Ectopic Bone Formation after Medial Femoral Condyle Graft to Scaphoid Nonunion

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Abstract

Keywords

- ectopic bone formation
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- scaphoid nonunion

Free vascularized bone graft from the medial femoral condyle has been described as a superior method for treatment of recalcitrant scaphoid nonunion with proximal pole avascularity and humpback deformity. Few complications and high union rates have been reported. In a series of three patients we describe an undesired volar ossification as a potential complication of the method. The risk of developing the ectopic bone formation can be minimized if the surgeon is aware of the strong osteogenic capacity of the periosteum. Meticulous dissection of the vascular bundle to the graft is mandatory to avoid the complication. Caution is warranted so as not to leave a periosteal sleeve under the vessels at the margin of the graft.

Avascular necrosis (AVN) of the proximal pole and humpback deformity have been recognized as predisposing factors for recalcitrant scaphoid nonunions.¹ Vascularized bone graft has been demonstrated to enhance the union rate in this particularly difficult subset of nonunions. In a 2002 meta-analysis of the literature, an 88% union rate was reported with vascularized bone grafts in the presence of avascularity of the proximal pole, while nonvascularized bone grafts had only a 47% union rate under the same circumstances.²

A vascularized pedicled bone graft from the distal radius has been widely used for scaphoid nonunions in recent decades. The bone graft based on the 1,2-intercompartmental suprarotational artery (ICSRA) has been particularly prevalent.³ However, the reported union rate varies significantly.¹ In 2006, Chang et al reported an overall union rate of 71% with the 1,2-ICSRA graft, while in the presence of an AVN of the proximal pole the union rate was only 50%.⁴ Chang et al concluded that it is difficult to obtain a sufficiently large and well-placed bone graft based on the 1,2-ICSRA to correct a significant humpback deformity.⁴

Significantly higher union rates have been reported with the free vascularized bone graft from the medial femoral condyle (MFC).⁵ In a comparative study, Jones et al reported a

100% union rate with the MFC graft ($n = 12$) and only a 40% union rate with the 1,2-ICSRA graft ($n = 10$). Moreover, the median time to healing was significantly shorter in the MFC group (13 weeks) compared with the 1,2-ICSRA group (19 weeks).¹

In 1989 Hertel and Masquelet described the MFC graft as a periosteal and osteoperiosteal graft.³ Subsequently, Sakai et al included the cortex, and in 1991 they described it as a corticoperiosteal graft.³ Currently, the graft is often used as a free structural corticocancellous graft, including the dense cancellous part of the bone. The structural basis of the graft is well suited to correct a humpback deformity, and its robust vascularity has the ability to revascularize an AVN.³ The graft is based on the descending genicular artery or, less frequently, the superomedial genicular artery. These arteries are much larger (1–2 mm in diameter)⁶ than the 1,2-ICSRA (0.3 mm in diameter).⁷ Iorio et al recently showed that the arteries nourish a very large portion of the medial femoral condyle.⁸

The high union rate and few complications have popularized the MFC graft in recent years, and it has been described as one of the new workhorses in reconstructive hand surgery.³ The consistently good results encouraged us to try the method. Our experience has in general been positive;

however, the potent osteogenic capacity of the graft can cause problems with ectopic bone formation in undesired locations.

Case Reports

Between September 2011 and May 2012 two males (aged 25 and 27 years, respectively) and one female (aged 39 years) with recalcitrant scaphoid nonunions were treated at our clinic with the free MFC graft. All three were nonsmokers and had previously undergone two surgical attempts with conventional methods without success. Humpback deformity and avascularity of the proximal pole of the scaphoid were present in all three cases.

Case 1

A 27-year-old fireman suffered a dislocated scaphoid fracture in November 2009 while playing ice hockey. After a doctor delay of 5 weeks the patient was admitted to our clinic. Open reduction and internal fixation (ORIF) was performed in December 2009 with a headless bone screw (HBS) and nonvascularized bone graft from the iliac crest. The nonunion prevailed, and a similar procedure was done in June 2010. The re-operation was unsuccessful, and a computed tomography (CT) scan in May 2011 revealed a persistent nonunion. The range-of-motion (ROM) in the wrist was 40/40 (flexion/extension).

A free vascularized MFC graft and Kirschner wire (K-wire) fixation was used in a third attempt to obtain union. Ten weeks postoperative a CT scan showed complete healing. The K-wires were removed 3 months postoperative. A protruding volar ossification at the proximal margin of the graft was found on lateral views (►Fig. 1). At the six-month follow-up, ROM in the wrist was limited to 20/30 (flexion/extension) compared with 70/70 on the contralateral side.

