November 16, 2020 10 min read

Knee stability drives prosthesis design, surgical technique for primary TKA

Current implants offer various pros, cons for patients, surgeons in primary TKA

Stability plays a key role in primary total knee arthroplasty for patients and affects their overall satisfaction, making it an important consideration for orthopedic surgeons during planning and execution of the procedure.

Available TKA implants approach stabilization in varying ways, some of which have emerged at the forefront of primary TKA surgical options. These include cruciate-retaining, posterior stabilized, medial pivot and medial-stabilized implants.

Stephen J. Incavo, MD, said medial-constrained TKA designs provide anteroposterior stability without a cam-post mechanism or relying on the PCL.

Source: William J. Bryan, MD

"With currently available implant options, my advice to patients is that I can entirely meet their stability needs," **James W. Pritchett, MD,** former chief of orthopedic surgery at Swedish Orthopedic Institute in Seattle, told Orthopedics Today. "For patients who have all four ligaments that we depend on intact, bicruciate-retaining implants are a solution for stability, and for those who do not have an intact anterior cruciate ligament, for instance, but who need a stable knee, the medial pivot implant becomes of interest."

James W. Pritchett

Although current knee implant designs appear to meet many patient stability needs, important considerations must be weighed regarding the implantation process, according to **Bryan D. Springer, MD,** who specializes in hip and knee orthopedics at The OrthoCarolina Hip and Knee Center in Charlotte, North Carolina.

"Yes, we can try and alleviate instability or achieve stability through technology and through implants, but I still think the bottom line is the technical aspects of the surgery, and oftentimes, unfortunately, surgeon error leads to the big issue with instability," Springer told Orthopedics Today.

Bryan D. Springer

As more data become available on the outcomes associated with different forms of knee implant designs for TKA, orthopedists interviewed for this *Cover Story* discussed the benefits and drawbacks of the most common prosthesis designs and the respective effects on stability, overall patient satisfaction and surgical complexity.

Cruciate-retaining design

David J. Backstein

In a cruciate-retaining knee implant, the PCL is maintained, which is thought to contribute to knee stability by retaining the nerves in this ligament and may better maintain the proprioception of the knee joint, according to **David J. Backstein, MD, MEd, FRCSC,** head of the Granovsky Gluskin Division of Orthopaedic Surgery at Sinai Health System in Toronto.

"There was thinking that by maintaining the cruciate, you'd have better stability and therefore better functions, such as going up and down stairs, which is something that puts forces on the knee that can cause it to be lax in the anteroposterior direction," Backstein said. "The posterior cruciate ligament function is to prevent the tibia from sliding backwards on the femur and so by maintaining that ligament, it was thought that would help with stability and therefore with functions, like going up and down stairs."

According to Springer, some orthopedists see the cruciate-retaining (CR) implant as a more bone-preserving option, because it avoids cutting out a notch that would have to be made for a posterior-stabilized (PS) implant; however, the amount of bone preservation in this design remains controversial.

"Some surgeons may argue that because you're retaining the posterior cruciate ligament, it helps to drive some of the more normal motion and kinematics of the knee," Springer said. "I think the biggest downside of the cruciate-retaining knee is that it does rely on the posterior cruciate ligament for stability, so if the stability of that ligament is compromised or it is not balanced appropriately at the time of surgery, or if it became incompetent later, then that patient may develop instability," he said.

According to Pritchett, surgery with bicruciate-retaining prostheses can be a particularly challenging procedure for surgeons to perform given the importance of precise balancing and that this design does not entail subluxation. However, it does offer "exceptionally good" long-term survivorship, per results of a 2015 study by Pritchett that involved minimum 20-year patient follow-up. Pritchett reported Kaplan-Meier survivorship of 89% at 23 years, and revision for any reason served as the endpoint. Further, competing-risks survivorship at 23 years was 94%, with a mean patient age of 84 years, mean flexion of 117° and an improvement in mean American Knee Society score from a preoperative mean of 42 to 91. A total of 5.6% of knees were revised, most commonly linked to polyethylene wear.

Posterior-stabilized design

Conversely, the PS knee prosthesis uses mechanical security, which places more stress on the implants, including articular sources, as well as the sources of attachment, Pritchett said.

