

Review

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Comparative analysis of the efficacy of quadriceps-sparing approaches in total knee arthroplasty

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Abstract

Introduction Total knee arthroplasty (TKA) is the gold-standard surgical intervention for end-stage knee osteoarthritis. With the widespread adoption of Enhanced Recovery After Surgery (ERAS) protocols, the selection of an optimal surgical approach has become increasingly relevant to achieving rapid functional recovery.

The **aim** of this study was to evaluate the efficacy of the subvastus (SV) and midvastus (MV) approaches compared to the medial parapatellar approach (MP) in terms of the rate and ultimate outcomes of functional recovery following TKA.

Materials and Methods This systematic review was conducted in accordance with the PRISMA 2020 guidelines. A literature search was performed across PubMed, Science Direct, Google Scholar, and eLibrary for the period 2020–2025. Eligible studies included original clinical investigations of primary TKA in patients with knee osteoarthritis. Of 607 initially identified publications, 12 studies were included in the final analysis.

Results SV and MV were associated with significantly earlier achievement of active straight leg raise (by 1.3–1.8 days), reduced pain intensity on the VAS during the first 1–3 postoperative days, and greater ROM during the first 3–6 weeks compared with the MP approach ($p < 0.05$). The rate of intraoperative lateral release was significantly lower in the SV and MV groups. Use of the SV approach was associated with longer operative time by 10–13 minutes. By 3–6 months of follow-up, intergroup differences in KSS, WOMAC, and OKS scores were no longer significant, and at 10–15 years the groups demonstrated full functional equivalence.

Discussion These findings are consistent with the conclusions of major meta-analyses confirming the transient nature of the functional advantages associated with quadriceps-sparing approaches. Heterogeneity in outcomes related to blood loss and length of hospital stay is largely attributable to variability in rehabilitation protocols and discharge criteria across institutions.

Conclusion The choice of surgical approach determines the rate, but not the ultimate outcome, of functional recovery. The SV approach is preferable within ERAS frameworks; however, an individualised strategy accounting for patient-specific anatomy, surgical expertise, and institutional rehabilitation capacity remains the most evidence-based strategy.

Keywords: total knee arthroplasty, subvastus approach, midvastus approach, medial parapatellar approach, systematic review, fast postoperative recovery

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INTRODUCTION

Total knee arthroplasty (TKA) is currently recognized as the most effective surgical treatment for end-stage knee osteoarthritis. This procedure not only significantly improves patients' quality of life but also demonstrates long-term cost-effectiveness [1, 2]. According to current data, approximately 1.3–1.5 million knee replacement surgeries are performed annually in various countries. Researchers note a steady upward trend in this number due to increasing life expectancy and growing demands on quality of life in older age population [1, 3, 4].

In today's healthcare system, optimization of surgical technologies aimed at reducing hospital stays, accelerating rehabilitation, and lowering overall treatment costs is becoming increasingly important. Enhanced Recovery After Surgery (ERAS) programs are becoming the standard of care, placing new demands on the choice of surgical techniques for TKA [5–6]. In this context, choosing the optimal surgical approach is crucial for achieving the best functional results in the shortest possible time.

Despite the high efficacy of TKA, the choice of the optimal surgical approach remains a subject of active debate in the orthopedic community. Various surgical approaches differ significantly in terms of invasiveness, their impact on anatomical structures, and, most importantly, the rate of patient's functional recovery in the postoperative period [7].

The classical medial parapatellar approach (MP), first described by B. Langenbeck in 1879, was long considered the "gold standard" for performing TKA [8]. However, in the 1970s and 1980s, in parallel with the development of new concepts in arthroplasty, an active search began for alternative surgical techniques aimed at modifying and improving approaches to the knee joint [1].

As an alternative, quadriceps-sparing techniques have been developed: the subvastus approach (SV), first described by A.A. Hofmann in 1991, and the midvastus approach (MA), proposed by G.A. Engh in 1997 [8]. Their fundamental difference lies in preserving the integrity of the quadriceps tendon. SV involves an L-shaped arthrotomy below the lower edge of the vastus medialis muscle without dissecting it, which ensures early restoration of the extension function and better blood supply to the patella [9]. MA involves blunt splitting of the muscle fibers of the vastus medialis muscle along their direction 2–5 cm from the superomedial angle of the patella, which improves surgical exposure compared to SV with less trauma to the extensor mechanism compared to the standard parapatellar approach [10, 11].

In light of current trends toward rapid rehabilitation and reduced hospitalization times, a comparative analysis of various surgical approaches for TKA is particularly relevant. Growing patient demands for quality medical care, the need to reduce the burden on the healthcare system, and economic factors dictate the need for techniques that ensure the fastest and safest possible restoration of knee function [12, 13].

