Autologous Chondrocyte Implantation for Focal Articular Cartilage Lesions

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Origination: 8/2000
Last Review: 3/2018
Next Review: 3/2019

Policy
Blue Cross and Blue Shield of Kansas City (Blue KC) will provide coverage for autologous chondrocyte implantation when it is determined to be medically necessary because the criteria shown below are met.

When Policy Topic is covered
Autologous chondrocyte implantation may be considered medically necessary for the treatment of disabling full-thickness articular cartilage defects of the knee caused by acute or repetitive trauma, when all of the following criteria are met:

- Adolescent patients should be skeletally mature with documented closure of growth plates (e.g., 15 years or older). Adult patients should be too young to be considered an appropriate candidate for total knee arthroplasty or other reconstructive knee surgery (e.g., younger than 55 years)
- Focal, full-thickness (grade III or IV) unipolar lesions of the weight bearing surface of the femoral condyles or trochlea, or patella at least 1.5 cm² in size
- Documented minimal to absent degenerative changes in the surrounding articular cartilage (Outerbridge Grade II or less), and normal-appearing hyaline cartilage surrounding the border of the defect
- Normal knee biomechanics, or alignment and stability achieved concurrently with autologous chondrocyte implantation

When Policy Topic is not covered
Autologous chondrocyte implantation for all other joints, including talar, and any indications other than those listed above is considered investigational.

Considerations
For smaller lesions (eg, smaller than 4 cm²), if débridement is the only prior surgical treatment, then consideration should be given to marrow-stimulating techniques before autologous chondrocyte implantation (ACI) is performed.
The average defect size reported in the literature is about 5 cm$^2$; many studies treated lesions as large as 15 cm$^2$.

Severe obesity, e.g., body mass index (BMI) greater than 35 kg/m$^2$, may affect outcomes due to the increased stress on weight bearing surfaces of the joint.

Misalignment and instability of the joint are contraindications. Therefore, additional procedures, such as repair of ligaments or tendons or creation of an osteotomy for realignment of the joint, may be performed at the same time. In addition, meniscal allograft transplantation may be performed in combination, either concurrently or sequentially, with ACI. The charges for the culturing component of the procedure are submitted as part of the hospital bill.

The entire matrix-induced autologous chondrocyte implantation (ACI) procedure consists of four steps: 1) the initial arthroscopy and biopsy of normal cartilage, 2) culturing of chondrocytes on an absorbable collagen matrix, 3) a separate arthrotomy to place the implant, and 4) post-surgical rehabilitation. The initial arthroscopy may be scheduled as a diagnostic procedure; as part of this procedure, a cartilage defect may be identified, prompting biopsy of normal cartilage in anticipation of a possible chondrocyte transplant. The biopsied material is then sent for culturing and returned to the hospital when the implantation procedure (i.e., arthrotomy) is scheduled.

There is a specific CPT category I code for ACI of the knee:
- 27412: Autologous chondrocyte implantation, knee

Arthroscopic harvesting of chondrocytes from the knee is reported using CPT code 29870. There is a HCPCS code for the autologous cultured chondrocyte implant - J7330.

State or federal mandates (eg, FEP) may dictate that certain U.S. Food and Drug Administration (FDA)–approved devices, drugs, or biologics may not be considered investigational, and thus these devices may be assessed only on the basis of their medical necessity.

### Description of Procedure or Service

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A variety of procedures are being developed to resurface articular cartilage defects. Autologous chondrocyte implantation (ACI) involves harvesting chondrocytes from healthy tissue, expanding the cells in vitro, and implanting the expanded cells into the chondral defect. Second- and third-generation techniques include combinations of autologous or allogeneic chondrocytes, minced cartilage, scaffolds, and growth factors.

For individuals who have focal articular cartilage lesions of the knee who receive ACI, the evidence includes systematic reviews, randomized controlled trials (RCTs) and prospective observational studies. Relevant outcomes are symptoms, change in disease status, morbid events, functional outcomes, and quality of life. There is a large body of evidence on ACI for the treatment of focal articular cartilage lesions of the knee. For large lesions, ACI results in better outcomes than microfracture, particularly in the long term. In addition, there is a limit to the size of lesions that can be treated with osteochondral autograft transfer, due to a limit on the number of osteochondral cores that can be safely harvested. As a result, ACI has become the established treatment for large articular cartilage lesions in the knee. In 2017, first generation ACI with a collagen cover was phased out and replaced with a preparation of ACI that seeds the chondrocytes onto a bio-resorbable collagen sponge. Although the implantation procedure is less technically demanding, studies to date have not shown improved outcomes compared to first generation ACI. There is also some evidence of an increase in hypertrophy (overgrowth) of the implant that may exceed that of the collagen membrane covered implant. Long-term studies with a larger number of patients will be needed to determine whether this impacts graft survival. Based on mid-term outcomes that approximate those of first generation ACI and the lack of alternatives, second generation ACI may be considered an option for large disabling full-thickness cartilage lesions of the knee. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have focal articular cartilage lesions of the knee who receive ACI, the evidence includes 1 RCT and systematic reviews of case series. Relevant outcomes are symptoms, change in disease status, morbid events, functional outcomes, and quality of life. The greatest amount of literature is for ACI of the talus. One systematic review found that outcomes following treatment with ACI were inferior to microfracture. However, as has been found with cartilage lesions for the knee, marrow stimulation may have a higher failure rate with larger lesions. Comparative trials are needed to determine whether ACI improves outcomes for larger lesions in joints other than the knee. The evidence is insufficient to determine the effects of the technology on health outcomes.

