

Does surgical approach affect patient outcomes of total knee arthroplasty?

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Background: Surgical approaches for total knee arthroplasty (TKA) include the medial parapatellar (MPA), subvastus (SV), midvastus (MV), and lateral parapatellar approach (LPA); it remains unclear which approach is superior.

Methods: Patients having undergone TKA at our institution were retrospectively organized into matched groups according to surgical approach (MPA, MV, SV, or LPA). Outcomes between the groups were compared using the Short-Form 12 (SF-12), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Knee Society Score (KSS), and range of motion (ROM) up to 2 years postoperative.

Results: Sixty-eight MV patients, 8 SV patients, and 4 LPA patients were matched with groups of MPA patients. There was no difference in outcomes between the MPA and MV groups up to 2 years. The SV group had significantly higher SF-12 Physical Composite Score (PCS; $p = 0.036$) and WOMAC stiffness score ($p = 0.014$) at 2 years, but significantly lower flexion at 1 year ($p = 0.022$) than the MPA group. The LPA group had significantly lower SF-12 PCS ($p = 0.011$) and WOMAC function scores ($p = 0.022$) at 1 year than the MPA group.

Conclusion: There was no significant difference between the MPA and MV approach. The SV approach had some improved long-term outcomes over the MPA approach (SF-12 and WOMAC), but had significantly lower flexion at 1 year. The LPA group showed inferior outcomes than the MPA group but had more severe valgus preoperative deformity ($p = 0.024$). Further studies are required to investigate the potential benefit of quadriceps-sparing approaches.

Contexte : Les voies chirurgicales d'arthroplastie totale du genou (ATG) sont les suivantes : parapatellaire interne (PI), subvastus (SV), midvastus (MV), et parapatellaire externe (PE); il n'est pas clair quelle voie est supérieure.

Méthodes : Les patients qui ont subi une ATG dans notre établissement ont été classés rétrospectivement en groupes appariés selon la voie chirurgicale (PI, MV, SV ou PE). Les résultats des différents groupes ont été comparés au moyen du Short-Form 12 (SF-12), de l'indice Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), du score de la Knee Society (KSS) et de l'amplitude du mouvement jusqu'à 2 ans après l'opération.

Résultats : Au total, 68 patients traités par voie MV, 8 par voie SV et 4 par voie PE ont été appariés avec des groupes de patients traités par voie PI. Il n'y avait aucune différence dans les résultats entre les groupes PI et MV jusqu'à 2 ans. Comparativement au groupe PI, le groupe SV avait des résultats significativement plus élevés pour le score physique fonctionnel (PCS) du SF-12 ($p = 0,036$) et le score de raideur de l'indice WOMAC ($p = 0,014$) après 2 ans, mais une flexion significativement plus faible après 1 an ($p = 0,022$). Encore comparativement au groupe PI, le groupe PE avait des résultats significativement plus faibles pour le PCS du SF-12 ($p = 0,011$) et les scores fonctionnels de l'indice WOMAC ($p = 0,022$) après 1 an.

Conclusion : Il n'y avait pas de différence significative entre les voies PI et MV. La voie SV offrait de meilleures issues à long terme que la voie PI (SF-12 et WOMAC), mais une flexion significativement plus faible après 1 an. Le groupe PE a eu des issues moins bonnes que le groupe PI, mais présentait plus souvent une déformation valgus préopératoire grave ($p = 0,024$). D'autres études seront requises pour établir les bienfaits potentiels de voies évitant le quadriceps.

Many approaches have been described for total knee arthroplasty (TKA), including the medial parapatellar (MPA), subvastus medialis (SV), midvastus (MV), and lateral parapatellar (LPA) approaches. The most commonly used of these is the MPA, which is considered the standard to which others are compared.

In a standard MPA, a midline incision is used and a medial parapatellar arthrotomy is made. It allows for excellent exposure and is relatively straightforward to perform.¹ An SV approach typically also involves a midline skin incision, but the incision may be positioned more oblique and medially. From there, the border of the vastus medialis is visualized, its fascia is incised, and the vastus medialis is bluntly elevated from the medial intermuscular septum.^{1,2} Engh and colleagues described a modification to the SV approach in which the vastus medialis is split in line with its muscle fibres proximally; this was named the MV approach.³ Finally, the LPA also involves a midline incision, but may be positioned lateral to the tibial tubercle. The arthrotomy is made lateral to the patella⁴ and extends into the quadriceps tendon, leaving a small lateral margin to enable repair.

