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# Does stature of female affect Knee Injury and Osteoarthritis Outcome Score following knee arthroplasty surgery: an observational pilot study

Vanita Ahuja[1*], Karnjot Gill[1], Deepak Thapa[1], Sonika Bishnoi[1], Sudhir Garg[2] and Souvik Nandi[1]

## Abstract

**Background** Knee osteoarthritis (OA) occurs frequently in females. So far, no study has evaluated postoperative outcome measures in females based on body height. We aimed to evaluate postoperative pain relief and Knee Injury and Osteoarthritis Outcome Score (KOOS) at 6 months in women following total knee arthroplasty (TKA).

In this prospective, observational pilot study, 20 women, 50–70 years, American Society of Anesthesiologist (ASA) physical status I and II, undergoing TKA surgery were enrolled. The patients were allocated to Group I ($n = 10$), women with a height less than 153 cm, and Group II ($n = 10$), women with a height greater than 153 cm. All patients received paracetamol, diclofenac, and epidural analgesia postoperatively for up to 72 h. The primary outcome was a comparison of KOOS scores from preoperative baseline value to 6 months following TKA.

**Results** The baseline demographics, KOOS, waist-hip ratio, and knee range of motion were similar. The height mean ± standard deviation (SD) (range) in Group I was 149.85 ± 3.28 (142.5–152.5) cm versus 157.25 ± 2.99 (155–165) cm in Group II, $p = 0.001$. KOOS score improved in patients of both Groups I and II as compared to the respective baseline. At 6 months, the KOOS pain score improved to 96.50 ± 3.14 [94.26–98.74 (89–100)] in Group I as compared to 89.40 ± 6.45 [84.79–94.01 (81–100)] in Group II, $p$ value = 0.02.

**Conclusions** Postoperative KOOS pain score at 6 months was superior in short stature versus normal stature women following TKA surgery.

**Keywords** Osteoarthritis, Knee Injury and Osteoarthritis Outcome Score, Total knee arthroplasty, Visual analog scale, Pain

## Background

Knee osteoarthritis (OA) is a chronic degenerative disorder of the synovial joints and a major cause of disability around the globe in the aging population (Lozano et al., 2012, Pal et al., 2016). The etiology of OA includes obesity, trauma and joint overuse. The OA biological pain mechanism involves weak quadriceps, bone pathology, and poor balance ability in patients. The surgical treatment of total knee arthroplasty (TKA) is a well-described technique with improvement in quality of life and functional outcome. Residual pain occurs after TKA as a

*Correspondence:
Vanita Ahuja
vanitaanupam@yahoo.co.in; vanitaanupam@gmail.com
[1] Department of Anaesthesia and Intensive Care, Government Medical College and Hospital, Chandigarh, India
[2] Department of Orthopaedics, Government Medical College and Hospital, Chandigarh, India

result of patient factors, surgical technique, peri-operative inadequate pain relief, unsupervised rehabilitation, and negative social support. In patient factors, residual pain is commonly observed in the female gender, younger age (< 60 years), diabetes mellitus, pulmonary disease, preoperative anxiety, depression, body mass index (BMI) > 40 kg/$m^2$, severity of knee osteoarthritis, and reduced local pain threshold (Bonnin 2011, Howells et al., 2016). However, depression and proximal knee tenderness are associated with pain regardless of the level of satisfaction (Howells et al.,2016, Dowsey 2016, Choi and Ra, 2016). Female patients are 2.6 times more prone for pain or stiffness following TKA surgery outcome at 1 year (Fisher et al., 2007). Women were found to have higher BMI and disability and also presented late for TKA surgery with advanced stages of OA as compared to men (Sancheti et al., 2017, Thati 2021).

