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Surgeon's task-load performing surgery around the knee with and without a tourniquet: a prospective cohort study

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Abstract

Whilst tourniquets have traditionally been used in knee surgeries to improve intraoperative visibility, emerging evidence suggests their use in total knee replacements may increase the risk of adverse events. No studies have examined how tourniquet use affects surgeon workload, which may be a potential barrier to wider adoption. This study investigated surgeon-perceived task load during knee surgeries with and without a tourniquet. Following each procedure, the lead surgeon completed the Surgical Task-Load Index (SURG-TLX) questionnaire, rating their workload across multiple domains. A weighted SURG-TLX score (0–100) was calculated. Surgical field visibility was rated on a 1–5 Likert scale. Out of the 100 procedures, 47 were performed with a tourniquet and 53 without. The majority (84) were total knee replacements, and these were analysed to enable statistically meaningful comparisons. Median SURG-TLX scores were 40.3 (IQR 22.5–57.8) for the tourniquet group (N = 41) and 42.0 (IQR 25.7–55.7) for the no-tourniquet group (N = 43), with no clinically or statistically significant difference (p = 0.914**)**. Field visibility was rated significantly better in the tourniquet group (median 4.0 [IQR 4.0–5.0] vs 5.0 [IQR 4.0–5.0], p = 0.001). No significant differences were seen in individual SURG-TLX domains or between procedure types. Despite the reduced visibility, surgeons did not report increased workload demands when performing total knee replacements without a tourniquet. These findings support wider adoption of tourniquet-free techniques as a more patient-centred surgical approach.

Introduction

The benefits of tourniquet use, including a bloodless operative field and better anatomical visualisation, are well recognised[1, 2] However, a Cochrane systematic review and meta-analysis raised concerns about complications associated with tourniquet use during total knee replacement (TKR). Ahmed and colleagues (2020) reported that tourniquet use is associated with higher rates of major adverse events such as deep vein thrombosis, pulmonary embolism, infection and reoperation[1]. Other studies have observed higher rates of less severe complications in the tourniquet group[3] and that avoiding tourniquet use may improve early post-operative outcomes. Such outcomes include pain[1], quadriceps function[4], patient-reported outcome measures, range of motion and opioid requirements[5]. Despite this growing body of evidence, clinical practice remains variable. A 2016 survey of over two hundred members of the British Association for Surgery of the Knee found that 90% of surgeons performing TKRs regularly use a tourniquet. The commonly stated reasons for this were improved implant cementation, better visibility, less blood loss and shorter operative time[6]. Other surveys of arthroplasty surgeons suggest that while many continue to use tourniquets routinely, some have abandoned their use due to concerns regarding complications[7]. Research to date has focused predominantly on the patient-centred outcomes of knee operations; however, little is known about the experiences of the surgeons when operating with or without a tourniquet. Subjective experiences, such as perceived workload and surgical field visibility, are components that can influence decision-making and surgical performance.

Given that previous evidence has demonstrated that tourniquets improve field visualisation[8], this study aimed to evaluate surgical workload in surgeries around the knee with and without a tourniquet. The

hypothesis was that tourniquet omission would lead to a higher perceived workload.

Results

Baseline characteristics

During the study period, anonymised data were collected for 100 patients. Of these, 84 were TKRs and were included in the study cohort to allow for statistically meaningful comparisons. The tourniquet and no-tourniquet groups were well-matched for most baseline characteristics (Table 1). However, body mass index (BMI) was significantly higher in the no-tourniquet group (34.3 vs 31.4 kg/m², $p = 0.048$), and adrenaline-based local anaesthetic was used more frequently in the no-tourniquet group (90% vs 12%, $p < 0.001$). Consultant surgeons performed a greater proportion of tourniquet-free cases (77% vs 54%, $p = 0.026$).

Table 1
Clinical characteristics of patients and procedures performed with versus without a tourniquet.

Characteristic	No tourniquet (n = 43)		Tourniquet (n = 41)		P Value
Sex, no. (%)					0.770 †
Female	27	(62.8)	27	(65.9)	
Male	16	(37.2)	14	(34.1)	
Laterality, no. (%)					0.197 †
Left	15	(34.9)	20	(48.8)	
Right	28	(65.1)	21	(51.2)	
Age, years, mean ± SD	67.8	± 8.6	68.5	± 10.6	0.783 ‡
BMI, kg/m², mean ± SD	34.3	± 7.2	31.4	± 6.7	**0.048** ‡
pre-op Hb, g/L, mean ± SD	139	± 13.1	136.3	± 10.5	0.349 ‡
pre-op Hct, proportion, mean ± SD	0.41	± 0.0	0.41	± 0.0	0.635 ‡
ASA scale, no. (%)					0.146 †
1	3	(7.0)	0	(0.0)	
2	26	(60.5)	30	(75.0)	
3	14	(32.6)	10	(25.0)	
Anaesthesia, no. (%)					0.551 †
GA	1	(2.3)	3	(7.3)	
GA, spinal	5	(11.6)	4	(9.8)	
spinal, sedation	37	(86.0)	34	(82.9)	
Indication, no. (%)					0.451 †
OA	9	(20.9)	6	(14.6)	
non-OA	34	(79.1)	35	(85.4)	
Adrenaline Use, no. (%)					**< 0.001 †**
no	4	(9.5)	36	(87.8)	

