CHAPTER **28**

OSTEOCHONDRAL GRAFTING FOR REPAIR OF OSTEOCHONDRAL DEFECTS IN THE ANKLE: An Experimental Approach and Clinical Applications

Thomas J. Chang, D.P.M.
Annalisa Y. Co, B.S.
Stanley J. Phillips, D.P.M.

Articular cartilage injuries or diseases are becoming more prevalent in today's more active and aging population. Diseases such as osteoarthritis (OA), osteochondritis dissecans (OCD), metaphyseal bone tumors or subchondral cysts, and osteonecrosis, can profoundly compromise one's daily activities. Through the years, surgical treatment options to restore articular cartilage have included abrasional arthroplasty, subchondral drilling or micro fracture, perichondral and periosteal grafts, and more recently chondrocyte transplantation and osteochondral grafting. The goals of surgical repair of cartilage defects include replacing the defect with hyaline-like cartilage, restoring cartilage congruity and full range of joint motion, and eliminating biomechanical strain to prevent further cartilage deterioration. Osteochondral grafting applies these principles and has met with excellent results. The earlier procedures produce, for the most part, fibrocartilage which is poor in biomechanical and biochemical properties compared to normal joint hyaline cartilage. Currently the technique known as the mosaic-plasty, utilizes allografts from freshly preserved cadavers or autografts commonly harvested from the ipsilateral "non-essential articular cartilage" of the lateral femoral condyle to restore hyaline-like cartilage.(Fig. 1)

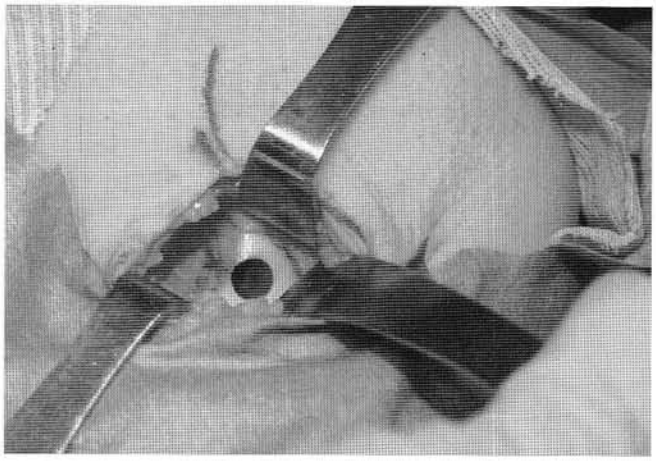

Figure 1. Donor site for the osteochondral graft from the lateral femoral condyle. The diameter of the grafts range from 4mm to 10mm.

Allografts have successfully been used in the knee and ankle, however, there are risks associated, including the spread of infectious disease or possible rejection by the immune system. Large defects in the knee and ankle however, may do well with single, large allograft techniques which may cover sizes of 30 to 50mm in diameter. Allograft femoral condyles or talus can be used which have the best chance of matching radius of curvature and the general shape of the recipient sites. Autografts have potentially higher survival rates of transplanted chondrocytes with increased graft incorporation. The long-term survival rate of the grafts depend on chondrocyte viability, subchondral bone support, and protecting the graft from biomechanical strain. Therefore, autografts are clearly superior to allografts with the exception of possible donor site morbidity.

The original description of the mosaic plasty technique for talar dome lesions, suggested that the lateral femoral condyle be used as the donor site. (Fig. 2) Current studies are investigating potential donor sites within the foot and ankle for "non-essential" cartilage. "Non-essential" cartilage is cartilage that is either non-articular or non-weight-bearing while the foot is loaded. Removal of "non-essential" cartilage should not affect or compensate the normal function of the foot or ankle. Advantages of using cartilage from within the foot or ankle include the possibility of a single incision as opposed to one at the knee and one at the lesion site. Secondly, the podiatric surgeon can perform the case without assistance of a second surgeon for the donor site portion of the procedure. Also, taking plugs from a donor site in closer proximity to the lesion may increase chances

