**ABSTRACT**

**Introduction:** Workforce development to address unmet neurosurgery needs in the Philippines requires increased trainee learning opportunities and modalities for mentorship of existing surgeons in remote areas of the archipelago. Telementorship adjuncts may facilitate these in an accessible, active, and continuing manner. This study aimed to assess the feasibility and efficacy of telementorship to instruct a cadaveric selective dorsal rhizotomy (SDR) dissection lab for neurosurgery residents in the Philippines.

**Methods:** Junior neurosurgical residents at the [BLINDED FOR REVIEW] participated in a virtual lecture followed by telementored cadaver dissections using an operative microscope, guided by an overseas faculty neurosurgeon via live audio/video exchange. Usability metrics and survey responses were recorded. Post-lab, un-proctored dissections were completed by each participant, and surgical skills as demonstrated on the video recordings were evaluated by two blinded adjudicators via the Objective Structured Assessment of Technical Skills (OSATS).

**Results:** A total of four rhizotomy-naïve junior residents participated. During each one-on-one telementored dissection session, an average of 30 question-answer or mentor-mentee redirection exchanges transpired. Internet connection problems were frequent, with a mean of 5 connectivity issues requiring reconnection per session. All residents reported improved confidence in performing SDR. In post-lab assessments, all successfully completed main components of the procedure. OSATS demonstrated basic proficiency in all surgical domains.

**Conclusion:** A telementored cadaver lab session was conducted by a live, remote surgical instructor to junior neurosurgery residents in a middle-income country setting. The study demonstrated the feasibility of teaching operative skills using this method, with evaluation and feedback via OSATS scoring. It is recommended that a reliable internet connection be ensured before telementorship is trialed in a live clinical setting.

**Abbreviations:**

| | |
|---|---|
| **HIC** | High-income country |
| **LMIC** | Low- and middle-income country |
| ******* | [BLINDED FOR REVIEW] |
| **OSATS** | Objective Structured Assessment of Technical Skills |
| ******* | [BLINDED FOR REVIEW] |
| **SDR** | Selective Dorsal Rhizotomy |
| **WLAN** | Wireless Local Area Network |

## INTRODUCTION

The Philippines faces a high burden of neurosurgical disease, with many cases unmet annually.[1,2] As an archipelago of over 7,000 islands, enhancing local neurosurgical capacity is crucial. Efforts include visits by local and overseas neurosurgeons to remote areas. Sustainable capacity-building needs both short-term outreach activities and longitudinal collaborative teaching relationships.

Virtual telementorship has emerged as a potential means to facilitate capacity-building. Telementorship can be defined as the use of telecommunication to augment workforce development and capacity-building through a mentor-mentee relationship.[3,4] Such modalities allow remote mentors to interact with an active clinician, fostering continued training and maintaining active teaching relationships.[5] However, before using new technology in a clinical patient-care context, it is important to test feasibility in a safe, non-clinical local setting. In this study, a resident cadaver lab session was conducted with a locally available telementorship platform, to assess its feasibility and efficacy in the Philippine setting.

## METHODS

This is a quantitative single-arm pilot study evaluating the feasibility and efficacy of telementorship using the TeleVU platform at the [BLINDED FOR REVIEW], in partnership with the [BLINDED FOR REVIEW]. Institutional Review Board approval was obtained from the [BLINDED FOR REVIEW] (#202301459).

### *Cohort and Lab Setup*

Junior neurosurgical residents participated in an optional didactic cadaver lab session. Four second-year residents (PGY2) were recruited and gave informed consent. All had limited microsurgery experience (mostly as first assist), no prior experience with selective dorsal rhizotomy (SDR), and no prior experience with telementorship or virtual didactic adjuncts. The SDR procedure was chosen for this lab because the use of the TeleVU platform was initiated between the [BLINDED FOR REVIEW] and [BLINDED FOR REVIEW], in an effort to build a multidisciplinary surgical spasticity program at [BLINDED FOR REVIEW] through telementorship.

