Review Article

Surgical approaches for total knee arthroplasty

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\section*{A B S T R A C T}

There are various surgical approaches to the knee joint and its surrounding structures and such approaches were originally designed to allow the best access to an area of pathology whilst safeguarding the important surrounding structures. Controversy currently surrounds the optimal surgical approach for total knee arthroplasty (TKA). The medial parapatellar approach, or anteromedial approach, has been the most used and has been regarded as the gold standard approach for exposure of the knee joint. It provides extensive exposure and is useful for open anterior cruciate ligament reconstruction, total knee replacement, and exposure of patellar fractures. Because this approach has been implicated in compromising the posterior circulation, some authors have advocated the subvastus, midvastus, and tranvastus approaches for exposure of the knee joint. While these approaches expose the knee from the medial side, the anterolateral approach exposes the knee joint from the lateral side. With careful planning and arthrotomy selection, the anterior aspect of the joint can be adequately exposed for TKA in different clinical scenarios.

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\section*{1. Introduction}

Total knee replacement surgery begins with correct planning of both the division and the exposure of the joint. Indeed, these are factors that are just as crucial to an optimal outcome as choosing the right implant, positioning the components, and balancing the ligaments.

Many knee procedures, nowadays, are routinely performed via arthroscopic or arthroscopic-assisted methods. However, knowledge of open surgical access to the knee remains vital for knee arthroplasty and cases where arthroscopy is not possible or practical. Controversy currently surrounds the optimal surgical approach for total knee arthroplasty (TKA). The best surgical approach in total knee replacement is still to be determined as none of the existing approaches could prove its superiority in previous studies.\textsuperscript{1-3}

First described in 1879 by von Langenbeck,\textsuperscript{1} the medial parapatellar approach on the inner side of the knee found early favor and it is regarded as the gold standard for which other
approaches are compared. Hofmann reported on the quadriceps preserving substavus approach in 1991. A compromise between preserving quadriceps function and good surgical exposure was achieved when Engh reported the midvastus approach in 1997. Others employ a lateral approach on the outside of the knee for TKA. Minimally invasive approaches are a more recent development, which aims to reduce damage to soft tissues.

We have reviewed current literature on most commonly used approaches for TKA. Some of the benefits and disadvantages have been discussed with the view to establish the optimal surgical approach for different clinical scenarios in TKA.

1.1. Anterior skin incisions

The most commonly used skin incision for primary TKA is an anterior midline incision and has been a utilitarian extensile approach to the knee. The incision should be done with the knee in flexion to allow the subcutaneous tissue to fall medially and laterally, which improves exposure and may obviate the need for raising skin flaps. A straight longitudinal incision beginning 6–12 cm proximal to superior pole of the patella, extending over patella midpoint, and ending at the medial border of tibial tuberosity or approximately 6 cm distal to the inferior pole of the patella; some surgeons prefer to vary the incision with a gentle medial curve over the patella, arguing that the curved incision is less likely to scar contract (Fig. 1). The extent of the skin incision should be dictated by the requirements of the surgery. The skin incision is deepened through subcutaneous tissues and the fascia split in line with the skin incision to develop skin flaps as thick as possible just superficial to the subcutaneous fat, to expose the quadriceps tendon, medial and lateral heads of the vastus medialis, and medial border of the patella, and the quadriceps tendon incision reduces degree of skin tension and hence risk of tissue necrosis.

If a preexisting anterior approach to the knee is in a usable position, it should be incorporated with the skin incision. Previous TKA skin incision should be used whenever possible. If multiple previous incisions are present, the most lateral usable incision should be selected if possible because the blood supply to the knee, the site for a new knee tend to come predominantly from the lateral side.

