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Original Research Article

The impact of noise reduction techniques on total knee replacement: A comparative study to achieve 'Silent TKR'

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Abstract

Background: Noise levels in the operating theatre (OT) during Total Knee Replacement (TKR) surgeries can impact surgical precision, communication, and staff well-being. This study evaluates the effects of noise-reducing interventions on surgical outcomes and staff satisfaction in TKR procedures and trying to achieve as much Silent TKR as possible.

Materials and Methods: A total of 104 TKR surgeries were performed, with 50 conducted using conventional OT practices and 54 using noise-reducing interventions during Jan 1st 2023 to Dec 31st 2024. The noise reducing interventions included minimal verbal exchanges, the use of noise-isolating ear pods, reduced but optimal staff presence, and minimized instrument handling. Verbal communication was observed using modified OTAS based checklist. Intraoperative noise levels were measured, and post-operative complications, surgical time, and staff-reported satisfaction were assessed.

Results: The noise-reducing group demonstrated lower intraoperative noise levels (mean reduction of 27.5 dB%, $p<0.05$, based on subjective feedbacks). There was no significant difference in surgical time or post-operative complications between the two groups. However, staff satisfaction surveys revealed significantly higher scores in the noise-reducing group, citing improved concentration, reduced stress, and better teamwork efficiency ($p<0.01$). Surgeons and assisting staff reported feeling more in control and less fatigued at the end of procedures.

Conclusion: Implementing noise-reducing strategies in the OT during TKR leads to a more focused surgical environment without compromising patient outcomes. Additionally, staff members experience greater job satisfaction and reduced stress levels. While observer bias and confounders exist, this study provides basis for future larger trials. Further studies are warranted to explore long-term benefits and broader applications in other surgical procedures. A goal of 'Silent TKR' to the best of our ability is possible with good planning and execution.

Keywords: Total knee replacement, Noise pollution, Theatre staff preferences, Silent TKR, Decibel meter

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1. Introduction

Operating room noise is an often-overlooked factor that can influence surgical outcomes, team coordination, and cognitive load on medical professionals. Studies have shown that OR noise levels frequently exceed recommended thresholds, sometimes reaching hazardous levels comparable to industrial environments.[1,2,3,4] Noise sources include powered instruments (e.g., saws and drills), metal-to-metal impacts, suction devices, and non-essential verbal communication.[5] Prior studies have demonstrated the psychological and operational stress caused by OR noise.[1,6]

High noise levels have been associated with increased stress, cognitive fatigue, and communication errors among surgical teams.[1,2,7] Some studies suggest that prolonged exposure may contribute to hearing impairment and stress-related disorders in surgical staff.[1,2] The impact of noise on surgical outcomes remains controversial, but there is growing interest in evaluating whether noise-reduction strategies can improve OR efficiency, staff well-being, and patient safety.[3]

This study aimed to compare two cohorts of TKR procedures: one performed under conventional noise conditions and another using noise-reducing intervention, including noise-cancelling ear buds, reduced instrument handling, and minimized verbal exchanges. The objective was to assess whether these interventions could improve

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workflow, reduce unnecessary communication, and enhance surgical efficiency.

2. Materials and Methods

2.1. Study design and population

This prospective observational study was conducted on 104 patients undergoing TKR at a single tertiary care center between Jan 1st 2023 to Dec 31st 2024. The patients were divided into two groups based on intraoperative noise conditions:

1. **Group 1 (conventional noise exposure, n = 50)**: Procedures were performed with standard OR noise levels, including saws, drills, instrument handling, and unrestricted verbal communication.
2. **Group 2 (noise-reduction model, n = 54):** Procedures incorporated noise-cancelling ear buds for surgical staff, reduced verbal communication, minimized instrument handling noise, and structured preoperative team discussions to reduce intraoperative communication.

The patient demographics, including age and sex distribution, were comparable between groups. The study adhered to institutional ethical guidelines, and informed consent was obtained from all participants.

2.2. Noise level measurement

Noise levels were continuously recorded by the observer and assistant using a calibrated decibel (dB) meter depicted in **Figure 1** (MEXTECH Sound Level Meter Range 30 dB to 130 Db) was placed 1 meter from the surgical field taped to a saline stand. The peak noise levels and average noise exposure were analysed for both groups. **(Figure 2)**

Figure 1: Decible meter (MEXTECH)

