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Treatment of Post-traumatic Ankle Arthrosis with Bipolar Tibiotalar Osteochondral Shell Allografts

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ABSTRACT

We report on tibiotalar osteochondral shell allografts for post-traumatic ankle arthropathy in seven patients. Average follow-up was 148 months (range, 85 to 198). Patients were evaluated by a questionnaire, SF-12 survey, ankle score, physical exam and radiographs. The ankle score increased from 25 preoperatively to 43 at latest follow-up (maximum score 100). SF-12 scores increased from 30 to 38 (Physical Component) and 46 to 53 (Mental Component). The failure rate was 42%. Four of seven patients reported good or excellent results. Five patients stated they would undergo a similar procedure again. Complications included graft fragmentation, poor graft fit, graft subluxation, and non-union. Follow-up radiographs demonstrated joint space narrowing, osteophytes, and sclerosis, even in cases with excellent clinical status. Fresh osteochondral shell allografting may provide a viable alternative for the treatment of post-traumatic ankle arthrosis in selected individuals.

Key Words: Osteochondral Allograft; Ankle Arthrosis; Joint Transplantation; Joint Reconstruction; Post-Traumatic Arthrosis; Cartilage Transplantation.

INTRODUCTION

Trauma to the tibiotalar joint such as seen in fracture or blunt chondral injury can progress to joint arthrosis. Post-traumatic tibiotalar arthrosis remains a difficult clinical challenge. Surgical treatment typically relies on arthrodesis or prosthetic arthroplasty. Arthrodesis provides satisfactory relief of pain but creates functional limitations.[18,20,25,28] Total ankle arthroplasty has demonstrated sub-optimal long-term success, particularly in younger, active individuals.[14,15] Fresh osteochondral shell allografting is an alternative procedure designed to replace diseased or damaged articular cartilage and maintain joint function. Previous studies in the knee and hip have shown that such osteochondral shell allografts are a viable alternative to arthrodesis, reconstructive arthroplasty, and other joint preserving procedures.[2,4,5,7,9-11,19,21,23,24] Our institution has performed bipolar tibiotalar fresh shell osteochondral allografts as an alternative treatment for post-traumatic ankle arthropathy in a small cohort of patients. We report our experience with tibiotalar osteochondral shell allografts as an alternative treatment for post-traumatic ankle arthropathy.

MATERIALS AND METHODS

In 1983, a fresh osteochondral allograft program was established after institutional review board approval. This program was designed to transplant fresh osteochondral allografts into injured and arthritic joints. Since 1983, over 300 allografts have been performed in the knee, hip, and ankle.

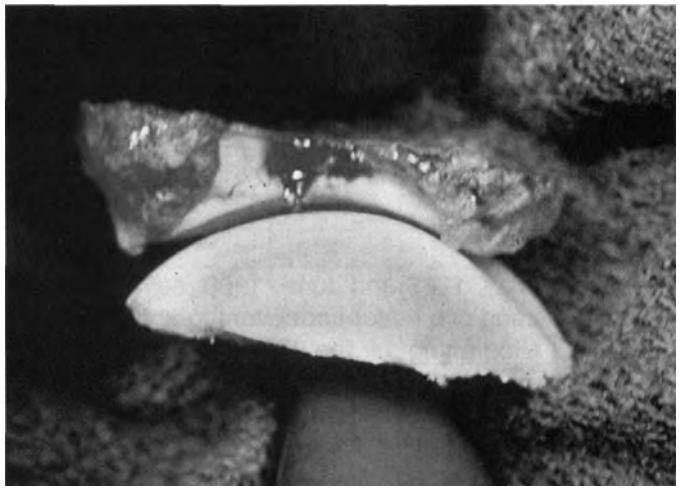

Fig. 1: Donor osteochondral shell allograft prior to preparation and transplantation.

Investigation performed at the Department of Orthopaedic Surgery, University of California, San Diego, CA.

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Fig. 2: Exposure of the recipient site using the anterior approach to the ankle. The weightbearing surface of the tibia and talus are resected with osteotomes.

Table 1: Ankle Score Survey

Patient	Preoperative	At latest follow-up	
1.JM	45	35	
2.TK	50	80	
3.NH	45	35	
4.MH	20	30	
5.VR	0	0	
6.BB	15	65	
7.LH	0	55	
Average Score	**25**	**43**	*p=0.07*

Between May, 1985 and June, 1990, seven patients (five female and two male) underwent fresh osteochondral shell allografting of the tibiotalar joint. Patients underwent careful history, physical, and radiographic evaluation confirming the diagnosis of post-traumatic tibiotalar degenerative arthrosis. All patients were referred after conventional non-operative measures, such as physical therapy, medication, braces, and walking aids had failed to provide satisfactory relief of pain. Patients were given a detailed explanation of the procedure and treatment alternatives, and chose to proceed with allografting. Patients were evaluated by clinical exam, radiographs, ankle score survey,[26] and the Short Form-12 General Health Survey.[29] The average age at surgery of the seven patients was 45 years (range, 34 to 67). Average clinical follow-up was 148 months (range, 85 to 198). Radiographs were available for six patients. Average radiographic follow-up was 148 months (range, 80 to 198) All patients were evaluated by one of the authors or an orthopaedic surgeon if local follow-up was not available.

PROCUREMENT

Osteochondral allografts were obtained from fresh cadavera of individuals meeting the criteria of the American Association of Tissue Banks.[13] The University of California, San Diego Tissue Bank and the Miami Tissue Bank supplied the allografts. Allografts were harvested within 24 hours of death and were transplanted fresh within five days from the time of procurement. Grafts were placed in sterile plastic bags and immersed in Ringer's lactate solution containing one-gram cephalothin (Keflin®) and 10 milligrams of gentamicin (Garamycin®) per liter. The sterile plastic bags were placed in sterile jars and stored at 4° Celsius until they were used. Specimens were tested for antibodies to HIV, syphilis, and hepatitis.[13]

Before the operation, the size of the donor tibia and talus was matched to the host using radiographs. No tissue or blood type matching was performed. The tibia and talus were isolated from the donor specimen and cut to create a graft of articular cartilage with approximately 1 cm of underlying bone (Fig. 1).

