

Design and implementation of assessment scales to improve the acquisition of basic skills in vascular microsurgery.

Diseño e implementación de escalas de evaluación para mejorar la adquisición de competencias básicas en microcirugía vascular.

Manuel Andrés Rojas-Galvis ^{1*}, Adolfo Alejandro López-Ríos ², Alfredo Salvador Patrón-Gómez ³.

¹CES University, Faculty of Veterinary Medicine and Animal Husbandry, Postgraduate Studies MVZ, Medellín, Colombia. mrojasga@ces.edu.co <https://orcid.org/0000-0001-5488-4663>

²Universidad de Antioquia, Faculty of Medicine - Section of Plastic, Maxillofacial and Hand Surgery, Medellín, Colombia. aalejandro.lopez@udea.edu.co <https://orcid.org/0000-0003-3477-7566>

³Universidad de Antioquia, Faculty of Medicine - Section of Plastic, Maxillofacial and Hand Surgery, Medellín, Colombia. alfredo.patron@udea.edu.co <https://orcid.org/0000-0001-5653-9775>

*Correspondence: mrojasga@ces.edu.co

Received: 3/31/25; Accepted: 5/15/25; Published: 5/19/25

Summary:

Introduction: The level of competence measures the skills and abilities that a student possesses to perform an activity. The objective of this study was to implement two OSATS (Objective Structured Assessment of Technical Skills) scales designed to evaluate microsurgery competencies in surgical residents who completed a training program in basic microsurgery skills in laboratory and simulation environments. **Methodology:** Descriptive, observational, and cross-sectional study conducted between August 2018 and March 2019, with a sample of 29 residents. A formative methodology was used for the acquisition of technical skills in microsurgery. As a measurement instrument, two evaluation scales were designed (OSATS M1.5 and OSATS M2-0), applied in five sessions: session 1 (diagnostic test), sessions 2, 3 and 4 (formative) and session 5 (final evaluation to identify the impact of the strategy on performance). **Results:** In session 1, 13.79% of residents performed poorly and 86.21% performed moderately. During training sessions (2, 3, and 4), 68.97% achieved high performance, while 31.03% were moderately performing, and there were no low performances. In session 5, 75.86% achieved high performance and 24.14% moderately performing. Positive vascular patency test scores increased from 34.48% in session 1 to 79.31% in session 5. **Conclusion:** The development and implementation of the OSATS assessment scales allow for effective performance monitoring, demonstrating significant progress. This suggests that the model is applicable and useful for vascular microsurgery training programs.

Keywords: Medical education, pedagogy, learning, simulation, vascular, microsurgery.

Resumen:

Introducción: El nivel de competencia mide las habilidades y destrezas que un estudiante posee para realizar una actividad. El objetivo de este estudio fue implementar dos escalas OSATS (Objective Structured Assessment of Technical Skills) diseñadas para evaluar competencias en microcirugía en residentes quirúrgicos que completaron un programa de entrenamiento en habilidades básicas de microcirugía en entornos de laboratorio y simulación. **Metodología:** Estudio descriptivo, observacional y transversal realizado entre agosto de 2018 y marzo de 2019, con una muestra de 29 residentes. Se empleó una metodología formativa para la adquisición de habilidades técnicas en microcirugía. Como instrumento de medición, se diseñaron dos escalas de evaluación (OSATS M1.5 y OSATS M2-0), aplicadas en cinco sesiones: sesión 1 (prueba diagnóstica), sesiones 2,

3 y 4 (formativas) y sesión 5 (evaluación final para identificar el impacto de la estrategia en el desempeño). **Resultados:** En la sesión 1, el 13.79% de los residentes presentó un rendimiento bajo y el 86.21% un rendimiento medio. Durante las sesiones formativas (2, 3 y 4), el 68.97% alcanzó un rendimiento alto, mientras que el 31.03% fue medio y no hubo rendimiento bajo. En la sesión 5, el 75.86% obtuvo un rendimiento alto y el 24.14% medio. La prueba de permeabilidad vascular positiva aumentó del 34.48% en la sesión 1 al 79.31% en la sesión 5. **Conclusión:** La creación e implementación de las escalas evaluativas OSATS permiten un seguimiento efectivo del desempeño, evidenciando un avance significativo. Esto sugiere que el modelo es aplicable y útil para los programas de formación en microcirugía vascular.