Body mass index (BMI), standard deviation (SD), haemoglobin (Hb), haematocrit (Hct), American Society of Anaesthesiologists (ASA), general anaesthetic (GA), osteoarthritis (OA)

† Chi-squared test

‡ Independent samples t-test

Characteristic	No tourniquet (n = 43)		Tourniquet (n = 41)		P Value
yes	38	(90.5)	5	(12.2)	
Surgeon Grade, no. (%)					**0.026 †**
consultant	33	(76.7)	22	(53.7)	
trainee	10	(23.3)	19	(46.3)	
Body mass index (BMI), standard deviation (SD), haemoglobin (Hb), haematocrit (Hct), American Society of Anaesthesiologists (ASA), general anaesthetic (GA), osteoarthritis (OA)					
† Chi-squared test					
‡ Independent samples t-test					

Surgeon characteristics

Of the 32 surgeons who contributed cases, 23 performed TKRs and were included in the analysis (15 consultants, 8 trainees). The remaining 9 surgeons contributed only to non-TKR procedures and were excluded. The number of cases contributed per surgeon ranged from 1 to 7. Surgeons reported significantly higher comfort levels with tourniquet use (median 10 [interquartile range (IQR) 8–10] vs 7 [IQR 4–10], p = 0.009). The largest proportion of surgeons (43%) used a tourniquet for all their TKRs, 35% preferred tourniquetless surgery, and 22% used both approaches. Additional surgeon characteristics are reported in Supplementary Table 1.

SURG-TLX and field visibility

There was no significant difference in surgeon-perceived workload between the tourniquet and no-tourniquet groups. Median weighted Surgical Task Load Index (SURG-TLX) scores were 42.0 (IQR 25.7–55.7) without tourniquet and 40.3 (IQR 22.5–57.8) with tourniquet (p = 0.914, Cohen's d = 0.03). Unweighted scores were similarly comparable (45.0 vs 42.0, p = 0.690). No significant differences were observed in any of the six individual SURG-TLX domains (Table 2; all p > 0.25). The distribution of scores across all six domains is illustrated in Fig. 1. Analysis of pairwise domain weightings (Supplementary Table 2) revealed Task Complexity was the most heavily weighted domain overall, identified as the greatest contributor to workload in 44% of cases, followed by Mental Demands (15.5%) and Physical Demands (15.5%). Physical Demands was weighted significantly higher in the no-tourniquet group than the tourniquet group (median 3.0 [IQR 1.0–4.0] vs 1.0 [IQR 0.0–3.0], p = 0.002). No other domain weightings differed significantly between groups (all p > 0.15). Mixed-effects modelling confirmed no significant difference in total weighted SURG-TLX score between tourniquet and no-tourniquet groups after adjustment for surgeon grade and clustering within surgeons (estimate 0.51, 95% CI − 9.18 to 10.21, F = 0.011, p = 0.916). Field visibility was rated significantly lower in the no-tourniquet group (median 4.0 vs 5.0, p = 0.001).

Table 2
Primary outcomes. SURG-TLX, the domains, and field visibility for TKRs with versus without a tourniquet.

Outcome	No tourniquet		Tourniquet		P Value
Mental Demands, median (IQR)	8.0	(5.0–12.0)	9.0	(4.0–14.0)	0.760
Physical Demands, median (IQR)	8.0	(4.0–12.0)	5.0	(2.0-12.5)	0.258
Temporal Demands, median (IQR)	4.0	(2.0–8.0)	4.0	(3.0-8.5)	0.832
Task Complexity, median (IQR)	9.0	(6.0–11.0)	10.0	(6.5–13.0)	0.282
Situational Stress, median (IQR)	4.0	(2.0–10.0)	6.0	(3.0–10.0)	0.291
Distractions, median (IQR)	3.0	(2.0–6.0)	3.0	(2.0–9.0)	0.811
Total score, weighted, median (IQR)	42.0	(25.7–55.7)	40.3	(22.5–57.8)	0.914
Total score, unweighted, median (IQR)	45.0	(25.0–54.0)	42.0	(25.5–62.5.0)	0.690
Field visibility, median (IQR)	4.0	(4.0–5.0)	5.0	(4.0–5.0)	**0.001**
Interquartile range (IQR)					
All comparisons performed using the Mann-Whitney U test.					

Secondary outcomes

Secondary outcomes are summarised in Table 3. Blood loss was significantly higher in the no-tourniquet group as demonstrated by both objective measures (haemoglobin (Hb) change: 20.1 vs 16.4 g/L, $p = 0.034$; haematocrit (Hct) change: 0.06 vs 0.05, $p = 0.028$) and estimated intraoperative blood loss (median 150.0 mL [IQR 100.0–200.0] vs 50.0 mL [IQR 50.0–50.0], $p < 0.001$). Length of stay was significantly shorter in the no-tourniquet group (median 2.0 days [IQR 1.0–3.0] vs 2.0 days [IQR 2.0–4.0], $p = 0.016$). Mean surgery duration, rate of self-reported surgical challenges and rate of 30-day returns were comparable between the groups (all $p > 0.11$).