Given the previous medial and lateral incisions and transverse incisions cannot be ignored. The anterior Kocher U incision and inverted U incision have become obsolete primarily because of complications associated with vascular injury to the skin. The anterior transverse incision may be cosmetically pleasing, but it does not allow extensile exposure. Cutaneous blood supply may be tenuous in cases of previous surgery (revision TKA) or poor host (rheumatoid, diabetics, chronic steroid/NSAIDs therapy, obesity, and smoking), and hence, more liberal incisions should be used to avoid necrosis from forceful retraction. Skin is supplied by perforating arteries, which run in the muscular fascia, and so any medial or lateral skin flaps (if needed) should be deep to the fascia to avoid skin necrosis. Old incisions should, as best as possible, be crossed at 90°. Parallel longitudinal incisions are problematic, so maximizing the

Fig. 1 – Skin incision marked on the skin. Circle represents the patella and the straight line the skin incision. Horizontal lines across the vertical line help in achieving accurate closure.

skin bridge of 5–6 cm is recommended. In case of multiple skin incisions, the most lateral should be selected.

2. Medial parapatellar approach

Historically, the medial parapatellar approach has been the standard to which other approaches are compared for TKA. As originally described by von Langenbeck in 1878, the approach followed the medial border of the quadriceps tendon, and left a cuff of tissue on the patella on which to repair the medial joint capsule. A standard longitudinal midline skin incision is done as previously described. The parapatellar retinacular incision is extended proximally along the length of the quadriceps tendon, leaving a 3- to 4-mm cuff of tendon on the vastus medialis for later closure (Fig. 2). The incision is continued around the medial side of the patella, extending 3–4 cm on to the antero-medial surface of the tibia along the medial border of the patellar tendon. Medial side of the knee is exposed by subperiosteally elevating the anteromedial capsule and deep
of the knee. Injury to this nerve can lead to postoperative neuroma. If inadvertently cut during surgery, resect and bury end to decrease chance of painful neuroma.

3. Insall’s modification to medial parapatellar approach

Insall reported a modification to the medial parapatellar approach, as described by Sir Robert Jones, to avoid dissection through the patellar articular surface. The extensor mechanism is exposed through a midline skin incision, as previously described; the quadriceps tendon is divided 3 cm above the patella. The quadriceps tendon is incised at the junction of the middle third and lateral one third of the patella and the quadriceps expansion is peeled from the middle third of the articular surface of the patella. Sharp dissection along the medial border of the patella is performed and the dissection is followed along the medial border of the patella leaving no cuff of tissue to make a repair (Fig. 3). The synovium is divided, and the fat pad is split along the midline and the patella is then dislocated laterally. The patellar retinaculum is then sutured back to the remaining soft tissue attachment to the lateral 2/3rd of the patella.

We routinely use this approach for performing exposure for simple traumatic patellar fractures. We also use the “three stitch test” for checking for patellar maltracking. At the time of closure of the extensor apparatus, 3 stitches are applied between the medial retinaculum and the patella and the knee is flexed to 90°. If all stitches hold on flexion, there is no maltracking of the patella and the remaining closure can be performed as per the

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Fig. 2 – Clinical image depicting the incision for medial parapatellar approach.

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Fig. 3 – Modified Insall’s approach. Electrocautery being used to elevate the extensor apparatus from the patella.
routine protocol. If even one of the stitches gives way, then there is apparent maltracking of the patella needs to be addressed.\textsuperscript{10}

The infrapatellar branch of the saphenous nerve is again at risk and should be protected. Advantage of this exposure is that it allows excellent exposures to the knee joint. However, reports of patellar dislocation, subluxation, stress fractures, and fragmentation of the patella secondary to avascular necrosis have been attributed to the approach.\textsuperscript{11,12}

4. **Subvastus approach**

Problems with the medial parapatellar approach motivated the search for more “anatomical” approaches. Hofman in 1991 popularized the subvastus approach for TKA, which first appeared in the German literature in 1929.\textsuperscript{13}

The ideal patient for this subvastus approach is a thin patient with mobile soft tissue. Patients with previous scars, obesity, undergoing revision TKRs, and severe deformities are relative contraindications for this approach.