In developing countries, the average height of women is lower as compared to developed countries. The research interest in post-TKA is growing and the evaluation of postoperative outcomes on basis of normal versus short stature in women has never been studied for Knee Injury and Osteoarthritis Outcome Score (KOOS) with pain as main subsets for evaluating short-term outcome measures (Roos and Lohmander, 2003). Women were found to present higher with OA on radiographic imaging as compared to men (Sancheti et al., 2017, Thati 2021). The anatomy of knee joint is different in men and women. There are some basic differences; women have lower quadriceps strength, high-fat mass to lower muscle mass, difference in pelvis, knee morphology, quadriceps angle, and increased ligament laxity as compared to men. The present study is the first attempt to compare postoperative KOOS scores from baseline to 6 months in short-stature versus normal-stature women following TKA surgery.

The aim of the present study was to compare postoperative KOOS scores from baseline to 6 months in short-stature versus normal-stature women following TKA surgery.

## Methods

This study was conducted after approval from the Hospital Ethics Committee (IEC/2018/142 dated 28.11.2018) and was registered with Clinical Trial Registry (CTRI/2018/12/016716). The written informed consent was taken from patients in the local vernacular language. The present study adhered to Good Clinical Practice quality standards and ethical guidelines defined by the Declaration of Helsinki.

This prospective, observational pilot study was conducted in a tertiary care hospital of a developing country between January 2019 to September 2019. Follow-up was done in all patients after 6 months of surgery from July 2019 to March 2020.

We included female patients of 50-70 years, American Society of Anesthesiologist (ASA) physical status I and II, and undergoing TKA surgery. Women scheduled for revision TKA surgery, impaired cognitive functions, and disabling neurological disease were excluded from the study.

After written informed consent, patients were enrolled in the orthopedic ward a day prior to surgery. Anthropometric measurements including weight, height, and BMI calculation were done. All enrolled patients were weighed on a calibrated scale, and height was measured with a stadiometer/measuring tape. Waist and hip circumferences were measured in centimeters at the height of the umbilicus and the largest area of the hips, respectively. Severity of knee OA was graded according to Kellgren-Lawrence grade (KLG) on anterior-posterior and lateral view of knee X-ray (Grade 0: no radiographic features of OA are present; Grade 1: doubtful joint space narrowing (JSN) and possible osteophytic lipping; Grade 2: definite osteophytes and possible JSN; Grade 3: multiple osteophytes, definite JSN, sclerosis, possible bony deformity; Grade 4: large osteophytes, marked JSN, severe sclerosis and definite bony deformity) (Kohn 2016). All patients were asked to fill out the KOOS questionnaire on enrollment (Roos and Lohmander, 2003). Patients were instructed to answer to questions based on the assessment of the previous week. Standardized answer options were given (5 Likert boxes) and each question was assigned a score from 0 to 4. A normalized score (100 indicating no symptoms and 0 indicating extreme symptoms) was calculated for each subscale of 9 items for knee pain, 7 items for symptoms, 17 items for activities of daily life (ADL), 5 items for sports, and 4 items for recreation and quality of life (QOL) (Roos and Larsen, 2003). The patients and surgeons were blinded to either of the two group allocations.

Group I or Group short stature ($n$ = 10): Women with a height less than 153 cm (Ray et al., 1990)
Group II or Group normal stature ($n$= 10): Women with a height greater than 153 cm (Ray et al., 1990)

All patients received either of the two standardized anesthetic techniques, i.e., combined spinal epidural analgesia or general anesthesia with epidural analgesia as per the discretion of the anesthesiologist. Perioperative standard anesthesia monitoring and care was done. All patients received standardized postoperative analgesia up to 72 h. This included intravenous (IV) paracetamol 1 gram every six hourly, IV diclofenac 75 mg twice daily, and epidural infusion (0.125 % bupivacaine and 2μg/ml fentanyl) at 5 ml/h, patient bolus of 5 ml with lockout

interval of 15 min. The number of epidural boluses was recorded. Rescue analgesia, IV tramadol 100 mg over 30 min (up to a maximum of 400 mg in 24 h) was given if the patient reported a visual analog scale (VAS) > 4 in spite of the above analgesia regimen.

