-->

(https://www.aetna.com/)

Allograft Transplants of the Extremities

Clinical Policy Bulletins | Medical Clinical Policy Bulletins

Number: 0364

Policy

I. **Allograft Transplant of the Knee**

Aetna considers allograft transplant of the knee (knee ligaments, osteochondral, and meniscus) medically necessary when selection criteria are met.

Anterior Cruciate Ligament (ACL), Posterior Cruciate Ligament (PCL), Medial Collateral Ligament, (MCL), and Lateral Collateral Ligament (LCL):

A. Members with ligament deficiency who are not candidates for autogenous transplantation (e.g., individuals whose autogenous tissues have been compromised by previous surgery, previous injury), *or*
B. Failed reconstruction or revision of a previous surgery; *or*

Policy History

Last Review
08/21/2018
Effective: 12/03/1999
Next Review: 03/28/2019

Review History

Definitions

Additional Information

C. Multiple ligament reconstruction; *or*
D. Members with any other contraindications to using their own tissue such as collagen disease or generalized ligamentous laxity.

Clinical Policy Bulletin Notes

Osteochondral (Femoral Articulation Only):

A. Avascular necrosis lesions of the femoral condyle; *or*
B. Non-repairable stage 3 or 4 osteochondritis dissecans; *or*
C. Otherwise healthy, active, non-elderly members who have either failed earlier arthroscopic procedures or are not candidates for such procedures because of the size, shape, or location of the lesion; *or*

D. Treatment of a focal lesion on distal femur that meets the following criteria:

1. Full-thickness depth (grade 3 or 4) lesion 2 cm or more in diameter by MRI or arthroscopy; *and*
2. Preferably surrounded by normal, healthy (non-arthritic) cartilage; *and*
3. Causing disabling localized knee pain that is unresponsive to conservative treatment (e.g., medication, physical therapy); *and*
4. Normal knee alignment or knee alignment will be surgically corrected (i.e., by osteotomy) at time of allograft; *and*
5. The opposing articular surface should be generally free of disease or injury, including no arthritis on the corresponding tibial surface.

Meniscus:

A. Degenerative changes must be absent or minimal (Outerbridge grade II or less), *and*
B. Knee must be stable prior to surgery or be surgically corrected at the time of the allograft (i.e., intact or reconstructed ACL), *and*
C. Members under the age of 55 years, *and*
D. Normal knee alignment or knee alignment will be surgically corrected (i.e., by osteotomy) at time of allograft; *and*
E. Pre-operative studies (MRI or previous arthroscopy) reveal absence or near absence of the meniscus; *and*

E. Pre-operative studies (MRI or previous arthroscopy) reveal absence or near-absence of the meniscus; *and*
F. Significant knee pain unresponsive to conservative treatment.

Aetna considers allograft transplant of the knee experimental and investigational for all other indications because its effectiveness for indications other than the ones listed above has not been established.

II. **Osteochondral Allograft of the Talus**

Aetna considers osteochondral allograft of the talus experimental and investigational because there are unanswered questions regarding the clinical outcomes of this approach when compared with ankle arthrodesis, especially in terms of pain, disability, functionality and durability.

III. **Vascularized Bone Graft**

Aetna considers the use of vascularized bone graft for the treatment of avascular necrosis of the talus experimental and investigational because its effectiveness has not been established.

IV. **Osteochondral Allograft**

Aetna considers osteochondral allograft experimental and investigational for the following:

A. Individuals who have had a previous total meniscectomy; *or*
B. Individuals with a cartilaginous defect associated with osteoarthritis or inflammatory diseases or where an osteoarthritic or inflammatory process significantly and adversely affects the quality of the perilesional cartilage; *or*
C. All other indications, including dysplasia epiphysealis hemimelica (Trevor's disease), femoral trochlear dysplasia, ilio-tibial band repair, shoulder instability, tarso-metatarsal arthrodesis, repairing chondral defects/lesions of the ankle, elbow, hip, patella, patello-femoral ligament, and shoulder (e.g., acromio-clavicular (AC) separation, Hill Sachs lesions) because its effectiveness has not been established.

V. **Synthetic Resorbable Polymers**

Aetna considers the use of synthetic resorbable polymers (e.g., TruFit Plug, PolyGraft) for osteochondral allografts of the knee and other joints experimental and investigational because its effectiveness has not been established.

VI. **Fast-Fix Meniscal Repair System**

Aetna considers the Fast-Fix meniscal repair system medically necessary for repair of meniscal tears.

VII. **Juvenile Cartilage Allograft Tissue Implantation**

Aetna considers juvenile cartilage allograft tissue implantation (e.g., the use of DeNovo ET engineered tissue graft (living cartilage allografts using juvenile chondrocytes) and DeNovo NT tissue graft (particulated juvenile cartilaginous allograft)) for repair of articular cartilage lesions experimental and investigational because its effectiveness has not been established.

VIII. **Manipulated Human Tissue Graft Products**

Aetna considers manipulated (decellularized) human tissue graft products (e.g., Chondrofix osteochondral allograft) experimental and investigational because their clinical value has not been established.

Background

Repair of knee ligaments refers to surgical treatment of acute injuries (ruptures), whereas primary reconstruction usually refers to surgical intervention of ligamentous laxity (chronic insufficiency) several months following an injury. Revision reconstruction means corrective surgery when the original reconstruction has failed. The bulk of the literature on ligamentous reconstruction of the knee deals with the primary reconstruction of the anterior cruciate ligament (ACL). Generally, there are 3 reconstructive methods for managing ACL insufficiency: (i) intra-articular replacements, (ii) extra-articular procedures, and (iii) combined

procedures. The first method is intended to replace the ACL, whereas the second method is intended to tighten the medial or lateral secondary restraints, or both in the third method. The sources for intra-articular replacements are quadriceps tendon, patellar tendon, hamstring tendons, and iliotibial band or tract. In particular, the bone-patellar tendon-bone autograft (the central one-third of the patellar tendon and its bony attachments to the patella and tibial tubercle) is the most common operation currently performed for reconstructing the ACL through arthroscopy.

Allograft, also known as allogeneic graft or homograft, is a graft between individuals of the same species, but of dissimilar genotype. Allografts may be used as an alternative to autografts for ligament reconstruction or meniscal transplantation of the knee. For tendon allografts, cadaver donors are usually used. Allograft tissue is procured from genetically unrelated cadaver donors and processed, stored and utilized according to US Food and Drug Administration (FDA) and the American Association

of Tissue Banks (AATB) standards. The advantages of allografts include no donor site morbidity, shorter surgical time, smaller incisions and greater availability. Allograft transplants are not rejected by the body as with other organ transplants. The donor tissues most commonly used are the patellar and Achilles tendons. An allograft may be preserved by freeze-drying or deep-freezing and can be sterilized either by sterile procurement with careful donor screening or by secondary sterilization with gaseous ethylene oxide or gamma irradiation. It is believed that freeze-drying or deep-freezing renders connective tissue allografts less immunogenic by killing the cells and denaturing surface histocompatibility antigens. However, while some investigators have claimed that freeze-drying of the allograft does not significantly change the mechanical properties of the grafts compared with deep-freezing; others have reported frequent late failures of freeze-dried allograft tissues. Fideler and co-workers (1994) concluded that a dose of 30,000 or 40,000 gray (3 or 4 megarad) of gamma radiation is necessary for the inactivation of the DNA of the human immunodeficiency virus in frozen bone-patellar ligament-bone allograft harvested from donors infected with the virus.

Knee ligament reconstruction with allograft tendons may be performed for the anterior cruciate ligament (ACL), posterior cruciate ligament, medial or lateral collateral ligaments. These ligaments are strong fibrous bands of tissue that attach to the femur, fibula patella and tibia bones providing strength and stability to the joint. Allografts are commonly used for ACL reconstruction.

Tendon allograft has been used for the repair/reconstruction of the ACL in patients following major knee injury. The advantages

of using these allografts are a more abundant supply of tissue for multiple ligament and revision surgery, a shorter operative time, faster rehabilitation, avoidance of morbidity associated with autograft harvesting, as well as a lower incidence of stiff knee. On the other hand, the disadvantages in employing allografts are a potentially increased failure rate, a risk of hepatitis or AIDS infection, as well as stimulation of an immune response.

Studies have shown high failure rates with use of allograft for ACL reconstruction (Gorschewsky et al, 2005; Pritchard et al, 1995; Roberts et al, 1991). Prodromos et al (2007) performed a meta-analysis of autograft and allograft stability data. Normal stability for all autografts was 72 % versus 59 % for all allografts ($p < 0.01$). Abnormal stability was 5 % for all autografts versus 14 % for all allografts ($p < 0.01$). Bone-patellar-tendon-bone (BPTB) autograft normal stability was 66 % versus 57 % for BPTB allografts ($p < 0.01$). Abnormal BPTB autograft stability was 6 % versus 16 % for BPTB allograft. Hamstring autograft normal or abnormal stability rates were 77 % and 4 % and were compared to soft tissue allografts as a group which were 64 % and 12 % ($p < 0.01$). The investigators reported that allografts had significantly lower normal stability rates than autografts. The investigators found that allograft abnormal stability rate, which usually represents graft failure, was nearly 3 times higher than that of autografts. The investigators concluded that autografts are the graft of choice for routine ACL reconstruction with allografts better reserved for multiple ligament-injured knees where extra tissue may be required.

A meta-analysis of patellar autograft versus allograft for ACL reconstruction found better outcomes with autograft (Krych et al, 2008). The investigators noted, however, that when irradiated and chemically processed allografts are excluded, the outcomes of autograft and allograft are more similar, but without the irradiation or chemical processing of allografts, there is an increased risk of transmission of infection.

A guidelines panel from the Italian National Guidelines System (Romanini et al, 2010) conducted a critical review of the literature of grafts for arthroscopic ACL reconstruction, and found that "[a]utograft shows moderate superiority compared with allograft" and that "[a]vailable evidence allows recommendation of use of autograft over allograft in arthroscopic ACL reconstruction." The guidelines panel also found that, for autograft, patellar tendon has better performance than hamstring. The guidelines panel also concluded that "[i]t is also appropriate to consider allograft and artificial ligaments only in very selected cases, discouraging widespread use, given the potential risks and paucity of well-performed, well-designed clinical studies."

Reinhard et al (2010) conducted a systematic review of the evidence for graft selection in ACL reconstruction. The investigators

found limited high-quality evidence comparing autograft to allograft. Most case series include a smaller number of young patients (i.e., less than 30 years of age) and there have been early reports of unacceptably high failure rates in young patients. The authors stated that procurement, storage, sterilization, and processing of allografts vary widely within the industry. The investigators noted that the sterilization process may affect the mechanical characteristics of allografts, and that this process is necessary to decrease viral disease transmission and bacterial infection rate, but it may also adversely affect the quality of the tissue. The review stated that several techniques have been used for this purpose. The review found that, although ethylene oxide sterilization does not alter directly the mechanical properties of the graft, it has been shown to cause clinical failure because of persistent synovitis, and therefore is less favorable. Another sterilization technique involves applying irradiation. The authors stated that high-dose irradiation (3 Mrad or more) is unacceptable as it severely affects mechanical properties of the tissue. The authors stated that lower doses of irradiation (2 to 2.5 Mrad) has also been shown in several studies to cause unacceptable inferior clinical outcomes and high failure rates..
Other more recent studies have found lower failure rates with patellar tendon autograft than allograft and/or hamstring autograft (Barrett et al, 2011; Barrett et al, 2010; Mehta et al, 2010).

Dopirak and colleagues (2008) noted that there has been substantial progress in the understanding of the medial patello-femoral ligament during the past 10 years. This structure is the primary static soft-tissue restraint to lateral patellar displacement. Substantial alteration of normal patellar tracking occurs after sectioning of the ligament. Clinical studies have demonstrated the medial patello-femoral ligament is disrupted during acute patellar dislocation. Recently, several medial patello-femoral ligament-based procedures have been developed for the treatment of patellar instability with good early results. However, the authors stated that further studies are needed to define the exact role of these procedures in the treatment of patello-femoral instability.

Oro et al (2011) compared operating room time and costs associated with ACL reconstruction with either bone-patellar tendon-bone (BPTB) autograft or BPTB allograft. The total mean cost per case was 25 % higher in the allograft group compared with the autograft group. The mean operating room time was only 12 mins greater in autograft cases. Other studies have found significantly higher costs with use of allograft than autograft in ACL reconstruction, with little differences in operating room costs (Cooper and Kaeding, 2010; Naqda et al, 2010).

