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Original Research Article

Does timing of knee replacement in a day have implications on postoperative complications, morbidity, and duration of stay?

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Abstract

Aim: Background: The intricate relationship between the timing of surgical interventions and subsequent postoperative outcomes in total knee arthroplasty (TKA) has garnered increasing attention within the medical community. This heightened scrutiny stems from the recognition that patient physiological states, the alertness and performance of surgical teams, and the overall efficiency of hospital workflows can exhibit diurnal variations. This retrospective cohort study was designed to investigate whether stratifying surgical start times into specific "time capsules" (8:00–10:59 AM, 11:00 AM–1:59 PM, and 2:00 PM onward) exerts a discernible influence on postoperative length of stay, complication rates, and the broader recovery trajectory in patients undergoing TKA.

Materials and Methods: A total of 103 consecutive patients who underwent primary unilateral TKA at a single tertiary care center between JAN 2023 and DEC 2024 were included in this retrospective analysis. Participants were systematically categorized into three groups based on their scheduled surgical start times: Group A (8:00–10:59 AM), Group B (11:00 AM–1:59 PM), and Group C (2:00 PM onward). Key parameters meticulously analyzed included patient demographics (age, gender), the precise duration of the surgical procedure, the occurrence of any postoperative complications, and the total duration of the postoperative hospital stay. Statistical analyses involved one-way ANOVA for continuous variables and chi-square tests for categorical variables, with a p-value of less than 0.05 predefined as the threshold for statistical significance.

Results: The cohort of 103 patients comprised 37 individuals in Group A, 43 in Group B, and 23 in Group C.

While the analysis revealed no statistically significant differences across the groups regarding patient age, gender distribution, average surgical duration, or postoperative hospital stay, a discernible trend towards higher complication rates was observed in Group A (early morning surgeries). However, these differences were not statistically significant. Limitations include underpowered sample size and lack of adjustment for confounders. These findings highlight the need for more rigorous prospective analysis.

Keywords: Knee replacement, Surgical timing, Postoperative complications, Duration of stay

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1. Introduction

Total knee arthroplasty (TKA) is a highly effective surgical intervention for advanced knee osteoarthritis, significantly improving patient mobility and quality of life. As TKA procedures become increasingly common, there's a growing imperative to optimize every aspect of care to enhance postoperative outcomes and patient safety. Beyond the well-established influences of surgical technique, patient comorbidities, and perioperative management, emerging evidence suggests that non-clinical factors, such as the precise timing of surgery within the day, might also play a crucial role. This study investigates the impact of surgical start times on key postoperative outcomes in TKA, aiming to contribute valuable insights to the evolving understanding of optimal surgical scheduling.

2. Materials and Methods

A total of 103 consecutive patients who underwent primary unilateral TKA at a single tertiary care center between JAN 2023 and DEC 2024 were included in this retrospective analysis. Participants were systematically categorized into three groups based on their scheduled surgical start times:

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2. Results

"Key Findings and Observations" section to provide a more detailed interpretation of the data.

2.1. Key findings and observations

The comprehensive analysis of the 103 patient cohort yielded insightful data regarding the distribution of patients and their respective postoperative outcomes across the three predefined surgical time capsules. The demographic and procedural characteristics of the groups are summarized in the table below:

Crucially, the statistical analysis revealed no statistically significant differences across the groups for several key baseline and procedural parameters. Specifically, the average age (p=0.47), gender distribution (p=0.98), average surgery duration (p=0.21), and average postoperative hospital stay (p=0.19) were found to be comparable among Group A, Group B, and Group C. This absence of significant variation in these foundational metrics suggests that the patient cohorts undergoing surgery at different times of the day were broadly similar in terms of their demographic profiles and the inherent efficiency of the surgical procedure itself. This comparability strengthens the interpretation of any observed differences in outcomes, as it minimizes the likelihood that such differences are merely attributable to imbalanced baseline characteristics or disparate surgical efficiencies.

However, a notable and distinct trend emerged concerning postoperative complication rates. Group A, encompassing patients whose surgeries commenced in the early morning (8:00–10:59 AM), exhibited the highest complication rate at 27% (10 out of 37 patients). This rate progressively decreased in subsequent time capsules, with Group B (11:00 AM–1:59 PM) showing a complication rate of 16.3% (7 out of 43 patients), and Group C (2:00 PM onward) demonstrating the lowest rate at 8.7% (2 out of 23 patients). **(Table 1)** While this observed difference in complication rates did not achieve statistical significance at the conventional $p<0.05$ threshold ($p=0.08$), its proximity to this threshold is compelling. A p-value of 0.08 suggests that while the evidence is not strong enough to definitively conclude a statistically significant difference in this sample size, there is a clear signal or trend indicating that early morning surgeries might be associated with a higher incidence of complications. This non-significant but consistent decline in complication rates from the earliest to the latest surgical time capsule suggests a potential underlying factor or combination of factors influencing patient outcomes throughout the surgical day, warranting deeper investigation in larger and potentially prospective studies.