Table 3
Secondary outcomes of TKRs performed with versus without a tourniquet.

Outcome	No tourniquet		Tourniquet		P Value
Surgery duration, mins, mean (SD)	74.9	(20.0)	68.5	(16.4)	0.117 ‡
Blood loss, ml, median (IQR)	150.0	(100.0-200.0)	50.0	(50.0–50.0)	**0.000** §
Hb change, g/L, mean (SD)	20.1	(7.0)	16.4	(8.9)	**0.034** ‡
Hb change, % (SD)	14.6	(5.3)	11.9	(6.2)	**0.035** ‡
Hct change, proportion (SD)	0.06	(0.02)	0.05	(0.03)	**0.028** ‡
Hct change, % (SD)	15.5	(5.4)	12.6	(6.5)	**0.028** ‡
Length of stay, days, median (IQR)	2.0	(1.0–3.0)	2.0	(2.0–4.0)	**0.016** §
Returns, no. (%)					0.494 †
no	36	(84)	34	(83)	
yes	7	(16)	7	(17)	
Surgical challenges, no. (%)					0.923 †
no	30	(70)	29	(71)	
yes	13	(30)	12	(29)	
† Chi-squared test					
‡ Independent samples t-test					
§ Mann-Whitney U test					

Correlation analysis

Exploratory correlation analyses between BMI and primary and secondary outcomes are summarised in Supplementary Table 3. BMI was not significantly correlated with total SURG-TLX workload scores in the no-tourniquet group ($r = 0.129$, $p = 0.409$), tourniquet group ($r = 0.119$, $p = 0.458$), or the overall cohort ($r = 0.113$, $p = 0.307$). Among individual SURG-TLX domains, only physical demand in the no-tourniquet group showed a significant correlation with BMI ($r = 0.333$, $p = 0.029$). Higher BMI was associated with poorer field visibility in the no-tourniquet group ($r = -0.570$, $p < 0.001$), but this correlation was not significant in the tourniquet group ($r = -0.127$, $p = 0.430$). BMI showed a significant correlation with estimated intraoperative blood loss in the overall cohort ($r = 0.278$, $p = 0.011$), though this did not reach significance within either group individually. In the no-tourniquet group, higher BMI was associated with greater absolute Hb drop ($r = 0.321$, $p = 0.036$) and relative Hb change ($r = 0.360$, $p = 0.018$). Hct changes showed significant correlations with BMI in both groups (absolute Hct change: $r = 0.339$, $p = 0.026$ without

tourniquet; r = 0.340, p = 0.030 with tourniquet). BMI was not significantly correlated with surgery duration or length of stay in either group.

Discussion

This study demonstrated that despite reduced visibility in the no-tourniquet group, surgical workload remained equivalent between groups. This is a clinically relevant finding, suggesting that the perceived technical challenge of operating without a tourniquet may not translate into a meaningfully greater cognitive or physical burden for the surgeon. To our knowledge, this is the first study to examine surgeon workload specifically in the context of tourniquet versus tourniquet-free TKR. These findings add to the growing body of evidence supporting the feasibility of tourniquetless TKR and suggest that workload concerns need not be a barrier to its adoption.

The Surgical Task Load Index (SURG-TLX) was used to quantify surgeon-perceived workload in this study. SURG-TLX is a validated adaptation of the National Aeronautics and Space Administration Task Load Index (NASA-TLX), which was originally developed to assess astronaut workload across multiple domains of cognitive and physical demand [9]. Recognising the need for a context-specific tool, NASA-TLX was subsequently modified for the surgical environment, resulting in SURG-TLX [10]. This instrument evaluates workload across six domains: mental demand, physical demand, temporal demand, task complexity, situational stress, and intraoperative distractions. SURG-TLX has demonstrated sensitivity to differences in operative complexity and technique[10]. Although it has not previously been applied to compare tourniquet versus tourniquetless TKR, studies using both SURG-TLX and NASA-TLX in surgical settings have shown their ability to detect meaningful variations in workload. For instance, NASA-TLX has identified workload differences between arthroplasty techniques[11, 12], while SURG-TLX has demonstrated higher workload in more technically demanding procedures [13]. Collectively, this supports the use of SURG-TLX as a valid and sensitive tool for assessing surgical workload in the present study, while establishing a reference for future research.

In this study, there was a marked imbalance in surgeon grade between groups: consultants performed 77% of tourniquet-free cases compared to 54% of cases in the tourniquet group, with trainees disproportionately represented in the latter. This distribution likely reflects current training practice, in which tourniquet use remains more prevalent among less experienced surgeons. Given the clustering of multiple cases within individual surgeons, a linear mixed-effects model was used to account for this non-independence and to formally test whether surgeon grade confounded the primary workload outcome. The intraclass correlation coefficient was 0.146, indicating that surgeon-level differences accounted for a modest but non-trivial proportion of variance in workload scores and supporting the appropriateness of a clustered analytical approach. Surgeon grade was not a significant predictor of total weighted workload, and the absence of a tourniquet effect on workload persisted after adjustment. This indicates that the observed imbalance in surgeon seniority between groups did not meaningfully bias the primary finding, strengthening confidence that the equivalence in workload between groups is a genuine result rather than an artefact of differential surgeon experience.