The dissection session was conducted in the anatomy laboratory of the [BLINDED FOR REVIEW]. Two formalin-fixed cadavers were positioned prone, with the thecal sac exposed ahead of the session via T12-L2 laminectomy and the cauda equina confirmed via ultrasound. The set-up included a single-viewer microscope and standard microsurgical instruments. Various connectivity formats were trialed in advance of the lab, with the final setup utilizing TeleVU video transmitted via cellular hotspot (Mobile network: Globe Telecom, Inc.), and Zoom audio transmitted via SmartBro Pocket WiFi (Mobile network: Smart Communications, Inc.) (**Figure 1**).

### *Telementorship Platform and Telementored Dissection*

The Vuzix/TeleVU system is a browser-based platform that creates an ecosystem of remote collaboration via wearables, mobile phones, laptops and personal computers, and medical or imaging screens. An integrated tablet PC was utilized to operate the TeleVU platform and connected to the lab microscope feed via an HDMI cable, allowing the remote telementor to see the cadaver through the operator's field of view (**Figure 1**). A "telestration" feature additionally allows the remote telementor to freeze the screen, annotate the image, and transmit it back to the local operator.

A pre-lab lecture on SDR and technology orientation was given by the telementor (PRA, **Figure 2A**). Each participant then underwent a 30-minute telementored cadaver SDR dissection session through the TeleVU platform (**Figure 2B and 2C**). Instructional exchanges between resident and telementor were tallied, including question-answer instances and other instances re-directing the participant to guide surgery. Each participant was given 10 minutes to complete a video-recorded post-lab SDR procedure utilizing the undissected side of the cadaveric spine. These videos were saved with de-identified labels and no audio that could be used to identify the participants.

Technical issues and session interruptions were recorded. Participants went in turns and were allowed to observe each other's sessions to foster group learning; however, they were not permitted to interrupt or prompt any of the actions of the operating mentee at the scope. Two mentors [BLINDED FOR REVIEW] were physically present to supervise the activity but did not participate in teaching.

*Pre- and Post-lab Self-Assessment and OSATS Resident Evaluation*

A pre-lab survey was administered to the participants consisting of questions in a 5-point Likert scale format (**Supplemental Digital Content 1**). Questions assessed participants' prior neurosurgical case experience, comfort, and skill level with SDR. The same was administered to resident participants at the end of the lab session. The participants were also asked about their impressions on telementorship before the session, and afterward, whether they would recommend it to others.

On the other hand, the video recordings of the four residents were transmitted to two blinded adjudicators [BLINDED FOR REVIEW], both pediatric neurosurgeons who had not participated in the live session. The two adjudicators scored each resident based on an OSATS rubric. Spearman's rank correlation was calculated, and Cohen's alpha was estimated to assess inter-rater reliability and agreement for each of the OSATS subscales. Regression analysis was utilized to estimate the pooled average association of all the OSATS scores with the number of instructional exchanges and number of session interruptions.

Statistical analysis was done using GoogleSheets (Google LLC, Menlo Park, CA, USA), Stata SE 17.0 (StataCorp, College Station, TX), and R (v2023.12.1, R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

*Feasibility*

During each session, an average of 30 ± 10 question-answer or surgical re-direction exchanges transpired between telementor and mentee. Internet connection problems included 1-7 interruptions per session requiring troubleshooting and reconnection. These resulted in connectivity dropouts, instability, and lagging or freezing of the video stream. Audio problems were minimal and only encountered during the first session. These included disturbing background noise and low volume, both resolved with repositioning. Difficulty manipulating the microscope led to a few interruptions during each session. These were resolved with the assistance of the microscope company's representative. The budget for the program totaled 80,143 PHP (3,227 USD), without the cost of donated or loaned equipment. (**Supplemental Digital Content 2**).

*Self-perceived Efficacy*

Comparing post-lab to pre-lab surveys, participants reported increased confidence in performing SDR. Formal statistical testing was not performed due to the small number of participants. However, the improvement in scores is visually represented in **Figure 3**. Overall confidence in performing the procedure prior to the lab was rated as a 1 on the Likert scale ("not confident at all") in all participants, improving to a post-lab median of 3 ("moderate" confidence). Resident perceptions of their own surgical skill level, anatomical understanding, and procedural independence as relating to the SDR procedure ranged between 1-2 pre-lab and improved to 3-4 post-lab. Only SDR-related procedural anxiety was similar pre- and post-lab. Telementorship adjuncts were perceived favorably before and after lab usage of the technology, without significant change after the session (**Table 1**).