Palabras clave: Educación médica, pedagogía, aprendizaje, simulación, vascular, microcirugía.

1. Introduction

The significant technological advances that occurred at the end of the 20th century favored a significant expansion in the use of microsurgical techniques in various medical and surgical specialties, given the variety of benefits these techniques represent for patients (1). However, the application of these techniques requires the use of highly specialized microscopes and instruments that allow precise visualization and controlled manipulation of the anatomical structures involved (2). As a result of their increasing adoption in clinical practice, the need arose to train professionals with specific skills in microsurgery, which prompted the design of training programs structured in various levels of difficulty (3). In their initial stages, these programs were based on instructional manuals that guided the learning of the techniques through the execution of sequential practical exercises. These manuals provided detailed information on the use of the microscope, the handling of surgical instruments, and the performance of dissection and suturing techniques in both synthetic and biological models (4-5). Since then, microsurgery training has been consolidated as an essential component in medical-surgical residency programs (6), as well as a key tool in veterinary practice and in the development of biomedical research (7).

Based on the premise that microsurgery is primarily learned in the laboratory (8), new trends in medical education and microsurgery training models focus on the use of simulated environments. Clinical simulation is a fundamental tool that facilitates the implementation of various pedagogical methodologies in medical training (9). In these spaces, multiple disciplines converge to create simulated clinical environments that allow students to face, in a safe and controlled manner, different clinical scenarios using innovative technologies and methods. This favors the learning and improvement of technical skills, as well as non-technical competencies such as decision-making, teamwork, and leadership in situations of stress, fatigue, and burnout, among others (10-11). Clinical simulation spaces not only allow the development of clinical competencies but also promote quality in patient care, with the aim of training health professionals capable of providing bioethical and humane care (12). In surgical residencies, the acquisition of experience in surgical techniques must be complemented by the acquisition of knowledge and the development of professional attitudes (13). However, formal assessment of technical skills in surgical residencies faces difficulties in identifying actual learning, and structured tests to evaluate residents' surgical competencies are not common (14). In the current context, the implementation of formal evaluations of specific technical and operative skills could serve to provide constructive feedback, facilitating decision-making regarding the promotion of residents and identifying potential deficiencies in training programs (15).

Although most operative skills are acquired in the operating room under direct supervision of teachers, the exclusive use of this environment to evaluate technical competence has important limitations, since the patient cannot be put at risk and this makes an objective and accurate evaluation of learning difficult (16).

The Objective Structured Assessment of Technical Skills (OSATS) assessment scales, developed in the 1990s at the University of Toronto, are a tool designed to evaluate the technical skills of surgical residents. These scales consist of a checklist that, through a global rating, allows the assessment of the resident's performance in performing a predetermined activity, under the supervision of both the instructor and the evaluator (17). The combined use of global ratings and checklists has been widely adopted in the assessment of technical skills in surgical specialties, proving to be an objective, useful and reliable tool for this purpose (18).

The present study explicitly hypothesizes that the proposed methodological approach favors the development of manual skills in students. In this context, the objective of this study is to present the results obtained from the application of two OSATS scales specifically designed to assess microsurgical skills in the laboratory (OSATS M1.5 and OSATS M2) in surgical residents at the University of Antioquia (Medellín, Colombia), who participated in a training program in basic microsurgical skills applicable in laboratory and simulation settings.

2. Methods

2.1 Type of study, location and study population

A descriptive, quasi-experimental study was conducted between August 2018 and March 2019. The study population consisted of all residents enrolled during that period in seven surgical specialties at the Faculty of Medicine of the University of Antioquia. To select participants, the directors of each surgical residency program were asked for a list of residents (specifying the year of training) who had not previously participated in courses or training activities in vascular or nerve microsurgery techniques. Once the lists were received, eligible residents were invited to participate in the study. After being informed in detail about the objectives, procedures (including the duration and number of sessions of the training program in basic microsurgical skills), and the type of assessment to be performed (using OSATS scales), a final sample of 29 residents was formed.