Of particular importance is the fact that even minor differences in surgical technique can have a significant impact on the rate of patient recovery, the severity of pain in the early postoperative period, the time point for the active rehabilitation, and the overall duration of treatment [6, 14]. In this regard, a detailed study of the advantages and disadvantages of various surgical approaches, accumulated in the world literature over the past five years, seems extremely relevant for current orthopedic practice.

The **aim** of this study was to evaluate the efficacy of the subvastus (SV) and midvastus (MV) approaches compared to the medial parapatellar approach (MP) in terms of the rate and ultimate outcomes of functional recovery following TKA.

MATERIALS AND METHODS

This systematic literature review was conducted in accordance with the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [15]. The study protocol was developed before the literature search. Institutional ethics board approval was not required.

The research question formulated using the PICOS model was: “What is the evidence from original clinical trials over the past five years (2020–2025) on the comparative effectiveness of the medial parapatellar, subvastus, and midvastus surgical approaches for primary total knee arthroplasty in adult patients with gonarthrosis in terms of functional outcomes, perioperative parameters, and complication rates?”

A search of literature published between 2020 and 2025 was conducted by two independent researchers in the PubMed, Science Direct, Google Scholar, and eLibrary databases.

PubMed query: ("total knee arthroplasty"[MeSH] OR "total knee replacement"[MeSH]) AND ("subvastus"[tiab] OR "midvastus"[tiab] OR "parapatellar"[tiab]) AND ("randomized controlled trial"[pt] OR "prospective study"[pt] OR "cohort study"[tiab] OR "comparative study"[tiab]).

Similar queries were used in Science Direct, Google Scholar, and eLibrary (in Russian). Additionally, a manual search of the reference lists of the selected publications was performed.

The following indicators were assessed in literature sources:

1) functional outcomes:

- time till first independent active straight leg raise (ASLR);
- knee range of motion;
- evaluation with functional scales:
 - KSS (Knee Society Score of the American Knee Society);
 - WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index);
 - OKS (Oxford Knee Score);
 - KSFS (Knee Society Functional Score of the American Knee Society);
 - HSS (New York Hospital for Special Surgery Knee Score).

2) Perioperative parameters:

- duration of surgery;
- blood loss;
- rate of lateral release (LR) and intraoperative complications.

3) Early postoperative results:

- pain severity by visual analogue scale (VAS);
- duration of hospital stay;
- start term of rehabilitation;
- rate of early postoperative complications.

4) Long-term results:

- functional status after 6 to 12 months;
- rate of long-term complications.

Inclusion criteria are presented in Table 1.

Exclusion criteria: meta-analyses, systematic reviews, narrative reviews, single clinical observations (these were not included in the main analysis and were used for comparison and discussion of results); TKA for rheumatoid arthritis or other inflammatory arthropathies; revision TKA, revision surgeries; duplication of samples from previously included publications.

Table 1

Inclusion criteria according to PICOS

| PICOS components | Criteria |
|------------------|---|
| P – Population | Adult patients (≥ 18 years) with a verified diagnosis of gonarthrosis who underwent primary TKA; minimum sample size of at least 15 patients in each comparison group |
| I – Intervention | TKA using quadriceps-sparing surgical approaches: SV (including its modification mini-SV) and/or MV (including mini-MV) |
| C – Comparison | TKA using standard MP; direct comparison of SV and MV is also allowed |
| O – Outcome | Functional outcomes (time to first active ROM, knee range of motion, KSS, KSFS, WOMAC, OKS, HSS scores); perioperative parameters (duration of surgery, blood loss, intraoperative LR rate); early postoperative results (pain according to VAS, length of hospital stay, early complication rate); long-term results (functional status after 6–12 months or more, patient satisfaction, late complication rate and revision surgery rate) |
| S – Study design | Original clinical studies in English or Russian: randomized controlled trials (RCTs), prospective and retrospective comparative cohort studies; minimum follow-up period of 3 months; publication period 2020–2025 |

The first step was title and abstract screening (performed by two independent researchers), and the second step was full-text evaluation. Disagreements were resolved by consensus. Data were extracted using a standardized format: authors, year of publication, country, study design, sample, surgical approaches, follow-up period, and outcome values. Given the heterogeneity of the included studies in terms of design and assessed outcomes, a quantitative meta-analysis was deemed inappropriate, and the results were synthesized using a narrative review. The selection flowchart is presented in Figure 1.