Surgical Procedure

An anterior approach to the ankle was made between the extensor hallucis longus and extensor digitorum longus. The weightbearing surfaces of the tibia and talus were excised with osteotomes or oscillating saws to create a size-matched defect that would accommodate the donor graft (Fig. 2). The medial and lateral ligamentous structures were preserved when possible. The grafts were either press fit or fixed with polydiaxanone (PDS) pins (Johnson & Johnson, Raynham, MA) or Herbert® screws (Zimmer Inc., Warsaw, IN). Postoperatively, patients were maintained non-weightbearing for 12 weeks. Passive range-of-motion was instituted within two weeks.

Ankle Score Survey

All subjects were asked to respond to a standardized questionnaire regarding pain, swelling, stiffness, work

Table 2: Clinical Questionnaire and Clinician Physical and Radiographic Evaluation

	Clinical Questionnaire								Clinical Examination					Radiographic Evaluation			
	Pain		Activity Supports		Maximum Walking Distance		Walking Surfaces		Gait Abnormality	Sagittal Motion	Hindfoot Motion	Ankle Hindfoot Stability	Clinical Alignment	Graft Interface	Joint Space	Osteophytes	Radiographic Alignment
Patient	Pre-operatively	At latest follow-up	Pre-operatively	At latest follow-up	Pre-operatively	At latest follow-up	Pre-operatively	At latest follow-up									
1. JM	Severe	Severe	Severe limitation	No Limitation of daily activity, Limitation of recreational activity	1-3 blocks	Greater than 6 blocks	Some difficulty with uneven terrain	Some difficulty with uneven terrain	None, Slight	No motion (Surgical arthrodesis)	Marked restriction (less than 25% of normal side)	Stable	Good Planti grade foot, ankle-hindfoot well aligned	Arthrodesis	N/A	N/A	N/A
2. TK	Severe	Moderate	Limited	No Limitation of daily activity, Limitation of recreational activity	4-6 blocks	Greater than 6 blocks	Severe difficulty with uneven terrain	Some difficulty with uneven terrain	None, Slight	Normal or mild restriction (30° or more)	Normal or mild restriction (75-100% of normal side)	Stable	Good Planti grade foot, ankle-hindfoot well aligned	Lucency on tibia graft interface 1-3 mm thickness	Marked narrowing 1-3 mm	3 or more	Normal (<5°)
3. NH	Lost to clinical follow-up	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Marked narrowing 1-3 mm	N/A	N/A
4. MH	Severe	Mild	Limited	No Limitation of daily activity, Limitation of recreational activity	1-3 blocks	2 miles	Severe difficulty with uneven terrain	Some difficulty with uneven terrain	None, Slight	Moderate restriction (15-29°)	Marked restriction (less than 25% of normal side)	Stable	Good Planti grade foot, ankle-hindfoot well aligned	N/A	N/A	N/A	N/A
5. VR	Severe	Moderate	Severe limitation	Limited	Less than 1 block	1-3 blocks	Severe difficulty with uneven terrain	Some difficulty with uneven terrain	None, Slight	No motion (Surgical arthrodesis)	Moderate restriction (25-74% of normal side)	Stable	Good Planti grade foot, ankle-hindfoot well aligned	Arthrodesis	N/A	N/A	N/A
6. BB	Severe	Mild	Limited	No limitation	Less than 1 block	Greater than 6 blocks	Severe difficulty with uneven terrain	Some difficulty with uneven terrain	None, Slight	Normal or mild restriction (30° or more)	Moderate restriction (25-74% of normal side)	Stable	Good Planti grade foot, ankle-hindfoot well aligned	Lucency on talus graft 1-3 mm thickness	Marked narrowing 1-3 mm	3 or more	Normal (<5°)
7. LH	Severe	Mild	Severe limitation	No Limitation of daily activity, Limitation of recreational activity	1-3 blocks	Greater than 6 blocks	Severe difficulty with uneven terrain	No difficulty on any surface	None, Slight	Normal or mild restriction (30° or more)	Normal or mild restriction (75-100% of normal side)	Stable	Good Planti grade foot, ankle-hindfoot well aligned	Fully healed	Marked narrowing 1-3 mm	3 or more	Normal (<5°)

Table 3: Summary of Patient Data

Patient	Age	Sex	Mos f/u	Fixation	Complication	Rating	Would do again?
1. JM	43	F	140	Pressfit	Tibial graft fragmentation. Failed. Arthrodesis successful.	Poor	No
2. TK	54	M	142	Pressfit		Good	Yes
3. NH	43	F	106	Herbert screws	Talar subluxation due to poor fit. Revised.	Poor	Yes
4. MH	67	M	105	PDS pins-talus Herbert screws-tibia		Good	Yes
5. VR	35	F	116	Pressfit	MM Fx, Non-union, Arthodesis successful	Poor	No
6. BB	41	F	149	Pressfit		Excellent	Yes
7. LH	34	F	155	Pressfit		Excellent	Yes

performance, and other daily activities. The Ankle Score is a functional rating system from 0 (totally impaired) to 100 (completely unimpaired).[26] Preoperative scores were obtained retrospectively.

Patient Questionnaire

Patients were asked to rate the performance of their ankle with regard to onset and duration of pain, limitation of activity and use of aids, maximum walking distance,