2.2 Measuring instruments

The Objective Structured Assessment of Technical Skills (OSATS) model, originally described by Reznick et al. (17), was selected as the measurement instrument. This model has demonstrated high reliability and construct validity, making it a suitable tool for evaluating surgical skills in residents (19–20). Based on this methodology, two specific scales were designed to evaluate residents' performance during sessions of the basic microsurgery skills training program: OSATS M 1.5 and OSATS M 2.0, presented in Table 1 and Table 2, respectively. The validation of the scales was performed according to the criteria of the teaching staff and was complemented by the adaptation of a modified video-based survey previously used in other surgical specialties (21–22). These characteristics make the OSATS scales a practical, accessible, and useful tool for the proposed curriculum.

2.3 Procedures

A training program in basic microsurgical skills was designed and implemented, focusing on the development of competencies such as technical rationale, triangulation, precision, posture, and movement control. This program was designed to be applied in laboratory and clinical simulation settings. The program consisted of five sessions, each lasting three hours, for a total of 15 hours of practical training. In each session, the OSATS M 1.5 and OSATS M 2.0 assessment scales were administered, as described in detail in the Measurement Instruments subsection. Each session had two instructors: a teacher trainer, responsible for providing pedagogical support during the activity (who was blinded to the assessment format to minimize observation bias), and a teacher evaluator, responsible for completing the OSATS scale for each participant. During the program, each resident had access to the following resources: a surgical microscope, basic surgical and microsurgical

instruments, a workstation equipped for performing the activities, and an instructional manual with a step-by-step description of each procedure. The activities performed in each of the five program sessions are described below.

2.3.1 Session 1 (Pre-training or diagnosis of the student's competencies in microsurgery).

Biomodel practice: An avian anatomical model (chicken thigh) was used to differentiate vascular bundles (femoral artery and vein). The end-to-end (TT) revascularization activity was then initiated in vascular components between 1.5 mm and 2 mm. Performance in this activity was assessed using the OSATS M 1-5 scale (Figure 1). Six training activities were conducted in these three sessions (two per session), all of which were assessed using the OSATS M 2.0 scale:

- Activity # 1. Translation of elements of a cigarette.
- Activity # 2. Writing on a blank sheet of paper.
- Activity # 3. Gauze figures with suture thread.
- Activity # 4. Plastic spheres with holes and a strand of 7-0 monofilament suture (Nylon).
- Activity # 5. Practice on organic plant material.
- Activity # 6. Suture in silicone synthetic material.

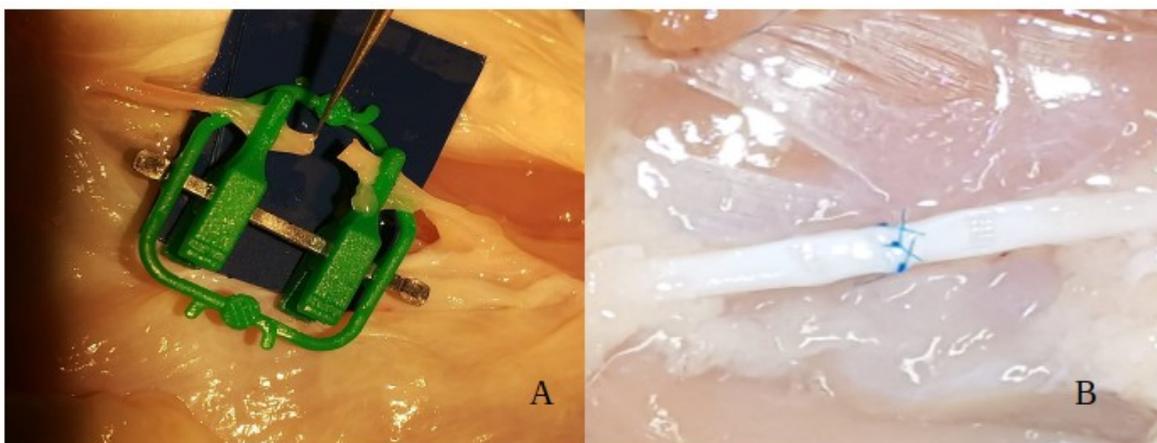


Figure 1. Revascularization exercise for sessions 1 and 5 A. Start of arterial revascularization activity. B. Completed arterial revascularization exercise. End-to-end arterial anastomosis with independent or separated sutures.

