Scaphoid Nonunion With Poor Prognostic Factors: The Role of the Free Medial Femoral Condyle Vascularized Bone Graft

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Abstract

Background: To report on the results of free medial femoral condyle (MFC) vascularized bone graft for scaphoid nonunions with 1 or more poor prognostic factors. **Methods:** We have used the free MFC vascularized bone graft for scaphoid nonunions that have 1 or more factors associated with a poor prognosis. These were, a delay in presentation of over 5 years, a proximal pole nonunion, the presence of avascular necrosis (AVN), or previous nonunion surgery. We used this technique on 20 patients over a 4.5-year period. **Results:** Our overall union rate was 88.5% (17 of 19 patients), with 1 patient failing to attend for follow-up. Our mean union time was 7 months (2–18). All patients had at least 1 poor prognostic factor and over half had 2 or more. Of those with AVN with or without other factors, the union rate was 85% (11 of 13). There were 2 donor site complications that required a further procedure and 2 patients with residual wrist pain that required a scapho-trapezio-trapezoid joint fusion and a radial styloidectomy, respectively. Both nonunions were offered further surgery, and 1 elected to undergo successful revision surgery. **Conclusions:** Overall, this technique showed good results, in a subgroup of patients that typically have poorer outcomes, with a low incidence of donor site morbidity. Our union rate compares favorably with other techniques for this difficult subset of patients with 1 or more poor prognostic factors, although results are clearly not as good as those of studies using the MFC graft for all scaphoid nonunions. We continue to reserve this technique for nonunions with 1 or more poor prognostic factors, and we believe that this technique should at least be considered in these patients.

Keywords: scaphoid, nonunion, medial femoral condyle

Introduction

Despite satisfactory management of many scaphoid fracture nonunions using simple bone grafting techniques, there remain certain categories of nonunion that continue to pose a surgical challenge. The results of simple bone grafting in the presence of avascular necrosis (AVN), bone loss, or after previous surgery remain variable. Hence, a variety of vascularized bone grafting techniques have been used to improve union rates for these patients and have resulted in published union rates between 27% and 100%.

The free medial femoral condyle (MFC) corticoperiosteal flap has been successfully used for difficult situations of nonunion and bone loss.^{4,5,15} Its use in the scaphoid as an alternative to a pedicled bone flap has been popularized over the last decade.^{6,11,17} Doi et al⁶ described union rates of 100% in a series of 10 cases of proximal pole nonunion with AVN. Further refinement of this technique has resulted in successful use of both a corticocancellous structural graft

and an osteochondral graft utilizing the convex trochlear articular surface when required.^{14,16} In our hand unit, we have reserved this technique for scaphoid nonunions with 1 or more specific poor prognostic factors. In this article, we describe our early results for these patients who typically have poorer outcomes using traditional techniques. These include proximal pole fractures, AVN of the proximal pole, long-standing nonunions of more than 5 years, and patients who have had previous failed nonunion surgery. The series represents 20 consecutive cases from a single center of scaphoid nonunion with 1 or more poor prognostic factors over a period of 4.5 years.

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Methods

Informed consent was taken from all patients, and the study complied with all necessary data protection/Health Insurance Portability and Accountability Act protocols. Institutional review board approval was not required at our institution.

Twenty patients were included in this study. All procedures were performed between September 2009 and March 2014. Scaphoid nonunion was defined as those that were greater than 6 months since initial treatment by either operative or closed techniques. Demographic data were collected, such as sex, age, hand dominance, occupation, and smoking history. The primary outcome measure was time to union. This was determined by plain radiographs at each follow-up as well as a computed tomography (CT) scan to confirm union whenever indicated by the radiographs and clinical exam. Secondary outcome measures included scapholunate angle, range of movement of the wrist joint, and postoperative complications. Patients were followed up postoperatively at 2 weekly intervals.

Surgical Technique

Surgery was performed by 2 consultant hand surgeons working simultaneously at the wrist and knee.

The scaphoid was approached by either a standard dorsal (16 of 20) or volar (4 of 20) approach described elsewhere.^{12,20} The MFC graft harvest was performed under tourniquet control using the technique described by Doi and Sakai.⁷ A headless compression screw was used to fix the MFC vascularized graft in place in 18 patients. Tension band wiring was used in 1 patient to achieve compression where screw hold across the bone fragments was poor. Kirschner wires alone were used in 1 patient for fixation and in 2 other patients as a supplementary fixation alongside a compression screw.