*Resident Evaluation*

On the OSATS assessment **(Figure 4)**, scores were computed on a scale of 1-5, with 1 being "deficient," 3 being "average," and 5 being "expert." Pooling both adjudicators' scores, participants scored an overall subdomain mean of $3.48 \pm 0.96$, supporting overall adequate performance of the procedure. There was a discrepancy between the scoring of the two adjudicators, with the mean Kappa coefficient for the 5 OSATS questions of -0.06 (mean expected agreement 20%), and the mean Spearman rank correlation for the 4 residents of 0.31 ($p=0.25$), denoting overall poor inter-rater reliability. Nevertheless, average proficiency or a score of 3 (i.e., knew all important steps of operation) or better was achieved in most surgical domain subscores. All participants were able to complete the most basic parts of the procedure in post-lab videos, and scored 3 in the "knowledge of specific procedures" domain.

Finally, in an estimated mixed effects linear model **(Supplemental Digital Content 3)**, the number of instructive exchanges during each training session were on average positively correlated with OSATS scores, when pooled across both adjudicators and self-ratings, controlling for experience, and treating baseline self-ratings as a control.

## DISCUSSION

This study evaluated the use of virtual telementorship during a neurosurgery resident cadaver lab session, one of few such reports based in a low- and middle-income country (LMIC) setting. Pre- and post-lab survey data support the feasibility of this model, demonstrating that the telementored lab was well-received among the resident participants, improving their confidence in performing SDR. In this teaching model, remote evaluation of surgical skills was possible using OSATS scoring, with residents demonstrating basic adequacy in all subdomains scored. Active engagement, content relevance, and active feedback,[6] with intraoperative instructional exchanges coupled with debriefing practices,[7] were all integrated in a telementored cadaver lab session to foster surgical training.

Since the COVID-19 pandemic, telemedicine and surgical tele-collaborations have become more common, and, in neurosurgery, has reduced time and costs for consultations and follow-ups.[8] Teleproctoring, telementoring, and tele-guidance experiences have been reported in training, education, and live clinical care contexts with both surgical procedures and medical assessments.[8–16] These include real-time clinical guidance in emergencies, such as organ procurement assessment in Texas,[11] elective surgeries including scoliosis surgery in Africa,[12] hand surgery in Mozambique,[9] otolaryngologic surgeries in California,[16] and intraventricular endoscopy in Vietnam.[17] Educational applications have included wartime fasciotomy simulations in the Netherlands,[10] field birth simulations in Spain,[13] and craniotomy cadaver labs in Minnesota.[15] Most of these collaborations occur between high-income countries (HIC) with few HIC-to-LMIC. This study highlights a case of HIC-LMIC collaboration in the Philippines, with potential for LMIC-to-LMIC use.

Prior telementorship reports have been generally well received,[8–16] despite challenges like battery life, patient privacy and compliance concerns, compatibility with surgical loupes, and time zone differences.[9,12,17] Basic elements of reported systems include a wearable headset or a camera with LCD that connects to one’s loupes, such as Vuzix or Google Glass.[16] These setups require orientation and comfort with the software and hardware, including usage of the LCD screen, hands-free voice command activations, aiming the camera optimally, and operating while wearing the headset. In microscope operations, an additional video card output platform requires a microscope with HDMI output. At [BLINDED FOR REVIEW], only one of the two most often-used hospital microscopes carried an HDMI port, so a loaned lab microscope was necessary.

*Feasibility and Scalability*

Internet connectivity was the biggest challenge for the lab session, and overcoming this in the Philippines is crucial for scaling up the system. Successful scale-up could enable remote clinical guidance from surgeons in the National Capital Region or urban areas like Cebu and Davao to operating rooms across the archipelago,[1] enhancing real-time care. However, during the lab, sessions were frequently interrupted by dropped calls, despite testing various connection methods beforehand. The system required multiple intraoperative components, and local signal transmission was challenging but possible, assisted by a lab facilitator frequently rebooting the call. However, this resource is not available in the local intraoperative setting, moreso in remote operating rooms.

