**Computer-Assisted Navigation for Orthopedic Procedure**

**Policy Number:** 7.01.96  
**Origination:** 12/2007  
**Last Review:** 6/2020  
**Next Review:** 12/2020

**Policy**

Blue Cross and Blue Shield of Kansas City (Blue KC) will not provide coverage for Computer-Assisted Navigation for Orthopedic Procedures. This is considered investigational.

**When Policy Topic is covered**

Not Applicable

**When Policy Topic is not covered**

Computer-assisted surgery for orthopedic procedures of the pelvis and appendicular skeleton is considered *investigational*.

**Description of Procedure or Service**

<table>
<thead>
<tr>
<th>Populations</th>
<th>Interventions</th>
<th>Comparators</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| Individuals  
• Who are undergoing orthopedic surgery for trauma or fracture | Interventions of interest are:  
• Computer-assisted navigation | Comparators of interest are:  
• Conventional/manual alignment methods | Relevant outcomes include:  
• Symptoms  
• Morbid events  
• Functional outcomes |
| Individuals  
• Who are undergoing ligament reconstruction | Interventions of interest are:  
• Computer-assisted navigation | Comparators of interest are:  
• Conventional/manual alignment methods | Relevant outcomes include:  
• Symptoms  
• Morbid events  
• Functional outcomes |
| Individuals  
• Who are undergoing hip arthroplasty and periacetabular osteotomy | Interventions of interest are:  
• Computer-assisted navigation | Comparators of interest are:  
• Conventional/manual alignment methods | Relevant outcomes include:  
• Symptoms  
• Morbid events  
• Functional outcomes |
| Individuals  
• Who are undergoing total knee arthroplasty | Interventions of interest are:  
• Computer-assisted navigation | Comparators of interest are:  
• Conventional/manual alignment methods | Relevant outcomes include:  
• Symptoms  
• Morbid events  
• Functional outcomes |
Computer-assisted navigation in orthopedic procedures describes the use of computer-enabled tracking systems to facilitate alignment in a variety of surgical procedures, including fixation of fractures, ligament reconstruction, osteotomy, tumor resection, preparation of the bone for joint arthroplasty, and verification of the intended implant placement.

For individuals who are undergoing orthopedic surgery for trauma or fracture and receive computer-assisted navigation, the evidence includes one retrospective clinical trial, reviews, and in vitro studies. Relevant outcomes are symptoms, morbid events, and functional outcomes. Functional outcomes were not included in the clinical trial, although it did note fewer complications with computer-assisted navigation versus conventional methods. The evidence is insufficient to determine the effects of the technology on net health outcomes.

For individuals who are undergoing ligament reconstruction and receive computer-assisted navigation, the evidence includes a systematic review of 5 randomized controlled trials (RCTs) of computer-assisted navigation versus conventional surgery for anterior and posterior cruciate ligament. Relevant outcomes are symptoms, morbid events, and functional outcomes. Trial results showed no consistent improvement of tunnel placement with computer-assisted navigation, and no trials looked at functional outcomes or need for revision surgery with computer-assisted navigation. The evidence is insufficient to determine the effects of the technology on net health outcomes.

For individuals who are undergoing hip arthroplasty and periacetabular osteotomy and receive computer-assisted navigation, the evidence includes older RCTs, a systematic review, and comparison studies. Relevant outcomes are symptoms, morbid events, and functional outcomes. Evidence on the relative benefits of computer-assisted navigation with conventional or minimally invasive total hip arthroplasty is inconsistent, and more recent RCTs are lacking. The evidence is insufficient to determine the effects of the technology on net health outcomes.

For individuals who are undergoing total knee arthroscopy and receive computer-assisted navigation, the evidence includes RCTs, systematic reviews of RCTs, and comparative studies. Relevant outcomes are symptoms, morbid events, and functional outcomes. The main difference found between total knee arthroscopy with computer-assisted navigation and total knee arthroscopy without computer-assisted navigation is increased surgical time with computer-assisted navigation. Few differences in clinical and functional outcomes were seen at up to 10 years post-procedure. The evidence is insufficient to determine the effects of the technology on net health outcomes.

**Background**

**IMPLANT ALIGNMENT FOR KNEE ARTHROPLASTY**

For total knee arthroplasty, malalignment is commonly defined as a variation of more than 3° from the targeted position. Proper implant alignment is believed to be an important factor for minimizing long-term wear, the risk of osteolysis, and loosening of the prosthesis.
Computer-Assisted Navigation

The goal of computer-assisted navigation (CAN) is to increase surgical accuracy and reduce the chance of malposition.

In addition to reducing the risk of substantial malalignment, CAN may improve soft tissue balance and patellar tracking. CAN is also being investigated for surgical procedures with limited visibility such as placement of the acetabular cup in total hip arthroplasty, resection of pelvic tumors, and minimally invasive orthopedic procedures. Other potential uses of CAN for surgical procedures of the appendicular skeleton include screw placement for fixation of femoral neck fractures, high tibial osteotomy, and tunnel alignment during the reconstruction of the anterior cruciate ligament.

CAN devices may be image-based or non-image-based. Image-based devices use preoperative computed tomography scans and operative fluoroscopy to direct implant positioning. Newer non-image-based devices use information obtained in the operating room, typically with infrared probes. For total knee arthroplasty, specific anatomic reference points are made by fixing signaling transducers with pins into the femur and tibia. Signal-emitting cameras (eg, infrared) detect the reflected signals and transmit the data to a dedicated computer. During the surgery, multiple surface points are taken from the distal femoral surfaces, tibial plateaus, and medial and lateral epicondyles. The femoral head center is typically calculated by kinematic methods that involve the movement of the thigh through a series of circular arcs, with the computer producing a 3-dimensional model that includes the mechanical, transepicondylar, and tibial rotational axes. CAN systems direct the positioning of the cutting blocks and placement of the prosthetic implants based on the digitized surface points and model of the bones in space. The accuracy of each step of the operation (cutting block placement, saw cut accuracy, seating of the implants) can be verified, thereby allowing adjustments to be made during surgery.

Navigation involves 3 steps: data acquisition, registration, and tracking.