"This implant design also has more noise, because the implants get their stability from how they articulate rather than from the ligaments, so noises like clunks, pops and clicks are much more commonly reported in patients with posterior stabilized knees, but are very rarely reported in patients with bicruciate-retained knees," Pritchett said.

Due to its design, the PS implant may feel less natural to patients, according to **Stephen J. Incavo, MD,** section chief of adult reconstructive surgery at Houston Methodist Orthopedics & Sports Medicine.

"When patients flex with the posterior stabilized implant, the tibial side has a plastic post made for the recess and the femoral component," Incavo said. "In the back of that recess, there's a bar which we call the cam, so when the knee flexes, and if the tibia wants to slide posteriorly, it can. It butts against the cam, which is how it provides stability in the posterior direction, but it doesn't provide stability in the anterior direction, so I think it's less natural feeling for patients, but that's a controversial opinion," he said.


Stefano A. Bini

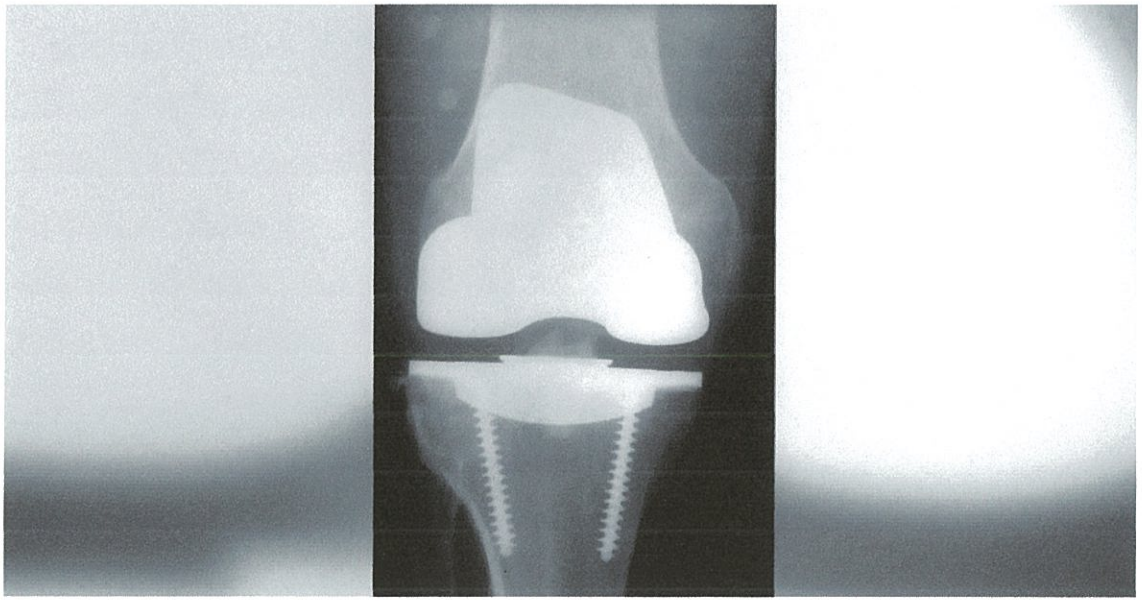
According to **Stefano A. Bini, MD,** of the department of orthopaedic surgery University of California, San Francisco, a major pro of the PS design is its implantation is easy to perform.

"You don't have to worry about the posterior cruciate ligament failing over time or being partially released or imbalanced," Bini said. "You also don't have to worry about restoring a native tibial slope, which can be tricky, and it is a more forgiving construct, which also has the potential to use a constrained insert if you just can't get that knee balanced, because there's no constraining a cruciate-retaining implant. The posterior cruciate-sacrificing knee is a much easier procedure, and the results have been comparable."

Overview of medial-based options

Medial pivot TKA prostheses are a newer design of knee implants meant to replicate the physiological kinematics of the normal knee, sources said.

"These designs were most likely developed to offer a stable option for an active person who does not have an anterior cruciate, meaning someone who needs stability but can't provide their own," Pritchett said. "A patient without an anterior cruciate ligament would not be a candidate for a cruciate-retaining or bicruciate-retaining knee, but they still needed to have a stable knee implant. Medial designs originally came out in 1998 and have been in constant use since. Because they're easier to implement than a bi-cruciate knee, the surgeon may select it because it is an easier option to get nearly the same result as if both cruciate ligaments were retained," he said.



