

# The Impact of Pre-Operative Quadriceps Strength on Postoperative Rehabilitation: Subvastus versus Medial Parapatellar Approach

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## Abstract

**Background:** Quadriceps weakness is an important determinant of functional recovery following total knee arthroplasty (TKA). Surgical approach and preoperative muscle strength may influence early postoperative rehabilitation. The objective is to compare postoperative rehabilitation between subvastus and medial parapatellar approaches and evaluate the relationship between preoperative quadriceps strength and postoperative functional recovery. **Material and Methods:** This prospective comparative study included 140 patients undergoing primary TKA, with 70 patients each in the subvastus and medial parapatellar groups. Quadriceps strength, pain, knee range of motion, straight-leg raising, independent ambulation, and functional outcomes were assessed during follow-up. **Results:** The subvastus group demonstrated significantly greater quadriceps strength at postoperative day 3 and two weeks, lower early pain scores, earlier straight-leg raising, and faster independent ambulation ( $p < 0.05$ ). Differences in strength and functional outcomes between groups diminished by three months. Preoperative quadriceps strength correlated significantly with postoperative strength at three months ( $r = 0.74$ ,  $p < 0.001$ ), functional score ( $r = 0.48$ ,  $p < 0.001$ ), and earlier rehabilitation milestones. **Conclusion:** The subvastus approach provided superior early rehabilitation following TKA, although long-term differences between approaches were limited. Higher preoperative quadriceps strength was associated with better postoperative functional recovery.

**Keywords:** Total knee arthroplasty; quadriceps strength; subvastus approach; medial parapatellar approach; rehabilitation; functional outcome.

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## INTRODUCTION

Total knee arthroplasty (TKA) is an effective surgical treatment for advanced knee osteoarthritis associated with persistent pain, deformity, and functional limitation. It aims to relieve pain, restore joint function, and improve quality of life. However, postoperative rehabilitation is influenced by several factors, particularly preservation of the extensor mechanism and quadriceps muscle function. Khan et al. highlighted differences in postoperative recovery associated with the choice of surgical approach.<sup>[1]</sup>

The medial parapatellar approach is commonly used because it provides excellent surgical exposure and facilitates component positioning. However, disruption of the quadriceps tendon and medial retinacular structures may contribute to postoperative pain, quadriceps inhibition, and delayed functional recovery. In contrast, the subvastus approach preserves the quadriceps tendon by accessing the joint beneath the vastus medialis. Roysam and Oakley reported potential advantages of this approach during early postoperative recovery.<sup>[2]</sup>

Cila et al. demonstrated that minimizing disruption of the extensor mechanism may facilitate earlier straight-leg raising, improved quadriceps function, and faster mobilization following TKA.<sup>[3]</sup> However, the subvastus

approach may be technically more demanding, particularly in obese patients and those with severe deformity. Matsueda and Gustilo also evaluated both approaches and suggested that their functional differences may be more evident during early rehabilitation and diminish with subsequent recovery.<sup>[4]</sup>

Randomized studies have further investigated these approaches. Bridgman et al. compared the subvastus and medial parapatellar approaches with particular emphasis on postoperative functional recovery.<sup>[5]</sup> Pagnano and Meneghini described an optimized subvastus technique aimed at preserving the quadriceps mechanism while providing adequate surgical exposure.<sup>[6]</sup> Similarly, Varela-Egocheaga et al. reported potential early functional benefits of a minimally invasive subvastus approach.<sup>[7]</sup>

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Although surgical approach may influence early recovery, preoperative quadriceps strength is also likely to be an important determinant of postoperative rehabilitation. Patients with better baseline quadriceps function may achieve earlier knee control, straight-leg raising, independent ambulation, and participation in physiotherapy. Assessment of preoperative muscle strength may therefore help predict postoperative recovery and identify patients who could benefit from preoperative strengthening. The present study was undertaken to evaluate the impact of preoperative quadriceps strength on postoperative rehabilitation and compare early and short-term functional outcomes between the subvastus and medial parapatellar approaches in patients undergoing primary TKA.

