Minimally Invasive Total Knee Arthroplasty: Is it for Everybody?

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Abstract The development of new instrumentation and techniques has led to the rapid advancement of less invasive surgical approaches in total knee arthroplasty (TKA). Compared to the standard approach, minimally invasive surgery (MIS) in TKA was shown to reduce postoperative pain, blood loss, and hospitalization time, and to improve functional recovery. Growing experience with MIS-TKA has defined the proper indications for this technique. With a limited exposure, the skin, capsular tissues, and bone surfaces receive higher stresses because of the retraction required. Several complications relating to the MIS learning curve are now being reported. The reliability of a TKA procedure performed through a mini-incision, and its success, seems to depend on patient selection, surgeon experience, and surgical environment.

Key words arthroplasty · knee · MIS · replacement

Introduction

Increasing interest in performing knee arthroplasty procedures through less invasive approaches has led to the investigation of whether minimal incision surgery (MIS) concepts have a role in total knee arthroplasty (TKA). Traditionally, successful outcomes in knee arthroplasty have been measured by long-term implant performance and low revision rates [1–3]. The parameters outlined by the Knee Society Score indicated the requirements for an excellent result after TKA [4, 5]. In this scoring system there was no mention of recovery time following the procedure. The driving focus toward less invasive techniques includes patients' concerns about postoperative pain,

prolonged rehabilitation, and less-than-ideal functional outcomes associated with standard TKA. Short-term outcomes have begun to matter, considering patient's demand and health-care savings.

The development of new instrumentation and techniques have stimulated the rapid advancement of minimally invasive TKA. A number of surgical approaches for MIS-TKA have been proposed: limited parapatellar, minimidvastus, minisubvastus, quadriceps sparing (Figs. 1 and 2). Initial worldwide experience with MIS-TKAs has started showing the benefits and potential risks of these procedures. The first series of peer-reviewed published comparative studies favored the MIS procedures compared to standard TKAs in terms of postoperative pain, blood loss, functional recovery considering various rehabilitation milestones, and hospitalization time [6–8] (Boerger et al, unpublished data). Although these benefits are being demonstrated, there is a higher incidence of postoperative complications after TKA is performed through limited approaches in the orthopaedic community due to the increased complexity of performing these operations "through a keyhole."

The reliability of a TKA procedure performed through a mini-incision, and its success, will depend on three basic factors: (1) appropriate patient selection, (2) surgeon experience, and (3) surgical environment. In this article, we describe the indications, technical aspects, and possible complications of MIS-TKA based on our experience gained from a prospective randomized trial of standard vs minisubvastus approach in TKA that we recently completed [9].

Mistakes and complications in MIS-TKA

Classic surgical approaches in knee arthroplasty have been designed to provide wide visibility and safe mobilization of the extensor mechanism, with the goals of reproducible primary fixation, restoration of alignment, optimal range of motion (ROM), and ligament balance. Using a limited

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Fig. 1. MIS-TKA of a right knee performed through a minisubvastus approach with trial components inserted

exposure, the skin, capsular tissues, and perhaps bone surfaces receive higher stresses both in tension and compression because of the retraction required. The use of differential force on retractors to properly “move the window” and the use of modified, less cumbersome instruments, are particularly helpful in minimizing tissue damage. In our experience, we observed a number of complications related to the MIS learning curve, which were considered obsolete in a standard TKA procedure. Surgeons should be aware of the following possible complications/mistakes:

- Femoral condylar fracture. Placement and tension on the lateral retractor must be controlled throughout the procedure. When the knee is brought from extension to flexion and the extensor mechanism with the laterally displaced patella is becoming taut, both the lateral femoral condyle (LFC) and lateral tibial plateau and the patella are at risk of damage or fracture particularly in osteoporotic bone because of compression from the retractor itself. The LFC is likewise at risk during the preparation of the tibia. If the lateral plateau is not exposed enough, the posterolateral corner of the tibial broach impactor, or the corner of the trial component itself, may impinge from upside down on the LFC.
- Patellar tendon disruption. Tension on the extensor mechanism is probably not the main reason to cause this lesion. A common denominator of MIS-TKA, whatever approach is used, is the patella not being everted, but laterally displaced. This places the patellar tendon under more tension with traction forces coaxial to the insertion of the tendon on the tuberosity. Cutting the proximal tibia from the medial side requires tilting of the saw, which may harm the patellar tendon, if not adequately protected, from inside to outside.
- Soft tissue invagination at interfaces. Trial and final components are inserted in the wound often without simultaneous visualization of all the components. Assis-

tants play an important role in taking care of the soft tissues while the surgeon is cementing the components.