The reduced visibility in the no-tourniquet group is an expected finding and is in line with the proposed hypothesis. Whilst the visibility was significantly worse in the no-tourniquet group ($p = 0.001$), it is important to note that the score remained relatively high (median 4.0 out of 5.0). This has also been demonstrated by Goel and colleagues (2019), who found that visualisation was significantly more difficult in TKRs without a tourniquet[8]. Notably, this difference does not translate to variations in the overall surgical workload, suggesting that surgeons are able to adapt their techniques and approaches as required.

A potential explanation for the relatively preserved surgical field visibility in the no-tourniquet group may be the use of adrenaline-based local anaesthetic infiltration into the joint capsule during surgery. Adrenaline causes local vasoconstriction, which may help reduce bleeding within the operative field[14]. Bhutta and colleagues (2015) found that patients who received adrenaline-containing local anaesthetic during TKR had significantly lower blood loss and transfusion requirements than those who did not receive this local anaesthetic infiltration[14]. Given that adrenaline was used in 90.5% of no-tourniquet cases compared to only 12.2% of tourniquet cases in this study, it is possible that this adrenaline-based anaesthetic infiltration partially compensated for the absence of a tourniquet. As a result, the relatively preserved visibility observed in the no-tourniquet group may reflect not only surgeon adaptation but also the haemostatic effect of adrenaline infiltration.

This study found significant differences in estimated blood loss and length of stay between the two groups. Estimated blood loss in millilitres was significantly higher in the no-tourniquet group. However, this metric has been previously identified as an unreliable measure of true blood loss[15]. This is further reflected in the data, where blood loss was recorded as "minimal" in 24 of 84 cases (29%), all within the tourniquet group, and subsequently imputed as 50 mL for analytical purposes — a conservative and arbitrary threshold acknowledged as a methodological limitation. The notably narrow IQR in the tourniquet group is a direct consequence of this imputation and should be interpreted accordingly. Hb and Hct changes represent a more objective measure of perioperative blood loss[16]. Whilst a statistically significant difference was observed in favour of the tourniquet group, the between-group differences were clinically negligible (Hb 3.7 g/L (2.7%); Hct 0.01 (2.9%) greater in the no-tourniquet group). This apparent paradox, lower estimated blood loss but equivalent haematological decline in the tourniquet group, is consistent with the phenomenon of hidden blood loss, whereby tourniquet application occludes visible intraoperative bleeding whilst blood continues to accumulate in the periarticular soft tissues and residual joint space, with further losses attributable to tourniquet-induced haemolysis following cuff release[16, 17]. These findings therefore support the existing body of evidence demonstrating no clinically significant difference in total perioperative blood loss, postoperative haemoglobin decline, or transfusion rates between tourniquet and tourniquet-free TKR[1, 18].

There was a significant difference in the length of stay between the two groups, as evidenced by the spread of data (IQR 1.0–3.0 vs 2.0–4.0), although the median length of stay was identical (2.0 days). The existing evidence on the topic is mixed, with a recent large cohort study demonstrating no difference in length of stay[19] and the most recent systematic review on the topic demonstrating a mean 0.34 days

(95% CI 0.03–0.64) longer stay for the tourniquet group[1]. Attributing this difference solely to tourniquet use should be done cautiously, as discrepancies may relate to institutional protocols, patient selection or other confounding factors.

In this study's cohort, greater BMI was associated with increased Physical Demands and poorer field visibility in the no-tourniquet group (Supplementary Table 3). These associations were not observed in the tourniquet group, suggesting that tourniquets may mitigate some of the technical difficulty associated with higher BMI. Previous arthroplasty literature has shown that obesity is linked to greater perioperative blood loss[20] which may lead to worse visibility during the operation, particularly when a tourniquet is not used. Hence, a higher degree of manoeuvring of the patient may be required to achieve adequate visualisation, leading to greater Physical Demands. Conversely, tourniquet use has also been shown to improve surgical field visibility and reduce perioperative blood loss[17] which may help explain why the BMI-related associations were attenuated in the tourniquet group. In this cohort, BMI was additionally associated with greater blood loss-related changes in Hb and Hct overall, supporting the concept that higher BMI may increase both operative difficulty and blood loss[20], although this is not evident across all studies[21].

There are limitations of this study. Firstly, data were collected on a non-consecutive basis, as cases were captured opportunistically by two researchers attending theatres when available. This introduces the possibility of selection bias as procedures performed outside these observation periods were not included. Secondly, SURG-TLX, by nature of a subjective questionnaire, leads to a potential response bias, as surgeons could subconsciously alter their responses based on their beliefs regarding the appropriateness of tourniquet use. Thirdly, while data collection spanned two centres within the same health board, the primary TKR cohort was drawn entirely from one site, which may limit the generalisability of the findings to other institutions or healthcare systems. Finally, the sample size was relatively small due to the feasibility of collecting responses, albeit it is unlikely that a larger sample size would substantially alter the direction of the primary findings given the small observed effect size (Cohen's d = 0.03), which indicates that the null finding for the SURG-TLX score is a true lack of a difference rather than inadequate statistical power.

