## Synthetic Cartilage Implants for Joint Pain

**Policy Number:** 7.01.160  
**Origination:** 2/2018  
**Last Review:** 9/2020  
**Next Review:** 3/2021

### Policy

Blue Cross and Blue Shield of Kansas City (Blue KC) will not provide coverage for Synthetic Cartilage Implants for Joint Pain. This is considered investigational.

### When Policy Topic is covered

n/a

### When Policy Topic is not covered

Synthetic cartilage implants are considered **investigational** for the treatment of articular cartilage damage.

### Description of Procedure or Service

<table>
<thead>
<tr>
<th>Populations</th>
<th>Interventions</th>
<th>Comparators</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| **Individuals:**  
  • With early-stage first metatarsophalangeal osteoarthritis | Interventions of interest are:  
  • Synthetic cartilage implant | Comparators of interest are:  
  • Conservative nonoperative treatment  
  • Cheilectomy | Relevant outcomes include:  
  • Symptoms  
  • Functional outcomes  
  • Quality of life  
  • Treatment-related morbidity |
| **Individuals:**  
  • With advanced first metatarsophalangeal osteoarthritis | Interventions of interest are:  
  • Synthetic cartilage implant | Comparators of interest are:  
  • Conservative nonoperative treatment  
  • Arthrodesis | Relevant outcomes include:  
  • Symptoms  
  • Functional outcomes  
  • Quality of life  
  • Treatment-related morbidity |
| **Individuals:**  
  • With articular cartilage damage in joints other than the great toe | Interventions of interest are:  
  • Synthetic cartilage implant | Comparators of interest are:  
  • Conservative nonoperative treatment  
  • Osteochondral autografting  
  • Autologous chondrocyte implantation  
  • Arthroplasty | Relevant outcomes include:  
  • Symptoms  
  • Functional outcomes  
  • Quality of life  
  • Treatment-related morbidity |
Summary
Articular cartilage damage, either from a focal lesion or diffuse osteoarthritis, can result in disabling pain. Cartilage is a hydrogel, comprised mostly of water with collagen and glycosaminoglycans, that does not typically heal on its own. There is a need for improved treatment options. In 2016, a synthetic polyvinyl alcohol hydrogel disc received marketing approval by the U.S. Food and Drug Administration for the treatment of degenerative or posttraumatic arthritis in the first metatarsophalangeal (MTP) joint. If proven successful for the treatment of the MTP joint, off-label use is likely.

Summary of Evidence
For individuals who have early-stage first MTP joint OA who receive a synthetic cartilage implant, the evidence is lacking. Relevant outcomes are symptoms, functional outcomes, quality of life, and treatment-related morbidity. The pivotal study was performed in patients with Coughlin stage 2, 3, or 4 hallux rigidus. No evidence was identified in patients with stage 0 to early-stage 2 hallux rigidus. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals who have advanced first MTP joint OA who receive a synthetic cartilage implant, the evidence includes a pivotal non-inferiority trial. Relevant outcomes are symptoms, functional outcomes, quality of life, and treatment-related morbidity. Arthrodesis is the established treatment for advanced arthritis of the great toe, although the lack of mobility can negatively impact sports and choice of footwear and is not a preferred option of patients. Implants have the potential to reduce pain and maintain mobility in the first MTP joint but have in the past been compromised by fragmentation, dislocation, particle wear, osteolysis, and loosening. A polyvinyl alcohol hydrogel implant has shown properties similar to articular cartilage in vitro and was approved by the U.S. Food and Drug administration in 2016 for the treatment of painful degenerative or post-traumatic arthritis in the MTP joint. Results at 2 years from the pivotal non-inferiority trial showed pain scores that were slightly worse compared to patients treated with arthrodesis and similar outcomes between the groups for ADL and sports. In a non-inferiority trial, some benefit should be observed to justify the non-inferiority margin. However, the benefit of Cartiva with respect to increased range of motion does not appear to translate to improved activities of daily living, sports activities, or patient report of well-being compared to arthrodesis. In addition, the Cartiva group showed a higher rate of adverse outcomes (Moderate Difficulty, Extreme Difficulty, and Unable to Do) compared to the arthrodesis group for walking for 15 min (16% vs 0%), Up Stairs (6% vs 0%) and Squats (19% vs 8%). Some bias in favor of the novel motion preserving implant was also possible, as suggested by the high dropout rate in the arthrodesis group after randomization. Five-year follow-up of both the randomized and run-in patients who received an implant was reported in 2018 for 135 of 152 patients. At this time point, 21% of implants had been removed with conversion to arthrodesis. Comparison to arthrodesis at long-term follow-up is needed to determine whether the implant improves function. Corroboration of long-term results in an independent study is also needed to
determine the benefits and risks of the implant. The evidence is insufficient to
determine the effects of the technology on health outcomes.