Data Acquisition

Data can be acquired in 3 ways: fluoroscopically, guided by computed tomography scan or magnetic resonance imaging or guided by imageless systems. These data are then used for registration and tracking.

Registration

Registration refers to the ability to relate images (ie, radiographs, computed tomography scans, magnetic resonance imaging, or patients’ 3D anatomy) to the anatomic position in the surgical field. Registration techniques may require the placement of pins or “fiduciary markers” in the target bone. A surface-matching technique can also be used in which the shapes of the bone surface model generated from preoperative images are matched to surface data points collected during surgery.
**Tracking**

Tracking refers to the sensors and measurement devices that can provide feedback during surgery regarding the orientation and relative position of tools to bone anatomy. For example, optical or electromagnetic trackers can be attached to regular surgical tools, which then provide real-time information of the position and orientation of tool alignment concerning the bony anatomy of interest.

VERASENSE (OrthoSense) is a single-use device that replaces the standard plastic tibial trial spacer used in total knee arthroplasty. The device contains microprocessor sensors that quantify load and contact position of the femur on the tibia after resections have been made. The wireless sensors send the data to a graphic user interface that depicts the load. The device is intended to provide quantitative data on the alignment of the implant and soft tissue balancing in place of intraoperative “feel.”

iASSIST (Zimmer) is an accelerometer-based alignment system with a user interface built into disposable electronic pods that attach onto the femoral and tibial alignment and resection guides. For the tibia, the alignment guide is fixed between the tibial spines and a claw on the malleoli. The relation between the electronic pod of the digitizer and the bone reference is registered by moving the limb into abduction, adduction, and neutral position. Once the information has been registered, the digitizer is removed, and the registration data are transferred to the electronic pod on the cutting guide. The cutting guide can be adjusted for varus/valgus alignment and tibial slope. A similar process is used for the femur. The pods use the wireless exchange of data and display the alignment information to the surgeon within the surgical field. A computer controller must also be present in the operating room.

Due to the lack of any recent studies on pelvic tumor resection, these sections of the Rationale were removed from this evidence review in 2016.

**Regulatory Status**

Because CAN is a surgical information system in which the surgeon is only acting on the information that is provided by the navigation system, surgical navigation systems generally are subject only to 510(k) clearances from the U.S. Food and Drug Administration (FDA). As such, FDA does not require data documenting the intermediate or final health outcomes associated with CAN. (In contrast, robotic procedures, in which the actual surgery is robotically performed, are subject to the more rigorous requirement of the premarket approval application process.)

A variety of surgical navigation procedures have been cleared for marketing by FDA through the 510(k) process with broad labeled indications. For example, The OEC FluoroTrak 9800 plus is marketed for locating anatomic structures anywhere on the human body.

Several navigation systems (eg, PiGalileo™ Computer-Assisted Orthopedic Surgery System, PLUS Orthopedics; OrthoPilot® Navigation System, Braun; Navitrack® Navigation System, ORTHOsoft) have received FDA clearance specifically for total
knee arthroplasty. The FDA-cleared indications for the PiGalileo™ system are representative. This system “is intended to be used in computer-assisted orthopedic surgery to aid the surgeon with bone cuts and implant positioning during joint replacement. It provides information to the surgeon that is used to place surgical instruments during surgery using anatomical landmarks and other data specifically obtained intraoperatively (eg, ligament tension, limb alignment). Examples of some surgical procedures include but are not limited to:

- Total knee replacement supporting both bone referencing and ligament balancing techniques
- Minimally invasive total knee replacement.”

FDA product code: HAW.

In 2013, the VERASENSE™ Knee System (OrthoSensor) and the iASSIST™ Knee (Zimmer) were cleared for marketing by FDA through the 510(k) process.

Several computer-assisted navigation devices cleared by the FDA are listed in the table below.

**Table 1. Computer-assisted Navigation Devices Cleared by the U.S. Food and Drug Administration**

<table>
<thead>
<tr>
<th>Device</th>
<th>Manufacturer</th>
<th>Date Cleared</th>
<th>510(k) No.</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>NuVasive Pulse System</td>
<td>NuVasive Inc.</td>
<td>6/29/2018</td>
<td>K180038</td>
<td>Computer-assisted Navigation for Orthopedic Surgery</td>
</tr>
<tr>
<td>VERASENSE for Zimmer Biomet Persona</td>
<td>OrthoSensor Inc.</td>
<td>6/7/2018</td>
<td>K180459</td>
<td>Computer-assisted Navigation for Orthopedic Surgery</td>
</tr>
<tr>
<td>NuVasive Next Generation NVM5 System</td>
<td>NUVASIVE Inc.</td>
<td>3/16/2017</td>
<td>K162313</td>
<td>Computer-assisted Navigation for Orthopedic Surgery</td>
</tr>
<tr>
<td>JointPoint</td>
<td>JointPoint Inc.</td>
<td>8/3/2016</td>
<td>K160284</td>
<td>Computer-assisted Navigation for Orthopedic Surgery</td>
</tr>
<tr>
<td>ExactechGPS</td>
<td>Blue Ortho</td>
<td>7/13/2016</td>
<td>K152764</td>
<td>Computer-assisted Navigation for Orthopedic Surgery</td>
</tr>
</tbody>
</table>
Rationale

This evidence review was created in February 2004 and has been updated regularly using the PubMed database. The most recent literature update was performed through February 11, 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, two 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.

For many orthopedic surgical procedures, optimal alignment is considered an important aspect of long-term success. For example, misplaced tunnels in the anterior cruciate ligament or posterior cruciate ligament reconstruction or malalignment of arthroplasty components are some of the leading causes of
instability and reoperation. In total hip arthroplasty (THA), the orientation of the acetabular component of the total hip arthroplasty (THA) is considered critical, while for total knee arthroplasty, alignment of the femoral and tibial components and ligament balancing are considered important outcomes. Ideally, one would prefer controlled trials comparing the long-term outcomes, including stability and reoperation rates.

**Computer-Assisted Navigation for Trauma or Fracture**

**Clinical Context and Therapy Purpose**
The purpose of computer-assisted navigation is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conventional/manual alignment methods, in patients who are undergoing orthopedic surgery for trauma or fracture.