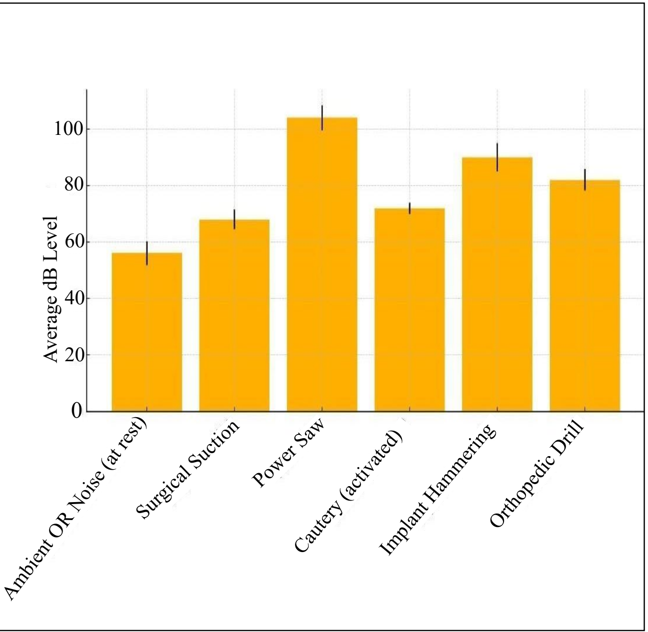

Figure 2: Comparison of average noise with SD in Operating Room by various instruments (104 cases).Experiment was done in triplicated and represented with SD values

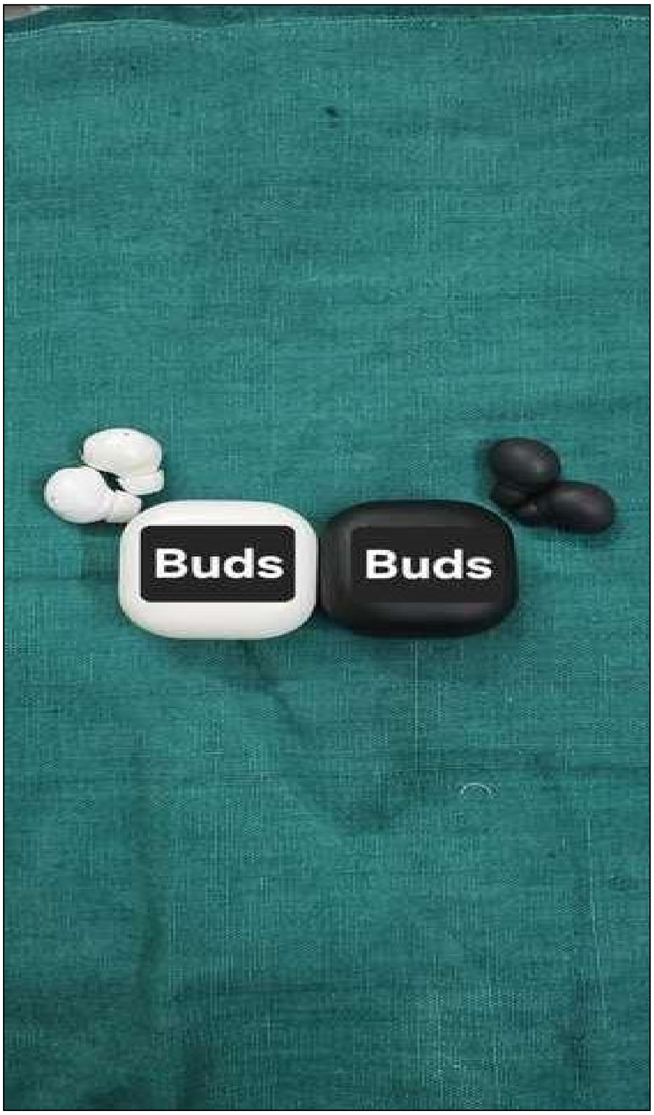

Figure 3: Airpods

2.3. Intraoperative communication and workflow assessment

Verbal exchanges were documented by an independent observer. An assistant second observer present next to the first ratified the logs of the first observer who noted the values and exchanges. Inter-observer reliability was assessed by Cohen's Kappa value of 0.81.

To assess intraoperative communication, we used a standardized checklist derived from the Observational Teamwork Assessment for Surgery (OTAS) framework, originally validated by Hull et al.[8] The OTAS tool is a widely accepted observational method for evaluating teamwork behaviours, including communication, coordination, and leadership, across distinct surgical phases. For the purpose of this study, we implemented a modified version focused specifically on verbal exchanges. Our adapted checklist retained the phase-based structure and categorical coding system of the original tool, focusing on elements such as information giving, information seeking, clarifications, miscommunications, repetitions, and interruptions. A trained observer independently recorded communication events in real time using this structured log, which enabled consistent, objective, and reproducible data collection. A second observer present next to the first main observer ratified the log by independent. This focused modification maintains fidelity to the communication component of the OTAS system and aligns with its intended use in assessing behavioural performance in the operating room.