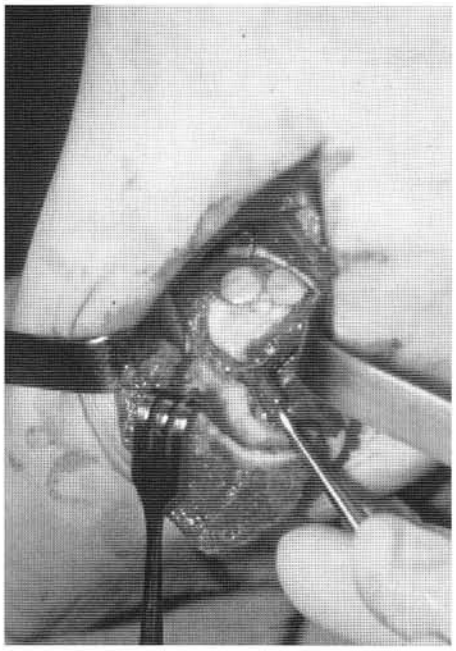

Figure 2. Intraoperative photo of two osteochondral grafts placed into a posterior medial talar dome lesion. This was performed with a medial malleolar osteotomy.

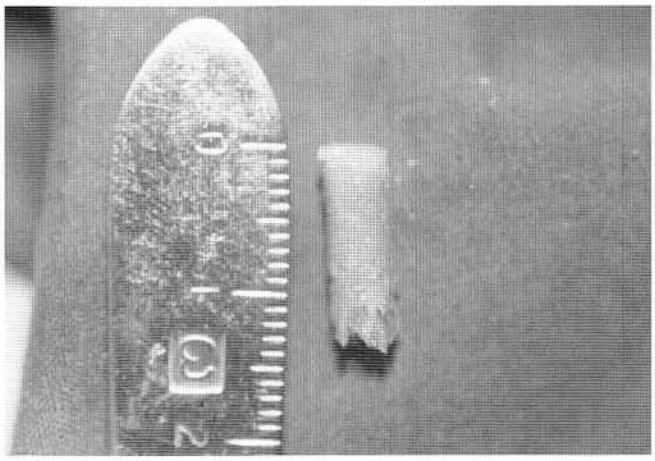

Figure 3. A 13mm osteochondral graft with 1 to 2 mm of articular cartilage present.

of acceptance and promote faster healing due to the similarities in the mechanical and biochemical structure of the cartilage.

There are many joints from which to remove cartilage plugs within the foot and ankle, but size and articulation must be considered. The talonavicular joint and parts of the ankle joint have exposed available cartilage in the foot's loaded position. The talar dome facets for the tibia and fibula have cartilage not articulating during weight-bearing stance. This was well demonstrated in a publication by Christensen et al. Also, deep to the spring ligament, there is cartilage on the plantar medial talar head (spring ligament area) only used in maximum supination or during the swing phase of the gait cycle, therefore this is off-loaded and non-articulating for majority of the gait cycle. These three areas have been considered as possible donor sites for cartilage grafting.(Figs. 3, 4)

EXPERIMENTAL DESIGN

An attempt was made to further evaluate and document the available cartilage in certain areas of the ankle and rearfoot. The foot and ankle unit of ten frozen cadavers were dissected to expose the tibial and fibular facets of the talus and the spring ligament area. Since the shapes of all three sites cannot be perfectly measured around their borders, a series of consistent measurements were noted. With gross dissection of the three possible donor sites, the cartilage that is considered "non-essential" could be observed. The specimens had an average of 307.2 mm2 (standard error, 37.3 mm2) of available cartilage covering the spring ligament area. In addition there was an average of 584.1 mm2 (standard error, 59.1 mm2) of available cartilage covering the tibial facet and 879.1 mm2 (standard error, 63.2 mm2) of cartilage covering the fibular facet on the talus. The significance of these results is that this area has a sufficient amount of non-articulating cartilage available to harvest. The average plug size ranges from five to ten millimeters making it possible to take one or more plugs of cartilage for grafting. These measurements indicate that these areas are potential donor sites to harvest multiple cartilage plugs for osteochondral grafting in the foot and ankle.