For individuals who have articular cartilage damage in joints other than the great
toe who receive a synthetic cartilage implant, the evidence includes observational
studies. Relevant outcomes are symptoms, functional outcomes, quality of life,
and treatment-related morbidity. No RCTs were identified. The evidence is
insufficient to determine the effects of the technology on health outcomes.

Background
Articular Cartilage Damage
Articular cartilage damage may present as focal lesions or as more diffuse
osteoarthritis (OA). Cartilage is a biological hydrogel that is comprised mostly of
water with collagen and glycosaminoglycans and does not typically heal on its
own. OA or focal articular cartilage lesions can be associated with substantial pain,
loss of function, and disability. OA is most frequently observed in the knees, hips,
interphalangeal joints, first carpometacarpal joints, first metatarsophalangeal
(MTP) joint, and apophyseal (facet) joints of the lower cervical and lower lumbar
spine. OA less commonly affects the elbow, wrist, shoulder, and ankle. Knee OA is
the most common cause of lower-limb disability in adults over age 50, however,
OA of the MTP joint with loss of motion (hallux rigidus) can also be severely
disabling due to pain in the “toe-off” position of gait. An epidemiologic study found
that OA of the first MTP joint may be present in as many as 1 in 40 people over
the age of 50.12

Treatment
Treatment may include débridement, abrasion techniques, osteochondral
autografting, and autologous chondrocyte implantation. Débridement involves the
removal of the synovial membrane, osteophytes, loose articular debris, and
diseased cartilage and is capable of producing symptomatic relief. Subchondral
abrasion techniques attempt to restore the articular surface by inducing the
growth of fibrocartilage into the chondral defect. Diffuse OA of the knee, hip,
shoulder or ankle may be treated with joint replacement.

Early-stage OA of the first MTP joint is typically treated with conservative
management, including pain medication and change in footwear. Failure of
conservative management in patients with advanced OA of the MTP joint may be
treated surgically. Cheliectomy (removal of bone osteophytes) and interpositional
spacers with autograft or allograft have been used as temporary measures to
relieve pain.

Although partial or total joint replacement have been explored for MTP OA,
complications from bone loss, loosening, wear debris, implant fragmentation, and
transfer metatarsalgia are not uncommon. Also, since the conversion of a failed
joint replacement to arthrodesis has greater complications and worse functional
results than a primary arthrodesis (joint fusion), MTP arthrodesis is considered
the most reliable and primary surgical option. Arthrodesis can lead to a pain-free foot,
but the loss of mobility in the MTP joint alters gait, may restrict participation in
running and other sports, and limits footwear options, leading to patient dissatisfaction. Transfer of stress and arthritis in an adjacent joint may also develop over time.

Because of the limitations of MTP arthrodesis, alternative treatments that preserve joint motion are being explored. Synthetic cartilage implants have been investigated as a means to reduce pain and improve function in patients with hallux rigidus. Some materials such as silastic were found to fragment with use. Other causes of poor performance are the same as those observed with metal and ceramic joint replacement materials and include dislocation, particle wear, osteolysis, and loosening.

Synthetic polyvinyl alcohol (PVA) hydrogels have water content and biomechanical properties similar to cartilage and they are biocompatible. PVA hydrogels have been used in a variety of medical products including soft contact lens, artificial tears, hydrophilic nerve guides, and tissue adhesion barriers. This material is being evaluated for cartilage replacement due to the rubber elastic properties and, depending on the manufacturing process, high tensile strength and compressibility.2

The Cartiva implant is an 8- to 10-mm PVA disc that is implanted with a slight (1- to 1.5-mm) protrusion to act as a spacer for the first MTP joint. It comes with dedicated reusable instrumentation, which includes a drill bit, introducer, and placer.