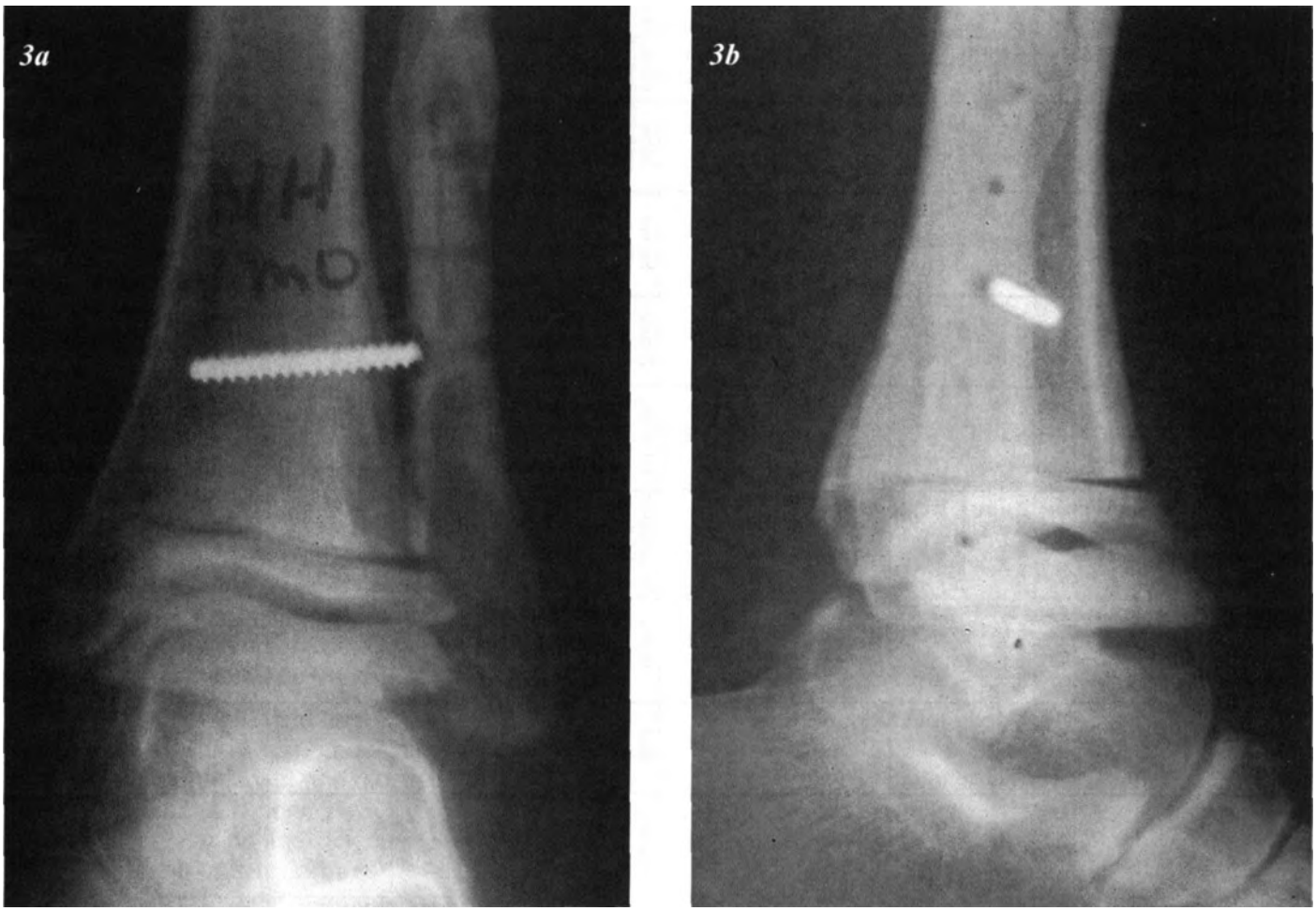


Fig. 3: (a,b) One month postoperative radiographs showing talar graft subluxation. **(c)** Talar graft revision and fixation with Herbert® screws (immediate postoperative radiograph). **(d)** Radiographs two years postoperatively showing malunion and subsequent joint arthrosis.

difficulty with walking surfaces. Preoperative data were obtained retrospectively.

Clinical Questionnaire

All patients were examined by an orthopaedic surgeon. Physical examination parameters included gait, sagittal motion, hindfoot motion, hindfoot stability, and clinical alignment of the tibiotalar joint.

Short Form-12 General Health Survey

All subjects were asked to respond to the Short Form-12 Health Survey (SF-12). The SF-12 is derived from the Short Form-36 but contains only 12 questions.[29] It is a measure of general health as it relates to two aspects of health perception.

The first component is the physical component summary (PCS) which reflects a patient's view of his/her physical well being.

The mental component summary (MCS) reflects a patient's view of his/her emotional well being. Scores are standardized for norm-based scoring with an average and standard deviation of 50±10 points. Preoperative scores were obtained retrospectively.

Patients were asked to subjectively rate the overall procedure as excellent, good, fair, or poor. They were also asked if they would undergo the same procedure on the other ankle if similar symptoms were encountered.

Radiographic Evaluation

At latest follow-up, standard AP, lateral, and mortise radiographs of the ankle were obtained on six patients. Two of these patients had undergone arthrodesis at time of latest follow-up. Radiographs were analyzed for lucency at the graft interface, the preservation of tibiotalar joint space, presence of osteophytes, and radiographic tibiotalar alignment.

Statistics

Ankle Score and SF-12 scores were analyzed using the paired t-test using one-tailed analysis. Statistical significance was set at $p<0.05$,

