The Journal of Foot & Ankle Surgery 51 (2012) 218–221

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Arthroscopic De Novo NT® Juvenile Allograft Cartilage Implantation in the Talus: A Case Presentation

Dustin L. Kruse, DPM, MA [1], Alan Ng, DPM, FACFAS [2], Matthew Paden, DPM, FACFAS [3], Paul A. Stone, DPM, FACFAS [4]

[1] Second Year Resident, Highlands–Presbyterian/St. Luke's Podiatric Medicine and Surgery Residency Program, Denver, CO
[2] Attending Surgeon, Highlands–Presbyterian/St. Luke's Podiatric Medicine and Surgery Residency Program, Denver, CO
[3] Program Director, Highlands–Presbyterian/St. Luke's Podiatric Medicine and Surgery Residency Program, Denver, CO
[4] Director of Research, Highlands–Presbyterian/St. Luke's Podiatric Medicine and Surgery Residency Program, Denver, CO

ARTICLE INFO

Level of Clinical Evidence: 4
Keywords:
ankle
bone
mosaicplasty
osteochondral defect
surgery

ABSTRACT

Osteochondral defects of the talus are a challenging subject facing foot and ankle surgeons. The available treatment options have relatively good subjective outcomes; however, they are limited by the ability to reproduce hyaline cartilage, the need for multiple surgeries, and high morbidity. We present a new technique using DeNovo NT® juvenile allograft cartilage implantation introduced into a talar lesion arthroscopically in a single procedure to repair a posteriomedial talar osteochondral defects in a healthy, active 30-year-old female. The patient tolerated the procedure well. At the 6-month follow-up visit, the patient had returned to full activity, and at 24 months, she remained completely pain free.

Osteochondral defects (OCDs) of the talus represent a broad category of injuries from fibrillation of the articular surface to full depth loss of cartilage and bone. OCDs are now considered a relatively common injury most often associated with an ankle sprain or fracture (1). An initial diagnosis of an OCD can be difficult because the symptoms often mimic the complaints associated with the initial trauma. Failure to properly treat an OCD can result in chronic pain, swelling, functional impairment, subchondral cyst formation, and end-stage osteoarthritis (2–4).

OCDs have significant treatment difficulties owing to the poor native healing potential of cartilage (5). Nonoperative treatment of OCDs includes bracing, immobilization, physical therapy, and multiple other modalities. However, most OCDs are recalcitrant to operative therapy. Berndt and Harty (6) found that 75% of nonoperatively managed lesions had poor results.

Current surgical treatment includes marrow stimulation (e.g., debridement, subchondral drilling, microfracture), autologous osteochondral transplant (e.g., osteochondral autograft transfer [OAT], mosaicplasty), autologous chondrocyte implantation, and allogenic osteochondral transplantation. Each surgical modality has benefits and disadvantages. In addition, very few high level studies have shown the benefit of any surgical procedure (7). The common drawbacks include the development of fibrocartilage rather than hyaline cartilage, access difficulty, donor site morbidity, necessity for malleolar osteotomies, and the need for multiple procedures. A large number of surgical treatments exist; however, most have few proven outcomes.

The DeNovo NT® (natural tissue) graft (Zimmer, Warsaw, IN) is a new product that uses scaffold-free allogenic juvenile cartilage that can be implanted into a defect and secured with a fibrin sealant. DeNovo NT® is composed of juvenile immature chondrocytes, which have a greater metabolic activity level and a propensity to regenerate hyaline-like cartilage (8,9).

We present a novel procedure for the treatment of OCDs using DeNovo NT® juvenile allograft cartilage implantation through the use of ankle arthroscopy. We believe this is the first published report detailing both the use of DeNovo NT® in the talus and the first case of DeNovo NT® implantation through arthroscopy.