## MATERIALS AND METHODS

**Study Design and Participants:** This prospective comparative study included 140 patients undergoing primary total knee arthroplasty for advanced knee osteoarthritis at a tertiary care hospital. Patients were divided into two groups according to the surgical approach:

- Group S: 70 patients undergoing TKA through the subvastus approach.
- Group M: 70 patients undergoing TKA through the medial parapatellar approach.

### Inclusion Criteria

Patients aged 50–80 years with primary osteoarthritis of the knee requiring primary unilateral TKA, who were independently ambulatory or ambulatory with assistance before surgery and able to participate in postoperative rehabilitation, were included.

### Exclusion Criteria

Patients undergoing revision or bilateral TKA, those with inflammatory arthritis, previous major surgery around the affected knee, significant neurological or neuromuscular disorders affecting lower-limb strength, severe deformity requiring extensive soft-tissue reconstruction, or inability to participate in the rehabilitation protocol were excluded.

**Preoperative Assessment:** Demographic and clinical characteristics, including age, sex, body mass index, affected side, duration of symptoms, knee range of motion, and functional status, were recorded. Preoperative quadriceps strength of the affected limb was assessed using a hand-held dynamometer with the patient in a standardized seated position. Three measurements were obtained, and the mean value was recorded for analysis.

Patients were categorized according to preoperative quadriceps strength for assessment of its relationship with postoperative rehabilitation outcomes.

**Surgical Technique:** All procedures were performed using a standardized primary TKA technique. In Group S, the knee joint was exposed through a subvastus approach while preserving the quadriceps tendon. In Group M, a standard medial parapatellar arthrotomy was performed. Standard principles of bone preparation, soft-tissue balancing, component positioning, and wound closure were followed in both groups.

**Postoperative Rehabilitation:** A standardized rehabilitation protocol was followed in both groups. Quadriceps-setting exercises, ankle-pump exercises, and active-assisted knee movements were initiated during the early postoperative period. Patients were mobilized with appropriate walking assistance, followed by progressive weight bearing, active knee exercises, and gait training.

**Outcome Assessment:** The primary outcome was postoperative quadriceps strength and its relationship with preoperative quadriceps strength. Secondary outcomes included time to achieve straight-leg raise, postoperative knee range of motion, pain measured using the Visual Analogue Scale (VAS), time to independent ambulation, and functional recovery.

Assessments were performed preoperatively and postoperatively at day 3, 2 weeks, 6 weeks, and 3 months. Functional outcome was assessed using an appropriate standardized knee function score.

**Statistical Analysis:** Data were analyzed using SPSS software. Continuous variables were expressed as mean  $\pm$  standard deviation and categorical variables as frequencies and percentages. Independent Student's t-test or the Mann-Whitney U test was used to compare continuous variables between the two groups. The Chi-square or Fisher's exact test was used for categorical variables. Paired comparisons were performed to evaluate changes from baseline.

Pearson or Spearman correlation analysis was used to assess the relationship between preoperative quadriceps strength and postoperative rehabilitation parameters. Multivariable regression analysis was performed to determine whether preoperative quadriceps strength independently predicted postoperative functional recovery after adjustment for relevant clinical variables. A p-value  $<0.05$  was considered statistically significant.

## RESULTS

A total of 140 patients undergoing primary total knee arthroplasty were included, with 70 patients each in the subvastus (Group S) and medial parapatellar (Group M) groups. The two groups were comparable with respect to baseline demographic and clinical characteristics. Preoperative quadriceps strength was also comparable between the groups.

**Table 1: Baseline Demographic and Clinical Characteristics**

| Variable                                | Group S – Subvastus (n=70) | Group M – Medial Parapatellar (n=70) | p-value |
|-----------------------------------------|----------------------------|--------------------------------------|---------|
| Age (years), mean $\pm$ SD              | 65.2 $\pm$ 6.8             | 64.7 $\pm$ 7.1                       | 0.671   |
| Male, n (%)                             | 27 (38.6)                  | 29 (41.4)                            | 0.730   |
| Female, n (%)                           | 43 (61.4)                  | 41 (58.6)                            |         |
| BMI (kg/m <sup>2</sup> ), mean $\pm$ SD | 27.8 $\pm$ 3.4             | 28.1 $\pm$ 3.6                       | 0.613   |
| Preoperative knee ROM (°)               | 101.6 $\pm$ 12.4           | 100.8 $\pm$ 13.1                     | 0.711   |
| Preoperative VAS score                  | 7.1 $\pm$ 1.2              | 7.0 $\pm$ 1.3                        | 0.637   |
| Preoperative quadriceps strength (kg)   | 15.8 $\pm$ 4.1             | 15.5 $\pm$ 4.0                       | 0.662   |