Clinical input was requested on multiple occasions, most recently in 2015 for the use of ACI in the patella. Prior clinical input supported use for localized chondral defects when other treatments have not been successful. The most recent clinical input was generally supportive of the use of ACI for large patellar lesions, although there was a range in the degree of support. Reviewers indicated that outcomes
were improved when realignment procedures were performed concurrently with ACI of the patella, and that success rates were lower when using ACI after a prior microfracture. A majority of reviewers recommended that a prior surgical procedure not be required for lesions greater than 4 cm².

**Background**

Damaged articular cartilage typically fails to heal on its own and can be associated with pain, loss of function, and disability and may lead to debilitating osteoarthritis over time. These manifestations can severely impair an individual’s activities of daily living and adversely affect quality of life.

Conventional treatment options include debridement, subchondral drilling, microfracture, and abrasion arthroplasty. Debridement involves the removal of synovial membrane, osteophytes, loose articular debris, and diseased cartilage and is capable of producing symptomatic relief. Subchondral drilling, microfracture, and abrasion arthroplasty attempt to restore the articular surface by inducing the growth of fibrocartilage into the chondral defect. Compared to the original hyaline cartilage, fibrocartilage has less capability to withstand shock or shearing force and can degenerate over time, often resulting in the return of clinical symptoms. Osteochondral grafts and ACI attempt to regenerate hyaline-like cartilage and thereby restore durable function. Osteochondral grafts for the treatment of articular cartilage defects are discussed in a separate policy.

With ACI, a region of healthy articular cartilage is identified and biopsied through arthroscopy. The tissue is sent to a facility licensed by the U.S. Food and Drug Administration (FDA) where it is minced and enzymatically digested, and the chondrocytes are separated by filtration. The isolated chondrocytes are cultured for 11 to 21 days to expand the cell population, tested, and then shipped back for implantation. With the patient under general anesthesia, an arthrotomy is performed, and the chondral lesion is excised up to the normal surrounding cartilage. Methods to improve the first generation ACI procedure have been developed, including the use of a scaffold or matrix-induced autologous chondrocyte implantation (MACI) composed of biocompatible carbohydrates, protein polymers, or synthetics. The only FDA-approved MACI product to date is supplied in a sheet, which is cut to size and fixed with fibrin glue. This procedure is considered to be technically easier and less time consuming than the first generation technique, which required suturing of a periosteal or collagen patch and injection of chondrocytes under the patch.

Desired features of articular cartilage repair procedures are the ability (1) to be implanted easily, (2) to reduce surgical morbidity, (3) not to require harvesting of other tissues, (4) to enhance cell proliferation and maturation, (5) to maintain the phenotype, and (6) to integrate with the surrounding articular tissue. In addition to the potential to improve the formation and distribution of hyaline cartilage, use of a scaffold with MACI eliminates the need for harvesting and suture of a periosteal or collagen patch. A scaffold without cells may also support chondrocyte growth.
**Regulatory Status**

The culturing of chondrocytes is considered by the U.S. Food and Drug Administration (FDA) to fall into the category of manipulated autologous structural (MAS) cells, which are subject to a biologic licensing requirement. In 1997, Carticel received FDA approval for the repair of clinically significant, “…symptomatic cartilaginous defects of the femoral condyle (medial lateral or trochlear) caused by acute or repetitive trauma....”

In 2016, MACI® (matrix-induced autologous chondrocyte implantation [ACI]; Vericel), received FDA approval for the repair of symptomatic, full-thickness cartilage defects of the knee in adult patients. MACI® consists of autologous chondrocytes which are cultured onto a bio-resorbable porcine-derived collagen membrane. MACI is indicated “for the repair of symptomatic, single or multiple full-thickness cartilage defects of the knee with or without bone involvement in adults.” In 2017, production of Carticel was phased out and MACI® is the only ACI product that is available in the U.S.

A number of other second-generation methods for implanting autologous chondrocytes in a biodegradable matrix are currently in development/testing or are available only outside of the United States. They include Atelocollagen (collagen gel; Koken), Bioseed® C (polymer scaffold; BioTissue Technologies) CaReS (collagen gel; Ars Arthro), Cartilix (polymer hydrogel; Biomet), Chondron (fibrin gel; Sewon Cellontech), Hyalograft C (hyaluronic acid-based scaffold; Fidia Advanced Polymers), NeoCart (ACI with a 3-dimensional chondromatrix; Histogenics, phase 3 trial), and Novocart®3D (collagen-chondroitin sulfate scaffold; Aesculap Biologics, phase 3 trial). ChondroCelect® (characterized chondrocyte implantation; TiGenix; phase 3 trial completed) uses a gene marker profile to determine in vivo cartilage-forming potential and thereby optimizes the phenotype (eg, hyaline cartilage vs fibrocartilage) of the tissue produced with each ACI cell batch. Each batch of chondrocytes is graded based on the quantitative gene expression of a selection of positive and negative markers for hyaline cartilage formation. Although clinical use of these second-generation ACI products has been reported in Europe and Asia, only MACI® is approved for use in the United States at this time.

