Treatment of Acute Osteochondral Fractures of the Talar Dome using Osteochondral Autograft Transplantation

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Background: Osteochondral fractures of the talar dome (OCFT) are frequently associated with ankle fractures. Controversy exists regarding the treatment of acute grade III and IV OCFT. Osteochondral autograft transplantation (OAT) is a possible operative solution.

Materials and Methods: We performed OAT in 16 patients with acute grade III or IV OCFT. There were ten males and six females with the average age of 33.9 (range, 18 to 49) years. OCFT was identified and clinically determined to be grade III or IV using radiographs and intraoperative assessment. Seven patients were grade III, nine patients were grade IV OCFT. The OAT consists of two following sequential procedures: 1) harvesting of osteochondral autograft cylinder from the non-weight bearing surface of the ipsilateral knee, and 2) implanting of the donor graft into the recipient of talus with press-fit technique. Single cylinder transplantation or the mosaicplasty was used. The outcome was determined by the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale, the simplified symptomatology evaluation, plain radiography and MRI.

Results: The average period of follow-up was 36.3 (range, 21 to 48) months. The mean size of the osteochonral fracture defects was 84.1 (range, 50 to 125) mm^2, and the mean depth was 2.5 (range, 1 to 5) mm. The mean AOFAS score was 95.4 (range, 86 to100) points postoperatively. At the latest follow-up, there was no radiographic evidence of posttraumatic arthritis. Based on the MRI of all patients, 93.7% of the osteochondral grafts showed bony integration and articular congruity of the talar dome.

***Conclusion*:** OAT was shown to be an effective treatment with excellent clinical outcome and radiographic evidence of graft integration.

Key Words: Ankle Fracture; Talar Dome; Osteochondral Fractures; Osteochondral Autograft Transplantation

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INTRODUCTION

Osteochondral fractures of the talar dome (OCFT) are frequently associated with ankle fractures. [1] In literature, the incidence of OCFT with ankle fracture is between 23% and 79%.[11, 16, 20, 21] Nonoperative treatment of the OCFT has been associated with early osteoarthritis, resulting in pain and loss of function of the ankle joint.[22] Due to limited capacity of the talar cartilage for repair, operative intervention may be beneficial. [25]

In general, operative management strategies of the OCFT include excision with or without drilling and internal fixation. The repair of acute grade III and IV OCFT is sometimes not feasible using internal fixation. Osteochondral autograft transplantation (OAT) is gaining the acceptance for the treatment of various chronic chondral defects. To our knowledge, the early treatment of the acute grade III and IV osteochondral fractures of talar dome using OAT has not been documented in literature. In our study, we demonstrated the restoration of anatomic articular congruency with the use of OAT simultaneously with the surgical treatment of ankle fractures.

MATERIALS AND METHODS

Clinical Materials

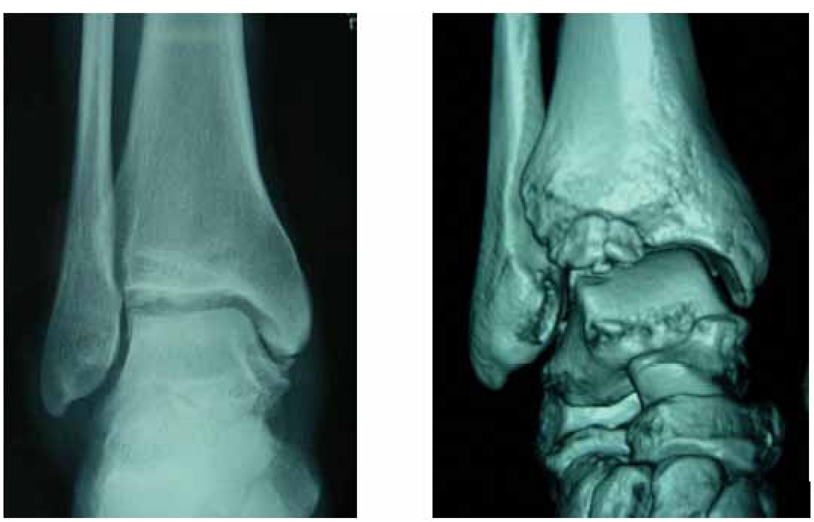
Sixteen patients with grade III or IV OCFT associated with ankle fracture **(See Figure 1, A and B)** were treated with OAT, simultaneously with the operative treatment of ankle fracture according to standard AO technique (**See Table 1**). Ten males and six females had a mean age of 33.9 (range, 18 to 49) years. Nine fractures involved the right ankle, and seven involved the left ankle. Based on Lauge-Hansen classification system, [14] there were nine supination external rotation (SER) injuries, three supination adduction (SAD) injuries and three pronation external rotation (PER) injuries. Three patients had Danis-Weber type A, nine patients had type B and three patients had type C fractures.[26] One fracture did not fit into any group. Of the sixteen OCFT, seven were grade III, and nine were grade IV.