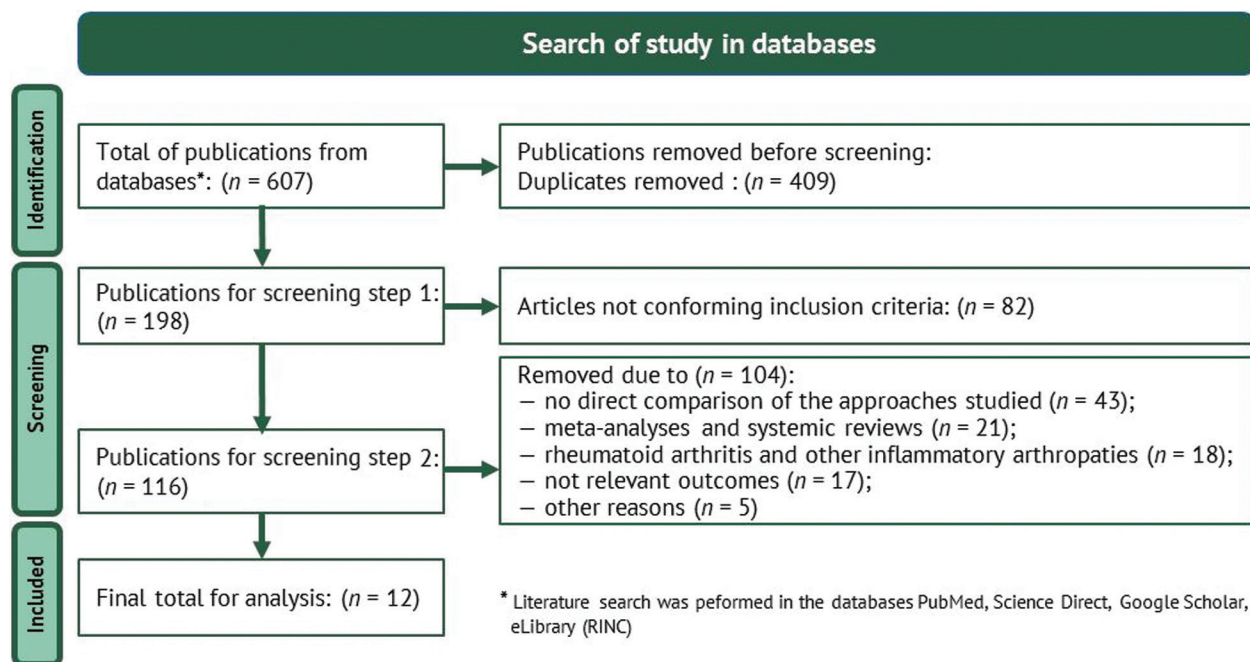


Fig. 1 Flowchart of a systematic literature review conducted according to the PRISMA protocol

RESULTS

Search results

A total of 607 publications were identified during the systematic search. After removing duplicates, 198 sources were screened. Based on the analysis of titles and abstracts, 82 records were excluded as not meeting the inclusion criteria. Full-text evaluation was performed for 116 studies, of which 104 were excluded for the following reasons: lack of direct comparison of the studied approaches ($n = 43$); meta-analyses and systematic reviews ($n = 21$); rheumatoid arthritis and other inflammatory arthropathies ($n = 18$); irrelevant outcomes ($n = 17$); other reasons ($n = 5$). The final analysis included 12 original clinical studies published over the past five years. A brief description of the studies included in this review is presented in Table 2.

Characteristics of the studies included in the review

The geography of the reviews covers eight countries: India ($n = 4$) [16–19], China ($n = 2$) [20–21], Saudi Arabia ($n = 1$) [22], Singapore ($n = 1$) [23], Iran ($n = 1$) [24], Turkey ($n = 1$) [25], Egypt ($n = 1$) [26], and Brazil ($n = 1$) [27].

In terms of design, the included studies included RCTs ($n = 3$) [16, 19, 20], prospective comparative or cohort studies ($n = 5$) [17, 22, 23, 25, 26], and retrospective comparative or cohort studies ($n = 4$) [18, 21, 24, 27].

The total sample size was 1280 patients. Separate study sizes ranged from 17 [25] to 300 [19] participants.

All included patients underwent total knee arthroplasty for gonarthrosis.

Thematic distribution of the compared surgical approaches: subvastus versus medial parapatellar — nine studies; midvastus versus medial parapatellar — three studies. No direct comparisons of the subvastus approach with the midvastus approach were presented in the included studies.

The outcomes assessed included: pain according to the visual analog scale (VAS), range of motion in the knee joint, time to the first active SLR, functional outcomes according to the KSS, KSFS, KOOS, WOMAC, OKS, HSS, HFKS scales, duration of surgery, volume of intraoperative blood loss, length of hospital stay, incidence of LR and postoperative complications.

Comparative analysis of perioperative indicators

Preoperative characteristics In all 12 studies included, the groups were comparable in terms of the main baseline demographic and clinical parameters, such as age, body mass index, and preoperative functional indices ($p > 0.05$), with one exception. Thus, in the study by Güven et al. [25], the baseline KSS score was significantly higher in the SV group, (46.6 ± 7.6) versus (38.1 ± 7.9) ($p = 0.045$), although no differences in WOMAC were found in the same study ($p = 0.352$).

