ORIGINAL ARTICLE

Comparing Early Outcomes of Standard Medial Parapatellar and Subvastus Approach in Mobile Bearing Cruciate Retaining Total Knee Arthroplasty in BMA General Hospital: A Randomized Controlled Trial Study

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Background: Variables such as implant prosthesis type, preservation of posterior cruciate ligament retaining (CR), standard medial parapatellar (MP), or minimally invasive surgical approach have been influenced by the outcomes of total knee arthroplasty (TKA). Previous studies that did not control similar factors, so the results have been controversial.

Objective: To compare early outcomes of standard MP and subvastus (SV) approach in mobile bearing with CR (MBCR) in TKA.

Materials and Methods: Sixty-six TKA by MB implant and CR technique were enrolled between February 2022 and December 2023 at BMA General Hospital and randomized equally between the control (MP) group and SV groups with early postoperative up to eight weeks follow-up.

Results: Of the 43 patients, 20 patients underwent unilateral TKAs and 23 patients had bilateral TKAs. The mean age of the patients was 70.2±6.7 years. The majority of them were women at 83.7%. The median preoperative varus deformity was 4.0 (IQR 2.5 to 6.5) degrees. The SV group had significantly better outcomes in operative time (p=0.002), tourniquet time (p=0.007), less blood loss (p=0.038), and get more straight leg raising at 6-hour, 12-hour, and 24-hour (p=0.009, 0.003, and 0.001, respectively). There was no difference between the two groups in incision length, knee society score (KSS), pain score, and duration of stay.

Conclusion: TKA under MBCR using SV approach has an early advantage outcome over standard MP approach. The authors gave confidence for these prosthesis type, design, and approach.

Keywords: Mobile bearing; Cruciate retaining; Standard; Medial parapatellar; Subvastus, Total knee arthroplasty

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Knee osteoarthritis is one of the major problems in elderly. Total knee arthroplasty (TKA) is recognized as the definitive treatment for advanced knee arthritis in patients that failed of the non-operative methods. This operation has evolved over more than 50 years[1]. There are aspects affecting successful outcomes such as implant designs[2,3] and surgical techniques[4].

In regards to the prosthesis, mobile bearing (MB) was claimed to be better than fixed bearing (FB) by several studies, in terms of no meniscal bearing dislocation[5], improvement of clinical and functional outcome[6], and low revision rate[7], however, a systematic review and meta-analysis of randomized controlled trials (RCTs) by Smith et al.[8] revealed no significant difference concerning postoperative range of motion (ROM), outcome of knee society score (KSS), and hospital special surgery scores (HSS). Related to design, the posterior cruciate retaining (CR) design does less damage to the tissue and increases joint stabilization by collateral ligament than the posterior cruciate substitution (PS) design. Nevertheless, Hofstede et al.[9] claimed that these methods, due to the rolling and gliding of the bone, may damage the polyethylene artificial meniscus surface. Furthermore, Calvisi et al.[10] solved the problem by a correction of the joint line position with the posterior tibial slope. A controversial opinion by Lozano-Calderón et al.[11] stated that there was no difference in results between the two designs. About

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surgical approach, the medial parapatellar (MP) approach is the most commonly used and may be called standard or conventional approach. In recent decades, the minimal invasive surgical approach such as subvastus (SV) approach had been developed as an alternative[12] aiming for less injury to the quadriceps tendon, thus, allows for faster recovery. The meta-analysis RCT[13] of quadriceps-sparing SV technique, comparing with the standard MP arthrotomy displayed no significantly different outcomes of KSS and adverse events at six week and one year follow up. Previous articles of TKA were individual study in terms of prosthetic character, design, and surgical approach with inconclusive outcomes.

The objective of the present study was to compare the early outcomes between standard MP approach and SV approach by MB TKA using posterior CR design.

