FOOT AND ANKLE

Arthrodesis of the ankle using an anterior sliding tibial graft for osteoarthritis secondary to osteonecrosis of the talus

A COMPARISON OF VASCULARISED NON-VASCULARISED GRAFTS

Aims

This retrospective cohort study compared the results of vascularised and non-vascularised anterior sliding tibial grafts for the treatment of osteoarthritis (OA) of the ankle secondary to osteonecrosis of the talus.

Patients and Methods

We reviewed the clinical and radiological outcomes of 27 patients who underwent arthrodesis with either vascularised or non-vascularised (conventional) grafts, comparing the outcomes (clinical scores, proportion with successful union and time to union) between the two groups. The clinical outcome was assessed using the Mazur and American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scores. The mean follow-up was 35 months (24 to 68).

Results

The mean outcome scores increased significantly in both groups. In the vascularised graft group, the mean Mazur score improved from 36.9 to 74.6 and the mean AOFAS scale improved from 49.6 to 80.1.

In the conventional arthrodesis group, the mean Mazur score improved from 35.5 to 65 and the mean AOFAS scale from 49.2 to 67.6.

Complete fusion was achieved in 13 patients (76%) in the vascularised group, but only four (40%) in the conventional group. The clinical outcomes and proportion achieving union were significantly better in the vascularised group compared with the conventional arthrodesis group, although time to union was similar in the two groups.

Take home message: Vascularised sliding tibial grafts may be used to achieve arthrodesis in patients with OA of the ankle secondary to osteonecrosis of the talus.

Cite this article: Bone Joint J 2016;98-B:359–64.

Arthrodesis is an effective procedure in reducing pain and disability resulting from osteoarthritis (OA) of the ankle. However, arthrodesis in patients with osteonecrosis of the talus is technically challenging and associated with high rates of nonunion and further collapse of the talus leading to shortening and persistent symptoms.

Arthrodesis of the ankle joint may be undertaken using a sliding bone graft from the tibia, as described by Blair during the second world war. This procedure allows the maintenance of leg length and preservation of movement at the talonavicular joint. However, as the graft is not fixed, it is inherently unstable and this often leads to a pseudarthrosis. Although other authors have modified this procedure by using an oblique osteotomy in the tibia or by stabilising the graft using rigid fixation, the rate of nonunion and talar collapse remains high.

Union to the necrotic body of the talus is difficult to achieve and there are high rates of failure when using conventional techniques of arthrodesis.

Vascularised bone grafts have become used for foot and ankle reconstruction in the presence of osteonecrosis over recent years. Their use in the treatment of osteonecrosis of the talus was introduced in an effort to enhance revascularisation. We reported a preliminary series of patients with osteonecrosis of the talus who were treated using this method in 2015. However, this study did not have a control group treated with non-vascularised grafting for comparison. The lack of studies comparing different techniques of arthrodesis has limited our ability to determine which is the most reliable.

The purpose of this study was to evaluate the clinical and radiological outcomes in

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©2016 The British Editorial Society of Bone & Joint Surgery
doi:10.1302/0301-620X.98B3.36154 $2.00
Received 15 March 2015; Accepted after revision 7 October 2015
patients undergoing arthrodesis of the ankle with an anterior sliding vascularised tibial graft for osteoarthritis secondary to osteonecrosis of the talus, and to compare these patients with a control group undergoing a conventional procedure using a non-vascularised graft.

**Patients and Methods**

We have previously reported the outcome of 12 patients undergoing the arthrodesis using a vascularised anterior sliding tibial graft at a mean of 31 months post-operatively. In this study, we wished to compare the clinical outcomes of the patients with control group using a conventional procedure. Following ethical approval, we retrospectively reviewed the clinical results of 27 patients. There were eight men and 19 women with a mean age at surgery of 57 years (23 to 76), who had undergone arthrodesis of the ankle using an anterior vascularised sliding tibial graft for OA secondary to osteonecrosis of the talus between 2003 and 2013. Prior to 2008, non-vascularised grafts were used (conventional arthrodesis); from 2008 onwards, following a cadaveric study of the vascular anatomy of the distal tibia, we used vascularised grafts.

