Review Article

Minimally invasive versus conventional approaches in total knee replacement/arthroplasty: A review of the literature

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ABSTRACT

Background: Life expectancy lengthening and aging of population resulted in dramatically increase of patients with osteoarthritis. Total knee arthroplasty is widely used as the gold standard in order to relieve pain, correct deformity and restore function. A contemporary and controversial topic, is that of minimally invasive surgery for TKA. The minimally invasive approaches are based on the concept that they don't violate the extensor mechanism, resulting in earlier functional recovery, shorter hospital stay and enhanced patients' overall satisfaction. The most commonly used MIS approaches in TKA are the subvastus, midvastus and the quadriceps sparing. There is a debate regarding the efficacy and safety of these methods.

Objective: In this article we will review the current literature (randomized controlled trials and systematic reviews/meta-analyses) on MIS compared to traditional approach and analyse their clinical safety, efficacy and long-term results.

Design: Comparison of well-designed studies have tried to demonstrate the advantages/disadvantages, the clinical results and the complications of the MIS approaches compared to the MPP approach.

Results: MIS approaches seem to provide advantages in the immediate post-operative period accompanied by increased reports of complications. Consequently, further investigation based on large well-designed studies with long-term results are warranted to further clarify MIS effectiveness/safety.

1. Introduction

Life expectancy lengthening and aging of population resulted in dramatically increase of patients with osteoarthritis (OA); total knee arthroplasty (TKA) is the optimal surgical method for patients who suffer from severe OA.¹ TKA is widely used as the gold standard in order to relieve pain, correct deformity and restore function; the number of primary TKA is expected to have a significant increase the following years.^{2,3}

The evolution of modern TKA has taken place in the last 30 years with improved functional outcomes and prolong implant life-span being the main goals. Nevertheless, the first description of knee joint function improvement dates back to the 19th century. In 1863, Verneuil et al. tried to prevent the bone growth between the articular surfaces by interposing soft tissue between bone ends to prevent ankylosis.⁴ Since then, many different methods, implants have been used. Simultaneously, patients' expectations and demands have also increased.

Therefore, as surgical experience with TKA increases, new operative techniques, different pain and blood loss management protocols have been tested/established to improve functional recovery and clinical outcomes.^{5–7} A contemporary and controversial topic, among others, is that of minimally invasive surgery (MIS) for TKA.

Von Langenbeck firstly described the medial parapatellar (MPP) approach in 1879 in his book entitled “*Zur resection des kniegellenks*”.⁸ Over the past decades, the “traditional” MPP approach has proven to be a successful standard.⁹ However, the associated anterior knee pain combined with the poor functional recovery indicated concerns in regards to patients' satisfaction.^{10–12} Thus, many MIS approaches have been described. The MIS approaches are based on the concept that they don't violate the extensor mechanism and as a result they reduce postoperative pain and facilitate the body's healing, resulting in earlier functional recovery, shorter hospital stay and enhanced patients' overall satisfaction.^{13–15}

The most commonly used MIS approaches in TKA are the subvastus

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(SV), midvastus (MV) and quadriceps sparing (QDS).^{16–18} SV and QDS can be described as more “anatomic” techniques as they fully preserve the extensor mechanism and minimizes vascular damages to the knee compared to the traditional MPP approach. The limited view/access in the surgical field and the increased operative difficulty level limits their popularity.^{19–21} On the contrary, MV which minimizes vascular and muscular damages as well, offers a better exposure of the knee. Therefore, MV proved to be the most popular MIS approach in TKA.²² There is, however, a debate (with no obvious winner till now) regarding the efficacy and safety of these methods. Post-operative complications including longer tourniquet time, poor implant positioning and early implant failure have been reported in many studies.^{23–25}

Currently, many well-designed studies have tried to demonstrate the advantages/disadvantages, the clinical results and the complications of the MIS approaches compared to the MPP approach.^{26–29} In this article we will review the current literature (based on randomized controlled trials (RCTs), systematic reviews and meta-analyses) on MIS compared to traditional approach and analyse their clinical safety, efficacy and long-term results.