Each approach has advantages and disadvantages. For example, although the MPA provides an excellent view of the joint, it involves violating the extensor mechanism and medial structures.¹ The SV and MV approaches are “quadriceps sparing,” but are more technically difficult to perform and often reserved for thinner patients.^{1,3,5-8} They may also result in decreased accuracy of implant positioning.⁹ The LPA provides direct access to lateral structures in valgus knees and spares medial soft tissues, but also can be technically challenging.^{1,4} It has also been described in conjunction with a tibial tubercle osteotomy (TTO).

Although several randomized controlled trials exist comparing the SV and MV approaches to the MPA, sample sizes are small and the results are mixed. For example, Cho and colleagues¹⁰ found results favouring the MV approach; Heekin and colleagues¹¹ and Pan and colleagues¹² found no significant difference between the approaches; Varela-Egocheaga and colleagues¹³ found results favouring the SV approach; and Varnell and colleagues¹⁴ found results favouring the MPA.

Similarly, RCTs comparing the lateral and medial parapatellar approaches also tend to have small sample sizes and report mixed results. Many studies also incorporate use of a TTO, which makes results difficult to interpret. Nonetheless, several studies have reported promising outcomes with this approach in valgus knees.^{15,16}

Given the small sample size and mixed results of existing studies, we aimed to add to the body of literature by retrospectively reviewing patients at our institution and comparing outcomes of the SV, MV, and LPA to the standard MPA.

METHODS

After obtaining approval from our institutional ethics board, we searched the institutional database for patients having undergone primary TKA between 2015 and 2019. Patients were included if they were older than 30 years and underwent primary TKA for osteoarthritis. Revision cases were excluded, as were patients who underwent arthroplasty for a reason other than osteoarthritis. All TKAs were performed by a single surgeon at our institution, with the vast majority of cases using a Triathlon implant (Stryker).

Patient demographic characteristics were recorded. Short-Form 12 (SF-12), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Knee Society Score (KSS), knee function scores, and range of motion (ROM) were recorded at yearly intervals from the initial surgical date. The WOMAC scores were reported on a scale of 0 (worst) to 100 (best). Any instance of revision, as well as the reason for revision, were also tracked.

Charts were retrospectively reviewed by the lead author in order to organize patients by surgical approach used. The MV and SV approaches were generally chosen to offer a potentially less invasive approach to patients with varus or neutral alignment and lower body mass index (BMI). The LPA was used in cases of severe valgus deformity, as it is the lead surgeon’s preferred approach for such cases. Patient groups were matched using propensity score matching for age, BMI, and gender.

Statistical analysis

Statistical analysis between groups was performed using SPSS Statistics version 23 (IBM). We used the Student *t* test to compare the cohorts; the Welch *t* test was used in cases when we were unable to assume similar variance.

RESULTS

Medial parapatellar v. midvastus approach

After matching for age and BMI, 68 patients met the inclusion criteria for the medial parapatellar group, with a mean age of 66.7 ± 9.6 years and a mean BMI of 30.5 ± 4.8 kg/m². Forty-eight (70.6%) of the MPA patients were male and 20 (29.4%) were female. Sixty-eight patients were included in the MV group, with a mean age of 68.0 ± 9.2 years and a mean BMI of 30.8 ± 4.7 kg/m². Twenty-nine (42.7%) of the MV patients were male and 39 (57.4%) were female. There was no significant difference in age ($p = 0.426$) or BMI ($p = 0.776$) between these groups. There was a significant difference in the gender make-up of these groups ($p = 0.001$). Of the patients who underwent an MPA, 29 had a final follow-up up to 1 year postoperative and 39 had a final follow-up up to 2 years

postoperative. In the MV group, 49 patients had a final follow-up up to 1 year postoperative and 19 had a final follow-up up to 2 years postoperative. Sixty (88.2%) of the MPA patients and 59 (86.8%) of the MV patients had preoperative varus alignment.

Outcome scores of the MPA and MV groups are summarized in Table 1. There were no significant differences up to 2 years between these 2 groups.

Of the MPA patients, 2 (2.9%) required revision; 1 patient underwent revision for lateral patellar subluxation and the other had patellar resurfacing for anterior knee pain. Three (4.4%) patients in the MV group required revision; 1 patient underwent revision for aseptic loosening of the tibial component and 2 patients underwent patellar resurfacing for anterior knee pain.