In total, 17 patients underwent arthrodesis using a vascularised graft and ten underwent a conventional arthrodesis. Outcome was assessed at a mean of 35 months (24 to 68) post-operatively. Osteonecrosis was attributed to steroid use in eight patients, to fracture in seven, and was idiopathic in 12. The demographic details of the patients are shown in Table I. The indication for surgery was isolated secondary tibiotalar joint OA without subtalar OA.
involvement causing pain and dysfunction, with radiographic findings showing Ficat and Arlet stage IV osteonecrosis, and MRI findings of partial or total involvement of the body of the talus (Fig. 1).

Radiographic examinations were performed before and after the operation with anteroposterior and lateral views of the ankle. Further collapse of the talus and osteoarthritis of the hindfoot or midfoot were noted at latest follow-up on radiographic images. The extent of talar necrosis was evaluated using MRI before surgery. Arthrodesis was defined as complete using radiography and CT scans in patients in whom the joint line of the ankle had entirely disappeared with clear trabeculation across the joint (Fig. 2), and moderate if some joint line was present with partial trabeculation (Fig. 3). If the entire joint space remained present, the arthrodesis was considered not to have united (Fig. 4). Clinical assessment was undertaken before surgery and at the latest follow-up using the Mazur ankle grading system and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle/hindfoot scale. The Mazur score is a patient- and clinician-completed scoring system based on pain, range of movement, and level of activity. In patients with an arthrodesis, it has a maximum score of 90 points as the ten points assigned to movement are excluded. An excellent score ranges from 80 to 90 points, good from 70 to 79, fair from 60 to 69, and poor less than 60.

**Surgical technique.** The first author performed all of the operations. After the ankle joint was exposed, the degenerative tibiotalar cartilage and subchondral necrotic bone were resected to provide a suitable bone surface for arthrodesis. Subsequently, the bone flap of distal tibia, shaped like a triangular prism at 2 cm in width, 1.5 cm in depth, and 4.5 cm in length was elevated with a medial, lateral, and proximal sharp osteotomy. The tibialis anterior vessel were included in the elevated bone flap with the periosteum. Thereafter, the anterior portion of the talus was resected to make a graft bed with a triangular defect matching the shape of the bone flap. The necrotic body of the residual talus was drilled several times to encourage integration of the graft. Finally, the vascularised tibial flap was shifted distally, and inserted into the graft bed of the talus to form a bridge between the tibia and talus with maintenance of a neutral ankle position. Cross pinning with 2.0 mm K-wires was performed to provide temporary fixation of the tibiotalar joint. The bone flap was fixed to the tibia and talus with two cannulated cancellous screws so as to not disturb circulation in the tibial flap.

Non-vascularised grafting was performed through the same approach. The periosteum of the tibia was stripped on both sides, and a tibial graft of similar dimensions was elevated without including the neurovascular bundle. After making a graft bed in the talus, the graft was similarly fixed with cannulated screws.

**Post-operative management.** This was the same in both groups. The patients remained non-weight bearing in a cast...
for four weeks (at which point the K-wires were removed.)
Partial weight-bearing continued in a below-knee splint for
six weeks, followed by full weight bearing.

Statistical analysis. Data are shown as means and standard
deviations (SD) or as medians and ranges. The Wilcoxon
signed-ranks test was used to compare pre-operative Mazur
and AOFAS scores with those obtained at the time of final
follow-up examination. Independent samples t-tests were
used to compare the clinical results between vascularised
and nonvascularised groups. P-values of < 0.05 were con-
sidered to be significant.

Results
The groups were similar in terms of age (p = 0.165), gender
(p = 0.974), and pre-operative Mazur and AOFAS scores
(p = 0.78 and p = 0.93, respectively). In the vascularised graft
group, eight patients (47%) were smokers, compared with
three (30%) in the conventional group. The mean follow-up
was 36 months (24 to 68) in the vascularised graft group and
36 months (30 to 58) in the conventional group. Complete
fusion was confirmed on plain radiographs and CT scans in
13 patients (76%) in the vascularised graft group and four
(40%) in the conventional group. Nonunion was confirmed

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Table II. Patient overall results with vascularised tibial grafting (n = 17)

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<th>Cause</th>
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<th>Time to union (wks)</th>
<th>X-p/ union CT/ union successful union confirmed</th>
<th>Mazur score Before surgery</th>
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Table III. Patient overall results with nonvascularised tibial grafting (conventional procedure, n = 10)

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<th>Time to union (weeks)</th>
<th>X-p/ union CT/ union successful union confirmed</th>
<th>Mazur score Before surgery</th>
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Cause: S, steroid/ F, fracture/ I, idiopathic Union: C, complete/ M, moderate/ N, nonunion