This approach uses a straight midline skin incision that is extended above and below the patella. After development of a medial subcutaneous flap, the lower border of the vastus medialis is visualized. Because the vastus medialis inserts into the superior medial corner of the patella, the fascial sheath along the inferior border of the vastus medialis is incised from the patella down to the medial intermuscular septum. It is suggested that two stay sutures be applied at the apex of the patella and the dissection carried out in-between the sutures. These sutures can later be used as landmarks for anatomic resuturing of the tissues. It follows a transverse incision at the midpatella level through the medial retinaculum, inferior to the vastus medialis. The medial aspect of the vastus medialis is bluntly dissected from the medial intermuscular septum approximately 10 cm proximal to the adductor canal. This incision separates the vastus medialis from the medial intermuscular septum staying distal to the aperture for femoral vessels. The arthrotyom then continues distally along the medial margin of the patella, with the medial retinaculum incised along the medial border of the patellar tendon and down onto the tibia; the extent of the exposure is dictated by the requirements of the surgery (Fig. 4).

Care should be taken at this point to avoid injury to the neurovascular contents of Hunter’s canal. To exposure to the joint, the capsule of the suprapatellar pouch is incised to release the patella, which is everted as it is located medially as the knee is flexed. The subvastus approach, which allows direct access to the anterior knee joint, has been described as being more anatomic than the medial parapatellar arthrotomy.

The subvastus approach uses the tensor mechanism and the majority of medial structures, thereby keeping the patella intact and studies suggest similar surgical advantages over other approaches. Patients exhibit earlier knee range of motion, reduced blood loss, lower extensor mechanism stress, and better knee flexion earlier in the postoperative process.\textsuperscript{14} When compared with the medial parapatellar approach, patellar tracking was significantly improved in the subvastus group\textsuperscript{14} while hamstring to quadriceps ratio reached normal levels sooner.\textsuperscript{16}

Advantages to this approach are offset by increased difficulty with exposure and greater difficulty evertting the patella which explains why this is not a popularized technique. The subvastus approach is applicable to most reconstructive procedures of the knee, with the exception of compartmental knee replacement arthroplasty.

5. **Midvastus approach**

Difficulties with exposure using the subvastus approach prompted surgeons to develop a compromise, the midvastus approach, which is a muscle splitting approach first described

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Fig. 4 – (a) Front view of the knee showing the dissection for subvastus approach. (b) Side view of the knee showing the plane along which the vastus medialis is elevated off the medial intermuscular septum.
The midvastus muscle-splitting approach is performed through a standard anterior midline skin incision. The midvastus muscle is split by blunt dissection, and the quadriceps musculature is exposed. The vastus medialis is identified and split full thickness, parallel to its muscle fibers by blunt dissection. The quadriceps tendon is not incised. The incision is extended to the superior medial corner of the patella and then continued distally along the medial patella and patellar tendon to the level of the patellar tubercle or as dictated by the requirement of the surgery. In the subvastus approach, the capsule of the suprapatellar pouch is divided so that the patella can be everted and displaced laterally.

Conflicting results have marked the development of the technique, as functional outcomes have been shown to be superior in the long term. Parentis et al. showed no differences in range of motion, straight leg raise, and requirement for lateral releases in a series of 100 patients. The authors did not recommend the approach as being superior to the medial parapatellar approach, but found blood loss and fewer intraoperative lateral releases to be reported. There have been equivocal opinions regarding the use of midvastus approach in patients with less difficulty. Advocates of this approach believe that it is easier to evert the patella with the midvastus approach than with the subvastus approach because of the more direct line of approach to the vastus medialis. In addition, this approach splits the muscle well away from its neurovascular supply.

