Clinical Research

Results and Functional Outcomes of Structural Fresh Osteochondral Allograft Transfer for Treatment of Osteochondral Lesions of the Talus in a Highly Active Population

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Abstract: Introduction. *Structural fresh osteochondral allograft transfer is an appropriate treatment option for large osteochondral lesions of the talus (OLTs), specifically lesions involving the shoulder of the talus. Sparse literature exists regarding functional outcome following this surgery in high-demand populations.* Materials and Methods. *Over a 2-year period, a single surgeon performed 8 structural allograft transfers for treatment of large OLTs in an active duty US military population. Lesion morphology and magnetic resonance imaging (MRI) stage were recorded. Preoperative and latest postoperative American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot-ankle and pain visual analog scores were compared.* Results. *Eight male service members with mean age 34.4 years underwent structural allograft transfer for OLTs with mean MRI stage of 4.9 and a mean lesion volume of 2247.1 mm*^{3}. *Preoperative mean AOFAS hindfoot-ankle score was 49.6, and mean pain visual analog score was 6.9. At mean follow-up of 28.5 months, postoperative mean AOFAS score was 73, and mean pain visual analog score was 4.5, representing overall improvements of 47% and 35%, respectively. Three patients were considered treatment failures secondary to continued ankle disability (2) or graft resorption requiring ankle arthrodesis.* Conclusions. *Despite modest improvements in short-term functional outcome scores, large osteochondral lesions requiring structural allograft transfer remain*

> "Most OLTs [osteochondral lesions of the talus] can be treated arthroscopically with debridement or marrow stimulation techniques, such as retrograde drilling or microfracture."

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difficult to treat, particularly in high-demand patient populations. Surgeons should counsel patients preoperatively on realistic expectations for return to function following structural allograft transfer procedures.

Levels of Evidence: *Level IV: Retrospective study*

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The incidence of osteochondral lesions of the talus (OLTs) in the general population remains unclear.[1-3] A recent study found an overall incidence of OLTs in the active duty US military population of 27 per 100 000 patient years over a 10-year period and found that patients with increased activity levels were at higher risk for developing OLTs.[3] These data suggest that OLTs may be more common in physically active populations such as military service members than previously noted in general populations.

Surgical management of OLTs is reserved for symptomatic cases in which appropriate nonoperative treatment has failed or in cases of symptomatic recurrence following prior surgical management.[1,2] Most OLTs can be treated arthroscopically with debridement or marrow stimulation techniques, such as retrograde drilling or microfracture[4,5]; however, open techniques, often requiring malleolar osteotomies (eg, osteochondral autograft or allograft transfer), may be indicated when these techniques fail or when the morphology of the lesion is such that arthroscopic techniques are inadequate (eg, large surface area or depth or cystic component to lesion).[6-14]

Structural osteochondral allograft transfer is an appropriate treatment option for a particular subset of OLTs such as large lesions with significant involvement of the shoulder of the talus. Advantages of structural allograft transfer include ability to replace large-volume defects, avoidance of donor site morbidity associated with autologous harvesting, and reliable recreation of native talar anatomy. Disadvantages include the inherent risk of disease transmission associated with fresh allograft tissue, limited graft availability, graft resorption, and the potential for failure of graft incorporation. Several small and one larger series have demonstrated satisfactory short and intermediate term outcomes following structural allograft transfer for treatment of large OLTs.[2,6,8,9,12,13,15,16] However, the patient populations in these studies were probably less active as a whole than an active duty military population.