Medial parapatellar v. subvastus medialis approach

After matching for age and BMI, 8 patients met the inclusion criteria for the MPA group, with a mean age of 68.2 ± 8.8 years and a mean BMI of 28.4 ± 1.9 kg/m². One (12.5%) patient in the MPA group was male and 7 (87.5%) were female. Eight patients were included in the SV group, with a mean age of 70.4 ± 6.5 years and a mean BMI of 28.5 ± 2.3 kg/m². Three (37.5%) patients in the SV group were male and 5 (62.5%) were female. There was no significant difference in age ($p = 0.575$), BMI ($p = 0.914$), or gender make-up ($p = 0.248$) between these groups. In the MPA group, all 8 patients had a final follow-up up to 2 years postoperative. In the SV group, 2 patients had a final follow-up up to 1 year postoperative and 6 patients had a final follow-up up to 2 years postoperative. All patients had preoperative varus alignment in both groups.

Outcome scores between the MPA and SV groups are summarized in Table 2. There was a significant difference in SF-12 Physical Composite Score (PCS) at 2 years postoperative ($p = 0.036$) and in the WOMAC stiffness score at 2 years postoperative ($p = 0.014$), both favouring the SV approach. The MPA group had significantly higher flexion at 1 year postoperative ($p = 0.022$). There were no other significant difference between the 2 approaches at other time points, as summarized in Table 3.

One patient (12.5%) in the MPA group required revision in the form of patellar resurfacing for anterior knee pain. No patients in the SV group underwent revision.

Medial parapatellar v. lateral parapatellar approach

As the LPA is generally reserved for valgus knees, only knees with valgus preoperative alignment in each group were compared. The matched valgus MPA group had a mean age of 69.0 ± 12.3 years and a mean BMI of 30.5 ± 0.4 kg/m². The valgus LPA group had a mean age of 69.6 ± 21.1 years and a mean BMI of 31.4 ± 6.9 kg/m².

Table 1. Outcome scores in patients who underwent medial parapatellar and midvastus approaches, up to 2 years postoperative

Outcome	Group; mean \pm SD		<i>p</i> value
	MPA	MV	
SF-12 MCS, 1 yr postop	52.3 \pm 10.4	52.3 \pm 10.9	0.79
SF-12 MCS, 2 yr postop	53.6 \pm 9.2	54.9 \pm 9.7	0.69
SF-12 PCS, 1 yr postop	41.0 \pm 10.1	44.0 \pm 10.4	0.12
SF-12 PCS, 2 yr postop	32.4 \pm 10.5	42.5 \pm 10.3	0.95
WOMAC pain, 1 yr postop	80.0 \pm 20.7	81.4 \pm 18.2	0.71
WOMAC pain, 2 yr postop	82.9 \pm 16.8	81.1 \pm 32.9	0.86
WOMAC stiffness, 1 yr postop	70.4 \pm 24.1	72.1 \pm 19.4	0.68
WOMAC stiffness, 2 yr postop	79.1 \pm 18.8	71.1 \pm 26.8	0.28
WOMAC function, 1 yr postop	78.5 \pm 20.2	78.9 \pm 18.3	0.92
WOMAC function, 2 yr postop	82.6 \pm 18.1	83.2 \pm 21.9	0.93
WOMAC total, 1 yr postop	77.8 \pm 19.7	78.9 \pm 16.6	0.78
WOMAC total, 2 yr postop	81.8 \pm 15.6	83.3 \pm 21.3	0.81
Extension, $^{\circ}$, 1 yr postop	0.2 \pm 1.4	0.5 \pm 1.8	0.31
Extension, $^{\circ}$, 2 yr postop	0.7 \pm 1.8	0.8 \pm 1.9	0.82
Flexion, $^{\circ}$, 1 yr postop	119.4 \pm 10.3	114.7 \pm 19.3	0.13
Flexion, $^{\circ}$, 2 yr postop	120.2 \pm 9.6	114.6 \pm 11.2	0.13
KSS function, 1 yr postop	83.2 \pm 21.2	85.2 \pm 18.9	0.61
KSS function, 2 yr postop	85.0 \pm 19.8	90.9 \pm 12.2	0.29
KSS knee, 1 yr postop	91.5 \pm 11.6	93.0 \pm 9.8	0.50
KSS knee, 2 yr postop	91.4 \pm 13.7	90.6 \pm 12.8	0.87
KSS total, 1 yr postop	173.5 \pm 28.9	176.3 \pm 25.6	0.63
KSS total, 2 yr postop	174.4 \pm 31.6	184.4 \pm 19.0	0.28

KSS = Knee Society Score; MPA = medial parapatellar approach; MV = midvastus approach; SF-12 MCS = Short-Form 12 Mental Composite Score; SF-12 PCS = Short-Form 12 Physical Composite Score; WOMAC = Western Ontario and MacMaster Universities Osteoarthritis Index.