The question addressed in this evidence review is: Does the use of computer assisted navigation improve the net health outcome when used for surgery for trauma or fracture?

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

**Patients**
The relevant population of interest is individuals who are undergoing orthopedic surgery for trauma or fracture.

**Interventions**
The therapy being considered is computer assisted navigation. Computer assisted navigation in orthopedic procedures describes the use of computer-enabled tracking systems to facilitate alignment in a variety of surgical procedures, including fixation of fractures, ligament reconstruction, osteotomy, tumor resection, preparation of the bone for joint arthroplasty, and verification of the intended implant placement.

Patients who are undergoing orthopedic surgery for trauma or fracture are actively managed by orthopedic surgeons in an inpatient surgical setting and by physical therapists and primary care providers following the procedure in an outpatient clinical setting.

**Comparators**
Comparators of interest include conventional/manual alignment methods. Treatment by means of conventional/manual alignment methods include medical reduction procedures, elastic bandaging, splints, and physical therapy. These are performed by a physical therapist and primary care provider in an outpatient clinical setting.

**Outcomes**
The general outcomes of interest are symptoms, morbid events, and functional outcomes.
The existing literature evaluating computer assisted navigation as a treatment for patients who are undergoing orthopedic surgery for trauma or fracture has varying lengths of follow-up. While studies described below all reported at least one outcome of interest, longer follow-up was necessary to fully observe outcomes.

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

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

**Review of Evidence**
Computer-assisted surgery has been described as an adjunct to pelvic, acetabular, or femoral fractures. For example, fixation of these fractures typically requires percutaneous placement of screws or guidewires. Conventional fluoroscopic guidance (ie, C-arm fluoroscopy) provides imaging in only one plane. Therefore, the surgeon must position the implant in one plane and then get additional images in other planes in a trial-and-error fashion to ensure that the device has been properly placed. This process adds significant time in the operating room and radiation exposure. Computer-assisted surgery may permit minimally invasive fixation and provide more versatile screw trajectories with less radiation exposure. Therefore, computed-assisted surgery is considered an alternative to the existing image guidance using C-arm fluoroscopy.

Ideally, investigators would conduct controlled trials comparing operating room time, radiation exposure, and long-term outcomes of those whose surgery was conventionally guided using C-arm versus image-guided using computer-assisted surgery. While several in vitro and review studies had been published, when this evidence review was created in 2004, only a single clinical trial of computer-assisted surgery in trauma or fracture cases was identified. Computer assisted navigation for internal fixation of femoral neck fractures was retrospectively analyzed in 2 cohorts of consecutive patients (20 each, performed from 2001 to 2003, at 2 different campuses of a medical center) who underwent internal fixation with 3 screws for a femoral neck fracture. Three of 5 measurements of parallelism and neck coverage were significantly improved by computer assisted navigation; they included a larger relative neck area held by the screws (32% vs 23%) and less deviation on the lateral projection for both the shaft (1.7° vs. 5.2°) and the fracture (1.7° vs. 5.5°) screw angles, all respectively. Slight improvements in anteroposterior screw angles (1.3° vs. 2.1° and 1.3° vs. 2.4°, respectively) were not statistically significant. There were 2 reoperations in the computer assisted navigation group and 6 in the conventional group. Complications (collapse,
subtrochanteric fracture, head penetration, osteonecrosis) were lower in the computer assisted navigation group (3 vs. 11, respectively).

**Section Summary: Computer-Assisted Navigation for Trauma or Fracture**

There is limited literature on the use of computer assisted navigation for trauma or fractures. Additional controlled studies that measure health outcomes are needed to evaluate this technology.

**Computer-Assisted Navigation for Anterior Cruciate Ligament or Posterior Cruciate Ligament Reconstruction**

**Clinical Context and Therapy Purpose**

The purpose of computer assisted navigation is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conventional/manual alignment methods, in patients who are undergoing ligament reconstruction.

The question addressed in this evidence review is: Does the use of computer assisted navigation improve the net health outcome when used for ligament reconstruction?

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

**Patients**

The relevant population of interest is individuals who are undergoing ligament reconstruction.

**Interventions**

The therapy being considered is computer assisted navigation. Computer assisted navigation in orthopedic procedures describes the use of computer-enabled tracking systems to facilitate alignment in a variety of surgical procedures, including fixation of fractures, ligament reconstruction, osteotomy, tumor resection, preparation of the bone for joint arthroplasty, and verification of the intended implant placement.

Patients who are undergoing ligament reconstruction are actively managed by orthopedic surgeons in an inpatient surgical setting and by physical therapists and primary care providers following the procedure in an outpatient clinical setting.

**Comparators**

Comparators of interest include conventional/manual alignment methods. Treatment by means of conventional/manual alignment methods include medical reduction procedures, elastic bandaging, braces, and physical therapy. These are performed by a physical therapist and primary care provider in an outpatient clinical setting.
Outcomes
The general outcomes of interest are symptoms, morbid events, and functional outcomes.

The existing literature evaluating computer assisted navigation as a treatment for patients who are undergoing ligament reconstruction has varying lengths of follow-up. While studies described below all reported at least 1 outcome of interest, longer follow-up was necessary to fully observe outcomes. Therefore, 2 years of follow-up is considered necessary to demonstrate efficacy.

Study Selection Criteria
Methodologically credible studies were selected using the principles described in the first indication.

Review of Evidence

Systematic Reviews
Eggerding et al (2014) published a Cochrane review that compared the effects of computer assisted navigation with conventional operating techniques for anterior cruciate ligament or posterior cruciate ligament reconstruction. Five RCTs (total N=366 participants) on anterior cruciate ligament reconstruction were included in the updated review; no studies involved posterior cruciate ligament reconstruction. The quality of evidence ranged from moderate- to very-low. Pooled data showed no statistically or clinically relevant differences in self-reported health outcomes (International Knee Documentation Committee subjective scores and Lysholm Knee Scale scores) at 2 or more years of follow-up. No significant differences were found for secondary outcomes, including knee stability, range of motion, and tunnel placement. Overall, there was insufficient evidence to advise for or against the use of computer assisted navigation. Four of the 5 trials included in the Cochrane review are described next.