There is inadequate evidence that the use of tendon allograft is equally effective as autograft in the primary reconstruction of ACL. In addition, due to the risk of disease transmission, it should not be used for primary, isolated ACL reconstruction. Tendon

allograft for reconstruction of the ACL should only be employed when an adequate autologous graft is not available for (i) revision surgery (in knees in which a primary reconstruction of the ligament had failed and in which an autograft had already been used) or for (ii) primary reconstruction surgery for combined ligament injuries (ACL and either the posterior cruciate ligament, or medial collateral ligament) when an adequate autologous graft is not available.

There are relatively few studies comparing allograft to autograft in posterior cruciate ligament (PCL) reconstruction. In an evidence review of outcomes of posterior collateral ligament treatment, Hammoud et al (2010) cited evidence of good results with Achilles allograft and hamstring autograft for posterior cruciate ligament reconstruction. Hermans et al published a 6- to 12-year follow-up (mean 9.1 years) study of single bundle PCL reconstruction. Twenty-two patients (88 % follow-up) with isolated PCL injuries underwent reconstruction using patellar tendon autograft (n = 9), 4-strand hamstring tendon autograft (n = 7), 2-

strand hamstring tendon autograft plus Achilles tendon allograft (n = 8), or Achilles tendon allograft alone (n = 1). The authors reported that there were no differences between grafts used in mean Lysholm score, Tegner score, or International Knee Documentation Committee (IKDC) rating between the patellar tendon and hamstring tendon reconstructions.

Osteochondral grafting is performed to treat cartilage damage or defects due to traumatic injury or degenerative conditions (eg, osteochondritis dissecans (OCD), osteonecrosis or osteoarthritis). Osteochondral allograft transplant refers to the replacement of damaged articular cartilage and bone with tissue from a cadaveric donor. These allografts can either be fresh or frozen. Osteochondral allograft transplantation is used predominantly in the treatment of large and deep osteochondral lesions resulting from conditions such as osteochondritis dissecans (OCD), osteonecrosis or traumatic osteochondral fractures.

Manipulated (decellularized) human tissue graft products (eg, Chondrofix osteochondral allograft) are made of bone and cartilage tissue that is harvested from a cadaveric donor that has been processed to remove blood, cells and fat from the tissue. It is sterilized to kill bacteria and other microorganisms purportedly promotes bone integration and remodeling, while reducing the risk of inflammation in repair of Grade III and Grade IV osteochondral lesions.

Synthetic resorbable polymers (eg, PolyGraft, TruGraft TruFit plugs) are polymer scaffolds that are being proposed for the repair of osteochondral articular cartilage defects. The implant functions as a scaffold for chondral and osteogenic cells with the synthetic polymer being resorbed as the cells produce their normal matrices.

Williams and Gamradt (2008) noted that the creation of cartilage repair tissue relies on the implantation or neosynthesis of cartilage matrix elements. One cartilage repair strategy involves the implantation of bioabsorbable matrices that immediately fill a chondral or osteochondral defect. Such matrices support the local migration of chondrogenic or osteogenic cells that ultimately synthesize new ground substance. One such matrix scaffold, TruFit Plug, a synthetic resorbable biphasic implant, is a promising device for the treatment of osteochondral voids. The implant is intended to serve as a scaffold for native marrow elements and matrix ingrowth in chondral defect repair. The device is a resorbable tissue regeneration scaffold made predominantly from polylactide-coglycolide copolymer, calcium sulfate, and polyglycolide. It is approved in Europe for the treatment of acute focal articular cartilage or osteochondral defects but is approved by the U.S. Food and Drug Administration

only for backfill of osteochondral autograft sites. Pre-clinical studies demonstrated restoration of hyaline-like cartilage in a goat model with subchondral bony incorporation at 12 months. Early clinical results of patients enrolled in the Hospital for Special Surgery Cartilage Registry have been favorable, with a good safety profile.

Carmont et al (2009) stated that TruFit plugs are synthetic polymer scaffolds that are inserted into an articular surface to provide a stable scaffold to encourage the regeneration of a full thickness of articular cartilage to repair chondral defects. These researchers reported promising early results for the repair of small articular cartilage defects within the knee. Others have reported "failures" in which patients have complained of persistent symptoms and joint effusion at 6 months after plug insertion and arthroplasty has been undertaken. These investigators reported a case of delayed incorporation of an articular cartilage defect of the lateral femoral condyle treated with 3 TruFit plugs. The patient eventually reported symptom alleviation and resumption of functional activity after 24 months of continued rehabilitation. The authors recommended that patients with continued symptoms persevere with rehabilitation and allow the regenerating articular cartilage time to mature fully before considering undertaking irreversible arthroplasty procedures.

The clinical value of TruFit Plug for osteochondral allografts of the knee has not been established.

Severe post-traumatic ankle arthritis poses a reconstructive challenge in the young and active patient. Bipolar fresh osteochondral allograft (BFOA) may represent an intriguing alternative to arthrodesis and prosthetic replacement. Giannini et al

(2010) described a lateral trans-malleolar technique for BFOA, and evaluated the results in a case series. A total of 32 patients, mean age of 36.8 +/- 8.4 years, affected by ankle arthritis underwent BFOA with a mean follow-up of 31.2 months. The graft was prepared by specifically designed jigs, including the talus and the tibia with the medial malleolus. The host surfaces were prepared by the same jigs through a lateral approach. The graft was placed and fixed with twist-off screws. Patients were evaluated clinically and radiographically at 2, 4, and 6 months after operation, and at a minimum 24 months follow-up. A biopsy of the grafted areas was obtained from 7 patients at 1-year follow-up for histological as well as immunohistochemical examination. Pre-operative American Orthopaedic Foot and Ankle Society (AOFAS) score was 33.1 +/- 10.9 and post-operatively 69.5 +/- 19.4 ($p < 0.0005$). Six failures occurred. Cartilage harvests showed hyaline-like histology with a normal collagen component but low proteoglycan presence and a disorganized structure. Samples were positive for MMP-1, MMP-13

and Capsase-3. The authors concluded that the use of BFOA represents an intriguing alternative to arthrodesis or arthroplasty; precise allograft sizing, stable fitting and fixation and delayed weight-bearing were key factors for a successful outcome. They stated that further research regarding the immunological behavior of transplanted cartilage is needed.

Injury of articular cartilage due to trauma or pathological conditions is a major cause of disability worldwide. There is extensive ongoing reseach focusing on strategies to repair and replace knee joint cartilage. Juvenile cartilage allograft tissue implantation (eg, DeNovo NT natural tissue graft, DeNovo ET engineered tissue graft) was developed to treat damaged cartilage. The natural tissue graft is an allograft transplantation process that involves transplanting minced juvenile donor cartilage into a cartilage defect using a fibrin adhesive. The engineered tissue is a living tissue graft grown from juvenile chondrocytes. The cells are isolated and expanded in vitro. The expanded cells are cryopreserved in a cell bank from which a large number of grafts can be grown. The cells are applied to defects of the surface joint using a fibrin adhesive.

DeNovo NT Graft has been used to treat focal articular defects in a wide range of anatomical applications (e.g., ankle, elbow, great toe, hip, knee, and shoulder). DeNovo NT Natural Tissue Graft, a human tissue allograft, is an available cartilage repair treatment in the United States. DeNovo ET Engineered Tissue Graft is undergoing a clinical study as an investigational biological product currently underoing clinical tials. In contrast to DeNovo ET (engineered tissue), DeNovo NT (natural tissue) is obtained directly from a juvenile allograft donor joint and the cartilage is then aseptically minced and packaged by the tissue processor. The particulated allograft is mixed intra-operatively with fibrin glue before being implanted in the recipient's prepared

articular lesion. Moreover, there is a lack of evidence regarding the clinical value of DeNovo tissue graft.

Ahmed and Hincke (2010) discussed strategies to repair and replace knee joint cartilage. Because of inadequacies associated with widely used approaches, the orthopedic community has an increasing tendency to develop biological strategies, which include transplantation of autologous (i.e., mosaicplasty) or allogeneic osteochondral grafts, autologous chondrocytes (autologous chondrocyte transplantation), or tissue-engineered cartilage substitutes. Tissue-engineered cartilage constructs represent a highly promising treatment option for knee injury as they mimic the biomechanical environment of the native cartilage and have superior integration capabilities. Currently, a wide range of tissue-engineering-based strategies are established and investigated clinically as an alternative to the routinely used techniques (i.e., knee replacement and autologous chondrocyte transplantation). Tissue-engineering-based strategies include implantation of autologous chondrocytes in combination with collagen I, collagen I/III (matrix-induced autologous chondrocyte implantation), HYAFF 11 (Hyalograft C), and fibrin glue (Tissucol) or implantation of minced cartilage in combination with copolymers of polyglycolic acid along with polycaprolactone (cartilage autograft implantation system), and fibrin glue (DeNovo NT natural tissue graft). Tissue-engineered cartilage replacements show better clinical outcomes in the short-term, and with advances that have been made in orthopedics they can be introduced arthroscopically in a minimally invasive fashion. Thus, the future is bright for this innovative approach to restore function.

Kruse et al (2012) presented the findings of a new technique using DeNovo NT juvenile allograft cartilage implantation introduced into a talar lesion arthroscopically in a single procedure to repair a posterio-medial 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. The findings of this case study need to be validated by well-designed studies.

Haene et al (2012) evaluated the intermediate outcomes of fresh osteochondral allografting for osteochondral lesions of the talus with use of validated outcome measures. A total of 16 patients (17 ankles) received a fresh osteochondral allograft, and all 16 were available for follow-up. Data were prospectively collected with use of the Ankle Osteoarthritis Scale (AOS), Short Form-36 (SF-36), and American Academy of Orthopaedic Surgeons (AAOS) Foot and Ankle Module outcome measures. Post-operative AOFAS hind-foot scale scores were also collected. All 16 patients underwent radiographic and computed tomographic (CT) analyses pre-operatively, and 15 patients had these studies post-operatively. The average duration of follow-up was 4.1

years. The latest follow-up CT evaluation identified failure of graft incorporation in 2 of 16 ankles. Osteolysis, subchondral cysts, and degenerative changes were found in 5, 8, and 7 ankles, respectively. Five ankles were considered failures, and 2 required a re-operation because of ongoing symptoms. The AOS Disability and the AAOS Foot and Ankle Core Scale scores significantly improved, but there was no significant change in the AOS Pain, AAOS Foot and Ankle Shoe Comfort Scale, or SF-36 scores. Overall, 10 patients had a good or excellent result; however, persistent symptoms remained in 6 of these patients; only 4 were symptom-free. The authors concluded that the use of a fresh osteochondral allograft is a reasonable option for the treatment of large talar osteochondral lesions. Moreover, they stated that the high re-operation rate (2 of 17) and failure rate (5 of 17) must be taken into consideration when one is choosing this procedure for the management of these lesions. The findings of this small case-series study need to be validated by well-designed studies with more patients and longer follow-up.

Gross et al (2012) performed a systematic review of clinical outcomes after cartilage restorative and reparative procedures in the glenohumeral joint to (i) identify prognostic factors that predict clinical outcomes, (ii) provide treatment recommendations based on the best available evidence, and (iii) highlight literature gaps that require future research. These investigators searched Medline (1948 to week 1 of February 2012) and Embase (1980 to week 5 of 2012) for studies evaluating the results of arthroscopic debridement, microfracture, osteochondral autograft or allograft transplants, and autologous chondrocyte implantation for glenohumeral chondral lesions. Other inclusion criteria included minimum 8 months' follow-up. The Oxford Level of Evidence Guidelines and Grading of Recommendations Assessment, Development and Evaluation (GRADE) recommendations were used to rate the quality of evidence and to make treatment recommendations. A total of 12 articles met inclusion criteria, which resulted in a total of 315 patients. Six articles pertained to arthroscopic debridement (n = 249), 3 to microfracture (n = 47), 2 to osteochondral autograft transplantation (n = 15), and 1 to autologous chondrocyte implantation (n = 5). Whereas most studies reported favorable results, sample heterogeneity and differences in the use of functional and radiographic outcomes precluded a meta-analysis. Several positive and negative prognostic factors were identified. All of the eligible studies were observational, retrospective case series without control groups; the quality of evidence available for the use of the afore-mentioned procedures is considered "very low" and "any estimate of effect is very uncertain". The authors concluded that more research is needed to determine which treatment for chondral pathology in the shoulder provides the best long-term outcomes. They encouraged centers to establish the necessary alliances to conduct blinded, randomized clinical trials and prospective, comparative cohort studies necessary to rigorously determine which treatments result in the most optimal outcomes. At this time, high-quality evidence is lacking to make strong recommendations, and decision-

making in this patient population is performed on a case-by-case basis.