In 1 patient, the proximal pole was fragmented with 2 main fragments that were cystic. These were deemed unsuitable for any fixation and unlikely to achieve revascularization across both proximal fragments. This patient underwent osteochondral grafting whereby, using a previously described technique, the standard MFC approach was extended to include a transverse branch of the descending genicular artery that could be traced toward the medial trochlea.⁹ The most distal dissection was performed subperiosteally to avoid injury to the small artery and veins at this level. Osteotomies were then used to harvest the most proximal portion of the articular cartilage bearing segment of the MFC. The proximal pole was excised and, after careful templating and shaping of the graft, it was secured to the waist of the remaining scaphoid with a Herbert screw.

In all cases, the vascular anastomosis was performed to either the dorsal carpal arch in an end-to-side fashion

(9 of 20) or the radial artery in an end-to-side fashion (11 of 20). The decision was made intraoperatively according to the length and orientation of the vessels. Venous anastomosis was end to end to a vena comitans.

The mean operating time was 4 hours using a 2-team approach.

We did not utilize postoperative flap monitoring techniques. Postoperative immobilization in a forearm cast was discontinued at 12 weeks, even if a CT scan suggested nonunion.

Results

All 20 patients were male with a mean age of 25.3 years (19-38). The nonunion was at the proximal pole of the scaphoid in 12 patients, at the waist in 7 patients, and at the distal pole in 1 patient. Ten patients were current smokers. The mean time from injury to surgery was 3.4 years (6 months to 10 years). Four of 20 patients had undergone previous fixation of their scaphoid fracture. The mean preoperative scapholunate angle was 58.2° (45°-88°) compared with 51.3° (40°-69°) postoperatively. Preoperative magnetic resonance imaging (MRI) scans to assess vascularity of the proximal pole were performed in 16 patients. Seven of these had evidence of AVN on the MRI, although 14 of 20 patients were found to have AVN at operation evidenced by a lack of punctate bleeding in the proximal pole. One patient had a preoperative CT scan.

The number of poor prognostic factors and time to union in each group are shown in Table 1.

Three patients were lost to follow-up in total. Two had confirmed union before failing to attend for physiotherapy and assessment of range of motion. One patient, who had an osteochondral MFC graft, failed to attend any postoperative follow-up clinic appointments, and the final outcome is therefore unknown, although a postoperative CT scan performed at 2 months showed good progress toward radiological union. Excluding this patient, we report a union rate of 88.5% (17 of 19 patients) with a mean union time of 7.0 months (range, 2-18). For all patients with AVN, our union rate was 85% (11 of 13 patients).

There were 2 confirmed nonunions in total (2 of 19 patients; 10.5%). One of these was a scaphoid waist nonunion that presented a year after injury. The second was a 5-year-old proximal pole nonunion with AVN. Both nonunions were offered revision surgery. One underwent removal of screw and revision fixation at a different hand unit, and the second patient was symptom free and therefore elected to avoid further surgery.

Two of the patients had a prolonged time to union (18 and 17 months), and this delay was at the proximal interface of the vascularized graft only. In these patients, the distal interface of the vascularized graft united at 2.75 and 3 months, respectively.

Table 1. Poor Prognostic Factors and Time to Union.

Patient	Delay >5 y	Proximal pole	Avascular necrosis	Previous surgery for nonunion	Poor prognostic factors	Time to union (mo)
1		*	*		2	2
2	*				1	2.25
3		*	*		2	2.5
4		*		*	2	3
5		*	*		2	3
6		*	*		2	3
7				*	1	4
8		*	*		2	6
9			*		1	6
10		*	*		2	8
11	*				1	8
12		*	*	*	3	12
13	*				1	12
14		*	*		2	18 ^a
15				*	1	17 ^a
16		*	*		2	Nonunion
17			*		1	Nonunion
18	*		*		2	10
19			*		1	3
20	*	*	*		3	Lost to follow-up

^aTime to union at the distal interface of graft was 2.75 and 3 months, respectively, whereas complete union including the proximal interface was 18 and 17 months, respectively.

Three patients complained of mild discomfort around the donor site. One patient underwent a knee washout of an infected hematoma, and another required treatment for a stitch abscess at the knee. Four patients required prominent screw removal following union. One patient developed scapho-trapezio-trapezoid (STT) joint symptoms and required subsequent STT joint arthrodesis. One patient underwent radial styloidectomy for localized impingement pain.