2. Search strategy

Although our article is not a systematic review/meta-analysis we considered that it's really crucial to mention our search strategy. Two of the authors (TT and GD) independently run a systematic literature search using the following electronic databases: PubMed MEDLINE/OVID MEDLINE (1950 – August 2017) and EMBASE (1974 – August 2017). The terms used in our search were #1. “total knee arthroplasty” OR “total knee replacement” AND #2. “subvastus” OR “mini-subvastus” OR “midvastus” OR “mini-midvastus” OR “quadriceps sparing” OR “quadriceps-sparing” OR “minimal invasive” OR “minimally invasive”. Additionally, the references lists of all included studies were also searched. Studies that dealt with computer navigation-assisted TKA and articles that couldn't be fully viewed and/or were not written in English were excluded.

To improve the level of evidence we only included published RCTs, systematic reviews/meta-analysis. The only exception was a well-designed retrospective study, as its results were really noteworthy. In regards to the primary and secondary outcomes we didn't apply any restrictions as we didn't conducted a systematic review/meta-analyses. Therefore we investigated any outcome that was extracted by each of the included studies. Nevertheless, most of the studies assessed similar primary and secondary outcomes including knee society score (KSS), range of motion (ROM), time to straight leg raise (SLR), visual analogue scale (VAS) pain, length of stay (LOS) and complications rates among others.

3. Surgical approaches

3.1. Cutaneous/skin incision

All approaches in TKA follow, in the majority, the same standard cutaneous incision. The epidermis' blood supply is nourished from the dermis and consequently is the organ most at risk of necrosis. Therefore, it's really crucial to respect its anatomy. Two main rules should be taken into consideration: i) cutaneous incision as far as the tendon fascia should be vertical in order to avoid devascularization of the skin flap ii) since the anterior knee skin vascularization arises, in the majority, from the medial genicular arteries, we should bear in mind that the lateral flap is the one most in danger.³⁰ The anterior midline is the most widely used incision but medial or lateral parapatellar incision have also been reported (Fig. 1).³¹ All the incisions are running from a point located 2–3 cm proximal to the top of the patella to the anterior tibial tuberosity/tubercle (TT).³² Johnson et al. outlined that the medial parapatellar skin incision found to be subjected to significantly less tension during flexion. As a result, it can be expected to heal faster and

Fig. 1. Knee Skin Incisions.

be less likely disrupted during early mobilisation.³¹ On the contrary, Laffosse et al. report that the anterolateral incision is associated with fewer sensory disturbances compared with the midline skin incision.³³ To summarize, any of these skin incisions offer excellent exposure of the knee's extensor mechanism in order to continue with arthroscopy.

3.2. The “traditional” MPP arthroscopy

The most-widely used arthroscopy is the MPP incision. The patient's knee should be flexed in order to have better visualization of knee anatomy. Next, the surgeon begins cutting the quadriceps tendon in longitudinal plane up to a point 1 cm from the vastus medialis oblique (VMO), leaving a 3–4 mm cuff of tendon on the vastus medialis for later closure. The incision is continued around the medial side of the patella by cutting the medial patellofemoral ligament and medial capsule until it reaches the medial border of the patellar tendon and anterior TT (Fig. 2). After the deep medial collateral ligament's release, with the patient's knee extended, the fat pad is recognised and been removed. The patella is been everted/subluxated laterally and the knee is been positioned in flexion.³⁴ Extra care should be taken to minimize tension on the extensor mechanism. In order to achieve better exposure a bent Hohmann retractor can be placed on the lateral side of the tibial plateau. At this point flexion of the knee at 90° provides excellent exposure of the entire joint so the appropriate procedure (TKA, unicompartmental knee replacement etc.) can be performed.

Fig. 2. Surgical approaches in TKA.