Farr et al (2012) noted that Cartilage Autograft Implantation System (CAIS; DePuy/Mitek, Raynham, MA) and DeNovo Natural Tissue (NT; ISTO, St. Louis, MO) are novel treatment options for focal articular cartilage defects in the knee. These methods involve the implantation of particulated articular cartilage from either autograft or juvenile allograft donor, respectively. In the laboratory and in animal models, both CAIS and DeNovo NT have demonstrated the ability of the transplanted cartilage cells to "escape" from the extracellular matrix, migrate, multiply, and form a new hyaline-like cartilage tissue matrix that integrates with the surrounding host tissue. In clinical practice, the technique for both CAIS and DeNovo NT is straightforward, requiring only a single surgery to affect cartilage repair. Clinical experience is limited, with short-term studies demonstrating both procedures to

be safe, feasible, and effective, with improvements in subjective patient scores, and with magnetic resonance imaging evidence of good defect fill. The authors concluded that while these treatment options appear promising, prospective randomized controlled studies are needed to refine the indications and contraindications for both CAIS and DeNovo NT.

Petrera et al (2013) reported their experience with the use of fresh glenoid osteochondral allograft in the treatment of a chronic post-traumatic posterior subluxation of the shoulder associated with glenoid bone loss in a 54-year old recreational football player. Based on the pathoanatomy of the lesion and availability of a bone bank providing fresh allograft, these researchers opted for an open anatomic reconstruction using a fresh glenoid allograft. A posterior approach was used; the prepared allograft was placed in the appropriate anatomic position and fixed with 2 small fragment screws with washers. At 2-year follow-up, the clinical outcome is excellent. The authors noted that this procedure may represent an effective option for the treatment of chronic posterior shoulder instability due to glenoid bone loss. However, they stated that the long-term effectiveness and the progression of glenohumeral osteoarthritis need to be evaluated.

DeNovo ET engineered tissue graft (ISTO Technologies, Inc. St. Louis, MO) is a scaffold-free hyaline cartilage implant designed for the repair and regeneration of knee cartilage. It uses tissue-engineered juvenile cartilage cells applied to defects of the joint surface using a protein-based adhesive. There is a lack of evidence regarding the clinical value of the DeNovo ET tissue graft.

Meniscal allograft transplantation (MAT) is a surgical technique for restoring knee function in individuals with destroyed or absent

menisci. The meniscus (or menisci) refers to the lateral and medial crescent shaped cartilaginous tissues that are located at the junction of the tibia and femur which provide structural integrity to the knee and absorbs shock. Allograft tissue is matched by size to the individual, inserted into the knee joint and anchored to supporting structures by hardware, soft tissue or bony tissue fixation. The procedure may be performed using an arthroscopic approach or by open incision and may be done alone or in tandem with other reconstructive knee procedures.

Vascellari et al (2012) reviewed the published clinical outcomes of meniscal repair using the Fast-Fix device comparing standard rehabilitation program to an accelerated rehabilitation protocol. A review of the Medline database was performed involving searches for clinical outcomes of all-inside meniscus repair performed with the Fast-Fix device. Eight studies were identified for inclusion. On the basis of the clinical outcomes of these studies, there appears to be no notable difference between an accelerated rehabilitation regimen with full weight bearing allowed as soon as tolerated and a standard post-operative rehabilitation program. Failure rate was 13 % for patients following an accelerated rehabilitation regimen, and 10 % for standard protocol. Accelerated rehabilitation after all-inside meniscal repair using the Fast-Fix device appears to be safe, and the incidence of re-tears is in line with those reported for standard rehabilitation protocol.

Giza and Howell (2013) noted that OCD of the talus are frequent sequelae of traumatic ankle injuries such as ankle sprains, fractures, and recurrent ankle instability. Initial management of talus lesions in most cases involves arthroscopy and microfracture/curettage. Tissue resulting from the microfracture is fibrocartilage. Clinical improvement in pain is seen in approximately 75 % to 85 % of people in a number of studies with long-term follow-up. Often, large lesions (greater than 1 cm(2)) or those with cystic changes require secondary procedures such as talus allograft/autograft or autologous chondrocyte implantation. The use of a juvenile articular chondrocyte allograft is an option for large or refractory lesions and has the advantage of obviating the need for a tibial or fibular osteotomy. The purpose of this article was to describe a novel arthroscopic surgical technique for transplantation of juvenile chondrocytes as a treatment for talus OCD defects.

Cerrato et al (2013) noted that osteochondral lesions of the talus can present a challenge to the orthopedic surgeon. Because of its avascular nature, articular cartilage has a poor capacity for self-repair and regeneration. A wide variety of strategies have been developed to restore the structure and function of injured cartilage. Surgical strategies range from repair of cartilage through the formation of fibrocartilage to a variety of restorative procedures, including tissue-engineering-based strategies. A novel treatment option involves the implantation of particulated articular cartilage obtained from a juvenile allograft donor, the

DeNovo NT graft.

Coetzee et al (2013) collected clinical outcomes of pain and function in retrospectively and prospectively enrolled patients treated with particulated juvenile cartilage for symptomatic osteochondral lesions in the ankle. This study collected outcomes and incidence of re-operations in standard clinic patients. The analysis presented here includes final follow-up to date for 12 males and 11 females representing 24 ankles. Subjects had an average age at surgery of 35.0 years and an average body mass index of 28 ± 5.8. Fourteen ankles had failed at least 1 prior bone marrow stimulation procedure. The average lesion size was 125 ± 75 mm2, and the average depth was 7 ± 5 mm. In conjunction with the treatment, 9 (38 %) ankles had 1 concomitant procedure and 9 (38%) had more than 1 concomitant procedure. Clinical evaluations were performed with an average follow-up of 16.2 months. Average outcome scores at final follow-up were American Orthopaedic Foot & Ankle Society Ankle-Hindfoot Scale 85 ± 18 with 18 (78 %) ankles demonstrating good to excellent scores, Short-Form 12 Health Survey (SF12) physical composite score 46 ± 10, SF12 mental health composite score 55 ± 7.1, Foot and Ankle Ability Measure (FAAM) activities of daily living 82 ± 14, FAAM Sports 63 ± 27, and 100-mm visual analog scale for pain 24 ± 25. Outcomes data divided by lesion size demonstrated 92 % (12/13) good to excellent results in lesions 10 mm or larger and those smaller than 15 mm. To date, 1 partial graft delamination has been reported at 16 months. The authors concluded that preliminary data from a challenging clinical population with large, symptomatic osteochondral lesions in the ankle suggested that treatment with particulated juvenile cartilage could improve function and decrease pain. They stated that longer follow-up and additional subjects are needed to evaluate improvement level and ideal patient indications.

The American College of Occupational and Environmental Medicine's occupational medicine practice guidelines on "Evaluation and management of common health problems and functional recovery in workers" (ACOEM, 2011) and the Work Loss Data Institute's clinical guidelines on "Ankle & foot (acute & chronic)" (2011) did not mention the use of allograft as a therapeutic tool.

In a review on "Osteochondral lesions of the talus: Aspects of current management", Hannon et al (2014) states that "Osteochondral lesions (OCLs) occur in up to 70 % of sprains and fractures involving the ankle. Atraumatic etiologies have also been described. Techniques such as microfracture, and replacement strategies such as autologous osteochondral transplantation, or autologous chondrocyte implantation are the major forms of surgical treatment". This review does not mention the use of allograft as a therapeutic option. Furthermore, UpToDate reviews on "Clinical features and management of ankle pain in the young athlete" (Chorley and Powers, 2014) "Talus fractures" (Koehler, 2014a) do not mention the use of

allograft as a management tool.

UpToDate reviews on “Acromioclavicular joint injuries” (Koehler, 2013a), “Acromioclavicular joint disorders” (Koehler, 2013b), and “Patient information: Acromioclavicular joint injury (shoulder separation) (Beyond the Basics)” (Koehler, 2013c) do NOT mention the use of allograft as a therapeutic option.

Jordan et al (2012) stated that young patients with cartilage defects in the hip present a complex problem for the treating physician with limited treatment modalities available. Cartilage repair/replacement techniques have shown promising results in other joints, however, the literature regarding the hip joint is limited. These researchers conducted a systematic review of clinical outcomes following various treatments for chondral lesions of the hip and defined the techniques for the treatment of these cartilage defects. The full manuscripts of 15 studies were reviewed for this systematic review including case studies, case series, and clinical studies. A variety of techniques have been reported for the treatment of symptomatic chondral lesions in the hip. Microfracture, cartilage repair, autologous chondrocyte implantation, mosaicplasty, and osteochondral allografting have all been used in very limited case series. Although good results have been reported, most studies lack both a control group and a large number of patients. However, the authors concluded that the reported results in this article provided a good foundation for treatments and stimulant for further study in an inherently difficult to treat young patient population with articular cartilage defects in the hip.

El Bitar et al (2014) noted that management of injuries to the articular cartilage is complex and challenging; it becomes especially problematic in weight-bearing joints such as the hip. Several causes of articular cartilage damage have been described, including trauma, labral tears, and femoro-acetabular impingement, among others. Because articular cartilage has little capacity for healing, non-surgical management options are limited. Surgical options include total hip arthroplasty, microfracture, articular cartilage repair, autologous chondrocyte implantation, mosaicplasty, and osteochondral allograft transplantation. Advances in hip arthroscopy have broadened the spectrum of tools available for diagnosis and management of chondral damage. However, the authors concluded that the literature is still not sufficiently robust to draw firm conclusions regarding best practices for chondral defects. They stated that additional research is needed to expand the knowledge of and develop guidelines for management of chondral injuries of the hip.

Farr et al (2014) evaluated the use of particulated juvenile articular cartilage (DeNovo NT) to treat patients with symptomatic

articular cartilage lesions on the femoral condyle or trochlear groove of the knee. A total of 25 patients were followed pre- and post-operatively through 2 years. Physical knee examinations, as well as multiple clinical surveys and magnetic resonance imaging (MRI) were performed at baseline and 3, 6, 12 and 24 month intervals. In some cases, patients voluntarily underwent diagnostic arthroscopic surgery with cartilage biopsy at 2 years post-op to assess the histological appearance of the cartilage repair. Clinical outcomes demonstrated statistically significant increases at 2 years compared with baseline, with improvement seen as early as 3 months. MRI results suggested the development of normal cartilage by 2 years. Histologically, biopsied repair tissue was noted to be composed of a mixture of hyaline and fibrocartilage and there appeared to be excellent integration of the transplanted tissue with the surrounding native articular cartilage. The authors concluded that particulated juvenile articular cartilage (DeNovo NT) provides for a rapid, safe and effective treatment of cartilage defects with clinical outcomes showing significant improvement over baseline and histologically favorable repair tissue at 2 years. There are several limitations from a small study without an appropriate surgical control. For example, the sample size is inadequately powered for anything other than an analysis of safety, only 3 surgeons participated, and the use of a single but experienced radiologist and pathologist prevents intra-rater reliability measurements. Further studies on this novel approach are needed, owing to the small number of lesions and relatively short follow-up time in this study.

Bisicchia et al (2014) stated that osteochondral lesions of the talus are being recognized as an increasingly common injury. They are most commonly located postero-medially or antero-laterally, while centrally located lesions are uncommon. Large osteochondral lesions have significant biomechanical consequences and often require resurfacing with osteochondral autograft transfer, mosaicplasty, autologous chondrocyte implantation (or similar methods) or osteochondral allograft transplantation. Allograft procedures have become popular due to inherent advantages over other resurfacing techniques. Cartilage viability is one of the most important factors for successful clinical outcomes after transplantation of osteochondral allografts and is related to storage length and intra-operative factors. The authors noted that while there is abundant literature about osteochondral allograft transplantation in the knee, there are few papers about this procedure in the talus.

Gelber et al (2014) noted that treatment of osteochondral lesions of the knee with synthetic scaffolds seems to offer a good surgical option preventing donor site morbidity. The TruFit® plug has frequently been shown to not properly incorporate into. These researchers evaluated the relationship between magnetic resonance imaging (MRI) findings and functional scores of patients with osteochondral lesions of the knee treated with TruFit®. Patients were evaluated with Magnetic Resonance Observation of Cartilage Tissue (MOCART) score for MRI assessment of the repair tissue. KOOS, SF-36 and visual analog

scale (VAS) were used for clinical evaluation. Correlation between size of the treated chondral defect and functional scores was also analyzed. A total of 57 patients with median follow-up of 44.8 months (range of 24 to 73) were included. KOOS, SF-36 and VAS improved from a mean 58.5, 53.9 and 8.5 points to a mean 87.4, 86.6 and 1.2 at last follow-up ($p < 0.001$). Larger lesions showed less improvement in KOOS ($p = 0.04$) and SF-36 ($p = 0.029$). Median Tegner values were restored to pre-injury situation (5, range of 2 to 10). Mean MOCART score was 43.2 ± 16.1. Although the cartilage layer had good integration, it showed high heterogeneity and no filling of the subchondral bone layer. The authors concluded that the TruFit® failed to restore the normal MRI aspect of the subchondral bone and lamina in most cases. The appearance of the chondral layer in MRI was partially re-established. This unfavorable MRI appearance did not adversely influence the patient's outcome in the short time and they restored their previous level of activity. There was an inverse linear relationship between the size of the lesion and the functional scores.