The purpose of the retrospective study is to present our short-term functional and occupational outcomes following structural osteochondral allograft transfer to treat large OLTs in an active duty US military population. To our knowledge, no previous studies have reported results of this procedure in a patient population with uniformly high physical activity demands. Active duty US military personnel represent a diverse, physically active population with varied occupational demands and generally participate in regular structured physical fitness training programs.[3]

Materials and Methods

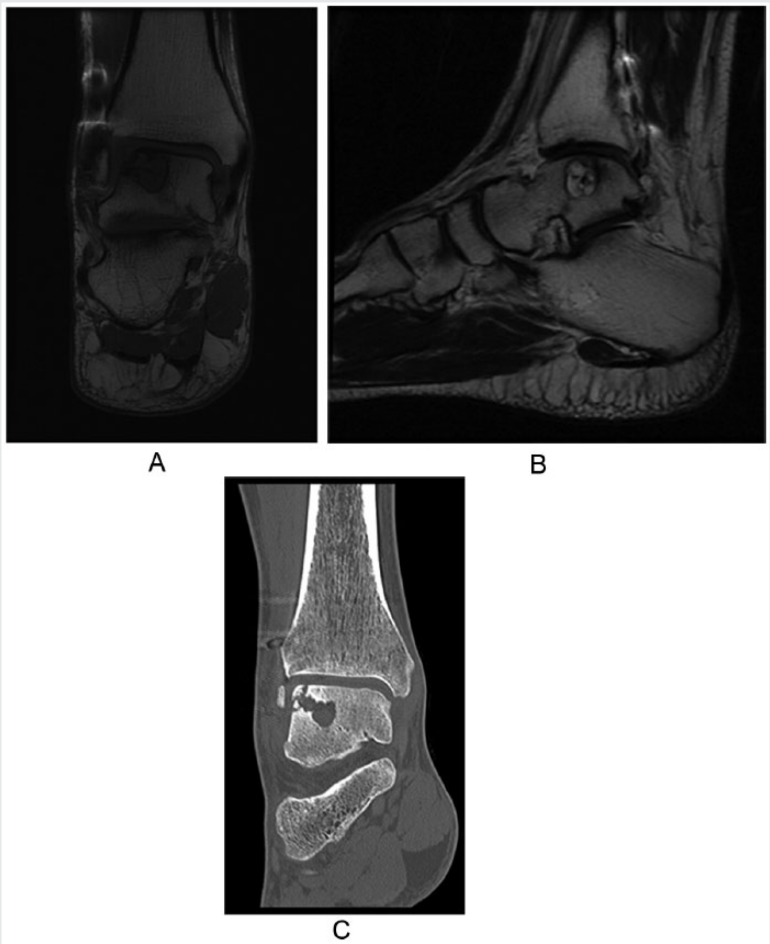
Following institutional review board approval, we reviewed the charts of 8 consecutively treated patients who underwent structural fresh osteochondral allograft transfer for treatment of large OLTs between October 2010 and June 2013. Indications for structural allograft transfer were similar to previous investigations' reported indications[6,8,9,12,13,15] that included lesions with significant involvement of the shoulder of the talus with a surface area greater than 150 mm^2 and largely a cystic component. All patients were active duty US Army service members with symptomatic OLTs who had failed appropriate nonoperative or previous operative treatments. Inclusion criteria for the study included any active duty military service member who underwent structural allograft transfer as a primary or salvage surgical procedure for a single symptomatic OLT during the study period. Patients with ankle joint arthrosis secondary to osteoarthritis, inflammatory arthropathy, osteonecrosis, or bony contusion without conclusive evidence of an associated cartilage defect were not indicated for cartilage restorative procedures and were not included in the current study. Preoperatively, each patient completed the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot-ankle and pain visual analog scoring questionnaires.

All patients received plain radiographs and magnetic resonance imaging (MRI) (Figure 1A and B) prior to surgery using a 1.5-T MRI scanner (GE Healthcare, Milwaukee, WI). Standardized ankle MRI protocols were used in all patients, consisting of fine-cut T1-weighted spin echo and T2 fast spin echo with fat suppression sequences in axial, coronal, and sagittal planes. All MRI scans were evaluated at a computer workstation using iSITE digitized radiographic software (Philips Healthcare Informatics, Foster City, CA). MRI lesion staging was performed in accordance with the Hepple et al[17] OLT MRI staging classification. OLT dimensions (anteroposterior and transverse diameters and depth) based on T1-weighted MRI were determined in accordance with previously described techniques.[18,19] MRI assessments, including localization, quantification of measurements, and staging classification, were performed by a board-certified orthopaedic surgeon not involved in the operations. Preoperative computed tomography (CT) imaging (Figure 1C) was performed in all 8 cases to further assess lesion morphology. Additionally, patient demographic information, lesion laterality, and AOFAS hindfoot-ankle and pain visual analog scores were recorded.