**Rationale**

Assessment of efficacy for therapeutic intervention involves a determination of whether the intervention improves health outcomes compared to available alternatives. The optimal study design for this purpose is a randomized controlled trial (RCT) that compares the therapeutic intervention with existing alternative treatments and includes clinically relevant measures of health outcomes. Nonrandomized comparative studies and uncontrolled studies can sometimes provide useful information on health outcomes but are prone to biases such as noncomparability of treatment groups, placebo effect, and variable natural history of the condition.
This evidence review was created in July 1996 and has been updated regularly with searches of the MEDLINE database. The most recent literature update was performed through November 13, 2017. This evidence review was informed by a 2003 TEC Assessment of autologous chondrocyte implantation (ACI), which updated previous TEC Assessments on the same subject.¹⁻⁴

Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are length of life, quality of life, and ability to function—including benefits and harms. Every clinical condition has specific outcomes that are important to patients and to managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance and the quality and credibility. To be relevant, studies must represent one or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. RCTs are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

**ACI for Focal Articular Cartilage Lesion(s) of the Knee**

**Systematic Reviews**

**Cartilage Repair Procedures**

In 2017, Riboh et al reported on a network meta-analysis on the comparative efficacy of cartilage repair procedures of the knee.⁵ Nineteen RCTs from 15 separate cohorts (total N=855 patients) were included. The procedures selected for the network analysis were matrix-induced autologous chondrocyte implantation (MACI), autologous chondrocyte implantation (ACI) with a collagen membrane, ACI with a periosteal membrane, osteochondral autograft transfer (OAT), and microfracture. Outcomes evaluated included graft hypertrophy, hyaline cartilage, Lysholm Knee Score, reoperation in the short, mid, and long term, and Tegner Activity Scale score. The rank order of treatment efficacy, taking into account all outcome measures, was ACI with a collagen membrane, OAT, MACI, ACI with a periosteal membrane, and microfracture.
ACI vs Other Cartilage Repair Procedures

In 2016, Mundi et al reported on a systematic review of level I studies for cartilage restoration of the knee. Included were 12 randomized trials with a total of 765 patients and a mean lesion size of 3.9 cm². Five trials compared ACI with marrow stimulation, three compared ACI with OAT, one compared OAT with microfracture, and three compared different generations of ACI. Eleven of the 12 trials were conducted in Europe. Four trials reported significant differences in function with ACI vs marrow stimulation. However, a meta-analysis showed no significant differences in pain or function between the 2 treatments at 24-month follow-up. The quality of the evidence was rated as poor to moderate, and only 4 trials reported a sample size calculation. Although meta-analysis could not be performed on the other comparisons, 5 of 6 trials found no significant difference in outcomes between ACI and OAT or different generations of ACI. The percentage of grafts that failed and the relation between lesion size and success rate were not assessed in this review.

A 2010 systematic review by Harris et al included 13 RCTs and nonrandomized trials of 917 subjects who underwent ACI (n=604), microfracture (n=271), or OAT (n=42). The mean study quality was rated as 54 (/100), with no studies considered of good or excellent quality, seven considered fair, and six considered poor. Four studies compared different generations of ACI, finding no difference in outcomes but higher complication rates with open, periosteal cover, first-generation ACI. At 1- to 5-year follow-up, 3 of 7 studies showed better clinical outcomes after ACI than after microfracture, one showed better outcomes after microfracture, and three showed no difference between these treatments. Clinical outcomes after microfracture deteriorated after 18 to 24 months in 3 of 7 studies. Studies comparing ACI with OAT showed similar short-term clinical outcomes, with more rapid improvement but an increase in arthrofibrosis and donor-site morbidity following OAT. Younger patients with a shorter preoperative duration of symptoms and fewer prior surgical procedures had the best outcomes after surgical intervention. A defect size greater than 4 cm² was the only factor predictive of better outcomes when ACI was compared with other surgical techniques.

Randomized Controlled Trials

In 2017, first-generation ACI with injection of chondrocytes under a collagen cover (sometimes called second-generation ACI) was phased out and replaced with MACI (matrix-induced). Three RCTs were identified specifically on MACI. They are described next.

MACI vs ACI

In 2005, Bartlett et al reported on a randomized comparison between MACI and ACI with a collagen cover in 91 patients. Overall, results were comparable for the 2 treatments. The modified Cincinnati Knee Rating System score improved by 17.6 points in the ACI group and by 19.6 points in the MACI group (p=0.32). Visual analog scale scores improved from 6.0 to 4.3 in the ACI group and from 6.0 to 4.1 in the MACI group. Factors associated with worse clinical outcomes were a failed prior procedure, duration of symptoms, and patient age. Second-look arthroscopy at 1 year for 42 patients showed excellent-to-good International Cartilage Repair...
Society scores in 79.2% of ACI and in 66.6% of MACI patients (p=0.3). The authors did not report whether the study was adequately powered for this comparison. Histology from 14 ACI and 11 MACI patients showed a similar percentage of hyaline-like cartilage (42.9% ACI, 36.4% MACI).