Duration of surgery This parameter was significantly higher in the SV group compared to MP in two studies. Mathew et al. [19] recorded a difference of (108.79 ± 7.36) versus (96.64 ± 5.30) min ($p < 0.001$), and Hu et al. [21] also confirmed a significant increase in the intervention time in SV ($p < 0.001$). In the remaining studies, no significant intergroup differences in this parameter were found.

Intraoperative blood loss The results for this indicator were heterogeneous. Two studies [16, 21] noted significantly lower blood loss in the SV group compared to the MP group ($p < 0.05$), while other studies [24, 26] did not find any intergroup differences in blood loss ($p < 0.05$).

Lateral release rate In a number of studies, approaches that do not involve patellar eversion were associated with a reduced need for intraoperative LR. Dileep et al. [17] recorded six cases of LR with SV versus 14 with MP ($p = 0.024$). Geng et al. [20] also showed a significantly lower rate of LR in the SV group. In another study [18], the authors noted a significantly lower rate of LR in MV group compared to MP (2 % versus 8.5 %; $p = 0.03$). Jhurani et al. [16] did not find any statistically significant differences in this indicator in their study.

Table 2

Brief description of the studies included in the review

| Authors, year, country | Design/sample size | Approaches compared | Follow-up | Assessed parameters | Key results |
|-------------------------------------|---|---------------------|-----------|---|---|
| Jhurani et al., 2021, India [16] | RCS, <i>n</i> = 186 | SV and MP | 2 years | Blood loss, ASLR, KSS, WOMAC, VAS, LR, range of motion, walking, length of hospital stay, complications | SV: — less blood loss ($p < 0.05$); — higher rate of wound dehiscence in SV ($p = 0.05$); No significant differences were found in terms of ASLR, walking, analgesics intake, duration of hospitalization, KSS, WOMAC, VAS, LR scales, and range of motion |
| Dileep et al., 2022, India [17] | Prospective, comparative, <i>n</i> = 54 | SV and MP | 12 months | Range of motion, KSS, VASH, ASLR, LR | SV: — better range of motion on day 3 (69.3 vs 63.7°; $p = 0.039$), at 2 and 6 weeks; — higher KSS on day ($p < 0.00001$); — lower Vas on days 1 and 3; — shorter time till ASLR (1.81 vs 2.85 days; $p < 0.00001$); — fewer LRs ($p = 0.024$). No differences from month 3 |
| Katragadda et al., 2023, India [18] | Retrospective cohort, <i>n</i> = 200 | MV and MP | 6 months | LR, ASLR, VAS, range of motion, KSS | MV: — lower LR (2 % vs. 8.5 %; $p = 0.03$); — shorter time to ASLR ($p < 0.05$); — better VAS; — better range of motion and KSS in the first month ($p < 0.05$). There are no differences further on and in patellar parameters (Feller scale) |
| Mathew et al., 2025, India [19] | RCS, <i>n</i> = 300 | SV and MP | 24 months | Duration of surgery, ASLR, length of hospital stay, KSS, complications | SV: — long surgery (108.8 vs 96.6 min; $p < 0.001$); — shorter time to ASLR (5.1 vs 6.1 days; $p < 0.001$); — shorter inpatient stay (5.3 vs 6.4 days; $p < 0.001$). KSS improved in both groups; no intergroup differences were found at any follow-up point (up to 24 months). No complications |
| Geng et al., 2022, Chin [20] | RCS, double blind, <i>n</i> = 58 | mSV and MP | 30 days | Range of motion, HSS, VAS, ASLR, LR | mSV: — higher ROM (118.9 vs 107.6°; $p < 0.001$) and HSS (72.0 vs 61.2; $p < 0.001$) on day 3; — lower VAS on days 1–3; — shorter time to ASLR (1.17 vs 3.09 days; $p < 0.001$); — fewer LRs. No differences on day 30 |
| Hu et al., 2025, Chin [21] | Retrospective cohort, <i>n</i> = 93 | SV and MP | 12 months | Blood loss, incision length, surgery duration, VAS, range of motion, WOMAC, OKS | SV: — lower blood loss ($p = 0.005$), — shorter incision length ($p < 0.001$), — longer surgery ($p < 0.001$); — lower VAS on day 3; — better ROM till 7 days; — better WOMAC up to 1 month; OKS up to 3 months ($p < 0.05$). There are no differences in long-term follow-up or radiological parameters |

Table 2 (continuation)