Case Report

A 30-year-old female presented to our clinic complaining of left ankle pain and instability for the previous 2 years. The patient reported a history of multiple ankle sprains; however, during the previous 6 months, the patient had noted increased pain within her ankle joint and swelling around her ankle without any recent trauma. The patient had no other pertinent medical history and used no

Financial Disclosure: None reported.
Conflict of Interest: None reported.
Address correspondence to: Paul A. Stone, DPM, FACFAS, Director of Research, Highlands–Presbyterian/St. Luke's Podiatric Medicine and Surgery Residency Program, Research HealthOne Denver Presbyterian, 5375 South Florence Court, Greenwood Village, CO 80111.
E-mail address: paulandgailstone@comcast.net (P.A. Stone).

1067-2516/$ - see front matter © 2012 by the American College of Foot and Ankle Surgeons. All rights reserved.
doi:10.1053/j.jfas.2011.10.027

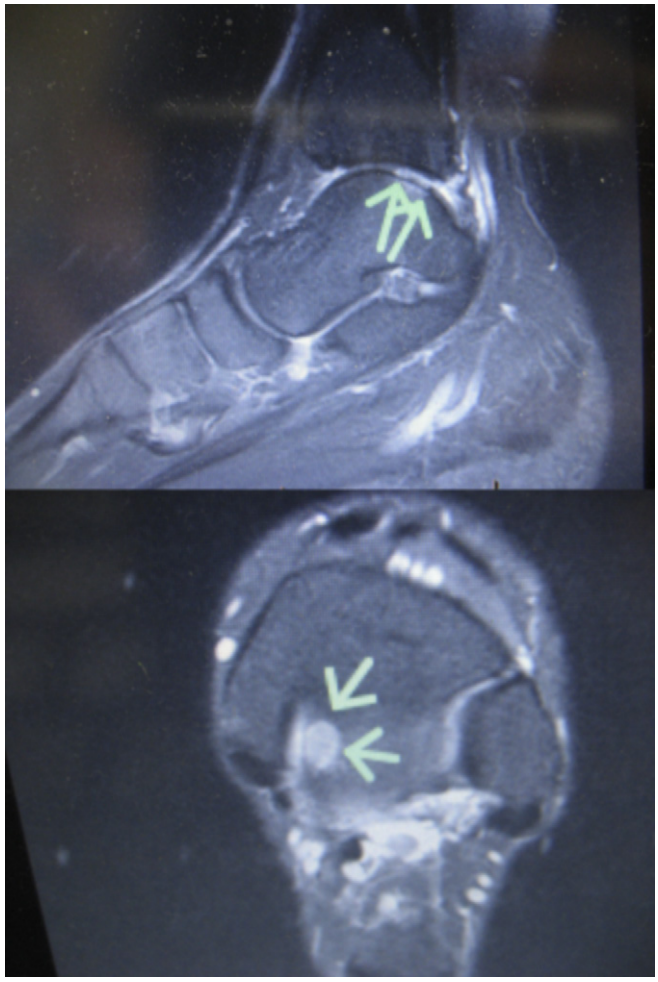

Fig. 1. Magnetic resonance imaging showing area of hyperintensity located in posteriomedial talar dome. Area of hyperintensity also seen at posterior talar process that was diagnosed as nondisplaced Shepherd's fracture.

medication. The physical examination revealed pain to palpation of the anterolateral ankle in the area of the anterior talofibular ligament and an increased anterior drawer test and increased talar tilt test compared with her right ankle. Plain film radiographs revealed early arthrosis of the tibiofibular articulation and possible loose bodies near the tip of the medial malleolus, all consistent with previous injuries without evidence of talar OCDs. Stress radiography revealed an increased talar tilt and positive anterior drawer sign of the left ankle. Magnetic resonance imaging was obtained and revealed a grade 4 OCD (6) of the posteriomedial shoulder of the talus and complete rupture of the anterior talofibular ligament and a nondisplaced Shepherd's fracture of the talus (Fig. 1). Given the 2-year history of pain and multiple attempts at conservative care, the patient opted for surgical intervention.