**MACI vs Microfracture**
SUMMIT was the pivotal, industry-sponsored multicenter randomized open-label trial (2014) comparing MACI with microfracture for larger cartilage defects (≥3 cm²), which typically fare worse than smaller lesions when treated with microfracture. Patients (N=144) included had at least 1 symptomatic grade III or IV focal cartilage defect on the femoral condyles or trochlea, a stable knee, an intact or partial meniscus, and a moderate-to-severe Knee Injury and Osteoarthritis Outcome Score (KOOS) pain value (<55). Average lesion size was 4.8 cm² (range, 3-20 cm²), and 34.6% of patients had undergone a prior marrow stimulation procedure. At 2-year follow-up, the MACI group had significantly better subscores for KOOS pain (coprimary outcome; difference, 11.76; p<0.001) and function in sport and recreation (coprimary outcome; difference, 11.41; p=0.16) as well as the other KOOS subscales (function in daily living, knee-related quality of life, other symptoms). With response to treatment defined as a 10-point improvement in both the KOOS pain and function subscales, significantly more patients in the MACI group responded to treatment (87.5%) than in the microfracture group (68.1%; p=0.016). There were no significant differences between groups for cartilage repair, as measured by second-look arthroscopy, biopsy, or magnetic resonance imaging (MRI). Results through 5 years are reported on www.clinicaltrials.gov (NCT 01251588). However, there was a differential follow-up for the 2 groups in the extension study (loss of higher responding MACI patients and lower responding microfracture patients), resulting in little to no differences between groups. Statistical analysis was not reported.

In 2010, Basad et al reported on a small randomized trial that compared MACI (n=40) with microfracture (n=20) in patients who had a single posttraumatic chondral defect between 4 and 10 cm². Both groups improved at the 2-year follow-up, with a significant advantage of MACI over microfracture on the Lysholm Knee Score (92 vs 69, p=0.005), TAS (4 vs 3, p=0.04), and ICRS patient (p=0.03) and ICRS surgeon (p=0.02) scores. Patients treated with MACI from this trial, along with newly enrolled patients (n=65), were followed for 5 years. However, the rate of follow-up decreased from 93.8% at 24 months to 38.5% at 60 months, limiting interpretation of the 5-year results. Twelve (18.5%) patients developed symptoms between 6 and 36 months such as pain, locking, crepitus, or recurrent effusion. Arthroscopy of these 12 showed partial disintegration of regenerated tissue (n=5), subchondral edema (n=2), graft fibrillation (n=4), and progression to osteoarthritis (n=1). All 12 underwent additional procedures, including OAT and microfracture, with good results.

**Observational Studies**
A variety of issues have been addressed with observational studies on ACI or MACI, including combination treatment with meniscal allograft, the durability of the procedure, realignment procedures performed in combination with ACI,
comparison of tibiofemoral defects and patellar defects, and influence of prior marrow stimulation. They are discussed next.

**Tibiofemoral vs Patellofemoral Lesions**

Fewer data are available on MACI for patellofemoral lesions, but comparative observational studies have suggested outcomes that do not differ substantially from those using MACI for tibiofemoral lesions.

**Systematic Reviews**

In 2017, Schuette et al published a systematic review of mid- to long-term clinical outcomes from use of MACI in the knee. They included 10 studies (2 level 1, 1 level 2, 1 level 3, 6 level 4 studies), with a total of 442 tibiofemoral and 136 patellofemoral lesions/patients and follow-up of at least 5 years, published through September 2016. Four of the studies used the type I and III collagen matrix, five used Hyalograft C, and one used both. The 2 level 1 studies compared early with late weight-bearing following MACI. Individual study quality was rated as good to fair, with an average rating of fair. Clinical outcomes, weighted for age and defect size, improved from baseline to latest follow-up. At follow-up the failure rate was 12.4% (3 studies, n=145 patients; range, 3.2%-21.6%) for tibiofemoral joints and 4.7% (4 studies, n=106 patients; range, 0%-50%) for patellofemoral joints (p=0.037). The highest failure rates were reported in studies with the largest lesions and the longest follow-up.

One of the studies included in the Schuette systematic review (Meyerkort et al, 2014) was a prospective cohort of 23 patients who were treated with MACI for patellofemoral lesions. The mean defect size was 3.5 cm$^2$, and 9 (39%) of the patients underwent concurrent patellofemoral realignment procedures. At the 5-year follow-up, MRI indicated an intact appearance in most grafts, with graft height of more than 50% of the surrounding cartilage in 82% of patients. Patient-reported outcomes, measured with the KOOS and 36-Item Short-Form Health Survey (SF-36), improved significantly compared with preoperative scores. The increase in distance walked in 6 minutes was statistically significant (p<0.001) but modest (from 570 to 590 m). Graft hypertrophy was detected in 3 (13%) patients by MRI, but symptoms were considered sufficient to merit débridement in only 1 (4.3%) patient.

A report by Zak et al (2012) was also included in the Schuette review. Zak et al evaluated return to sports at 5 years in 70 patients who had MACI, 15 of whom had MACI in the patellofemoral joint. Significant improvements in the KOOS function in sport and recreation, Noyes grading system, and Tegner Activity Scale scores were reported between presurgery and follow-up. Patients with 2 lesions had worse outcomes than patients with a single tibiofemoral lesion, but there were no significant differences in outcomes between the tibiofemoral and patellofemoral groups.