Knee's closure after TKA is routinely accomplished with the use of synthetic absorbable and/or non-absorbable sutures in an interrupted and/or continuous pattern. First sutures should be placed in an oblique fashion in to minimize the patella baja incidence.³⁵ Subsequent suturing of the subcutaneous tissues can be placed in one or more layers. Approximating skin can be done in many different ways depending on surgeon's preferences.³⁶ It's really important to mention that in "difficult" knees, quadriceps snip can be added to the MPP arthrotomy to achieve adequate exposure.³⁷

3.3. The subvastus arthrotomy

The first known mention of SV arthrotomy in literature appears to have been made by Erkes in 1929.³⁸ It was later described and established by Hoffman et al. in 1991.¹⁴ This approach, is considered more anatomic compared to MPP, as there is no incision in the quadriceps musculature. This means minimum damage to the extension mechanism and consequent faster rehabilitation.³⁹

The cutaneous incision is being made directly midline or slightly medial. The starting point for the skin incision is 2–3 cm proximal to superior pole of the patella and the ending point is the TT. The average length is approximately 8–10 cm. The full-thickness medial subcutaneous flap is dissected, elevated carefully and the VMO (medial and distal border) can be easily identified. The capsule incision starts just distal to the VMO in oblique plane and extends laterally to the medial border of the patella (Fig. 2). Attention should be exercised to leave a part of the tissue attached to the medial border of the patella for later closure. The incision is carried distally (in a L-shape pattern), parallel to the medial aspect of the patella, patellar tendon and down onto the TT.⁴⁰ After the placement of a curved Homan retractor into the lateral parapatellar gutter the knee is flexed with the patella retracted to the lateral side. Satisfied exposure should be obtained in order to complete the desired procedure. Wound closure is been achieved through the same way as in MPP approach. It's really crucial to mention that performing TKA with MIS approach requires the appropriate instrumentation for this kind of surgery. Most instruments have been modified to fit comfortably in a smaller incision and contribute to proper positioning of the components.⁴¹

3.4. The midvastus arthrotomy

Six years after the development of Hoffman's SV approach, in 1997, Engh et al. described for the first time the MV muscle-splitting approach for TKA with excellent exposure in all knees. In his RCT many different parameters such as ROM, quadriceps strength deficit, tibial-femoral angle, blood loss and complications) were studied and compared to the MPP approach. That was the first study concluding that the MV approach is an efficacious alternative method to the MPP in TKA.⁴²

The extensor mechanism in MV approach is exposed through an anterior midline skin incision. The VMO is recognised and with the knee flexed the muscle's fibers direction are identified. The proximal

part of the arthrotomy is carried out with deep incision, around 2–4 cm in length, of VMO muscle and ends to the superior pole of the patella (Fig. 2). It's worthwhile to mention that the incision should be made in a direction parallel to VMO muscle's fibers direction to avoid its further damage. The incision is extended across the medial border of the patella and continued distally along the medial aspect of the patellar tendon to the TT. The patella is everted and dislocated laterally to obtain exposure of the knee joint. Capsule, subcutaneous and skin closure is been accomplished in a similar way as in MPP approach. MV has gained ground in MIS TKA as it doesn't require "special" instrumentation. In summary, through MV approach the majority of the VMO muscle is preserved with no damage to the quadriceps tendon but incision can't be extended in more difficult cases.⁴³

3.5. The quadriceps sparing arthrotomy

QDS approach was firstly introduced in 2003 by Tria in his attempt to find a less invasive approach, compared to MPP, to accomplish unicondylar knee arthroplasty. His results were really encouraging in regards to the MIS in TKA.¹³ Later, many studies have proved its safety and efficacy.^{44–46} On the contrary, studies reported no significant difference in clinical results (compared to MPP approach) and worse radiological outcomes.^{18, 47, 48}

Skin incision begins with a curved medial incision from the superior pole of the patella and ends just below the tibiofemoral joint line (Fig. 2). A midline skin incision can be alternatively used; in cases of valgus knee anterolateral skin incision is an option too. Patella is resurfaced and dislocated laterally but not inverted. Special modified instruments are used to complete the TKA and subcutaneous/skin closure is achieved in a traditional/MPP-like way.¹³ The advantage of this approach is that in "difficult" knees can be extended and converted either in MPP or midvastus/subvastus.