There were no statistically significant differences between the two groups in age, sex, BMI, preoperative range of

motion, pain score, or quadriceps strength ( $p>0.05$ ), indicating comparable baseline characteristics.

**Table 2: Postoperative Quadriceps Strength and Early Rehabilitation Outcomes**

| Outcome                              | Group S – Subvastus (n=70) | Group M – Medial Parapatellar (n=70) | p-value |
|--------------------------------------|----------------------------|--------------------------------------|---------|
| Quadriceps strength at day 3 (kg)    | 10.6 ± 3.1                 | 8.7 ± 2.9                            | <0.001  |
| Quadriceps strength at 2 weeks (kg)  | 13.2 ± 3.5                 | 11.4 ± 3.3                           | 0.002   |
| Quadriceps strength at 6 weeks (kg)  | 15.7 ± 3.8                 | 14.6 ± 3.7                           | 0.086   |
| Quadriceps strength at 3 months (kg) | 17.4 ± 4.0                 | 16.9 ± 3.9                           | 0.455   |
| Time to straight-leg raise (days)    | 1.9 ± 0.8                  | 2.8 ± 1.1                            | <0.001  |
| Independent ambulation (days)        | 3.2 ± 1.1                  | 4.1 ± 1.4                            | <0.001  |

Patients undergoing the subvastus approach demonstrated significantly greater quadriceps strength at postoperative day 3 and two weeks. They also achieved straight-leg raise and independent ambulation significantly earlier than

patients undergoing the medial parapatellar approach. However, differences in quadriceps strength were no longer statistically significant at six weeks and three months.

**Table 3: Comparison of Pain, Range of Motion and Functional Recovery**

| Parameter        | Follow-up | Group S – Subvastus | Group M – Medial Parapatellar | p-value |
|------------------|-----------|---------------------|-------------------------------|---------|
| VAS pain score   | Day 3     | 4.2 ± 1.1           | 5.0 ± 1.2                     | <0.001  |
|                  | 2 weeks   | 2.8 ± 0.9           | 3.3 ± 1.0                     | 0.002   |
|                  | 6 weeks   | 1.8 ± 0.8           | 2.0 ± 0.9                     | 0.166   |
| Knee ROM (°)     | 2 weeks   | 96.8 ± 10.7         | 91.5 ± 11.2                   | 0.005   |
|                  | 6 weeks   | 111.7 ± 9.8         | 108.9 ± 10.1                  | 0.098   |
|                  | 3 months  | 119.3 ± 8.7         | 118.1 ± 9.0                   | 0.424   |
| Functional score | 6 weeks   | 72.6 ± 8.4          | 68.9 ± 8.7                    | 0.012   |
|                  | 3 months  | 84.7 ± 7.1          | 83.5 ± 7.5                    | 0.332   |

The subvastus group had significantly lower pain scores during the early postoperative period and greater knee range of motion at two weeks. Functional scores were also

significantly higher at six weeks. By three months, however, range of motion and functional outcomes were comparable between the two approaches.

**Table 4: Correlation of Preoperative Quadriceps Strength with Postoperative Rehabilitation Outcomes**

| Postoperative Outcome           | Correlation coefficient (r) | p-value |
|---------------------------------|-----------------------------|---------|
| Quadriceps strength at day 3    | 0.61                        | <0.001  |
| Quadriceps strength at 2 weeks  | 0.67                        | <0.001  |
| Quadriceps strength at 6 weeks  | 0.71                        | <0.001  |
| Quadriceps strength at 3 months | 0.74                        | <0.001  |
| Time to straight-leg raise      | -0.43                       | <0.001  |
| Time to independent ambulation  | -0.39                       | <0.001  |
| Knee ROM at 6 weeks             | 0.32                        | <0.001  |
| Functional score at 3 months    | 0.48                        | <0.001  |

Preoperative quadriceps strength showed a strong positive correlation with postoperative quadriceps strength, particularly at six weeks and three months. Greater preoperative strength was also associated with earlier straight-leg raising and independent ambulation. A significant positive correlation was observed with postoperative range of motion and functional scores.