Patient's baseline demographics were recorded including height, weight, BMI, and severity of knee OA preoperatively. VAS at rest and on movement (Dworkin et al., 2008) baseline, 12, 24, 48, and 72 h postoperatively. The number of epidural boluses and rescue analgesia was taken 12, 24, 48, and 72 h postoperatively. Waist hip ratio, degree of knee movement, and KOOS score (Roos et al., 1998) at baseline and postoperatively at 6 months. Any adverse effect during the study period was recorded.

### Sample size

Sample size was calculated using the formula n: $= (Z_{\alpha/2}+Z_{\beta})^2 *2*\sigma^2 /d^2$,where $Z_{\alpha/2}$ is the critical value of the Normal distribution at α/2 (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), $Z_{\beta}$is the critical value of the Normal distribution at β (e.g., for a power of 95%, the critical value is 1.64), $\sigma^2$ is the population variance, and d is the difference between two means. As per a previous study change in KOOS scores was observed from a baseline value of 38 ±18 to 79± 20 at 6 months following TKA (Roos and Larsen, 2003). A mean difference of 41 with SD of 20 of KOOS Score was calculated from baseline to 6 months and with $\sigma^2$ population variance of 400, the sample size came out to be 7 subjects per group at a power of 95 %. To compensate for any possible dropouts during follow-up, we included 10 patients per group.

### Statistical analysis

After completion of the study, data was analyzed using IBM statistical package for social science (SPSS) Statistics (version 22.0) The continuous data was represented as mean and standard deviation or median and interquartile range. Discrete data was written as n (%) in the study. The normality of data was checked using the Kolmogorov-Smirnov test and *t*-test was applied. For data that was skewed, Mann-Whitney *U*-test was applied. For categorical data, Pearson chi-square or Fisher's exact test was applied as found appropriate. All statistical tests were two-sided and $p < 0.05$ was considered statistically significant.

## Results

We assessed 25 patients for eligibility and enrolled the first 10 women in each group. Rest 5 patients with height > 153 cm were excluded. We enrolled 10 patients per group. Age, body mass index, KLG grade 4, waist-hip circumference, and range of movement were similar in both groups (Tables 1 and 2). The mean ± SD (range) height in group short stature was 149.85 ± 3.28 (142.5–152.5) cm versus 157.25 ± 2.99 (155–165) cm in group normal stature, $p = 0.001$ (Table 1). The mean ± SD [95% CI (range)] KOOS baseline score, was 30.80 ± 9.82 [24.75–37.25 (18–50) in group short stature and 30.10 ± 11.03 [21.75–35.25 (13–51)]in group normal stature, $p$ value = 0.91

**Table 1** Baseline demographics of women undergoing total knee arthroplasty (TKA)

| Variables | Group short stature ($n = 10$) | Group normal stature ($n = 10$) | *p* value |
|---|---|---|---|
| Age (years) | 66.40 ± 9.41 (54–81) | 63.60 ± 6.62 (52–75) | 0.45 |
| Height (cm) | 149.85 ± 3.28 (142.5–152.5) | 157.25 ± 2.99 (155–165) | 0.001 |
| Body mass index (kg $m^{-2}$) | 32.14 ± 2.57 (29.50–36.50) | 30.83 ± 3.76 (25.70–37.40) | 0.37 |
| Kellgren-Lawrence grading 4 | 9 (90) | 10 (100) | 0.23 |
| Bilateral TKA | 1(10) | 5 (50) | 0.05 |

Data is represented as mean ± SD (range) or number (%)

**Table 2** Waist-hip (W-H) ratio and range of movement (ROM) in patients of short versus normal stature undergoing total knee arthroplasty

| Variables | Group short stature ($n = 10$) | Group normal stature ($n = 10$) | *p* value |
|---|---|---|---|
| W-H ratio baseline | 0.92 ± 0.05 (0.85–1.02) | 0.90 ± 0.06 (0.80–1.00) | 0.29 |
| W-H ratio at 6 months | 0.95 ± 0.07 (0.86-1.07) | 0.92 ± 0.05 (0.83–0.98) | 0.91 |
| ROM baseline, degrees | 74.50 ± 20.34 (45–100) | 89 ± 12.87 (60–100) | 0.07 |
| ROM at 6 months, degrees | 110 ± 9.42 (90–120) | 109 ± 11.97 (90–130) | 0.72 |