Surgical Technique

The patient was placed on the operating table in the supine position with a tourniquet on the proximal thigh and the left leg placed in a thigh holder. After induction of general anesthesia, the patient's left foot was inserted into an ankle distractor, and the ankle was accessed through standard anteromedial and anterolateral portals. Arthroscopy revealed a loose osteochondral fragment in the posteromedial aspect of the ankle joint that was excised in total. The OCD located on the posteromedial shoulder was then visualized, and the loosely adhered fibrocartilage regrowth was debrided down to fresh subchondral bone using curettes and arthroscopic shavers. It is imperative to maintain a border of healthy cartilage and intact subchondral bone to provide an inset border for the DeNovo allograft. The defect was measured to be approximately 0.7 cm × 0.5 cm (Fig. 2).

The OCD was then prepared for DeNovo NT® application by thoroughly drying the joint using an abdominal insufflator at 20 mm Hg in 1 portal and the Frazier tip of operating room suction through the other portal. The joint was dried for approximately 5 minutes, with the Frazier tip maintained in the bed of the freshly debrided OCD. The subchondral bone must be dry with minimal bleeding. If excessive subchondral bleeding is noted, an Arthrocare RF Arthrowand® (ArthroCare Sports Medicine, Austin, TX) can be used to coagulate any bone bleeding. The DeNovo graft pieces were then loaded into a 10-gauge catheter to be inserted through the anteromedial arthroscopic portal (Fig. 3). Eye spears were placed through the anteriomedial portal into the OCD bed to thoroughly dry the bed of subchondral bone, and an initial thin layer of Tisseel® (Baxter, Westlake Village, CA) fibrin sealant was placed in the debrided OCD using a preloaded syringe through the anteromedial portal. The 10-gauge catheter (loaded with DeNovo NT® pieces) was then inserted into the anteromedial portal. With arthroscopic visualization, the DeNovo® was layered into the OCD with care taken to fill the depth up to the native cartilage level. A second layer of Tisseel® was then applied on top of the inserted graft, and the abdominal insufflator was used to

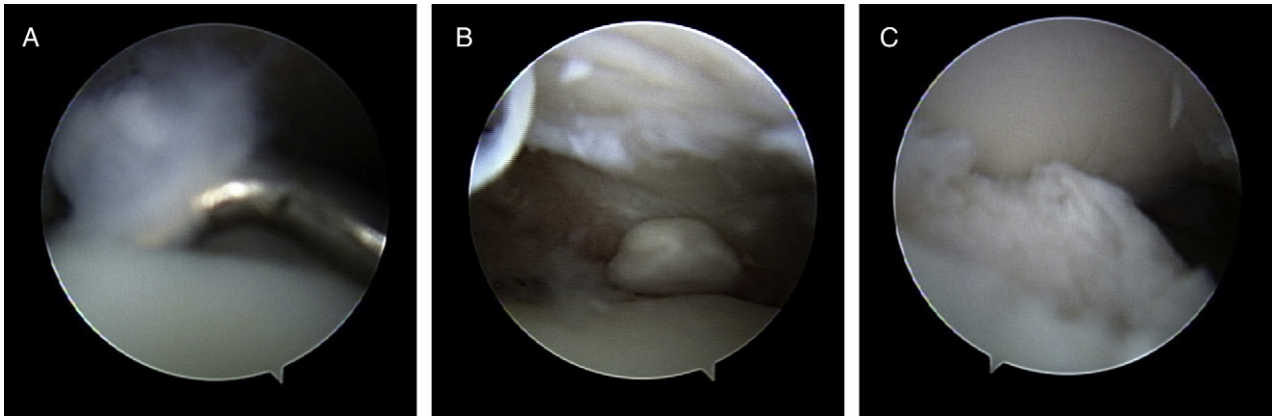

Fig. 2. (*A*) Identification of talar osteochondral defect filled with loose fibrocartilage. (*B*) Identification of loose-floating osteochondral defect, which was removed. (*C*) Freshly debrided osteochondral defect down to level of subchondral bone. Note, lack of bleeding subchondral bone to maintain dry environment for reception of graft.