All patients in both groups were female. There was no significant difference in age ($p = 0.96$), BMI ($p = 0.83$), or gender make-up between the groups. All patients had a final follow-up up to 1 year postoperative. The mean preoperative valgus angle in the LPA group was $17.4^{\circ} \pm 5.1^{\circ}$, which was significantly higher than the mean valgus angle of $7.0^{\circ} \pm 4.7^{\circ}$ in the MPA group ($p = 0.024$).

Outcome scores for each group are summarized in Table 3. There was a significant difference in SF-12 PCS at 1 year postoperative ($p = 0.011$) and in WOMAC function score at 1 year postoperative ($p = 0.022$), both favouring the MPA. There was no significant difference in SF-12 Mental Composite Score (MCS), WOMAC pain, stiffness, and total scores, ROM, or KSS at 1 year postoperative.

No patients in either group required revision.

DISCUSSION

Although there are several randomized controlled trials comparing the MPA, MV, SV, and LPA approaches, many are small in sample size, report mixed results, and have short follow-up duration.^{16,17} We aimed to add to this body of literature by reporting outcomes of a single-surgeon, expertise-based study.

Table 2. Outcome scores in medial parapatellar and subvastus approach patients up to 2 years postoperative

Outcome	Group; mean ± SD		p value
	MPA	SV	
SF-12 MCS, 1 yr postop	56.7 ± 11.5	58.0 ± 2.3	0.82
SF-12 MCS, 2 yr postop	53.7 ± 10.3	52.2 ± 8.8	0.82
SF-12 PCS, 1 yr postop	45.4 ± 13.2	43.1 ± 13.1	0.77
SF-12 PCS, 2 yr postop	38.6 ± 11.5	53.2 ± 5.1	0.036
WOMAC pain, 1 yr postop	71.4 ± 26.3	86.4 ± 19.3	0.25
WOMAC pain, 2 yr postop	72.5 ± 20.6	98.0 ± 2.7	0.09
WOMAC stiffness, 1 yr postop	62.5 ± 29.8	75.0 ± 21.6	0.39
WOMAC stiffness, 2 yr postop	56.3 ± 12.5	85.0 ± 13.7	0.014
WOMAC function, 1 yr postop	74.1 ± 25.2	84.6 ± 18.7	0.41
WOMAC function, 2 yr postop	65.9 ± 26.2	94.4 ± 6.9	0.12
WOMAC total, 1 yr postop	72.5 ± 27.0	83.3 ± 18.5	0.41
WOMAC total, 2 yr postop	66.7 ± 19.8	94.0 ± 5.8	0.07
Extension, °, 1 yr postop	0.8 ± 2.0	0 ± 0	0.39
Extension, °, 2 yr postop	1.7 ± 2.9	0 ± 0	0.42
Flexion, °, 1 yr postop	126.7 ± 4.1	114.0 ± 8.2	0.022
Flexion, °, 2 yr postop	110.0 ± 21.8	121.0 ± 2.2	0.47
KSS function, 1 yr postop	90.7 ± 14.3	85.0 ± 28.1	0.65
KSS function, 2 yr postop	66.7 ± 28.9	98.0 ± 4.5	0.20
KSS knee, 1 yr postop	97.3 ± 2.58	94.8 ± 2.9	0.16
KSS knee, 2 yr postop	72.7 ± 25.7	97.8 ± 2.5	0.23
KSS total, 1 yr postop	186.5 ± 16.8	176.8 ± 31.5	0.56
KSS total, 2 yr postop	139.3 ± 53.5	195.3 ± 4.8	0.21

KSS = Knee Society Score; MPA = medial parapatellar approach; SF-12 MCS = Short-Form 12 Mental Composite Score; SF-12 PCS = Short-Form 12 Physical Composite Score; SV = subvastus approach; WOMAC = Western Ontario and MacMaster Universities Osteoarthritis Index.