Material and Methods

The present study was a prospective study approved by the Human Research Ethics Committees of Bangkok Metropolitan Administration, Thailand (No. S002h/65). All voluntary participants signed the consent form. Forty-two adult patients, for 66 TKA operations, of primary osteoarthritis of knee with radiographic evidence of late stage (Kellgren Lawrence classification III-IV) osteoarthritis of the knee and failure to conservative treatment at least six months in Orthopedic Department of BMA General Hospital were enrolled between February 1, 2022, and December 31, 2023. Exclusion criteria composed of secondary osteoarthritis such as inflammatory arthritis, infective arthritis and posttraumatic arthritis, subsequently involving previously high tibial osteotomy, more than 38 of body mass index (BMI), as morbid obesity[14,15], and elderly or above 90 years old, which may have poor operative risk-benefit[16]. The withdrawal subject criteria were severe medical complications. The participants were randomly allocated to control and study groups by computer (Microsoft® Excel program, data sampling menu) generated number. The control group received TKA, which used MB total knee replacement by standard MP approach with CR design. The study group was assigned MB total knee replacement with CR the same as the first group but used the SV approach. To prevent potential confounding variables such as pre-existing health conditions or other that make differences between the two groups, all the patient would be randomized on the operative day and the nurse, who recorded the parameters of outcome and was not involved in the trial, was unable to know which group the patient was in. Due to the same protocol in all cases, there were no variations from the rehabilitation.

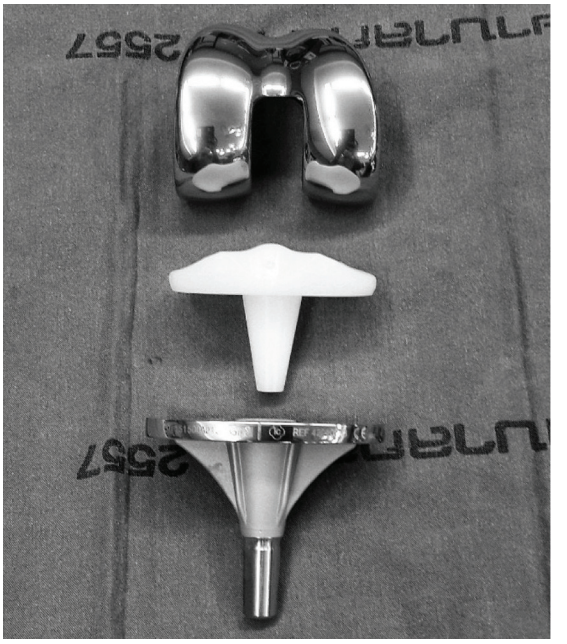

Figure 1. Mobile bearing with posterior cruciate retaining knee prosthesis.

Operative details

Under spinal anesthesia with tourniquet control, both groups were operated by a single surgeon using the same MB CR total knee prosthesis (ACS® Implantcast, Germany), which is normally used in the BMA General Hospital (Figure 1). In the control group, after the skin and subcutaneous incision, the surgeon made the incision via the quadriceps tendon above the superior pole of the patella to the tibial tubercle for knee arthrotomy. In the study group, the surgeon identified the inferior border of the Vastus Medialis Oblique (VMO). Using a blunt dissection, the VMO attaching with the patella was retracted laterally to perform the arthrotomy. With this approach, the surgeon would not cut through the quadriceps tendon (Figure 2). After the knee arthrotomy in both group, the surgeon performed the same bony procedures. The perpendicular cut with 5 degrees posterior slope of proximal tibia was done by extramedullary guide and the distal femoral cut used the intramedullary technique with 6 degrees valgus alignment. Femoral sizing and external rotation of 3 degrees to posterior condylar axis was measured.

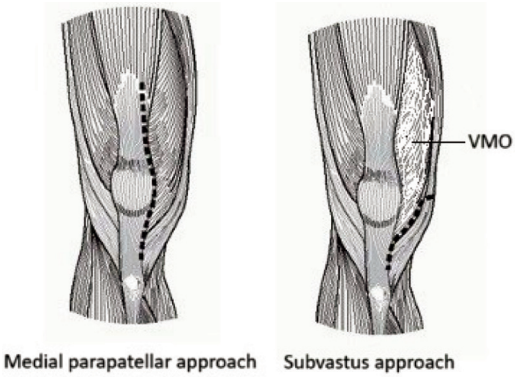

Figure 2. Diagram demonstrate medial parapatellar and subvastus approach (dot line), Vastus Medialis Oblique (VMO) in gray color.

The 4 in 1 distal femoral cutting block was placed to perform the final femoral bony cut and then finished with the tibial rotating base plate. The patella was not resurfacing in all cases. However, the osteophytes were removed and denervation with electrocautery was done. After the examination of the knee stability and the patellar tracking, the lateral retinacular release was performed in cases of tight patellar tracking. Both femoral and tibial components were put in position by bone cement and using cone-type of MB polyethylene tibial insert. The vacuum drain was placed, and the wound was closed. In the control group, the surgeon repaired the quadriceps tendon with sutures. In the study group, the surgeon relocated the patella and VMO and then sutured. All TKAs used intermittent pneumatic pump postoperatively. Drain was removed on postoperative day 1 and then rehabilitation program started to get the patient walking.