All 8 patients underwent medial or lateral malleolar osteotomies with size-matched structural allograft transfer using a fresh, *non-frozen* cadaveric osteochondral talar allograft as described by previous authors (Figure 2A and B).[6,8,9,11-13,15,16] No realignment osteotomies were performed. For lateral lesions, the lead author chose to perform

Figure 1.

Preoperative radiographic evaluation for patient with large, cystic centrolateral (zone 6) osteochondral lesions of the talus (OLT) requiring structural fresh osteochondral allograft transfer (patient 1, Table 1). (A) Coronal magnetic resonance image (MRI) demonstrating cystic lateral OLT. (B) Sagittal MRI demonstrating same OLT. (C) Coronal computed tomography (CT) scan further delineating the morphology of the OLT.



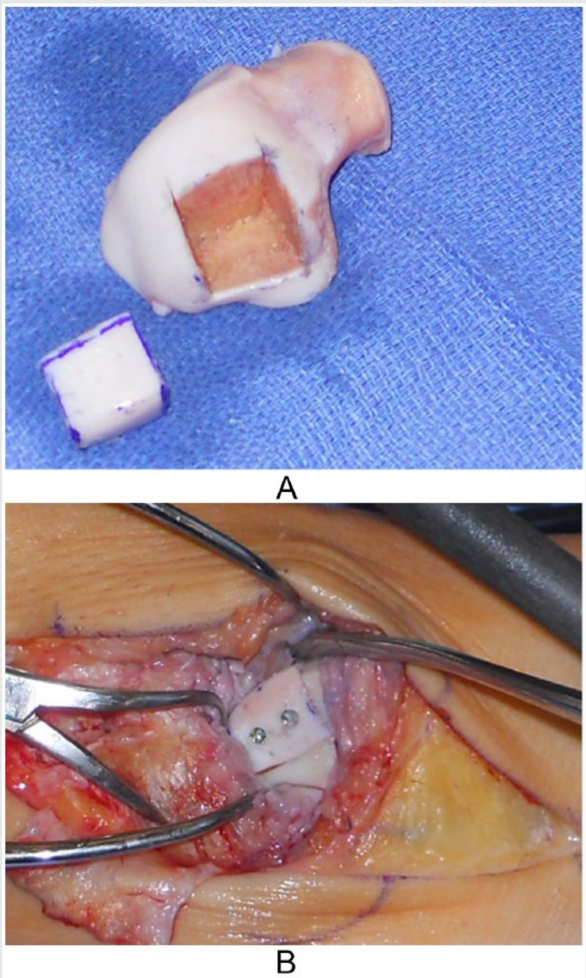
fibular osteotomies rather than anterolateral distal tibial osteotomies based on surgeon preference and previous reports of enhanced exposure with fibular osteotomies.[20] All fresh osteochondral allografts were obtained from established tissue providers in compliance with the US Food and Drug Administration and the American Association of Tissue Banks and arrived within 48 hours of surgery, where they were stored at 2°C to 4°C to maintain chondrocyte viability until surgery. Preoperative templating using CT scan and MRI determined the precise anteroposterior, transverse, and depth dimensions of the recipient site. Based on this preoperative templating, the involved portion of the talar dome was cut and removed with an oscillating saw. Next, using metallic calipers, an exact size-matched piece of fresh osteochondral structural allograft was cut from the donor talus allograft with an oscillating saw. Donor allografts were anatomically inserted in a press-fit manner and secured with appropriate internal fixation techniques using headless compression screw fixation. Malleolar osteotomy fixation was performed in accordance with standard internal fixation principles (Figure 3). When lateral-based fibular osteotomies were required, syndesmotic screw fixation as well as lateral ligamentous repairs were routinely performed.