Table 3. Outcome scores in medial parapatellar and lateral parapatellar approach patients with valgus preoperative alignment up to 1 year postoperative

Outcome	Group; mean ± SD		p value
	MPA	LPA	
SF-12 MCS, 1 yr postop	46.5 ± 17.7	43.0 ± 7.1	0.73
SF-12 PCS, 1 yr postop	53.0 ± 7.1	34.5 ± 3.7	0.011
WOMAC pain, 1 yr postop	92.5 ± 3.5	71.7 ± 10.4	0.08
WOMAC stiffness, 1 yr postop	62.5 ± 17.7	66.3 ± 7.5	0.81
WOMAC function, 1 yr postop	89.0 ± 9.9	61.7 ± 4.5	0.022
WOMAC total, 1 yr postop	85.0 ± 5.7	67.0 ± 6.6	0.05
Extension, °, 1 yr postop	1.7 ± 2.9	2.5 ± 2.9	0.72
Flexion, °, 1 yr postop	123.3 ± 5.8	110.0 ± 11.5	0.11
KSS function, 1 yr postop	93.3 ± 11.5	43.8 ± 54.4	0.17
KSS knee, 1 yr postop	98.3 ± 2.1	95.3 ± 2.5	0.15
KSS total, 1 yr postop	191.7 ± 10.2	139.0 ± 56.1	0.16

KSS = Knee Society Score; LPA = lateral parapatellar approach; MPA = medial parapatellar approach; SF-12 MCS = Short-Form 12 Mental Composite Score; SF-12 PCS = Short-Form 12 Physical Composite Score; WOMAC = Western Ontario and MacMaster Universities Osteoarthritis Index.

The MV approach for TKA was first described as a modification of the SV approach to allow for easier exposure.³ Similar to the other quadriceps-sparing approaches, it offers the theoretical benefits of improved patellar tracking, decreased postoperative pain, and quicker return of quadriceps strength.⁶ Results in the lit-

erature, however, have been mixed. Quadriceps-sparing approaches may have a higher risk of malalignment and component malposition.⁹ An early study by Keating and colleagues published in 1999 comparing short-term outcomes between MV and MPA found no difference in ROM, straight leg raise, extensor lag, or rehabilitation at time of discharge.⁶ There was a higher rate of postoperative hematoma and manipulation in the MV patients, leading the group to conclude that they could not recommend this approach. Subsequent studies have been more promising. A recent meta-analysis of 32 randomized controlled trials showed that MV patients had significantly lower pain scores at 2 weeks postoperative than MPA patients, but found no difference at other time points.¹⁷ Range of motion was also significantly greater at 1 week postoperative for the MV group, but there was no difference at other time points. Midvastus approaches took significantly longer in terms of surgical time than MPA. There was also no difference in KSS, time to straight leg raise, intraoperative blood loss, length of hospital stay, or postoperative complications.¹⁷

In our cohort of MV patients, we found no significant difference in SF-12, WOMAC, ROM, or KSS scores at 1 and 2 years postoperative. This was consistent with the results of prior studies, which tend to show short-term benefits of quadriceps-sparing approaches, but no difference in long-term outcomes.^{3,17}

Another quadriceps-sparing approach, the SV approach was first popularized in 1991 by Hofmann, who sought out a more anatomic approach to the knee.⁵ Advantages of this approach include the fact that it also does not violate the extensor mechanism. Additionally, it leaves the majority of vessels supplying the patella intact, if the dissection is carried out carefully.¹ Unfortunately, the SV approach is limited by difficulty with exposure and everting the patella.^{7,8} Currently, it is typically used only in thin patients with mobile tissues undergoing primary TKA. Randomized controlled trials comparing this approach to the MPA have reported mixed results. Some, such as that by Roysam and colleagues, reported earlier straight leg raise, reduced blood loss, lower opiate consumption, improved patellar tracking, and better knee flexion earlier in the recovery process.⁸ A meta-analysis by Liu and colleagues showed that the SV approach resulted in improved ROM at 1 week postoperative ($p < 0.05$), but no significant difference at 6 weeks or later.¹⁷ The SV group also had earlier ability to straight leg raise. Otherwise, there were no significant differences in outcomes or complication rates.