The early postoperative outcomes within 24 to 48 hours of both groups comprised of intraoperative and postoperative blood loss, duration of operation, length of incision wound, visual analog pain scales (VAS) at six hours, 12 hours and 24 hours, preoperative KSS, operative time, tourniquet time, and clinical complications such as replacement blood transfusion and degree angle of active straight leg raising by goniometer presuming quadricep muscle power. Those postoperative outcomes were collected. There was the safety postoperative surveillance for major complications such as death, postoperative intubation, cerebrovascular event, hypovolemic shock, pulmonary thromboembolic event, myocardial infarction, acute renal failure, sepsis, wound dehiscence, superficial infection, and wound infection or deep surgical organ/space infection that needed to be treated. These complications will be recorded in the medical record and reported in the case-record form. Early physical rehabilitation, which started within 48 hours, using the same standard treatment protocol for TKA of all participants were performed. The goals of rehabilitation were progressive reduction in swelling and pain, range of knee motion from 0 to 90 degrees, knee extension strength, self-ambulation using a walker, and weight-bearing as tolerated. These goals would be achieved before discharge. After two weeks of postoperative follow up, the patient would be re-evaluated at the outpatient department (OPD) for surgical wound, postoperative radiograph, pain reduction, any complications, improvement in ROM, and activities of daily living. In addition, KSS was recorded for eight weeks during postoperative follow up.

The IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA), licensed to BMA, the Medical Service Department was used for data analysis. Descriptive statistics were used to analyze demographic data. The Independent samples t-test or the Mann-Witney U test was used to compare differences between the standard MP group and the SV group, including age, BMI, operative duration, tourniquet time, wound length, KSS, VAS, the straight leg raising angle, blood volume loss, and length of stay. The Pearson's chi-square test or Fisher's exact test was used to test whether two categorical variables are related to each other, such as gender, side operation, and unilateral/bilateral TKAs. A p-value of less than 0.05 was considered statistically significant.

The sample size for comparing the time to actively perform a straight leg raise between the SV approach and the standard MP approach was calculated based on the study results of Pan et al[17]. The authors calculated 23 patients, however, to ensure more accurate data, the authors increased the sample size by 30%, requiring each group to have 33 knees.

Results

Forty-three patients, representing 66 TKAs, were included in the present study. Twenty patients underwent unilateral TKAs, and 23 patients had bilateral TKAs. The majority of them was women, with 36 patients (83.7%), as shown in Table 1. The mean age of the patients was 70.2±6.7 years with a range of 54 to 85 and 95.3% of the patients were 60 years or older. The mean BMI was 25.7±3.5 kg/m² with a range of 18.7 to 34.1. In 32 TKAs the right knee was operated, in 34 TKAs the left knee, for a right to left side ratio of 0.9:1. The mean preoperative

Table 1. Demographic data of study population

Characteristics	Patients (n=43, 66 TKAs)
Age (years); mean±SD	70.2±6.7
<60 years; n (%)	2 (4.7)
≥60 years; n (%)	41 (95.3)
Sex; n (%)	
Male	7 (16.3)
Female	36 (83.7)
BMI (kg/m^2); mean±SD	25.7±3.5
Side (operation); n of TKAs (%)	
Right	32 (48.5)
Left	34 (51.5)
Unilateral/bilateral TKAs; n	20/23
Preoperative KSS; mean±SD	69.4±6.5
Preoperative varus deformity (degree); median (IQR)	4.0 (2.5 to 6.5)

TKA=total knee arthroplasty; BMI=body mass index; KSS=knee society score; SD=standard deviation; IQR=interquartile range

Table 2. Comparison of baseline characteristics of participants between standard MP and subvastus

Characteristics	Subvastus (n=33, 33 TKAs)	Standard MP (n=32, 33 TKAs)	p-value
Age (years); mean±SD	69.6±7.1	71.1±6.5	0.373
Sex (male/female); n	4/29	7/25	0.294
BMI (kg/m^2); mean±SD	25.8±3.4	25.6±3.5	0.826
Side (right/left); n of TKAs	14/19	18/15	0.325
Unilateral/bilateral TKAs; n	33/0	31/1	0.492

TKA=total knee arthroplasty; MP=medial parapatellar; BMI=body mass index; SD=standard deviation

No statistically significant between-group difference (p>0.05)

KSS was 69.4±6.5. The median preoperative varus deformity was 4.0 (IQR 2.5 to 6.5) degrees.