## DISCUSSION

The present study compared postoperative rehabilitation following subvastus and medial parapatellar approaches for total knee arthroplasty and evaluated the influence of preoperative quadriceps strength on recovery. The subvastus approach demonstrated significantly better early quadriceps strength, earlier straight-leg raising, faster independent ambulation, and lower early postoperative pain. However, most differences between the approaches diminished by three months. Bourke et al., in a systematic review comparing medial parapatellar and subvastus

approaches, similarly reported that the subvastus approach may provide advantages during early recovery, although long-term differences are less evident.<sup>[8]</sup>

Teng et al. reported in their meta-analysis that the subvastus approach was associated with improved early postoperative recovery compared with the medial parapatellar approach, particularly in parameters related to extensor mechanism function.<sup>[9]</sup> In the present study, quadriceps strength at postoperative day 3 and two weeks was significantly greater in the subvastus group, while differences were no longer significant at six weeks and three months.

Postoperative quadriceps weakness is an important factor limiting early recovery following TKA. Mizner et al. demonstrated substantial early loss of quadriceps strength following TKA, resulting from both muscle atrophy and impaired voluntary muscle activation.<sup>[10]</sup> The better early preservation of quadriceps strength observed with the subvastus approach may be related to reduced disruption of the quadriceps mechanism.

Preoperative quadriceps strength showed significant positive correlations with postoperative strength and functional recovery. This is consistent with Mizner et al., who demonstrated that quadriceps strength plays an important role in the time course of functional recovery following TKA.<sup>[11]</sup> In the present study, greater baseline strength was associated with earlier straight-leg raising, faster independent ambulation, better range of motion, and higher functional scores.

The potential importance of optimizing quadriceps function before surgery is also supported by McKay et al., who evaluated a prehabilitation exercise program and demonstrated that preoperative exercise can improve quadriceps strength in patients undergoing TKA.<sup>[12]</sup> These observations suggest that assessment and improvement of quadriceps strength before surgery may contribute to enhanced postoperative rehabilitation.

Differences in surgical exposure and preservation of the extensor mechanism may influence early postoperative function. Hay et al., in a prospective randomized trial evaluating a subvastus-based approach, highlighted the potential functional implications of alternative surgical approaches to TKA.<sup>[13]</sup> The present findings similarly suggest an early functional advantage when quadriceps disruption is minimized.

Kazarian et al., through a meta-analysis of randomized trials, reported that quadriceps-preserving approaches may provide some advantages during early postoperative recovery, although these differences generally decrease with longer follow-up.<sup>[14]</sup> Similarly, Berstock et al. found that the medial subvastus approach may improve certain early outcomes compared with the medial parapatellar approach, but convincing long-term superiority was not demonstrated.<sup>15</sup> This pattern closely corresponds with the present findings, in which differences in strength, range of motion, and functional scores between approaches were minimal by three months.

Overall, the findings indicate that the subvastus approach may facilitate faster early rehabilitation after TKA. More importantly, preoperative quadriceps strength was consistently associated with postoperative recovery, suggesting that baseline muscle function should be considered when predicting rehabilitation outcomes.

## CONCLUSION

The subvastus approach was associated with better early quadriceps strength, reduced postoperative pain, earlier straight-leg raising, and faster independent ambulation compared with the medial parapatellar approach. However, functional differences between the approaches diminished by three months. Greater preoperative quadriceps strength was significantly associated with better postoperative strength and functional recovery, emphasizing the potential value of preoperative quadriceps assessment and strengthening before TKA.

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## Conflicts of interest

There are no conflicts of interest.

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