In the Philippines, only 53% of people have internet access,[18] with variable speeds and poor connection stability due to limited coverage, leading to frequent interruptions. This is a significant barrier in many LMICs, where telementorship is most needed. Many prior reports of telementorship also faced internet connectivity challenges.[9,12,17] Although the technology requirements are relatively minimal, a pre-telementoring process flow and checklist should ensure basic technology availability and a secure, stable network connection.[9,19] Collaboration with institutional information technology departments may allow use of wireless local area network (WLAN) infrastructure with a large-bandwidth designation for the program. Unfortunately, both the university and hospital lacked reliable WLAN access during the month this didactic session was held. One particularly successful HIC-to-LMIC telementored neuroendoscopy program addressed this by installing a router with dedicated internet subscription,[17] resulting in only one dropped call. Widespread improvements in [BLINDED FOR REVIEW] internet infrastructure and the country's 5G growth are needed in future studies, and these challenges underscore that many issues in surgical capacity-building in LMICs lie not in the operating theater, but in basic healthcare infrastructure.

*Learner-perceived Efficacy*

Among participants, an increase in surgical confidence was demonstrated in the post-lab surveys, suggesting that the session helped improve trainees' self-confidence. Post-lab assessment videos demonstrated accomplishment of all basic steps, including dissection and sectioning of rootlets, supporting the validity of learning in this format. OSATS evaluation by two blinded adjudicators also supported the feasibility of incorporating remote evaluation into this learning format. Nearly all OSATS subdomain scores were scored as a 3 ("adequate") or higher, suggesting basic proficiency in SDR.

Poor inter-rater reliability on specific sub-domain scores between the two post-lab adjudicators may be attributable to a lack of pre-rating standardization. Future lab sessions could ameliorate this by training adjudicators to a standard video defining benchmarks of insufficiency, adequacy, and mastery. Nevertheless, all residents completed basic parts of the procedure in post-lab scoring, and both adjudicators awarded adequate or better scores in nearly all subdomains. Moreover, the frequency of instructive telementor-trainee exchanges during each session correlated with post-lab OSATS scores in an adjusted regression model, also supporting the impact of the telementorship component specifically. Overall, these results supported the value of a telementored group dissection activity in helping trainees to feel comfortable with SDR, gain confidence, and acquire procedure-specific anatomic and surgical knowledge.

*Cost*

The cost of telementorship adjuncts can be a challenge in LMICs. In this study, the total cost of the telementored cadaver lab session was 80,143 PHP (3,227 USD), made possible through partnerships and existing resources (**Supplemental Digital Content 2**).[21] Despite this, the cost remains significant, particularly in rural or lower-resource settings,[9] underscoring the need for stakeholder support and public-private partnerships. [21] In contrast, a full intra-operative program reported by Davis et al required a 15,000 USD budget,[17] which is still less costly than recurring in-person mentoring or trainee visits abroad. Telementored training allows for operative learning within one's own system, potentially enhancing existing programs and addressing gaps in neurosurgical training, including specialized procedures like SDR.[20]

*Limitations*

This study aimed to assess feasibility of a telementored didactic session. However, its small sample size and single-arm design limit generalizability about long-term and comparative efficacy. Self-reported assessments were prone to social desirability bias. Due to the limited number of available cadavers, only one OSATS score per trainee was computed, with no baseline score for comparison. The didactic session was arranged in a group format, allowing residents to be telementored at the cadaver station in turn, observing each other along the way to maximize trainee education. Therefore, group learning transpired. Nevertheless, none of the junior residents had participated in or witnessed an SDR prior to this lab, and none had extensive microsurgery experience. Thus, any mastery demonstrated likely supports the adequacy of and validity of this telementored group didactic session.

Finally, only immediate OSATS scores and immediate post-lab change in resident-reported confidence were measured, without long-term follow up data on retention of knowledge and operative skills. Improvement in these domains require multiple learning sessions and deliberate practice. Future studies could investigate how prior learning experience through telementorship affects subsequent surgical outcomes when the learners perform the taught procedure on actual patients. Despite these limitations, the findings and lessons from this pilot may help iteratively improve the system’s usage in the Philippines and inform future global neurosurgical partnerships for education and capacity-building.