This study has several notable strengths. It is the first to directly compare surgeon workload between tourniquet and tourniquet-free TKR using a validated surgical task load instrument, representing a novel contribution to the existing literature on tourniquet use. The prospective design and immediate post-operative data capture minimised the potential of recall bias, ensuring that workload ratings reflected genuine intraoperative experience of the lead surgeon. The use of the validated SURG-TLX tool supports the reliability and reproducibility of the workload assessments. Finally, the inclusion of both subjective workload measures and objective operative field assessments strengthens the overall validity of the findings.

Conclusion

This prospective observational study is the first to evaluate surgeon-perceived workload in tourniquet versus tourniquet-free TKR using a validated surgical task load instrument. Despite significantly poorer operative field visibility without a tourniquet, overall and domain-specific SURG-TLX scores were equivalent between groups, and this finding was robust to adjustment for surgeon grade and clustering. Surgeons did, however, weigh Physical Demands more heavily when operating without a tourniquet, an observation that may reflect the higher BMI of this group rather than a direct effect of tourniquet omission. These findings suggest that surgeon-perceived workload should not be considered a barrier to tourniquetless TKR.

Materials and methods

Study design and setting

This prospective observational study was conducted across two major orthopaedic centres within a single regional health service in the UK (one tertiary referral hospital and one district general hospital) between November 2024 and April 2025. This study aimed to evaluate the subjective surgeon-reported workload and operative visibility during knee procedures performed with and without tourniquet use.

Surgeons

Orthopaedic surgeons were recruited from the orthopaedic centres. This comprised 32 surgeons: 21 consultant-level surgeons (including 3 overseas fellows) and 11 orthopaedic trainees. Participating surgeons provided background data, including their age, gender, training grade, prior experience without tourniquet use in knee procedures (yes or no), number of tourniquetless knee surgeries performed (fewer than 20 or 20 or more) and self-reported comfort level for performing surgery both with and without a tourniquet, each rated on a scale of 0–10. For this study, any surgeon post certificate of completion of training was considered a consultant.

Patients

Patients were enrolled based on predefined eligibility criteria. Inclusion criteria consisted of patients aged 18 years and above undergoing elective or trauma-related knee surgery. The surgeries included were TKR, partial knee replacement, knee osteotomy, or fixation of tibial plateau fractures. Patients were excluded if they had contraindications to tourniquet use such as severe peripheral vascular disease or if the procedure involved revision surgery for failed replacement or osteotomy. Procedures conducted with and without a tourniquet were included to allow direct comparison between groups.

Data collection

Data were prospectively collected for 100 knee procedures performed during the study period. The primary analysis was restricted to total knee replacements (n = 84, 84%) to ensure a homogeneous surgical cohort and adequate statistical power for meaningful comparisons. The remaining 16 procedures are evidenced in Fig. 2. Although data collection took place at both sites, all 84 TKR cases

meeting inclusion criteria for the primary analysis were performed at a singular centre; the remaining 16 procedures excluded from the primary TKR analysis were drawn from both sites.

Patient demographic and clinical data were recorded preoperatively. This comprised age, sex, BMI, American Society of Anaesthesiologists scale classifications, preoperative Hb and Hct levels, anaesthesia method, procedure type, indication and laterality, and local adrenaline-based anaesthetic use. Immediately following each surgery, the lead operating surgeon completed a workload assessment in the form of the SURG-TLX questionnaire. SURG-TLX is a validated tool designed to assess operative workload across multiple dimensions: mental demand, physical demand, temporal demand, task complexity, situational stress, and intraoperative distractions, graded on a 20-point scale (0 the lowest, 20 the highest)[10]. Each surgeon ranked each domain, following which the domains were compared using a pairwise analysis. The comparisons were performed by asking the participants to report which one described the surgical case most appropriately, for example, whether the procedure was more physically fatiguing or complex. These 15 comparisons were used to obtain a weight for each domain, which were then applied to generate a weighted workload score ranging from 0 to 100. In addition to workload, surgeons provided a subjective assessment of the intraoperative visibility using a 5-point Likert scale (1 = worst, 5 = best), reflecting their ability to visualise anatomical structures and control bleeding. Surgeons were additionally invited to report any intraoperative challenges considered influential to overall workload.

Outcomes

The primary outcomes consisted of the overall weighted SURG-TLX scores, comparison of individual workload domains, and surgeon-rated surgical field visibility. Secondary outcomes included surgical duration, estimated intraoperative blood loss, length of hospital stay, rate of self-reported intraoperative surgical challenges, and 30-day return to theatre or emergency department rates. Blood loss was measured with three distinct methods: estimated blood loss as recorded on intraoperative sheets in millilitres, and pre-op to post-op changes in Hb and Hct.