**Regulatory Status**
The Cartiva PVA implant was approved by the U.S. Food and Drug Administration (FDA) in 2016 for the treatment of arthritis of the MTP joint. It has been distributed commercially since 2002 with approval in Europe, Canada, and Brazil. The Cartiva® Synthetic Cartilage Implant (Cartiva, Alpharetta, GA) was approved by the FDA through the premarket approval process (P150017) for painful degenerative or posttraumatic arthritis in the first MTP joint along with hallux valgus or hallux limitus and hallux rigidus. Lesions greater than 10 mm in size and insufficient quality or quantity of bone are contraindications. Continued approval depends on a study evaluating long-term safety and effectiveness. The post-approval study will follow the subjects treated with Cartiva® Synthetic Cartilage Implant for 5 years. FDA product code: PNW.

**Rationale**
This evidence review was created in December 2017 and updated with a search of the PubMed database through June 3, 2020.

Evidence reviews assess the clinical evidence to determine whether the use of technology improves the net health outcome. Broadly defined, health outcomes are the 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 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 a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of technology, 2 domains are examined: the relevance, and 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.

**Early-Stage First Metatarsophalangeal Osteoarthritis**

**Clinical Context and Therapy Purpose**

The purpose of a synthetic cartilage implant in patients who have early-stage first metatarsophalangeal (MTP) joint osteoarthritis (OA) is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The question addressed in this evidence review is: Does a synthetic cartilage implant in patients who have early-stage first MTP OA improve the net health outcome?

The following PICO was used to select literature to inform this review.

**Patients**

The relevant population of interest is patients with early-stage first MTP OA.

**Interventions**

The therapy being considered is the Cartiva synthetic cartilage implant.

**Comparators**

The following therapies are currently being used:

- Conservative nonoperative treatment which would include modification of footwear and non-steroidal anti-inflammatory drugs (NSAIDS).
- Cheilectomy

**Outcomes**

The general outcomes of interest are symptoms, typically measured with a visual analog score (VAS) for pain. Functional outcomes and quality of life are measured with the Foot and Ankle Ability Measure (FAAM). The FAAM is a validated measure
of sports activities and activities of daily living (ADL), with a minimal clinically important difference defined as 9 points for sports and 8 points for ADL subscales. Adverse events from the implantation procedure would be measured within 30 days, while dislocation and wear would be monitored at 5 to 10 years.

A beneficial outcome of the implant would be a reduction in pain and improvement in function.

A harmful outcome of the implant would be an increase in pain and a reduction in function.

**Study Selection Criteria**
Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess long-term outcomes and adverse effects, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

**Review of Evidence**
No studies were identified on the use of synthetic cartilage implants for early-stage first MTP OA.

**Section Summary: Early-Stage First Metatarsophalangeal Osteoarthritis**
The evidence is insufficient to determine the effects of the synthetic cartilage implant for early-stage first MTP OA. RCTs and long-term follow-up are needed to determine implant survival and its effect on health outcomes.

**Advanced First Metatarsophalangeal Osteoarthritis**

**Clinical Context and Therapy Purpose**
The purpose of a synthetic cartilage implant in patients who have advanced first MTP OA to provide a treatment option that is an alternative to or an improvement on existing therapies.

The question addressed in this evidence review is: Does the synthetic cartilage implant in patients who have advanced first MTP OA improve the net health outcome?

The following PICO was used to select literature to inform this review.

**Patients**
The relevant population of interest is patients with advanced MTP OA.
Interventions
The therapy being considered is the Cartiva synthetic cartilage implant.

Comparators
The following therapies are currently being used:

- Conservative nonoperative treatment which would include modification of footwear and NSAIDS.
- Cheilectomy
- Arthrodesis

Outcomes
The general outcomes of interest are symptoms, typically measured with a VAS for pain. Functional outcomes and quality of life are assessed with the FAAM. Adverse events from the implantation procedure would be measured within 30 days while harms from dislocation and wear would be measured at 5 to 10 years.

A beneficial outcome of the implant would be a reduction in pain and improvement in function.

A harmful outcome of the implant would be an increase in pain and a reduction in function.