Case 2

A 25-year-old male carpenter suffered a scaphoid fracture in a bicycle accident in May 2005. He was treated in a cast for 6 weeks. The fracture did not unite, and the patient was admitted to our clinic. The first surgical attempt was in September 2006, with K-wire fixation and ChronOS bone-substitute (Synthes, Solna, Sweden). Because of persistent nonunion, reoperation was performed in March 2008, with a pedicled vascularized bone graft from the first metacarpal bone. The scaphoid nonunion prevailed, and a free vascularized MFC graft with K-wire fixation was done in May 2012. The ROM in the wrist prior to this procedure was 40/70 (flexion/extension). Eight weeks later the nonunion had healed. The K-wires were removed 3 months postoperative. At the 1-year follow-up, ROM in the wrist was limited to 20/60 (flexion/extension) compared with 75/80 on the contralateral side. A relatively prominent volar ossification at the proximal margin of the graft was found on plain radiographs. The ectopic bone formation mechanically restricted wrist flexion, as seen in lateral views (►Fig. 2).

Case 3

A 39-year-old female sustained a scaphoid fracture in May 2010 after a fall. Cast immobilization for two months

Fig. 1 CT scan showing a protruding volar bone formation in Case 1.

failed. Iliac crest bone grafting and screw fixation (Acutrak, Acumed, Hillsboro, Oregon) failed. A second attempt with conventional bone grafting and fixation with two screws (HBS) also failed and the patient was admitted to our clinic. The condition of the scaphoid, with three screw-holes after the previous surgeries, was troublesome. The ROM in the wrist at this stage was 35/60 (flexion/extension). A final try with a free vascularized MFC graft and K-wire fixation was done in May 2012. After 8 weeks the graft was incorporated distally. Finally, after 14 weeks, proximal healing was also confirmed. A temporary donor-site seroma formation subsided spontaneously a few weeks postoperative. The K-wires were removed 4 months postoperative. At the 6-month follow-up, ROM in the wrist was restricted to 20/55 compared with 75/60 on the contralateral side. A large volar ossification was seen at the proximal margin of the graft. The ectopic

Fig. 2 Case 2, wrist extension (a) and flexion (b). Plain radiographs showing ectopic bone formation deep to the vascular bundle of the graft, causing mechanical conflict with the volar margin of the distal radius during flexion (right panel). Note the microclips along the vascular bundle of the graft.

Fig. 3 CT scan (a) and a plain radiograph (b) in Case 3, showing a beaklike bone formation along the course of the vascular bundle of the graft. Note the microclips further proximal.

bone-formation had a beaklike appearance on the lateral view, extending along the course of the vascular bundle of the graft (►Fig. 3). The wrist had a tendency to deviate ulnarly during flexion, which could be explained by the radial-sided ossification restraining normal balance in the wrist. As a result of local pain and persistent problems in flexing the wrist, the ectopic bone was resected. The 9×9 mm (width $\times$ length) bone formation was located deep to the vascular bundle of the graft. Two months later the local problems had subsided significantly, but the restricted ability to flex the wrist persisted.

Discussion

Free vascularized bone grafts from the MFC have been described as the superior option for treatment of recalcitrant scaphoid nonunion with proximal pole avascularity and humpback deformity.³ Few complications and high union rates have been reported.³ The strong osteogenic capacity of the vascularized MFC graft leads not only to high union rates despite poor preconditions. The thick periosteum over the medial femoral condyle results in a risk for developing undesired bone formation. The volar ossification seen in our series, especially in Case 3, is a noteworthy complication of the method. To the best of our knowledge, this volar beaklike bone formation following MFC grafting to scaphoid nonunion has not been described previously in the literature. In 2000, Doi et al reported ectopic bone formation with this method in two out of 10 patients.⁶ However, they did not specify where the bone formation occurred. Moreover, they positioned the graft with the vascular bundle in a loop entering the graft distally,⁶ in contrast to the presently prevailing technique, where the graft is rotated 90 degrees, which directs the vascular bundle in a straight proximal direction over the radiocarpal joint.^{1,5} The ectopic bone formation described by Doi et al probably occurred distally, under the vascular bundle, as it did not restrict wrist motion and was easily resected at the same time as the K-wires were removed.⁶

The protruding part of the graft can partly be explained by difficulties in positioning the graft deep enough and flush with the cortical surface of the scaphoid. The proximal margin of the graft may protrude a few millimeters volar to the cortex of the proximal part of the scaphoid. However, this technical problem is probably not the whole answer. During harvest the graft is cut out perpendicular to the cortex of the bone (i.e., the edges of the graft are square-shaped). However, as seen in the follow-up radiographs, the right-angled proximal margin of the graft was changed into an ossification elongating proximally. The beaklike appearance of the ossification, as seen on lateral radiographs, is most likely new bone formation induced by the periosteum of the graft (►Fig. 3). The location of the ectopic bone formation corresponds well to the area where the vascular bundle enters the graft.