## CONCLUSION

A telementored cadaver lab session was successfully conducted by a live, remote surgical instructor to junior neurosurgery residents in an LMIC setting. The didactic session improved the residents’ self-reported confidence and was associated with basic proficiency on post-lab OSATS assessments. Internet connectivity problems must be resolved prior to use in a clinical setting. Nevertheless, this neurosurgery education model has great potential for scale up, to facilitate training, mentorship, and capacity-building in remote areas of the Philippines and other LMICs.

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## Figures

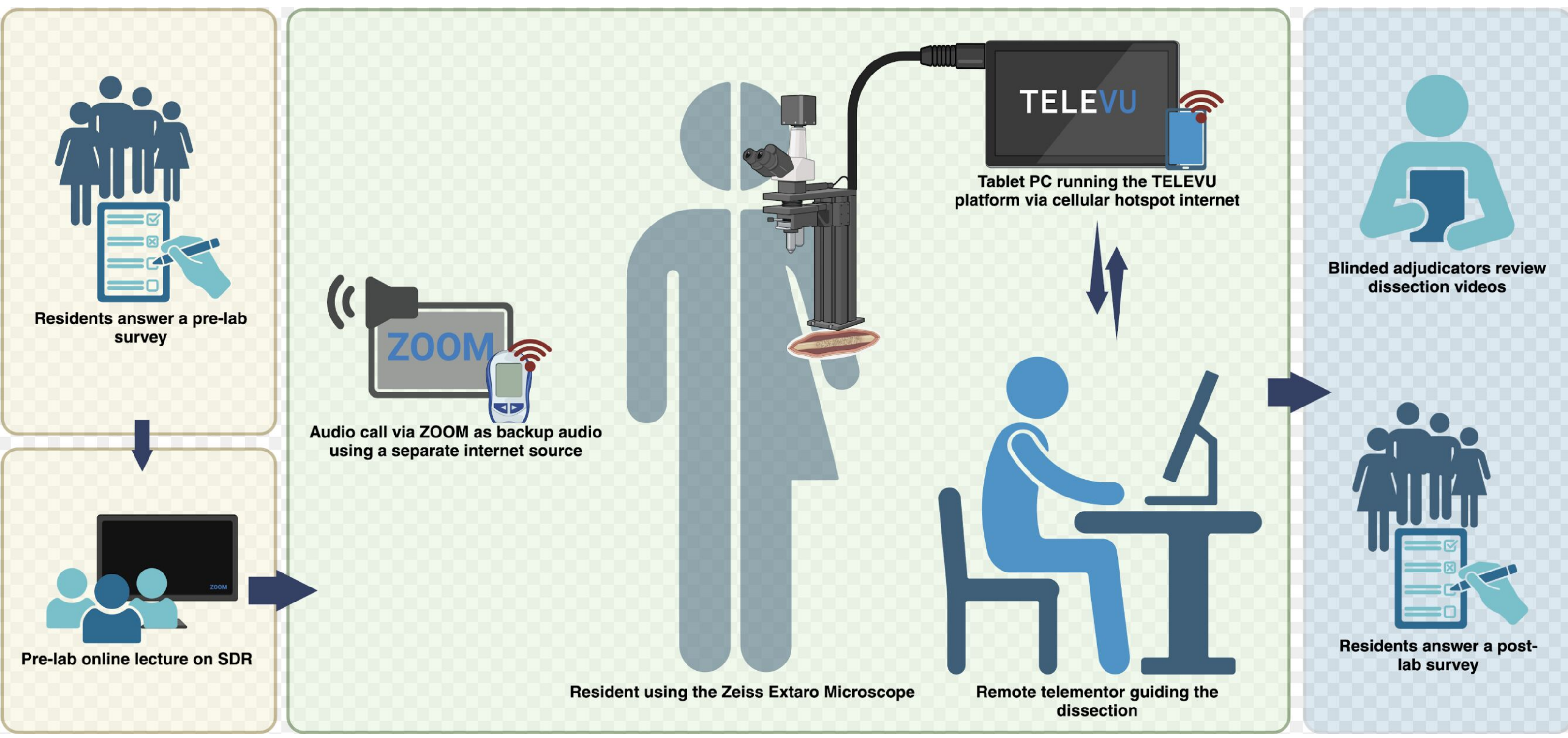
**Figure 1: Diagram of Study Methodology**
A schematic depicting the didactic session's sequence is illustrated, with pre-dissection activities (left), telementored dissection lab setup (middle), and post-lab activities (right). Created with BioRender.com by the authors and used with permission.