Range of motion at the last follow-up visit was recorded for 17 of 20 patients with 3 of 20 failing to attend for physiotherapy or clinic follow-up. These patients achieved a mean range of 65° (25°-120°) with a mean dorsiflexion of 29° (range, 5°-60°) and a mean palmar flexion of 36° (range, 15°-60°).

Discussion

The free MFC vascularized bone graft for scaphoid nonunion has produced some promising results particularly for scaphoid nonunions with humpback deformity, loss of carpal alignment, previously failed fixation, or the need for a large structural graft.

A systematic review of vascularized bone grafts has suggested that the paucity of reported results currently makes it difficult to draw any substantial conclusion about the exact role of this technique.¹ We hope to add to the increasing

evidence in the literature to support the use of this technique in certain categories of scaphoid nonunion.

We have reserved vascularized MFC grafting for a subset of scaphoid nonunion with 1 or more poor prognostic factors and have found the MFC to be a useful technique in this set of patients. The advantages include an arterial anatomy that is consistent, with little variation. The vessels are greater than 1.5 mm, and the length of the pedicle is more than adequate. The full thickness of the cortex in this area is thin and flexible if only this is needed, but there is also abundant cancellous bone. Radiologically, on CT scans, the radius of curvature of the MFC fits that of the proximal carpal row.¹⁰ We found that the harvested bone provided good structural support to correct any humpback deformity and preserved carpal alignment well. In our view, the potential for harvesting an osteochondral graft, following an intraoperative decision to excise the proximal pole, greatly enhances the usefulness of this graft in difficult scaphoid nonunions. Disappointingly, the 1 patient who underwent this technique in our series was lost to follow-up in spite of an encouraging early postoperative course. Previous series have reported good results however.⁹

Overall, our time to union or union rate have not been as good as those reported in earlier series using the MFC vascularized bone graft (100% union in 3 months).¹³ This may reflect our decision to reserve the technique for nonunions

with 1 or more poor prognostic factors rather than for all nonunions. Both of the nonunions in the current study had evidence of AVN, as did one of the delayed unions, but overall there was no clear relationship between the number of poor prognostic factors and failure of union.

When looking specifically at subgroups of nonunion with poor prognostic factors, our results using the MFC vascularized bone graft compare favorably to other surgical techniques. Although 2 small series of 5 and 3 patients looking specifically at nonunions with AVN achieved 100% union rates using a pedicled vascularized bone graft, other larger series with this graft have reported union rates of 50% to 60%.^{2,3,18,19} Our union rate for the AVN subgroup was 85%.

Elgammal and Lukas⁸ used the MFC vascularized bone graft in difficult nonunions that had AVN, severe humpback deformity, or previous failed nonunion surgery and reported an overall union rate of 80% which is comparable with our overall union rate of 88.5%.

Our mean time to union is also longer than that in some previously reported series, and again a possible explanation for delayed union may be specific to our selection of patients for the technique, many of whom had their nonunion for 5 to 10 years, with a significant number that had proximal pole AVN.¹³ The 2 patients who had a prolonged time to union at the proximal interface of the graft, as well as the 2 nonunions that had AVN of the proximal pole, may have been suitable candidates for osteochondral grafts.

Although it is important to manage these patients like any other free flap, ensuring they are kept warm and well hydrated, and the limb is elevated to reduce congestion, we did not utilize the osteofasciocutaneous flap that can be harvested by including the saphenous branch of the descending genicular artery. This may have a role in post-operative flap monitoring and can aid coverage of the operative site. Although we did not have problems with wound closure, we are unable to say whether monitoring of the graft by incorporating such a skin paddle or even an implantable Doppler would have improved our overall union rate.

Furthermore, we found intraoperatively that anastomosis to the dorsal carpal arch did not produce as good an arterial inflow to the flap as the radial artery, and following our 2 nonunions, all subsequent patients had an anastomosis to the radial artery.

In conclusion, we have found that the MFC free vascularized graft represents a promising alternative to local vascularized bone grafts to attain union in this subgroup of difficult scaphoid nonunions with 1 or more factors associated with a poor prognosis. We have been able to demonstrate a high rate of union with a low incidence of donor site morbidity. Despite our results, the number of reported series remains low, and larger series with longer term follow-up

are required to fully evaluate the exact role and efficacy of the technique. We propose that the technique should at least be considered in difficult scaphoid nonunions with 1 or more poor prognostic factors.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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