Study Selection Criteria
Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess long-term outcomes and adverse effects, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence
The U.S. Food and Drug Administration (FDA) approval of the Cartiva synthetic cartilage implant was based on an unmasked multicenter noninferiority trial (Cartiva MOTION) that compared the implant with arthrodesis of the first MTP joint (see Table 1). This study was published by Baumhauer et al (2016). The primary outcome was a composite of a 30% or greater difference in VAS scores for pain, maintenance of function on the FAAM ADL subscale, and absence of major safety events at 2 years. The primary effectiveness endpoint was achieved by 80% of patients in both groups, and the implant met the 15% noninferiority margin (p<0.0075).
Table 1. Summary of Key RCT Characteristics

<table>
<thead>
<tr>
<th>Study; Trial</th>
<th>Countries</th>
<th>Sites</th>
<th>Dates</th>
<th>Participants</th>
<th>Active Intervention</th>
<th>Comparator Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumhauer et al (2016); MOTION</td>
<td>US, Canada, EU</td>
<td>12</td>
<td>2009-2012</td>
<td>197 Patients with advanced hallux rigidus (Coughlin grade 2, 3, or 4 [see Appendix Table 1]) with VAS ≥ 40/100. Patients were excluded if they had lesions &gt; 10 mm in size, hallux varus to any degree or hallux valgus &gt; 20</td>
<td>132 patients received the Cartiva cartilage implant</td>
<td>65 patients underwent arthrodesis</td>
</tr>
</tbody>
</table>

RCT: Randomized controlled trial; VAS: visual analog score

VAS pain scores decreased significantly in both groups but were consistently lower in the arthrodesis group from 6 weeks through 2 years (see Table 2). Nearly all patients (97%) who underwent fusion had 30% or greater relief in pain compared with 89% of patients who received the implant. Maintenance of function, as measured by the FAAM ADL subscale, was observed in 98.3% of patients who received the implant and in 97.6% of patients who underwent fusion. Fourteen (9.2%) implants were removed and converted to arthrodesis, while in the arthrodesis group 6 (12%) patients had removal of screws or screws and plates. As expected, dorsiflexion was significantly better in the implant group (29) than in the fusion group (15; p<0.001). Radiographic measurements showed 4 (8%) occurrences of mal-union or non-union in the fusion group and no device displacement, fragmentation, or avascular necrosis with the implant. Some instances of radiolucency, bony reactions, and heterotopic ossification were observed, but these events did not correlate with individual patient success.

Glazebrook et al (2018) reported a reduction in operative and recovery time with the implant compared to arthrodesis. Additional analysis of data (2017) from the pivotal trial did not identify any factors (eg, hallux rigidus grade, preoperative pain, duration of symptoms, body mass index) that affected the success of the procedure. Analysis raised questions whether Coughlin grade (symptoms, radiographic measures, range of motion), is the most appropriate method to identify patients for the procedure, leading the investigators to recommend using only clinical signs and symptoms to guide treatment.

Table 2. Outcome Scores for Synthetic Cartilage Implant and Arthrodesis

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Baseline</th>
<th>6 Weeks</th>
<th>3 Months</th>
<th>6 Months</th>
<th>1 Year</th>
<th>2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implant</td>
<td>68 (13.9)</td>
<td>33.3 (24.7)</td>
<td>29.4 (23.2)</td>
<td>28.9 (27.75)</td>
<td>17.8 (23.0)</td>
<td>14.5 (22.1)</td>
</tr>
<tr>
<td>Arthrodesis</td>
<td>69.3 (14.3)</td>
<td>17.2 (17.6)</td>
<td>15.5 (13.1)</td>
<td>11.7 (18.3)</td>
<td>5.7 (8.5)</td>
<td>5.9 (12.1)</td>
</tr>
<tr>
<td>P value</td>
<td>.571</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.001</td>
<td>.002</td>
</tr>
<tr>
<td>FAAM ADL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A selection of results from the FAAM ADL questionnaire, which is made up of 21 related questions, were reported on the FDA’s Summary of Safety and Effectiveness (see Table 3). Only the "Up on Toes" was superior in the Cartiva group. Of concern is the greater difficulty of the Cartiva group (Moderate Difficulty, Extreme Difficulty, and Unable to Do) compared to the arthrodesis group for walking for 15 min (16% vs 0%), Up Stairs (6% vs 0%) and Squats (19% vs 8%).