6. Trivector-retaining approach

The origin of the term trivector retaining approach is interesting. Using vector analysis, the vectors acting on the patella can be divided into medial, lateral, and superior vectors. The incision guides the magnitude and resultant direction of the pull on the patella. It is believed that by using the trivector approach, a significant part of the medial vector is retained and there is possibility of earlier recovery of quadriceps function. The trivector-retaining arthroscopy is a muscle cutting approach. The quadriceps musculature is exposed through an anterior midline skin incision. The vastus medialis obliquus muscle fibers are transected 1.5–2 cm medial to the quadriceps tendon. Because the quadriceps tendon is not incised with this approach, the incision is extended distally 1 cm medial to the patella and the patellar tendon to the level of the tibial tubercle. It is recommended that this approach be performed with the knee flexed 90–110°, so that the quadriceps musculature is under maximal tension and thinned out as much as possible during the incision. To evert the patella and dislocate it laterally, the capsule of the suprapatellar pouch must be divided. This approach compromises some of the medial vessels supplying the patella and has been associated with increased blood loss, increased consumption of osteotomy, and disruption of the quadriceps mechanism.

7. Lateral approach

The lateral approach, first published in 1982 and further developed by Keblisch et al. in 1991, involves releasing the lateral soft tissues to access the joint from the lateral side of the patellar tendon. It is considered more technically demanding and as such it is used principally for TKA in valgus knees where use of the standard medial parapatellar approach can exacerbate patellar maltracking. The contracted lateral soft tissues can be approached directly while preserving the medial patellar blood supply. In performing this approach, a curvilinear midline skin incision or a laterally placed anterior skin incision is made.
and extended distally over the lateral border of the tibial tubercle. The joint is entered through a latero-parapatellar retinacular incision that extends from the lateral border of the quadriceps tendon, over the patellar defect, and continues distally into the anterior compartment fascia. 1.5 cm from the tibial tubercle, and for a distance from 3 cm from the tibial tubercle (Fig. 7). A portion of the lateral condylar hinge is maintained along with the infrapatellar fat pad, which is used for later closure of the lateral retinacular incision. The lateral parapatellar approach is the classic “Y” for fixed valgus deformities that are fixed or associated with flexion contractures or external tibial rotation. Medial varus deformity represents the lateral retinacular incision.

8. Techniques for exposure of difficult TKA

Operative exposure for revision TKA, bony or fibrous ankylosis preceding previous surgeries, trauma, or infection around the knee pose a challenge to surgeons and require special consideration during exposure. A standard medial parapatellar approach is used in most revisions; however, the scarred capsule may need to be thinned, especially in reimplantation for infection. Scarring of the peripatellar fat pad and adjacent retinaculum may make patellar eversion difficult. Recreation of the medial and lateral gutters, subperiosteal release of the medial soft tissues from the proximal tibia, external rotation of the tibia, and lateral retinacular release often are required to allow eversion without placing excessive stress on the insertion of the patellar tendon. Avulsion of the patellar tendon from the tibial tubercle can compromise knee function drastically and must be avoided. During eversion of the patella and flexion of the knee, the insertion of the patellar tendon should be directly observed. If the medial fibers of the insertion begin to peel away from the tibial tubercle, tension should be released, and a more extensive, parapatellar skin incision exposure should be considered.

8.1. Modified V-Y plasty

The modified V-Y quadriceps tendon snip procedure described by Scott and Siliski26 consists of a midlateral parapatellar retinacular incision with an inverted V extending as an inverted V across the quadriceps tendon through the lateral patellar retinaculum to the superior geniculate artery, which runs parallel to the border of the vastus lateralis, is identified and preserved as possible. Excessive thinning of the scarred patellar fat pad should be avoided to prevent further development of the patellar. During closure of the quadriceps tendon down, the inverted V can be converted to a Y by allowing the patellar tendon and attached quadriceps tendon to be advanced distally. This is useful in obtaining flexion in knees with the lateral retinacular contractures from long-standing lack of motion.

Closure must be secured with nonabsorbable sutures to maintain passive motion within a “safe” range determined at the time of surgery to avoid excessive stress on the repair. Intraoperatively, a useful guide is to perform the repair so that gravity alone produces 90° of knee flexion. Studies by Windsor and Insall29 and Trousdale et al.30 have shown postoperative extension lag that tends to resolve over several months as quadriceps strength return to near-normal levels. Radiographic changes consistent with osteonecrosis of the patella were documented by Smith et al.31 in eight of the 29 revision total knee exposures using a quadriceps turndown, although clinical symptoms were absent.

