of the proximal third of the scaphoid and avascular necrosis (AVN) adversely affects the chances of achieving union by fixation and conventional bone grafting.[1-5] Vascularised bone grafting has thus evolved as an option, with reported rates of union ranging between 27% and 100%.[6-11]

Despite the potential advantages of this technique in achieving union, technical problems include difficulty in seating the graft, particularly when the proximal fragment is small, difficulty in achieving stable fixation, extrusion and fragmentation of the graft and dorsoradial impingement by the graft.[6,12]

Many studies have shown that the periosteum regenerates both cartilage and bone from its progenitor cells.[13-17] The osteogenic potential of free periosteum may be controversial,[18,19] but the vascularised periosteal flap has been shown to have an excellent osteogenic capacity.[20-23]

We describe a surgical technique for the management of chronic nonunion of the proximal third of the scaphoid using a vascularised periosteal onlay patch graft based on the intercompartmental supraretinacular artery.[1,2] We present our results using this technique in a small series of patients.

Patients and Methods

We undertook bone grafting with the application of a vascularised periosteal onlay patch based on the 1,2 intercompartmental supraretinacular artery in 12 patients with chronic nonunion of the proximal third of the scaphoid. All the operations were performed by or under supervision of the senior author (MJH). Approval of the Local Ethical Committee was obtained before commencement of the study.

One patient was lost to follow-up and was excluded leaving 11 patients (ten men and one woman) in the final analysis. Their mean age was 31 years (21 to 45) with the dominant hand being involved in eight. The mean duration of nonunion at the time of surgery was 24 months (10 to 55). Three had previous fixation of the scaphoid and non-vascularised bone grafting. One patient had early radioscaphoid arthritis on the pre-operative radiographs. Six patients were smokers.

Operative technique. Under tourniquet control, a dorsal longitudinal incision was made just ulnar to Lister's tubercle to expose the extensor retinaculum and the 1,2 intercompartmental supraretinacular artery (Fig. 1). A periosteal patch was raised on a pedicle of sufficient length to reach the dorsal aspect of the nonunion at the proximal pole of the scaphoid (Fig. 2). The extensor retinaculum was reflected in an ulnar

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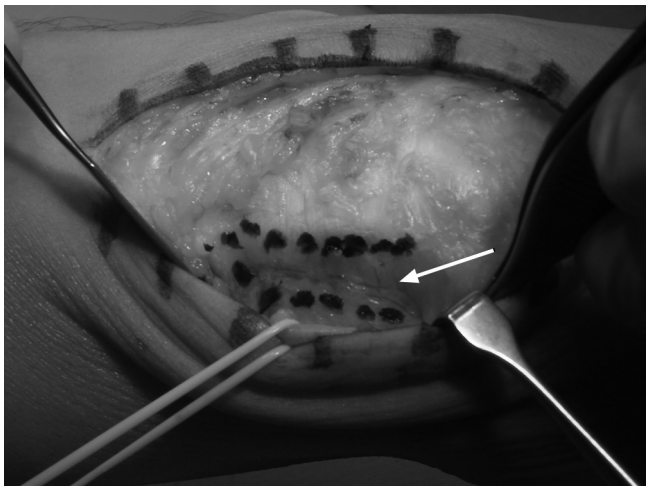

Fig. 1

Photograph of the vascularised periosteal patch based on the 1,2 intercompartmental supraretinacular artery (boundary of patch outlined with a marker pen; artery indicated by arrow).

Fig. 2

Photograph of the harvesting of the vascularised periosteal patch on its pedicle (arrow).

direction and the extensor tendons retracted to expose the dorsal capsule of the wrist.

A distally-based capsular flap was raised to expose the nonunion which was carefully debrided and any metalwork removed. The proximal fragment was drilled using a fine Kirschner wire to determine the presence of punctate bleeding as a guide to its vascularity.[6,24] Corticocancellous bone graft harvested from the iliac crest was packed into the defect to correct the length of the scaphoid and alignment followed by the insertion of a cannulated compression screw device (Kompressor compression screw system; Kinetikos Medical Inc., Carlsbad, California) under fluoroscopic control to stabilise the graft and to achieve compression (Fig. 3). The periosteal

Fig. 3

Fluoroscopic image showing the compression screw *in situ*.

patch was then secured over the dorsal aspect of the grafted nonunion using either transosseous sutures or mini-bone anchors (DePuy Mitek, Bracknell, United Kingdom). A below-elbow cast was applied for a minimum of six weeks.

Union was defined on plain radiographs according to the criteria described by Dias.[24] All patients had longitudinal axis CT of the scaphoid[25] approximately six months after surgery, which was evaluated by an experienced musculoskeletal radiologist (DT).

Patients who did not require subsequent surgery were recalled for clinical review at a mean of 19.4 months (13 to 27). This included the assessment of pain with palpation as evidence of clinical union, the assessment of pain during rest and on activity using a ten-point visual analogue score (VAS) in which zero indicated no pain, and ten the worst possible pain, and measurement of the range of movement and grip strength. Range of movement was measured using a hand-held goniometer and grip strength assessed by a Jamar Dynamometer (JA Preston, Jackson, Michigan).