Randomized Controlled Trials
Plaweski et al (2006) reported on a trial that randomized 60 patients to manual or computer-assisted guidance for tunnel placement with follow-up at 1, 3, 6, 12, 18, and 24 months. There were no differences between groups in measurements of laxity. However, there was less variability in side-to-side anterior laxity in the navigated group (eg, 97% were within 2 mm of laxity in the navigated group vs. 83% in the conventional group at an applied force of 150 N). There was a significant difference in the sagittal position of the tibial tunnel (distance from the Blumensaat line, 0.4 mm vs. -1.2 mm, respectively), suggesting possible impingement in extension for the conventional group. At the final follow-up (24 months), all knees had normal function, with no differences observed between groups.

Hart et al (2008) compared biomechanical radiographic with functional results in 80 patients randomized to anterior cruciate ligament reconstruction using computer assisted navigation (n=40) or to the standard manual targeting technique (n=40). The blinded evaluation found more exact bone tunnel
placement with computer assisted navigation, but no overall difference in biomechanical stability or function between groups.

Other studies have found no significant improvement in the accuracy of tunnel placement when using computer assisted navigation. Meuffels et al (2012) reported on a double-blind controlled trial that randomized 100 patients to conventional or computer-assisted surgery.\(^8\) Evaluation by 3-dimensional computed tomography (CT) found no significant difference between groups for the accuracy or the precision of the femoral and tibial tunnel placement.

### Table 2. Summary of Characteristics of Key RCTs Comparing Computer-Assisted Navigation With Manual Placement for Anterior or Posterior Cruciate Ligament Reconstruction

<table>
<thead>
<tr>
<th>Study</th>
<th>Countries</th>
<th>Sites</th>
<th>Dates</th>
<th>Participants</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaweski et al (2006)(^6)</td>
<td>USA</td>
<td>1</td>
<td>Oct 2014 to Jan 2016</td>
<td>Patients (n=50) undergoing ACL reconstruction.</td>
<td>CAN (n=30) Manual placement (n=30)</td>
</tr>
<tr>
<td>Hart et al (2008)(^2)</td>
<td>Czech Republic</td>
<td>1</td>
<td>NR</td>
<td>Patients (n=80) undergoing ACL reconstruction for chronic rupture of the ACL; only chronic ACL-insufficiency knees were included in the study (&gt;6 mo after injury). Other inclusion criteria were no other prior or simultaneous intra-articular surgical procedure, no cartilage degeneration of meniscal tear, and a normal contralateral knee. Ages ranged from 16 to 39 years with a mean of 29.4. Mean body weight was 74 kg.</td>
<td>CAN (n=40) Manual placement (n=40)</td>
</tr>
<tr>
<td>Meuffels et al (2012)(^8)</td>
<td>Netherlands</td>
<td>1</td>
<td>Jan 2007-Nov 2009</td>
<td>Patients (n=100) patients≥18 years of age and eligible for primary ACL reconstruction without additional posterior cruciate ligament or lateral collateral ligament injury were included.</td>
<td>CAN (n=49) Conventional (n=51)</td>
</tr>
</tbody>
</table>

ACL: anterior cruciate ligament; CAN: computer-assisted navigation; NR: not reported; PCL: posterior cruciate ligament; RCT: randomized controlled trial.
Table 3. Summary of Key RCTs Comparing Computer-Assisted Navigation With Manual Placement for Anterior or Posterior Cruciate Ligament Reconstruction

<table>
<thead>
<tr>
<th>Study</th>
<th>IKDC</th>
<th>Laxity &lt; 2 mm</th>
<th>Lachman Test (0)</th>
<th>Lachman Test (2+)</th>
<th>Placement of the Femoral Tunnel</th>
<th>Tibial Tunnel Border</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaweski et al (2006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NR</td>
</tr>
<tr>
<td>CAN (n=26 knees)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mean ATB, -0.2 (5 to +4)</td>
</tr>
<tr>
<td>Mean Level A laxity level (n=26 knees)</td>
<td>mean, 1.3 mm at 200 N; p=.49</td>
<td>96.7%; p=.295</td>
<td>23 (76.7)</td>
<td>1 (3.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual (n=22 knees)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NR</td>
</tr>
<tr>
<td>Mean Level A laxity level (n=22 knees)</td>
<td>mean, 1.5 mm at 200 N; p=.49</td>
<td>83%; p=.292</td>
<td>26 (87)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN (n=40)</td>
<td>Mean post-op Improvement: 76.5 points; SD, 10.3; p&lt;.01</td>
<td>Mean difference in anterior laxity compared with contralateral (healthy) knee: 1.43 mm (range, 0 to 4 mm)</td>
<td>12 (30%) 14 (35%)</td>
<td>Ideal a/t value: 24.8%Mean, 25.5% (SD, 1.63)</td>
<td>Zone 2 location: 39 (97.5%)</td>
<td></td>
</tr>
<tr>
<td>Manual (n=40)</td>
<td>Mean post-op Improvement: 73.1 points; SD, 11.8; p&lt;.01</td>
<td>Mean difference in anterior laxity compared with contralateral (healthy) knee: 1.24 mm (range, -2 to 5 mm)</td>
<td>18 (45%) 10 (25%)</td>
<td>Ideal a/t value: 24.8%Mean, 27.7% (2.76)</td>
<td>Zone 2 location: 38 (95.0%)</td>
<td></td>
</tr>
</tbody>
</table>
The purpose of the limitations tables (see Tables 4 and 5) is to display notable limitations identified in each study. This information is synthesized as a summary of the body of evidence following each table and provides the conclusions on the sufficiency of evidence supporting the position statement.

### Table 4. Summary of Study Relevance Limitations in Key RCTs Comparing Computer-Assisted Navigation With Manual Placement

<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>Hart et al (2008)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3. The study setting and source of study participants is missing (as is the referral pattern)—this could create</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a/t value: ratio identifies anterior-posterior femoral tunnel placement; ATB: anterior tension band plate; CAN: computer-assisted navigation; IKDC: International Knee Documentation Committee; NR: not reported; Post-op: postoperative; RCT: randomized controlled trial; SD: standard deviation.*
referral-filter bias.

2. Inconsistent fidelity of intervention protocol: There is a lack of consistency as to the best method for performing the intervention.

