

**AAHKS Position Statement on
Computer Assisted Orthopaedic Surgery (CAOS)
For Total Hip and Knee Replacement:
What Patients Should Consider**

Purpose

The purpose of this position statement is to provide information for patients about Computer Assisted Orthopaedic Surgery (CAOS) for Total Hip and Knee Replacement Surgery.

Background

Total hip and knee replacement are among the most common and successful orthopaedic operations. The indications for joint replacement are well established and quality of patient outcomes are well documented (1,2). Pain relief, increased joint motion, improved joint function and durability are predictably achieved in the majority of patients. Surgical goals are accomplished using techniques that mechanically or visually reference anatomical landmarks to reconstruct the damaged joint. CAOS is a new technology designed to either compliment or add information during joint replacement surgery. CAOS has the potential to improve the accuracy and reproducibility of joint replacement operations.

Definitions, Terminology and Technology

CAOS is surgical technology that assists surgeons through creation and display of images showing the replacement components in their relationships to the bones and ligaments of the joint being replaced. CAOS is also called Imaged Guided Surgery or Surgical Navigation. CAOS has two basic components:

1. a special camera designed to see the surgical joint and limb and create a picture or image of the hip or knee
2. computer programs which integrate these images with surgical information and assist the surgeon during the operation

CAOS can use actual images of the joint (X-Rays/fluoroscopic, ultrasound or CT images) or can create virtual images of the damaged joint. The camera and computer are given information by the surgeon about the normal and abnormal anatomic landmarks of the joint and limb. This information can be transmitted in several ways. Some CAOS systems use special cameras to identify and record the position of photo reflective spheres or infra-red light emitting devices. Some other systems use ultrasonic devices to identify bony landmarks. The surgeon uses the computer generated information and images to accurately and reproducibly reconstruct the damaged joint and limb.

Goals and Basic Principles of Total Hip and Knee Replacement

The goal of total hip and knee replacement surgery is to relieve pain and restore joint function. This goal can be accomplished successfully when several basic principles are followed:

1. restoration of joint and limb alignment
2. correction of joint and limb deformity
3. restoration of joint motion
4. maintenance or restoration joint stability
5. proper sizing, positioning and fixation of the joint replacement implants
6. balancing of soft tissues

Basic Objective of CAOS

The basic objective of CAOS is to provide improved information for surgeons during hip and knee replacement surgery. This new information may help surgeons make more accurate and more reliable surgical decisions.

Other Possible Uses for CAOS

CAOS can be used as a research tool to store data gathered at the time of surgery. This stored data includes anatomical and mechanical information about the reconstructed joint and limb. Integration of CAOS data with patient outcomes after joint replacement surgery may increase the reliability and quality of the surgical results. CAOS may also increase the reliability of joint replacement surgeries performed through limited or less invasive surgical approaches. More reproducible alignment may be achieved in patients with implants in the same limb and those with bony deformities. Lastly, the technology may allow safer surgery in patients at higher risk for embolization of marrow contents.

Current Knowledge

Most CAOS studies to date validate the use of this technology as a surgical technique that can add accuracy and reliability to joint replacement operations. The success, however, depends on a number of factors including the type of system used as well as the operator (how the system is used). During hip replacement surgery, CAOS has demonstrated more reliable limb length restoration. During knee replacement surgery, CAOS has demonstrated an increased reliability of limb alignment (more consistent straightening of the knee deformity). CAOS studies of both hip and knee replacement have shown an increased reliability of prosthetic component sizing and positioning. Most of the CAOS studies have been published by experienced CAOS users and joint replacement surgeons. It is too early to predict the future role of CAOS. Since CAOS techniques have only been used for several years, no long term data is available to compare the results of total hip and knee replacement performed with and without CAOS technology.

Reported Complications of CAOS

Reported CAOS complications are very infrequent (less than 1%). Complications have been reported related to the pins used to attach the photo reflective or emitting devices to the bone. These complications include occasional pin site fractures and pin site infections. If infection involves the new joint this type of problem can be very serious.