A radiograph of a bicruciate total knee replacement prosthesis is shown.

Source: James W. Pritchett, MD

According to Springer, a sharp distinction between medial pivot and medial stabilized designs may not be entirely necessary.

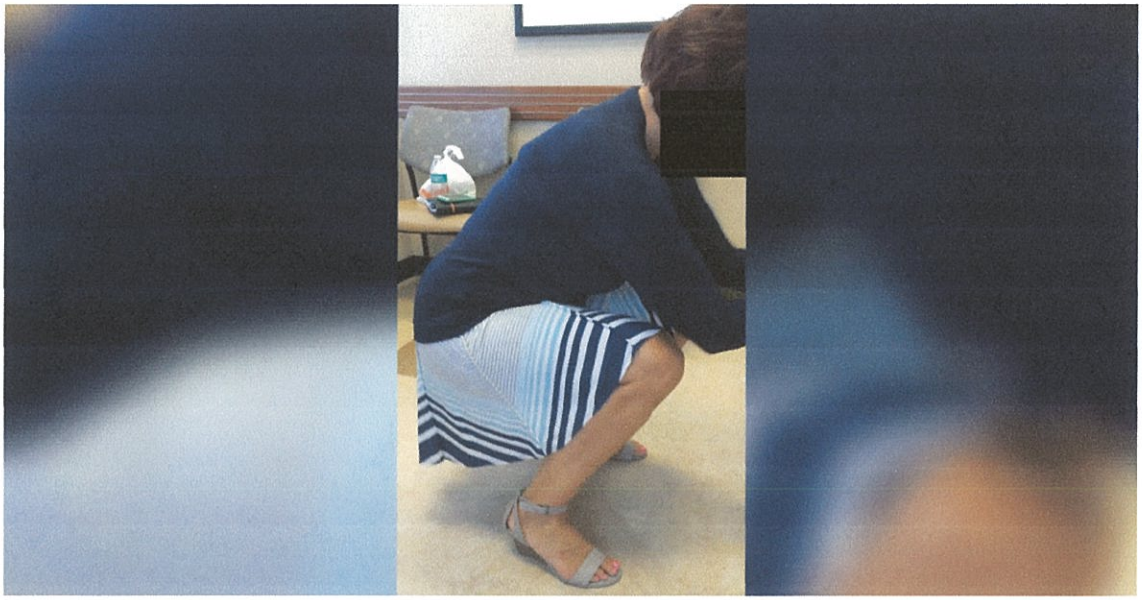
"Conceptually, they're much the same thing, but some of the implants that are less constrained on the medial side of the knee would be considered more of a medial-stabilized designed, but both forms are trying to accomplish the same thing," he said. "The rationale behind the medial-stabilized knee and the medial-pivot knee is that if you look at the normal kinematics of the knee for most people, they will have a medial pivot kinematic, so that as the knee goes into flexion, the medial side stays relatively still and the lateral side of the femur rolls backward to provide more bend in the knee. By creating stability that is more centered on the medial side of the knee, medial prostheses reproduce the medial pivot motion that occurs in many knees, and the stability of the knee is built into the implants themselves, as opposed to relying on the ligaments of the knee to provide stability."

Survivorship, techniques

During the past 2 decades, long-term survivorship of medial prosthetic knees has been "very good," Pritchett said, and it has appeared as effective as other designs, except for the bicruciate-retaining implant, which offers a low failure rate in the long term.

"An initial concern regarding medial congruent implants was whether there would be excessive wear of the articular surface because of their congruence, but that has not happened, and it remains at par with or exceeds other designs," he said.

According to Incavo, medial designs can be implanted via two techniques: measured resection or gap balancing, the latter of which, he noted, is his personal preference.



A patient with a medial pivot TKA is shown performing a deep squat, which requires TKA stability, as well as flexibility.