8.2. Rectus snip

The rectus “snip” as a modification of the quadriceps turndown procedure was described by Insall.32 The proximal extent of a medial parapatellar arthroplasty is extended laterally across the quadriceps tendon to incise the rectus tendon and the underlying tendinous insertion of the vastus muscles. The lateral attachment from the vastus lateralis is left intact along with the superior lateral geniculate vessels; a lateral release can be added distally. Meek et al.33 reported no differences in outcome between patients treated with a rectus snip and patients treated with a standard medial parapatellar approach.

8.3. Tibial tubercle osteotomy

Tibial tubercle osteotomy was originally reported by Dolin34 and modified by Whiteside and Ohl35 for quadriceps relaxation during primary or revision TKA. Whiteside and Ohl recommended elevation of an 8- to 10-cm segment of the bone that
includes the tibial tubercle and a portion of the anterior crest of the tibia, leaving the anterior compartment musculature attached to the fragment laterally for vascularity. The tubercle can be advanced proximally for patella baja or if the joint line is elevated significantly. They described reattaching the tubercle with multiple wires; other authors have advocated using screws. It is advisable to predrill the tibial tubercle before the osteotomy is done, if no proximal migration of the tubercle is contemplated. With secure fixation, passive range of motion can begin early, but active extension still must be delayed. Complications, including nonunion or proximal migration of the osteotomized fragment, tibial shaft fracture, wound infection, wound necrosis, and prominent hardware, have been reported with this technique.

Barrack et al.36 compared the standard medial arthroscopy, rectus snip, V-Y quadricepsplasty, and tibial tubercle osteotomy in revision TKA. The outcomes with the standard approach and rectus snip were identical in all clinical parameters. V-Y quadricepsplasty resulted in greater extensor lag, but increased patient satisfaction compared with tibial tubercle osteotomy, which resulted in more difficulty with kneeling and stooping. The quadricepsplasty and osteotomy groups had significantly lower outcome ratings compared with the standard arthroscopy and rectus snip.

9. Modifications for minimal invasive TKA

The concept of mini-invasive prosthetic surgery was introduced in the late 1990s by Repicci,37 and it was based on the principles of a small incision (3 in.) and maintenance of the extensor mechanism on the basis of a unicompartmental prosthesis. Since then, many other authors have felt it necessary to extend this concept to total knee and hip replacement.38–40

Rosenberg et al.41 maintained that skin flaps does not define MIS per se; but the incise length should not exceed 10 cm. DiGioia et al.42 and variations should be between 8 and 10 cm.

The aim of minimally invasive TKA is the preservation of soft tissues and consequently quadriceps function and knee stability. Incision is shorter than that used for other approaches. An important feature in the TKA is the retraction rather than elevation of the patella. Patient selection

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### Table 1 – Comparative table depicting the advantages and disadvantages of all approaches to the knee for arthroplasty.