5, 6. Clinically significant difference not prespecified or mentioned.

1, 2. Follow-up was 4 days, not long enough to determine intermediate- or long-term outcomes.

RCT: randomized controlled trial; CAN: computer-assisted navigation; CT: computed tomography; ACL: anterior cruciate ligament.

The study limitations stated in this table are those notable in the current review; this is not a comprehensive limitations 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. Not 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 established 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>
<thead>
<tr>
<th>Study</th>
<th>Populationa</th>
<th>Interventionb</th>
<th>Comparatorc</th>
<th>Outcomesd</th>
<th>Follow-Upc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meuffels et al (2012)8</td>
<td>3. Study population is incompletely characterized.</td>
<td>2. Inconsistent fidelity of intervention protocol: There is a lack of consistency as to the best method for performing the intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mauch et al (2007)</td>
<td>1, 4. Intended use population is unclear. Limited to athletes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


1. Unclear whether patients were blinded.

3. Randomization techniques are not described


1. Unclear whether patients were blinded.

3. Randomization techniques are not described


1. Power calculations not reported.

3. Confidence intervals not reported.
### Section Summary: Computer-Assisted Navigation for Anterior Cruciate Ligament or Posterior Cruciate Ligament Reconstruction

The evidence on computer assisted navigation for anterior cruciate ligament or posterior cruciate ligament reconstruction includes a systematic review of five RCTs. These RCTs, of moderate- to low-quality, did not consistently demonstrate more accurate tunnel placement with computer assisted navigation. No studies have shown an improvement in functional outcomes or need for revision when computer assisted navigation is used for anterior cruciate ligament or posterior cruciate ligament reconstruction.

### Computer-Assisted Navigation for Total Hip Arthroscopy and Periacetabular Osteotomy

#### Clinical Context and Therapy Purpose

The purpose of computer assisted navigation is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conventional/manual alignment methods, in patients who are undergoing total hip arthroplasty (THA) and periacetabular osteotomy.
The question addressed in this evidence review is: Does the use of computer assisted navigation improve the net health outcome when used for THA and periacetabular osteotomy?

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

**Patients**
The relevant population of interest is individuals who are undergoing THA and periacetabular osteotomy.

**Interventions**
The therapy being considered is computer assisted navigation. Computer assisted navigation in orthopedic procedures describes the use of computer-enabled tracking systems to facilitate alignment in a variety of surgical procedures, including fixation of fractures, ligament reconstruction, osteotomy, tumor resection, preparation of the bone for joint arthroplasty, and verification of the intended implant placement.

Patients who are undergoing THA and periacetabular osteotomy are actively managed by orthopedic surgeons in an inpatient surgical setting and by physical therapists and primary care providers following the procedure in an outpatient clinical setting.

**Comparators**
Comparators of interest include conventional/manual alignment methods. Treatment by means of conventional/manual alignment methods include medical reduction procedures, and physical therapy. These are performed by a physical therapist and primary care provider in an outpatient clinical setting.

**Outcomes**
The general outcomes of interest are symptoms, morbid events, and functional outcomes.

The existing literature evaluating computer assisted navigation as a treatment for patients who are undergoing THA and periacetabular osteotomy has varying lengths of follow-up, ranging from 6-40 months. While studies described below all reported at least one outcome of interest, longer follow-up was necessary to fully observe outcomes.

**Study Selection Criteria**
Methodologically credible studies were selected using the principles described in the first indication.

Parratte and Argenson (2007) randomized patients to computer assisted navigation (n=30) or freehand cup positioning (n=30) for THA by an experienced surgeon. The mean additional time for the computer-assisted procedure was 12 minutes. There was no difference between the computer-assisted group and the freehand-placement group with regard to the mean abduction or anteversion.
angles measured by computed tomography. A smaller variation in the positioning of the acetabular component was observed in the computer assisted navigation group; 20% of cup placements were considered to be outliers in the computer assisted navigation group compared with 57% in the freehand-placement group.

Lass et al (2014) compared the acetabular component position for computer assisted navigation and the conventional freehand technique in their randomized trial of 125 patients. CT scans identified higher accuracy for acetabular component anteversion, less deviation from the target position for anteversion, and fewer outliers from the target for inclination and anteversion. Surgical time was 18 minutes longer for computer assisted navigation. Functional outcomes were not assessed.

Manzotti et al (2011) compared leg length restoration in a matched-pair study. Forty-eight patients undergoing THA with computer assisted navigation were compared with patients who were matched for age, sex, arthritis level, preoperative diagnosis, and preoperative leg length discrepancy and underwent conventional freehand THA using the same implant in the same period. The mean preoperative leg length discrepancy was 12.17 mm in the computer assisted navigation group and 11.94 mm in the standard group. Surgical time was increased by 16 minutes in the computer assisted navigation group (89 minutes vs. 73 minutes). There was a significant decrease in both the mean postoperative leg length discrepancy (5.06 mm vs. 7.65 mm) and the number of cases with a leg length discrepancy of 10 mm or more (5 patients vs. 13 patients), all respectively. Outcomes at 40-month follow-up (range, 7-77 months) did not differ significantly for the Harris Hip Score (88.87 vs. 89.73) or the 100-point normalized Western Ontario and McMaster Universities Arthritis Index score (9.33 vs. 13.21; p=0.050), all respectively. Longer follow-up with a larger number of subjects is needed to determine whether computer assisted navigation influences clinical outcomes.

**Minimally Invasive Total Hip Arthroscopy**

It has been proposed that computer assisted navigation might overcome the difficulties of reduced visibility of the surgical area associated with minimally invasive procedures. Ulrich et al (2007) summarized study results that compared outcomes from minimally invasive THA using computer assisted navigation with standard THA. Seventeen studies were described in this evidence-based review, including 9 prospective comparisons, 7 retrospective comparisons, and 1 large (N=100) case series. Reviewers concluded that alignment with minimally invasive computer assisted navigation appears to be at least as good as standard THA, although the more consistent alignment must be balanced against the expense of the computer systems and increased surgical time.