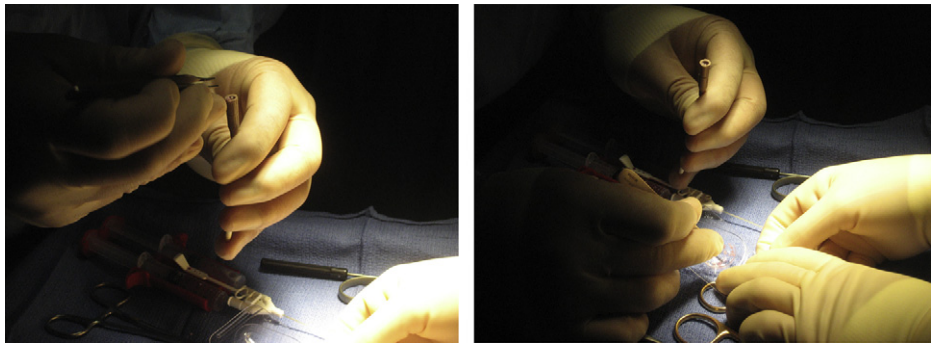

Fig. 3. Loading DeNovo graft pieces into 10-gauge catheter for athroscopic insertion.

keep the joint space dry until the fibrin glue was firm to the touch (Fig. 4). The arthroscopic portals were closed in a layered fashion. A modified Broström lateral ankle stabilization was performed in standard fashion. On completion, the patient was placed in a bivalved fiberglass cast and discharged to home.

Postoperative Management

The patient was maintained non–weight-bearing with biweekly cast changes for 4 weeks. After 4 weeks, the patient was placed in a removable cast boot and instructed to begin range of motion activities but to maintain her non–weight-bearing status. The patient was allowed to begin weight-bearing in her removable cast boot at 6 weeks, and she was transitioned out of her boot during the next 2 weeks. At 3 months, the patient returned to light athletic activity (swimming, spinning on a stationary bike, and walking for long periods). At 4 months postoperatively, the patient was allowed to begin light jogging. At 6 months, the patient was completely pain free, with a full range of motion and full activity. The patient was able to walk, jog, and stand for prolonged periods at the 6-month period without pain, swelling, or stiffness, and her activity was at her preinjury level without any limitations. The patient was discharged from care at the 6-month follow-up visit. At 2 years postoperatively, the patient reported by telephone interview that she remained pain free with no limitation in activity. There has been no need for follow-up radiographs or magnetic resonance imaging owing to the complete resolution of her pain and symptoms.

Discussion

DeNovo NT® juvenile allograft cartilage transplantation is a new technique that uses young particulated allogenic cartilage grafts to fill osteochondral defects with hyaline-like cartilage. The use of juvenile cartilage increases the amount of immature chondrocytes, which are more metabolically active and capable of spontaneous repair (10). The increased activity of young chondrocytes allows differentiation into hyaline-like cartilage instead of fibrocartilage, which is seen in multiple other OCD repair techniques. DeNovo® is in the early stages of postclinical trials and is currently pending Food and Drug Administration approval; however, early research in animals and humans has demonstrated a hyaline-like cartilage regrowth visualized through second-look arthroscopy and histopathologic biopsies (11,12).

The arthroscopic implantation of DeNovo NT® decreases postoperative morbidity and shortens the recovery time. DeNovo® is available "off the shelf," eliminating the need for high morbidity autograft harvest and multiple procedures for chondrocyte harvest. The graft is a particulated allograft, which enables arthroscopic implantation—avoiding invasive ankle arthrotomies and malleolar osteotomies. The arthroscopic approach can improve the outcomes by allowing outpatient treatment, decreasing postoperative morbidity, and permitting faster and more functional rehabilitation (13). The use of fibrin glue for fixation avoids the technically demanding periosteal flap and, again, allows arthroscopic implantation. Studies have shown that chondrocytes have the ability to migrate through fibrin glue within 2 weeks of implantation (14,15).