**Figure 2A to 2C: Didactic Session and Cadaver Lab Telementorship Setup**
A: Residents participate in a pre-dissection lecture on SDR conducted by the remote mentor. B: View of the SDR procedure on the TeleVU platform fed live to the remote mentor (inset). A Penfield dissector is shown holding one nerve root, with a micro-instrument being utilized to separate its rootlets. A blue piece of plastic is visible, placed by the trainee between the dorsal and ventral nerve roots. C: A resident participant performing the SDR procedure under remote guidance.

**Figure 3: Comparison of Pre- and Post-Lab Survey Results**
Boxplots illustrate group scores pre-lab (green bars) and post-lab (blue bars) in response to each survey question. The median and interquartile range are denoted by the boxes and central line. The mean and 95% confidence intervals are shown by the central "X" marker and upper and lower error bars.

**Figure 4: OSATS Scores**
A bar graph shows OSATS scores (Y axis) clustered by sub-domain (X axis). Colors denote the score for each of the 4 residents. The two blinded adjudicators' scores are overlaid, with one adjudicator denoted in solid colors and one in stripes.

**Figure 1: Diagram of Study Methodology. A schematic depicting the didactic session's sequence is illustrated, with pre-dissection activities (left), telementored dissection lab setup (middle), and post-lab activities (right). Created with BioRender.com by the authors and used with permission.**


Residents answer a pre-lab survey
Pre-lab online lecture on SDR
ZOOM
Audio call via ZOOM as backup audio using a separate internet source
TELEVU
Tablet PC running the TELEVU platform via cellular hotspot internet
Resident using the Zeiss Extaro Microscope
Remote telementor guiding the dissection
Blinded adjudicators review dissection videos
Residents answer a post-lab survey

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A
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B
C