Brief description of the studies included in the review

| Authors, year, country | Design/sample size | Approaches compared | Follow-up | Assessed parameters | Key results |
|---|-------------------------------------|---------------------|-------------|--|---|
| Aladraii et al., 2024, Saudi Arabia [22] | Retrospective cohort, $n = 98$ | SV and MP | 12 months | WOMAC, OKS, complications | MP: <ul style="list-style-type: none"> — better WOMAC (15.3 vs 25.1; $p = 0.002$) and OKS (20.5 vs 27.6; $p = 0.001$) at 3 months; — differences persist at 6 months ($p < 0.001$). No significant differences at 12 months. No complications in both groups |
| Quah et al., 2025, Singapore [23] | Retrospective cohort, $n = 72$ | MV and MP | 4–6 weeks | Walking, ASLR, length of hospital stay, duration of surgery, complications | MV: <ul style="list-style-type: none"> — longer distance of walking on day 1 (30 vs 18 m; $p < 0.001$); — shorter time to ASLR (0 vs 1 day; $p = 0.016$). No differences in hospital stay, time of surgery and complications |
| Hosseini-Monfared et al., 2024, Iran [24] | Retrospective cohort, $n = 60$ | SV and MP | 10–15 years | ASLR, WOMAC, KSFS, KSS, VAS, surgery time, blood loss, hospital stay, complications | SV: <ul style="list-style-type: none"> — shorter time to ASLR (1.8 vs 3.6 days; $p < 0.001$); — better WOMAC and KSFS after a year ($p < 0.05$). No differences in KSS and VAS after 10–15 years. Surgery time, blood loss, hospital stay and complications did not differ |
| Güven et al., 2024, Turkey [25] | Retrospective comparative, $n = 17$ | SV and MP | 3 months | WOMAC, KSS, ASLR | After 3 months, there were no significant between-group differences in WOMAC and KSS ($p < 0.05$). There was a trend toward earlier ASLR in SV (0.8 vs. 1.4 days; $p = 0.053$). According to ultrasound elastography, the stiffness of the vastus medialis and lateralis muscles recovered equally in both groups |
| Badawi et al., 2024, Egypt [26] | Retrospective comparative, $n = 60$ | SV and MP | 6 months | KSS, WOMAC, VAS, duration of surgery, blood loss, length of hospital stay, complications | Both groups showed a significant improvement in functional parameters ($p < 0.001$). No significant differences were found between the groups in KSS, WOMAC, VAS, surgery duration, blood loss, hospitalization, or complications |
| Silva et al., 2025, Brazil [27] | Retrospective comparative, $n = 82$ | MV and MP | 15–60 days | VAS, walking | MV: <ul style="list-style-type: none"> — higher quadriceps strength on day 60 (78.7 vs. 68.3 Nm; $p = 0.006$); — a trend toward smaller extension deficit on day 30 (–2.6 vs. –4.7°; $p = 0.092$); — a more frequent combined favorable outcome (50 % vs. 26.2 %; $p = 0.026$). There were no differences in VAS, walking, or stair climbing |

Early postoperative results

Pain severity Most researchers who assessed pain using VAS in the early postoperative period noted the advantage of alternative approaches over traditional Geng et al. [20] showed significantly lower pain intensity at rest and during movement on the first and third days in the SV group. Dileep et al. [17] reported lower VAS scores in the SV group on the first–third days ($p < 0.05$), and Hu et al. [21] on the third day ($p < 0.001$), whereas by the seventh post-op day the differences had leveled out. In studies comparing MV with MP, no significant differences in pain severity were found [18, 27]. Jhurani et al. [16] and Badawi et al. [26] did not find intergroup differences in VAS at any time point.

Straight leg raise Time to first active SLR is an indirect marker of hip extensor function preservation. This clinically significant parameter was significantly shorter in approaches without patellar eversion in most of the included studies. Thus, Geng et al. [20] revealed a difference of (1.17 ± 0.38) versus (3.09 ± 0.76) days in favor of SV ($p < 0.001$), Hosseini-Monfared et al. [24] found (1.8 ± 1.3) versus (3.6 ± 1.5) days in favor of SV ($p < 0.001$), Dileep et al. [17] marked (1.81 ± 0.88) versus (2.85 ± 0.91) days in favor of SV ($p < 0.00008$). Quah et al. [23] showed in their study that the median time to the first ASLR was 0 days in the MV group versus one day in the MP group ($p = 0.016$), and another study [18] confirmed a similar advantage of MV ($p < 0.05$). Güven et al. [25] recorded only a tendency towards earlier recovery of ASLR in SV — (0.8 ± 0.6) versus (1.4 ± 0.5) days; $p = 0.053$.

Range of motion In the early postoperative period, the advantage due to alternative approaches in terms of joint range of motion was temporary. Geng et al. [20] demonstrated a significantly greater range of motion in the SV group on the third day, $(118.91 \pm 8.21)^\circ$ versus $(107.60 \pm 7.99)^\circ$; $p < 0.001$, but by the 30th day the differences disappeared. Dileep et al. [17] revealed the advantage of SV on the third day, after two and six weeks ($p < 0.05$), while from the third month the differences leveled out. Hu et al. [21] confirmed a significantly greater range of motion with SV procedure on the third and seventh days ($p < 0.05$), with no differences at later times. In other studies [16, 26], no intergroup differences in this indicator were found at any of the time-points.