With the same ten specimens, the talus and first metatarsal had been dissected out for radius of curvature (ROC) studies. The first metatarsophalangeal joint (1st MPJ) is the second most common degenerative joint next to the knee. If the spring ligament area were to be used as a potential donor site and the first metatarsal head as the potential recipient, would the ROC's have a significant match? If so, this would increase chances of achieving maximal congruity. The bones were cut in the same plane of the curvature to be measured. The first metatarsal was cut in half in the sagittal plane, and the talar head was cut at its largest diameter in the frontal plane. Circles were drawn to find the central

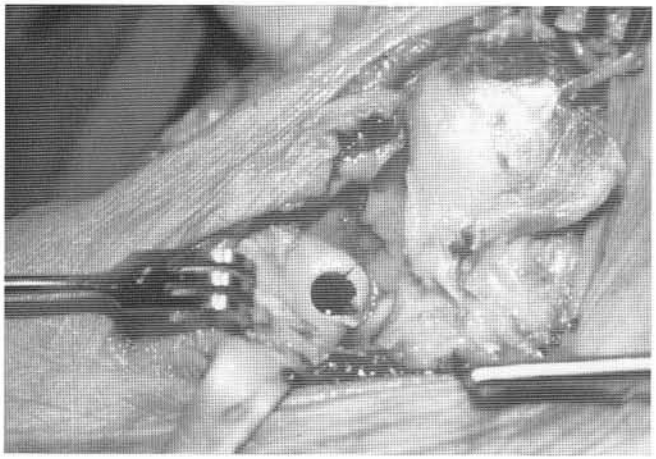

Figure 4. Cadaver dissection of the exposure and amount of cartilage noted at the spring ligament area. The PT tendon is seen retracted on the lower left portion of this photo.

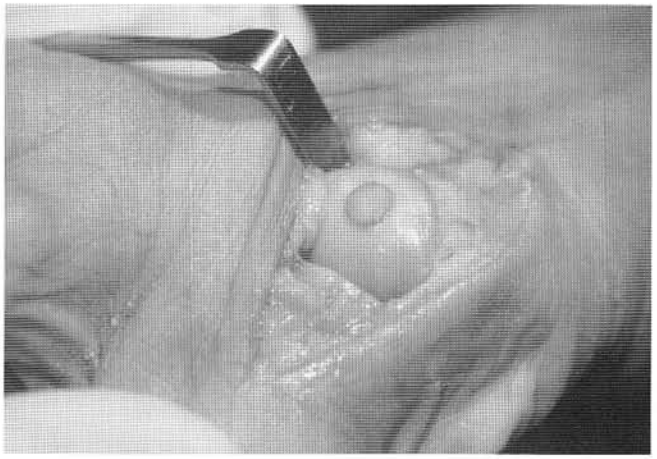

Figure 5. Example of osteochondral graft into the 1st MPJ for cartilage defects in this joint

point. The radius was measured from that point to the apex of the curvature. The average radius curvature of the spring ligament was 10.6 ± 0.876 millimeters (range, nine to twelve millimeters) and the first metatarsal head was 12.95 ± 1.88 millimeters (range, ten to sixteen millimeters). The average curvature match between each donor and recipient was 81.85% with the highest being 100%. This significant matching percentage further indicates that the spring ligament area is a potential donor site for future 1st MPJ repair. Inserting a plug or multiple plugs can possibly restore the contact characteristics that have been lost by the cartilage defect. (Fig. 5)

CLINICAL APPLICATIONS

Osteochondral grafting to the ankle is being utilized with increasing frequency throughout the podiatric profession. Approximately 50 cases have been performed in 5 centers around the country over the past 4 years. Several cases have even been performed on the 1st MPJ. Follow-up is now approaching 3 to 4 years on some patients, and their results have been encouraging at this early time. The cases were all performed through an open ankle arthrotomy since it is vital to approach the talar dome at a 90 degree angle with the instrumentation. The authors do not anticipate that arthroscopic approaches will be possible with these current techniques. It will be interesting to see if the viability of the osteochondral grafts will actually outlast the 2 to 4 year reported success with fibro-cartilage repair techniques.