Reininga et al (2013) reported short-term outcomes of minimally invasive THA approach with computer assisted navigation (n=35) compared with conventional posterolateral THA (n=40). This randomized comparison found no group differences in the recovery of gait at up to 6 months postsurgery.
Periacetabular Osteotomy
Hsieh et al (2006) reported on 36 patients with symptomatic adult dysplastic hip who were randomized to CT-based navigation or the conventional technique for periacetabular osteotomy. An average of 0.6 intraoperative radiographs were taken in the navigated group compared with 4.4 in the conventional group, resulting in a total surgical time that was 21 minutes shorter for computer assisted navigation. There were no differences between groups for correction in femoral head coverage or functional outcomes (pain, walking, range of motion) at 24 months.

Total Hip Resurfacing
Stiehler et al (2013) reported on short-term radiographic and functional outcomes from a randomized comparative trial of total hip resurfacing using computer assisted navigation and conventional total hip resurfacing in 75 patients. For most of the radiographic measures, there were no significant differences between the computer assisted navigation and conventional total hip resurfacing groups. There were fewer outliers (≥5°) for the femoral component with computer assisted navigation (11%) compared with conventional placement (32%). At 6-month follow-up, there were no differences between groups in the final Western Ontario and McMaster Universities score or Harris Hip Score. The computer assisted navigation group did show a greater percentage improvement in the Western Ontario and McMaster Universities scores and Harris Hip Score due to differences between groups at baseline.

Section Summary: Computer-Assisted Navigation for Total Hip Arthroscopy and Periacetabular Osteotomy
Relatively few RCTs have evaluated computer assisted navigation for hip procedures. Although there was early interest in this technology, no recent RCTs have been identified. There is inconsistent evidence from these small trials on whether computer assisted navigation improves alignment with conventional or minimally invasive THA. One RCT found improved alignment when computer assisted navigation was used for hip resurfacing, but there was little evidence of improved outcomes at short-term follow-up. Overall, improved health outcomes have not been demonstrated with computer assisted navigation for any hip procedures.

Computer-Assisted Navigation for Total Knee Arthroscopy
Clinical Context and Therapy Purpose
The purpose of computer assisted navigation is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conventional/manual alignment methods, in patients who are undergoing total knee arthroscopy.

The question addressed in this evidence review is: Does the use of computer assisted navigation improve the net health outcome when used for total knee arthroscopy?
The following PICO was used to select literature to inform this review.

**Patients**
The relevant population of interest is individuals who are undergoing total knee arthroscopy.

**Interventions**
The therapy being considered is computer assisted navigation. Computer assisted navigation in orthopedic procedures describes the use of computer-enabled tracking systems to facilitate alignment in a variety of surgical procedures, including fixation of fractures, ligament reconstruction, osteotomy, tumor resection, preparation of the bone for joint arthroplasty, and verification of the intended implant placement.

Patients who are undergoing total knee arthroscopy are actively managed by orthopedic surgeons in an inpatient surgical setting and by physical therapists and primary care providers following the procedure in an outpatient clinical setting.

**Comparators**
Comparators of interest include conventional/manual alignment methods. Treatment by means of conventional/manual alignment methods include medical reduction procedures, elastic bandaging, splints/braces, and physical therapy. These are performed by a physical therapist and primary care provider in an outpatient clinical setting.

**Outcomes**
The general outcomes of interest are symptoms, morbid events, and functional outcomes.

The existing literature evaluating computer assisted navigation as a treatment for patients who are undergoing total knee arthroscopy has varying lengths of follow-up, ranging from 1 to 8 years. While studies described below all reported at least one outcome of interest, longer follow-up was necessary to fully observe outcomes.

**Study Selection Criteria**
Methodologically credible studies were selected using the principles described in the first indication.

Alignment of a knee prosthesis can be measured along several different axes, including the mechanical axis, and the frontal and sagittal axes of both the femur and tibia.

**Systematic Reviews**
A TEC Assessment (2007) evaluated computer assisted navigation for total knee arthroscopy. Nine studies from 7 RCTs were reviewed. Selection criteria for the RCTs included having at least 25 patients per group and comparing limb alignment and surgical or functional outcomes following total knee arthroscopy with
computer assisted navigation or conventional methods. Also reviewed were cohort and case series that evaluated long-term associations between malalignment of prosthetic components and poor outcomes. In the largest of the cohort studies, which included more than 2000 patients (3000 knees) with an average follow-up of 5 years, 41 revisions for tibial component failure (1.3% of the cohort) were identified. The relative risk for age was estimated at 8.3, with a greater risk observed in younger, more active patients. For malalignment (defined as >3° varus or valgus), the relative risk was estimated to be 17.3.

Pooled data from the prospective RCTs showed:

- A significant decrease in the percentage of limbs considered to be outliers (eg, >3° of varus or valgus from a neutral mechanical axis) with computer assisted navigation.
- Surgical time increased by 10 to 20 minutes in all but 1 study. Computer assisted navigation associated reduction in blood loss was less consistent, with only some of the studies showing a decrease in blood loss of 100 to 200 mL.
- RCTs that assessed function (up to 2 years of follow-up) did not find evidence of improved health outcomes. However, the studies were not adequately powered to detect functional differences, and data on long-term follow-up were not available.

Based on the deficiencies in the available evidence (eg, potential for bias in observational studies, lack of long-term follow-up in the RCTs), TEC reviewers concluded that it was not possible to determine whether the degree of improvement in alignment reported in the RCTs led to meaningful improvements in clinically relevant outcomes such as pain, function, or revision surgery.

Xie et al (2012) included in their meta-analysis 21 randomized trials (total N=2,658 patients) that reported on clinical outcomes with or without the use of computer assisted navigation. Most trials included in the review had short-term follow-up. As was found in the 2007 TEC Assessment, surgical time was significantly increased with computer assisted navigation for total knee arthroscopy, but there was no significant difference between approaches in total operative blood loss, the Knee Society Score, or range of motion.

Rebal et al (2014) conducted a meta-analysis of 20 RCTs (total N=1,713 knees) that compared imageless navigation technology with conventional manual guides. Nine studies were considered to have a low risk of bias due to the blinding of patients or surgical personnel. Fifteen studies were considered to have a low risk of bias due to evaluator blinding. The improvement in Knee Society Score was statistically superior in the computer assisted navigation group at 3 months and 12 to 32 months. However, these improvements did not achieve the minimal clinically significant difference, defined as a change of 34.5 points.