The fracture defect was on the medial talar dome in six patients, and on the lateral talar dome in ten patients. In the case of medial talar dome injuries, two were isolated fibula fractures, three were bimalleolar fractures, and one was a trimalleolar fracture. For lateral talar dome injuries, four were fibular fractures, three were bimalleolar fractures, two were trimalleolar fractures, and one only involved the anterior tibial rim. Eleven patients were treated with single cylinder OAT, while five patients received multiple cylinders OAT. All fractures were sustained through a low energy mechanism.

Inclusion criteria consisted of grade III or IV OCFT with

Patient	Age yrs	Sex	Ankle	Injury pattern	Location	OCFT Grade	Size mm^2	Depth mm	Cylinder	Follow-Up, mo	SSE	AOFAS	MRI Integration
1	33	F	Right	SER	Lateral	III	91	5	Single	33	Excellent	95	Yes
2	23	M	Left	SAD	Medial	IV	125	3	Multiple	27	Excellent	97	Yes
3	18	M	Right	SER	Lateral	III	70	2	Single	48	Excellent	100	Yes
4	41	F	Right	SER	Medial	III	60	4	Single	42	Excellent	96	Yes
5	43	M	Right	SER	Lateral	IV	91	2	Single	36	Good	95	Yes
6	31	F	Right	SAD	Medial	IV	112	3	Multiple	36	Excellent	98	Yes
7	38	F	Left	SER	Lateral	IV	91	2	Single	42	Excellent	95	Yes
8	30	M	Left	PER	Medial	III	74	1	Single	30	Excellent	96	Yes
9	45	M	Right	SER	Lateral	IV	102	1	Multiple	39	Good	99	Yes
10	35	M	Right	SER	Medial	IV	101	3	Multiple	21	Excellent	97	Yes
11	26	F	Left	PER	Lateral	III	81	2	Single	45	Excellent	96	Yes
12	49	M	Left	SAD	Lateral	IV	53	3	Single	45	Good	86	IROS
13	46	M	Right	SER	Lateral	IV	67	2	Single	43	Excellent	95	Yes
14	30	F	Right	SER	Lateral	III	50	3	Single	27	Good	89	Yes
15	34	M	Left	PER	Medial	III	70	1	Single	42	Excellent	97	Yes
16	21	M	Left	NO	Lateral	IV	108	3	Multiple	24	Excellent	96	Yes
Mean	33.9±9..3	F=6	R=9	SER=9	L=10	III =7	84.1	2.5	S =11	36.3	E =12	95.4	Yes=15
or		M=10	L=7	SAD=3	M =6	IV =9	±	±	M =5	±	G =4	±	IROS=1
SUM				PER=3			22.0	1.1		8.4		3.5	
				NO=1									

Table 1: Patients' characteristics
Note 1: F, female; M, male; SER, supination external rotation injuries; SAD, supination adduction injuries; PER, pronation external rotation injuries; NO, did not fit into any group; OCFT, osteochondral fracture of talar dome; IROS, irregularity of the surface