Functional scores A number of studies recorded a significant advantage of alternative approaches in the first days and weeks in KSS scores, with subsequent leveling of the differences [17, 20]. Katragadda et al. [18] noted higher KSS scores in MV in the first month ($p < 0.05$). Mathew et al. [19], Güven et al. [25] and Badawi et al. [26] did not find any intergroup differences in KSS at any follow-up point. Hu et al. [21] found an advantage of SV after one month in WOMAC score ($p < 0.05$), while another study [22], on the contrary, recorded significantly better WOMAC scores and the OKS scale in the MP group at three and six months ($p \leq 0.002$), while by 12 months the differences in both cases leveled out. Silva et al. [27] found significantly greater quadriceps strength in the MV group at 60 days (78.7 ± 13.1) vs. (68.3 ± 12.1) ; $p = 0.006$, and a higher rate of achieving a combined favorable functional outcome (50 % vs. 26.2 %; $p = 0.026$).

Duration of hospitalization Mathew et al. [19] found a significantly shorter duration of hospitalization in the SV group: (5.29 ± 0.61) versus (6.36 ± 0.74) days; $p < 0.001$. In other studies, no significant intergroup differences in this parameter were found [16, 18, 23, 24, 26].

Postoperative complications The complication profile was generally comparable between the groups. Jhurani et al. [16] recorded a significantly higher incidence of wound dehiscence and delayed healing in the SV group ($p = 0.03$). In the studies of Mathew et al. [19] and Aladrai et al. [22], postoperative complications such as deep vein thrombosis, contracture, or joint instability were not recorded in any of the study groups. Other studies did not reveal significant intergroup differences in complication rates.

Analysis of long-term results

Data on long-term results indicate that the functional advantages of alternative approaches in TKA, revealed in the early postoperative period, are leveled out as the follow-up term increases. Thus, the longest follow-up term is presented in the work of Hosseini-Monfared et al. [24], no significant

differences were found between the SV and MP groups in the WOMAC ((6.3 ± 1.3) vs. (6.2 ± 1.2) ; $p = 0.69$), KSS ((95.0 ± 3.2) vs. (93.1 ± 6.8) ; $p = 0.42$) and VAS ((2.5 ± 0.3) vs. (2.5 ± 0.4) ; $p = 0.33$) scores 10–15 years after TKA. However, the same authors noted a significant advantage of SV at one year in terms of WOMAC (total score: (14.5 ± 5.5) versus (18.4 ± 5.3) ; $p = 0.008$) and KSFS ((93.8 ± 7.1) versus (83.7 ± 2.3) ; $p < 0.001$), which indicates faster functional recovery in the medium term but without differences in the long term.

Mathew et al. [19] confirmed the comparability of KSS scores in the SV and MP groups at all follow-ups during two years, from the fifth day to 24 months ($p > 0.05$). Aladrai et al. [22] showed that the advantage of MP in the WOMAC and OKS scales in the third and sixth months completely disappeared by 12 months ($p > 0.05$). Dileep et al. [17] noted the absence of differences in the range of motion and KSS scores between the SV and MP groups starting from the third month and throughout one year of follow-up. Geng et al. [20] demonstrated that the advantage of SV in the range of motion and HSS scores, evident on the third day, disappeared by the 30th day.

Hu et al. [21], who used a modified minimally invasive subvastus approach, found no intergroup differences in WOMAC, OKS, and radiographic parameters starting from the sixth month and during a follow-up of one to two years. Katragadda et al. [18] showed that the advantages of MV according to VAS, range of motion, and KSS scale, identified in the first month, were not retained at subsequent follow-up visits; also, patellar function parameters according to the Feller scale and radiographic parameters did not differ at any follow-up period. Radiographic results in all studies that assessed this parameter did not demonstrate intergroup differences.

Thus, the data from the studies included in the analysis indicate that alternative surgical approaches provide earlier functional recovery in the first days and weeks after TKA compared to the traditional medial parapatellar approach. However, in the medium and long term, no clinically or statistically significant differences in functional outcomes were observed between the compared groups, consistent with the concept that the choice of surgical approach primarily determines the pace of recovery, not its final outcome.

DISCUSSION

The obtained data in general are consistent with the results of previously published studies and meta-analyses. Alternative surgical approaches (SV and MV) provide significantly faster functional recovery in the early stages after TKA compared to the traditional medial parapatellar approach; however, this advantage is temporary and disappears by 6–12 months of follow-up [28–32].

