We reviewed, retrospectively, 13 patients who had undergone open anterograde autologous bone grafting of the talus for symptomatic osteochondral defects of the dome of the talus. The mean age of the seven men and six women was 38.4 years. The defects included the full thickness of articular cartilage, extended through the subchondral plate and were associated with subchondral cysts. Six patients (46%) were clinical failures requiring further surgery. Of the remaining seven, functional outcome results were obtained at a mean of 51.9 months after surgery. The mean outcome scores for the Musculoskeletal Outcomes Data Evaluation and Management System foot and ankle questionnaire and the American Orthopaedic Foot and Ankle Society ankle-hindfoot scale were 87.0 and 84.3, respectively. There was an overall 46.2% patient satisfaction rate.

We believe that the technique of autologous bone grafting presented should be used with extreme caution, when considered as the primary treatment for the adult patient with a symptomatic advanced osteochondral defect of the talus.

The treatment options for osteochondral defects (OCDs) of the talus vary in the literature from non-operative to open and arthroscopic surgical measures, depending on the location, appearance, size and stage of the lesion, as well as the surgeon’s preference. Non-operative management can provide good results and should generally be considered the first line of treatment. When a talar OCD remains symptomatic, despite prolonged conservative management, a variety of surgical modalities are considered, including internal fixation with or without bone peg fixation, simple excision and curettage with or without drilling, retrograde drilling, autologous osteochondral grafting, autologous chondrocyte implantation and allografting and autogenous bone grafting.2-25

Several published reports have described the use of autologous bone in the treatment of osteochondral defects in the knee.8,15,19,26 There are few reports in the literature, however, as to the efficacy of using autologous bone grafting to treat osteochondral defects of the talus.9,13,18,19 We present a follow-up study using a standardised outcome analysis of both the management and prognosis of osteochondral defects of the talus, treated with autologous bone grafts.

**Patients and Methods**

We reviewed, retrospectively, 13 consecutive patients with symptomatic, advanced OCDs of the dome of the talus with subchondral cysts, surgically treated by the senior author (MW) with autologous corticocancellous bone grafting, between November 1995 and October 1997. There were seven men and six women (Table I). Their mean age was 38.4 years (20 to 52). The lesions were examined using plain radiographs, CT, CT arthrography, MRI, and arthroscopy. Before surgery, CT imaging identified each defect to be associated with subchondral cysts. There were six left and seven right ankles, with the defect of the talar dome located medially in ten (Fig. 1) and laterally in three.

Regarding the activity level of the patients before surgery, five were active sportsmen or women (cases 1, 2, 3, 9, 12). The other seven
were ordinary walkers involved in light recreational sporting activities; one patient (case 7) was a 40-pack-a-year cigarette smoker and four (cases 5, 11, 12, 13) had undergone prior surgical intervention of the ankle consisting of either arthroscopic or open debridement and drilling of the defect. The aetiology of the defects was believed to be secondary to trauma in ten patients (three lateral lesions and seven medial), as these involved either a single, twisting ankle injury or a chronic ankle sprain. No clear cause was found in three patients (all medial lesions). Indications for surgery included a symptomatic focal lesion involving the weight-bearing dome of the talus, which had failed to respond to non-operative or operative management, and measuring at least 1 cm in length or diameter and with associated subchondral cysts.

**Operative technique.** Under general anaesthesia, the patient was placed supine with a tourniquet on the affected thigh. The lesion was exposed through an oblique, medial malleolar osteotomy for a medial lesion, or either a distal fibular osteotomy or a release of the anterior talofibular ligament for a lateral lesion. The defect was prepared, excising the necrotic sequestrum and curetting the crater to bleeding bone. Autogenous corticocancellous graft from either the ipsilateral iliac crest (six patients) or locally from the distal tibial metaphysis (seven patients). The graft, press-fitted into the recipient site to fill the defect, was inset so that its superior level was flush with the level of the subchondral plate. When a bony approach was used, the osteotomy was firmly fixed internally or, if a soft-tissue approach was used, a modified Brostrom repair was carried out to reconstruct the lateral ligaments. The wounds were then closed in layers and a well-padded below-knee splint was applied.