**Nonrandomized Comparative Studies**

Three studies in the systematic review were by Ebert and colleagues. In 2017, Ebert et al reported a comparative study with 24-month follow-up. The study
included 194 patients with lesions on the medial or lateral femoral condyle (n=127), patella (n=35), or trochlea (n=32). There were no significant differences between groups in demographics, defect size, prior injury, or surgical history. Patient-reported outcome measures, including the KOOS, Visual analog scale for pain, SF-36, and satisfaction scores, were collected by an independent assessor. Most clinical scores were similar preoperatively except for the KOOS function in daily living and quality of life subscales, which were worse in the combined patella and trochlea group. Patellofemoral malalignment was corrected when indicated. Postoperative scores on the KOOS function in daily living, knee-related quality of life, and function in sport and recreation were significantly higher in the tibiofemoral group, but both groups improved over time. Graft hypertrophy assessed using MRI was more frequent in the tibiofemoral group (32.1%) than the patellofemoral group (10.4%). All lesions with hypertrophy were asymptomatic at the 24-month follow-up.

**Combined Meniscal Allograft and Cartilage Repair**
The 2011 systematic review by Harris et al evaluated combined meniscal allograft transplantation and cartilage repair/restoration. Six level IV studies (case series) with a total of 110 patients were included. Patients underwent meniscal allograft transplantation with ACI (n=73), osteochondral allograft (n=20), OAT (n=17), or microfracture (n=3). All studies showed improvements in clinical outcomes at final follow-up compared with the preoperative baseline. Outcomes were also compared with historical outcomes of each procedure performed in isolation. Four of the 6 studies found outcomes equivalent to procedures performed in isolation, while two found that outcomes with combined surgery were not as good as the historical controls. Across the 6 studies, 13 (12%) failures were reported; they included 11 isolated meniscal allograft transplantation failures, one combined meniscal allograft and ACI failure, and one isolated ACI failure. Three knees with failed meniscal allograft transplantation were converted to total knee arthroplasty. Nearly 50% of patients underwent 1 or more subsequent surgeries after combined meniscal allograft transplantation and cartilage repair/restoration procedures.

**Durability and Effects of Realignment and Prior Procedures**
A 2014 study by Nawaz et al evaluated functional outcomes and survival rates for ACI (periosteal or collagen membrane covered) and MACI in 869 patients. For the group as a whole, graft survival was estimated by Kaplan-Meier analysis to be 78.2% (95% confidence interval [CI], 74.9% to 81.1%) at 5 years and 50.7% (95% CI, 45.2% to 55.9%) at 10 years. Graft survival did not differ between the first- and second-generation (MACI) procedures. Functional and pain scores were significantly better in the MACI group, but this finding may have been confounded by the shorter follow-up with the newer technique.

Minas et al (2014) prospectively followed 210 ACI-treated patients (362 grafts) for at least 10 years. Malalignment, patellar maltracking, and meniscal or ligamentous deficiency had also been corrected as needed. At a mean follow-up of 12 years, 53 (25%) patients had graft failure. For the 157 patients who had successful grafts, functional outcomes were significantly improved from baseline to follow-up, as measured by the Western Ontario and McMaster Universities Index,
Knee Society Score for knee and function, and SF-36 (all p<0.001). Graft survival was significantly longer in patients with complex vs salvage-type lesions (p=0.03), with concomitant high tibial osteotomy vs no high tibial osteotomy (p=0.01), and with primary ACI vs ACI after a prior marrow stimulation procedure (p=0.004). For example, primary graft survival was 79% compared with 44% for defects previously treated with microfracture.

A 3-fold increased ACI failure rate after previous treatment with marrow stimulation techniques was found in a cohort of 321 patients with more than 2 years of follow-up. Independent analysis showed a failure rate of 8% (17/214) of joints without prior marrow stimulation of the lesion, compared with 26% (29/111) of joints that had not. The 2014 Nawaz study of 869 patients treated with ACI or MACI (described above) found that overall graft survival was 78.2% at 5 years and 50.7% at 10 years using Kaplan-Meier analysis. Graft failure was 5 times more likely with a previously treated lesion (<25% survival at 12 years) compared with a previously untreated lesion (>75% survival at 12 years) (hazard ratio, 5.33; 95% CI, 4.07 to 6.99; p<0.001). Other factors affecting survival were graft location and the severity of degenerative changes.

**Graft Hypertrophy**

In 2015, Ebert et al reported on graft hypertrophy (tissue overgrowth) at 24 months after MACI in a consecutive series of 180 patients. Patients were assessed clinically using the KOOS and underwent MRI at 3, 12, and 24 months post-MACI. Seventeen (9.4%) grafts had failed by 24 months. Three grafts were hypertrophic at 3 months, but the hypertrophy had resolved by 24 months. At 24 months, 47 (26.1%) grafts were hypertrophic. KOOS scores did not differ between patients with hypertrophic grafts and those with normal tissue infill. Longer follow-up is needed to evaluate whether tissue growth continues and to determine the effect of the hypertrophy on graft stability.

**Section Summary: ACI for Treatment of Focal Articular Cartilage Lesions of the Knee**

The evidence on ACI for the treatment of focal articular cartilage lesions of the knee includes a network analysis, systematic reviews, RCTs, and longer term observational studies. For large lesions, ACI results in better outcomes than microfracture, particularly in the long term. Studies comparing ACI with OAT have shown similar outcomes with smaller lesions, and improved outcomes with ACI when a defect is greater than 4 cm². In 2017, first-generation ACI was replaced with a preparation that seeds the chondrocytes onto a bioresorbable collagen sponge (MACI). Studies to date have not shown improved outcomes compared with first-generation ACI. There is some evidence of an increase in implant hypertrophy (overgrowth) at 2 years, particularly on the femoral condyles that may exceed that of the collagen membrane covered implant. Long-term studies with a larger number of patients are needed to determine whether hypertrophy impacts graft survival. MACI for patellar lesions has been evaluated in a systematic review and a nonrandomized comparative study. The included studies reported outcomes that did not differ substantially from those using MACI for tibiofemoral lesions. Observational studies have indicated that a prior cartilage
procedure may negatively impact the success of ACI, realignment procedures improve the success of ACI for patellar lesions, and ACI combined with meniscal allograft results in outcomes similar to either procedure performed alone.