Data is represented as mean ± SD (range)

(Table 3). At 6 months, KOOS Score, improved to 86.50 ± 4.37 [83.37- 89.63(78-93)]in group short stature and 83.50 ± 7.40 [78.75–89.00 (71.00–92.00)] in group normal stature, *p* value =0.38. A subgroup analysis of KOOS at 6 months was performed using the Mann-Whitney test. Pain improved to 96.50 ± 3.14 [94.26–98.74 (89–100)] in Group short stature as compared to 89.40 ± 6.45 [84.79–94.01 (81–100)] in Group normal stature, *p* value = 0.02. ADL, sports, and QOL were similar in both groups and could not establish statistical significance (Table 4). Intragroup analysis of KOOS Score and its subtypes improved in patients of both groups compared to the respective baseline (Figs. 1 and 2).

In Group short stature, the intragroup comparison of the range of motion of the knee improved, from baseline mean ±SD (range) value of 74.50± 20.34 (45–100)° to 110 ± 9.42 [90–120] ° at 6 months postoperatively, *p* value = 0.005. In the Group normal stature, the intragroup comparison of the range of motion of the knee improved, from a baseline value of 89 ± 12.87 (60–100)° to109 ± 11.97 (90–130)° at 6 months postoperatively, *p* value = 0.02. At 6 months follow-up, waist-hip circumference ratio and range of motion of the operated knee, did not show any statistical significance between the two groups (Table 2). The perioperative requirement of epidural boluses postoperatively and tramadol consumption at 12, 24, 48, and 72 h were similar in both groups, *p* value = 0.63. The perioperative hemodynamics and median VAS score at rest and on movement were comparable at baseline; postoperatively at 12, 24, 48, and 72 h. No adverse events were reported during the study.

## Discussion

We reported that intragroup KOOS score improved both clinically and statistically difference in both women with normal and short stature from preoperative baseline to 6 months following TKA surgery. In intergroup comparison, at 6 months KOOS pain score in short-stature females was superior to normal-stature females following TKA. So far, no study has compared preoperative baseline KOOS with postoperative KOOS outcome at 6 months following TKA surgery in short versus normal-stature females.

The basis of these findings draws evidence from the knee being a major weight-bearing joint of the body and higher knee heights increase symptomatic OA among women. The knee height is affected by both patellofemoral and tibiofemoral OA. Hunter et al reported that knee height quartile was associated with the severity of knee pain in women with OA with an odds ratio (OR) of 1.8 for the highest quartile versus the lowest quartile of knee height with a 95% confidence interval (CI) of 1.3–2.5. Any force that passes the joint can cause a moment at that joint. Moment of a joint is a product of force and moment arm length (it is the length from that force's line of action to the center of the joint). The rationale of this

**Table 3** Preoperative Knee Injury and Osteoarthritis Outcome Score (KOOS) and subtypes in patients of short versus normal stature scheduled for total knee arthroplasty

| Baseline | Group short stature (*n* = 10) | Group normal stature (*n* = 10) | *p* value |
|---|---|---|---|
| KOOS | 30.80 ± 9.82 [24.75–37.25 (18–50) | 30.10 ± 11.03 [21.75–35.25 (13–51)] | 0.91 |
| Symptoms | 33.60 ± 14.20 [23.44–43.76 (14–61)] | 33.60 ± 16.42 [21.85–45.35 (11–61)] | 1.00 |
| Pain | 36.20 ± 16.92 [24.09–48.31 (17–67)] | 33.70 ± 11.04 [25.75–44.75 (19–47)] | 0.91 |
| ADL | 33.30 ± 10.08 [26.08–40.52 (15–47) ] | 30.70 ± 14.14 [20.59–40.81 (7–56)] | 0.64 |
| Sports | 8.50 ± 11.32 [0.40–16.60 (0–25)] | 5.00 ± 6.24 [0.54–9.46 (0–15)] | 0.74 |
| QOL | 28.80 ± 12.71[19.71–37.89 (13–56)] | 25.00 ± 12.07[16.37–33.63 (0–44)] | 0.61 |