The early functional benefit of alternative approaches identified in this review is consistent with the findings of the largest meta-analyses in this area. Berstock et al. [33] in a systematic review and meta-analysis of 20 RCSs showed that SV provides a decrease in pain intensity according to the VAS by 0.8 points (95 % CI 0.22–1.35) on the first day and an acceleration of the ASLR recovery by 1.7 days (95 % CI 1.0–2.3). The data are consistent with the results of our review, in which a similar benefit was 1.3–1.9 days [17, 20], and in the study of Hosseini-Monfared et al. [24] it reached 1.8 days. The meta-analysis of Stubnya et al. [34], which included 33 RCSs, could clarify the presented data and establish that SV reduces the intensity of pain according to VAS by 1.98 points on the first day after surgery and provides an increase in the range of motion by 7–27° in the early phase after the intervention. Comparable results were also obtained in our review. Similarly, Geng et al. [20] found a difference in the range of motion in the joint between SV and MP of 11.3° on the third day, and Dileep et al. [17] noted a difference of 5.6° during the first six weeks of observation.

The most significant contribution to the comparative evaluation of the long-term results of the use of various surgical approaches in TKA was made by the meta-analysis of Bouché et al. [35], which included 60 RCSs. The key conclusion of this study about the absence of significant differences between the different approaches according to the KSS and WOMAC functional scales six months

after knee arthroplasty is fully confirmed by the results of our review. Nevertheless, the authors noted the preservation of the advantage of the SV over the parapatellar approach in terms of range of motion at the sixth month of follow-up. The difference of was 7.3° in favor of the SV (95 % CI from -14.1 to -0.1) [35], which is somewhat at odds with the data of our review, in which the majority of the included studies recorded the leveling of intergroup differences by the third postoperative month [17, 20, 21]. This discrepancy is likely due to differences in the measurement thresholds in the RCSs included in the meta-analysis, as well as variability in the rehabilitation protocols used.

In terms of reducing the incidence of intraoperative LR, the obtained data are consistent with the results of a number of previous studies [33, 36, 37]. The meta-analysis of Berstock et al. [33] demonstrated a significant reduction in the incidence of LR if SV was used with an odds ratio of 0.4 (95 % CI 0.2–0.7), while in the meta-analysis of Peng et al. [37], the relative risk for SV was 0.37 (95 % CI 0.17–0.81). In the present review, this advantage was confirmed in three out of four studies that reported low LR in SV compared to MP [17, 18, 20]. The identified pattern can be explained by maintaining the anatomical integrity of the m. vastus medialis obliquus in SV, which provides a native medial vector of patellar traction and reduces the need for additional surgical balancing of the patellofemoral joint [38–40].

Many studies and meta-analyses do not reveal statistically significant differences in the volume of intraoperative blood loss and its indirect markers, including the rate of blood transfusions, the dynamics of the hemoglobin level and the volume of discharge through the wound drainage, when comparing the SV, MV and traditional MP approaches in TKA [33, 37, 41, 42]. The data presented in this review are characterized by significant heterogeneity, since two included studies recorded a lower volume of blood loss with SV compared to MP [16, 21], while the remaining studies did not reveal significant differences. Meta-analyses by Berstock et al. [33] and Migliorini et al. [43] showed a decrease in blood loss in SV by an average of 58–77 ml compared to the traditional MP approach. However, this difference appears to be clinically insignificant and is apparently leveled by longer duration of surgery when alternative approaches are used, which partly explains the inconsistency of the results in some studies. An increase in the duration of surgery with SV by an average of 10 minutes, according to Berstock et al. [33], is also confirmed by two studies in our review [19, 21] that revealed a statistically significant increase in the duration of surgery by 12–13 minutes with SV approach.

The main mechanism of increased duration of surgery with SV approach is probably its technical complexity which requires careful mobilization of the quadriceps muscles and careful handling of soft tissues compared to the classical incision [44–46]. Statistically, this is manifested as a significant increase in the duration of surgery, shown both in RCSs and in meta-analyses [20, 33]. However, it should be noted that some data are inconsistent. Thus, in the study by Gupta et al. [47], SV approach turned out to be shorter in duration than MP, which the authors attribute to the high level of surgical training and the characteristics of the technique used. Moreover, it is necessary to point that SV is associated with significant limitations in patient selection, since obesity with a body mass index of more than 30 kg/m^2 , severe joint deformities and previous arthrotomies significantly complicate its implementation [48–50].

To date, the widespread use of hemostatic drugs and controlled arterial hypotension techniques during total knee arthroplasty allow for a significant reduction in the volume of intraoperative blood loss, optimization of the conditions for performing the intervention, and a reduction in its overall duration [51, 52].

With regard to the length of hospital stay, the present review revealed only a few statistically significant differences, in particular a reduction in the length of hospital stay by 1.07 days with SV compared to MP ($p < 0.001$) [19]. However, meta-analyses show a heterogeneous picture. Thus, Liu et al. [53] and Migliorini et al. [43] noted a reduction in the length of hospital stay with SV by 0.9–1.3 days, whereas Berstock et al. [33] did not find significant differences in this indicator. Such heterogeneity

of results may be due to significant intercenter differences in institutional protocols for accelerated postoperative recovery and hospital discharge criteria, which largely negate the effect of surgical approach on the length of in-hospital treatment [54–56].