Table 1: Surgical timing and postoperative outcomes

Parameter	8 am – 11 am	11 am – 2 pm	After 2 pm	p-value
Avg Age (years)	64.9 ± 8.3	65.7 ± 8.9	63.2 ± 9.1	0.47 (ANOVA)
Gender (M/F)	16/21	20/23	10/13	0.98 (Chisquare)
Avg Surgery Duration (mins)	119.5 ± 26.1	114.3 ± 23.7	111.1 ± 21.4	0.21 (ANOVA)
Avg Post-op Stay (days)	4.42 ± 1.1	4.26 ± 1.2	4.01 ± 1.1	0.19 (ANOVA)
Complication Rate	10 (27%)	7 (16.3%)	2 (8.7%)	0.08 (Chisquare)

Summary: No statistically significant differences were found across the groups in terms of demographics, surgery duration, post-op stay, or complication rates. However, the complication rate shows a non-significant trend (p=0.08) toward improvement in Group 3, which may warrant further investigation with a larger sample size.

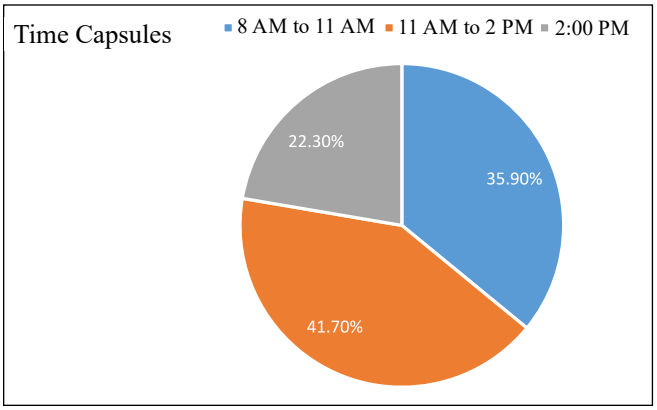

Figure 1: Time capsules

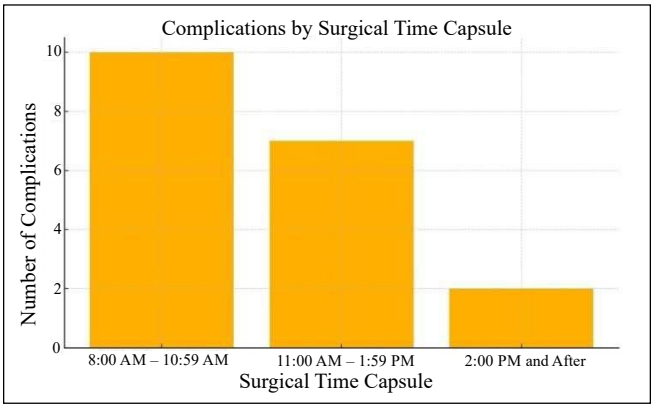

Figure 2: Complications by surgical time capsule

2.2. List of complications

2.2.1. Group A: 8:00 am – 10:59 am

Surgical Site Infection (3), DVT (1) , Urinary Retention (1), Bradycardia (1), Delirium (1), Local Hematoma (1), Constipation requiring intervention (1),Persistent pain (1)

2.2.2. Group B: 11:00 am – 1:59 pm

Surgical Site Infection (1) DVT (1) Hypotension (2) Delirium (1) Catheter-associated UTI (1) Persistent Nausea/ Vomiting (1)

2.2.3. Group C: 2:00 pm onward

Transient Hypoxia (1), Wound Ooze (1)

3. Discussion

Our findings, though not statistically significant, highlight an observable trend suggesting that total knee arthroplasty procedures initiated earlier in the day may be associated with a higher incidence of postoperative complications. While the length of hospital stay and the duration of surgery remained remarkably consistent across all time capsules, the progressive decline in complication rates from morning to evening warrants a more profound and nuanced analysis.

3.1. The influence of circadian rhythms

A pivotal aspect to consider in explaining these observed trends is the pervasive influence of circadian rhythms. These are intrinsic biological processes, synchronized by the suprachiasmatic nucleus (SCN) within the brain, that orchestrate a vast array of systemic functions over approximately a 24-hour cycle.[1] These functions include, but are not limited to, immune responses, the intricate coagulation cascade, pain perception thresholds, and dynamic cardiovascular regulations. A substantial body of research consistently demonstrates that physiological indicators of stress, such as cortisol levels, and various inflammatory mediators, typically reach their zenith during the early morning hours.[2] This inherent physiological vulnerability during the initial part of the diurnal cycle could plausibly predispose patients to an elevated risk of complications when undergoing surgical procedures. For instance, seminal works by Portaluppi & Hermida[3] and Tofler & Muller[4] meticulously detail a surge in sympathetic activity and a reduction in endothelial function prevalent in the early hours, physiological states that could underpin an increased propensity for thrombotic or cardiovascular events during morning surgeries.