Song and colleagues (2014) stated that there have been no studies evaluating the clinical results after repair of a radial tear in the posterior horn of the lateral meniscus (PHLM) using the FasT-Fix system. In a case-series study, these researchers evaluated the clinical outcomes after repair of a radial tear in the PHLM using the FasT-Fix system in conjunction with ACL reconstruction. Between September 2008 and August 2011, a total of 15 radial tears in the PHLM identified during 132 consecutive ACL reconstructions were repaired using the FasT-Fix meniscal repair system. These investigators classified the radial tears into 3 types according to the tear patterns: (i) simple radial tear, (ii) complex radial tear, and (iii) radial tear involving the popliteal hiatus. Post-operative evaluation was performed using the Lysholm knee score and Tegner activity level. Second-look arthroscopy was performed in all cases. The mean follow-up period was 24 months. None of the patients had a history of recurrent effusion, joint line tenderness or a positive McMurray test. The meniscal repair was considered to have a 100 % clinical success rate. At the final follow-up, the Lysholm knee score and Tegner activity level were significantly improved compared to the pre-operative values. On the second-look arthroscopy, repair of radial tears in the PHLM in conjunction with ACL reconstruction using the FasT-Fix device resulted in complete or partial healing in 86.6 % of cases. The authors concluded that clinical results after meniscal repair of a radial tear in the PHLM by using the FasT-Fix system were satisfactory. The study only provided Level IV evidence; its main drawbacks were its small sample size (n = 15) and its short-term follow-up (mean of 24 months).

Osteochondral Allograft for Dysplasia Epiphysealis Hemimelica (Trevor's disease)

In a case study, Anthony and Wolf (2015) presented the case of a 5- year old boy with a 2-year history of right knee pain and

In a case study, Anthony and Wolf (2015) presented the case of a 5-year old boy with a 2-year history of right knee pain and evidence of dysplasia epiphysealis hemimelica (DEH or Trevor's disease) on imaging who underwent initial arthroscopic resection of his lesion with subsequent recurrence. The patient then underwent osteochondral allograft (OCA) revision surgery and was asymptomatic at 2-year follow-up with a congruent joint surface. This was the first reported case of a DEH lesion treated with OCA and also the youngest reported case of OCA placement in the literature. The authors concluded that OCA may be a viable option in DEH and other deformities of the pediatric knee. The main drawbacks of this study were that it was a single-case report and short-term follow-up (2 years).

Osteochondral Allograft for Knee Osteoarthritis

Giannini et al (2015) noted that bipolar fresh osteochondral allografts (BFOA) recently became a fascinating option for articular cartilage replacement, in particular in those young patients non-suitable for traditional replacement because of age. While the use of OCA for the treatment of focal osteochondral lesions in the knee is well-established, their use in the treatment of end-stage arthritis is far more controversial. These researchers described their experience in a series of 7 patients who underwent a resurfacing of both tibio-femoral and patello-femoral joints by BFOA. From 2005 to 2007, 7 patients (mean age of 35.2 ± 6.3 years) underwent BFOA for end-stage arthritis of the knee. Patients were evaluated clinically, radiographically and by CT scan pre-operatively and at established intervals up to the final follow-up. No intra-operative complications occurred. Nevertheless, joint laxity and aseptic effusion, along with a progressive chondrolysis, lead to early BFOA failure in 6 patients, which were revised by total knee arthroplasty (TKA) at 19.5 ± 3.9 months follow-up. Only 1 patient, who received the allograft to convert a knee arthrodesis, gained a satisfactory result at the last follow-up control. The authors concluded that BFOA in the knee joint still remains an inapplicable option in the treatment of post-traumatic end-stage arthritis of the young patient, due to the high rate of failure. They stated that further studies are needed to examine the causes of failure and improve the applicability of this method.

Osteochondral Allograft for Patellar Cartilage Injury

In a case-series study, Gracitelli et l (2015) evaluated functional outcomes and survivorship of the grafts among patients who underwent OCA for patellar cartilage injuries. An institutional review board-approved OCA database was used to identify 27 patients (28 knees) who underwent isolated OCA transplantation of the patella between 1983 and 2010. All patients had a

patients (28 knees) who underwent isolated OCA transplantation of the patella between 1995 and 2010. All patients had a minimum 2-year follow-up. The mean age of the patients was 33.7 years (range of 14 to 64); 54 % were female; 26 (92.9 %) knees had previous surgery (mean of 3.2 procedures; range of 1 to 10). The mean allograft area was 10.1 cm(2) (range of 4.0 to 18.0). Patients returned for clinical evaluation or were contacted via telephone for follow-up. The number and type of re-operations were assessed. Any reoperation resulting in removal of the allograft was considered a failure of the OCA transplantation. Patients were evaluated pre- and post-operatively using the modified Merle d'Aubigné-Postel (18-point) scale, the International Knee Documentation Committee (IKDC) pain, function, and total scores, and the Knee Society function (KS-F) score. Patient satisfaction was assessed at latest follow-up. Seventeen of the 28 knees (60.7 %) had further surgery after the OCA transplantation; 8 of the 28 knees (28.6 %) were considered OCA failures (4 conversions to total knee arthroplasty, 2 conversions to patella-femoral knee arthroplasty, 1 revision OCA, 1 patellectomy). Patellar allografting survivorship was 78.1 % at 5 and 10 years and 55.8 % at 15 years. Among the 20 knees (71.4 %) with grafts in-situ, the mean follow-up duration was 9.7 years (range of 1.8 to 30.1). Pain and function improved from the pre-operative visit to latest follow-up, and 89 % of patients were extremely satisfied or satisfied with the results of the OCA transplantation. The authors concluded that OCA transplantation was successful as a salvage treatment procedure for cartilage injuries of the patella. The main drawback of this study was its small sample size (n = 27) and its case-series design. The level of evidence of this study was 4. These findings need to be validated in well-designed studies.

Noyes and Barber-Westin (2013) examined if there is an ideal operation for large symptomatic articular cartilage lesions on the undersurface of the patella in young patients. These researchers performed a systematic search of PubMed to determine the outcome of operations performed for large patellar lesions in young patients. Inclusionary criteria were English language, original clinical trials published from 1992 to 2012, patellar lesions 4 cm(2) or larger, mean patient age 50 years or younger, and all evidence levels. Of 991 articles identified, 18 met the inclusionary criteria, encompassing 840 knees in 828 patients. These included 613 knees that underwent autologous chondrocyte implantation (ACI) (11 studies), 193 knees that had patello-femoral arthroplasty (PFA) (5 studies), and 34 knees that underwent osteochondral allografting (OA) (2 studies). The mean patient age was 37.2 years and the mean follow-up was 6.2 years. Long-term follow-up (greater than 10 years) was available in only 4 studies (2 PFA, 1 ACI, 1 OA). All studies except 1 were Level IV and none was randomized or had a control group. Twenty-one outcome instruments were used to determine knee function. When taking into account knees that either failed or had fair/poor function, the percentage of patients who failed to achieve a benefit averaged 22 % after PFA and 53 % after OA and ranged from 8 % to 60 % after ACI. In addition, all 3 procedures had unacceptable complication and re-operation rates. The authors concluded that combinations of failure rates and fair/poor results indicated that all 3 procedures had unacceptable results. The

concluded that combination of failure rates and fair/poor results indicated that all 3 procedures had unpredictable results. They stated that that a long-term beneficial effect might not occur in one of 3 ACI and PFA procedures and in 2 of 3 OA procedures. The authors were unable to determine an ideal surgical procedure to treat large symptomatic patellar lesions in patients 50 years or younger.

Chahal et al (2013) conducted a systematic review of clinical outcomes after osteochondral allograft transplantation in the knee and identified patient-, defect-, and graft-specific prognostic factors. These investigators searched PubMed, Medline, EMBASE, and the Cochrane Central Register of Controlled Trials. Studies that evaluated clinical outcomes in adult patients after osteochondral allograft transplantation for chondral defects in the knee were included. Pooled analyses for pertinent continuous and dichotomous variables were performed where appropriate. There were 19 eligible studies resulting in a total of 644 knees with a mean follow-up of 58 months (range of 19 to 120). The overall follow-up rate was 93 % (595 of 644). The mean age was 37 years (range of 20 to 62), and 303 patients (63 %) were men. The methods of procurement and storage time included fresh (61 %), prolonged fresh (24 %), and fresh frozen (15 %). With regard to etiology, the most common indications for transplantation included post-traumatic (38 %), osteochondritis dissecans (30 %), osteonecrosis from all causes (12 %), and idiopathic (11 %); 46 % of patients had concomitant procedures, and the mean defect size across studies was 6.3 cm(2). The overall satisfaction rate was 86 %; 65 % of patients (72 of 110) showed little to no arthritis at final follow-up. The reported short-term complication rate was 2.4 %, and the overall failure rate was 18 %. Heterogeneity in functional outcome measures precluded a meta-analysis; a qualitative synthesis allowed for the identification of several positive and negative prognostic factors. The authors concluded that osteochondral allograft transplantation for focal and diffuse (single-compartment) chondral defects resulted in predictably favorable outcomes and high satisfaction rates at intermediate follow-up. Patients with osteochondritis dissecans and traumatic and idiopathic etiologies have more favorable outcomes, as do younger patients with unipolar lesions and short symptom duration. The authors stated that future studies should include comparative control groups and use established outcome instruments that will allow for pooling of data across studies. (Level of Evidence: IV)

In a case-series study, Gracitelli et al (2016) evaluated functional outcomes and survivorship of the grafts among patients who underwent osteochondral allograft (OCA) for patellar cartilage injuries. An institutional review board-approved OCA database was used to identify 27 patients (28 knees) who underwent isolated OCA transplantation of the patella between 1983 and 2010. All patients had a minimum 2-year follow-up. The mean age of the patients was 33.7 years (range of 14 to 64); 54 % were female. Twenty-six (92.9 %) knees had previous surgery (mean of 3.2 procedures; range of 1 to 10). The mean allograft area

was 10.1 cm(2) (range of 4.0 to 18.0). Patients returned for clinical evaluation or were contacted via telephone for follow-up. The number and type of re-operations were assessed. Any re-operation resulting in removal of the allograft was considered a failure of the OCA transplantation. Patients were evaluated pre- and post-operatively using the modified Merle d'Aubigné-Postel (18-point) scale, the International Knee Documentation Committee (IKDC) pain, function, and total scores, and the Knee Society function (KS-F) score. Patient satisfaction was assessed at latest follow-up. Seventeen of the 28 knees (60.7 %) had further surgery after the OCA transplantation; 8 of the 28 knees (28.6 %) were considered OCA failures (4 conversions to total knee arthroplasty, 2 conversions to patella-femoral knee arthroplasty, 1 revision OCA, 1 patellectomy). Patellar allografting survivorship was 78.1 % at 5 and 10 years and 55.8 % at 15 years. Among the 20 knees (71.4 %) with grafts in-situ, the mean follow-up duration was 9.7 years (range of 1.8 to 30.1). Pain and function improved from the pre-operative visit to latest follow-up, and 89 % of patients were extremely satisfied or satisfied with the results of the OCA transplantation. The authors

concluded that OCA transplantation was successful as a salvage treatment procedure for cartilage injuries of the patella. The main drawback of this study was its small sample size (n = 27) and its case-series design; these findings need to be validated in well-designed studies.

An UpToDate review on “Patella fractures” (Blount, 2016) does not mention osteochondral allograft as a therapeutic option.