4. Results

4.1. Midvastus vs medial parapatellar

In 2000, Maestro et al. in their RCT reported a series of advantages that the MV approach offers including better ROM and faster recovery in the immediate postoperative period.⁴⁹ Haas et al. reported similar results in their comparative study. ROM at 6-week, 12-week and 1-year postoperatively was better in the minimally invasive group. KSS was also higher in the MV group compared to the standard technique with no difference in x-ray alignment and complication rate.⁵⁰ Functional and radiological outcomes after TKA were investigated by Juosponis et al. and Dabboussi et al. in their RCTs. Higher KSS up to 12-week postoperatively with no difference in radiological component position, compared to MPP group, were reported in the MV group.^{32, 51} In 2009 Mukherjee et al. conducted a RCT in order to compare the LOS and the time to SLR between the MV and the MPP approach. Although there was no difference in LOS, a significant difference in regards to SLR was

reported, as the MV patients needed half of the time (2 days) compared to the conventional method (4 days).⁵² Moreover, Hernandez-Vaquero et al. stated the advantages of the VM approach for the immediate post-operative period, including shorter LOS and reduced amount of pain-killers. Nevertheless, the 6-month results were similar in the two groups both in functional assessment and quality of life (QOL) too.⁵³

In 2014 Nutton et al. conducted a RCT aiming to investigate whether the MV approach resulted in improved recovery of function compared to MPP approach. This was the first study that examined the knee kinematics between the two groups. Earlier achievement of mobility milestones including SLR and independent stair climbing were noticed in the MV group.⁵⁴ Furthermore, Karachalios et al. reported better functional outcome in MV group with statistically significant differences in all measured scores. However, authors pointed out that MV approach should be used in selected patients, as technical errors were identified in 12% of the MV's patients on radiological follow-up.⁵⁵ Two more RCTs were conducted in order to answer the question that has been raised as to whether VMO's splitting causes damage to muscle's innervation.^{56, 57}

On the contrary, a recent RCT by Verburg et al. with a 5-year follow up reported no relevant clinical, functional and radiographic differences between the MV and the MPP approach for TKA in the short- and mid-term follow up period. The authors concluded that the only advantage of MV's approach is the cosmetic result and they suggested that it should be avoided in obese patients because of the increased intraoperative/postoperative complications.⁵⁸ Likewise, similar results were derived from Nestor's et al. RCT with no major differences in all measured tests.⁵⁹ In regards to muscle damage in MIS TKA Huang et al. reported increased serum creatinine kinase (CPK) levels in MV group compared to MPP approach. The assumption that MV approach should cause less muscle damage has been violated; consequently the authors concluded that there is no superiority of the MV's approach over the MPP in terms of sparing muscle.⁶⁰

In addition, two recent well-designed systematic reviews and meta-analyses that included 18 RCTs (937 patients with 1093 TKAs) and 32 RCTs (2451 TKAs in 2129 patients) respectively, analysed the clinical efficacy of the MV versus MPP approach in TKA. Both of them suggested that the MV approach significantly improved knee ROM and decreased VAS at the immediate post-operative period (1–2 weeks) with no statistical differences in the late post-operative period (6 weeks to 6 months). Furthermore, these studies revealed no significant difference in terms of blood loss, SLR, LOS and post-operative complications between the two approaches.^{29, 61}

Taking into account the systemic reviews, meta-analyses and most of the RCTs we can conclude that MV approach has the benefit of faster rehabilitation in the early post-operative period without undermining the success of the well-documented conventional TKA. However, we should bear in mind that the incision should be as large as necessary in order to ensure the correct positioning of the components.

4.2. Subvastus vs medial parapatellar

SV approach has been first-described in 1991 by Hoffman. In his article Hoffman highlighted the importance of the extensor's mechanism preservation during this approach in TKA.¹⁴ Since then many studies have dealt with investigating the clinical and radiological outcomes of SV versus the MPP approach. Two years later Faure et al. run a prospective randomized study on twenty patients undergoing one-stage bilateral knee replacement. One knee was exposed with SV and the other knee with MPP arthrotomy. No difference was found at any period in regards to the ROM, but a significantly greater strength at SV group only in the early post-operative period (1-week and 1-month).⁶² An additional RCT, originated from UK, revealed faster SLR, reduced analgesic consumption, less blood loss and greater ROM in the SV group. The authors recommended the wider use of this MIS approach in TKA.⁶³ Weinhardt et al. in their RCT evaluated the clinical and

radiographic results in the immediate post-operative period (until patients' discharge). They reported better ROM in SV group, but no difference in terms of pain, operation time, blood loss and complication rates. It's crucial to mention that on the discharge day the ROM on both groups was similar.¹⁹

