Seminars in Arthroplasty

Minimally Invasive Total Knee Replacement Surgery with a Lateral Approach

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Minimally invasive total knee arthroplasty surgery (MIS TKA) combines established knowledge gained from the long-term success of conventional TKA with the benefits of a less invasive surgical approach. Because MIS TKA is built on the foundations and principles of conventional TKA, most surgeons are more familiar with the medial approach used in most knee replacement surgery. Experience in conventional TKA and in the medial approach is needed before the lateral approach is adopted. While many aspects of the lateral and medial approaches are similar, or even identical, the lateral approach offers the advantage of completely sparing the quadriceps, in particular the vastus medialis obliquus, as well as branches of the saphenous nerve and the genicular artery.

KEYWORDS minimally invasive surgery, total knee arthroplasty, lateral approach

Patients have benefited from continuous improvements in total knee arthroplasty (TKA) procedures and materials since the first total knee replacement was performed in the mid-1970s.[1] These improvements are reflected in the two decades of satisfactory results for conventional total knee components implanted with conventional TKA surgical procedures.[2-7] Progress has been achieved through careful research, controlled trials, and thorough collection and reporting of data.

The most recent development in TKA to gain widespread attention is the application of techniques termed minimally invasive surgery (MIS).[8-10] MIS offers the promise of limiting not merely the incision size but also minimizing the interruption and dissection of muscles, tendons, ligaments, and neurovascular tissue. MIS TKA combines established knowledge gained from the long-term success of conventional TKA with the benefits of a less invasive surgical approach. The focus on this procedure has been enhanced by patient interest in reduced postoperative pain and recovery time and a possible reduction in cost. The peer-reviewed literature on MIS TKA is still in its infancy, with only a relative handful of articles having reported results and offered guidance on the procedure.[11-20] Indeed, the very term "minimally invasive" is open to debate not only as it applies to TKA but to a number of other procedures.

The lead author of this report began using a minimally invasive lateral parapatellar approach for TKA in 1992, after cadaveric evaluations to explore various approaches to the knee. Encouraging early results with the lead author's patient population showed reduced recovery times, less pain, and improved mobility, with long-term mobility and function equivalent to that of conventional TKA patients with similar histories. These results, combined with the reported success of others using MIS techniques for unicondylar knee replacement surgery, have resulted in further development of MIS techniques for TKA.[21,22]

Because MIS TKA is built on the foundations and principles of conventional TKA, most surgeons are more familiar with the medial approach used in most knee replacement surgery. Thus one purpose of this article is to review the similarities and differences, as well as disadvantages, of the minimally invasive lateral approach in comparison with the medial approach. Special attention is paid to the advantages of the lateral approach in preservation of neurovascular structures, and a step-by-step description of the lateral procedure is detailed.

Goals of MIS TKA

The primary goals of MIS TKA, whether through a lateral or a medial approach, are threefold. The first is to minimize interruption of the supply of blood and avoid damage to neurological tissue. The second is to minimize dissection of

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muscle, tendon, ligament, and bone. The third is to reduce the size of the incision while maintaining outcomes associated with conventional, larger midline incisions. A detailed understanding of these goals is necessary to evaluate the merits of lateral MIS TKA.

Minimizing Interruption of Vascular Supply and Nervous Tissue

A proper MIS TKA approach will minimize devascularization of the soft tissues surrounding the knee and decrease blood loss. Thus, a thorough study of the neurological tissue and blood supply to the region is necessary to guide the surgeon before a minimally invasive approach is undertaken in any procedure.

The descending genicular artery arises, with the articular portion entering the substance of the vastus medialis, before the femoral artery enters the adductor canal. That articular branch emerges from the vastus medialis obliquus (VMO) to form an anastomosis with the superior lateral genicular artery and the superior medial genicular artery. The anterior tibial recurrent artery branches inferolaterally from the anterior tibial artery, anastomotically connecting with the inferior medial genicular artery and the inferior lateral genicular artery. This extrapopliteal origin is similar to the superomedial anastomosis of the descending genicular artery. Otherwise, the popliteal artery is the origin of all of the important blood supply in the form of medial and lateral, superior and inferior, genicular arteries.[23]

The genicular arteries form anastomoses with each other and injury to the medial arteries does not prevent adequate supply of blood from reaching the medial structures through lateral vessels. However, an incorrect bipatellar exposure that extends too far proximal or distal can compromise the vascularity of the extensor mechanism. The lateral MIS TKA, like its medial counterpart, does not present a vascular concern, so long as an excessive bilateral incision is avoided.