Osteochondral Allograft for the Talus

Caravaggi et al (2015) noted that severe ankle arthritis is a life-limiting condition that often requires surgery. Ankle arthroplasty via artificial or "biological" reconstruction is a viable option in those patients who are not comfortable with arthrodesis. More functional studies are needed to compare the performance and outcomes of the 2 function-preserving arthroplasties. In this study, 2 groups of 10 patients affected by severe ankle arthritis were treated either with a 3-component ankle prosthesis or with bipolar fresh OCA transplantation. Patients were evaluated pre-operatively and at 5-year follow-up. The American Orthopaedic Foot and Ankle Society score was used for clinical evaluation, and gait analysis for functional assessment. Activation pattern of lower limb muscles was obtained by surface electromyography (EMG). In each group, kinematic, kinetic, and EMG data were compared between pre-op and follow-up assessments, and also versus corresponding data from a 20 healthy subject control group. The median clinical score significantly increased between pre-op and follow-up from 53 to 74.5 in the transplantation and from 28.5 to 80 in the prosthesis group. Spatio-temporal parameters showed a statistically significant improvement in cadence and cycle time. Improvement of gait speed was also observed only in the prosthesis group; EMG patterns at follow-up were

and cycle time. Improvement of gait speed was also observed only in the prosthesis group. EMG patterns at follow-up were strongly correlated with the corresponding control data for both groups. The authors concluded that although no significant amelioration in the joints' range of motion (ROM) was detected in either surgical procedure, preservation of the functional conditions at medium-term, along with significant improvement of the clinical score, may be considered a positive outcome for both techniques. Long-term outcomes are important in the evaluation of interventions used in the field of orthopedic.

Johnson and Lee (2015) stated that the treatment of ankle arthritis remains controversial. Ankle cartilage allograft replacement is a novel and complex procedure. Many clinical studies have shown some level of promise, as well complications. These investigators performed a systematic review of the clinical outcomes to evaluate the different techniques and clinical outcomes for ankle cartilage allograft replacement. They performed a review of the published studies using MEDLINE(®) by way of PubMed(®) and Google Scholar(®) from January 2000 through October 2014, ranging from case reports to clinical studies. The inclusion criteria consisted of ankle cartilage allograft procedures with objective findings and clinical outcome scoring and complication and fusion rates and excluded non-allograft synthetic graft techniques, bone substitutes or expanders, review reports, and technique instructional manuals. Evidence with the combination of objective findings and clinical outcomes for all 3 type of allograft replacement (osteochondral, unipolar, and bipolar) is lacking. Several techniques for cartilage fixation have been described, including absorbable and metallic fixation. Most of the studies reported many occurrences and a variety of complications. A myriad of techniques for ankle cartilage allograft replacement exists. The authors concluded that the findings from the present systematic review of the published studies appeared promising; however, the lack of statistical power and inconsistent documentation made it difficult to determine the superiority of any one intervention compared with another for the treatment of ankle arthritis.

Pinski et al (2016) examined the level of evidence and methodological quality of studies reporting surgical treatments for osteochondral lesions of the ankle. A search was performed using the PubMed/Medline, Embase, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and Cochrane databases for all studies in which the primary objective was to report the outcome after surgical treatment of osteochondral lesions of the ankle. Studies reporting outcomes of micro-fracture, bone marrow stimulation, autologous osteochondral transplantation, OCA transplantation, and autologous chondrocyte implantation were the focus of this analysis because they are most commonly reported in the literature. Two independent investigators scored each study from 0 to 100 based on 10 criteria from the modified Coleman Methodology Score (CMS) and assigned a level of evidence using the criteria established by the Journal of Bone and Joint Surgery. Data were collected on the study type,

year of publication, number of surgical procedures, mean follow-up, pre-operative and post-operative American Orthopaedic Foot & Ankle Society score, measures used to assess outcome, geography, institution type, and conflict of interest. A total of 83 studies reporting the results of 2,382 patients who underwent 2,425 surgical procedures for osteochondral lesions of the ankle met the inclusion criteria; 90 % of studies were of Level IV evidence. The mean CMS for all scored studies was 53.6 of 100, and 5 areas were identified as methodologically weak: (i) study size, (ii) type of study, (iii) description of post-operative rehabilitation, (iv) procedure for assessing outcome, and (v) description of the selection process. There was no significant difference between the CMS and the type of surgical technique (p = 0.1411). A statistically significant patient-weighted correlation was found between the CMS and the level of evidence (r = -0.28, p = 0.0072). There was no statistically significant patient-weighted correlation found between the CMS and the institution type (r = 0.05, p = 0.6480) or financial conflict of interest

(r = -0.16, p = 0.1256). The authors concluded that most studies assessing the clinical outcomes of cartilage repair of the ankle are of a low level of evidence and of poor methodological quality.

Orr and associates (2017) reported that over a 2-year period, a single surgeon performed 8 structural allograft transfers for treatment of large osteochondral lesions of the talus (OLTs) in an active duty US military population. Lesion morphology and MRI stage were recorded. Pre-operative and latest post-operative AOFAS hindfoot-ankle and pain VAS scores were compared. A total of 8 male service members with mean age of 34.4 years underwent structural allograft transfer for OLTs with mean MRI stage of 4.9 and a mean lesion volume of 2,247.1 mm3. Pre-operative mean AOFAS hindfoot-ankle score was 49.6, and mean pain VAS score was 6.9. At mean follow-up of 28.5 months, post-operative mean AOFAS score was 73, and mean pain VAS score was 4.5, representing overall improvements of 47 % and 35 %, respectively; 3 patients were considered treatment failures secondary to continued ankle disability (n = 2) or graft resorption requiring ankle arthrodesis. The authors concluded that despite modest improvements in short-term functional outcome scores, large osteochondral lesions requiring structural allograft transfer remain difficult to treat, particularly in high-demand patient populations. They stated that surgeons should counsel patients pre-operatively on realistic expectations for return to function following structural allograft transfer procedures. Level of Evidence = IV (Retrospective study).

A guideline from the "Clinical Tissue Regeneration" Group of the German Society of Orthopaedics and Traumatology (Aurich et al, 2017) stated that osteochondral lesions (OCL) of the ankle are a common cause of ankle pain. Although the precise

pathophysiology has not been fully elucidated, it can be assumed that a variety of factors are responsible, mainly including traumatic events such as ankle sprains. Advances in arthroscopy and imaging techniques, in particular MRI, have improved the possibilities for the diagnosis of OCLs of the ankle. Moreover, these technologies aim at developing new classification systems and modern treatment strategies. These researchers reviewed the literature and provided recommendations on the treatment of OCLs of the ankle. The review gave a concise overview on the results of clinical studies and discussed advantages and disadvantages of different treatment strategies. Non-operative treatment showed good results for selected indications in children and adolescents, especially in early stages of OCD. However, surgical treatment is usually indicated in OCLs in adolescents and adults, depending on the size and location of the lesion. Various arthroscopic and open procedures are frequently employed, including re-attachment of the fragment, local debridement of the lesion with fragment removal and curettage of the lesion, bone marrow-stimulation by microfracture or microdrilling (antegrade or retrograde), and autologous matrix-induced chondrogenesis (AMIC) -- with or without reconstruction of a subchondral bone defect or cyst by autologous cancellous bone grafting. Isolated subchondral cysts with an intact cartilage surface can be treated by retrograde drilling and possibly additional retrograde bone grafting. For larger defects or as salvage procedure, osteochondral cylinder transplantation (OATS or Mosaicplasty) or matrix-induced autologous chondrocyte transplantation (MACT) were recommended. Transplantation of so-called (osteochondral) mega grafts (e.g., autologous bone grafts or allografts) were used for very large osteochondral defects that cannot be reconstructed otherwise. Implantation of the so-called "small metal implants" (e.g., HemiCAP Talus) is reserved for selected cases after failed primary reconstruction. Corrective osteotomies are indicated in accompanying axial mal-alignments. The authors concluded that there are several different treatment strategies for OCLs, of the ankle, but clinical studies are rare and evidence is limited. Therefore, interventional studies (e.g., randomized controlled trials [RCTs], observational studies) are needed.

Saltzman and colleague (2017) reported on their institution's early results from juvenile particulate cartilage allograft transplantation of the talus. Because of the relative rarity of the procedure at the talus, it was decided to provide a comprehensive understanding of the currently available evidence via a 2-part study with (i) a systematic review of the literature, and (ii) a retrospective single-center cohort study of the authors' patients, their demographics, and their early outcomes. A total of 4 studies were included with 33 ankles with a weighted mean follow-up of 14.3 months. Only 1 ankle (3.3 %) was converted to a revision open osteochondral allograft with medial malleolar osteotomy at 16 months post-operative; 6 (18.2 %) required non-revision type re-operations at an average of 15 months post-operative. Six patients with mean age 35.7 ± 14.4 years were evaluated from the authors' institution at mean 13.04 ± 8.35 months' follow-up. All reported subjective

improvements in pain and motion, and functional improvements, although post-operative MRI in 3 patients at time-points between 3 months and 2 years post-operative demonstrated persistent subchondral edema and non-uniform chondral surface in the talus. There were no intra-operative or post-operative complications, and there have been no re-operations. The authors concluded that these preliminary data suggested that treatment of large, traumatic or atraumatic, symptomatic osteochondral talar defects with particulated juvenile cartilage transplantation may improve patient subjective complaints of pain and function; systematic review of the available literature highlighted the need for future prospective, larger cohort studies of its use on the talus but suggested similar potential for the technology.

Okeagu and colleagues (2017) stated that OLTs are an increasingly implicated cause of ankle pain and instability. Several treatment methods exist with varying clinical outcomes. Due in part to successful OCA in other joints, such as the knee and shoulder, OCA has gained popularity as a therapeutic option, especially in the setting of large lesions. The clinical outcomes of talar OCA have been inconsistent relative to the positive results observed in other joints. Current literature regarding OCA failure focuses mainly on 3 factors: the effect of graft storage conditions on chondrocyte viability, graft/lesion size, and operative technique. Several pre-clinical studies have demonstrated the ability for bone and cartilage tissue to invoke an immune response, and a limited number of clinical studies have suggested that this response may have the potential to influence outcomes after transplantation. The authors concluded that further research is needed to examine the role of immunological mechanisms as an etiology of OCA failure

TruFit Plug for Repair of Osteochondral Defects

Verhaegen and colleagues (2015) performed a systematic search in 5 databases for clinical trials in which patients were treated with a TruFit plug for osteochondral defects. Studies had to report clinical, radiological, or histological outcome data. Quality of the included studies was assessed. A total of 5 studies described clinical results, all indicating improvement at follow-up of 12 months compared to pre-operative status. However, 2 studies reporting longer follow-up showed deterioration of early improvement. Radiological evaluation indicated favorable MRI findings regarding filling of the defect and incorporation with adjacent cartilage at 24 months follow-up, but conflicting evidence existed on the properties of the newly formed overlying cartilage surface. None of the included studies showed evidence for bone ingrowth. The few histological data available

cartilage surface. None of the included studies showed evidence for bone ingrowth. The few histological data available confirmed these results. The authors concluded that there are no data available that support superiority or equality of TruFit compared to conservative treatment or mosaicplasty/micro-fracture. They stated that further investigation is needed to improve synthetic biphasic implants as therapy for osteochondral lesions; RCTs comparing TruFit plugs with an established treatment method are needed before further clinical use can be supported.

In a retrospective, case-series study, Di Cave and colleagues (2017) evaluated the long-term functional and MRI outcomes of the TruFit Plug for the treatment of OLT. A total of 12 consecutive patients treated from March 2007 to April 2009 for OLT were evaluated. Clinical examination included the AOFAS ankle score and the VAS for pain. MRI scans were obtained pre-treatment and at last follow-up. The MOCART score was used to assess cartilage incorporation. Mean follow-up was 7.5 years (range of 6.5 to 8.7 years). The average age was of 38.6 years (range of 22 to 57 years). The sex ratio between males and females was 3:1 (9 men, 3 women). The mean AOFAS score improved from a pre-operative score of 47.2 ± 10.7 to 84.4 ± 8 ($p < 0.05$). According to the post-operative AOFAS scores, 1 case obtained excellent results, 9 were classified as good, and 2 were fair; VAS score improved from a pre-operative value of 6.9 ± 1.4 points to 1.2 ± 1.1 points at last follow-up ($p < 0.05$). The MOCART score for cartilage repair tissue on post-operative MRI averaged 61.1 points (range of 25 to 85 points). The authors concluded that the long-term results suggested that the technique of Trufit Plug for OLT was safe and demonstrated good post-operative scores including improvement of pain and function, with discordant MRI results. However, RCTs comparing TruFit Plug with an established treatment method are needed to improve synthetic biphasic implants as therapy for osteochondral lesions. Level of Evidence = 4.