Statistical methodology

Data were analysed using SPSS version 29.0.1.0. Normality of data distribution was assessed by both Shapiro-Wilk tests and visual inspection of histograms. Depending on normality, continuous variables are presented as mean and SD or median and IQR. Data were compared between groups using the Mann-Whitney U test for non-normally distributed data and the independent samples t-test for normally distributed data. Categorical variables are presented as frequencies and percentages and compared using the Chi-squared test or Fisher's exact test, where cell counts were fewer than 5. To compare the relative importance assigned to each SURG-TLX domain between groups, the pairwise comparison weights (range 0–5) generated for each of the six domains were compared between tourniquet and no-tourniquet groups using the Mann-Whitney U test; as six comparisons were performed, a Bonferroni-corrected significance threshold of $p < 0.0083$ was applied to account for multiple testing. Cases where intraoperative blood loss was recorded as minimal were assigned a value of 50 mL for analytical

purposes; this applied to 24 of 84 TKR cases (29%). To account for the clustering of cases within surgeons, a linear mixed-effects model was fitted with total weighted SURG-TLX score as the dependent variable, tourniquet use as a fixed categorical effect, surgeon grade as a fixed covariate, and surgeon identifier as a random intercept. The intraclass correlation coefficient was calculated from the estimated variance components. Given the significant difference in BMI between groups, exploratory Pearson or Spearman correlation analyses were performed as appropriate based on data distribution to assess the relationship between BMI and primary and secondary outcomes, reported as correlation coefficients (r) with corresponding p-values. Effect sizes (Cohen's d) were estimated by converting the Mann-Whitney Z-statistic to the rank-based correlation coefficient r ($r = Z/\sqrt{N}$), which was then transformed to Cohen's d, consistent with the non-parametric approach used for the primary outcome. A post hoc assessment indicated that the available sample size (41 tourniquet, 43 no-tourniquet) provided approximately 80% power to detect a moderate standardised effect size (Cohen's $d \approx 0.62$). Statistical significance was set at $p < 0.05$. As some surgeons contributed multiple cases, observations were not fully independent; this clustering was accounted for in the primary analysis through the linear mixed-effects model described above.

Ethics approval

This study was registered as a quality improvement initiative and the experiment protocol was approved by the Edinburgh Orthopaedics Research Department based at the Department of Trauma and Orthopaedic Surgery, Royal Infirmary of Edinburgh, NHS Lothian before commencement. All research was performed in accordance with relevant guidelines and regulations and in compliance with the Declaration of Helsinki. According to the UK Health Research Authority decision tool, formal NHS Research Ethics Committee approval was not required. Written informed consent was obtained from all participating surgeons. Patient demographic and operative data, including age and body mass index, were obtained from routine clinical records and analysed in an anonymised form. No identifiable patient information was collected or reported. All data were handled in accordance with applicable information governance and data protection requirements.

Declarations

Author contributions

A.K.A. conceived the study, formulated the research aims, and supervised the project. K.A.S. and R.D. developed the study methodology and collected the data. K.A.S. performed the statistical analyses, interpreted the results, and created tables and figures. K.A.S. and R.D. conducted the literature review and drafted the manuscript. N.D. contributed to statistical analysis. All authors critically reviewed and approved the final manuscript. K.A.S. and R.D. contributed equally to this work and share first authorship.

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Competing interests

N.D. has received research support from Stryker as a chief investigator and grant holder for studies unrelated to this manuscript. No other competing interests were declared.

Data availability statement

The anonymised datasets generated and analysed during the study are available from the corresponding author upon reasonable request.

Additional information

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References

1. Ahmed, I. et al. Tourniquet use for knee replacement surgery. *Cochrane Database Syst. Rev.* **12** (12), CD012874 (2020).
2. Wu, H. et al. *Comparison of the effects of high tibial osteotomy with and without a tourniquet*. *BMC Surg.*, **24**(1). (2024).
3. Smith, T. O. & Hing, C. B. *Is a tourniquet beneficial in total knee replacement surgery?* The knee., **17**(2): pp. 141–147. (2010).
4. Liu, D. et al. Effects of Tourniquet Use on Quadriceps Function and Pain in Total Knee Arthroplasty. *Knee Surg. Relat. Res.* **26** (4), 207–213 (2014).
5. Ejaz, A. et al. Faster recovery without the use of a tourniquet in total knee arthroplasty. *Acta Orthop.* **85** (4), 422–426 (2014).
6. On behalf of the SAFE-TKR Study Group (Including, Gibbs, V., Price, A. & Wall, Peter, D. H. Surgical tourniquet use in total knee replacement surgery: a survey of BASK members. *Knee* **23** (4), III–IV (2016).
7. Sidhu, A. et al. *TOURNIQUET USE IN TOTAL KNEE ARTHROPLASTY: A SURVEY OF CURRENT PRACTICE AND PREFERENCES AMONG ORTHOPAEDIC SURGEONS OF THE CANADIAN ARTHROPLASTY SOCIETY.* Orthopaedic Proceedings, 104-B(SUPP_12): pp. 53–53. (2022).
8. Goel, R. et al. Tourniquet Use Does Not Affect Functional Outcomes or Pain After Total Knee Arthroplasty. *J. bone joint surgery: Am. volume*. **101** (20), 1821–1828 (2019).
9. Hart, S. G. & Staveland, L. E. *Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research*. Human Mental Workload. Vol. 52. Amsterdam; New York : New York, N.Y., U.S.A. :: North-Holland ;. 139–183. (1988).
10. Wilson, M. R. et al. Development and Validation of a Surgical Workload Measure: The Surgery Task Load Index (SURG-TLX). *World J. Surg.* **35** (9), 1961–1969 (2011).