<table>
<thead>
<tr>
<th>Surgical approach</th>
<th>Pros</th>
<th>Cons</th>
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<tr>
<td>Medial parapatella</td>
<td>• Excellent exposures to the knee joint</td>
<td>• Patellar dislocation, subluxation, stress fractures</td>
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<td></td>
<td>• Extensible</td>
<td>• Fragmentation of the patella secondary to avascular necrosis</td>
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<td>• Relatively easy to safely execute</td>
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<td></td>
<td>• Ideal for patients with previous scars, and those undergoing</td>
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<td>revision TKRs, and revision TKAs</td>
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<tr>
<td>Subvastus approach</td>
<td>• More &quot;anatomical&quot; approach</td>
<td>• Difficulty with exposure and greater difficulty evertig the patella</td>
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<td></td>
<td>• Extensor mechanism maintained</td>
<td>• Risk of neurovascular damage in 'Hunters canal'</td>
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<td></td>
<td>• Reduced blood loss and operative consumption</td>
<td>• Ideal mainly for thin patient with mobile soft tissue</td>
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<td></td>
<td>• Patients can undergo earlier knee raise, better knee flexion,</td>
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<td></td>
<td>and early recovery process</td>
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<td></td>
<td>• Compartment with medial parapatellar approach patellar tissue</td>
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<td>was significantly improved in the subvastus group</td>
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<td>• Muscular tension ratio reached normal levels sooner</td>
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<td>Midvastus approach</td>
<td>• Less difficulty with exposure and evertiging the patella than</td>
<td>• Electromyographic abnormalities in vastus medialis</td>
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<td></td>
<td>with the subvastus approach</td>
<td>• No differences in range of motion, straight leg raise, requirement</td>
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<td>• Less blood loss and fewer intraoperative lateral releases</td>
<td>for lateral releases, and functional outcome compared to medial parapatella</td>
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<td>• Compared to medial parapatella</td>
<td>• Compromises some of the medial vessels</td>
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<td>Trivastus approach</td>
<td>• Ability to minimize the loss of quadriceps function</td>
<td>• Increased blood loss</td>
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<td>• Increased consumption of opiate</td>
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<td>• Disruption of the quadriceps mechanism</td>
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<td>• More technically demanding</td>
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<td>• Fixed varus deformity is a relative contraindication</td>
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<tr>
<td>Lateral approach</td>
<td>• Contracted lateral soft tissues can be approached directly</td>
<td>• Obesity and poor bone stock are relative contraindications.</td>
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<td>while preserving the medullary patellar blood supply</td>
<td>• Development still in evolution (surgical precision,</td>
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<td>• Considered for fixed varus deformities that are isolated or</td>
<td>long-term functional outcome unclear)</td>
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<td></td>
<td>combined with flexion contracture or external tibial rotation</td>
<td>• Steep learning curve</td>
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<td></td>
<td>• Lower incidence of patellar maltracking</td>
<td>• Cost implications (Expensive)</td>
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<tr>
<td>Minimal invasive</td>
<td>• Smaller incision with less esthetic impact</td>
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<td>total knee arthroplasty</td>
<td>• Less soft tissue violation (capsule, tendon, and muscle</td>
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<td>structures) and faster postoperative recovery</td>
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<td></td>
<td>• Retraction rather than elevation of the patella</td>
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<td>• Reduced intraoperative blood loss</td>
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<td>• Shorter hospital stays</td>
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<td>• Intact quadriceps function and knee stability.</td>
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<td>• Greater patient satisfaction</td>
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is an important consideration for this approach with weight and poor bone stock being relative contraindications.

The theoretical principles of less invasive surgery are sound, and certainly desirable. A smaller incision with less esthetic impact, greater patient satisfaction, greater respect for the capsule, tendon and muscle structures, faster postoperative recovery, reduced intraoperative blood loss, shorter hospital stays, increased range of motion at 6 weeks follow-up whilst achieving similar implant positioning are undoubtedly parameters of interest to all orthopedic surgeons, but it remains to be demonstrated that these objectives can be achieved by going down the MIS route. Ultimately, a “less invasive” approach based on maximum safeguarding of the anatomical structures through reduction of surgical exposure (in accordance with the surgeon’s skill and experience) is desirable, but only if it is not at the expense of the surgical precision that is crucial for a good long-term outcome.

10. Conclusion

Critical to surgical exposure of the knee is a complete understanding of the local anatomy. With such knowledge, the pathological condition and planned surgery can be correlated. Although the medial parapatellar arthroscopy or anteromedial approach has been the most used and has been regarded as the standard approach of exposure of the knee joint, the choice of surgical approach for TKA should be dictated by the presenting clinical scenario, as well as the training and experience of the surgeon (Table 1). With careful planning and arthroscopy selection, the anterior aspect of the joint can be adequately exposed for TKA.

Conflicts of interest

The authors have none to declare.

REFERENCES