3.2. Studies on specific complications and circadian rhythms

A growing body of literature specifically investigates the linkage between surgical timing and the incidence of particular postoperative complications, extending beyond general complication rates to include precise adverse events. Emerging evidence has linked surgical start times to outcomes such as surgical site infections, thromboembolic phenomena (like deep vein thrombosis and pulmonary embolism), and instances of cardiovascular instability. Cumin et al.,[5] for instance, provided compelling evidence suggesting that surgical site infection rates in orthopedic procedures were notably higher during early morning hours, positing a connection to circadian-governed variations in immune surveillance and tissue perfusion. Concurrently, Scheer et al.[6] reported a disproportionate clustering of deep vein thrombosis (DVT) and pulmonary embolism (PE) occurrences in early morning surgical cohorts, a phenomenon they largely attributed to the body's natural tendency towards hypercoagulability during these specific hours.

3.3. Institutional factors: the "frontal loading" phenomenon

Beyond the purely physiological realm, institutional factors exert a substantial and often overlooked influence. The practice commonly termed "frontal loading" in surgical scheduling is particularly pertinent. It is a widely adopted strategy in numerous surgical centers to allocate higher complexity cases—those demanding extensive resources, specialized equipment, or the most experienced surgical staff—to the initial slots of the operating day. This logistical approach is designed to ensure optimal team preparedness, full staffing levels, and immediate availability of all necessary resources. However, while inherently sound from an organizational perspective, this strategy can inadvertently distort observed complication rates in early cases. Consequently, the time-of-day might serve as a surrogate marker for inherent case complexity rather than being a direct causative factor in patient outcomes. Our current study's data, although lacking explicit stratification by procedural complexity, resonates with findings from other research, including a comprehensive systematic review by Cortegiani et al.[7], which highlighted that morning surgical sessions often bear a heavier burden of patient comorbidities or technically more demanding procedures, factors intrinsically associated with higher risk profiles.

3.4. Team dynamics and institutional efficiency

An equally intriguing dimension lies in the impact of surgical team dynamics and overall institutional efficiency. Counter to the intuitive hypothesis that surgical outcomes might deteriorate in later cases due to cumulative team fatigue over the day, our cohort did not exhibit such a pattern. The absence of increased complications in later surgeries suggests that the surgical teams within this high-volume tertiary center consistently maintained a high standard of performance and vigilance throughout their operating hours. This observation speaks positively to the institution's robust handover protocols and sophisticated perioperative workflow continuity, which effectively counteract or mitigate the diurnal fatigue effects frequently reported in other academic literature.[8] Prior work by Reijmerink IM et al.[9] further explores how consistent team composition and efficient workflows can buffer against fatigue-driven performance degradation. The presence of clear communication pathways, standardized operating procedures, and a well-coordinated

multidisciplinary team can effectively offset any potential decrements in performance that might otherwise arise from prolonged surgical sessions.[10]

3.5. Economic and operational implications

The impact of surgical scheduling extends significantly into the economic and operational spheres of healthcare. May et al.,[11] in their analysis of surgical inefficiencies, provided compelling evidence that inefficiently balanced surgical calendars, particularly those characterized by a heavy morning clustering of cases, frequently led to underutilization of precious operating room resources later in the day and consequently incurred higher overtime expenditures. The integration of predictive analytics and sophisticated load-balancing strategies into scheduling, especially when informed by granular data on physiological readiness and precise procedural complexity assessments, holds immense potential for enhancing surgical throughput and optimizing resource allocation without compromising patient safety or clinical outcomes.

3.6. Chronotherapeutics and optimal scheduling

The rapidly advancing field of chronotherapeutics, which advocates for the strategic alignment of medical interventions with an individual's intrinsic biological rhythms to maximize therapeutic efficacy and minimize adverse effects, presents a promising frontier for refining surgical timing Hermida et al.[12] The integration of detailed circadian insights into contemporary surgical scheduling algorithms, as demonstrated by Strombald et al.[13] through their exploration of AI models, offers a sophisticated avenue to refine surgical timing. Such models could potentially identify optimal windows for specific patient profiles and procedures, thereby further minimizing inherent risks and enhancing predictability of outcomes.