The post-operative regime included a 12-week period of non-weight-bearing. Unprotected weight-bearing, as toler-

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**Table I.** Details of the 13 patients with OCD of the talus treated with autologous bone grafting

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yrs)</th>
<th>Gender</th>
<th>Side</th>
<th>Defect location</th>
<th>Defect size (mm x mm)</th>
<th>Bipolar defect</th>
<th>Donor site</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47</td>
<td>M</td>
<td>R</td>
<td>Medial</td>
<td>15 x 15</td>
<td>0</td>
<td>Tibia</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>M</td>
<td>R</td>
<td>Medial</td>
<td>22 x 12</td>
<td>0</td>
<td>Ilium</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>F</td>
<td>R</td>
<td>Medial</td>
<td>10 x 18</td>
<td>1</td>
<td>Ilium</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>F</td>
<td>L</td>
<td>Medial</td>
<td>20 x 15</td>
<td>0</td>
<td>Ilium</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>F</td>
<td>R</td>
<td>Medial</td>
<td>6 x 15</td>
<td>1</td>
<td>Tibia</td>
</tr>
<tr>
<td>6</td>
<td>48</td>
<td>F</td>
<td>L</td>
<td>Lateral</td>
<td>6 x 15</td>
<td>0</td>
<td>Tibia</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>M</td>
<td>L</td>
<td>Lateral</td>
<td>10 x 16</td>
<td>1</td>
<td>Tibia</td>
</tr>
<tr>
<td>8</td>
<td>38</td>
<td>M</td>
<td>L</td>
<td>Medial</td>
<td>8 x 15</td>
<td>0</td>
<td>Tibia</td>
</tr>
<tr>
<td>9</td>
<td>32</td>
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<td>R</td>
<td>Lateral</td>
<td>12 x 14</td>
<td>0</td>
<td>Tibia</td>
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<tr>
<td>10</td>
<td>47</td>
<td>F</td>
<td>L</td>
<td>Medial</td>
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<td>0</td>
<td>Tibia</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>F</td>
<td>R</td>
<td>Medial</td>
<td>16 x 25</td>
<td>1</td>
<td>Ilium</td>
</tr>
<tr>
<td>12</td>
<td>39</td>
<td>M</td>
<td>L</td>
<td>Medial</td>
<td>6 x 15</td>
<td>0</td>
<td>Ilium</td>
</tr>
<tr>
<td>13</td>
<td>52</td>
<td>M</td>
<td>R</td>
<td>Medial</td>
<td>8 x 15</td>
<td>1</td>
<td>Ilium</td>
</tr>
<tr>
<td>Mean</td>
<td>38.4</td>
<td></td>
<td></td>
<td></td>
<td>12 x 15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The lesions were exposed through an oblique, medial malleolar osteotomy for a medial lesion, or either a distal fibular osteotomy or a release of the anterior talofibular ligament for a lateral lesion. The defect was prepared, excising the necrotic sequestrum and curetting the crater to bleeding bone. Autogenous corticocancellous graft from either the ipsilateral iliac crest (six patients) or locally from the distal tibial metaphysis (seven patients). The graft, press-fitted into the recipient site to fill the defect, was inset so that its superior level was flush with the level of the subchondral plate. When a bony approach was used, the osteotomy was firmly fixed internally or, if a soft-tissue approach was used, a modified Brostrom repair was carried out to reconstruct the lateral ligaments. The wounds were then closed in layers and a well-padded below-knee splint was applied.

The post-operative regime included a 12-week period of non-weight-bearing. Unprotected weight-bearing, as toler-

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**Fig. 1a**
Coronal and axial CT images of the right ankle of a 34-year-old woman (case 3) showing a medial lesion.
ated, was then permitted after clinical and radiological confirmation of solid union of the osteotomy. The rehabilitation programme allowed gentle jogging between six and 12 months post-operatively, but running and impact activities were suspended for one year.

The mean size of the defects was 12 mm x 15 mm (72 mm² to 400 mm²). All lesions were full-thickness defects extending through the subchondral plate. The overlying articular cartilage was more or less deficient in every patient. Subchondral cysts were always present. Additionally, there were five bipolar lesions (kissing lesions) with focal defects of the distal tibial plafond opposite the corresponding talus lesion. Plain radiographs and a CT scan of the ankle were obtained at review.

Functional outcome results were obtained for the ankle using the Musculoskeletal Outcomes Data Evaluation and Management System (MODEMS) foot and ankle follow-up questionnaire28 using the foot and ankle scoring algorithm (outcome collection instrument version 2.0) with a score range from 0 to 100. We also recorded the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score which ranges from 0 to 100 (score of 90 to 100, excellent; 80 to 89, good; 65 to 79, fair; <65, poor).29

Patient satisfaction was, subjectively, determined on a scale of overall satisfaction, including very satisfied, somewhat satisfied, neutral, somewhat dissatisfied and very dissatisfied.