**ACI for Joints Other Than the Knee**

There has been interest in applying ACI to cartilage defects in other joints. The most commonly reported is the use of ACI for the talus.

In 2010, Zengerink et al published a systematic review of treatment of osteochondral lesions of the talus.\textsuperscript{24} Fifty-one nonrandomized and 1 randomized trial were included in the review. Success rates were 85% for bone marrow stimulation, 87% for osteochondral autografting, and 76% for ACI. Because of the high cost of ACI and the knee morbidity seen with osteochondral autografting, reviewers concluded that bone marrow stimulation is the treatment of choice for primary osteochondral talar lesions.

A 2012 meta-analysis by Niemeyer et al evaluated 16 studies (213 patients) assessing ACI or MACI for lesions of the talus.\textsuperscript{25} All were case series, with a mean sample of 13 patients (range, 2-46 patients) and mean follow-up of 32 months (range, 6-120 months). Most series were prospective. In 6 studies, periosteum-covered ACI was applied while 10 studies used second-generation MACI. Nine different methods were used to evaluate pre- and postoperative clinical function, with the most common being the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score. Overall clinical success rate, defined as the percentage of good and excellent results, was 89.9% (range, 50%-100%).

A 2009 report examined the association between defect size and outcomes following marrow stimulation techniques in 120 ankles.\textsuperscript{26} Eight ankles subsequently underwent osteochondral transplantation, and 22 ankles were considered clinical failures (AOFAS ankle-hindfoot score, <80). Linear regression suggested a cutoff defect size of 1.5 cm\textsuperscript{2} for marrow stimulation techniques, with an 80% failure rate compared with a 10.5% failure rate for ankles with a defect size of less than 1.5 cm\textsuperscript{2}. Three (5.2%) of 58 ankles with a defect area of less than 1 cm\textsuperscript{2} showed clinical failure, while 7 (18.9%) of 37 ankles with a defect area between 1.0 and 1.5 cm\textsuperscript{2} failed.

**Section Summary: ACI for Joints Other Than the Knee**

The evidence on use of ACI for joints other than the knee includes systematic reviews primarily of observational studies. The most commonly reported use of ACI is for the talus. One systematic review found that outcomes following treatment with ACI were inferior to microfracture. As has been found with ACI for the knee, marrow stimulation has a higher failure rate with larger lesions. Comparative trials are needed to determine whether ACI improves outcomes for larger lesions of the talus.

**Summary of Evidence**

For individuals who have focal articular cartilage lesion(s) of the weight-bearing surface of the femoral condyles, trochlea, or patella who receive ACI, the evidence
includes systematic reviews, randomized controlled trials, and prospective observational studies. Relevant outcomes are symptoms, change in disease status, morbid events, functional outcomes, and quality of life. There is a large body of evidence on ACI for the treatment of focal articular cartilage lesions of the knee. For large lesions, ACI results in better outcomes than microfracture, particularly in the long term. In addition, there is a limit to the size of lesions that can be treated with osteochondral autograft transfer, due to a limit on the number of osteochondral cores that can be safely harvested. As a result, ACI has become the established treatment for large articular cartilage lesions in the knee. In 2017, first-generation ACI with a collagen cover was phased out and replaced with an ACI preparation that seeds the chondrocytes onto a bioresorbable collagen sponge. Although the implantation procedure for this second-generation ACI is less technically demanding, studies to date have not shown improved outcomes compared with first-generation ACI. Some evidence has suggested an increase in hypertrophy (overgrowth) of the new implant that may exceed that of the collagen membrane covered implant. Long-term studies with a larger number of patients will be needed to determine whether this hypertrophy impacts graft survival. Based on mid-term outcomes that approximate those of first-generation ACI and the lack of alternatives, second-generation ACI may be considered an option for large disabling full-thickness cartilage lesions of the knee. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have focal articular cartilage lesions of joints other than the knee who receive ACI, the evidence includes a randomized controlled trial and systematic reviews of case series. Relevant outcomes are symptoms, change in disease status, morbid events, functional outcomes, and quality of life. The greatest amount of literature is for ACI of the talus. One systematic review found that outcomes following ACI treatment were inferior to microfracture. However, as has been found with cartilage lesions for the knee, marrow stimulation may have a higher failure rate with larger lesions. Comparative trials are needed to determine whether ACI improves outcomes for larger lesions in joints other than the knee. The evidence is insufficient to determine the effects of the technology on health outcomes.

Supplemental Information

Clinical Input From Physician Specialty Societies and Academic Medical Centers
While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

2015 Input
In response to requests on the use of autologous chondrocyte implantation (ACI) for patellar lesions, input was received from 2 physician specialty societies (6
reviewers) and 4 academic medical centers while this policy was under review in 2015. Input was generally supportive of the use of ACI for large patellar lesions, although the degree of support varied. Reviewers indicated that outcomes were improved when realignment procedures were performed concurrently with ACI of the patella, and that success rates were lower when using ACI after a prior microfracture. Most reviewers recommended that a prior surgical procedure not be required for lesions greater than 4 cm².