Marrow stimulation techniques are commonly used as a first-line treatment because of its relative ease and quicker recovery time and the ability to perform it arthroscopically. Retrospective studies of marrow stimulation techniques have shown a wide range of outcomes with good to excellent results in 39% to 96% of cases (7). The reparative process lays down newly formed fibrocartilage composed of both type I and type II collagen, which is weaker than the native hyaline cartilage (primarily type II collagen) and therefore might be insufficient for large defects (16,17).

OAT requires harvesting of 1 or multiple osteochondral plugs from non–weight-bearing portions of joints such as the femoral condyles,

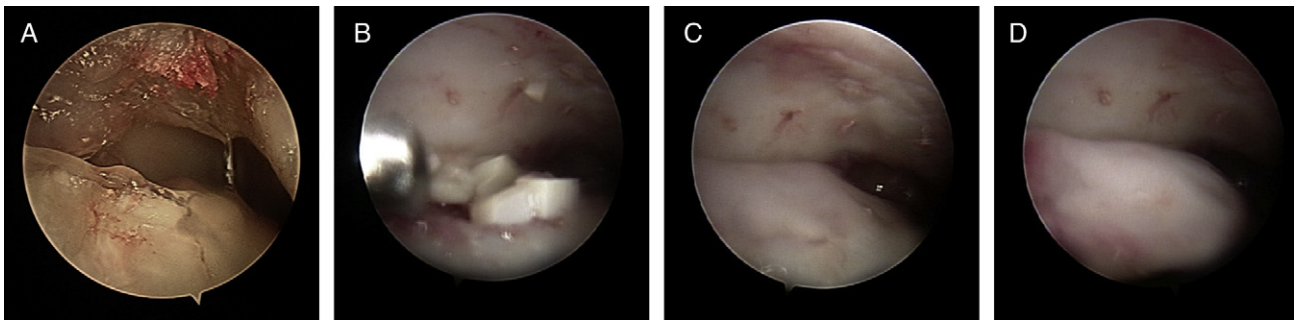

Fig. 4. (*A*) Applying base layer of Tisseel® fibrin glue to debrided osteochondral defect bed. (*B*) Inserting graft pieces into osteochondral defect bed with Tisseel® fibrin glue as base layer. (*C*) Graft covered with second layer of Tisseel® fibrin glue. (*D*) Area of repair after Tisseel® glue has dried over graft.

supracondylar notch, or ipsilateral talus (18). OAT has been shown to be more effective than marrow stimulation techniques because of the ability to transplant hyaline cartilage (19). Second-look arthroscopy and biopsy have confirmed chondrocyte viability after OAT (20,21). However, the transplanted plugs must be inserted perpendicular to the articular surface, which requires open arthrotomy and medial, lateral, or anterolateral osteotomies to access the lesion (22). The reported morbidity rate ranges from 0% to 55% for the osteotomy and donor sites (3). Studies have correlated that an increase in age and body mass index can increase the morbidity to knee donor sites (23). OAT procedures can be used for large lesions because of the capability of acquiring multiple circular grafts (mosaicplasty); however, the "dead spaces" between the circular grafts are left to heal with fibrocartilage (24).

Autologous chondrocyte implantation involves harvesting a patient's chondrocytes, culturing them in vitro, and reimplanting them into the defect using a periosteal cover or chondrogenic membrane (25). The major advantage of autologous chondrocyte implantation is the production of hyaline cartilage from an autologous graft. Histologic and immunuhistochemical evaluations have confirmed hyaline-like cartilage at the location of the transplant (26,27). However, autologous chondrocyte implantation requires 2 procedures, often necessitates a malleolar osteotomy, and providing a good periosteal seal can be technically demanding (25,28). Recent studies have advocated an arthroscopic technique for implantation of the autologous chondrocytes using a hyaluronic acid scaffold, decreasing the morbidity associated with open arthrotomies and osteotomies. However, this technique still requires the first procedure to obtain the autologous chondrocytes for in vitro culturing (28).