In the small amount of osteochondral grafts taken from the talus, the experience has been mixed. The talus is a short bone with dense trabeculation and requires considerable amount of trauma and manipulation to secure a plug of 1 to 1.5cm in depth. Depending on the location of the defect, concern of violating the STJ and also creating stress fractures can be problematic.

With the current grafts coming from the lateral condyle of the knee, concern of postoperative knee pain must be discussed with the patient. The literature has reported several cases of knee pain of upwards to 10% to 15%, although the authors have found a slightly smaller percentage within their patients.

Some surgeons feel the amount of postoperative bleeding from the donor site may be an issue and have elected to pack these donor sites with allogenic bone. The authors have not found this to be necessary. The available amount of femoral cartilage is not as large as one may think, since the lateral patellar groove is the limiting border medially. Several orthopedists will retrieve cartilage from the patellar notch and the authors anticipate exploring this possible site in the future.

There have even been very early reports of Autologous Cartilage Transplantation (Carticel) techniques performed into the ankle and this may hold future promise for this difficult population.

SUMMARY

In summary, the tibial and fibular facets, and the spring ligament area on the talar head have enough available cartilage for plug removal. The significant matching radius percentage between the spring ligament area and the first metatarsal further indicates

this area as a good potential donor in repairing defects in the 1st MPJ. In the future, using the mosaic plasty technique to repair cartilage defects can be easier for the podiatric surgeon, if the donor and recipient sites are both within the foot and ankle. Furthermore, the autogenous grafts will better incorporate and help restore hyaline-like articular cartilage function. The surgeon should also insure the underlying etiology of the cartilage defect is identified and treated appropriately.

BIBLIOGRAPHY

Beaver RJ, Mahomed M., Backstein D, Davis A, Zukor DJ, Gross AE: Fresh osteochondral allografts for posttraumatic defects in the knee; a survivorship analysis. *J Bone Joint Surg* 74B:105-110, 1992.

Garrett JC: Treatment of osteochondral defects of the distal femur with fresh osteochondral allografts: a preliminary report. *Arthroscopy* 2:222-226, 1986.

Handgody L, Kish G, Karpati Z, Udvarhelyi I, Szigeti I, Bely M: Mosaic plasty for the treatment of articular cartilage defects: Application in clinical practice. *Orthopedics* 21(7):751-6, 1998.

Handgody L, Kish G, Karpati Z, Szerb I, Eberhardt R: Treatment of osteochondritis dissecans of the talus: use of the mosaic plasty technique–a preliminary report. *Foot Ankle Int* 18(10):628-34, 1997.

Imhoff et al: Autologous osteochondral transplantation on various joints. *Orthopade* 28(1):33-44, 1999.

Mankin HJ, Doppelt SH, Tomford WW: Clinical experience with allograft implantation: the first 10 years. *Clin Orthop* 174:69-76, 1983.

Matsusue Y, Yamamuro T, Hama H: Arthroscopic multiple-osteochondral transplantation to the chondral defect in the knee associated with anterior cruciate ligament disruption: case report. *Arthroscopy* 9(3):318-321, 1993

Muehleman C, Chubinskaya S, Cole AA, Noskina Y, Arsenis C, Kuettner KE: Morphological and biochemical properties of metatarsophalangeal joint cartilage. *J Am Podiatr Med Assoc* 87(10):447-59, 1997.

Yamashita F, Sakakida K, Susu F, Takai S: The transplantation of an autogenic osteochondral fragment for osteochondritis dissecans of the knee. *Clin Orthop* 201:43-50, 1985.