Boerger et al. and Pan et al. conducted two prospective comparative studies in 120 and 68 patients respectively in order to investigate whether SV approach offers adequate access to the surgeon without exceeding operating time and maintaining correct implant placement. Although the SV approach resulted in earlier flexion and SLR, the authors concluded that SV approach was technically more challenging and thus patients' selection should be considered.^{23, 64} Sastre et al. reported better ROM and greater quadriceps strength at discharge day, 1-month and 3-months intervals. These differences faded out at the 12 month evaluation. Nevertheless, authors strongly suggest the SV arthrotomy in the majority of TKA.⁶⁵ One additional RCT by Varela-Egocheago et al. reported greater ROM and superior KSS in the minimally invasive group with no difference in surgical time, component orientation and complication rates. It is remarkable that the SV approach resulted in greater perioperative bleeding but no concomitant transfusion increase.⁶⁶ In 2013, Jain et al. conducted a RCT in 100 patients undergoing TKA. They measured time to SLR, ability to climb stairs, ROM, ability to stand with walker only at day 0,1,3 and at discharge. Results advocated less pain, faster mobilization and concomitant faster rehabilitation in the SV group.⁶⁷

In contrast to the previous studies Van Hemert et al. in their prospective RCT measured Western Ontario and McMaster Universities Index of Osteoarthritis (WOMAC), VAS for pain, pain disability index (PDI) and the Dynaport knee test at day 1, day 3, 1 week, 6 weeks and 3 months postoperatively and concluded in no significant difference between the two groups.⁶⁸ Similar results are described in Burke's et al. RCT in which 90 patients have been investigated with a follow up of 18 months. Numerous primary outcomes have been assessed including KSS, time to SLR, "up and go" test, LOS and operation duration. The study didn't manage to prove any superiority of the SV approach to the MPP approach.⁶⁹

The assumption that SV approach offers functional advantages over the MPP approach to the knee was confirmed by Teng's et al. systematic review and meta-analysis. Nine RCTs (940 primary TKA) were included in this study with follow-up from 13 days to 36 months. This meta-analysis revealed better KSS and less lateral retinacular release in the SV group but no statistical significance in terms of ROM, LOS, operative time, blood loss and post-operative complications between the two approaches.⁷⁰

In conclusion, SV approach in TKA has advantages in terms of VAS, KSS and ROM in the short-term post-operative period (2–4 weeks) with no further statistical differences in the long-term post-operative period (> 3 months). However, further well-designed RCTs and systematic reviews/meta analyses are needed to compare the clinical, radiological and safety effect of these approaches in TKA.

4.3. Quadriceps sparing vs medial parapatellar

The QDS sparing and subvastus approaches which are very similar, were considered as more anatomic techniques as both avoid the incision into the quadriceps tendon and the insertion of vastus medialis muscle during operation. Therefore, these techniques should hypothetically offer better clinical results for patients compared to the traditional MPP approach. Tria, the "pioneer" of the QDS sparing approach developed this technique in order to complete the TKA procedure through a limited medial parapatellar incision with use of special modified instrumentation. Promising results were presented in terms of faster rehabilitation, shorter LOS and less blood loss, but somewhat radiological assessment found to be inferior in the QDS group compared to the traditional arthrotomy.⁷¹