- Bone overresections. Referencing only from the medial worn side, in case of varus deformity, may lead to underestimation of the amount of bone that will be removed from the proximal tibia and the distal femur. This leads to the use of a thicker-than-usual polyethylene insert, joint line elevation, and patella baja. Care should be taken regarding bone overresection particularly when the opposite compartment is outstretched.
- Retained cementophytes. They can be source of pain if prodded and in proximity of a collateral ligament. Components’ cementation is a difficult phase of the procedure. It needs coordination between the surgical team, avoiding application of excessive amount of cement, particularly in the posterior and lateral aspect of the joint. Smear technique (application of cement in the doughy phase on the backside of the components) on the components is useful. Insertion of the femoral component starting with a flexed position helps to prevent cement entrapment in the posterior femoral recess. Positioning a thin laminar spreader in the notch with the knee flexed, before inserting the final polyethylene, enables a final check for cement fragments in the back of the knee.
- Radiographic outliers. Although current published studies on MIS-TKA do not show an increased incidence of postoperative component malalignment, there has been an observed tendency toward less-optimal radiographic alignment compared to the standard approach. Surgeons have to take into account the new position of their instruments with respect to the long axis of the bones. Positioning of the tibial component in particular represents a challenge in MIS-TKA. Errors can be committed both in the coronal plane, resulting in limb malalignment, and in the axial plane resulting in malrotations and/or suboptimal medial–lateral positioning (medialization).

Fig. 2. MIS-TKA of a right knee performed through a quadriceps sparing approach

Patient's factors

Previously operated knees

Knees that underwent arthroscopic procedures (e.g., meniscectomy) in the past do not represent a problem when a minimally invasive procedure needs to be performed, nor does it interfere even if meniscectomy is performed with the open technique. The small vertical medial incision can be easily incorporated in the new short anteromedial skin incision. Revision procedures through a limited approach are not recommended, although it is technically possible to convert a unicompartmental to total knee arthroplasty or to perform a partial revision (e.g., patellar resurfacing or isolated polyethylene exchange).

In case of previous incisions, care should be taken to select patients for MIS procedure. They can be suitable if transverse, such as following a closing wedge high tibial osteotomy (HTO). Short anteromedial incision can be incorporated. Short lateral incision can accept a parallel incision if the resultant skin bridge is larger than two-thirds of the first incision. Patients with a long anterolateral incision are usually not suitable for MIS-TKA, unless a minimally invasive lateral approach is adopted (Boerger et al, unpublished data). It is not cautious to embark on MIS procedure in patients with insulin-dependent diabetes mellitus, rheumatoid arthritis, patients under chronic usage of steroids, or the in presence of skin adherence because of the high risks of skin complications.

Extensor mechanism problems

Patella moderately baja (Caton index: 0.8–0.7) does not represent an absolute contraindication to MIS, but it introduces significant technical difficulties throughout the procedure. To laterally dislocate the patella, the tension to be applied to the extensor mechanism is higher when the patellar tendon is short. Patella infera (Caton index: <0.6) should be considered impossible to manage through an MIS approach. Cases with chronically dislocated patella are difficult to successfully address with a short incision, because they usually require an extensive soft tissue work and extensor mechanism mobilization. We discourage the MIS approach in the presence of a previous tibial tubercle transfer procedure because it results in a distortion of the anatomy that is difficult to manage through a limited view.

The extensor mechanism is typically tight after HTO performed using lateral closing wedge techniques and postoperative immobilization. For these cases, the complexity of the deformity may require a standard parapatellar approach. Less-deformed knees after HTO, or those done with opening wedge techniques, do not represent an additional challenge in performing an MIS procedure.

Restricted range of motion

There is no doubt that a stiff knee can be the worst-case scenario in performing an MIS-TKA. The extensive intra-articular adhesions and the quadriceps scarring present in

these cases need to be adequately addressed. Minor to moderate limitation of maximum active flexion is acceptable. It is safe to perform a “gravity test” under anesthesia to verify that the knee can passively bend at least 95° before considering it suitable for MIS. This test is performed, after the anesthesia has been administered, by passively flexing the patient's hip 90° and allowing the weight of the lower leg to flex the knee joint [10]. Fixed flexion contracture up to approximately 15° can be managed without significant additional maneuvers during MIS-TKA. If the extension loss is greater, there is a need for a complete view of the joint to address the deformity.

Severe varus or valgus deformity

Some authors describe limitations of indications for MIS-TKA for coronal deformity greater than 15° [6]. We have not yet encountered cases where the amount of deformity prevented MIS techniques. Varus deformity can be managed in the standard fashion through a short incision. All the required steps of medial release can be performed having access to the medial compartment of the joint. Valgus deformities are relatively easy to correct by using the “pie-crusting” technique with multiple punctures in extension, holding the gap opened with a laminar spreader.