*ADL*, activities of daily life; *QOL*, quality of life. Data is represented as Mean ± SD [95% CI (range)]. *$P < 0.005$ is statistically significant

**Table 4** Knee Injury and Osteoarthritis Outcome Score (KOOS) and subtypes in patients of short versus normal stature at 6 months following total knee arthroplasty

| At 6 months | Group short stature (*n* = 10) | Group normal stature (*n* = 10) | *p* value |
|---|---|---|---|
| KOOS | 86.50 ± 4.37 [83.37–89.63 (78–93)] | 83.50 ± 7.40 [78.75–89.00 (71.00–92.00)] | 0.38 |
| Symptom | 91.80 ± 4.89 [88.30–95.30 (14–61)] | 89.80 ± 10.73 [81.82–97.18 (64–100)] | 0.55 |
| Pain | 96.50 ± 3.14 [94.26–98.74 (89–100)] | 89.40 ± 6.45 [84.79–94.01 (81–100)] | 0.02* |
| ADL | 90.00 ± 4.24 [86.96–93.04 (85–96)] | 90.10 ± 6.23 [85.65–94.55 (82–99)] | 0.97 |
| Sports | 54.50 ± 19.36 [40.65–68.35 (25–85)] | 40.50 ± 17.71[27.83–53.17 (20–70)] | 0.11 |
| QOL | 85.70 ± 6.83 [80.81–90.59 (75–94)] | 78.90 ± 10.30 [78.00–86.60 (63–94)] | 0.09 |

*ADL* Activities of daily life, *QOL* Quality of life. Data is represented as Mean ± SD [95% CI (range)]. *$P < 0.005$ is statistically significant

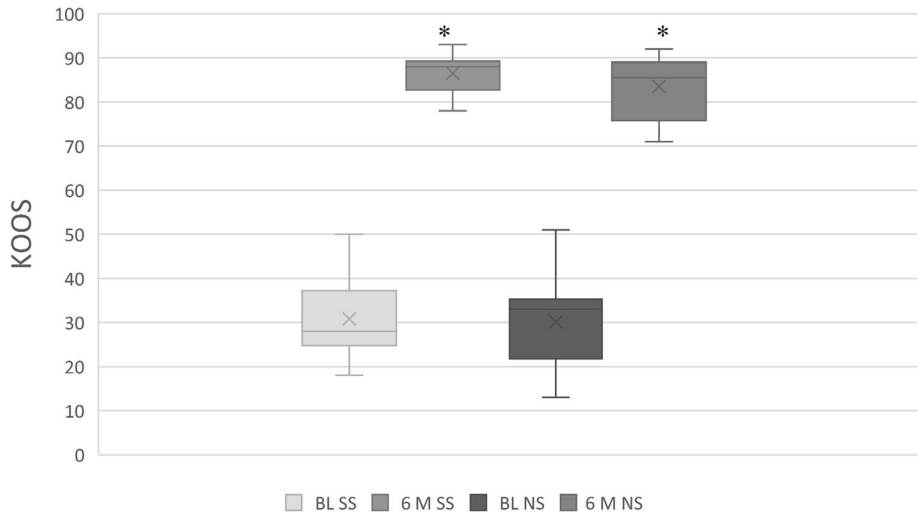


**Fig. 1** Box and whisker plot showing Knee Injury and Osteoarthritis Outcome Score (KOOS) total score in patients scheduled for total knee arthroplasty. BL SS, baseline short stature; 6 M SS, postoperative 6 months short stature; BL NS, baseline normal stature; 6 M NS, postoperative 6 months normal stature. The line inside the box signifies the median, the box signifies the interquartile range (IQR), and the whiskers describe the range. * $p < 0.05$