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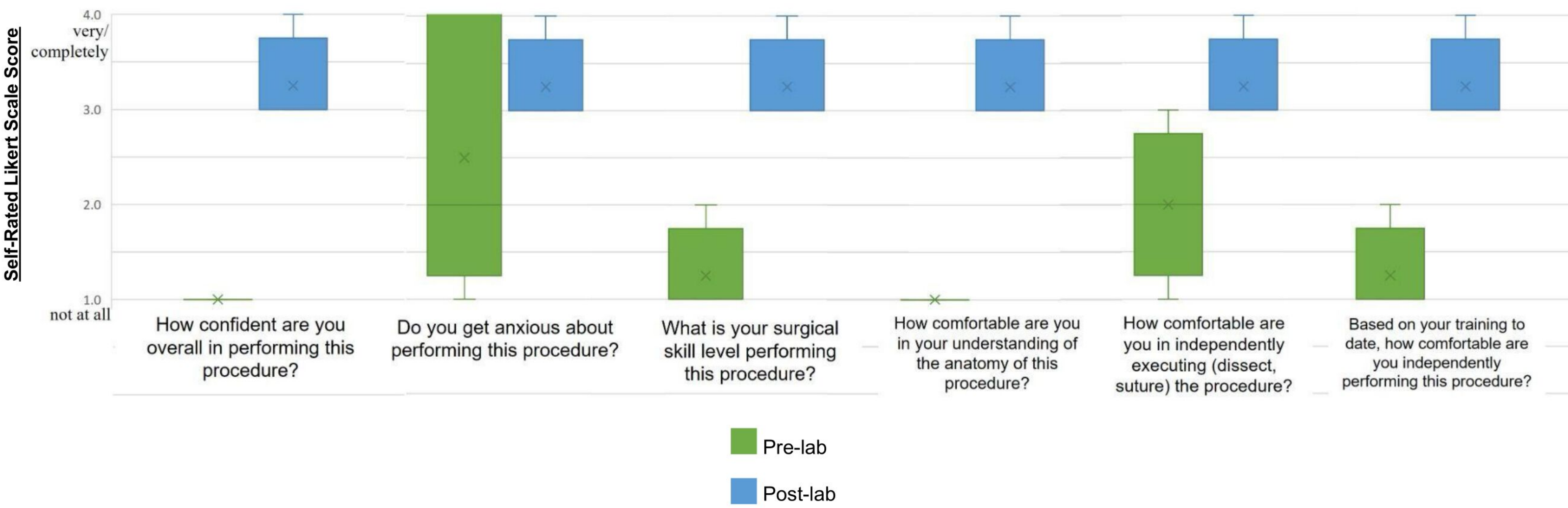
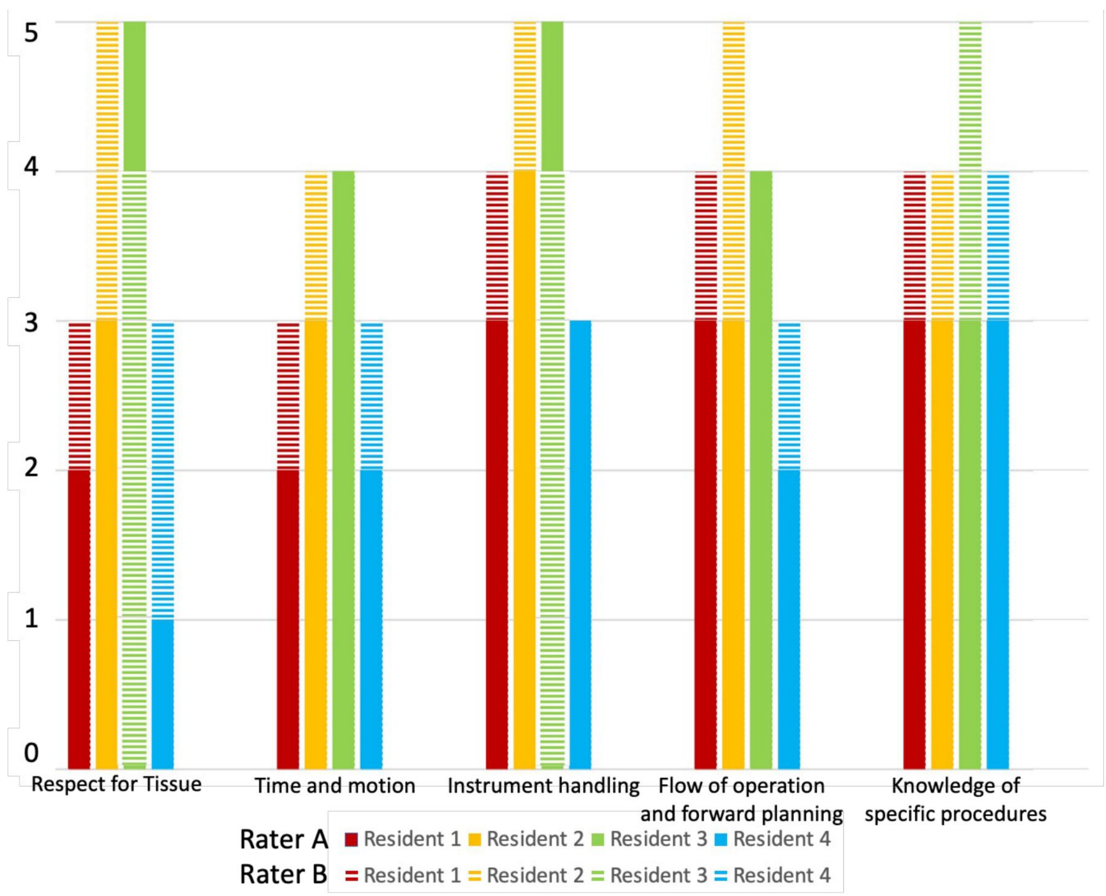


Self-Rated Likert Scale Score
4.0
very/
completely
3.0
2.0
1.0
not at all
How confident are you overall in performing this procedure?
Do you get anxious about performing this procedure?
What is your surgical skill level performing this procedure?
How comfortable are you in your understanding of the anatomy of this procedure?
How comfortable are you in independently executing (dissect, suture) the procedure?
Based on your training to date, how comfortable are you independently performing this procedure?
Pre-lab
Post-lab