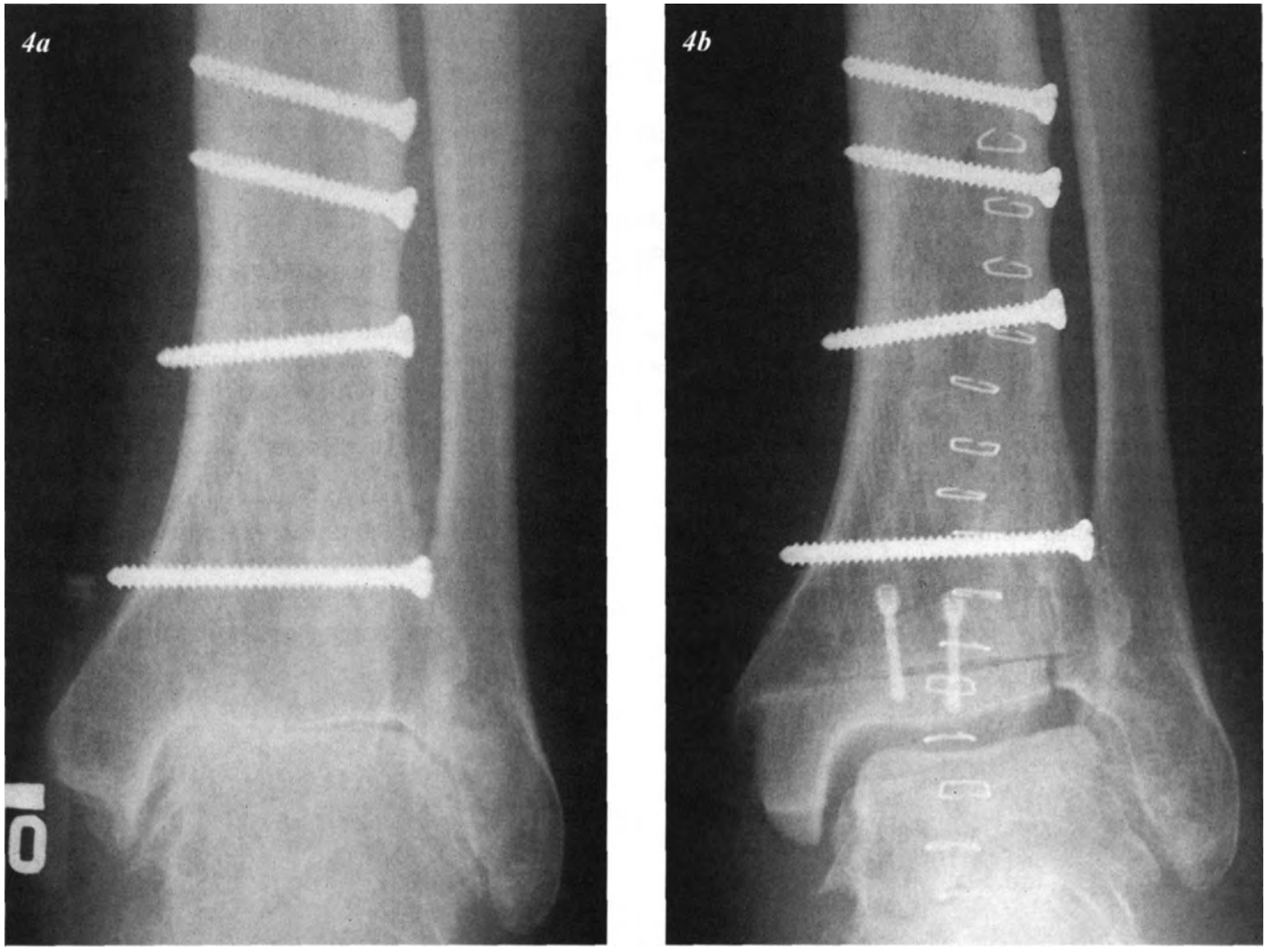


Fig. 4: (a) Preoperative radiographs of patient MH showing severe post-traumatic degenerative arthritis of the tibiotalar joint. **(b)** Immediate postoperative radiograph showing Herbert® screw fixation of the tibial graft and PDS pin fixation of the talar graft. **(c)** AP and mortise radiograph two years postoperatively showing good allograft incorporation and maintenance of joint space. **(d)** Radiograph six years postoperatively showing full allograft incorporation but significant decrease in joint space.

RESULTS

Ankle Score

The average Ankle Score increased from 25 preoperatively (range, 0 to 50), to 43 at latest follow-up (range, 0 to 80). (Table 1) This difference was not statistically significant. However, in those patients rating the result of the procedure as good or excellent, the average increase in score was 38 points.

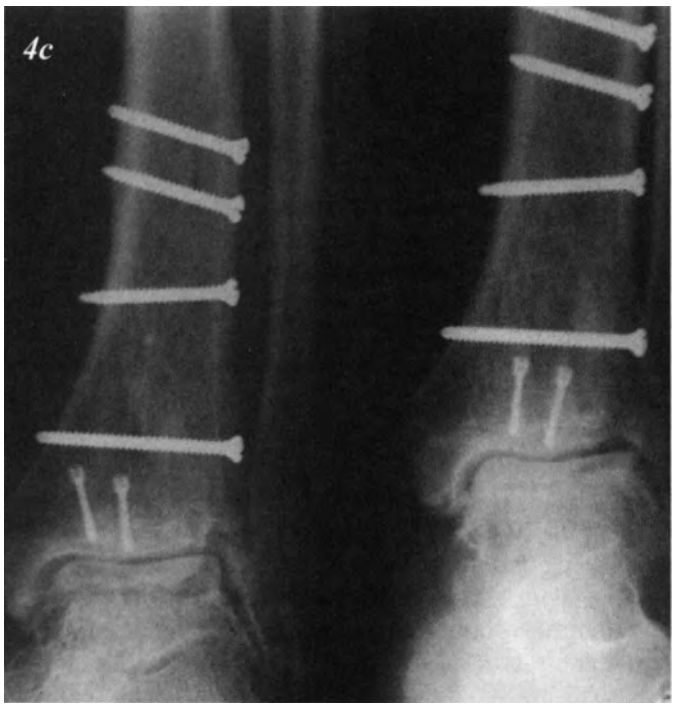
Patient and Clinical Questionnaire

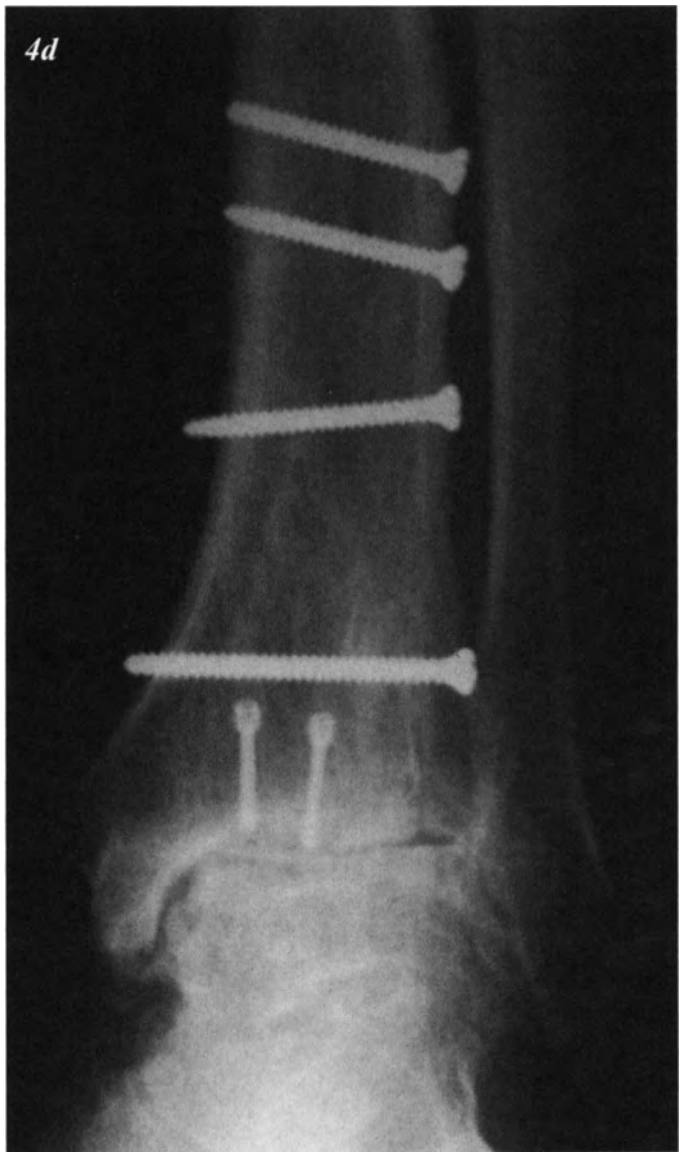
Patient responses to the clinical questionnaire and the clinician evaluation obtained at latest follow-up are shown in Table 2. The responses demonstrate the severe limitations of the patients prior to surgery and a trend toward improvement in pain, use of supports, maximum walking tolerance, and walking on uneven surfaces. The two patients who underwent fusion were evaluated post-arthrodesis.

