# Enhancing Medical Student Education in Neurosurgery: The Impact of the Sub-Internship Rotation

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## Background

Neurosurgical sub-internships (SubIs) are among the most influential experiences for medical students pursuing neurosurgery and are heavily weighted in residency selection. These rotations play a critical role in validating specialty choice, increasing involvement in patient care, and preparing students for intern-level responsibilities.

Despite their importance, SubI curricula remain highly variable and largely unstandardized across institutions. Many students report feeling underprepared for residency, highlighting a mismatch between the time invested in sub-internships and the consistency of educational outcomes. Objective evaluation of the SubI experience is therefore necessary to assess educational impact, identify gaps in training, and inform development of standardized curricula.

## Objective

To evaluate the educational impact of a neurosurgical sub-internship on fourth-year medical students and identify domains of strength and persistent knowledge gaps that could inform development of a standardized, competency-based SubI curriculum.

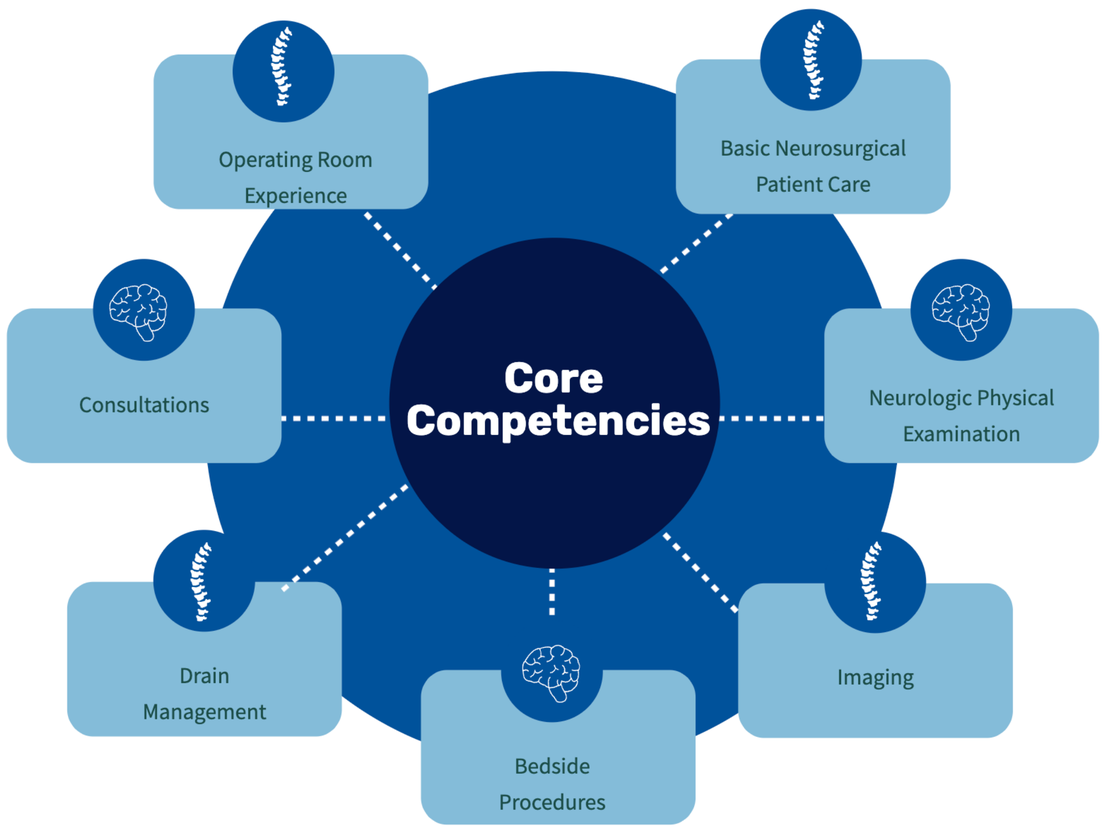


**Figure 1.** Pre- and post-rotation performance of fourth-year medical students across seven intern-level neurosurgical knowledge domains during a four-week sub-internship..

## Methods

We conducted a prospective observational study of fourth-year medical students completing a four-week neurosurgery SubI between May 2022 and August 2024.

Key methodological features:

- Pre- and post-rotation surveys administered at the start and end of each SubI
- Assessment of seven intern-level knowledge domains (Figure 1):
  - Basic neurosurgical patient care
  - Neurologic physical examination
  - Bedside procedures
  - Imaging interpretation
  - Drain management
  - Consultations
  - Operating room experience

Pre- and post-rotation scores compared using paired t-tests

## Results

Thirty-two students completed both pre- and post-rotation assessments.