In three patients, we examined, histologically, a core obtained from the centre of the grafted area at least 12 months after the surgery. Each specimen was fixed in cold 10% neutral buffered formalin for seven days, decalcified in ethylenediaminetetra-acetic acid, embedded in paraffin and cut into 7 µm sections. Sections were taken perpendicular to the bone/cartilage interface and described in the five zones namely superficial, middle and deep cartilage, calcified cartilage, and subchondral bone. Specimens were stained with haematoxylin and eosin, and Safranin O.

Immunohistochemical examination for type II collagen was performed using a polyclonal antibody provided by the Developmental Studies Hybridoma Bank (Iowa City, Iowa) to distinguish fibrocartilage from hyaline cartilage. Statistical analysis was carried out using the SAS system statistical software package version 6.12 for Windows (SAS Institute, Cary, North Carolina).

Results

Before surgery, the mean AOFAS ankle-hindfoot score was 55; this improved to 72 (36 to 97) at a mean follow-up of 37.4 months (Table II). At a mean of 20.5 months (12 to 36), six patients (46%) were clinical failures with a mean AOFAS score of 57.7 (36 to 68). They required further surgery in the form of either a tibiotalar fusion or autologous osteochondral grafting of the talar defect (Table II). Of the remaining seven patients, functional outcome results were obtained at a mean of 51.9 months. The mean MODEMS and AOFAS ankle-hindfoot scores were 87.0 (60.5 to 98) and 84.3 (55 to 96), respectively.

Persistent severe pain, refractory to non-operative management at 12 months, limiting the patient’s activities of daily living, was an indication for further open surgery. Three patients (cases 4, 11, 13) developed symptomatic, degenerative arthritis involving the tibiotalar joint and required a tibiotalar fusion at a mean of 16 months after initial surgery (12 to 24), and three patients (cases 3, 5, and 12) underwent autologous osteochondral grafting of the talar defect, at a mean of 25 months (15 to 36). One patient (case 5) later required a tibiotalar fusion as well. These patients were considered clinical failures of the initial procedure.

Subjective results for the ankles of the seven patients not requiring further open reconstructive surgery included mild to moderate pain in five, swelling in one, mild stiffness in two, mild perceived reduced range of movement in four and mild difficulty on uneven surfaces in three. There were no
instances of locking or giving way. Objective results for the ankle included reduced range of movement to less than 10° in two patients, and mild to severe degenerative changes in three. Union and incorporation of the bone graft were achieved in all patients within six months. When the iliac crest was used as the donor site, it was free of symptoms in all six patients at follow-up.

In all patients, incorporation of the bone graft into the host bed with subchondral union was demonstrated on CT and plain radiographs (Figs 2 and 3). ‘Second-look’ arthroscopy was done in two patients (cases 7 and 8) at nine and 24 months respectively after surgery for continued pain and symptoms. It revealed partial restoration of the surface contour of the grafted area with synovitis. One patient (case 7) was also found to have a 10 mm x 15 mm defect of the distal tibial articular surface, opposing the talar lesion, which was present prior to autologous bone grafting.
Histological study of the grafted defect, obtained in three patients at the time of conversion to tibiotalar fusion in two patients or autologous osteochondral grafting in one, showed that the grafted area was filled with a thick cellular fibrocartilage cap which was well integrated at 12 months with the host bone and with viable underlying bone with new lamellae. The subchondral plate and tidemark were absent (Fig. 4).

There was 46.2% overall satisfaction in the whole group, with five patients very satisfied, one somewhat satisfied, and seven somewhat dissatisfied with the results of the bone grafting procedure. Six patients (46.2%) reported that they would have surgery again if suggested. Regarding the overall activity level of the patients who had not undergone either tibiotalar fusion or further osteochondral grafting within the final follow-up period, six had improved functionally from their respective post-injury status (five considerably, and one moderately), and one noted no improvement. There was one delayed union of the medial malleolar osteotomy site (case 10) and a broken medial malleolar screw was incidentally seen on a post-operative radiograph (case 9). There were no infections or deep vein thromboses.