Patients were randomly assigned to the study group to represent 33 TKAs with the SV approach and to the control group with 33 TKAs with a standard MP approach. The mean age of the patients was 71.1±6.5 years, with a range of 58 to 85 years, in the standard MP group versus 69.6±7.1 years, with a range of 54 to 85 years in the SV group. The comparison of baseline characteristics of participants between the SV approach and the standard MP approach is shown in Table 2. No significant differences in age, gender, BMI, side operated, and unilateral/bilateral TKAs were found between the two groups.

The operative time and the tourniquet time in the SV group were significantly less than in the MP group (p=0.002 and 0.007, respectively). The quadricep function as the degree of straight leg raising at 6 hours, 12 hours, and 24 hours in the SV group was significantly higher than in the standard MP group (p=0.009, 0.003, and 0.001, respectively), while at 1 hour, it was higher but not significantly. No significant differences in incision length, preoperative or postoperative KSS, VAS pain score, blood loss, and the length of stay were found between the two groups, as shown in Table 3.

The VAS scores, the straight leg raising angle, and the blood loss of the patients in the SV group and the standard MP group was measures at 1 hour, 6 hours, 12 hours, and 24 hours. Normality checks were carried out on the data, which showed that the VAS scores and the straight leg raising angle were normally distributed, while the blood loss was not. A repeated measures ANOVA with a Greenhouse-Geisser correction showed that mean VAS score in the SV group and the standard MP group differed significantly between time points (p<0.001 and <0.001, respectively). Post hoc tests using the Bonferroni correction revealed that VAS score in the SV group increased by an average of 1.3 between 1 hour and 6 hours (p=0.002) and then reduced by an average of 0.8 between 6 hours and 24 hours (p=0.032). While the VAS score in the standard MP group increased by an average of 1.6 between 1 hour and 6 hours (p<0.001) and then reduced by an average of 1.2 between 6 hours and 24 hours (p=0.006).

The mean straight leg raising angle in the SV group and the standard MP group differed significantly between time points (p<0.001 and <0.001, respectively). Post hoc tests revealed that mean straight leg raising angle in the SV group increased by an average of 25.9 degrees between 1 hour and 6 hours (p<0.001) and then increased by an average of 16.7 degrees between 6 hours and 12 hours (p=0.032), and an average of 9.1 degrees between 12 hours and 24 hours (p<0.001). While mean straight leg raising angle in the MP group increased by an average of 18.8 degrees between 1 hour and 6 hours (p<0.001) and then increased by an average of 16.7 degrees between 6 hours and 12 hours (p<0.001), and an average of 9.4 degrees between 12 hours and 24 hours (p<0.001).

The Friedman test was used to assess the difference in blood loss between time points. In this study, we found that there was a statistically significant difference in blood loss between time points in the SV group (p<0.001) and the standard MP group (p<0.001). Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at p<0.013 (0.05/4=0.013). Median blood loss in the SV group for 1 hour, 6 hours, 12 hours, and 24 hours