Postoperatively, all patients were nonweightbearing in a postoperative splint for 10 to 12 days. At the initial 2-week postoperative appointment, sutures were removed and patients were placed in a short leg fiberglass cast. Touchdown weightbearing with crutches was then permitted. At the 6-week postoperative appointment, the cast was removed and simulated weightbearing ankle radiographs were obtained. Patients were then placed in a controlled ankle motion (CAM) boot, and a standardized strengthening and range of motion physical therapy protocol was initiated. Twelve-week postoperative CT scans to assess osteotomy site and osteochondral allograft healing were obtained in all 8 cases. Full weightbearing was usually possible at this point, once radiographic healing of the osteotomy and allograft were confirmed. After confirmation of osteotomy and graft healing, and only on achieving full range of motion and strength through physical therapy, patients were permitted to gradually return to full activities and military duties as tolerated. Full return to duty typically occurred at 9 to 12 months postoperatively.

Minor complications were defined as superficial wound infection, delayed wound healing, or uneventful delayed osteotomy healing or graft incorporation of greater than 3 months. Major complications were defined as deep wound infection, osteotomy or allograft fixation hardware failure, osteotomy nonunion, failure of allograft incorporation, or allograft resorption and/or subsidence. AOFAS hindfoot-ankle and pain visual analog scores were collected at 6 and 12 months postoperatively. The latest available functional outcome scores are reported in this study. Failure of

Figure 2.

(A) Intraoperative demonstration of harvesting of fresh talar osteochondral allograft for treatment of lateral osteochondral lesion of the talus (OLT). (B) Final subchondral headless compression screw fixation of transferred allograft at recipient site.



treatment was defined as continued ankle disability and inability to perform military occupation (eg, evidenced by military separation secondary to ankle disability) or progression to fulminant ankle arthrosis requiring need for further surgical interventions (eg, ankle arthrodesis). Differences in preoperative and latest mean postoperative AOFAS hindfoot-ankle and pain visual analog scores were compared using Wilcoxon signed-rank tests to determine statistical significance. Statistical significance was assigned as a P value <.05.

Results

Lesion location and morphology and preoperative functional outcome data for all 8 patients are presented in Table 1. One patient (patient 1) had undergone prior failed treatment by another surgeon with a biosynthetic scaffold for a cystic lateral OLT. Two other patients (patients 2 and 3) had undergone prior failed microfracture treatments by other surgeons for lateral and medial OLTs, respectively. All 8 patients were male, and mean patient age was 34.4 years (range, 26.7-41.4 years).

Each of the 8 patients had a solitary symptomatic OLT. There were 5 centromedial (zone 4) and 3 centrolateral (zone 6) OLTs.[13,18] Seven of the OLTs were MRI stage 5 (cystic), and 1 lesion was MRI stage 4, resulting in a mean MRI stage of 4.9 (range, 4-5). Mean lesion dimensions were as follows: anteroposterior diameter, 16.7 mm (range, 11.9-22.8 mm); transverse diameter, 10.9 mm (range, 7.2-17.2 mm); and depth, 11.9 mm (range, 9.1-16.6 mm). Mean lesion volume was 2247.1 mm^3 (range, 1116.0-4454.1 mm^3). Preoperatively, mean AOFAS hindfoot-ankle score was 49.6 (range, 30-65), and pain visual analog score was 6.9 (range, 5.25-8.75).

At the latest mean follow-up of 28.5 months (range, 18.0-62.6 months), mean AOFAS hindfoot-ankle score was 72.8 (range, 48-85). Similarly, mean pain visual analog score was 4.5 (range, 1.0-7.0) (Table 2). This represents overall improvements in mean AOFAS hindfoot-ankle scores of 47% and pain visual analog scores of 35%. These results represent a statistically significant improvement in AOFAS hindfoot-ankle scores and no significant improvement in pain visual analog scores postoperatively. There were 2 minor complications and 1 major complication. The 2 minor complications were uneventful cases of delayed medial malleolar osteotomy union (patients 4 and 5) with eventual union. The major complication was a failure of allograft incorporation with subsequent graft resorption, which ultimately required ankle arthrodesis secondary to fulminant ankle arthrosis (patient 4). All other patients had graft incorporation and no signs of graft resorption during their available follow-up periods. Three patients required removal of symptomatic malleolar osteotomy fixation hardware.