### Table 3. Foot and Ankle Ability Measure (FAAM) Activities of Daily Living Questionnaire Excerpt

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Group</th>
<th>No Difficulty</th>
<th>Slight Difficulty</th>
<th>Moderate Difficulty</th>
<th>Extreme Difficulty</th>
<th>Unable to Do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Activities</td>
<td>Arthrodesis</td>
<td>94%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Cartiva</td>
<td>88%</td>
<td>10%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Walk 15 Min</td>
<td>Arthrodesis</td>
<td>85%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Cartiva</td>
<td>67%</td>
<td>17%</td>
<td>9%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Upstairs</td>
<td>Arthrodesis</td>
<td>87%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Cartiva</td>
<td>83%</td>
<td>10%</td>
<td>4%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Up on Toes</td>
<td>Arthrodesis</td>
<td>36%</td>
<td>28%</td>
<td>17%</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Cartiva</td>
<td>37%</td>
<td>33%</td>
<td>15%</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>Squat</td>
<td>Arthrodesis</td>
<td>70%</td>
<td>21%</td>
<td>6%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Cartiva</td>
<td>57%</td>
<td>18%</td>
<td>11%</td>
<td>6%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Limitations in relevance and design and conduct are shown in Tables 4 and 5.

### Table 4. Study Relevance Limitations

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Intervention</th>
<th>Comparator</th>
<th>Outcomes</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumhauer et al (2016); MOTION</td>
<td></td>
<td></td>
<td></td>
<td>2. Range of motion is an intermediate measure.</td>
<td>1,2. Follow-up in this publication was for 2 years, but the Cartiva group will be followed for 5 years.</td>
</tr>
</tbody>
</table>

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

a Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.
b Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. the intervention of interest.
c Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
d Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not establish and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
e Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 5. Study Design and Conduct Limitations

<table>
<thead>
<tr>
<th>Study</th>
<th>Allocation&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Blinding&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Selective Reporting&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Data Completeness&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Power&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Statistical&lt;sup&gt;f&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumhauer et al (2016);&lt;sup&gt;4&lt;/sup&gt; MOTION</td>
<td></td>
<td></td>
<td></td>
<td>1. Withdrawals after randomization were higher in the control group (15/65 vs 2/132), suggesting possible bias in expectations and subjective outcome assessments in favor of the novel joint preserving procedure. A modified intention-to-treat analysis was requested by the U.S. Food and Drug Administration to adjust for the difference in study withdrawals. The modified intention-to-treat analysis included 130 patients in the Cartiva group and 50 patients in the fusion group.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.


<sup>b</sup> Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.

<sup>c</sup> Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.

<sup>d</sup> Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).

<sup>e</sup> Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference.

<sup>f</sup> Statistical key: 1. Analysis is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Analysis is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4. Comparative treatment effects not calculated.

An FDA regulated safety and efficacy follow-up study was required through 5 years.<sup>8,9</sup> The patients in the follow-up study included the randomized and nonrandomized run-in group who received the implant for a total of 152 patients (see Table 5) but did not include the arthrodesis group. By year 5, 15.1% of the
implant group had undergone removal and conversion to arthrodesis (see Table 6). The overall Kaplan-Meier synthetic cartilage implant survivorship at 5.8 years of follow-up was 84.9%. Of the patients who retained the implant, 97.2% reported a clinically significant improvement in pain, 90.5% reported a clinically significant improvement in FAAM ADL, and 93.3% reported a clinically significant improvement in FAAM sports. Independent radiographic review found no evidence of avascular necrosis, device migration, or fragmentation. Because there was no follow-up of the arthrodesis arm from the randomized trial, conclusions about the comparative effectiveness of the 2 treatment options are limited.

Cassinelli et al (2019) conducted a retrospective review of early outcomes and complications from the Cartiva implant for the treatment of hallux rigidus at their institution. Sixty consecutive patients treated between August 2016 and April 2018 with a mean of 15 months of follow-up (range 2 to 30) were included. Out of 60 patients (64 implants) 30% of patients underwent magnetic resonance imaging due to pain, 20% had additional surgery and 38% were unsatisfied or very unsatisfied. Magnetic resonance imaging (MRI) showed residual capsular inflammation, bone marrow edema, and degenerative changes/edema of the phalanx or metatarsal. A limitation of these results is that 45% of patients underwent additional procedures at the time of implantation and 23% had prior surgery of the hallux. Therefore, these results are not representative of isolated implant procedures, but may be indicative of results outside of the investigational setting.