Table 3. Outcome comparison between standard MP and Subvastus

Parameters	Subvastus (n=33, 33 TKAs)	Standard MP (n=32, 33 TKAs)	Effect size (95% CI)	p-value
Operative time (minutes); mean±SD	63.5±7.7	69.3±7.4	–5.8 (–9.6 to –2.2)	0.002*
Tourniquet time (minutes); mean±SD	47.3±6.6	52.3±7.8	–5.0 (–8.6 to –1.4)	0.007*
Incision length (cm); mean±SD	10.3±0.4	10.5±0.4	–0.2 (–0.4 to 0.1)	0.071
KSS score; mean±SD				
Preoperative	69.6±6.5	69.3±6.7	0.3 (–3.0 to 3.5)	0.867
Postoperative (8 weeks)	95.3±2.5	94.7±2.9	0.6 (–0.7 to 1.9)	0.364
VAS score; mean±SD				
At 1 hour	0.8±1.2	1.1±1.4	–0.3 (–1.0 to 0.4)	0.360
At 6 hours	2.1±1.4	2.7±1.5	–0.6 (–1.4 to 0.1)	0.082
At 12 hours	1.9±1.2	1.9±1.1	0.0 (–0.6 to 0.6)	1.000
At 24 hours	1.2±1.1	1.5±1.1	–0.3 (–0.8 to 0.3)	0.388
Straight leg raising (degree); mean±SD				
At 1 hour	14.4±17.7	9.2±13.1	5.2 (–2.5 to 12.9)	0.185
At 6 hours	40.3±19.3	27.4±19.6	12.9 (3.3 to 22.4)	0.009*
At 12 hours	56.9±14.9	43.9±19.4	13.0 (4.5 to 21.5)	0.003*
At 24 hours	66.0±10.9	53.9±17.2	12.1 (5.1 to 19.2)	0.001*
Blood loss (mL); median (IQR)				
At 1 hour	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.644
At 6 hours	40.0 (27.5 to 100.0)	60.0 (30.0 to 100.0)	–10.0 (–40.0 to 10.0)	0.178
At 12 hours	100.0 (60.0 to 160.0)	120.0 (90.0 to 195.0)	–20.0 (–60.0 to 0.0)	0.126
At 24 hours	120.0 (100.0 to 215.0)	150.0 (120.0 to 275.0)	–40.0 (–80.0 to 0.0)	0.079
Total blood loss	300.0 (187.5 to 470.0)	330.0 (275.0 to 605.0)	–80.0 (–170.0 to 10.0)	0.081
Length of stay (days); mean±SD	7.8±2.7	8.3±2.9	–0.5 (–1.9 to 0.9)	0.484

TKA=total knee arthroplasty; MP=medial parapatellar; KSS=knee society score; VAS=visual analog scale; SD=standard deviation; IQR=interquartile range

were 0.0 (0.0 to 0.0), 40.0 (27.5 to 100.0), 100.0 (60.0 to 160.0), and 120.0 (100.0 to 215.0), respectively. There were significant differences between 1 hour and 6 hours ($p<0.001$), between 6 hours and 12 hours ($p<0.001$), and between 12 hours and 24 hours ($p<0.001$). While median blood loss in the standard MP group for 1 hour, 6 hours, 12 hours, and 24 hours were 0.0 (0.0 to 0.0), 60.0 (30.0 to 100.0), 120.0 (90.0 to 195.0), and 150.0 (120.0 to 275.0), respectively. There were significant differences between 1 hour and 6 hours ($p<0.001$), between 6 hours and 12 hours ($p<0.001$), and between 12 hours and 24 hours ($p<0.001$).

The patellar tracking was excellent in all cases, and no lateral retinacular release was required. Furthermore, no major complications such as death, postoperative intubation, cerebrovascular accident, hypovolemic shock, pulmonary thromboembolic event, myocardial infarction, acute renal failure, sepsis, wound dehiscence, superficial infection, wound infection, or deep surgical organ/space infection were found. Early postoperative at two weeks and up to eight weeks follow-up time was obtained. No patients were lost to follow-up.

Discussion

Two bearing knee designs for TKA comprises of fixed and mobile types. The round femoral architecture with flat tibial articular surface of fixed design produces axial rotation that results in high stress contact between the femoral and the tibia surface. Due to these conditions, the MB design has emerged to harmonize the tibiofemoral interface with a natural kinematic to reduce the tear process, diminishing interface stress of the implant and increasing knee function[18]. Moreover, Grupp et al.[19] recommended that the additional surface of MB design could decrease the wear process at the articulation site. In addition, Buechel et al.[5] claimed that the MB design was better than the fixed type because of the decrease in pain and the restoration of knee function without the meniscus bearing dislocation. Also supported by Fransen et al. study[6], exhibiting the MB significantly increased clinical and functional outcome and better KSS, comparing with FB. Furthermore, long term ten years follow-up by Vogt & Saarbach study[7] reported that MB design was safer and had a lower revision rate than fixed design. Nevertheless, the meta-analysis by Hao &

Wang[20] in 2021 from six RCTs that had follow-up of ten years and 451 patients with 612 knees, found no significant difference between the two design groups according to VAS pain score, KSS, ROM, and complication rates. The studies by Bistolfi et al.[21] and McGonagle et al.[22] had the same results. Finally, Hao & Wang study[20] concluded that MB had advantage about lower revision rates over the FB when the posterior cruciate ligament was replaced. Their subgroup analysis also ascribed that MB was stronger, with an increase of KSS, than FB in CR design (p=0.009).