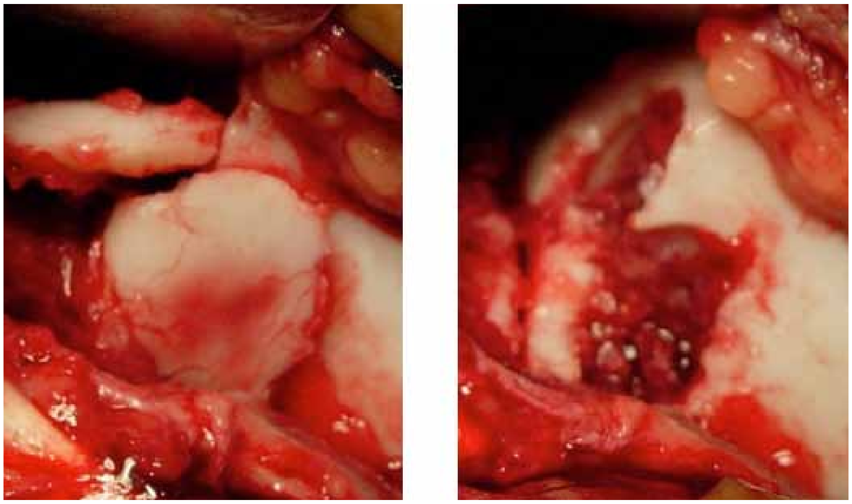


A B

Fig.1: A 21-year-old male with a grade IV osteochondral fracture of talar dome associated with left ankle fracture (patient No.16). Preoperative plain film (A) and the CT reconstruction image (B).

concomitant ankle fracture, an osteochondral defect less than 150 mm^2, and the absence of previous arthritic changes. All patients were reviewed prospectively. Preoperative imaging with standard anteroposterior, lateral, and mortise radiographs and CT were obtained. The location and size of the osteochondral fracture defects were clinically determined during surgical treatment with direct visualization and palpation (See **Figure 2, A and B**). The osteochondral fracture grades of the talar dome were classified according to Berndt and Hardy classification system.[3] The integrity of the osteochondral graft cylinder was examined with MRI at the latest follow-up examination.

Ankle function was evaluated with use of the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale[12]. Of a



A B

Fig. 2: Intraoperative photographs of a left grade IV osteochondral fracture of talar dome (A) and the fracture defects after removal of osteochondral fragments (B).

maximum score of 100 points, 50 points were assigned to function, 40 points assigned to pain, and 10 points assigned to alignment. Assessment of patient symptoms was conducted with the simplified symptomatology evaluation[6] which the condition of the ankle was graded as excellent (no pain, swelling, or locking with strenuous activity), good (mild aching with strenuous activity but no swelling or locking), fair (moderate pain with strenuous activity and occasional swelling but no locking), or poor (pain at rest, swelling, and locking). All operations were performed at our institution by a single surgeon. Ankle radiographs were taken at two, six, and twelve weeks postoperatively. After fracture healing of the tibia and fibula, ankle radiographs were taken every 3 months. MRI was taken after 12 months and at the latest follow-up. All postoperative evaluations including clinical and radiographic assessments were done by an independent, blinded observer. All results were secondarily confirmed by the authors. Hospital ethics committee approval was obtained for the study. All patients provided written informed consent.

Operative Technique

The details of the OAT technique is described elsewhere.[6] Briefly, the same approach for operative fixation of the ankle fracture was utilized to reach the osteochondral defect by opening the ankle fracture and distracting the articular capsule. No medial or lateral malleolar osteotomy was used. **Direct visual** inspection was paramount to ensure that the fracture was unstable to fixation and suitable for OAT.