During harvest, the vascular bundle is carefully freed and lifted from the bone proximal to the planned donor site. The periosteal incision around the peripheral margins of the graft is straightforward until the proximal margin of the graft is reached. Great care must be taken not to injure the vascular bundle of the graft, and the area where the vessels enter the graft is of critical importance. Pinal et al recommend that the periosteum should be incised a few millimeters larger than the size of the planned bone graft.⁹ This is to ensure that the connection between the periosteum and the bone is protected. The periosteum tends to retract a little after being incised. If the bone graft is small and the periosteal incision is equal to the size of the graft, the periosteum-bone connection may be jeopardized as the edges of the periosteum curl up.

However, in the area where the vascular bundle enters the graft, the retraction of the periosteum is less prominent because of its close connection to the overlying vessels. Moreover, the surgeon might hesitate to free the vessels all the way to the proximal border of the graft, leaving a few extra millimeters of periosteum beneath the vascular bundle. The periosteum is thick on the medial side of the knee, and its osteogenic capacity is strong. A few millimeters of periosteum left under the vascular bundle is probably the main reason for the beaklike bone formation seen in our cases.

The protruding ossification can obviously cause a mechanical conflict with the volar margin of the radius during wrist flexion (►Fig. 2). Such a conflict might explain the relatively poor flexion ability in our series, and the tendency in Cases 2 and 3 to deviate ulnarly during wrist flexion. This could be explained by the radial-sided conflict between the bone-formation and the volar margin of the radius, forcing the wrist ulnarly during flexion. In Case 3 the protruding ossification was excised because it caused local problems with pain. During excision, the location of the ectopic bone was confirmed to be just beneath the vascular bundle as it entered the graft.

Our three cases with recalcitrant scaphoid nonunion treated with free vascularized MFC graft unified after a median of 11 weeks. These figures are comparable to the figures of Jones et al, who reported a 100% union rate

($n = 12$) in 13 weeks.⁵ Donor site morbidity after MFC grafting has been reported to be low, with temporary pain¹ and occasionally with seroma formation.¹⁰ We experienced similar findings with transient pain and a seroma formation in Case 3.

Vascularized bone graft from the medial femoral condyle is a reliable method for treating recalcitrant scaphoid nonunion with avascularity of the proximal pole and carpal collapse. The strong osteogenic capacity of the MFC graft leads not only to fast healing with high union rates despite poor preconditions; the potent osteogenic capacity of the thick periosteum must also be taken into account. Undesired new bone formation may develop from the periosteum.

Hence, caution is warranted; the surgeon should be meticulous in dissecting the vessels and should not leave a periosteal sleeve under the vascular bundle where it enters the graft.

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Conflict of interest

None

References

- 1 Jones DB Jr, Bürger H, Bishop AT, Shin AY. Treatment of scaphoid waist nonunions with an avascular proximal pole and carpal collapse. A comparison of two vascularized bone grafts. *J Bone Joint Surg Am* 2008;90(12):2616–2625
- 2 Merrell GA, Wolfe SW, Slade JF III. Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. *J Hand Surg Am* 2002;27(4):685–691
- 3 Friedrich JB, Pederson WC, Bishop AT, Galaviz P, Chang J. New workhorse flaps in hand reconstruction. *Hand (NY)* 2012;7(1):45–54
- 4 Chang MA, Bishop AT, Moran SL, Shin AY. The outcomes and complications of 1,2-intercompartmental supraretinacular artery pedicled vascularized bone grafting of scaphoid nonunions. *J Hand Surg Am* 2006;31(3):387–396
- 5 Jones DB Jr, Moran SL, Bishop AT, Shin AY. Free-vascularized medial femoral condyle bone transfer in the treatment of scaphoid nonunions. *Plast Reconstr Surg* 2010;125(4):1176–1184
- 6 Doi K, Oda T, Soo-Heong T, Nanda V. Free vascularized bone graft for nonunion of the scaphoid. *J Hand Surg Am* 2000;25(3):507–519
- 7 Sheetz KK, Bishop AT, Berger RA. The arterial blood supply of the distal radius and ulna and its potential use in vascularized pedicled bone grafts. *J Hand Surg Am* 1995;20(6):902–914
- 8 Iorio ML, Masden DL, Higgins JP. The limits of medial femoral condyle corticoperiosteal flaps. *J Hand Surg Am* 2011;36(10):1592–1596
- 9 Del Piñal F, García-Bernal FJ, Regalado J, Ayala H, Cagigal L, Studer A. Vascularised corticoperiosteal grafts from the medial femoral condyle for difficult non-unions of the upper limb. *J Hand Surg Eur Vol* 2007;32(2):135–142
- 10 Rodríguez-Vegas JM, Delgado-Serrano PJ. Corticoperiosteal flap in the treatment of nonunions and small bone gaps: technical details and expanding possibilities. *J Plast Reconstr Aesthet Surg* 2011;64(4):515–527