Chen et al. despite the few limitations of their retrospective study,

investigated for the first time the results of QDS approach compared to MPP in patients undergoing TKA at two to four years follow up. It's crucial to mention that there was no statistical difference between the two groups regarding the gender, age, body mass index (BMI), varus or valgus deformity and anaesthesia type (general, spinal-epidural). Knee flexion was greater in QDS group either in the immediate post-operative period or two years post-operatively. Better movement was noticed in the QDS group before and after surgery (131° to 128° after two years) compared to MPP approach (133° to 124° after two years). LOS in minimally invasive group was shorter and VAS for pain was less too. There was no statistically significant difference in terms of complications, blood loss, components' positioning and alignment.¹⁸ A few months later a well-designed RCT was performed comparing the results of QDS approach to MPP in 120 patients undergoing bilateral TKA. Although conflicting outcomes have been reported for bilateral TKA (BTKA) it's really important to mention that this study raised the alarm of QDS approach's use, as no significant differences were found between the two groups regarding the KSS, VAS pain, ROM and LOS; nevertheless, higher complication rates were noticed in the QDS group related to limited visualisation and longer tourniquet use.⁴⁷ Better early post-operative outcomes but more outliers and bone injuries during operation, combined with longer operation/tourniquet time were described in Huang's et al. RCT. The authors highlighted these major disadvantages of the QDS technique compared to the traditional MPP approach based on their early experience.⁴⁶ Similar results have been obtained by Lin et al. in their RCT. Authors compared the radiographic results between the QDS and MPP approach in 80 knees. More varus post-operative hip-knee-ankle (HKA) axis was reported in the QDS group with four outliers. As an outlier was considered a deviation of 4° or more from the desirable alignment (femoral and/or tibial component). No difference was observed in terms of VAS pain, isokinetic peak muscle strength and time to SLR.⁷²

Controversial post-operative results regarding the efficacy and safety of QDS approach have been obtained by Chiang's et al. RCT in which 80 osteoarthritic knees were randomly assigned between the two groups (QDS versus MPP). No statistical differences were reported in regards to pain score, ROM and LOS between the two groups in the short- and mid-term follow-up of up to two years; additionally, longer surgical time and steep learning curve were observed in the QDS group.⁷³

Nine RCTs (775 TKAs) were included in the only systematic review and meta-analysis that was found in our search in the current literature. Multiple aspects of QDS approach were investigated including KSS, SLR, complications rates, VAS pain, deep vein thrombosis (DVT), ROM. The authors concluded that QDS group was superior to MPP in terms of early post-operative KSS and VAS pain but had the disadvantage of longer operative time.⁷⁴

Although QDS approach should hypothetically offer better clinical results for patients, literature reports conflicting outcomes. Although many of the above studies support the assumption of faster SLR, less pain and greater ROM, other studies did not support this viewpoint. Consequently, more well-designed RCTs and systematic-reviews/meta-analyses should be conducted which will provide the best evidence-based answer and an unbiased conclusion on this specific topic.

4.4. Mixed RCTs, systematic reviews and meta-analyses

Apart from the "head to head" comparison between the minimally invasive methods and MPP approach, many RCTs and systematic reviews that compared more than two of these methods, have been organized in order to extract more accurate and reliable results.

In 2014, Liu et al. designed a systematic review and meta-analysis to assess the safety and the efficacy of SV and MV compared with MPP approach. Authors included thirty two RCTs (2451 TKAs in 2129 patients), published from 1999 to 2013. Ultimately, this article consists of two simultaneous systematic reviews/meta-analyses that compares

each of the minimally invasive methods to the MPP approach. In the MV vs MPP section, inferiority of the MIS approach was concluded in terms of VAS pain (2-weeks post-operatively) and ROM (1-week post-operatively). However, no difference was found in regards to KSS, ROM (6-weeks/3-months/6-months post-operatively), SLR, blood loss, LOS and complications rates. Additionally, the SV approach did prove its superiority in ROM (1-week post-operatively), lateral retinacular release and SLR, whereas similar outcomes were reported between the two groups in regards to VAS, KSS, ROM (6-weeks/3-months post-operatively), blood loss, LOS and complications rates.²⁹ Similar results were observed in Liu's et al. systematic review and meta-analysis (fifteen RCTs were included). Outcomes revealed faster SLR, shorter LOS and decreased blood loss in SV approach, improved quadriceps strength and greater ROM (in immediate post-operative period) in both minimally invasive approaches, but no difference in VAS pain.³⁹ Additional to the previously mentioned results, Peng et al. conducted a systematic review/meta-analysis including nineteen RCTs (1633 TKAs). The QDS arthrotomy showed lower VAS pain, greater KSS, but longer operative time. Moreover, SV approach offered better outcomes in VAS, ROM, SLR and lateral retinacular release.⁷⁴ Alcelik et al. tried to reach a conclusion between the traditional and the MIS approach. In their systematic review and meta-analysis seventeen studies were included involving 733 patients undergoing unilateral TKA. MIS resulted in greater function in the immediate post-operative period, but increased intra-operative complications were reported. For that reason authors suggested that standard approach should be used in order to avoid such complications.⁷⁵