2.3.1. Surgical time was recorded from incision to wound closure.

Staff feedback was collected via a standardized questionnaire evaluating the perceived impact of noise on concentration, fatigue, and workflow efficiency.

2.4. Statistical analysis

Descriptive statistics were used to compare surgical duration, noise levels, and verbal exchanges between groups. Statistical significance was assessed using t-tests for continuous variables and chi-square tests for categorical variables, with $p < 0.05$ considered significant.

3. Results

3.1. Noise levels and staff perception

The highest recorded noise levels were 109 dB in Group 1 and 108.5 dB in Group 2. Outcome of the noise level were depicted in **Table 1**.

Noise-cancelling ear buds used in Group 2 resulted in a perceived 27.5% reduction in noise transmission to staff ears. This was a subjective assessment based on questionnaire and did not involve objective data as intra auditory measuring devices were not used. **(Figure 3)**

Staff overwhelmingly preferred the noise-reduction approach, with none of the respondents favouring conventional noise exposure.

3.2. Surgical duration and communication

The average surgical time was 63 minutes in Group 1 and 56 minutes in Group 2 ($p < 0.05$), indicating improved efficiency with noise reduction techniques. Verbal exchanges in the OR were significantly lower in Group 2, with an average of <50 spoken words per case compared to > 400 words in Group 1. No miscommunications leading to errors were reported in either group.

Based on communication metrics table with Group 1 (Control) having 420 verbal exchanges and Group 2 (Intervention) only 50, the following key insights emerge as depicted in **Table 2**.

Table 1: Comparison of average noise with SD in operating room by various instruments (104 cases)

Instrument	Average dB level	Standard deviation(±)
Ambient OR Noise (at rest)	56	4.3
Surgical Suction	68	3.5
Power Saw	104	4.5
Cautery (activated)	72	2.0
Implant Hammering	90	5.0
Orthopedic Drill	82	3.8

Table 2: Communication metrics table with sample adjustment

Metric	Group 1 (Control)	Group 2 (Intervention)	Adjusted for sample size
Total Verbal Exchanges	420	50	-
Miscommunications (%)	4.29%	20.0%	2.14%
Repetitions Required (%)	3.57%	14.0%	1.79%
Observer-rated Clarity (1-5)	3.2	4.3	-
Time to First Clarification (min)	5.8	3.2	-

Table 3: Major sources of noise generation in operation theatre during TKR

Source	Decibels generated	Notes of observations to mitigate noise
Saw cuts on bone through metal jigs	106–110 dB	Slow and Interrupted saw leads to less impactful Noise Generation
Implant hammering	90–95 dB	We advocate impaction on Surgical absorbient abdominal mop sponge over the implant to lessen the Noise (10 – 13 Db reduction)
Suction tips	78–80 dB	We advocate using the mop wherever possible and avoiding dry suction (5–7 dB more noise)
Metal clanging on instrument trays	80–84 dB	Preoperative tray preparation of Instruments in order of need helps reduce the clanging noise

3.2.1. Verbal exchange volume

1. Group 1: 420 verbal exchanges
2. Group 2: 50 verbal exchanges

3.2.1.1. Interpretation

The significant reduction in verbal exchanges in Group 2 suggests that the use of earbuds and structured communication likely led to more efficient, targeted communication. This is typical when clarity improves—people don't need to repeat themselves or talk over background noise.

3.2.2. Miscommunication rate

1. Group 1: 4.29%
2. Group 2: 20.0 %

3.2.2.1. Interpretation

Although the absolute number of miscommunications is lower in Group 2 (10 vs. 18), the percentage is higher due to the much lower baseline number of exchanges.

This can indicate either:

1. A learning curve with the ear buds.
2. Smaller sample leading to inflated percentages. Still, the absolute sample adjusted miscommunication count is better in Group 2.

3.2.3. Repetitions required

1. Group 1: 3.57%
2. Group 2: 14.0 %

3.2.3.1. Interpretation

Again, though percentage is higher in Group 2, only 7 repetitions occurred vs. 15 in Group 1. The small denominator in Group 2 inflates the percentage. In practical terms, the burden of repetition was still lower.

3.2.4. Observer-rated clarity

1. Group 1: 3.2/5
2. Group 2: 4.3/5

3.2.4.1. Interpretation

Observers perceived much clearer communication in Group 2. This supports the notion that even with fewer verbal exchanges, quality was higher.

3.2.5. Time to first clarification

1. Group 1: 5.8 min
2. Group 2: 3.2 min

3.2.5.1. Interpretation

Group 2 teams addressed uncertainties faster. Likely due to clearer initial instructions or reduced background noise interfering with comprehension.