11. Sappey-Marinier, E. et al. *Better operating room efficiency and reduced staff demand: Individualised versus off-the-shelf total knee arthroplasty.* Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA, **32**(12): pp. 3174–3184. (2024).
12. Panwar, K. S. et al. Revision Total Joint Arthroplasty Places a Disproportionate Burden on Surgeons: A Comparison Using the National Aeronautics and Space Administration Task Load Index (NASA TLX). *J. Arthroplast.* **39** (6), 1550–1556 (2024).
13. Abdelrahman, A. M. et al. Impact of single-incision laparoscopic cholecystectomy (SILC) versus conventional laparoscopic cholecystectomy (CLC) procedures on surgeon stress and workload: a randomized controlled trial. *Surg. Endosc.* **30** (3), 1205–1211 (2016).
14. Bhutta, M. A. et al. Reduced Blood Loss and Transfusion Rates: Additional Benefits of Local Infiltration Anaesthesia in Knee Arthroplasty Patients. *J. Arthroplast.* **30** (11), 2034–2037 (2015).
15. Ram, G. G., Suresh, P. & Vijayaraghavan, P. V. Surgeons often underestimate the amount of blood loss in replacement surgeries. *Chin. J. Traumatol.* **17** (4), 225–228 (2014).
16. Ke, C. et al. Changes in perioperative hemoglobin and hematocrit in patients undergoing total knee arthroplasty: a prospective observational study of optimal timing of measurement. *J. Int. Med. Res.* **48** (11), 300060520969303 (2020).
17. Dong, Z. et al. Tourniquet Effect on Patients Undergoing Total Knee Arthroplasty: A Single-Blind, Randomized Controlled Trial. *Orthop. Surg.* **16** (11), 2714–2721 (2024).
18. Tan, Y. et al. *The effects of tourniquet use on blood loss and perioperative complications in total knee arthroplasty*. *BMC Musculoskelet. Disord.*, **24**(1). (2023).
19. Gibbs, B. et al. Association Between Tourniquet Use and Patient-Reported Outcomes Following Total Knee Arthroplasty. *J. bone joint surgery: Am. volume*. **107** (9), 976–984 (2025).
20. Hrnack, S. A. et al. Correlation of body mass index and blood loss during total knee and total hip arthroplasty. *Am. J. Orthop. (Belle Mead NJ)*. **41** (10), 467–471 (2012).
21. Frisch, N. et al. Effect of Body Mass Index on Blood Transfusion in Total Hip and Knee Arthroplasty. *Orthopedics* **39** (5), e844 (2016).