The clinician evaluation at latest follow-up is notable for ambulation with minimal limp, good sagittal motion, decreased hindfoot motion, and general preservation of stability and alignment.

SF-12 Health Survey

The average Physical Component Summary (PCS) score improved from 30 preoperatively to 38 at latest follow-up. The average Mental Component Summary (MCS) score improved from 46 preoperatively to 53 at latest follow-up. These differences were not statistically significant. In those patients rating the result of the procedure as good or excellent, the average increase in





score in the physical component summary was 12.75 and in the mental component summary 16.5.

General Satisfaction Survey

Four of the seven patients subjectively rated the procedure as good or excellent (Table 3). Three patients rated the procedure as poor. Given the opportunity of having a similar operation on the contralateral ankle if it developed degenerative arthrosis, five of seven responded that they would (Table 3).

Complications

Three patients had a poor result. JM developed fragmentation of the tibial graft secondary to malalignment of the tibial and talar grafts. She continued to have pain and subsequently underwent a successful arthrodesis. NH developed a malunion with talar subluxation secondary to poor fit of the talus (Figs. 3a, 3b). The talar graft was revised and fixed with Herbert® screws (Fig 3c), but she continues to have pain and disability due to malunion (Fig. 3d). VR developed a medial malleolus fracture intra-operatively which was treated with internal fixation. She developed a non-union of the allograft and subsequently underwent successful arthrodesis. She also seroconverted for the HIV antibody. The source of infection is unknown. No other recipients of donor tissue from the same cadaver are known to have developed antibodies to HIV.

Representative Case from Current Series

The serial radiographs from a representative case are shown in Figure 4. In this case, the tibial component was internally fixed with screws (Fig 4b). There was full incorporation of the grafts into the host bone. Tibiotalar joint space was well maintained at two years follow-up (Fig. 4c). At six years follow-up, there was interim loss of joint space, but the grafts continued to be well incorporated.(Fig. 4d) This patient (MH) continues to do well clinically nearly nine years after her surgery. There was improvement of the Ankle Score (Table 1), improvement in the Physical Component Score of the SF-12 (Table 3) and the patient subjectively rated the result as good and would have the surgery on the other ankle if similar symptoms developed (Table 3). These findings are similar to the other three successful transplant cases.

Revised Surgical Technique

A difficulty encountered with this procedure is a lack of precision instrumentation resulting in suboptimal

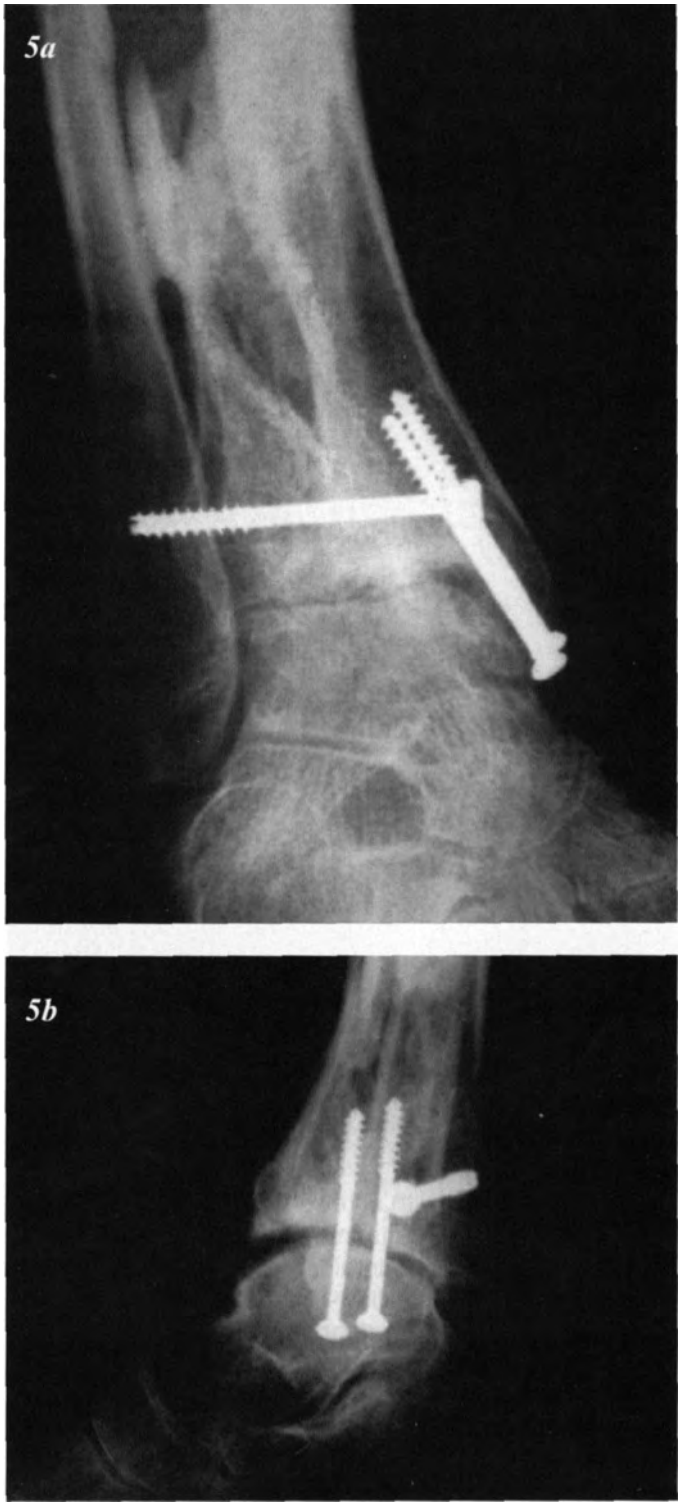


Fig. 5: Preoperative AP **(a)** and lateral **(b)** view of ankle with post-traumatic arthritis.