Military retention data are presented in Table 2. Overall, at a mean follow-up of 28.5 months, 6 patients remained on full active duty military status. Two patients (patients 5 and 8) required medical separation from the military secondary to continued ankle-related disabilities. Patient 8 requested medical separation

Figure 3.

Final postoperative radiographs of patient from Figure 2, demonstrating anatomic fixation of lateral structural osteochondral allograft transfer and fibular osteotomy sites.

very early in the postoperative course, despite a 37% improvement in AOFAS hindfoot-ankle score. While 1 patient (patient 4) developed fulminant ankle arthrosis requiring ankle arthrodesis, the service member remains on full active duty status to date. Among these 3 patients who were considered treatment failures, overall mean improvement in AOFAS hindfoot-ankle score was only 10% with a worsening mean pain visual analog score of 1%. As well, final AOFAS hindfoot-ankle scores in these patients were all <70, and previous authors have used this benchmark to denote poor-to-fair results. Among the 5 patients who were considered treatment successes, overall mean improvement in AOFAS hindfoot-ankle score was 70%, with an overall improvement in pain visual analog score of 53%. Of the 6 service members who remain on active duty military service, 1 (patients 1 and 3) have gone on required overseas combat deployments, and 2 (patients 3 and 6) returned to running following allograft transfers. Finally, while it would appear that lateral OLT patients (patients 1, 2, and 7) overall did better than medial OLT patients, it is not possible with the number of patients in the current study to draw conclusions regarding lesion laterality and its effect on outcomes.

Discussion

This study analyzed our results in an active duty military population using structural allograft transfer for large, symptomatic OLTs. Previous authors have reported their results of using structural osteochondral allograft for treatment of tibiotalar joint cartilage restoration; however, only 6 others have focused directly on treatment of single OLTs in otherwise nonarthritic ankle joints, accounting for total of 99 patients reported in the literature.[6,8,9,12,13,15,16] Gross et al[8] reported on 9 consecutive patients who underwent this procedure for isolated OLTs but did not provide functional outcome data. At mean 12 years' follow-up, 4 patients developed graft resorption, with 3 requiring ankle arthrodesis secondary to resorption. Another series described 15 consecutive patients who underwent similar structural allograft transfers for large cystic osteochondral lesions of the talus over a 7-year period. The authors showed a >100% improvement in postoperative AOFAS hindfoot-ankle scores and a 62% improvement in pain visual analog scores with greater than 4 years' follow-up.[12] Similarly, at mean follow-up of 4 years, Adams et al[6] reported a 76% improvement in Lower Extremity Functional Scale scores and a final mean postoperative AOFAS hindfoot-ankle score of 84 in 8 patients who underwent structural allograft transfers for large OLTs. The authors also demonstrated an 83% reduction in pain visual analog scores over this same period. A retrospective study of 13 patients with large OLTs concluded that structural allograft transfer was a reasonable procedure, reporting an 80% improvement in AOFAS hindfoot-ankle scores at 4 years' follow-up.[9] In the largest published series, authors reported on 38 patients who underwent structural allograft transfers, demonstrating a 51% improvement in mean AOFAS hindfoot-ankle scores and a 60% improvement in pain visual analog scores.[15] Most recently, Haene et al[16] reported modest overall improvements in 16 patients who underwent structural allograft transfer for large OLTs but an overall failure rate of 31%, most closely paralleling the current series. With a postoperative AOFAS score of 79, and a one-third overall failure rate, the authors recommended tempering patient expectations following structural allograft transfer.