What Patients Should Consider

CAOS is an evolving surgical technology. The surgical indications, added values for patients, limitations of the technique and complications are currently being studied. Like any surgical technology, evaluation of the surgeon's and the surgical team's knowledge and experience is important. Since CAOS is a recent technology used in total joint replacement surgery, it will take several years to determine if the long term outcomes of CAOS joint replacement patients are improved.

CAOS techniques can be bypassed during surgery if computer malfunction occurs. Anatomical and mechanical references can be used to confirm or substitute for computer based decisions. CAOS has some potential advantages and disadvantages for patients. There are also some important unknown factors and outcomes of CAOS. All CAOS systems work on different assumptions and computer algorithms. The patient should take into consideration the experience of the surgeon and if special training utilizing these systems has been undertaken by their surgeon. These systems rely on accurate input of anatomical and surgical landmarks by the surgeon and are only as accurate as the data that are provided.

Potential Advantages of CAOS for Patients:

Hip and Knee Patients

1. Computer organized and directed surgical work flow
2. Improved reliability of sizing and positioning of joint implants
3. Added information about ligament and muscle balancing
4. Improved documentation of limb/joint anatomy and deformity
5. Enhanced data storage for research and outcome analysis
6. Added information during less invasive surgical approaches

Hip Replacement Patients

1. Improved reliability of reconstructed limb length
2. Improved reliability of prosthetic component alignment
3. Fewer prosthetic hip joint dislocations

Knee Replacement Patients

1. Increased reliability of limb alignment
2. Decreased surgical trauma by eliminating instrumentation of the canals (hollow centers) of the femur (thigh bone) or tibia (shin bone)

Potential Disadvantages of CAOS for Patients:

1. Increased time required to perform the operation
2. Additional incisions (wounds) required for attachment of the reference arrays (holding the reflective spheres or emitting devices) attached to the bones about the joint
3. Increased hospital costs from the additional equipment, software and surgical time
4. Increased incidence of fractures or infections related to the pins and their incisions (wounds) needed to attach the reflective or emitting devices to the bones (less than 1% reported complication rate)

Unknown Surgical Factors and Outcomes:

1. Reliability of CAOS techniques by less experienced or infrequent CAOS users.
2. Impact on overall patient outcomes and patient satisfaction
2. Impact on prosthetic joint longevity and durability
3. Decreased frequency of revision surgeries

Conclusion

Total hip and knee replacement are very reproducible and successful surgeries. CAOS is a technology currently being evaluated in many orthopaedic centers world-wide. Because this technology is new, expensive, and adds time to the surgical procedure, the technology has not been widely adopted. As CAOS is used and studied, its utility and value will be better understood. To date, few complications have been reported. Current studies demonstrate that CAOS technology adds reliability to total hip and knee replacement surgery in the short term.

Longer and more comprehensive follow-up CAOS studies are needed to better understand the indications, limitations and complications of this surgical technology. Future studies will also determine if the short term improvements reported from CAOS can increase joint implant longevity and improve overall outcomes for patients undergoing total hip and knee replacement surgery.

Credentialing

Surgeons who are engaged in new techniques are responsible to be competent, proficient and qualified to perform these new approaches. The surgeon should discuss any additional risks associated with these approaches as well as their own experience and qualifications in performing any surgical procedure in the informed consent process.

The AAHKS, through its educational endeavors, attempts to educate orthopaedic surgeons and other practitioners about new and existing technology and techniques. However, the AAHKS does not certify the competence of an individual for clinical use of a new technique or provide any credentials.

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References

1. NIH Consensus Statement, Total Hip Replacement, Sept. 12-14, 1994, Vol. 12, No. 5
<http://consensus.nih.gov/1994/1994HipReplacement098html.htm>
2. NIH Consensus Development Conference on Total Knee Replacement, Dec. 8-10, 2003, Final Statement
<http://consensus.nih.gov/2003/2003TotalKneeReplacement117html.htm>

AAHKS Mission Statement:

The mission of the AAHKS is to promote education, research and advocacy related to the health and disorders of the hip and knee. The vision of the AAHKS is to be the premier organization of hip and knee surgeons.

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