Regarding the comparison of MV and MP approaches, the present review included three studies that demonstrated the advantage of MV in early functional indicators [18, 23, 27], which is consistent with the results of a meta-analysis by Xu et al. [57], who summarized the data of 18 RCSs and found significantly lower pain scores according to VAS and range of motion with MV in the first one to two weeks of the postoperative period. At the same time, this meta-analysis did not reveal any differences between MV and MP in the volume of blood loss and length of hospital stay, which is consistent with the results of our review. The study by Onggo et al. [58], who compared mini-MV and mini-MP approaches, did not find significant differences in any of the analyzed outcomes, which suggests that the potential benefits of MV may be lower by using a standardized minimally invasive surgical approach.

Among the long-term follow-up data, the registry study by Blom et al. [59] deserves special consideration. They analyzed 875,166 cases of TKA from the UK National Joint Registry. Its key result was a 20 % reduction in the risk of revision interventions with MV compared to MP (OR = 0.80; 95 % CI 0.65–0.98; $p = 0.03$), which represents one of the few pieces of evidence in the modern literature of a possible long-term advantage of one of the alternative approaches. However, the registry design of the study does not allow for the full elimination of the influence of systematic selection bias, since MV was used in only approximately 3 % of knee arthroplasties, and the surgeons who preferred it may have had specific manual skills and worked with a certain category of patients. The data from this review cannot confirm or refute this finding due to the lack of relevant outcomes and a sufficient follow-up period in most of the included studies. The only study with a 10–15-year follow-up period included in our review [24] indicates complete equivalence of the compared surgical approaches in terms of WOMAC, KSS, and VAS scores, which is consistent with previously published data.

Data on wound complications deserve special attention. In the present review, according to Jhurani et al. [16], a higher incidence of wound dehiscence was noted in SV ($p = 0.03$); however, this observation was not confirmed in previously published studies, since none of the large meta-analyses revealed significant differences in the incidence of wound complications. However, Kazarian et al. [60] indicated an increased risk of component orientation in case of the most restrictive quadriceps-sparing techniques. The results of the only study that recorded wound complications do not allow for general conclusions to be drawn, but they indicate the need for caution while using SV in patients with a high risk of impaired postoperative wound healing.

A significant limitation of both this review and the majority of the literature reviews remains the lack of direct comparisons of the SV and MV approaches published in the last five years. Most meta-analyses that used a network design [35, 61] reproduce this gap by constructing indirect comparisons through a general control rather than by directly comparing the two approaches with each other. The data on the advantage of SV over MV in terms of range of motion (+7.3°; 95 % CI from -14.1 to -0.1) identified in the meta-analysis by Bouché et al. [35] require confirmation in randomized trials. An important methodological limitation of most of the available studies remains the relatively small sample size and insufficient duration of the follow-up period. In the most recent systematic review by Rainey et al. [62], which combined data from 27 RCSs for the period from 2010 to 2024, concluded that none of the surgical approaches used in knee arthroplasty demonstrates consistent superiority over the others in terms of range of motion, outcomes, or reoperation rates, which is fully consistent with the conclusions of our review.

Thus, this systematic review expands the evidence in this area by consolidating relevant data reported by authors from different countries over the past five years. The findings are consistent with the emerging consensus in the global literature, which holds that the SV approach is preferred in enhanced recovery after surgery (ERAS) protocols, providing early postoperative benefits, while

the traditional MP approach demonstrates comparable, albeit somewhat less pronounced benefits with fewer technical limitations. However, in the medium and long term, the choice of surgical approach does not have a decisive influence on the final functional outcome. From a practical perspective, this suggests that an individualized approach that considers the patient's anatomical and clinical characteristics, the surgeon's level of training, and institutional rehabilitation capabilities, remains the most justified approach for TKA.

CONCLUSION

This systematic literature review confirms that quadriceps-sparing surgical approaches, specifically the subvastus and midvastus approaches, provide significantly faster functional recovery in the early postoperative period compared to the traditional medial parapatellar approach. Their advantages include reduced pain intensity in the first three days, earlier restoration of active straight leg raise, higher range of motion in the first three to six weeks, and a significantly lower rate of intraoperative lateral release. However, the temporary nature of these advantages is crucial, as by three to six months postoperatively, functional scores (KSS, WOMAC, OKS) and range of motion in the compared groups become comparable, and at follow-up periods of up to 10 to 15 years, they are completely equivalent. Thus, the choice of surgical approach determines the rate of recovery, but not the final outcome. From a practical standpoint, the subvastus approach appears preferable within the framework of enhanced postoperative recovery protocols. However, it is associated with an increase in surgical time by 10–13 minutes and, according to several studies, an increased risk of delayed wound healing. Large, multicenter, randomized, controlled trials with long-term follow-up and standardized rehabilitation protocols and discharge criteria are needed to definitively determine the role of each of the approaches under consideration in contemporary TKA surgery.

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