Osteochondral allograft transplants are generally reserved to treat OCDs that are not amenable to other procedures. Allografts are obtained from cadavers, tested to be free of communicable diseases, and maintained as either a fresh or frozen graft. Osteochondral autografts are indicated for large defects, which can be difficult to reproduce with autografts, and ankle osteoarthritis in the young patient. The advantages of osteochondral allografts include the ability to tailor the graft to the size and contour necessary, the use of hyaline cartilage without fear of fibrocartilage ingrowth, and the elimination of donor site morbidity (7). However, the use of osteochondral allografts can be very difficult, with high morbidity associated with open arthrotomy and a long graft incorporation period, as well as a risk, albeit low, of disease transmission. In addition, the number of frozen allograft chondrocytes begins to decrease at 9 days, with a rapid decrease in viability at 21 days and no growth at 34 days (29).

The technique we have presented has a very large learning curve that is primarily dependent on the surgeon's arthroscopy competency. In addition, the technique might need to be converted to an open or mini-open arthrotomy in cases of excessive bleeding, excessive scar tissue, or an inability to access the lesion through the arthroscopic portals. Our report had many shortcomings, because it was only a single case retrospective study. We did not include a standardized pain or functional evaluation, and the follow-up period was relatively short. However, we believe this new technique is an extremely viable alternative to existing OCD treatments with quick recovery and low morbidity. Since completion of our first case, we have performed the same technique multiple times, and we are currently collecting data and plan to publish our results with a larger study population and longer follow-up.

Conclusion

We present a new technique for the repair of talar dome OCDs that we believe has a greater potential for re-creating hyaline-like cartilage with lower morbidity compared with other treatment options. The technique and DeNovo NT® product are in their infancy; however, as increased information is published, we will consider this technique a first-line treatment option for all talar OCDs. We are currently in the process of collecting subjective outcomes pertaining to the use of this technique and plan to publish our results in the future.