**Figure 4: OSATS Scores. A bar graph shows OSATS scores (Y axis) clustered by sub-domain (X axis). Colors denote the score for each of the 4 residents. The two blinded adjudicators' scores are overlaid, with one adjudicator denoted in solid colors and one in stripes.**



5
4
3
2
1
0
Respect for Tissue
Time and motion
Instrument handling
Flow of operation and forward planning
Knowledge of specific procedures
Rater A
Resident 1
Resident 2
Resident 3
Resident 4
Rater B
Resident 1
Resident 2
Resident 3
Resident 4

**Supplemental Digital Content 1 (Table) - Pre- and Post-lab Surveys**

A pre- and post-lab survey consisting of questions in a 5-point Likert scale to assess participants' neurosurgical case experience, comfort, and skill level with SDR, and impression of telementorship.

| | | |
|---|---|---|
| **Supplemental Digital Content 1.**<br>**Please answer these questions based on how comfortable you are with selective dorsal rhizotomy now (before / after) the lab.** | | |
| **How confident are you overall in performing this procedure?** | | |
| Not confident at all | 1 2 3 4 5 | Completely confident |
| **Do you get anxious about performing this procedure?** | | |
| Constantly | 1 2 3 4 5 | Not anxious at all |
| **What is your surgical skill level performing this procedure?** | | |
| No skills | 1 2 3 4 5 | Expert |
| **How comfortable are you in your understanding of the anatomy of this procedure?** | | |
| Very uncomfortable | 1 2 3 4 5 | Very comfortable |
| **How comfortable are you in independently executing (dissect, suture) the procedure?** | | |
| Very uncomfortable | 1 2 3 4 5 | Very comfortable |
| **Based on your training to date, how comfortable are you independently performing this procedure?** | | |
| Very uncomfortable | 1 2 3 4 5 | Very comfortable |
| | | |
| **Please answer the following questions based on how you feel about telementorship adjuncts now (before / after) having used them in this lab**<br>**(Vuzix Glasses, ScreenVU microscope streaming live telementorship platforms).** | | |
| | | |
| Strongly disagree | 1 2 3 4 5 | Strongly agree |
| **Telementorship adjuncts are stimulating** | | |
| **Telementorship adjuncts increase my interest in the procedure** | | |
| **Telementorship adjuncts allow me to learn the procedure** | | |
| **Telementorship adjuncts are clear** | | |
| **Telementorship adjuncts are effective means of learning to perform this procedure** | | |
| **I would recommend the telementorship adjuncts to others learning this procedure** | | |

**Supplemental Digital Content 2 - Program Budget**

| Item | Actual expenditure (PhP) | Actual Expenditure (USD) | Funding Source |
|---|---|---|---|
| IRB writing and processing | 0 | 0 | Self-funded |
| Visiting resident to help facilitate lab (airfare, lodging) | ~11,143 | ~2,000 | [BLINDED FOR REVIEW] |
| Telementor for lab dissection (PRA) | 0 | 0 | [BLINDED FOR REVIEW] |
| Cadaver (lumbar spine used only) x2 | 58,000 | 1,031 | [BLINDED FOR REVIEW] |
| Cadaver lab technician time (2 technicians x 4 hours ea.) | 12,000 | 196 | [BLINDED FOR REVIEW] |
| Surgical Instruments, ultrasound | 0 | 0 | Loaned [BLINDED FOR REVIEW] |
| Microscope | 0 | 0 | Loaned [BLINDED FOR REVIEW] |
| Monitors, HDMI cables | 0 | 0 | Existing cadaver lab equipment |
| Zoom | 0 | 0 | Institutional license |
| TeleVU subscription | 0 | 0 | [BLINDED FOR REVIEW] |
| Vuzix tablet | 0 | 0 | [BLINDED FOR REVIEW] |
| Total | 80,143 | 3,227 | |

**Supplemental Digital Content 2 (Table) - Program Budget**
Breakdown of the budgetary requirement for the research shown in two different currencies, Philippine Peso and US Dollar, and their corresponding source.