Results

At operation the proximal pole of the scaphoid was deemed to be avascular in all patients with complete absence of punctate bleeding. Of the 11 patients, four required salvage operations for persistent, symptomatic nonunion by scaphoidectomy and four-corner fusion in three patients and proximal row carpectomy in the fourth. From the plain radiographs of all 11 patients, six were deemed to have

Fig. 4a

Fig. 4b

Radiographs a) six weeks after vascularised periosteal patch grafting and b) six months after operation showing union of the scaphoid.

united, but only three had definite evidence of bony union confirmed by CT.

Of the group of seven patients who did not require further surgery only three had evidence of bony union on CT. All were free from pain except for one with a pain score of 3 of 10 on heavy manual activity. In these seven patients, the mean grip strength was only 80% (75% to 85%) of the contralateral side and the mean wrist flexion and extension were 60° (50° to 70°) and 40° (30° to 50°) respectively. The mean ulnar deviation was 20° (10° to 30°) and the mean radial deviation 15° (10° to 20°).

Examination of the four patients with persistent nonunion but who have not required further surgery revealed pain scores ranging from 0 to 1 at rest, to 1 to 5 on activity. The mean grip strength was 89% (76% to 100%) of the contralateral side and the mean wrist flexion and extension 42° (30° to 55°) and 45° (35° to 60°) respectively. The mean ulnar deviation was 20° (10° to 30°) and the mean radial deviation 15° (10° to 20°).

One patient required evacuation of a haematoma from the donor site of the iliac-crest bone graft 48 hours after surgery. No other complications were encountered.

Discussion

Periosteum is a specialised connective tissue which forms a thin but tough fibrous membrane firmly anchored to the underlying bone. It is a well-vascularised tissue consisting of two discrete layers, an outer fibrous and an inner cambium layer. The latter serves as a reservoir of undifferentiated pluripotent mesenchymal cells able to differentiate into chondrogenic and osteoblastic lineages and as a source of growth factors involved in bone healing and remodelling.[26-31] In adults, periosteum is inactive, but its bone-forming potential can be reactivated by stimuli such as trauma or infection.

Animal studies have demonstrated the osteogenic potential of periosteum elevated as a vascularised flap.[32-34] In the clinical setting, vascularised periosteal grafts have been used in the treatment of fractures of the femoral neck,[23] AVN of the femoral head[35] and in head and neck surgery.[36,37] Thus, it would seem that periosteum provides the potential for the reconstruction of small skeletal defects or defects with poorly vascularised tissue. The vascularised periosteal onlay patch has several technical advantages over the pedicled vascularised bone graft. First, it avoids the necessity of harvesting a block of bone on the vascular pedicle which may be difficult to bed particularly in the presence of a small proximal fragment. The graft may protrude from the dorsoradial border of the scaphoid and interfere with the function of the radiocarpal joint and the bone block may split or fragment during fixation and become devascularised due to disruption of its intra-osseous blood supply. Extrusion of the graft may also occur.[12] Secondly, it eliminates the need for accurate sizing of the bone block before raising the pedicle. With the patch technique, the scaphoid deformity can be corrected using non-vascularised bone graft with the vascularised periosteum providing a source of osteogenic cells and growth factors.

Thirdly, the vascularised pedicle may obscure the view of the graft within the nonunion bed and it can be difficult to ensure that there is good bone contact between the graft and the fragments of the fracture. In the periosteal patch method the defect can be packed under direct vision before application of the periosteal flap.

Despite these technical advantages only three of 11 scaphoid fractures in our series united (Fig. 4). This may have been due to a number of factors. First, the mean duration of nonunion was 24 months. Secondly, all the nonunions involved the proximal third of the scaphoid with avascularity of the proximal fragment in all cases. Thirdly, six patients were smokers. Chang et el[12] reported proximal pole AVN and tobacco use as univariate risk factors for failure of pedicled vascularised bone grafts in their series. Fourthly, we used the more revealing technique of longitudinal axis CT to confirm union rather than relying on the less sensitive method of plain radiography alone. Whereas six patients showed evidence of union on plain films only three did so on CT. Finally, since cell density and hence the osteogenic potential of periosteum may vary between different donor sites[38] and the osteogenic potential of periosteum may be reduced with ageing,[39] it may be that the periosteal flap raised on the 1,2 intercompartmental supraretinacular artery in adult patients does not provide any significant osteogenic input.

We accept that in the three patients who proceeded to union we cannot be certain whether the presence of the screw fixation and non-vascularised grafting resulted in union as opposed to the vascularised periosteal patch. Because of the small size of the study we did not attempt to draw any statistical comparisons between those who achieved union and those who did not.

Finally, it is noteworthy that persistent nonunion of the scaphoid after surgery was relatively asymptomatic and provided satisfactory function as indicated by the pain score, grip strength and range of movement in four of our 11 patients. Partial denervation of the wrist and stabilisation of the fragments even in the absence of bony union may account for these findings. However, we acknowledge that, in the longer term, the screw may loosen and that this group of patients may become symptomatic.

In summary, the achievement of healing in chronic nonunion involving the proximal scaphoid remains a challenge. We found that the rate of union obtained by this method was disappointing. Therefore we do not recommend this technique for the treatment of nonunion of the proximal scaphoid.

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