Osteochondral Allograft for Femoral Trochlear Dysplasia

Vansadia and colleagues (2016) stated that the risk factors for patella-femoral joint instability include laxity of medial patellar restraints, abnormal limb geometry, femoral and tibial mal-rotation, patella alta, and trochlear dysplasia. Femoral trochlear dysplasia is characterized by a hypoplastic or shallow trochlear groove. These investigators reported the case of a 31-year old female with trochlear dysplasia and recurrent patella dislocations, laxity of the medial patella-femoral ligament (MPFL), and high-grade chondromalacia of the trochlea and the patella. Surgical treatment goals were to re-create a trochlear groove, restore bony restraint, and re-align and offload the patella. First, a triplane tibial tubercle osteotomy (TTO) was performed, and the patella was everted 360° with a subvastus approach. The MPFL was reconstructed using a gracilis allograft. A fresh osteochondral allograft transplant trochlea was sized, and a 35-mm diameter graft was transplanted to re-create the groove.

osteochondral allograft transplant trochlea was sized, and a 30 mm diameter graft was transplanted to re-create the groove. The TTO was secured in a new anterior, medial, and distal position. The patient was braced for 6 weeks and completed a rehabilitation protocol. At 9-month follow-up, she had made significant gains in ROM (0° to 140°) and activity compared to her pre-operative status. She reported no pain or recurrent dislocations. The authors concluded that this case demonstrated a viable surgical option for treatment of instability resulting from trochlear dysplasia with patella-femoral chondromalacia. The osteochondral allograft transplantation surgery technique allowed patients to have a stable, pain-free knee joint and participated in activities compared to non-operative management. However, they noted that the long-term outcomes of this procedure are unknown, and studies are needed.

The investigators noted that no large studies demonstrate long-term outcomes of treating trochlear dysplasia with OATS (Vansadia, eet al., 2016). The investigators cited Brucker and colleagues (2008) showing good outcomes of large-size OATS procedures in the knee femoral condyle. This case series showed that at mean follow-up of 55 months, the Lysholm knee score improved from 62 to 81 (P<0.001), and 90% of patients had high subjective satisfaction rates (citing Brucker, et al., 2008).

Osteochondral Allografts for the Hip

Oladeji and colleagues (2017) stated that articular cartilage lesions of the hip are difficult to effectively treat. Osteochondral allograft transplantation in the knee has been associated with long-term success, but OCA for the hip has not been extensively studied. These researchers presented the clinical and radiological outcomes from a cohort of 10 patients treated with fresh OCA transplants for large osteochondral defects of the femoral head and/or acetabulum. A total of 10 patients who had undergone osteochondral allograft transplantation of the femoral head and/or acetabulum at the authors' institution between 2013 and 2016 were identified from their Institutional Review Board-approved registry. Hip disability and Osteoarthritis Outcome Score (HOOS) was used to track patient progress. Patients with an average clinical follow-up of 1.4 years were included in this study; 4 patients were treated solely with OCA plugs for femoral head defects, while the remaining 6 received femoral OCA plugs and at least 1 concomitant procedure for additional intra-articular pathology; 7 patients (70 %) had successful functional outcomes, while 3 (30 %) had unsuccessful outcomes and were subsequently converted to total hip arthroplasty (THA) 5 to 29 months after OCA. The authors concluded that OCA transplantation can be an effective treatment strategy for young, healthy individuals with articular cartilage lesions of the hip. Smoking, avascular necrosis etiology, acetabular involvement and

individuals with articular cartilage lesions of the hip. Smoking, avascular necrosis etiology, acetabular involvement and concomitant procedures may be risk factors for unsuccessful outcomes necessitating salvage with THA. Moreover, they stated that long-term clinical studies to refine indications and determine functional outcomes and survival rates are needed. The 2 main drawbacks of this study were its small sample size (n = 10) and short-term follow-up (average of 1.4 years).

Fast-Fix Meniscal Repair System

Furumatsu and colleagues (2017) stated that extrusion of the medial meniscus (MM) is associated with knee joint pain in osteoarthritic knees. The relationships among MM radial/oblique tears, MM extrusion (MME), and the effect of arthroscopic meniscal repair are not established. These researchers evaluated the effects of arthroscopic all-inside MM repair on MME and the clinical outcomes in patients with radially oriented MM tears and mildly osteoarthritic knees. A total of 20 patients with a symptomatic radial or oblique tear of the MM posterior segment, MME greater than or equal to 2.5 mm, and mildly osteoarthritic knees were treated using FasT-Fix 360 All-inside Meniscal Suture devices. These investigators used MRI to measure the patients' MM body width (MMBW), absolute MME, and relative MME. The Japanese Knee Injury and Osteoarthritis Outcome Score, Lysholm, Tegner, IKDC Subjective Knee Evaluation, and VAS scores were obtained. Arthroscopic all-inside MM repair prevented increases of absolute and relative MME. The pre-operative and 3- and 12-month MRI-based MMBW values were similar. Over a 24-month follow-up after the MM repairs, the clinical scores showed significant improvements. The authors concluded that these findings suggested that all-inside meniscal repairs would be useful in preventing the progression of MME in patients suffering from symptomatic MM radial/oblique tears associated with mildly osteoarthritic knees.

The authors stated that this study had several drawbacks. First, the sample size was small (n= 20); further investigations with larger patient numbers are needed. Second, this study was not a prospective/comparative analysis that included partial meniscectomy or conservative treatment. Further MRI examinations and clinical assessments based on longer follow-up periods are needed to evaluate the effects of all-inside MM repair on the prevention of the progression of MME and degenerative knee abnormalities. The identification of these effects will also be useful in understanding whether MME precedes or follows progressive osteoarthritic changes in the knee.

Laurendon and co-workers (2017) noted that repair is indicated for tears in non-degenerative menisci. The literature reported a 15 % failure rate for all-inside repair. In a retrospective, cohort study, these researchers determined prognostic factors for failure of all-inside meniscal repair. This study included 87 meniscal repairs in young adults with or without ACL tear. Meniscal repair was evaluated

of all-inside meniscal repair. This study included 87 meniscal repair procedures, with or without ACL tear. Lesions were located in red-red or red-white zones. After freshening, repair comprised an all-inside arthroscopic technique using the FasT-Fix system, with (70.1 %) or without ligament reconstruction; all ACL tears were reconstructed. Pre-operative data comprised: age, gender, smoking status, sports activity, trauma-to-surgery time, body mass index (BMI), frontal morphotype, and IKDC score. Intra- and post-operative data comprised: meniscal lesion characteristics, location, number of sutures, type of ACL reconstruction, presence of chondropathy, authorized post-operative ROM, and IKDC score. Failure was defined by secondary meniscectomy. At 31 months' follow-up, there were 13 failures (15 %). Mean post-operative IKDC score was 88.19 (range of 64.37 to 98.95). Bucket-handle lesion (p = 0.006) and BMI greater than 25 (p = 0.014) emerged as significant factors of poor prognosis. The authors concluded that the present failure rate matched those reported in the literature. The more extensive the lesion, the higher the risk of failure; high BMI incurred mechanical stresses that increase the risk of failure. Level of Evidence = 4.

Juvenile Allogenous Articular Cartilage

Ng and Bernhard (2018) stated that particulated juvenile allograft cartilage (PJAC) has significant promise and is currently supported by several studies. Potential benefits of this new technique include single-stage procedure, simplicity in the surgical technique, implantation of juvenile tissue, and a lack of donor site morbidity.

Desandis and associates (2018) noted that juvenile allogenic chondrocyte implantation (JACI; DeNovo NT Natural Tissue Graft; Zimmer, Warsaw, IN) with autologous bone marrow aspirate concentrate (BMAC) is a relatively new all-arthroscopic procedure for treating critical-size OCLs of the talus. Few studies have investigated the clinical and radiographic outcomes of this procedure. These researchers collected the clinical and radiographic outcomes of patients who had undergone JACI-BMAC for talar OCLs to assess treatment efficacy and cartilage repair tissue quality using MRI. A total of 46 patients with critical-size OCLs (greater than or equal to 6 mm widest diameter) received JACI-BMAC from 2012 to 2014. These investigators performed a retrospective medical record review and assessed the functional outcomes pre- and post-operatively using the Foot and Ankle Outcome Score (FAOS) and SF12-item general health questionnaire. MRI was performed pre-operatively and at 12 and 24 months post-operatively. Cartilage morphology was evaluated on post-operative MRI scans using the MOCART score. The pre- to post-operative changes and relationships between outcomes and lesion size, bone grafting, lesion location, instability, hypertrophy, and MOCART scores were analyzed. Overall, the mean questionnaire scores improved significantly, with almost every FAOS subscale showing significant improvement post-operatively. Concurrent instability resulted in more changes that were statistically significant. The use of bone grafting and the presence of hypertrophy did not result in statistically significant

were statistically significant. The use of bone grafting and the presence of hypertrophy did not result in statistically significant changes in the outcomes. Factors associated with outcomes were lesion size and hypertrophy. Increasing lesion size was associated with decreased FAOS quality of life (QOL) subscale and hypertrophy correlating with changes in the pain subscale. Of the 46 patients, 22 had undergone post-operative MRI scans that were scored. The average MOCART score was 46.8. Most patients demonstrated a persistent bone marrow edema pattern and hypertrophy of the reparative cartilage. The authors concluded that juvenile articular cartilage implantation of the DeNovo NT allograft and BMAC resulted in improved functional outcome scores; however, the reparative tissue still exhibited fibrocartilage composition radiographically. They stated that further studies are needed to examine the long-term outcomes and determine the superiority of the arthroscopic DeNovo procedure compared with microfracture and other cartilage resurfacing procedures.

Karnovsky and colleagues (2018) compared the functional and radiographic outcomes of patients who received JACI-BMAC for treatment of talar osteochondral lesions with those of patients who underwent microfracture (MF). A total of 30 patients who underwent MF and 20 who received DeNovo NT for JACI-BMAC treatment between 2006 and 2014 were included. Additionally, 17 MF patients received supplemental BMAC treatment. Retrospective chart review was performed and functional outcomes were assessed pre- and post-operatively using the FAOS and VAS. Post-operative MRIs were reviewed and evaluated using a modified MOCART score. Average follow-up for functional outcomes was 30.9 months (range of 12 to 79 months). Radiographically, average follow-up was 28.1 months (range of 12 to 97 months). Both the MF and JACI-BMAC showed significant pre- to post-operative improvements in all FAOS subscales; VAS also showed improvement in both groups, but only reached a level of statistical significance ($p < 0.05$) in the MF group. There were no significant differences in patient reported outcomes between groups. Average osteochondral lesion diameter was significantly larger in JACI-BMAC patients compared to MF patients, but size difference had no significant impact on outcomes. Both groups produced reparative tissue that exhibited a fibrocartilage composition. The JACI-BMAC group had more patients with hypertrophy exhibited on MRI than the MF group ($p = 0.009$). The authors concluded that JACI-BMAC and MF resulted in improved functional outcomes. However, while the majority of patients improved, functional outcomes and quality of repair tissue were still not normal. Based on these findings, lesions repaired with DeNovo NT allograft still appeared fibrocartilaginous on MRI and did not result in significant functional gains as compared to MF.

Appendix

The Outerbridge classification system facilitates an objective description of chondral damage in the knee. Classifications are from a grade 0 to grade IV.