References

1. Schenck R, Goodnight JM. Osteochondritis dissecans: current concepts review. J Bone Joint Surg Am 78:439–456, 1996.
2. Schacter AK, Chen AL, Reddy PD, Tejwani NC. Osteochondral lesions of the talus. J Am Acad Orthop Surg 13:152–158, 2005.
3. Canale ST, Belding RH. Osteochondral lesions of the talus. J Bone Joint Surg Am 62:97–102, 1980.
4. Mankin HG. The response of articular cartilage to mechanical injury. J Bone Joint Surg Am 64:460–466, 1982.
5. Buckwalter JA, Mow VC, Ratcliffe A. Restoration of injured or degenerated articular cartilage. J Am Acad Orthop Surg 2:192–201, 1994.
6. Berndt AL, Harty M. Transchondral fractures (osteochondritis dissecans) of the talus. J Bone Joint Surg Am 41:988–1020, 1959.
7. McGahan PJ, Pinney SJ. Current concept review: osteochondral lesions of the talus. Foot Ankle Int 31:90–98, 2010.
8. McNickle AG, Provencher MT, Cole BJ. Overview of existing cartilage repair technology. Sports Med Arthrosc Rev 16:196–201, 2008.
9. Friel NA, Cole BJ. Sports medicine and translational research: solving clinical problems in shoulder and knee through basic science research. Rush Orthopedics J 1:77–82, 2009.
10. Namba RS, Meuli M, Sullivan KM, Le AX, Adzick NS. Spontaneous repair of superficial defects in articular cartilage in a fetal lamb model. J Bone Joint Surg Am 80:4–10, 1998.
11. Frisbie DD, Lu Y, Colhoun HA, Kawcak CE, Binette F, McIlwraith CW. In vivo evaluation of a one step autologous cartilage resurfacing technique in a long term equine model. 51st Annual Meeting of the Orthopedic Research Society 2005, Washington, DC, February 20-23, 2005.
12. Farr J, Yao JQ. Chondral defect repair with particulated juvenile cartilage allograft. Zimmer Technical Memo. Zimmer Inc, Warsaw, IN, 2010.
13. Van Dijk CN, van Bergen CJ. Advancements in ankle arthroscopy. J Am Acad Orthop Surg 16:635–646, 2008.
14. Willers C, Wood DJ, Zheng MH. A current review of the biology and treatment of articular cartilage defects. J Musculoskeletal Res 7:157–181, 2003.
15. Visna P, Pasa L, Cizmar I, et al. Treatment of deep cartilage defects of the knee using autologous chondrograft transplantation and by abrasive techniques: a randomized controlled study. Acta Chir Belg 104:709–714, 2004.
16. O'Driscoll SW. The healing and regeneration of articular cartilage. J Bone Joint Surg Am 80:1795–1812, 1998.
17. Chuckpaiwong B, Berkson EM, Theodore GH. Microfracture for osteochondral lesions of the ankle: outcome analysis and outcome predictors of 105 cases. Arthroscopy 24:106–112, 2008.
18. Zengerink M, Szerb I, Hangody L, Dipirak RM, Ferkel RD, van Dijk CN. Current concepts: treatment of osteochondral ankle defects. Foot Ankle Clin 11:331–359, 2006.
19. Hangody L, Feczko P, Bartha L, Bodo G, Kish G. Mosaicplasty for the treatment of articular defects of the knee and ankle. Clin Orthop Relat Res 391:S328–S336, 2001.
20. Baltzer AW, Arnold JP. Bone-cartilage transplantation from the ipsilateral knee for chondral lesions of the talus. Arthroscopy 21:159–166, 2005.
21. Hangody L. The mosaicplasty technique for osteochondral lesions of the talus. Foot Ankle Clin 8:259–273, 2003.
22. Van Bergen CA, de Leeuw PJ, van Dijk CN. Treatment of osteochondral defects of the talus. Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur 94S:S398–S408, 2008.
23. Paul J, Sagstetter A, Kriner M, Imhoff AB, Spang J, Hinterwimmer S. Donor-site morbidity after osteochondral autologous transplantation for lesions of the talus. J Bone Joint Surg Am 91:1683–1688, 2009.
24. Giannini S, Vannini F. Operative treatment of osteochondral lesions of the talar dome: current concepts review. Foot Ankle Int 25:168–175, 2004.
25. Bartlett W, Skinner JA, Gooding CR, Carrington RW, Flanagan AM, Briggs TW, Bentley G. Autologous chondrocyte implantation versus matrix-induced autologous chondrocyte implantation for osteochondral defects of the knee: a prospective, randomised study. J Bone Joint Surg Br 87:640–645, 2005.
26. Giannini S, Buda R, Grigolo B, Vannini F. Autologous chondrocyte transplantation in osteochondral lesions of the ankle joint. Foot Ankle 22:513–517, 2001.
27. Brittberg M, Lindahl A, Nilsson A, Ohlsson C, Isaksson O, Peterson L. Treatment of deep cartilage defects in the knee with autologous chondrocyt transplantation. N Engl J Med 331:889–895, 1994.
28. Giannini S, Buda R, Vannini F, Di Caprio F, Grigolo B. Arthroscopic autologous chondrocyte implantation in osteochondral lesions of the talus: surgical technique and results. Am J Sports Med 36:873–880, 2008.
29. Malinin T, Temple HT, Buck BE. Transplantation of osteochondral allografts after cold storage. J Bone Joint Surg Am 88:762–770, 2006.