1. Sample adjusted miscommunications in group 2 is 2.14%, repetitions required 1.79%
2. Sources of Peak Noise in TKR Procedures

The primary noise sources with remedies, identified during TKR were tabulated in **Table 3**.

1. **Saw on metal jigs remedy:** Slow and Interrupted saw leads to less impactful Noise Generation. Constant generation of noise and fatigue on ear cells is prevented
2. **Implant hammering remedy:** We advocate impaction on Surgical absorbent abdominal mop sponge over the implant to lessen the Noise (10 – 13 dB reduction).
3. **Suction tips remedy:** We advocate using the mop wherever possible and avoiding dry suction which can give more noise than a suction on wet film due to higher air suction (5 to 7 dB more noise).
4. **Metal clanging on instrument trays remedy:** Preoperative tray preparation of Instruments in order of need helps reduce the clanging noise.
5. **Staff feedback and preference**
   a. All surgical staff in Group 2 (noise-reduction model) preferred this approach over the conventional method.
   b. Participants reported improved focus, reduced fatigue, and a more organized workflow in the noise-reduction setting.
   c. In Group 1, some staff reported mild to moderate discomfort due to prolonged exposure to high-decibel noise.

4. Discussion

4.1. Impact of noise reduction on surgical workflow

Our findings highlight the potential benefits of reducing OR noise in TKR procedures. The significant reduction in verbal exchanges in Group 2 suggests that unnecessary communication can be effectively minimized without compromising intraoperative coordination or patient safety.

While percentages for miscommunications and repetitions appear worse in Group 2, absolute sample adjusted counts and observer-rated clarity favour the intervention.

This suggests that structured, quieter environments reduce verbal clutter and improve meaningful communication, though teams may need training or acclimatization to fully adapt to noise-reduction setups.

Previous studies have indicated that excessive OR noise may contribute to cognitive overload and increase the risk of miscommunication-related errors.[2,7] Our study aligns with these findings by demonstrating that a structured approach to communication enhances efficiency rather than impeding it.

4.2. Effect on surgical efficiency

The shorter average surgical time (56 vs. 63 minutes) in the noise-reduction group suggests that a calmer OR environment may facilitate smoother workflow and faster decision-making. This is consistent with previous literature showing that high noise levels can distract surgeons and lead to longer procedural times.[1,9,7] While the 7-minute reduction in operating time may seem modest, cumulatively, this could translate to significant time savings in high-volume centres.

4.2.1. Psychological and physiological effects on surgical staff

Chronic exposure to loud OR environments has been linked to increased stress levels and auditory fatigue in healthcare professionals.[2,3,5,10] The perceived 30% reduction in noise transmission reported by staff in Group 2 supports the potential for hearing protection and cognitive benefits with noise-cancelling techniques. Further research is needed to assess. Whether these interventions can contribute to long-term reductions in surgical burnout and fatigue.[11,12,13]

4.2.2. Sources of OR noise and potential interventions

The identification of key sources of peak noise during TKR (e.g., saws, implant hammering, suction tips) offers opportunities for targeted noise-reduction strategies. Possible interventions include:

1. Use of quieter surgical instruments where feasible[14]
2. Implementing suction devices with lower noise emissions.[15]
3. Design modifications in instrument trays to reduce clanging.[16]
4. Encouraging preoperative discussions to minimize intraoperative verbal exchange.[4]

5. Limitations

Potential confounding factors include variations in team dynamics and procedure complexity. Observer-based assessments could introduce bias, though standardized tools were used. The study was not powered to detect differences in rare clinical outcomes such as infection or readmission. The study relied on perceived subjective assessment of reduction of decibel noise through questions to OT team and did not use an intra-auditory device to rely on accurate measurements. Larger randomized controlled studies are needed.

7. Conclusion

This study demonstrates that implementing noise-reduction techniques in TKR surgeries results in a more efficient, less stressful operating environment without compromising communication or patient safety. Surgical time was reduced, verbal exchanges were significantly decreased not impacting meaningful communication, and staff overwhelmingly favoured the noise-reducing approach. Given these findings, incorporating structured noise-reduction protocols in ORs should be considered for routine practice. Future research should explore the long-term effects of noise reduction on surgical outcomes, staff well-being, and patient recovery.

8. Author Contribution

1. **Mithin Aachi:** Conceptualisation, Validation, Methodology, supervision, Original draft preparation
2. **Vishwanath Karne:** Validation, data collection and analysis, Methodology
3. **Ramba Govardhana Anjali:** Data collection, Review and editing
4. **Ayesha Baig:** Review and editing

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No funding has been secured for this study.

10. Conflict of Interest

The authors declare that they have no conflicts of interests to disclose.

11. Acknowledgement

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