Mazur score: Mazur ankle grading system is based on pain, range of movement and activity level with the maximum scores 90 points because of lack of ankle motion. An excellent result scored 80 to 90 points; a good result 70 to 79; a fair result 60 to 69; and a poor result scored less than 60

AOFAS (American Orthopaedic Foot and Ankle Society) score P: pain, F: function, A: alignment

Mazur score: Mazur ankle grading system is based on pain, range of movement and activity level with the maximum scores 90 points because of lack of ankle motion. An excellent result scored 80 to 90 points; a good result 70 to 79; a fair result 60 to 69; and a poor result scored less than 60 AOFAS (American Orthopaedic Foot and Ankle Society) score P: pain, F: function, A: alignment
in one patient (6%) in the vascularised group and in four (40%) in the conventional group. The mean time to union was similar in the two groups: 13.3 weeks (9 to 20) in the vascularised group and 15 weeks (12 to 21) in the conventional group (p = 0.26). The overall results of the two groups are shown in Tables II and III. In radiographic images, osteoarthrosis of the hindfoot or midfoot was noted post-operatively in one patient in the vascularised group and in three in the conventional group. In addition, no further collapse occurred following the vascularised grafting.

The mean Mazur and AOFAS scores improved significantly in both groups following surgery. (Tables II and III)

The clinical outcomes were significantly better in the vascularised graft group compared with the conventional group at the latest follow-up (Table IV). However, there was no significant difference between two groups in the rate of union.

### Discussion

This series has demonstrated better functional outcome for vascularised grafts when compared with conventional non-vascularised grafts. At a mean of 35 months, the vascularised graft technique successfully prevented further talar collapse, despite only about a third of the necrotic bone in the talus having to be resected grossly to make way for the vascularised graft. The prime purpose of a vascularised graft is to substitute the resected necrotic bone with bone and periostium which has normal biological healing properties. The vascularised technique necessitates the elevation of the tibialis anterior vessels, which adds about 20 minutes to the procedure when compared with the conventional sliding procedure. However, no vascular anastomosis is required.

The aetiology of osteoarthritis of the ankle secondary to osteonecrosis of the talus has been attributed to several conditions. Traumatically-induced osteonecrosis is the most commonly reported, as a complication of a fracture of the neck of the talus. Dodd and Lefaivre reported a 31% rate of avascular necrosis in a systematic review, and other investigators have described similar rates. In our series, seven patients (26%) had osteonecrosis secondary to a fracture of the talus. Atraumatic osteonecrosis of the talus is less common, and may be idiopathic or secondary to corticosteroid use, alcoholism, or autoimmune disease. In spite of being less common, 12 (44%) of the patients in our series had idiopathic osteonecrosis; six of these were smokers, but the remainder had no identifiable risk factors. The high proportion of patients with idiopathic osteonecrosis may be a result of the fact that ours is a referral centre, and, as a result, treats a large proportion of patients with idiopathic disorders.

There are several well-described surgical techniques for arthrodesis of the ankle. Excellent results have been reported when a non-vascularised sliding tibial graft has been used in OA without AVN. Takakura et al reported a 93% rate of union in this setting. However, when talar AVN is present, non-vascularised grafts have a higher rate of non-union with progressive collapse of the talus resulting in shortening of the ankle. There are several well-described surgical techniques for arthrodesis of the ankle. The vascularised anterior sliding tibial technique was easy to perform, and found it to be applicable for the treatment of both primary and secondary arthritis of the ankle. Complete ankle fusion was obtained for three patients at a mean follow-up of 20 months. We are not aware of any studies in the literature comparing the results of vascularised and non-vascularised surgeries for the treatment of OA secondary to osteonecrosis of the talus.

This study has several limitations. As the condition is infrequent, only a small number of patients could be enrolled into the study. Secondly, we inferred the presence of remodelling of the talus from the fact that no further collapse occurred following grafting; however, this could have...
been confirmed more accurately post-operatively using MRI.

Our results show that the clinical outcome and rate of union were superior when vascularised grafts were used for arthrodesis of the ankle compared with conventional grafts.

Author contributions:
N. Kodama: Writing the paper, Data collection and analysis, Performed surgeries.
Y. Takemura: Provided assistance during operation and with manuscript.
S. Shioji: Provided assistance during operation and with manuscript.
S. Imai: Provide direction of manuscript, tables, figures.
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

This article was primary edited by A. D. Liddle and first proof edited by J. Scott.

References