Figures

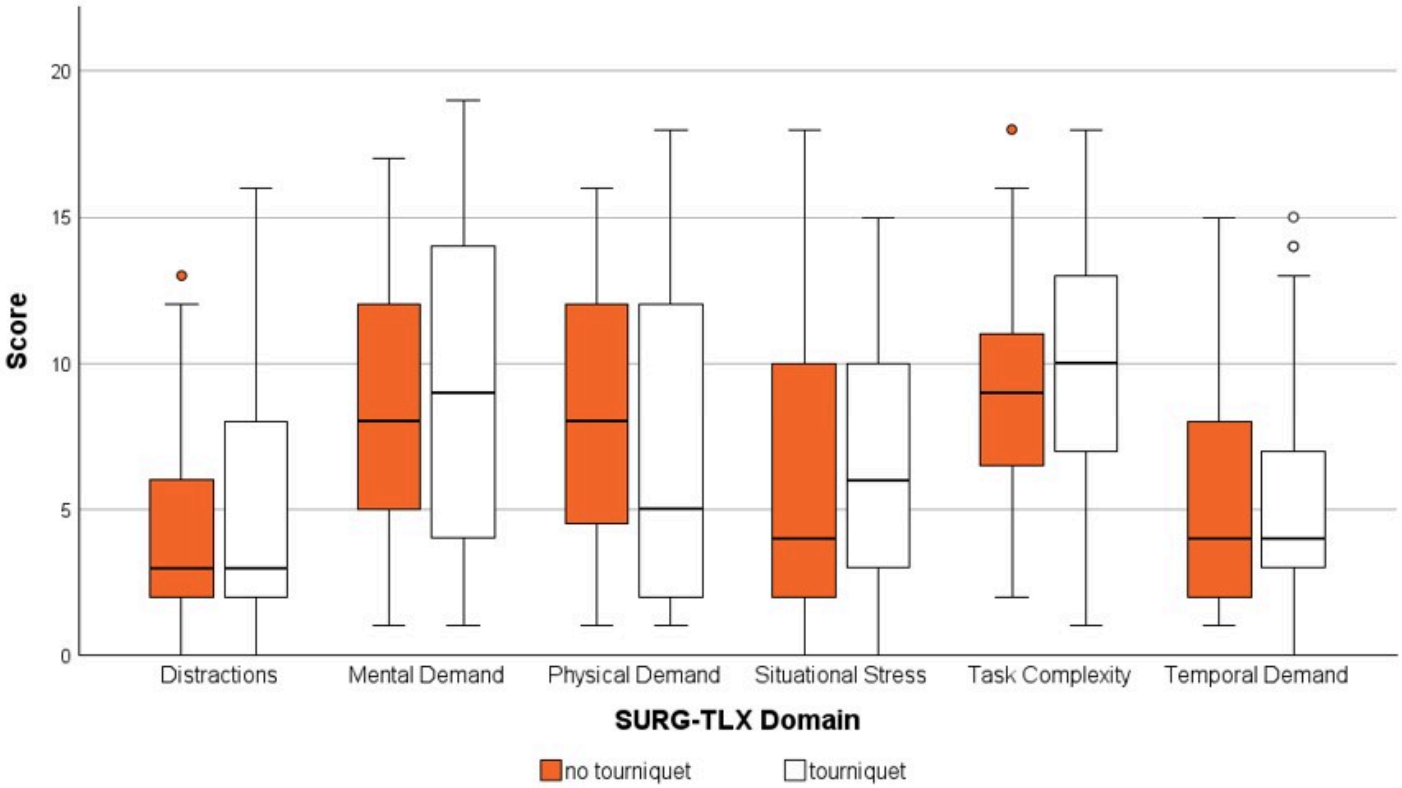


Figure 1

Domain scores of SURG-TLX for tourniquet vs no-tourniquet groups.

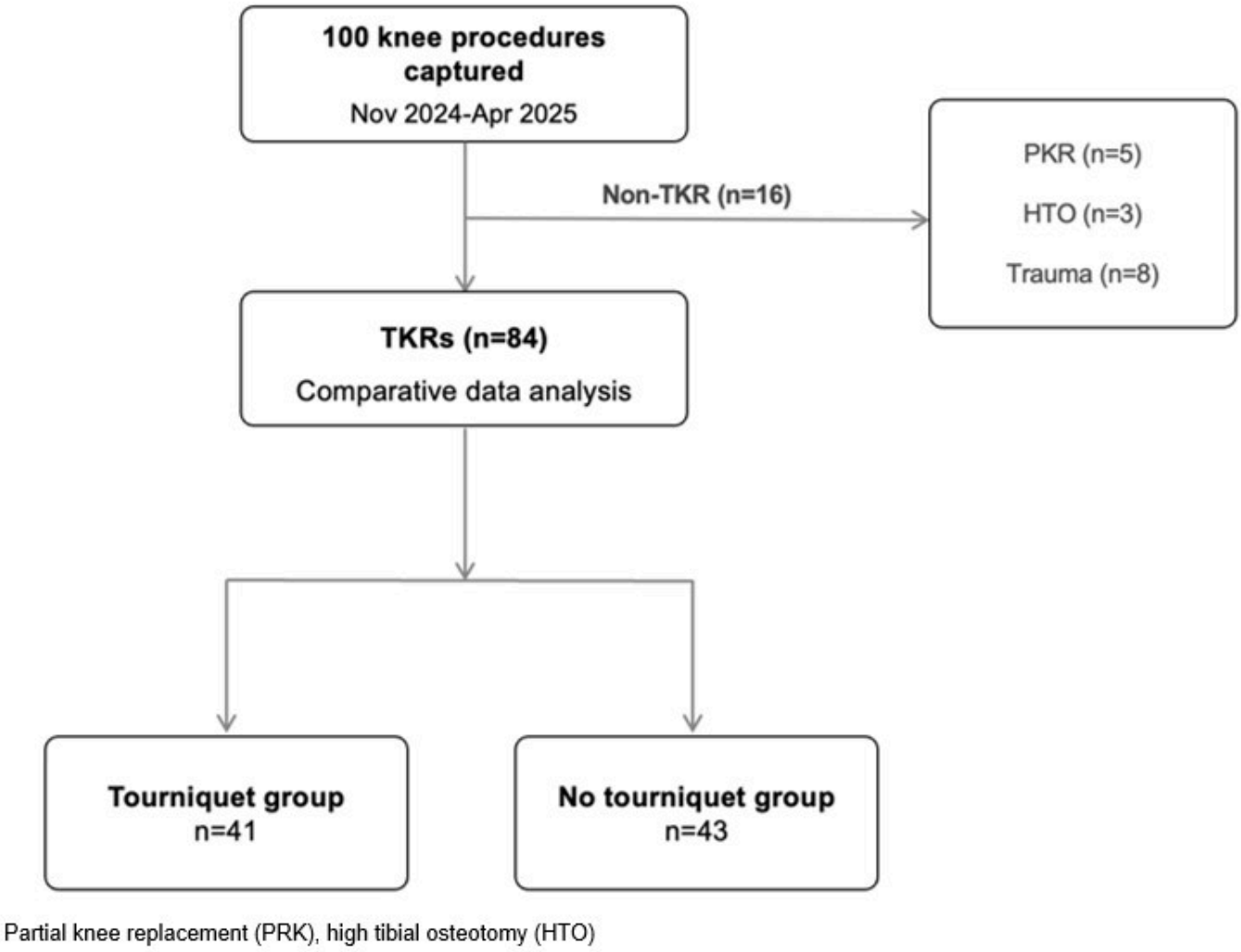


Figure 2

Flowchart illustrating case selection, exclusion, and categorization process for the study.

Supplementary Files

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- Supplementarymaterialscombined.pdf