Overall findings (Figure 2):

- Statistically significant improvement in all seven domains ($p < 0.05$)
- Greatest improvements observed in:
  - Bedside procedures: +23.4%
  - Operating room experience: +22.5%
- Highest baseline performance:
  - Basic neurosurgical patient care (85.3%), with the smallest relative improvement (+4.96%)
- Lowest-performing domain:
  - Drain management
    - Baseline: 55.5%
    - Post-rotation: 72.5%
    - Improved but remained the weakest area

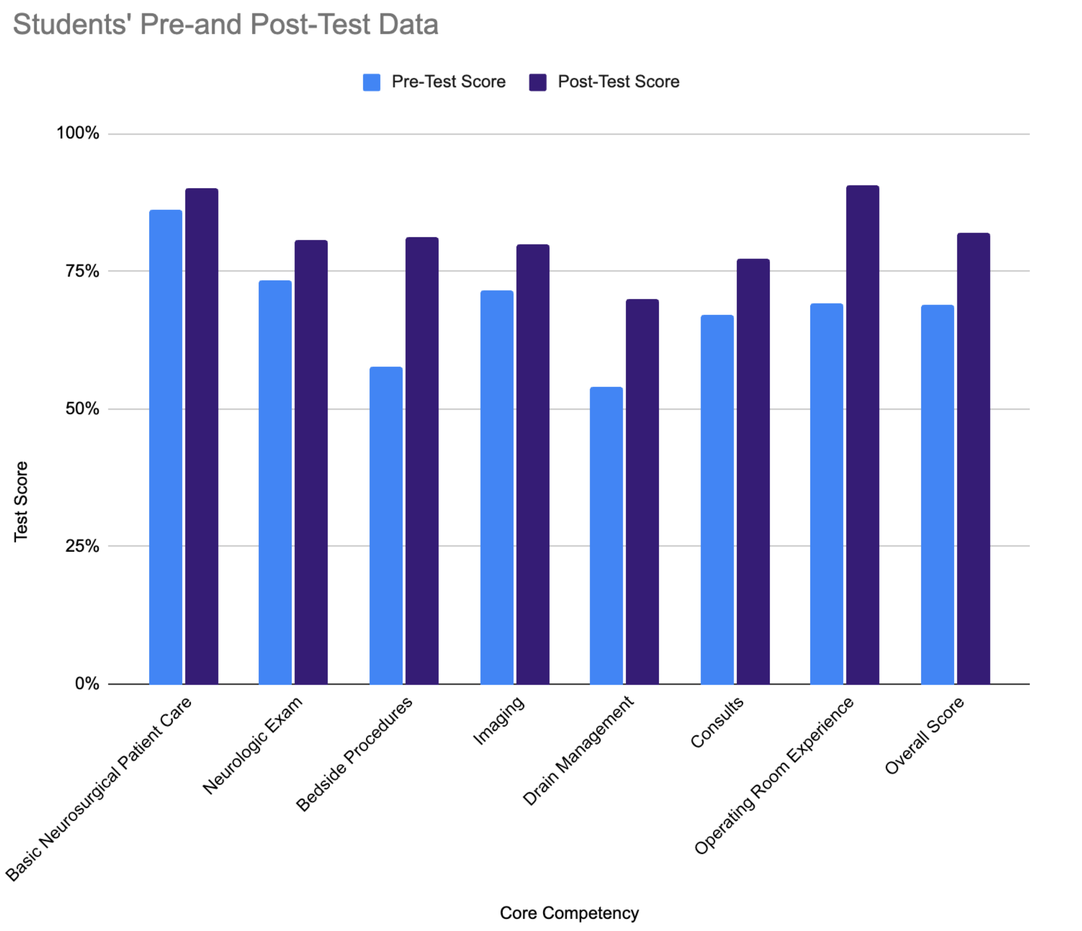


**Figure 2.** Relative gains in neurosurgical knowledge after a sub-internship, highlighting greatest improvement in bedside procedures and operating room experience and persistently lower performance in drain management..

## Discussion

These findings demonstrate that neurosurgical sub-internships provide meaningful gains in intern-level knowledge across a broad range of clinical domains. Hands-on clinical exposure appears to be particularly effective in improving procedural skills and operative confidence.

However, persistent underperformance in drain management highlights a high-risk, intern-level skill that may not be adequately addressed through experiential learning alone. This underscores the importance of targeted instruction, standardized teaching, and objective assessment to complement traditional clinical exposure.

Objective evaluation tools offer insights beyond subjective assessments, allowing programs to identify actionable curricular gaps.

## Conclusions and Future Directions

Neurosurgical sub-internships significantly improve intern-level knowledge but also reveal persistent gaps that warrant targeted curricular intervention.

Future directions include:

- Development of a standardized, competency-based SubI curriculum
- Implementation of focused training modules for high-risk gaps
- Evaluation of downstream effects on intern preparedness and early residency performance

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