Although our sample size was small, our SV patients showed some promising results. The SV group had higher SF-12 PCS ($p = 0.036$) and WOMAC stiffness scores ($p = 0.014$) at 2 years postoperative. Interestingly, our study showed long-term benefits with this quadriceps-sparing approach, unlike most of the existing literature.¹⁷

The MPA group did, however, have significantly higher flexion at 1 year postoperative ($p = 0.022$). This was quite surprising, given that prior randomized controlled trials found no difference in long-term ROM between the 2 approaches, or in the case of the work by Varela-Egocheaga and colleagues, improved ROM in SV patients at 1 year postoperative.^{13,17} It was surprising that the group with reduced flexion had superior stiffness scores. The WOMAC stiffness score is a subjective scale in which patients rate their stiffness from none to extreme. Although we are unsure why the SV group had higher stiffness scores yet reduced flexion, it may have to do with a discrepancy in the patients' perceived subjective stiffness and objectively measured ROM. It is also possible that patients interpreted "stiffness" as being more than just a restriction in ROM. Clinically, it is often interesting that patients' reports of stiffness do not seem to be related to their ROM.

Finally, the LPA is another alternative to the MPA, which was first described in 1982 and later popularized by Kewish in 1991.^{4,18} While also technically demanding,⁴ LPA allows for more direct access to lateral soft tissues in valgus knees.¹ Some proponents use this approach in valgus knees because they fear a standard MPA would further promote patellar maltracking.¹⁹ Additionally, the LPA leaves the medial vasculature and nervous structures undisturbed.¹ Studies on the LPA unfortunately focus on valgus knees, with little data available to analyze this approach in varus or neutral knees. Furthermore, many studies incorporate use of a TTO, which makes results difficult to interpret. Nonetheless, several studies have reported promising outcomes with LPA in valgus knees. Sekiya and colleagues found improved postoperative flexion in the LPA group ($p < 0.001$), but used extensive lateral releases, including the iliotibial band in many cases.¹⁵ They found no difference in surgical duration, complications, blood loss, postoperative alignment, laxity, patient-reported outcome scores, and KSS. A recent meta-analysis also compared the LPA to the MPA for valgus knees and found improved KSS in the LPA group, but similar alignment, operative duration, blood loss, WOMAC scores, postoperative pain, and ROM between the 2 approaches.¹⁶

As the LPA is commonly described for valgus knees, allowing for direct access to the tight lateral structures, our analysis for this group involved only knees with valgus preoperative alignment. Our comparison of the MPA and LPA in valgus knees actually showed significantly lower SF-12 PCS ($p = 0.011$) and WOMAC function scores ($p = 0.022$) at 1 year postoperative for the LPA group. There was no significant difference in other components of the SF-12, WOMAC, ROM, or KSS. This is also unlike findings from prior randomized trials, which showed no significant difference or advantage with the LPA.¹⁶ It is important to note, however, that

our LPA patients tended to have a more severe preoperative valgus deformity than the MPA patients ($p = 0.024$).

Limitations

Our study did have notable limitations. Alternative TKA approaches are not typically performed by surgeons at our institution and, as such, this was a single-surgeon study with a small sample size. The study was also retrospective in nature, and patient outcome data were not collected earlier than 1 year postoperative, which prevented us from analyzing any early benefits of quadriceps-sparing approaches. A large, high-quality randomized trial with extended follow-up is required to compare surgical approaches for TKA.

CONCLUSION

Compared with a standard MPA, the MV approach shows no significant difference in outcomes up to 2 years. The SV approach shows superior SF-12 and WOMAC scores at 2 years postoperative, but worse flexion at 1 year. The LPA for valgus knees had inferior SF-12 and WOMAC scores than the MPA, but selected for a more severe preoperative valgus deformity. Ultimately, a large randomized trial with extensive follow-up is recommended to verify the benefits of quadriceps-sparing approaches to TKA.

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Competing interests: R. Willing is a paid consultant for Lima Corp. and receives research support from Stryker, outside the submitted work. M. Teeter reports stock in IdealFit Spacer Technologies and is a member of the advisory boards of the International Society for Technology in Arthroplasty and the Canadian RSA Network.

Contributors: S. Sidhu, M. Teeter and B. Lanting designed the study. S. Sidhu, L. Somerville and A. Sidhu acquired the data, which S. Sidhu, R. Willing and B. Lanting analyzed. S. Sidhu and B. Lanting wrote the article, which all authors reviewed. All authors gave final approval of the article to be published.

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