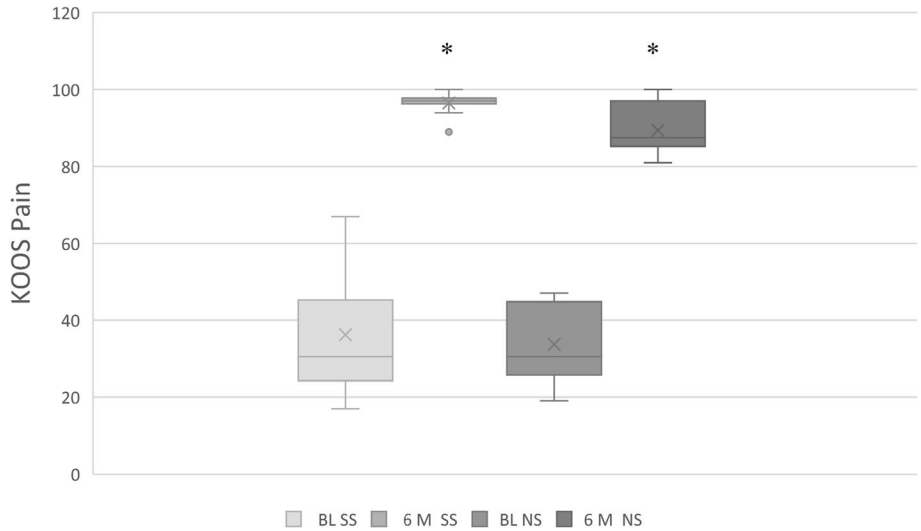


**Fig. 2** Box and whisker plot showing Knee Injury and Osteoarthritis Outcome Score (KOOS) pain subtype in patients at 6 months following total knee arthroplasty. BL SS, baseline short stature; 6 M SS, postoperative 6 months short stature; BL NS, baseline normal stature; 6 M NS, postoperative 6 months normal stature. The line inside the box signifies the median, the box signifies the interquartile range (IQR), and the whiskers describe the range. * $p < 0.05$

finding could be that adduction moments and flexion/extension moments are higher in legs that are longer. In knee OA, coronal plane adduction/abduction moments and flexion/extension moments are abnormal. Any force that crosses the joint can contribute to total torque or moment at that joint. Hunter et al. in an observational study, used knee height of only the right leg as an outcome measure for exploring the association between knee height, knee OA and Knee pain in patients of both sex. The authors reported that knee height was an important factor in women for determining the severity of knee symptoms irrespective of radiological changes (Hunter et al., 2005). Similarly, in the present study, KOOS pain score at 6 months was superior in women with short stature as compared to normal stature. There was a difference in measuring the height in the present study where we used total height instead of knee height. The total height can be influenced by vertebral crush fractures,

kyphosis, mobility problems, and hip abnormalities. However, none of the patients in the present study had any of these comorbidities.

In the present study, the baseline flexion was 74.50 ± 20.34 (45–100)° as compared to 110 ± 9.42 [90–120]° in group I and baseline flexion of 89 ± 12.87 (60–100)° as compared to 109 ± 11.97 (90–130)° in Group II. Similar findings were supported by published literature where active flexion in weight-bearing was 113°as compared to 127° in passive flexion during non-weight bearing in TKA patients (Dennis et al., 1998). On the contrary, Ritter et al reported that patients with maximum knee flexion between 128 and 132° had better functional outcomes as compared to patients with knee flexion greater than 132° (Ritter et al., 2008). An indicator of knee function after TKA includes active and passive maximum knee flexion in weight and non-weight bearing after surgery at 12 and 24 months. In the present study, we measured the maximum flexion at 6 months as compared to baseline using the non-weight wearing method. The association of the degree of maximum flexion and functional outcome have proven to be weak or modest. This was possible as the passive maximum flexion in non-weight bearing which is taken normally for measuring knee motion arc is not a true representative of the amount of knee motion required for functional activities. The authors demonstrated that active maximum flexion in weight-bearing with or without arm support was smaller than passive or active maximum flexions in non-weight bearing (Kim et al., 2015).

There was no difference in the waist-hip ratio in both intra- and intergroup comparisons indicating that patients did not consider weight reduction as a modality for knee functions and better outcomes.