2011 Input
In response to requests, input was received from 2 physician specialty societies and 3 academic medical centers while this policy was under review in 2011. Input was generally in agreement with the stated criteria for ACI, except the following: input was mixed on the requirement for an inadequate response to a prior surgical procedure and the requirement for an absence of meniscal pathology. Input was also mixed on the investigational status of ACI in patellar and talar joints.

2008 Input
In response to requests, input was received from 1 physician specialty society and 3 academic medical centers while this policy was under review in 2008. Reviewers generally agreed that ACI should be considered when all other treatments have been unsuccessful in patients with a localized chondral defect in an otherwise normal joint articular surface. Reviewers noted the lack of alternative options for larger lesions (eg, >4 cm²). Additional literature was provided, which was subsequently reviewed.

Practice Guidelines and Position Statements

American Academy of Orthopaedic Surgeons
In 2010 guidelines on the diagnosis and treatment of osteochondritis dissecans, the American Academy of Orthopaedic Surgeons did not recommend for or against a specific cartilage repair technique in symptomatic skeletally immature or mature patients with an unsalvageable osteochondritis dissecans lesion. This finding of insufficient evidence was based on a systematic review that found 4 level IV studies addressing cartilage repair techniques for an unsalvageable osteochondritis dissecans lesion. Because each level IV article used different techniques, different outcome measures, and differing lengths of follow-up, the Academy deemed the evidence for any specific technique inconclusive.

National Institute for Health and Care Excellence
In 2005, the National Institute for Health and Care Excellence updated its guidance on the use of autologous chondrocyte implantation. The Institute found evidence insufficient to determine the benefits of autologous chondrocyte implantation and indicated this technology “should not be used for the treatment of articular cartilage defects except where the treatment is part of a clinical study.” The Institute noted many limitations in available trial data, including length of follow-up, comparison with conservative treatment, assessment of the quality of cartilage produced, and the impact of cartilage produced on functional outcomes and health-related quality of life.
**U.S. Preventive Services Task Force Recommendations**
Not applicable.

**Medicare National Coverage**
There is no national coverage determination. In the absence of a national coverage determination, coverage decisions are left to the discretion of local Medicare carriers.

**Ongoing and Unpublished Clinical Trials**
Some currently unpublished trials that might influence this review are listed in Table 1.

**Table 1. Summary of Key Trials**

<table>
<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ongoing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT01656902</td>
<td>A Prospective Randomized Controlled Multicenter Phase-III Clinical Study to Evaluate the Safety and Effectiveness of NOVOCART® 3D Plus Compared to the Standard Procedure Microfracture in the Treatment of Articular Cartilage Defects of the Knee</td>
<td>261</td>
<td>Mar 2020</td>
</tr>
<tr>
<td>NCT01222559</td>
<td>Prospective, Randomised, Open Label, Multicentre Phase-III Clinical Trial to Compare the Efficacy and Safety of the Treatment With the Autologous Chondrocyte Transplantation Product co.Don Chondrosphere (ACT3D-CS) With Microfracture in Subjects With Cartilage Defects of the Knee With a Defect Size Between 1 and 4 cm²</td>
<td>102</td>
<td>Dec 2020</td>
</tr>
<tr>
<td><strong>Unpublished</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT01251588</td>
<td>An Extension Protocol for Participants of Genzyme-Sponsored Prospective, Randomized, Open-Label, Parallel-Group, Multicenter Study of Matrix-Induced Autologous Chondrocyte Implantation (MACI® Implant) for the Treatment of Symptomatic Articular Cartilage Defects of the Femoral Condyle Including the Trochlea for the Repair of Articular Cartilage Injuries in the Knee</td>
<td>128</td>
<td>Mar 2015 (completed)</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.

Denotes industry-sponsored or cosponsored trial.

**References**

**Billing Coding/Physician Documentation Information**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J7330</td>
<td>Autologous cultured chondrocytes, implant</td>
</tr>
<tr>
<td>S2112</td>
<td>Arthroscopy, knee, surgical for harvesting of cartilage (chondrocyte cells)</td>
</tr>
<tr>
<td>27412</td>
<td>Autologous chondrocyte implantation, knee</td>
</tr>
</tbody>
</table>