graft fit. The surgical technique has been recently modified in order to improve precision of this "osteochondral arthroplasty." This has been possible with the use of cutting jigs from the Agility® ankle arthroplasty system (Depuy, Warsaw IN). These cutting jigs and alignment systems allow more precise size matching and improved fit of the tibiotalar allografts in order to improve stability and incorporation of the graft as well as to restore tibiotalar anatomy. This technique has been utilized at our institution in 17 patients with excellent success with a follow-up of approximately one year.

Case Presentation

MP is a 45-year-old woman who suffered a grade IIIB open tibial pilon fracture. This was treated with open debridement and irrigation with reduction and internal fixation. This was complicated by an acute infection requiring a gastrocnemius flap with bone allograft reconstruction to the distal tibia. Over the next three years she developed progressive post-traumatic arthrosis of the right ankle (Fig. 5). Ambulation was limited to several blocks. Range of motion was from neutral to 5° of plantarflexion. She failed treatment with non-steroidal anti-inflammatory medications and aggressive physical therapy. She required high dose narcotic pain medication. She was counseled on the risks, benefits and alternatives of treatment of her condition, including ankle arthrodesis and total ankle arthroplasty. She elected to proceed with fresh tibiotalar osteochondral allografting.

Surgical Procedure

An external fixator (EBI®, Parsippany, NJ) was applied to the leg medially with pins in the talar neck, calcaneus, and two pins in the tibia for the purpose of distraction. An anterior approach to the ankle was made, in the interval between the tibialis anterior and extensor hallicus longus. Subperiosteal dissection was carried out along the anterior tibia and talus to expose the entire ankle joint. Debridement of the anterior joint was performed with rongeurs and osteotomes, and the external fixation was then engaged to distract the joint approximately 1 cm.

The patient was templated to a size 3 ankle and the corresponding Agility® ankle arthroplasty jig was fixed onto the anterior ankle (Fig. 6). Utilizing a blunt-tipped reciprocating saw, the talar dome was resected to a depth of approximately 7 mm and the tibial plafond was resected to a depth of approximately 7 mm including a 3-4 mm articular portion of the medial malleolus (Fig. 7). Extreme care was taken due to the proximity of the posteromedial neurovascular bundle. On the lateral aspect of the tibial cut, care was taken to avoid contact with the fibula. Careful removal of this bone was performed using rongeurs leaving the posterior capsule intact. This left a gap measuring approximately 19.5 mm.

Next the tibial and talar fresh allografts were opened. These grafts had previously been matched to the

Fig. 6: Agility® ankle arthroplasty jig (Depuy, Warsaw, IN) placement on anterior ankle.

patient's size by measurement of talar width. The size 4 Agility® ankle cutting jig, one size larger than the jig used on the recipient, was pinned onto the graft in the appropriate orientation and checked under fluoroscopy. The tibial graft was then cut with an oscillating saw (Fig. 8). The graft was seated in the recipient site on the tibia. Next, the gap between the tibial graft and the osteotomized talar dome was measured at 8 mm. The talus graft was then cut with an oscillating saw using a free-hand technique to a final thickness of 9 mm. Both grafts were lavaged to remove all marrow elements. With the ankle in plantarflexion, the grafts were seated into the recipient mortise with excellent fit (Fig. 9). The external fixator was removed. The ankle was brought through a range-of-motion. Imaging confirmed grafts had complete apposition to host bone and that the anatomy of the tibiotalar joint had been restored. Two 3.0 mm cannulated screws (Synthes, West Chester, PA) were placed into each graft for additional fixation. Range-of-motion exercises were started on postoperative day 10 and touch down weightbearing maintained for three months. At six months, the allograft demonstrated complete radiographic healing (Fig 10). At eight

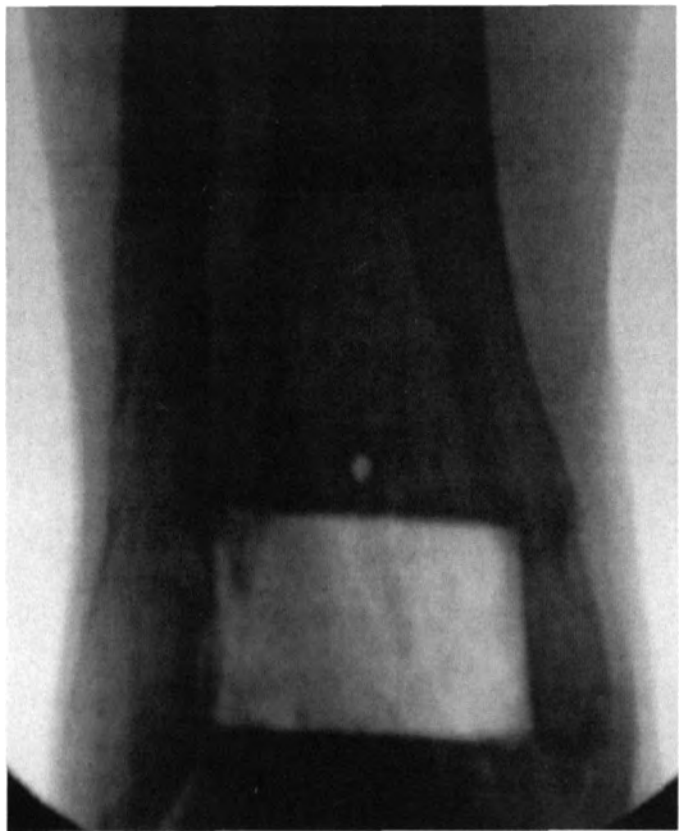


Fig. 7: Intra-operative fluoroscopy image after tibiotalar resection.

months follow-up, the patient reports dramatic functional improvement. Current range-of-motion is 25° of dorsiflexion to 10° of plantarflexion. She has essentially unlimited walking tolerance. She is extremely satisfied with the surgery.