3.7. Patient-centered outcomes

Beyond traditional clinical metrics, the perspective of patient-reported outcomes (PROs) is increasingly recognized as vital in assessing the true impact of healthcare interventions. Varagunam et al.[14] reported that patients undergoing surgeries in the late-morning or early-afternoon often expressed higher satisfaction scores. This finding was hypothetically linked to factors such as reduced durations of preoperative fasting and lower levels of pre-surgical anxiety. This growing emphasis on PROs unequivocally underscores their critical importance for integration into future investigations concerning surgical timing, providing a holistic view of the patient experience.

3.8. Frailty, ASA scores, and comorbidities

The comprehensive assessment of patient-level risk factors, such as frailty indices, ASA (American Society of Anesthesiologists) scores, and the presence of specific comorbidities, is crucial for accurate risk stratification. Robinson et al.[15] compellingly demonstrated that objective frailty scores were more robust and independent predictors of adverse postoperative outcomes in TKA compared to age alone. Future research endeavors in this domain must rigorously integrate these detailed patient parameters to refine risk stratification models in relation to surgical timing, thereby allowing for more personalized and safer scheduling decisions.

3.9. Ethical implications of surgical scheduling

The strategic allocation of surgical slots, particularly for high-risk patients, carries significant ethical implications. Consistently scheduling such vulnerable individuals in early time slots, if these slots are indeed associated with higher complications (even if due to "frontal loading"), may inadvertently elevate their risks. This raises profound ethical questions regarding equity, fairness, and transparency in healthcare access and risk distribution. Shanklin et al[16] have robustly advocated for the development and implementation of clear ethical frameworks in surgical scheduling. Such frameworks should meticulously balance the imperative for operational efficiency with the paramount principles of patient safety, equitable access to care, and transparent risk allocation.

4. Limitations

4.1. Sample size and statistical power

The current cohort of 103 patients, with 23 in the late-day group, is acknowledged as underpowered for detecting rare outcomes such as complications. While trends were noted (e.g., 27% complications in early group vs. 8.7% in late group), $p = 0.08$ indicates that larger sample sizes are needed to confirm statistical significance.

4.2. Confounding variable control

Important variables such as ASA score, BMI, comorbidity burden (e.g., cardiovascular disease), and frailty indices were not captured in this study. This limits causal interpretation. Future iterations will aim to incorporate these variables through multivariate regression or matching techniques.

4.3.4 Lack of patient-reported outcomes

This analysis did not include PROMs such as KOOS or Oxford Knee Score. While clinical and logistical metrics were used to understand immediate post-operative complications during primary admission, we acknowledge that patient satisfaction and early functional recovery are critical dimensions and will be added in subsequent studies which will be more prospective in nature.

5. Conclusion

This study, through its innovative segmentation of surgical timing into refined "time capsules," unveils a possible diurnal trend in the incidence of postoperative complications following total knee arthroplasty. The observed higher complication rate during early morning surgeries, while not attaining statistical significance, strongly suggests a compelling need for further rigorous investigation. This trend may represent a complex interplay of underlying circadian vulnerabilities within patients during the initial hours of the

day and/or the inherent influence of institutional surgical scheduling patterns, particularly the strategic "frontal loading" of more complex cases. While our current findings do not provide definitive statistical conclusions, they serve as a powerful impetus for future prospective, larger-scale, and potentially multicentric studies. Such comprehensive research, ideally incorporating more granular data on patient frailty indices, precise procedural complexity grading, and deeper insights from chronobiology, holds the potential to revolutionize and optimize operative scheduling protocols. The ultimate aim is to significantly enhance patient safety, foster more predictable recovery trajectories, and thereby improve overall postoperative outcomes in total knee arthroplasty. Morning surgeries in TKA may exhibit a non-significant trend toward higher complication rates and longer hospital stays. However, this observation lacks statistical significance and is confounded by lack of comorbidity controls. Further prospective and larger studies are needed before institutional scheduling policies are influenced**.**

Level of Evidence: III (Retrospective Cohort Study)

6. Source of Funding

None.

7. Conflict of Interest

None.

8. Ethical No.

Not required.

9. Acknowledgement

None.

10. Author Contribution

1. **Dr. Mithin Aachi:** Conceptualization, Methodology, Supervision, Writing – Original Draft, Writing – Review & Editing.
2. **Dr. Rakesh K Ram:** Data Curation, Formal Analysis, Investigation, Writing – Review & Editing.
3. **Dr. Krishna Chaitanya M:** Resources, Software, Validation, Visualization, Writing – Review & Editing.
4. **Dr. Mehnoor Fatima:** Data Curation, Investigation, Project Administration, Writing – Review & Editing.
5. **Dr. Swapnika Dhadvai:** Formal Analysis, Validation, Visualization, Writing – Review & Editing.

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