More recent studies (2014, 2015) have also found longer surgical times and few differences in clinical outcome measures at 1-year follow-up.
Table 6. Characteristics of Systematic Reviews and Meta-Analyses Investigating Total Knee Arthroscopy

<table>
<thead>
<tr>
<th>Study</th>
<th>Dates</th>
<th>Trials</th>
<th>Participants</th>
<th>N (Range)</th>
<th>Design</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xie et al (2012)</td>
<td>PubMed (1966 to August 2011) and EMBASE (1984 to August 2011)</td>
<td>21</td>
<td>Included 2658 patients. Among these 1376 were randomly allocated to the computer-assisted TKA group and 1282 to the conventional group</td>
<td>2658 (25-120)</td>
<td>RCT</td>
<td>NR</td>
</tr>
<tr>
<td>Rebal et al (2014)</td>
<td>2004-2009</td>
<td>20</td>
<td>a combined 869 knees in the computer-assisted groups, and 844 knees in the control groups for a total of 1,713 knees analyzed</td>
<td>1713 knees (46-166)</td>
<td>RCT</td>
<td>3 mos and 12-32 mos</td>
</tr>
</tbody>
</table>

RCT: randomized controlled trial; NR: not reported; TKA: total knee arthroplasty.

Table 7. Results of Systematic Reviews and Meta-Analyses Investigating Total Knee Arthroscopy

<table>
<thead>
<tr>
<th>Study</th>
<th>Knee Society Score</th>
<th>Operative Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean standard difference</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>-1.05 to 9.99</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>.36</td>
</tr>
<tr>
<td>Xie et al (2012)</td>
<td>CAN (min)</td>
<td>3 Months</td>
</tr>
<tr>
<td></td>
<td>Conventional (min)</td>
<td>53.1</td>
</tr>
<tr>
<td>Rebal et al (2014)</td>
<td>CAN (min)</td>
<td>68.5</td>
</tr>
<tr>
<td></td>
<td>Conventional (min)</td>
<td>58.1</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>1.13 to 19.78</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>.03</td>
</tr>
</tbody>
</table>

CAN: computer-assisted navigation; CI: confidence interval; min: minutes.

Effect of Computer-Assisted Navigation on Mid- to Long-Term Outcomes

Most studies comparing outcomes at mid- to long-term generally have shown a reduction in the number of outliers with computer assisted navigation, but little to no functional difference between the computer assisted navigation and conventional total knee arthroscopy groups. Hsu et al (2019) reported such results with their randomized study of 60 patients who underwent computer assisted navigation total knee arthroscopy on one knee and conventional total knee arthroscopy on the other. At a mean follow-up of 8.1 years, investigators saw similar clinical and functional outcomes with the 2 procedures, although computer
assisted navigation achieved better radiographic alignment and fewer outliers. They suggested that total knee arthroscopy with computer assisted navigation may not provide an advantage to the typical osteoarthritis patient, but it may benefit certain patients, such as those with severe deformity of the knee joint, extra-articular deformities, and severe femoral bowing. The study was limited by its solely Asian patient population, single center, and small sample size.

Cip et al (2018) published the results of a prospective randomized trial in which 100 conventional total knee arthroscopys were compared with 100 computer-assisted total knee arthroscopys with a mean follow-up of 12 years postoperatively. The trial was aimed at determining the long-term outcomes of computer assisted navigation for total knee arthroscopy as a tool to expedite long-term survival based on improved postoperative implantation. The follow-up rate was 75%. No difference in long-term total knee arthroscopy survival was found between the conventional group (91.5%) and the computer assisted navigation group (98.2%) at 12 years (p=0.181).

Follow-up from 4 randomized trials was published between 2013 and 2016; they assessed mid-term functional outcomes following computer assisted navigation for total knee arthroscopy. Blakeney et al (2014) reported on 46-month follow-up for 107 patients from a randomized trial of computer assisted navigation versus conventional surgery.24 There was a trend toward higher scores on the Oxford Knee Questionnaire with computer assisted navigation, with a mean score of 40.6 for the computer assisted navigation group compared with 37.6 and 36.8 in extramedullary and intramedullary control groups. There were no significant differences in the 12-Item Short-Form Health Survey Physical Component or Mental Component Summary scores. The trial was underpowered, and the clinical significance of this trend for the Oxford Knee Questionnaire is unclear.

Lutzner et al (2013) reported on 5-year follow-up for 67 of 80 patients randomized to computer assisted navigation or conventional total knee arthroscopy.25 There was a significant decrease in the number of outliers with computer assisted navigation (3 vs. 9; p=0.048) but no significant differences between groups on the Knee Society Score or Euroquality of life questionnaire for quality of life. Cip et al (2014) found a significant decrease in malalignment with computer assisted navigation, but no significant differences in implant survival or consistent differences clinical outcome measures between the navigated (n=100) and conventional (n=100) total knee arthroscopy groups at minimum 5-year follow-up.26 Song et al (2016) also reported on a reduction in the number of outliers with computer assisted navigation (7.3% vs. 20%; p=0.006), with no significant differences in clinical outcomes at 8-year follow-up.27 The trial, which assessed 80 patients (88 knees) was powered to detect a 3-point difference in Knee Society Score results.

**Comparative Studies**

Other comparative study designs have found no significant differences in clinical outcomes following computer assisted navigation. Kim et al (2009), in their
A comparative study assessed 160 bilateral total knee arthroscopies performed by experienced surgeons in Asia; differences in alignment measures between the conventionally prepared knee and the knee prepared with computer assisted navigation assistance were minimal. Kim et al (2012) 28 also reported longer-term follow-up (mean, 10.8 years) on 520 patients who underwent computer assisted navigation for one knee and conventional total knee arthroscopy for the other knee (randomized).29 There were no significant differences between groups for knee function or pain measures. Kaplan-Meier survivorship at 10.8 years was 98.8% in the computer assisted navigation knee and 99.2% for the conventional knee. Hoppe et al (2012)30 and Yaffe et al (2013)31 found an improvement in alignment with computer assisted navigation, but no difference in clinical or functional outcomes at 5-year follow-up compared with conventional total knee arthroscopy in their nonrandomized comparative studies.