While the current investigation demonstrated improvements in mean AOFAS hindfoot-ankle scores (47%) and pain visual analog scores (35%), these improvements are not as substantial in this active duty military population as in some other civilian populations.[6,8,9,12,13,15,16] When the results of previous series on OLTs are pooled and overall means are proportionately determined (Table 3), the mean postoperative AOFAS hindfoot-ankle score at a mean 47.4 months (range, 38-54 months) was 80.2 (range, 79-84), and the mean postoperative pain visual

Table 1.

Preoperative Lesion Characteristics and Patient Functional Outcome Scores.

Patient	Age (Years)	Lesion Laterality	Lesion Morphology				Preoperative AOFAS (HA) Score	Preoperative Pain VAS
			MRI Stage	Surface Area (mm^2)	Depth (mm)	Approximate Volume (mm^3)		
1	36.5	Lateral	5	268.3	16.6	4454.1	55	7.5
2	40.7	Lateral	5	138.0	13.3	1835.9	30	8.75
3	33.1	Medial	5	111.6	10.0	1116.0	63	5.4
4	39.7	Medial	5	233.2	13.6	3171.2	65	5.25
5	41.4	Medial	5	120.1	10.9	1309.3	55	6
6	29.1	Medial	5	228.3	11.9	2716.3	34	8
7	27.7	Lateral	5	130.2	9.1	1184.8	60	7
8	26.7	Medial	4	225.7	9.7	2189.5	35	7
Mean (SD)	34.4 (6.0)		4.9 (0.4)	181.9 (62.7)	11.9 (2.5)	2247.1 (1159)	49.6 (14.3)	6.9 (1.2)

Abbreviations: AOFAS (HA), American Orthopaedic Foot and Ankle Society (Hindfoot-Ankle); MRI, magnetic resonance imaging; VAS, visual analog score.

Table 2.

Short-Term Functional and Occupational Outcomes Following Talus Bulk Allograft Transfer in Active Duty Military Personnel.

Patient	Latest Follow-Up (Months)	Postoperative AOFAS (HA) Score (% Improvement)	Postoperative Pain VAS (% Improvement)	Medical Separation From Military[a]	Comments
1	62.6	85 (55)	5.0 (33)	No	(+) Active duty status Completed combat deployment
2	20.8	84 (180)	3.8 (57)	No	(+) Active duty status
3	39.3	85 (35)	1.0 (82)	No	(+) Active duty status Completed combat deployment (+) Running
4	22.9	57 (–12)	5.5 (–5)	No	(+) Active duty status Delayed osteotomy union *Treatment failure:* Failure of graft incorporation requiring ankle arthrodesis
5	15.0	65 (18)	6.0 (0)	Yes	Delayed osteotomy union *Treatment failure:* Medical separation[a]
6	25.2	78 (129)	3.5 (56)	No	(+) Active duty status (+) Running
7	24.2	80 (33)	5.0 (29)	No	(+) Active duty status
8	18.0[b]	48 (37)	7.0 (0)	Yes	Medical separation
Mean (SD)	28.5	72.8 (14.3)[c] 47% Improvement	4.5 (1.8) 35% Improvement		

Abbreviations: AOFAS (HA), American Orthopaedic Foot and Ankle Society (Hindfoot-Ankle); VAS, visual analog score.
[a]Medical separation from the military secondary to continued ankle-related disabilities.
[b]Patient lost to follow-up immediately on medical separation from the military.
[c]Statistically significant result.

Table 3.

Results of Other Osteochondral Bulk Allograft Transfer Series Reporting Functional Outcomes for Treatment of Osteochondral Lesions of the Talus Only.