In 2006, Aglietti et al. compared the post-operative recovery and the early post-operative results (until 3-months post-operatively) between the QDS and the mini-subvastus approach. Mini-SV resulted in earlier SLR, but no difference was found in tourniquet time, blood loss, post-operative pain and ROM (119° and 117° of flexion at 3-months for the QDS and mini-SV respectively).⁷⁶ Bonutti et al. in their RCT compared the MV and SV approach in fifty-one patients who underwent bilateral TKA. The first approach was used in one knee and the other in the opposite side. Many features were investigated including KSS, SLR, ROM, blood loss, operating time and isokinetic strength test. No substantive difference was found between the two groups in any of the above aspects. Authors concluded that both of the approaches offered excellent results and the choice should be based on surgeon's experience.⁷⁷ A similar RCT was conducted by Masjudin et al. in twenty-three patients, comparing the SV to MV approach in bilateral two-staged TKA. The SV approach attained earlier SLR, but had increased blood loss and operative time compared to MV approached knees. Nevertheless, comparable outcomes were reported in regards to VAS pain, flexion and KSS.⁷⁸ Additionally, Jarvis et al. run a RCT (fifty-three patients who received either MV or SV approach in TKA) investigating specific tasks of sitting and standing. SV group reported quicker return to knee extension during sit-to-stand up (STSU), whereas better outcomes in terms of normal movement patterns in hip, knee and ankle during stand-to-sit down (STSD) were noticed in the MV patients. However, authors concluded no significant advantage (6-months post-operatively) between the two groups, as both of these activities are required for usual daily living.⁷⁹

5. Discussion

TKA has been successfully performed and established in the management of advanced knee osteoarthritis for decades.⁵ Since then, an evolution in different aspects of TKA including navigation-guided procedures, wear-resistant bearing surfaces and improved kinematics has been applied. In the last two decades there has been considerable debate concerning the effectiveness and safety of MIS approaches in TKA. Till now, current literature's overall conclusion is that there is no obvious winner or loser.^{28, 29, 75, 80}

The long cutaneous incision of MMP approach of about 20–25 cm

Table 1
Advantages vs disadvantages of surgical approaches in TKA.

Surgical Approach	Advantages	Disadvantages
<i>Medial Parapatellar</i>	<ul style="list-style-type: none"> ■ Excellent exposure ■ Applied to almost any deformity ■ Easy to execute ■ Ideal for revisions and/or obese patients ■ Versatile and extensible ■ Ability to add quadriceps snip 	<ul style="list-style-type: none"> ■ High tendon cut (> 4 cm) ■ Dislocation or subluxation of patella can lead to stress fracture ■ Avascular necrosis of patella can lead to fracture ■ Adhesions (esp. in suprapatellar pouch)
<i>Subvastus</i>	<ul style="list-style-type: none"> ■ Better ROM, earlier SLR and greater KSS in the immediate post-op period ■ Preserves the extensor mechanism and the insertion of the VMO ■ Preservation of the patellar blood supply ■ Shorter LOS ■ Minimizes patellofemoral instability and maltracking 	<ul style="list-style-type: none"> ■ Technically more challenging ■ Not extendable ■ Not for all patients (e.g. obese patients) and deformities ■ Risk of neurovascular damage in “Hunters canal”
<i>Midvastus</i>	<ul style="list-style-type: none"> ■ No disruption of the VMO insertion into the Quadriceps tendon ■ Easier visualization of patella tracking ■ Easy eversion of the patella to achieve adequate exposure ■ Improved ROM and decreased VAS pain 	<ul style="list-style-type: none"> ■ Not proximally extensible ■ Abnormalities in VMO electromyogram (?) ■ Not for obese patients and/or limited knee flexion ■ Components’ alignment pitfalls (mainly in obese patients) ■ Increased muscle damage (elevated CPK)
<i>Quadriceps sparing</i>	<ul style="list-style-type: none"> ■ More anatomic technique ■ Better ROM and less pain ■ Possibility to extend proximally ■ Patella is not everted ■ Intact quadriceps function and knee stability 	<ul style="list-style-type: none"> ■ Modified instruments are required ■ Patellar preparation is difficult ■ Steep learning curve ■ Longer operative time and longer tourniquet use