2.3.2 Session 5 (Post-training or final evaluation):

Biomodel practice: The same activity as in session 1 was performed under the same conditions. Performance was also assessed using the OSATS M 1-5 scale. A summary of all scheduled activities has been provided (Table 3).

2.4 Data analysis

A descriptive analysis was performed using measures of central tendency and frequencies for each session, based on the different activities developed. Additionally, a chi-square test of independence was applied to compare the scores obtained in the diagnostic assessment sessions (pre-training) and post-training, both overall and by specific categories. Data processing was carried out using IBM SPSS Statistics, version 22.0. The items derived from the OSATS scales applied in each session were analyzed, allowing the results to be grouped by numerical variables with a predefined range and classified according to nominal performance levels: low, medium, and high (see Table 4). This classification was applied to each session individually for each student, which facilitated segmented analysis by participant, specialty, or previously defined groups, thus optimizing academic management and teacher support. Student performance was classified according to the score ranges established for each OSATS scale, and data are presented using absolute and relative frequencies by session.

Vascular permeability test "End-to-end (TT) revascularization":

This consists of verifying the execution of the vascular anastomosis or revascularization procedure. This evaluation is taken from item 14 of the OSATS M 1-5 and verifies the integrity and functionality of the intervened vessel. The evaluator describes the activity, assigning scores of 1, 3, and 5, based on the student's performance. The scores are then grouped into predetermined ranges (low, medium, or high).

2.5 Ethical considerations

The study took into account the ethical principles for medical research in human subjects established by the Declaration of Helsinki (23) and the provisions on health research of Resolution 8430 of 1993 of the Ministry of Health of Colombia (24); in addition, it was approved by the institutional bioethics committee of the Faculty of Medicine of the University of Antioquia. Likewise, the participants approved their participation through informed consent after knowing the dynamics of the study.

3. Results

The study included 29 residents from seven medical-surgical specialties, with general surgery being the most represented (44.81%). Regarding sociodemographic characteristics, 75.86% of the participants were between 18 and 30 years old, and the gender distribution was 55.17% men and 44.83% women (see Table 5). During session 1 (diagnostic evaluation or pre-training), 86.21% of the residents showed average performance, while the remaining 13.79% had low performance. In the training sessions (sessions 2, 3, and 4), 68.97% achieved high performance. Finally, in session 5 (post-training evaluation), 75.86% of the participants achieved high performance, demonstrating a progressive improvement in performance (see Table 6). To analyze the relationship between performance and the training intervention, a chi-square test of independence was applied with a 95% confidence interval. Performances in sessions 1 (pre-training) and 5 (post-training) were compared, obtaining a p-value < 0.05, indicating a statistically significant relationship between the intervention (use of biomodels) and the improvement in performance. This change is reflected in the notable increase in participants with high performance in session 5 (75.86%) compared to session 1 (0%), as well as in the reduction in low performance levels. The decrease in the average performance group is explained by the transition of these participants to the high performance group (see Table 7 and Figure 2).