Series	No. of Patients	Mean Follow-up (Months)	Lesion Volume (mm^3)	Postoperative AOFAS (HA) Score (% Improvement)	Postoperative Pain VAS (% Improvement)
Raikin (2009)[12]	15	54	6059	83 (118)[a]	3.3 (62)[a]
Hahn et al (2010)[9]	13	48	NR[b]	81 (80)[a]	NR
Adams et al (2011)[6]	8	48	2089	84 (—)[c]	1.0 (83)[a]
El-Rashidy et al (2011)[15]	38	38	NR[b]	79 (51)[a]	3.3 (60)[a]
Haene et al (2012)[16]	16	49	3408	79 (—)[d]	NR
Proportional results (n = 90)		47	—	80 (—)	3.0 (—)
Orr et al (2015), current study	8	29	2247	73 (47)	4.5 (35)

Abbreviations: AOFAS (HA), American Orthopaedic Foot and Ankle Society (Hindfoot-Ankle); NR, not reported; VAS, visual analog score.
[a]Denotes statistically significant improvement from preoperative.
[b]Only surface areas reported.
[c]Authors did not obtain preoperative AOFAS (HA) scores but did note a 76% improvement in Lower Extremity Functional Scale (LEFS) score.
[d]Authors did not obtain preoperative AOFAS (HA) scores but did note a 31% improvement in American Osteoarthritis Scale (AOS) score.

analog score among studies reporting was 3.0 (range, 1.0-3.3). Conversely, the current series demonstrated a mean AOFAS hindfoot-ankle score of 72.8 and a mean pain visual analog score of 4.5 at more than 2 years' follow up. These differences cannot be attributed to differential lesion volume, as our population had similar lesion volume as 2 other series[6,16] and a notably smaller mean lesion volume than another.[12] As well, these differences cannot be attributed to the high number of stage 5 cystic lesions in the current series, as one published series included only cystic OLTs.[12] It is our supposition that the higher occupational demands and daily pressures to perform at a high level among the active duty military service members in the current series contribute to our relatively lower improvements in AOFAS hindfoot-ankle and pain visual analog scores following structural allograft transfer. Active duty service members participate daily in mandatory organized physical fitness training programs, as well as physically demanding military occupational specialty requirements. For example, 2 service members in the current series completed unrestricted combat deployment tours of duty following structural allograft transfers.

There was 1 case of graft resorption and subsequent need for ankle arthrodesis among 8 patients in the current study. In the largest reported structural allograft outcomes series, the authors noted minimal graft subsidence and no frank resorption in 15 of 38 patients who were available for postoperative MRI.[15] In another series, 10 of 15 patients demonstrated subclinical radiographic subsidence or resorption, but this did not adversely affect functional outcomes.[12] Others have reported no radiographic graft resorption or requirement for ankle arthrodesis or arthroplasty at intermediate follow-up.[6] Finally, Haene et al[16] reported a 13% failure of graft incorporation rate and frequent graft subsidence and surrounding progression of arthritis at 4 years' follow-up. The current report does not have the benefit of long-term follow-up, and possibly with more follow-up our incidence of graft resorption and subsequent ankle arthrodesis might increase.

The authors acknowledge the strengths and weaknesses in the current series. First, this is a retrospective study and retains the inherent limitations of such studies, although all prior series on this topic have similarly been retrospective. Second, this series represents a small patient sample size; however, only 6 other series have been published to date, with only five of them (n = 90), providing functional outcomes data.[6,8,9,12,13,15,16] Third, the active duty military population is a relatively unique patient population, which may limit the external validity of the current study. These results can be appropriately compared to other physically active adult patient populations whose activity demands are through sports or high-demand occupational activities. The authors contend that the high-demand nature of this patient population serves as a relative strength, as these results represent the first and only outcomes ever reported in such a ubiquitously high-function cohort. Fourth, the authors recognize that the AOFAS hindfoot-ankle score is not a scientifically-validated outcomes measure but can serve as an indicator of patient outcomes.[21-23] Fifth, as in all previous studies on this topic, there was no comparison group, indicating the need for further comparative treatment outcome studies for large OLTs.

Conclusions

With the described limitations of this study, we conclude that good short-term results can be obtained using structural fresh osteochondral allograft transfer for treatment of appropriately indicated OLTs in a high-demand patient population.

Authors' Note

The authors are employees of the US Federal Government and the US Army. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of William Beaumont Army Medical Center, the Department of Defense, or United States Government. FAS

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