**Discussion**

Subchondral bone grafting, using either cancellous or corticocancellous autograft or allograft, has been used with encouraging results for OCDs in the ankle with intact overlying cartilage. It can be undertaken in either a retrograde or antegrade fashion so that the overlying articular cartilage is not damaged.\(^9,13,18,19\) Several reports describe bone grafting of *in situ* osteochondral lesions of the talus with intact overlying cartilage with, at most, minimal violation of the integrity of the overlying articular surface.\(^9,13,18,19\) Greenspoon and Rosman\(^13\) compared the results of six children with medial OCD of the talus, treated with distal tibial metaphyseal cancellous bone grafting and approached using a medial malleolar osteotomy, with the results of ten children treated by excision. More favourable results (five good and one fair) were seen in the bone graft group. Lee and Mercurio\(^19\) presented a case of a 28-year-old male with OCD of the medial talar dome treated with retrograde drilling and cancellous bone grafting with significant improvement of symptoms at five-year follow-up. Most recently, Draper and Fallat\(^9\) compared the results of 14 patients with Berndt and Harty stage III OCD of the talar dome, treated using autologous local cancellous bone grafting from the distal tibial metaphysis, with 17 patients treated with curettage and subchondral drilling. The mean area of the talar defect in the bone graft group was \(156.4 \pm 69.4\) mm\(^2\). At a mean of 56.3 months, bone grafting yielded better results than curettage plus drilling, giving a better range of movement, less pain and the presence of subchondral bone on plain radiographs.

Kouvalchouk et al\(^18\) carried out talar bone grafting primarily on *in situ* lesions with intact overlying cartilage. In doing so, they violated the integrity of the overlying articular surface. They reported the results of 33 patients with OCDs of the talar dome with subchondral necrosis and/or cysts treated with curettage and cancellous bone grafting harvested from the distal tibial metaphysis. Of the 27 patients reviewed at a mean 39-month follow-up, 22 had good or very good functional results and five had fair or poor results.

The indication for bone grafting in our series of patients was generally different to the above-mentioned studies. We considered patients with advanced OCDs of the talar dome with either deficient or absent overlying cartilage, above subchondral cysts. The concept behind debridement of the necrotic sequestrum and subchondral bone grafting was to restore the talar subchondral support by restoring the structural bony base and encouraging local revascularisation. What happens with the hyaline cartilage void depends on the reparative process beginning with vascular ingrowth, with consequent filling of the full-thickness chondral defect with fibrous connective tissue.\(^30\) The biological difficulty is
that the defect in mature hyaline cartilage has a limited capacity to regenerate and, consequently, is replaced by fibrocartilage with comparatively poorer mechanical properties.\textsuperscript{30-33} In cartilage defects greater than 1 cm in diameter, the fibrocartilage may not be able to withstand the wear and tear of joint contact pressure loads over time, and consequently may not be sufficient to remit pain.

Regarding the functional outcomes, good to excellent results were obtained in only six patients. Of the seven patients (54\%) who had fair to poor results, six were graded as clinical failures requiring further surgery.

Although histological examination showed the grafted area to be filled with a thick, fibrocartilaginous cap well incorporated into the underlying bone, this did not correlate with a successful outcome. In our series, open bone grafting did not predictably improve symptoms and yielded poor results. This raises concern as to the overall efficacy of such a procedure, when used in the treatment of full-thickness, advanced, osteochondral defects of the talar dome.

The presence of a bipolar lesion, history of prior ankle surgery, patient age, defect size, location, degree of containment, status of the surrounding cartilage, duration of symptoms prior to surgery, history of cigarette use, activity level, and patient reliability should be considered. Four patients underwent prior surgical intervention of the ankle and five patients had bilateral defects which may have adversely affected the results. We are also unclear as to whether the six satisfied patients had these results simply due to the curettage alone, to the bone grafting, or both. The overall results in this series also mirror the natural history of untreated osteochondral defects of the talus in the literature.

Autologous osteochondral grafting and osteochondral allografts have the ability to restore the osseous void, which occurs in OCDs with subchondral cysts.\textsuperscript{22} These techniques have the added advantage of replacing the cartilage defect with hyaline cartilage and have been shown to provide good to excellent results.\textsuperscript{11,14,16,22} For deep, focal defects unamenable to either autologous osteochondral grafting or autologous chondrocyte implantation alone, bone grafting can perhaps be used in combination with these procedures to abet in the reconstitution of the subchondral osseous void. We do not, however, recommend autologous bone grafting alone as primary treatment for the patient with a symptomatic advanced OCD of the talus and deficient or absent overlying cartilage.

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.

References

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