**Other non-specific codes that might be used are:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29870</td>
<td>Arthroscopy, knee, diagnostic, with or without synovial biopsy (separate procedure)</td>
</tr>
<tr>
<td>29871</td>
<td>Arthroscopy, knee, surgical; for infection, lavage and drainage</td>
</tr>
<tr>
<td>29873</td>
<td>Arthroscopy, knee, surgical; with lateral release</td>
</tr>
<tr>
<td>29874</td>
<td>Arthroscopy, knee, surgical; for removal of loose body or foreign body (eg, osteochondritis dissecans fragmentation, chondral fragmentation)</td>
</tr>
<tr>
<td>29875</td>
<td>Arthroscopy, knee, surgical; synovectomy, limited (eg, plica or shelf resection) (separate procedure)</td>
</tr>
<tr>
<td>29876</td>
<td>Arthroscopy, knee, surgical; synovectomy, major, 2 or more compartments (eg, medial or lateral)</td>
</tr>
<tr>
<td>29877</td>
<td>Arthroscopy, knee, surgical; debridement/shaving of articular cartilage (chondroplasty)</td>
</tr>
<tr>
<td>29879</td>
<td>Arthroscopy, knee, surgical; abrasion arthroplasty (includes chondroplasty where necessary) or multiple drilling or microfracture</td>
</tr>
<tr>
<td>29880</td>
<td>Arthroscopy, knee, surgical; with meniscectomy (medial AND lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed</td>
</tr>
<tr>
<td>29881</td>
<td>Arthroscopy, knee, surgical; with meniscectomy (medial OR lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed</td>
</tr>
<tr>
<td>29882</td>
<td>Arthroscopy, knee, surgical; with meniscus repair (medial OR lateral)</td>
</tr>
<tr>
<td>29883</td>
<td>Arthroscopy, knee, surgical; with meniscus repair (medial AND lateral)</td>
</tr>
<tr>
<td>29884</td>
<td>Arthroscopy, knee, surgical; with lysis of adhesions, with or without manipulation (separate procedure)</td>
</tr>
<tr>
<td>29885</td>
<td>Arthroscopy, knee, surgical; drilling for osteochondritis dissecans with bone grafting, with or without internal fixation (including debridement of base of lesion)</td>
</tr>
<tr>
<td>29886</td>
<td>Arthroscopy, knee, surgical; drilling for intact osteochondritis</td>
</tr>
</tbody>
</table>
dissecans lesion

29887  Arthroscopy, knee, surgical; drilling for intact osteochondritis dissecans lesion with internal fixation

**ICD10 Codes**

<table>
<thead>
<tr>
<th>Code Range</th>
<th>Description</th>
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<tbody>
<tr>
<td>M17.0-</td>
<td>Osteoarthritis of knee primary code range</td>
</tr>
<tr>
<td>M17.12</td>
<td>Osteoarthritis of knee secondary code range</td>
</tr>
<tr>
<td>M17.4-</td>
<td>Osteoarthritis of knee unspecified code range</td>
</tr>
<tr>
<td>M17.5</td>
<td>Traumatic arthropathy, knee code range</td>
</tr>
<tr>
<td>M17.9</td>
<td>Unspecified, internal derangement of knee code range</td>
</tr>
<tr>
<td>M23.8x1-</td>
<td>Other internal derangement of knee code range</td>
</tr>
<tr>
<td>M23.8x9</td>
<td>Other specified joint disorder, knee code range</td>
</tr>
<tr>
<td>M25.861-</td>
<td>Osteochondritis dissecans knee code range</td>
</tr>
<tr>
<td>M25.869</td>
<td>Other specified disorder of bone, lower leg</td>
</tr>
<tr>
<td>M93.261-</td>
<td>Other specified disorder of cartilage, lower leg</td>
</tr>
<tr>
<td>M93.269</td>
<td>Unspecified injury of lower leg code range</td>
</tr>
<tr>
<td>S99.811-</td>
<td>Other specified injuries of ankle and foot code range</td>
</tr>
</tbody>
</table>

**Additional Policy Key Words**

DeNovo NT

**Policy Implementation/Update Information**

- **8/1/00**: New policy, considered medically necessary. Requires prior authorization.
- **8/1/01**: Policy statement revised to include transplantation for the treatment of meniscal defects as investigational. Temporary codes added to the policy.
- **8/1/02**: No policy statement changes.
- **9/1/03**: Policy statement revised to indicate this procedure is considered investigational. New temporary s-codes added. Prior Authorization no longer required.
- **8/1/04**: No policy statement changes.
- **2/1/05**: No policy statement changes. New specific CPT code added to policy.
- **8/1/05**: Policy statement revised to indicate this procedure is investigational for the treatment of cartilage defects.
- **2/1/06**: No policy statement changes.
- **8/1/06**: No policy statement changes.
- **2/1/07**: No policy statement changes.
8/1/07  No policy statement changes. Policy titled changed from Autologous Chondrocyte Transplantation or Implantation to Autologous Chondrocyte Transplantation.

8/1/08  No policy statement changes.

11/13/08 Policy statement changed, ACI of the knee medically necessary if previous surgical treatments have failed; all other indications considered investigational.

3/1/10  Policy statement added; Matrix-induced autologous chondrocyte implantation (MACI) is considered investigational.

11/1/10 Policy statements added on minced cartilage and allogeneic cartilage cells; considered investigational. Title changed to include “Other Cell-based Treatments of Focal Articular Cartilage Lesions.”

3/1/11  No policy statement changes.

3/1/12  Meniscal pathology removed from policy statement per policy 7.01.15

3/1/13  No policy statement changes.

3/1/14 Sections and policy statements on minced cartilage moved to policy No. 7.01.78 (Autografts and Allografts in the Treatment of Focal Articular Cartilage Lesions) and “Other Cell-based Treatments” removed from title.

3/1/15  Removed Arthrotomy codes. No policy statement changes.

12/1/15  No policy statement changes.

3/1/16  Autologous chondrocyte implantation of the patella considered medically necessary; need for a prior surgical procedure removed from policy statement.

3/1/17  No policy statement changes.

5/1/17  Investigational statement on matrix-induced autologous chondrocyte implantation removed.

3/1/18  No policy statement changes.

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