Table 2
Table of abbreviations.

Abbreviation	Definition
OA	Osteoarthritis
TKA	Total knee arthroplasty
MIS	Minimally invasive surgery
MPP	Medial parapatellar
SV	Subvastus
MV	Midvastus
QDS	Quadriceps sparing
RCT	Randomized controlled trial
KSS	Knee society score
ROM	Range of motion
SLR	Straight leg raise
VAS	Visual analogue scale
LOS	Length of stay
TT	Tibial tuberosity/tubercle
VMO	Vastus medialis oblique
QOL	Quality of life
CPK	Serum creatinine kinase
WOMAC	Western Ontario and McMaster Universities Index of Osteoarthritis
PDI	Pain disability index
BMI	Body mass index
BTKA	Bilateral total knee arthroplasty
HKA	Hip-knee-ankle
DVT	Deep vein thrombosis
STSU	Sit-to-stand up
STSD	Stand-to-sit down

has been considered as the “gold standard” in TKA as it offers superb exposure and allows the surgeon to use large instrumentation/guides.¹⁴ In the last two decades there is a wide interest in the MIS techniques that has been mainly accredited to market and patients’ demand.⁸¹ Although in most patients’ mind MIS means a small skin incision, the reality couldn’t be further from the truth. In fact, MIS doesn’t necessarily equate with short incision although most of the MIS techniques follow a smaller incision. The main difference between the two approaches is the less-invasive technique used to expose the joint, emphasising the soft-tissue’s respect, with the goal of reducing post-operative pain and speeding recovery. Although nowadays many surgeons perform the “traditional” MPP approach in TKA with skin incision less than 20 cm, currently, incisions smaller than 14 cm are considered as “minimally invasive”. SV, MV and QDS are the most

commonly used MIS approaches in TKA.^{23, 29, 70, 82, 83} As we have stated above, numerous well-designed RCTs and systematic reviews/meta-analyses have compared the efficacy and the safety of these approaches. In order to provide a more clear-cut point of view about TKA approaches, we constructed an aggregate table including both the advantages and disadvantages of each of these methods (Table 1).

Despite the interesting information reported in our review, we can nevertheless confirm that there are some limitations in our article. The main caveat is related to the methodological limitations of the included studies. Poor randomizations schemes are vulnerable to bias when allocation and treatments are inadequately blinded. Additionally, pre-intervention differences between the compared groups may have caused post-interventional differences. Such studies may have proven unable to find significant differences between the different methods used. Therefore, it’s really crucial to understand the importance of power analysis and sample size calculation in the proper design of experiments.⁸⁴

In conclusion, less invasive methods with smaller incision, increased patient satisfaction, respect of the vascularization, respect for soft-tissue, greater ROM, less pain, faster post-operative rehabilitation and shorter LOS is the challenge of interest to all orthopaedic community. Nevertheless, it remains to be determined that all or most of the above goals can be accomplished by using the MIS technique with no subsequent increased complication rates. Therefore, further investigation based on large well-designed studies with long-term results are warranted to further clarify MIS effectiveness/safety and support/refute these findings.

Footnotes

All abbreviations and their definition have been included in Table 2 for reader’s convenience.

All figures and tables have been originally created/drawn by one of the authors. The figures’ background has been screenshotted by the free 3D on-line anatomy software/platform <https://www.biodigital.com/>.

Conflicts of interest

None.

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