With the exception of the VMO, the femoral nerve innervates all of the muscles forming the extensor mechanism proximal to entering the adductor canal. The vastus medialis longus (VML) and the VMO represent the proximal and distal portions, respectively, of the same muscle. Several branches of the femoral nerve innervate the VML, with a single branch of the femoral nerve extending distally through the VML, innervating the VMO.[24-27] The only other nerve to innervate the VMO is a branch from the saphenous nerve.[28] The VMO branch leaves the saphenous nerve just distal to the adductor canal and just proximal to the origin of the infrapatellar branch of the saphenous nerve.

Minimizing Dissection of Muscle and Bone

The four muscles that compose the quadriceps group are the rectus femoris, vastus interomedialis, vastus lateralis (VL), and vastus medialis (VM). They act in concert to extend the knee while the rectus femoris, in addition, flexes the hip. The distal third of the VMO acts with the VML to stabilize the patella during knee extension.[29-32] Each member of the quadriceps group approaches the quadriceps tendon and the patella at a different angle in the extension mechanism of the knee and, when contracted, each muscle acts along its own vector to accomplish knee extension.[33,34] The quadriceps extensor mass extends across the femur at a 4 to 7° lateralized angle in the coronal plane of the knee. In this angled extension, the patella passes proximally up the trochlear groove, which is biased to tilt and subluxate the patella laterally. One of the primary functions of the VMO is to prevent the lateral movement of the patella in the trochlear groove as the knee extends.[30-32]

The maintenance of proper patellar alignment during extension is critical to proper knee function, and many patients suffer from the effects of patella maltracking. Malalignment, abnormal Q angle, recurrent lateral patellar dislocation, lateral patella compression syndrome, and chondromalacia patella are all pathologic descriptions of a patella that does not track properly within the trochlear groove of the femur during knee extension.[30,35] Quadriceps muscles imbalance likely contributes to the spectrum of patellofemoral disorders. Proper balance of this complex muscle group is essential for the proper function of a lower extremity that has undergone an arthroplasty.

The anatomy of the extensor mechanism has conventionally been approached through a medial parapatellar approach for TKA, because the medial approach permits lateral dislocation and eversion of the patella, with its attached quadriceps tendons. Medial incisions offer improved exposure of the proximal tibia, and the normal femoral–tibial angle of the knee is in 4 to 7° of valgus.[34,35] This angulation, caused by cephalad recession of the lateral femoral condyle, compensates for the proximal varus angulation of the femoral neck.[36] The resulting alignment of the varus proximal femur and the valgus-angled distal femur is a mechanically straight femur, with the patella experiencing lateral subluxation during knee extension in the absence of a well-functioning VMO.

In any TKA procedure, bone resection should be minimized so that only the bone needed to provide an effective surface for the implant fixation is achieved. Existing TKA systems replace worn and deficient articular surfaces with a one-piece metal prosthesis resurfacing on the femoral side of the knee joint and a single metal tray containing a polyethylene insert at least 10 mm in thickness on the tibial side. Future improvements in implant materials may result in bearing surfaces with lower profiles or a diminished need for thick chamfer cuts, reducing the amount of bone resection required.

Minimizing Surgical Incisions

Conventional midline incisions serve three purposes: exposing pathology, avoiding neuromuscular structures, and allowing the exposure needed for conventional instrumentation and implantation of components. A guiding principle of MIS is never to reduce incision size if it in any way compromises patient outcomes by subverting one of these goals achieved by conventional incisions. Ironically, the smaller size of incision— which in most patients' minds is the reason