- Grade 0: normal cartilage
- Grade I: cartilage with swelling and softening
- Grade II: partial thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter
- Grade III: fissuring to the level of subchondral bone in an area with a diameter greater than 1.5 cm
- Grade IV: exposed subchondral bone

CPT Codes / HCPCS Codes / ICD-10 Codes

Information in the [brackets] below has been added for clarification purposes. Codes requiring a 7th character are represented by "+":

Code	Code Description
Allograft transplant of the knee ligaments:	
CPT codes covered if selection criteria are met:	
27427	Ligamentous reconstruction (augementation), knee; extra-articular
27428	intra-articular (open)
27429	intra-articular (open) and extra-articular
29888	Arthroscopically aided anterior cruciate ligament repair/augmentation or reconstruction
29889	Arthroscopically aided posterior cruciate ligament repair/augmentation or reconstruction
ICD-10 codes covered if selection criteria are met:	
M22.2X1 - M22.3X9	Patellofemoral disorders and other derangements of patella [including lateral, medial, anterior and posterior ligaments]

Code	Code Description
	ligaments]
M22.8X1 - M22.8X9	Other disorders of patella [including lateral, medial, anterior and posterior ligaments]
M23.50 - M23.52	Chronic instability of knee [including lateral, medial, anterior and posterior ligaments]
M23.601 - M23.8X9	Other spontaneous disruption of ligament(s) of knee and other internal derangements of knee [including lateral, medial, anterior and posterior ligaments]
M76.50 - M76.52	Patellar tendinitis
Allograft transplant of the knee, osteochondral:	
CPT codes covered if selection criteria are met:	
27415	Osteochondral allograft, knee, open

29867	Arthroscopy, knee, surgical; osteochondral allograft(s) (e.g., mosaicplasty)
Other CPT codes related to the CPB:	
29870 - 29889	Arthroscopy, knee
73721 - 73723	Magnetic resonance (eg, proton) imaging, any joint of lower extremity
ICD-10 codes covered if selection criteria are met:	
M87.051 - M87.059	Idiopathic aseptic necrosis of femur
M87.151 - M87.159	Osteonecrosis due to drugs, femur
M87.251 - M87.256	Osteonecrosis due to previous trauma, femur
M87.351 - M87.353	Other secondary osteonecrosis, femur
M87.851 - M87.859	Other osteonecrosis, right femur
M93.20 - M93.29	Osteochondritis dissecans
ICD-10 codes not covered for indications listed in the CPB:	
M17.0 - M17.9	Osteoarthritis of knee
Q68.2	Congenital deformity of knee [femoral trochlear dysplasia]

Code	Code Description
Q74.1	Congenital malformation of knee [femoral trochlear dysplasia]
Allograft transplant of the knee, meniscus:	
CPT codes covered if selection criteria are met:	
29868	Arthroscopy, knee, surgical; meniscal transplantation (includes arthrotomy for meniscal insertion), medial or lateral
Other CPT codes related to the CPB:	
27427 - 27429	Ligamentous reconstruction (augmentation), knee
29870 - 29889	Arthroscopy, knee
73721 - 73723	Magnetic resonance (e.g., proton) imaging
ICD-10 codes covered if selection criteria are met:	
M23.200 - M23.369	Derangement of medial and lateral meniscus
Q68.6	Discoid meniscus
S83.200+	Tear of unspecified meniscus, current injury
S83.211+ - S83.249+	Tear of medial meniscus, current injury
S83.251+ - S83.289+	Tear of lateral meniscus, current injury
S83.30X+ - S83.32X+	Tear of articular cartilage of knee, current
Osteochondral allograft of talus:	
CPT codes not covered for indications listed in the CPB:	
20962	Bone graft with microvascular anastomosis; other than fibula, iliac crest, or metatarsal
28103	Excision or currettage of bone cyst or benign tumor, talus or calcaneus; with allograft
Other CPT codes related to the CPB:	
28705 - 28725	Arthrodesis; pantalar; triple; or subtalar
ICD-10 codes not covered for indications listed in the CPB:	
M87.071 - M87.076	Idiopathic aseptic necrosis of ankle and foot [talus]
M87.171 - M87.176	Osteonecrosis due to drugs, ankle and foot [talus] [avascular necrosis of bone]

Code	Code Description
M87.271 - M87.276	Osteonecrosis due to previous trauma, ankle and foot [talus] [avascular necrosis of bone]
M87.371 - M87.376	Other secondary osteonecrosis, ankle and foot [talus] [avascular necrosis of bone]
M87.871 - M87.876	Other osteonecrosis, ankle and foot [talus] [avascular necrosis of bone]
Osteochondral allograft of tarsal-metatarsal:	
CPT codes not covered for indications listed in the CPB:	
20957	Bone graft with microvascular anastomosis; metatarsal
28107	Excision or curettage of bone cyst or benign tumor, tarsal or metatarsal, except talus or calcaneus; with allograft
Other CPT codes related to the CPB:	
28730 - 28735	Tarso-metatarsal arthrodesis

Osteochondral allograft other than knee, talus or tarsal-metatarsal:
Osteochondral allograft of shoulder or hip:
No specific code
ICD-10 codes not covered for indications listed in the CPB:

M89.9	Disorder of bone, unspecified [chondral lesions of the hip]
M94.9	Disorder of cartilage, unspecified [chondral lesions of the hip]
M95.8	Other specified acquired deformities of musculoskeletal system [chondral defects of the hip]
S43.101+ - S43.109+	Unspecified dislocation of acromioclavicular joint [acromio-clavicular (AC) separation]

DeNovo ET engineered tissue graft and DeNovo NT tissue graft, TruFit Plug (a synthetic resorbable biphasic implant), PolyGraft, Chondrofix for osteochondral allografts of the knee:
Fast-Fix meniscal repair system:
No specific code
ICD-10 codes not covered for indications listed in the CPB:

S83.200+	Tear of unspecified meniscus, current injury
S83.211+ - S83.249+	Tear of medial meniscus, current injury
S83.251+ - S83.289+	Tear of lateral meniscus, current injury

Code	Code Description
S83.30X+ - S83.32X+	Tear of articular cartilage of knee, current

The above policy is based on the following references:

1. Roberts TS, Drez D Jr, McCarthy W, Paine R. Anterior cruciate ligament reconstruction using freeze-dried, ethylene oxide-sterilized, bone-patellar tendon-bone allografts. Two year results in thirty-six patients. Am J Sports Med. 1991 Jan-Feb;19(1):35-41.
2. Valenti JR, Sala D, Schweitzer D, et al. Anterior cruciate ligament reconstruction with fresh-frozen patellar tendon allografts. Int Orthop. 1994;18(4):210-214.
3. Levitt RL, Malinin T, Posada A, et al. Reconstruction of anterior cruciate ligaments with bone-patellar tendon-bone. Clin Orthop. 1994;303:67-78.
4. Fideler BM, et al. Effects of gamma irradiation on the human immunodeficiency virus. J Bone Joint Surg. 1994;76(7):1032-1035.
5. Miller MD, Harner CD. The use of allograft: Techniques and results. Clin Sports Med. 1993;12(4):757-770.
6. Nin JR, Leyes M, Schweitzer D, et al. Anterior cruciate ligament reconstruction with fresh-frozen patellar tendon allografts: Sixty cases with 2 years' minimum follow-up. Knee Surg Sports Traumatol Arthrosc. 1996;4(3):137-142.
7. Shelton WR, Papendick L, Dukes AD, et al. Autograft versus allograft anterior cruciate ligament reconstruction. Arthroscopy. 1997;13(4):446-449.
8. van Arkel E, de Boer HH. Human meniscal transplantation: Preliminary results at 2 to 5 year follow-up. J Bone Joint Surg. 1995;77(4):589-595.
9. Pritchard JC, Drez D Jr, Moss M, Heck S. Long-term followup of anterior cruciate ligament reconstruction using freeze-dried fascia lata allografts. Am J Sports Med. 1995;23(5):593-596.
10. Wilcox T, Goble EM. Indications for meniscal allograft reconstruction. Am J Knee Surg. 1996;9:35-36.
11. Goble EM, Kohn D, Verdonk R, et al. Meniscal substitutes -- human experience. Scand J Med Sci Sports. 1999;9(3):146-157.

12. Convey FR, Meyers MH, Akeson WH. Fresh osteochondral allografting of the femoral condyle. Clin Orthop. 1991;273:139-145.
13. Mahomed MN, Beaver RJ, Gross AE. The long-term success of fresh, small fragment osteochondral allografts used for intraarticular post-traumatic defects in the knee joint. Orthopedics. 1992;15(10):1191-1199.
14. Garrett JC. Fresh osteochondral allografts for treatment of articular defects in osteochondritis dissecans of the lateral femoral condyle in adults. Clin Orthop. 1994;303:33-37.
15. Ghazavi MT, Pritzker KP, Davis AM, et al. Fresh osteochondral allografts for post-traumatic osteochondral defects of the knee. J Bone Joint Surg Br. 1997;79(6):1008-1013.
16. Bakay A, Csonge L, Papp G, et al. Osteochondral resurfacing of the knee joint with allograft. Clinical analysis of 33 cases. Int Orthop. 1998;22(5):277-281.
17. Chu CR, Convery FR, Akeson WH, et al. Articular cartilage transplantation. Clinical results in the knee. Clin Orthop. 1999;360:159-168.
18. Noyes FR, Barber-Westin SD. Reconstruction of the lateral collateral ligament of the knee with patellar tendon allograft. Report of a new technique in combined ligament injuries. Am J Sports Med. 1999;27(2):269-270.
19. Peterson RK, Shelton WR, Bomboy AL. Allograft versus autograft patellar tendon anterior cruciate ligament reconstruction: A 5-year follow-up. Arthroscopy. 2001;17(1):9-13.
20. Allum RL. BASK Instructional Lecture 1: Graft selection in anterior cruciate ligament reconstruction. Knee. 2001;8(1):69-72.
21. Felix NA, Paulos LE. Current status of meniscal transplantation. Knee. 2003;10(1):13-17.
22. Washington State Department of Labor and Industries, Office of the Medical Director. Meniscal allograft. Health Technology Assessment. Olympia, WA: Washington State Department of Labor and Industries; revised October 22, 2002. Available at: http://www.lni.wa.gov/omd/TechAssessDocs.htm. Accessed August 7, 2003.
23. Gross AE, Agnidis Z, Hutchison CR. Osteochondral defects of the talus treated with fresh osteochondral allograft transplantation. Foot Ankle Int. 2001;22(5):385-391.
24. Hayes DW Jr, Averett RK. Articular cartilage transplantation. Current and future limitations and solutions. Clin Podiatr Med Surg. 2001;18(1):161-176.
25. Tasto JP, Ostrander R, Bugbee W, Brage M. The diagnosis and management of osteochondral lesions of the talus: Osteochondral allograft update. Arthroscopy. 2003;19 Suppl 1:138-141.

26. Graf KW Jr, Sekiya JK, Wojtys EM; et al. Long-term results after combined medial meniscal allograft transplantation and anterior cruciate ligament reconstruction: Minimum 8.5-year follow-up study. Arthroscopy. 2004;20(2):129-140.
27. Raikin SM. Stage VI: Massive osteochondral defects of the talus. Foot Ankle Clin. 2004;9(4):737-744, vi.
28. Noyes FR, Barber-Westin SD, Rankin M. Meniscal transplantation in symptomatic patients less than fifty years old. J Bone Joint Surg Am. 2005;87 Suppl 1(Pt.2):149-165.
29. Caldwell PE 3rd, Shelton WR. Indications for allografts. Orthop Clin North Am. 2005;36(4):459-467.
30. Chapovsky F, Kelly JD 4th. Osteochondral allograft transplantation for treatment of glenohumeral instability. Arthroscopy. 2005;21(8):1007.
31. Gorschewsky O, Klakow A, Riechert K, et al. Clinical comparison of the Tutoplast allograft and autologous patellar tendon (bone-patellar tendon-bone) for the reconstruction of the anterior cruciate ligament: 2- and 6-year results. Am J Sports Med. 2005;33(8):1202-1209.
32. Rodriguez EG, Hall JP, Smith RL, et al. Treatment of osteochondral lesions of the talus with cryopreserved talar allograft and ankle distraction with external fixation.Surg Technol Int. 2006;15:282-288.
33. Moore DR, Cain EL, Schwartz ML, Clancy WG Jr. Allograft reconstruction for massive, irreparable rotator cuff tears. Am J Sports Med. 2006;34(3):392-396.
34. Simon TM, Jackson DW. Articular cartilage: Injury pathways and treatment options. Sports Med Arthrosc. 2006;14(3):146-154.
35. Schoenfeld AJ, Leeson MC, Grossman JP. Fresh-frozen osteochondral allograft reconstruction of a giant cell tumor of the talus. J Foot Ankle Surg. 2007;46(3):144-148.
36. Colangeli M, Donati D, Benedetti MG, et al. Total knee replacement versus osteochondral allograft in proximal tibia bone tumours. Int Orthop. 2007;31(6):823-829.
37. Prodromos C, Joyce B, Shi K. A meta-analysis of stability of autografts compared to allografts after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2007;15(7):851-856.
38. Gross AE, Kim W, Las Heras F, et al. Fresh osteochondral allografts for posttraumatic knee defects: Long-term followup. Clin Orthop Relat Res. 2008;466(8):1863-1870.
39. Krych AJ, Jackson JD, Hoskin TL, Dahm DL. A meta-analysis of patellar tendon autograft versus patellar tendon allograft in anterior cruciate ligament reconstruction. Arthroscopy 2008;24(3):292-298.
40. Adelaar RS, Madrian JR. Avascular necrosis of the talus. Orthop Clin North Am. 2004;35(3):383-395, xi.