In a subsequent report, An et al (2019) provided further detail on the 16 of 60 (27%) treated patients from their institution who were evaluated for persistent pain following Cartiva implantation. There was a reduction of joint space on plain radiographs, MRI showed a reduction in implant diameter from 10 mm to 9.7 (SD 0.4) mm and bony channel widening to 11.2 (SD 0.8) mm. Peri-implant fluid suggested instability at the implant-bone interface. There was also evidence of subsidence, with the implant below the subchondral bone of the metatarsal head, and persistent edema was observed in all 16 cases. Radiographic findings from another series of 27 consecutive patients by Shi et al (2019) also suggested subsidence of the implant into the soft medullary canal. It has been noted that the implants in the reports by Cassinelli et al and An et al were initially seated 2 to 2.5 mm above the adjacent bone, rather than the 0.5 to 1.5 mm that is recommended by the manufacturer. Further study is needed to clarify these issues.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country/institution</th>
<th>Participants</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazebrook et al (2018)</td>
<td>US, Canada, EU</td>
<td>152 randomized and roll-in patients treated with Cartiva cartilage implant from the pivotal trial.</td>
<td>5 yr</td>
</tr>
<tr>
<td>Cassinelli et al (2019)</td>
<td>US</td>
<td>60 patients who recieved the Cartiva implant between August 2016 and April 2018</td>
<td></td>
</tr>
</tbody>
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## Table 7. Summary of Key Case Series Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Baseline</th>
<th>2 Year</th>
<th>5 Year</th>
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<tbody>
<tr>
<td><strong>Glazebrook et al (2018)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n (%)</td>
<td>152</td>
<td>135</td>
<td>112</td>
</tr>
<tr>
<td>Cumulative Device Removals n (%)</td>
<td>14/135</td>
<td>23/112</td>
<td></td>
</tr>
<tr>
<td>Number of Patients with Device Present at 5 Years and Assessed for Clinical Outcomes</td>
<td>106</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td>Patients Reporting Pain VAS ≥30% decrease</td>
<td>100/106 (94.3%)</td>
<td>103/106 (97.2%)</td>
<td></td>
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<tr>
<td>FAAM ADL ≥8 points increase n (%)</td>
<td>98/105 (93.3%)</td>
<td>95/105 (90.5%)</td>
<td></td>
</tr>
<tr>
<td>FAAM Sports ≥9 points increase</td>
<td>94/103 (91.3%)</td>
<td>97/104 (93.3%)</td>
<td></td>
</tr>
<tr>
<td>Cassinelli et al (2019)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients unsatisfied and very unsatisfied</td>
<td>64</td>
<td>24/64 (38%)</td>
<td></td>
</tr>
<tr>
<td>Magnetic resonance imaging due to pain</td>
<td>19/64 (30%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reoperation Rate</td>
<td>13/64 (20%)</td>
<td></td>
<td></td>
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ADL: activities of daily living; FAAM: Foot and Ankle Ability Measure; VAS: visual analog score.

### Section Summary: Advanced First Metatarsophalangeal Osteoarthritis

Results at 2 years from the pivotal non-inferiority trial showed pain scores that were slightly worse compared to patients treated with arthrodesis and similar outcomes between the groups for ADL and sports. In a non-inferiority trial, some benefit should be observed to justify the non-inferiority margin. However, the benefit of Cartiva with respect to increased range of motion does not appear to translate to improved activities of daily living, sports activities, or patient report of well-being compared to arthrodesis. In addition, the Cartiva group showed a higher rate of adverse outcomes (Moderate Difficulty, Extreme Difficulty, and Unable to Do) compared to the arthrodesis group for walking for 15 min (16% vs 0%), Up Stairs (6% vs 0%) and Squats (19% vs 8%). Some bias in favor of the novel motion preserving implant was also possible, as suggested by the high dropout rate in the arthrodesis group after randomization. Five-year follow-up of both the randomized and run-in patients who received an implant was reported in 2018 for 135 of 152 patients. At this time point, 15% of implants had been removed with conversion to arthrodesis. There are additional safety signals in an independent study by Cassinelli et al (2019) and An et al (2019). In that report, 30% of patients underwent magnetic resonance imaging due to pain, 20% had additional surgery and 38% were unsatisfied or very unsatisfied.
study of potential adverse events with this novel technology is needed. In addition, comparison to arthrodesis at long-term follow-up is needed to determine whether the implant improves function. Corroboration of long-term results in an independent RCT is also needed to determine the effect of the implant on health outcomes.