DISCUSSION

Severe fractures and dislocations about the ankle may lead to post-traumatic ankle arthrosis.[1,12] Ten percent of fractures with good reduction and 85% of fractures with poor reduction result in post-traumatic arthrosis.[16] Traditionally, post-traumatic arthrosis has been treated by tibiotalar arthrodesis, which provides a satisfactory outcome in the majority of patients.[3,6,25] However, arthrodesis causes functional limitations such as difficulty with participation in vigorous sporting activities.[18] Long-term results of ankle arthrodesis in 23 patients at a mean follow-up of 22 years were reported by Coester et al.[3] A statistically significant increase in radiographic osteoarthritis of the adjacent joints of the foot was demonstrated relative to the contralateral side.

Total ankle arthroplasty is another option. Long-term results have prevented wide acceptance of this procedure, particularly in younger, active individuals.[14,15] Pyevich et al. reported the University of Iowa experience

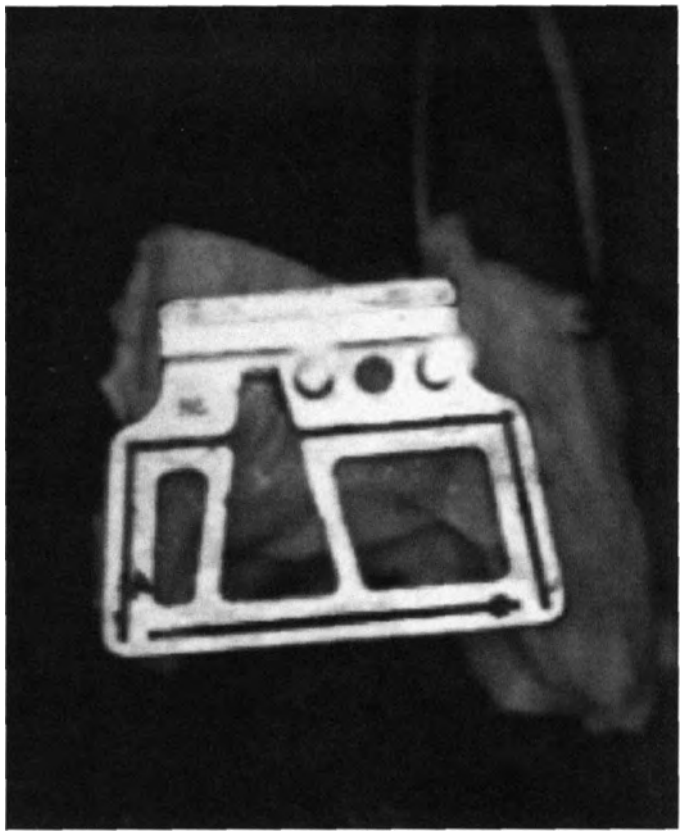


Fig. 8: Size 4 Agility® ankle jig placement onto the tibial graft prior to resection.

Fig. 9: *In vivo* placement of fresh tibiotalar allograft prior to screw fixation.

with the Depuy Agility® total ankle arthroplasty in 85 ankles at average follow-up of 4.8 years.[27] Fifty-five percent of patients who still had the original implant were without pain, and 28% were only mildly painful.

Resurfacing of the tibiotalar joint with fresh osteochondral shell allograft is a biologic alternative that relies on two principles:

1. fresh cartilage contains viable chondrocytes that survive transplantation and support the intact cartilage matrix
2. transplanted bone is incorporated and replaced by host bone through creeping substitution.

The graft is thus a composite of living cartilage and non-living bone.

The recent report by Gross et al.[8] discussed the use of fresh osteochondral allografts in nine patients (mean age 38 years) with displaced osteochondritis dissecans lesions of the talar dome. Their technique involved a medial malleolus osteotomy in all patients. The allograft was placed in the prepared defect cavity. At average follow-up of 12 years (range, 4 to 20), three patients had been converted to ankle arthrodesis. Six patients were considered successes based on functional range-of-motion, minimal swelling, and walking tolerance greater than one hour. In contrast to the present study, these individuals underwent single surface (talar) grafting rather than replacement of both surfaces of the tibiotalar joint. Nonetheless, their long-term outcomes (6/9 successful) were similar to the cohort described herein.

Outcome measurement tools, such as the Olerud and Molander Ankle Score[26] and the SF-12 General Health Survey, evaluate the effectiveness of various medical treatments and operative procedures from the patient's point of view.[29] A potential bias in this study is the use of questionnaires in a retrospective fashion. The preoperative scores for both the Ankle Score and SF-12 rely on patients to accurately recall their status preoperatively. Lingard et al. reported on the pitfalls of using patient recall in determining preoperative status in outcome studies focusing on total knee arthroplasty. They found that patients' recall of preoperative pain and functional status three months after total knee arthroplasty demonstrates only moderate agreement with the prospective rating.[17] Nearly all questions on the Olerud and Molander Ankle Score and the SF-12 are simple and straightforward. The accuracy of the questionnaires was optimized in this setting by telephone interviews with all patients. Telephone follow-up of questionnaires