Bone loss

Bone deficiency represents a relative contraindication. If the deficit is not extensive and does not require grafting or implant modularity, it can be also managed through a limited exposure. Moderate to severe bone deficiencies, such as in posttraumatic cases or cases with extensive bone cysts, require a standard exposure to gain adequate implant position and fixation.

Osteoporosis

Good bone quality is an important requirement for minimally invasive surgery. Compression on the bone surfaces by retractors is higher in MIS-TKA compared to the standard procedure. If bone quality is poor, there is an increased risk of intraoperative fractures. In case of preoperative clinical suspicion of osteoporotic bone, it is worthwhile to perform a dual-energy x-ray absorptiometry (DEXA) scan to confirm it.

Synovitis

MIS approaches do not violate the suprapatellar pouch; therefore, in the presence of extensive synovitis it should be considered a standard exposure to access the patellofemoral gutters and the suprapatellar area.

Hypertrophic arthritis

The presence of large osteophytes around the femur and the tibia creates additional tension on the surrounding soft tissue envelope. It is possible to remove osteophytes in each location of the knee even using a minimally invasive

approach. Osteophyte removal should be done early in the procedure in order to create space, to smoothen and define the bone margins and to relieve soft tissue tension.

Obesity

Obesity per se is not a contraindication to MIS. Fat distribution and consistency is more important. Body mass index (BMI) cannot be used in an algorithmic fashion to predict candidates for MIS-TKA [11]. Obese patients with relatively thin lower limbs and elastic tissues can be good candidate for short incisions. Limb length is an additional factor to be considered. A short, fatty lower limb is often not eligible for this technique, even if there are no absolute guidelines in this regard.

Muscular males

Muscular patients, especially men with a prominent vastus medialis, require a longer incision because of the bulk of the quadriceps muscle. A low insertion of the vastus medialis obliquus in the patella reduces the possibility of easily dislocating the patella laterally, particularly if a minisubvastus, or minimidvastus, approach is chosen. This type of patient usually requires a large implant size because of the width of the knee itself. Scuderi et al [11] observed that the wider the femur (as measured by the epicondylar width), the longer is the incision required. It is recommended to template the knee x-rays and to measure the thickness of bone resection before selecting the case for an MIS procedure.

Environmental and surgeon's factors

The operative environment where MIS techniques are performed has a primary role for a successful outcome of these procedures. Knee arthroplasties performed with MIS techniques definitely take longer operation time. Considering that the time required to close the wound is slightly reduced, the overall extra time for an MIS procedure is calculated to be around 30 min on average for a surgeon who has completed the learning curve [6]. The operative environment must guarantee an efficient flow of the surgical steps without interruptions to optimize the surgical time and to avoid any interference with the decision-making process throughout the procedure. Everything in the operative theater should work properly, from the anesthesia to the tourniquet.

The surgical team needs to be well trained on a solid arthroplasty background. Assistants play an important role because exposure is, by definition, suboptimal in MIS techniques. They should understand how to manage retractors to achieve the best "mobile window" for that particular phase. During MIS-TKA, there are no stable position of the limb such as in the standard approach with the knee flexed and the patella everted. Parts of the operation are done in extension. Interactions between the surgeon and the assistants have to be well coordinated for a smooth procedure and to reduce the risk of complications.

The minimally invasive technique for TKA is without any doubt more challenging than the standard procedure, with a longer learning curve. For this reason, teaching centers needing to train young residents are less suitable for this type of surgery. Residents should learn the principles of TKA using standard approaches to see what they do and to be guided and corrected when required.

The ideal surgeon for MIS-TKA is a high-volume arthroplasty surgeon, with extensive experience on standard open TKA. The surgeon should be able to anticipate possible sources of mistakes based on his experience with the standard procedure. It is easy to commit minor mistakes, such as leaving corners of incompletely resected bone or small pieces of cement, without the possibility of seeing them throughout the steps of the operation. The experienced surgeon knows where and how to look in the joint to double-check the work performed. The amount of bone resections and ligaments release should be planned more carefully than usual. The surgeon must be prepared to perform the procedure using less landmarks and without the need to see the joint entirely in each step of the procedure. Moreover, a backup plan with alternative solutions to both implants and surgical equipment must be available in case of complications.

Conclusions

We believe that MIS-TKA is appropriate for most, but not all, knees. Tria [12] estimated that at least 28% of the knees is suitable for minimally invasive TKA using a quadriceps sparing approach. We perform approximately 80% of MIS-TKA with a minisubvastus or a quad sparing approach.

Certainly, this technique is not for every surgeon, but for most dedicated knee surgeons with considerable experience in joint arthroplasty surgery. It is not for every hospital, and requires an efficient organization and a well-trained surgical team with a solid knee arthroplasty background. Those who want to embark on MIS-TKA need to allow ample time to learn and teach.

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