The patients were evaluated at 6 months postoperatively as prevention and treatment of pain after TKA is a clinical priority. The postoperative pain usually plateaus after three months of surgery but it was reported that women are 45% more likely to suffer moderate to severe pain at 2 years as compared to men after TKA. After 5 years this difference was nonsignificant (Singh et al., 2008, Cherian et al., 2015). Another interesting finding is that women tend to wait longer than men before getting TKA and also exhibit lower preoperative scores (Fortin et al., 2002). However, extensive discussions and explanations before surgery can reduce patient dissatisfaction after TKA (Choi and Ra, 2016).

Chronic pain after TKA is best defined as pain present and it bothers the patient at least 3 to 6 months after surgery which is reported to be 10-34 % (Beswick et al., 2012). This is the reason that we evaluated the patients at 6 months following TKA. This has a clinical implication that patients having persistent pain at this stage can receive targeted management to halt the progression into longer-term pain and disability (Shipton 2005). For assessing chronic pain after TKA, a comprehensive assessment with patient-based questionnaire and clinician assessment is required. Earlier Oxford Knee Score, Western Ontario and McMaster Universities Arthritis Index (WOMAC), and KOOS have been used in patients undergoing TKA (Roos et al., 1998, Dawson et al., 1998, Bellamy et al., 1988). None of the patients in the present study reported any signs and symptoms of chronic pain during follow up at 6 months following TKA. The study has implications for identifying patients with persistent post-surgical pain and chronic pain. Since many anesthesiologists are also managing pain clinics, the study may be of importance to these patients.

There are a few limitations of the present study. Firstly this was a non-randomized convenience sample, a small sample size with a sub-group analysis which could lead to a risk of statistical error. Secondly, the outcome assessors could not be blinded as stature was visible. Thirdly, patient-administered questionnaires are based on the patient's understanding of the questions, and sometimes inability to determine the character of pain, resting pain, or pain on movement and recall bias may give confounding results (Wylde et al., 2013).

Recently, there is a core outcome set for chronic pain after TKA which does not include pain intensity but other aspects of pain which affect daily living, function of a patient, temporal aspects of pain, emotional aspect, medications used, and satisfaction with pain relief (Wylde et al., 2015). Studies using such comprehensive assessments based on questionnaires and clinician assessments are required in future trials.

## Conclusions

Postoperative KOOS pain score at 6 months was superior in short-stature women as compared to normal-stature women following TKA surgery.

**Abbreviations**

| | |
|---|---|
| ADL | Activities of daily life |
| ASA | American Society of Anesthesiologist |
| BMI | Body mass index |
| CI | Confidence interval |
| IV | Intravenous |
| JSN | Joint space narrowing |
| KLG | Kellgren-Lawrence grade |
| KOOS | Knee Injury and Osteoarthritis Outcome Score |
| OA | Osteoarthritis |
| OR | Odds ratio |
| QOL | Quality of life |
| SD | Standard deviation |
| SPSS | Statistical package for social science |
| TKA | Total knee arthroplasty |
| VAS | Visual analog scale |
| WOMAC | Western Ontario and McMaster Universities Arthritis Index |

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None declared

**Authors' contributions**
VA – conceptualization, design, protocol writing, supervision, analysis, manuscript preparation, critical review. KG – Conduct of study, analysis, manuscript preparation, critical review. DT – supervision, analysis, manuscript preparation. SB – Design, protocol writing, critical review. SG – supervision, analysis, manuscript preparation. SN – Data collection, analysis, manuscript writing. All authors have read and approved the manuscript.

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**Availability of data and materials**
Yes. The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## Declarations

**Consent to publication**
Not applicable (no individual data included)

**Ethics approval and consent to participate**
The study was approved by Institutional Ethics Committee (ECR/658/Inst/PB/2014/RR-2017), Government Medical College and Hospital, sector 32, Chandigarh, India via letter number IEC/2018/142 dated 28.11.2018. (proof attached below).
The study is registered with Clinical Trial Registry India via the number (CTRI/2018/12/016716). Informed written consent to participate in the study was provided by all participants.

**Competing interests**
The authors declare that they have no competing interests.

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