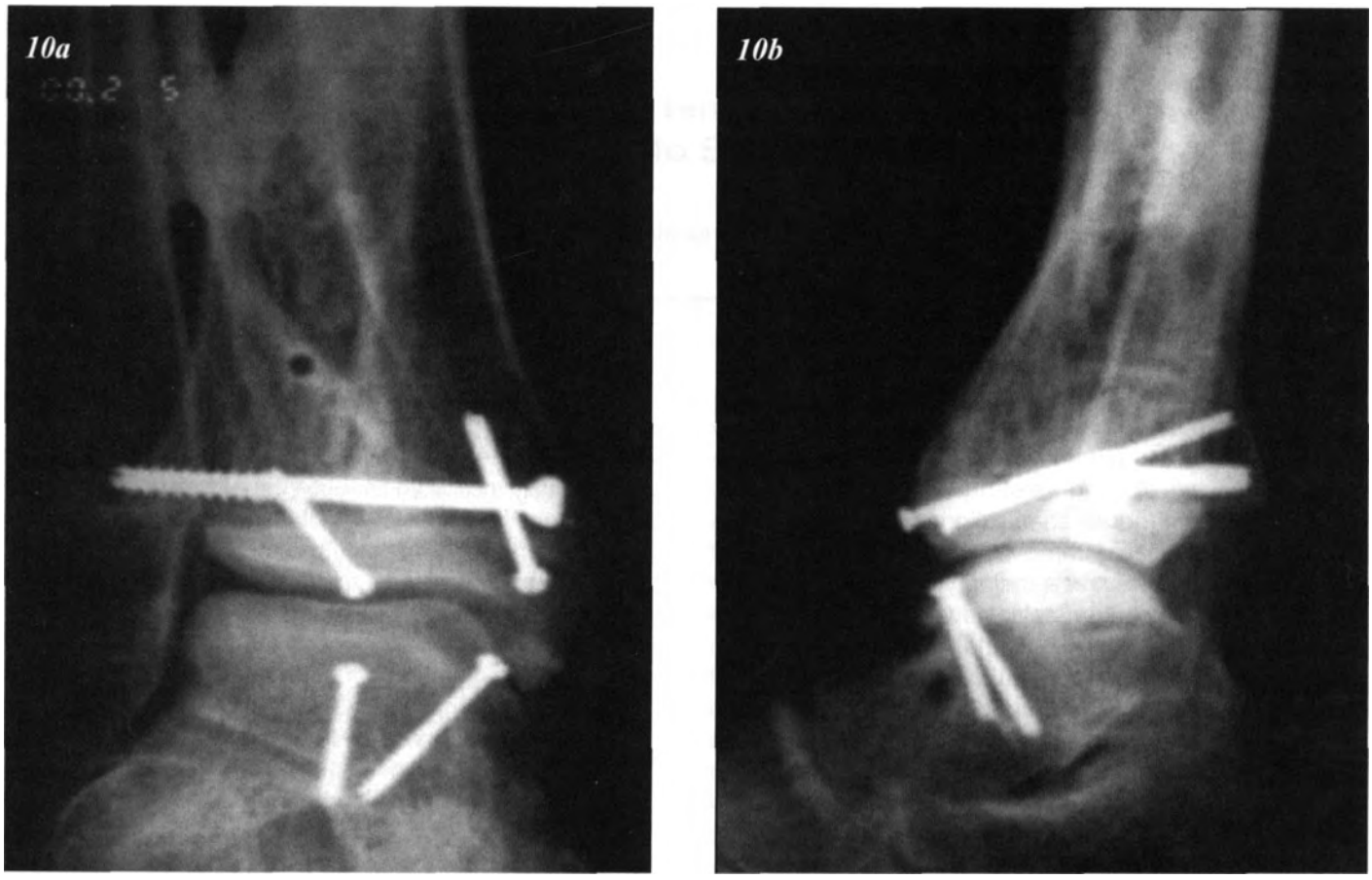


Fig. 10: Six month postoperative AP **(a)** and lateral **(b)** view of operative ankle.

have been shown to improve data accuracy.[22] Additional clinical information was thus available in assessing the patients' activity level before and after the operation. Final physical and radiographic evaluation demonstrated improvement in patient function with this intervention. A relative strength of the analysis was the mean follow-up interval of over 12 years. The relatively modest improvements in ankle score and SF-12 scores should also be considered in the context of the aging of the study cohort over the follow-up period.

We have reported the long-term results of ankle osteochondral shell allografts in patients with post-traumatic tibiotalar degenerative arthrosis. Most patients were satisfied with their results, had good relief of pain, and had acceptable function. Preservation of some ankle motion may preclude arthrosis of the hindfoot and midfoot seen after arthrodesis.[3,25] The allografting procedure may be more conservative than prosthetic arthroplasty in that failure of the allograft does not preclude revision of the graft nor does it appear to lead to difficulties in conversion to arthrodesis. We have not had the opportunity to convert an allograft to prosthetic arthroplasty but it appears that bone stock is preserved in both failed and successful allografts.

The radiographic findings of joint space narrowing seen in some allografts are of concern, suggesting a deterioration of the articular surface with time. However, we were unable to correlate these radiographic changes with clinical outcome. Due to the uncommon nature of this procedure, there are only a small number of cases. However, there is a minimum of 80 months of follow-up (mean 148 months) allowing a good perspective on the long-term outcome of these procedures. There is a much larger experience with the use of fresh osteochondral allografts in the knee extending over two decades.[4,10] In the knee, single surface grafts have demostrated 70 to 85% success at up to 10-year follow-up. Bipolar and multiple surface knee allografts have shown approximately 60% success, similar to the results of ankle bipolar allografts.

Analysis of Failures and Technique Modification

There were three poor results in our series. In these cases, early failure was secondary to technical errors such as poor graft fixation and fit. In the first case, the tibial graft was placed too far posteriorly with reference to the talus. This appears to have placed excess load on the anterior portion of the tibial graft, causing this portion

to fragment. In the second case, the talar graft was inadequately fixed and slipped forward, causing incongruity between the tibial and talar articular surfaces. The third case of failure was due to non-union of the tibial graft. In this case, there was also an intra-operative fracture of the medial malleolus. It is important to note that a failed allograft did not preclude a revision of the allograft nor a successful arthrodesis.

More precise cuts using the total ankle arthroplasty instruments and jigs marks an improvement of the original technique of osteochondral shell allografting. At our institution 17 patients have undergone this new technique without a single case of early graft malfunction.

CONCLUSION

Fresh osteochondral shell allografts for tibiotalar arthrosis resulted in improved ankle function and improved overall health in a majority of patients at long-term follow-up. Most patients viewed their outcomes favorably and state they would undergo a similar operation on the contralateral ankle if needed. The procedure is technically demanding, but the problems are identifiable, and improvements in surgical technique appear to have decreased early graft failures. In cases of allograft failure, arthrodesis can be carried out successfully. We continue to offer fresh osteochondral shell allografts as an alternative treatment for post-traumatic ankle arthropathy to selected patients who refuse ankle arthrodesis. It should be noted that patients with post-traumatic arthrosis represent one end of the spectrum of articular cartilage disease in the ankle.

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