A systematic review and meta-analysis about the comparison of CR and PS in TKA during gait by Li et al.[23], Shanxi Medical University, China included nine studies in term of gait analysis which revealed that CR design had a significant lower knee flexion angle than PS design, however, no significant difference was shown in all kinematic gait parameters such as knee extension, walking speed, and KSS. These articles are limited in data, thus better quality and long term follow up of RCTs study should be done to increase the parameters such as pain relief, walking and climbing stairs, to measure the patient's ability. Mahoney et al.[24] and Dennis et al.[25] studies documented that CR design could increase ROM and knee flexion by restoring anatomical femoral rollback and normal knee biomechanics, but some studies showed a default of posterior femorotibial translation in knee flexion of this design. On the other hand, a study by Victor et al.[26] claimed that posterior translation of the femur creates more clearance on the tibia, and theoretically, more knee flexion. Eventually, a systematic review of nine studies included in the meta-analysis reports by Li et al.[23] showed no significant difference in overall kinematic gait parameters, knee extension, walking speed, and KSS between both of two designs. In the present study, the authors chose MB type because of less operative time than fixed model, which Olivecrona et al.[27], documented that the average tourniquet time in TKA was about 100 minutes. They also found that prolonging tourniquet time increased the risk of complications[28]. Tourniquet time of more than 90 minutes may be associated with an increase odds ratio of complications[29]. The authors also appreciated CR design in basic, due to more ligament and bone preservation.

With regard to surgical approach, Peng et al.[30] meta-analysis reviewed 19 RCTs with 1,578 patients on the database PubMed, up to July 2014. The results suggested SV approach showed better ends in VAS, ROM, straight leg raise, and lateral retinacular release than MP approach. There was no difference in KSS, complications, wound infections, deep vein thrombosis, hospital stay, and blood loss. This is consistent with the overview of RCTs in primary TKA, from a systematic reviews and meta-analysis by Matar et al.[31] that included 34 RCTs with 2,459 subjects, about surgical approach. It showed only one RCT research that demonstrated better early outcomes with SV approach. The early return of straight leg raise ($p<0.001$), lower opiate use in the first week ($p<0.001$), less blood loss ($p<0.001$), and greater knee flexion at first week ($p<0.001$). As supported by Liu & Yang et al.[32] in a 2011 meta-analysis about the comparison between the minimally invasive SV and standard MP approaches for TKA, it found early recovery by minimally invasive SV in respect of blood loss, ROM, surgical duration, straight leg test, and hospital stay, comparing with MP approach. However, it was not significant in the long-term follow-up of more than one year. Surprisingly, the present study searched on the Cochrane Central Register of Controlled Trials, and no article exhibited early result between SV and standard MP approach in TKA using only cruciate retained ligament design by MB implant.

Therefore, the present study is the first, and there is a learning curve. The authors compared early outcomes of TKA, using MB with CR design between SV and standard MP approach. The result showed that operative time, tourniquet time, and degree of straight leg raising in the SV group were significantly better than in the MP group. However, the length of stay, VAS pain score, KSS, incision length, and blood loss in the SV group were better than in MP group, but not significantly.

The strength of the present study is that there is no article in the literature about the early outcome between SV approach and MP groups in TKA in aspects of using only CR technique and MB implant. Nevertheless, the limitation is that it is a small number of patients. Further prospective long-term studies with larger TKA operations by using CR model with MB implant should be encouraged.

Conclusion

TKA using MB with CR design by SV approach have less operative time than MP approach. This may be due to the design of MB prosthesis having less steps of operation. Furthermore, the less operative and tourniquet times result in less blood loss. SV approach increases the angle of active straight leg

raising, presuming improvement in quadricep muscle function.

What is already known about this topic?

In terms of approach in TKA, the previous studies were controversial. Some revealed that SV approach was better than MP approach regarding to VAS, ROM, straight leg raising test, whereas some was not significant in the long-term follow up. However, each study used different prosthetic designs such as CR, PS, or others, and types of prosthesis such as MB or FB.

What does this study add?

The present study is the first article, displaying early outcomes at eight weeks between SV and standard MP approaches in TKA, using only a single type of prosthesis, CR technique and MB implant type. It revealed that SV approach produced less operative time, tourniquet time, less blood loss and increased the angle of active straight leg raising test.

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Conflicts of interest

The authors declare no conflict of interest.

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