Source: Stephen J. Incavo, MD

"Anyone who is a candidate for primary knee replacement could have a medial-stabilized or medial-pivot implant, so there is no specific contraindication for them," Incavo said. "They are good for most patients because they do not rely on either the ACL or the PCL for stability."

Near normal kinematics

The natural motion of the human knee when it is functioning normally is a medial pivot pattern, and fluoroscopic studies have shown that CR and PS knees do not have a medial pivot pattern once they are implanted, but rather a pattern of motion dictated by the implant, according to Incavo.

"There haven't been many studies on medial prostheses, but the thought is that they provide a more physiologic, natural motion for the patient through stability and motion," Incavo said. "However, stability and motion are opposites, so if a knee is stable, it may not get much motion, and if it's unstable, it will get motion but sacrifice stability. The trick is to aim for physiologic normal stability while still allowing regular motion."

Incavo added, the normal knee can flex 140° or 150°, but knee replacements generally do not have that much flexion, so surgeons should "approach normal," but must bear in mind that normal flexion and extension in stability may not be achievable.

Backstein gave an overview of how a medially stabilized knee recreates normal knee kinematics in vivo vs. a design that provides lateral stability.

"Because the medial congruence of the implant mimics the medial congruence in the normal human knee, the medial side is fixed in a more stable position, which means it does not move front-to-back much," he said. "The action happens on the lateral side, which doesn't require a lot of energy vs. the medial side. In day-to-day activity, the medial side stays relatively stable and the femur pivots around it, moving mainly on the lateral side as the knee goes from flexion to extension, and that is much closer to the way a knee that is not diseased and has not been replaced works."

Patient satisfaction

Regarding whether patient satisfaction differs according to the implant design used, Bini said the short answer is "no."

"The problem is patient satisfaction scores are poor at differentiating the variation, particularly at the top or at the bottom," Bini said. "The scores are blunt and can not necessarily tell the difference between someone who is playing 18 holes of golf and someone who needs to use a cart, or someone who is an avid hiker and someone who can only walk a flat surface without pain."

Heading into the future, Bini said machine-learning algorithms and augmented artificial intelligence may help tailor patient feedback in a more granular manner. Advances, like biometric sensors worn on a patient's wrist or incorporated into their phone, may also provide data at regular and frequent intervals to get a better sense of a patient's activity and needs.

Surgeon preferences

Bini noted that cruciate-retaining, medial pivot, kinematically aligned knees are likely the current option that provides the best restoration of a normal knee.

In Pritchett's view, bicruciate-retaining knee implants seem to offer the most amount of patient satisfaction, followed closely by medial-pivot designs.

"There is only one manufacturer that is currently offering the bicruciate knee, and that is the Journey II XR from Smith & Nephew," Pritchett said. "For the medial pivot design, I use the Zimmer Persona Medial Congruent, which is the most versatile implant on the market."

Backstein cited the MicroPort Evolution, a medial-pivot TKA system, as his implant of choice.

"I find it ends up giving the best results and I like the instrumentation," he said.

Incavo uses the Zimmer Persona Medial Congruent and MicroPort medial systems.

"I use the Stryker Triathlon Total Knee System, which is what I would consider a soft tissue-driven, unconstrained type of knee," Springer said. "I've used it since 2008 and have had very good results with it. However, if an implant is well done technically, the patient does the rehab and everybody involved does their job, it's not necessarily the implant that puts the patient over the top. Implants will not make up for poor surgical technique and poor patient compliance with rehab and therapy," he said.

Look at the future

According to Pritchett, implant-specific complications are rare.

"It is issues with the surrounding tissues, instability, infection and periprosthetic fracture loosening that dominate the complications," he said.

With regard to medial pivot implants, Springer said complications may relate to characteristics other than stability.

"Patients may experience stiffness if the implant is too tight or too constrained on one side of the joint, but that has been more in my anecdotal experience," he said.

Springer provided an overview of what the future of implants for stability in TKA may hold.

"Future progress in this area will likely revolve around individualized alignment and kinematics of patients' knees, meaning we may determine an individual's kinematic pattern/alignment to determine the best implant for them," Springer said. "That may include one of these designs we've currently discussed, or it may be something completely different down the line. A lot of enabling technologies, such as robotics, are going to aim toward a more individualized approach to patients' knee stability."

Reference:

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