**Articular Cartilage Lesions of Joints Other Than the Great Toe**

**Clinical Context and Therapy Purpose**
The purpose of a synthetic cartilage implant in patients who have advanced OA of joints other than the first MTP joint is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The question addressed in this evidence review is: Does the synthetic cartilage implant in patients who have OA of joints other than the first MTP joint improve the net health outcome?

The following PICO was used to select literature to inform this review.

**Patients**
The relevant population of interest is patients with OA of joints other than the MTP joint.

**Interventions**
The therapy being considered is the synthetic cartilage implant.

**Comparators**
The following therapies are currently being used:

- Conservative nonoperative treatment
- Osteochondral autografting
- Autologous chondrocyte implantation
- Arthroplasty

**Outcomes**
The general outcomes of interest are symptoms, typically measured with a VAS for pain. Functional outcomes and quality of life are measured with questionnaires such as the FAAM.) Adverse events from the implantation procedure would be measured within 30 days while harms from dislocation and wear would be measured at 5 to 10 years.

A beneficial outcome of the implant would be a reduction in pain and improvement in function.

A harmful outcome of the implant would be an increase in pain and a reduction in function.
Study Selection Criteria
Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess long-term outcomes and adverse effects, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence
Use of polyvinyl alcohol hydrogel implants has been reported in a few observational studies for articular cartilage lesions of the knee and the second MTP joint. A study is in progress to evaluate the polyvinyl alcohol hydrogel implant for OA of the first carpometacarpal joint, but the study is not expected to be completed until 2024 (see Table 8). No other RCTs on synthetic cartilage implants for joints other than the great toe have been identified.

Section Summary: Articular Cartilage Lesions of Joints Other Than the Great Toe
The evidence is insufficient to determine the effects of the synthetic cartilage implant for joints other than the great toe. RCTs and long-term follow-up are needed to determine implant survival and the effect on health outcomes.

Summary of Evidence
For individuals who have early-stage first MTP joint OA who receive a synthetic cartilage implant, the evidence is lacking. Relevant outcomes are symptoms, functional outcomes, quality of life, and treatment-related morbidity. The pivotal study was performed in patients with Coughlin stage 2, 3, or 4 hallux rigidus. No evidence was identified in patients with stage 0 to early-stage 2 hallux rigidus. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals who have advanced first MTP joint OA who receive a synthetic cartilage implant, the evidence includes a pivotal non-inferiority trial. Relevant outcomes are symptoms, functional outcomes, quality of life, and treatment-related morbidity. Arthrodesis is the established treatment for advanced arthritis of the great toe, although the lack of mobility can negatively impact sports and choice of footwear and is not a preferred option of patients. Implants have the potential to reduce pain and maintain mobility in the first MTP joint but have in the past been compromised by fragmentation, dislocation, particle wear, osteolysis, and loosening. A polyvinyl alcohol hydrogel implant has shown properties similar to articular cartilage in vitro and was approved by the U.S. Food and Drug administration in 2016 for the treatment of painful degenerative or post-traumatic arthritis in the MTP joint. Results at 2 years from the pivotal non-inferiority trial showed pain scores that were slightly worse compared to patients treated with arthrodesis and similar outcomes between the groups for ADL and sports. In a
non-inferiority trial, some benefit should be observed to justify the non-inferiority margin. However, the benefit of Cartiva with respect to increased range of motion does not appear to translate to improved activities of daily living, sports activities, or patient report of well-being compared to arthrodesis. In addition, the Cartiva group showed a higher rate of adverse outcomes (Moderate Difficulty, Extreme Difficulty, and Unable to Do) compared to the arthrodesis group for walking for 15 min (16% vs 0%), Up Stairs (6% vs 0%) and Squats (19% vs 8%). Some bias in favor of the novel motion preserving implant was also possible, as suggested by the high dropout rate in the arthrodesis group after randomization. Five-year follow-up of both the randomized and run-in patients who received an implant was reported in 2018 for 135 of 152 patients. At this time point, 21% of implants had been removed with conversion to arthrodesis. Comparison to arthrodesis at long-term follow-up is needed to determine whether the implant improves function. Corroboration of long-term results in an independent study is also needed to determine the benefits and risks of the implant. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals who have articular cartilage damage in joints other than the great toe who receive a synthetic cartilage implant, the evidence includes observational studies. Relevant outcomes are symptoms, functional outcomes, quality of life, and treatment-related morbidity. No RCTs were identified. The evidence is insufficient to determine the effects of the technology on health outcomes.