Hoffart et al (2012) used an alternate allocation design with 195 patients to compare functional outcomes following computer assisted navigation assisted total knee arthroscopy with conventional instrumentation.32 An independent observer performed the preoperative and postoperative assessments. After 5 years, complete clinical scores were only available for 121 (62%) patients. There was no significant difference in the frequency of malalignment between groups. The computer assisted navigation group had a better mean Knee Society Score as well as mean function and knee scores. Mean pain scores did not differ between groups. Study limitations included the high loss to follow-up and lack of subject blinding.

Dyrhovden et al (2016) assessed survivorship and the relative risk of revision at 8-year follow-up for 23,684 cases from the Norwegian Arthroplasty Register for patients treated with computer assisted navigation or conventional surgery.33 Overall prosthesis survival and risk of revision were similar for both groups, although revisions due to malalignment were reduced with computer assisted navigation (relative risk, 0.5; 95% confidence interval [CI], 0.3 to 0.9; \( p=0.02 \)). There were no significant differences between groups for other reasons for revision (e.g., aseptic loosening, instability, periprosthetic fracture, decreased range of motion). At 8 years, the survival rate was 94.8% (95% CI, 93.8% to 95.8%) in the computer assisted navigation group and 94.9% (95% CI, 94.5% to 95.3%) for conventional surgery.

**Section Summary: Computer-Assisted Navigation for Total Knee Arthroscopy**

A large number of RCTs have assessed outcomes for total knee arthroscopy using computer assisted navigation or conventional total knee arthroscopy without computer assisted navigation. Results are consistent in showing reductions in the proportion of outliers greater than 3° in alignment. Results up to 12 years postoperatively have not shown that these differences in alignment lead to improved patient outcomes.
Summary of Evidence
For individuals who are undergoing orthopedic surgery for trauma or fracture and receive computer-assisted navigation, the evidence includes one retrospective clinical trial, reviews, and in vitro studies. Relevant outcomes are symptoms, morbid events, and functional outcomes. Functional outcomes were not included in the clinical trial, although it did note fewer complications with computer-assisted navigation versus conventional methods. The evidence is insufficient to determine the effects of the technology on net health outcomes.

For individuals who are undergoing ligament reconstruction and receive computer-assisted navigation, the evidence includes a systematic review of 5 randomized controlled trials (RCTs) of computer-assisted navigation versus conventional surgery for anterior and posterior cruciate ligament. Relevant outcomes are symptoms, morbid events, and functional outcomes. Trial results showed no consistent improvement of tunnel placement with computer-assisted navigation, and no trials looked at functional outcomes or need for revision surgery with computer-assisted navigation. The evidence is insufficient to determine the effects of the technology on net health outcomes.

For individuals who are undergoing hip arthroplasty and periacetabular osteotomy and receive computer-assisted navigation, the evidence includes older RCTs, a systematic review, and comparison studies. Relevant outcomes are symptoms, morbid events, and functional outcomes. Evidence on the relative benefits of computer-assisted navigation with conventional or minimally invasive total hip arthroscopy is inconsistent, and more recent RCTs are lacking. The evidence is insufficient to determine the effects of the technology on net health outcomes.

For individuals who are undergoing total knee arthroscopy and receive computer-assisted navigation, the evidence includes RCTs, systematic reviews of RCTs, and comparative studies. Relevant outcomes are symptoms, morbid events, and functional outcomes. The main difference found between total knee arthroscopy with computer-assisted navigation and total knee arthroscopy without computer-assisted navigation is increased surgical time with computer-assisted navigation. Few differences in clinical and functional outcomes were seen at up to 10 years post-procedure. The evidence is insufficient to determine the effects of the technology on net 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.
In response to requests, input was received from 3 academic medical centers while this policy was under review in 2011. Input was mixed on whether computer-assisted navigation is considered investigational. One reviewer provided additional references on high tibial osteotomy and pelvic tumor resection.

**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**

One currently unpublished trial that might influence this review is listed in Table 8.

<table>
<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpublished</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT01469299a</td>
<td>Prospective Study Measuring Clinical Outcomes of Knee Arthroplasty Using the VERASENSE™ Knee System</td>
<td>285</td>
<td>Dec 2016 (updated 01/11/17)</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.

a Denotes industry-sponsored or cosponsored trial.

**REFERENCES**


Billing Coding/Physician Documentation Information

20985 Computer-assisted surgical navigational procedure for musculoskeletal procedures; image-less (List separately in addition to code for primary procedure)

0054T Computer-assisted musculoskeletal surgical navigational orthopedic procedure, with image-guidance based on fluoroscopic images (List separately in addition to code for primary procedure)

0055T Computer-assisted musculoskeletal surgical navigational orthopedic procedure, with image-guidance based on CT/MRI images (List separately in addition to code for primary procedure)

All of the codes are intended to be used in addition to the code for the primary procedure.

CPT codes 20986 and 20987 were deleted effective 1/1/2009. The category III codes were re-instated effective 1/1/2009.

Additional Policy Key Words

N/A

Policy Implementation/Update Information

12/1/07 New policy; considered investigational.

6/1/08 No policy statement changes. Coding updated.

12/1/08 No policy statement changes.

6/1/09 No policy statement changes. Coding updated.

12/1/09 No policy statement changes.

6/1/10 No policy statement changes.

12/1/10 No policy statement changes.

6/1/11 No policy statement changes.

12/1/11 No policy statement changes.

6/1/12 No policy statement changes.
12/1/12  No policy statement changes.
6/1/13  No policy statement changes.
12/1/13  No policy statement changes.
6/1/14  Added Verasense to Regulatory Status. No policy statement changes.
12/1/14  No policy statement changes.
6/1/15  No policy statement changes.
12/1/15  No policy statement changes.
6/1/16  No policy statement changes.
12/1/16  No policy statement changes.
12/1/17  No policy statement changes.
6/1/18  No policy statement changes.
12/1/18  No policy statement changes.
6/1/19  No policy statement changes.
12/1/19  No policy statement changes.
6/1/20  No policy statement changes.

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