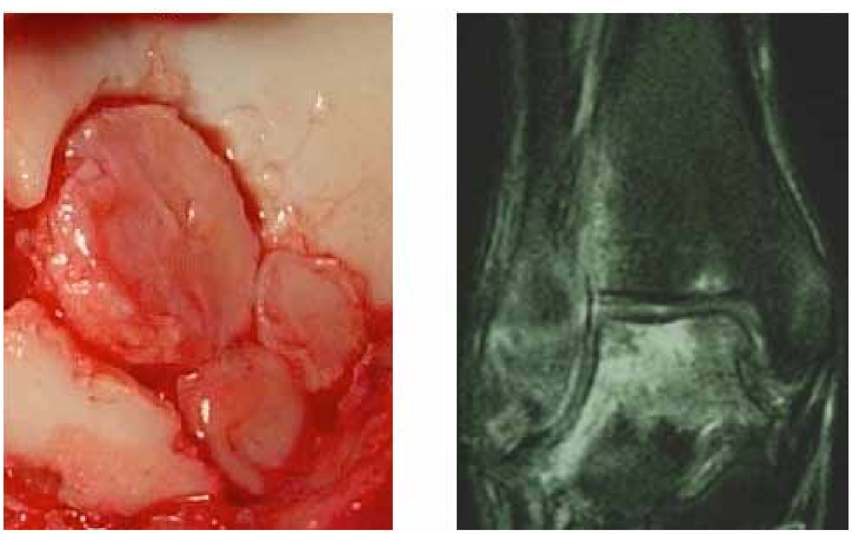
Following the debridement, the osteochondral graft cylinder was harvested to depth of 10 mm along the lateral edge of the lateral femoral condyle. An osteochondral cylinder was gently impacted into the recipient sites. After implantation, range of motion was tested to ensure that the osteochondral graft was seated and secure at the level of the surrounding articular cartilage (**See Figure 3, A**). The procedure was then repeated if additional grafts were needed. The ankle fractures were fixed using plate or screw based on standard AO principles after OAT.

The ankles were immobilized in splint for 3 weeks postoperatively, and toe-touch ambulation with crutches was permitted. The patients progressed gradually to partial weight-bearing over the course of 3 to 12 weeks. After three months, full weight-bearing activity was allowed.

RESULTS

The average duration of follow-up was 36.3 (range, 21 to 48) months. All ankle fractures healed successfully at an average of 3 months. The mean size of the fracture defects was 84.1 (range, 50 to 125) mm^2. The mean depth of fracture defects was 2.5 (range, 1 to 5) mm. There were twelve excellent and four good results, using the simplified symptomatology evaluation. The mean AOFAS score was 95.4 (range, 86 to100) points at the time of the latest follow-up (**See Table 2**). No complications were observed, and there was no reported incidence of donor site morbidity.

Final radiographs revealed no narrowing of joint space in the ankle and no osteophytes on the anterior tibial plafond, on MRI imagines 93.7% of the osteochondral grafts showed bony integration and articular congruity of the talar dome **(See Figure 3, B)**. One patient (6.3%) showed irregularity of the joint surface (**See Table 2**).



A B

Fig. 3: Implantation of the donor graft into the recipient defects of the talus, the central fragment was fixed with bio-absorbable pin (A). Postoperative MRI evidence of graft integration and articular congruity of the talus after 2 year of operation andbone marrow edema is present (B).

Mean	AOFAS	SSE		X-Ray	MRI
Follow-Up	Mean	Excellent	Good	Posttraumatic	Graft Integration
mo	Score			OA (%)	(%)
36.3±8.4	95.4±3.5	12	4	0	93.7%

Table 2: The clinical and imaging outcome of OAT
Note 2: OAT, osteochondral autografrs transplantation; AOFAS, American Orthopaedic Foot and Ankle Society; SSE, simplified symptomatology evaluation; OA, osteoarthritis.

DISCUSSION

Osteochondral fractures refer to injuries of the articular cartilage and the underlying subchondral bone. It is distinct from the classic, chronic "osteochondritis dissecans". In literature, ankle fractures are commonly associated with osteochondral injuries.[2, 7, 11, 20, 23] Nonoperative management of OCFT has a high failure rate. Tol *et al* [24] noted an average success rate of only 45% with nonoperative treatment. The osteochondral fracture of talar dome damages the vascular supply to the subchondral bone. If treated early, capillaries can restore blood flow across the fracture site via the process of creeping substitution.[17] Otherwise fibrous tissue accumulates, blocking capillary ingrowth and leading to avascular necrosis. Ultimately, pain ensues and the chondral pathology can progress to degenerative joint disease.