**SUPPLEMENTAL INFORMATION**

**Practice Guidelines and Position Statements**
No guidelines or statements were identified.

**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 ongoing and unpublished trials that might influence this review are listed in Table 8.

**Table 8. Summary of Key Trials**

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<th>NCT No.</th>
<th>Trial Name</th>
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<tr>
<td>NCT03935880</td>
<td>Treatment of Hallux Rigidus With Synthetic Hemiarthroplasty Versus Cheilectomy: A Randomized Controlled Trial</td>
<td>120</td>
<td>Apr 2022</td>
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<td>NCT No.</td>
<td>Trial Name</td>
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<td>NCT03247439a</td>
<td>A Prospective Study to Evaluate the Safety and Effectiveness of the Cartiva® Synthetic Cartilage Implant for CMC in the Treatment of First Carpometacarpal Joint Osteoarthritis as Compared to LRTI Comparator (GRIP2)</td>
<td>47</td>
<td>Jan 2024</td>
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<tr>
<td>NCT02391506a</td>
<td>A Prospective Study to Evaluate the Safety and Effectiveness of the Cartiva® Synthetic Cartilage Implant for CMC in the Treatment of First Carpometacarpal Joint Osteoarthritis</td>
<td>50</td>
<td>Mar 2019</td>
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NCT: national clinical trial. a Denotes industry-sponsored or cosponsored trial.

REFERENCES

 Billing Coding/Physician Documentation Information

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<td>28291</td>
<td>Hallux rigidus correction with cheilectomy, debridement and capsular release of the first metatarsophalangeal joint; with implant</td>
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<td>L8699</td>
<td>Prosthetic implant, not otherwise specified</td>
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<td>L8641</td>
<td>Metatarsal joint implant</td>
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<td>L8642</td>
<td>Hallux implant</td>
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 ICD-10 Codes

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<td>M19.071- M19.079</td>
<td>Osteoarthritis of ankle and foot range</td>
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<tr>
<td>M19.271- M19.279</td>
<td>2ndary osteoarthritis ankle and foot code range</td>
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<td>M24.174- M24.176</td>
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<td>M25.571- M25.579</td>
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<td>M948X7</td>
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 Additional Policy Key Words

 N/A

 Policy Implementation/Update Information

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 Appendix

 Appendix Table 1. Coughlin Clinical-Radiographic System for Grading Hallux Rigidus

<table>
<thead>
<tr>
<th>Grade</th>
<th>Dorsiflexion</th>
<th>Radiographic Findings</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40°-60° and/or 10%-20% loss vs</td>
<td>Normal</td>
<td>No pain; only stiffness and loss of motion</td>
</tr>
<tr>
<td>Grade</td>
<td>Normal Side</td>
<td>Minimal Changes</td>
<td>Mild or Occasional Pain and Stiffness</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>-----------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>30°-40° and/or 20%-50% loss vs normal side</td>
<td>Minimal changes</td>
<td>Mild or occasional pain and stiffness</td>
</tr>
<tr>
<td>2</td>
<td>10°-30° and/or 50%-75% loss vs normal side</td>
<td>Osteophytes, mild-to-moderate joint-space narrowing</td>
<td>Moderate-to-severe pain and stiffness that may be constant; pain occurs at maximum flexion</td>
</tr>
<tr>
<td>3</td>
<td>≤10° and/or 75%-100% loss vs normal side</td>
<td>Osteophytes, substantial joint space narrowing</td>
<td>Nearly constant pain and substantial stiffness at extremes ROM, not at mid-range</td>
</tr>
<tr>
<td>4</td>
<td>Same as grade 3</td>
<td>Same as grade 3</td>
<td>Same as grade 3 but definite pain at mid-ROM</td>
</tr>
</tbody>
</table>

ROM: range of motion.

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