41. Dopirak RM, Steensen RN, Maurus PB. The medial patellofemoral ligament. Orthopedics. 2008;31(4):331-338.
42. Williams RJ, Gamradt SC. Articular cartilage repair using a resorbable matrix scaffold. Instr Course Lect. 2008;57:563-571.
43. Carmont MR, Carey-Smith R, Saithna A, et al. Delayed incorporation of a TruFit plug: Perseverance is recommended. Arthroscopy. 2009 Jul;25(7):810-814.
44. Giannini S, Buda R, Grigolo B, et al. Bipolar fresh osteochondral allograft of the ankle. Foot Ankle Int. 2010;31(1):38-46.
45. Melton JT, Wilson AJ, Chapman-Sheath P, Cossey AJ. TruFit CB bone plug: Chondral repair, scaffold design, surgical technique and early experiences. Expert Rev Med Devices. 2010;7(3):333-341.
46. Hermans S, Corten K, Bellemans J. Long-term results of isolated anterolateral bundle reconstructions of the posterior cruciate ligament: A 6- to 12-year follow-up study. Am J Sports Med. 2009;37(8):1499-1507.
47. Romanini E, D'Angelo F, De Masi S, et al. Graft selection in arthroscopic anterior cruciate ligament reconstruction. J Orthop Traumatol. 2010;11(4):211-219.
48. Hammoud S, Reinhardt KR, Marx RG. Outcomes of posterior cruciate ligament treatment: A review of the evidence. Sports Med Arthrosc. 2010;18(4):280-291.
49. Barrett GR, Luber K, Replogle WH, Manley JL. Allograft anterior cruciate ligament reconstruction in the young, active patient: Tegner activity level and failure rate. Arthroscopy. 2010;26(12):1593-1601.
50. Cooper MT, Kaeding C. Comparison of the hospital cost of autograft versus allograft soft-tissue anterior cruciate ligament reconstructions. Arthroscopy. 2010;26(11):1478-1482.
51. Reinhardt KR, Hetsroni I, Marx RG. Graft selection for anterior cruciate ligament reconstruction: A level I systematic review comparing failure rates and functional outcomes. Orthop Clin North Am. 2010;41(2):249-262.
52. Mehta VM, Mandala C, Foster D, Petsche TS. Comparison of revision rates in bone-patella tendon-bone autograft and allograft anterior cruciate ligament reconstruction. Orthopedics. 2010;33(1):12.
53. Nagda SH, Altobelli GG, Bowdry KA, Brewster CE, Lombardo SJ. Cost analysis of outpatient anterior cruciate ligament reconstruction: Autograft versus allograft. Clin Orthop Relat Res. 2010;468(5):1418-1422.
54. Hospodar SJ, Miller MD. Controversies in ACL reconstruction: Bone-patellar tendon-bone anterior cruciate ligament reconstruction remains the gold standard. Sports Med Arthrosc. 2009;17(4):242-246.
55. Barrett AM, Craft JA, Replogle WH, et al. Anterior cruciate ligament graft failure: A comparison of graft type based on age and Tegner activity level. Am J Sports Med. 2011;39(10):2194-2198.

56. Oro FB, Sikka RS, Wolters B, et al. Autograft versus allograft: An economic cost comparison of anterior cruciate ligament reconstruction. Arthroscopy. 2011;27(9):1219-1225.
57. Ahmed TA, Hincke MT. Strategies for articular cartilage lesion repair and functional restoration. Tissue Eng Part B Rev. 2010;16(3):305-329.
58. Kruse DL, Ng A, Paden M, Stone PA. Arthroscopic De Novo NT(®) juvenile allograft cartilage implantation in the talus: A case presentation. J Foot Ankle Surg. 2012;51(2):218-221.
59. Haene R, Qamirani E, Story RA, et al. Intermediate outcomes of fresh talar osteochondral allografts for treatment of large osteochondral lesions of the talus. J Bone Joint Surg Am. 2012;94(12):1105-1110.
60. Gross CE, Chalmers PN, Chahal J, et al. Operative treatment of chondral defects in the glenohumeral joint. Arthroscopy. 2012;28(12):1889-1901.
61. Farr J, Cole BJ, Sherman S, Karas V. Particulated articular cartilage: CAIS and DeNovo NT. J Knee Surg. 2012;25(1):23-29.
62. Petrera M, Veillette CJ, Taylor DW, et al. Use of fresh osteochondral glenoid allograft to treat posteroinferior bone loss in chronic posterior shoulder instability. Am J Orthop (Belle Mead NJ). 2013;42(2):78-82.
63. Coetzee JC, Giza E, Schon LC, et al. Treatment of osteochondral lesions of the talus with particulated juvenile cartilage. Foot Ankle Int. 2013;34(9):1205-1211.
64. Tompkins M, Hamann JC, Diduch DR, et al. Preliminary results of a novel single-stage cartilage restoration technique: Particulated juvenile articular cartilage allograft for chondral defects of the patella. Arthroscopy. 2013;29(10):1661-1670.
65. American College of Occupational and Environmental Medicine (ACOEM). Ankle and foot disorders. In: Hegmann KT, editor(s). Occupational medicine practice guidelines. Evaluation and management of common health problems and functional recovery in workers. 3rd ed. Elk Grove Village, IL: ACOEM; 2011.
66. Work Loss Data Institute. Ankle & foot (acute & chronic). Encinitas, CA: Work Loss Data Institute; 2011.
67. Vascellari A, Rebuzzi E, Schiavetti S, Coletti N. All-inside meniscal repair using the FasT-Fix meniscal repair system: Is still needed to avoid weight bearing? A systematic review. Musculoskelet Surg. 2012;96(3):149-154.
68. Jordan MA, Van Thiel GS, Chahal J, Nho SJ. Operative treatment of chondral defects in the hip joint: A systematic review. Curr Rev Musculoskelet Med. 2012;5(3):244-253.
69. Giza E, Howell S. Allograft juvenile articular cartilage transplantation for treatment of talus osteochondral defects. Foot Ankle Spec. 2013;6(2):141-144.

70. Cerrato R. Particulated juvenile articular cartilage allograft transplantation for osteochondral lesions of the talus. Foot Ankle Clin. 2013;18(1):79-87.
71. Hannon CP, Smyth NA, Murawski CD, et al. Osteochondral lesions of the talus: Aspects of current management. Bone Joint J. 2014;96-B(2):164-171.
72. Chorley J, Powers CR. Clinical features and management of ankle pain in the young athlete. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed January 2014.
73. Koehler SM. Talus fractures. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed January 2014a.
74. Koehler SM. Acromioclavicular joint injuries. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed January 2014b.
75. Koehler SM. Acromioclavicular joint disorders. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed January 2014c.
76. Koehler SM. Patient information: Acromioclavicular joint injury (shoulder separation) (Beyond the Basics). UpToDate [online serial]. Waltham, MA: UpToDate; reviewed January 2014d.
77. El Bitar YF, Lindner D, Jackson TJ, Domb BG. Joint-preserving surgical options for management of chondral injuries of the hip. J Am Acad Orthop Surg. 2014;22(1):46-56.
78. Farr J, Tabet SK, Margerrison E, et al. Clinical, radiographic, and histological outcomes after cartilage repair with particulated juvenile articular cartilage: A 2-year prospective study. Am J Sports Med. Published on-line April 9, 2014.
79. Bisicchia S, Rosso F, Amendola A. Osteochondral allograft of the talus. Iowa Orthop J. 2014;34:30-37.
80. Gelber PE, Batista J, Millan-Billi A, et al. Magnetic resonance evaluation of TruFit® plugs for the treatment of osteochondral lesions of the knee shows the poor characteristics of the repair tissue. Knee. 2014;21(4):827-832.
81. Song HS, Bae TY, Park BY, et al. Repair of a radial tear in the posterior horn of the lateral meniscus. Knee. 2014;21(6):1185-1190.
82. Anthony CA, Wolf BR. Dysplasia epiphysealis hemimelica treated with osteochondral allograft: A case report. Iowa Orthop J. 2015;35:42-48.
83. Giannini S, Buda R, Ruffilli A, et al. Failures in bipolar fresh osteochondral allograft for the treatment of end-stage knee osteoarthritis. Knee Surg Sports Traumatol Arthrosc. 2015;23(7):2081-2089.
84. Gracitelli GC, Meric G, Pulido PA, et al. Fresh osteochondral allograft transplantation for isolated patellar cartilage injury. Am J Sports Med. 2015;43(4):879-884.
85. Caravaggi P, Lullini G, Leardini A, et al. Functional and clinical evaluation at 5-year follow-up of a three-component

prosthesis and osteochondral allograft transplantation for total ankle replacement. Clin Biomech (Bristol, Avon). 2015;30(1):59-65.

86. Johnson P, Lee DK. Evidence-based rationale for ankle cartilage allograft replacement: A systematic review of clinical outcomes. J Foot Ankle Surg. 2015;54(5):940-943.
87. Verhaegen J, Clockaerts S, Van Osch GJ, et al. TruFit Plug for repair of osteochondral defects -- Where Is the evidence? Systematic review of literature. Cartilage. 2015;6(1):12-19.
88. Ahmad J, Jones K. Comparison of osteochondral autografts and allografts for treatment of recurrent or large talar osteochondral lesions. Foot Ankle Int. 2016;37(1):40-50.
89. Pinski JM, Boakye LA, Murawski CD, et al. Low level of evidence and methodologic quality of clinical outcome studies on cartilage repair of the ankle. Arthroscopy. 2016;32(1):214-222.
90. Noyes FR, Barber-Westin SD. Advanced patellofemoral cartilage lesions in patients younger than 50 years of age: Is there an ideal operative option? Arthroscopy. 2013;29(8):1423-1436.
91. Chahal J, Gross AE, Gross C, et al. Outcomes of osteochondral allograft transplantation in the knee. Arthroscopy. 2013;29(3):575-588.
92. Gracitelli GC, Meric G, Pulido PA, et al. Fresh osteochondral allograft transplantation for isolated patellar cartilage injury. Am J Sports Med. 2015;43(4):879-884.
93. Vansadia DV, Heltsley JR, Montgomery S, et al. Osteochondral allograft transplantation for femoral trochlear dysplasia. Ochsner J. 2016;16(4):475-480.
94. Brucker PU, Braun S, Imhoff AB. [Mega-OATS technique--autologous osteochondral transplantation as a salvage procedure for large osteochondral defects of the femoral condyle]. Oper Orthop Traumatol. 2008;20(3):188-198.
95. Orr JD, Dunn JC, Heida KA Jr, et al. Results and functional outcomes of structural fresh osteochondral allograft transfer for treatment of osteochondral lesions of the talus in a highly active population. Foot Ankle Spec. 2017;10(2):125-132.
96. Aurich M, Albrecht D, Angele P, et al. Treatment of osteochondral lesions in the ankle: A guideline from the Group "Clinical Tissue Regeneration" of the German Society of Orthopaedics and Traumatology (DGOU). Z Orthop Unfall. 2017;155(1):92-99.
97. Blount JG. Patella fractures. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed January 2017.
98. Saltzman BM, Lin J, Lee S. Particulated juvenile articular cartilage allograft transplantation for osteochondral talar lesions. Cartilage. 2017;8(1):61-72.

99. Di Cave E, Versari P, Sciarretta F, et al. Biphasic bioresorbable scaffold (TruFit Plug®) for the treatment of osteochondral lesions of talus: 6- to 8-year follow-up. Foot (Edinb). 2017;33:48-52.
100. Okeagu CN, Baker EA, Barreras NA, et al. Review of mechanical, processing, and immunologic factors associated with outcomes of fresh osteochondral allograft transplantation of the talus. Foot Ankle Int. 2017;38(7):808-819.
101. Furumatsu T, Kodama Y, Kamatsuki Y, et al. Arthroscopic repair of the medial meniscus radial/oblique tear prevents the progression of meniscal extrusion in mildly osteoarthritic knees. Acta Med Okayama. 2017;71(5):413-418.
102. Laurendon L, Neri T, Farizon F, Philippot R. Prognostic factors for all-inside meniscal repair. A 87-case series. Orthop Traumatol Surg Res. 2017;103(7):1017-1020.
103. Oladeji LO, Cook JL, Stannard JP, Crist BD. Large fresh osteochondral allografts for the hip: Growing the evidence. Hip Int. 2017 Oct 17: [Epub ahead of print].
104. Ng A, Bernhard K. The use of particulated juvenile allograft cartilage in foot and ankle surgery. Clin Podiatr Med Surg. 2018;35(1):11-18.
105. DeSandis BA, Haleem AM, Sofka CM, et al. Arthroscopic treatment of osteochondral lesions of the talus using juvenile articular cartilage allograft and autologous bone marrow aspirate concentration. J Foot Ankle Surg. 2018;57(2):273-280.
106. Matsumoto T, Kakinoki R, Ikeguchi R, et al. Vascularized bone graft to the lunate combined with temporary scaphocapitate fixation for treatment of stage III Kienböck disease: A report of the results, a minimum of 2 years after surgery. J Hand Surg Am. 2018 Feb 14 [Epub ahead of print].
107. Karnovsky SC, DeSandis B, Haleem AM, et al. Comparison of juvenile allogenous articular cartilage and bone marrow aspirate concentrate versus microfracture with and without bone marrow aspirate concentrate in arthroscopic treatment of talar osteochondral lesions. Foot Ankle Int. 2018 Jan 1 [Epub ahead of print].