The treatment of acute grade III and IV OCFT with ankle fracture is a challenge to orthopaedic surgeons. The goals of treating such fractures of the talar dome are recovery of joint function and avoidance of early joint degeneration. Debridement of the fragments combined with drilling of the subchondral fracture defect is usually effective.[15, 17] However, the defect typically fills with a fibrocartilaginous tissue which is known to have inferior biomechanical characteristics. Furthermore, the clinical results of these procedures often deteriorate over time.[8]

The OAT technique was originally developed to treat focal cartilage defects of the femoral condyles of the knee and then was subsequently adapted for the ankle. [9] Histological studies have noted hyaline cartilage in the transplanted grafts and provided durable results. [10] Aktas et al. [1] performed arthroscopic drilling of grade III and IV OCFT. The mean AOFAS score was 95.6 postoperatively, and they suggested an arthroscopic or open inspection of the talar dome should be routinely considered in the operative repair of ankle fractures. On the other hand, Boraiah et al.[5] studied 153 patients who did not undergo any interventions on the grade III and IV osteochondral fracture at a mean follow-up of 20.9 months. They concluded osteochondral fracture lesions had no significant impact on the functional outcome when associated with ankle fractures. Many studies, however, lack long-term follow-up.

In our opinion, treatment of OCFT is based on acuity, grade, and stability of fragment. Acute grade I and II OCFT are probably best treated conservatively with immobilization, limited weight bearing, and supportive physical therapy. For grade III and IV fractures, on the other hand, operative intervention is generally favored. If the fragments have intact cartilage and bone at the level of or beyond the subchondral plate, they can be fixed with 1.5-mm mini or headless screws, or with absorbable pins. If the fragments are mostly cartilaginous, comminuted or unstable to fixation and OCFT could be inspected through the operative field, they should be débrided directly and the fracture defect can be treated with OAT.

The talar "shoulder" injuries are often associated with the lateral OCFT and it is more challenging to treat than other talar dome fractures.[19] Only one of our patients (#16) had the talar "shoulder" involved. We fixed the intact fragment with bio-absorbable pin after implantation of the cylinders into the lateral recipient defects of the talus. The outcome was excellent with graft integration. The medial and lateral lesions differ in mechanism of injury and the morphology of the defect[4, 18, 19, 25], but the clinical significance, including the "shoulder" injury, remains unclear.

The success of this technique is directly related to the careful harvest of grafts and accurate recipient bed preparation for implantation. The harvester must be perpendicular to cartilage surface. The recipient site should be cut at a perpendicular angle similar to the manner in which the donor plug was harvested. Matching graft and recipient bed depth determines the precision of articular surface contour and congruity restoration, which significantly influence graft function and patient outcomes.[13]

The donor site choice is primarily based on availability of non-articulating, non-weight-bearing hyaline cartilage with adequate thickness and surface contour.[15] The knee joints are commonly used. An additional incision is required at the knee to harvest the osteochondral plug. While no donor site morbidity was observed in our series, long term sequelae of violating the uninjured articular cartilage is unknown. Furthermore, each area of hyaline cartilage has a distinct characteristic composition and architecture, which may not be compatible with different weight bearing surfaces and joint mechanics. Possible solutions include graft material harvested from the talus to avoid donor site morbidity in the knee and more closely match the mechanical properties of the talus.

There are some limitations to our study. No control group was available for comparison. It is unclear how much benefit patients receive with restoration of osteochondral defect compared to fixation of the ankle fracture alone. The age of the patient may also contribute to healing potential of the articular cartilage and subchondral bone, affecting outcome. However, given the small number of patients, such distinction could not be made. Lastly, the development of post-traumatic arthritis is a chronic process, and our average follow-up of 36 months may not be adequate.

In summary, we believe that OAT is an effective treatment of acute grade III and IV OCFT, in setting of a routine ankle fracture. This method yielded good mid-term clinical outcome with radiographic evidence of osteochondral integration. While the preliminary results are promising, further investigations are warranted to compare its effectiveness to other available treatments, and long-term follow-up is needed to better establish outcome.

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