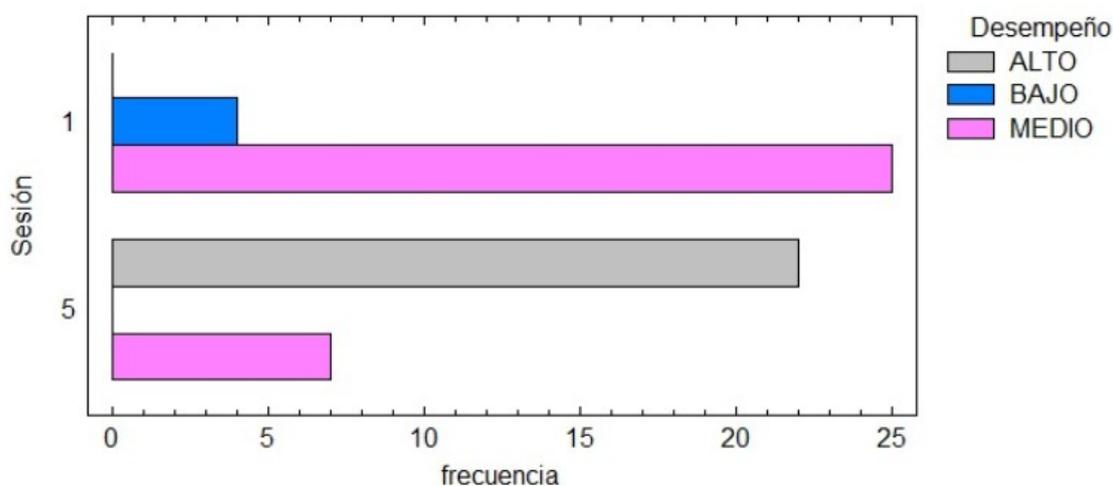


Figure 2. Frequencies by performance categories for sessions 1 and 5.

Vascular permeability test "End-to-end revascularization".

Once the analyses were completed, it was essential to highlight the residents' performance in the vascular patency verification activity using the biomodel (end-to-end revascularization - TT), specifically assessed on item 14 of the OSATS M 1-5 scale, called Vascular Patency Test. During session 1 (pre-training), the results showed that 20.68% of participants achieved high performance, 44.82% average performance, and 34.48% low performance. In contrast, for session 5 (post-training), a substantial improvement was evident: 79.31% achieved high performance and 20.68% average performance, with no records at the low level (see Figure 1). This item represents a critical component in training, as it constitutes the "gold standard" in the evaluation of vascular skills, since it simulates the surgeon's ability to guarantee continuous and functional blood flow through the intervened vessel, with multiple applications in both human and veterinary clinical practice.

4. Discussion

Surgical training programs seek to respond to current demands by promoting methods that guarantee patient safety. Several trends point toward controlled teaching-learning environments, such as clinical simulation, where students can learn, practice, and perform tasks in different areas through progressive experiences. This approach allows them to develop skills, abilities, and, above all, assume responsibilities in a cumulative manner (25). However, the assessment of these competencies is not always straightforward, and evaluation models in surgery continue to evolve. The development of specific skills within medical practice, particularly surgical skills, constitutes an interdisciplinary axis that integrates knowledge, technical skills, values, decision-making capacity, and clinical problem-solving. All of this gives rise to the key concept of competencies (26), understood as the integrated set of knowledge, skills, and attitudes that enable professional performance in accordance with the standards of the work environment, promoting continuous improvement and elevating the quality of professional practice (27–29).

In this context, the need to implement valid and reliable assessments of technical competencies has been a constant in surgical training programs (29). One of the most widely used strategies to evaluate technical skills in residents is the use of Objective Structured Assessment of Technical Skills (OSATS) scales (17, 30–31). This instrument consists of a series of specific tasks evaluated using numerical scales (1, 3, and 5 points), with behavioral descriptors defined for each level. The evaluator assigns scores upon completion of the activities, which allows determining whether the resident has reached the required level of competency or needs additional training. This approach has proven applicable in both medical-surgical residency programs and in intensive courses and other medical training sessions (32–33). OSATS can be implemented in simulated environments or in clinical practice, with different levels of demand (15, 19, 34–35).

This research has designed specific assessment scales for each stage of the training process: OSATS M 1.5 "Vascular Exercise Performance Evaluation" (Table 1) and OSATS M 2.0 "Training Process Performance Evaluation" (Table 2). The proposed methodological model seeks to optimize the acquisition of skills, abilities, and competencies through a series of carefully selected exercises. These exercises are aimed at developing fine motor skills with both hands, motor coordination, safe optical delimitation under the microscope, triangulation, and precision. To achieve this, trainees must master the use of magnifying lenses in different planes and depths, as well as the proper handling of microsurgical instruments, recognizing their characteristics and adapting them to their own needs. The progressive complexity of the parametry exercises allows for perfecting manual control, precise closure of the forceps, manipulation of instruments and tissues, and mastery of key concepts such as ergonomics, correct posture of arms and forearms, control of involuntary tremors, and body position in front of the microsurgical station (36–37).

The results obtained from the OSATS M 1.5 and 2.0 performance curves over five sessions (Table 5) demonstrate a clear dynamic in the acquisition of competencies, as reflected in the averages and scores recorded. This methodology allowed residents to optimize the development of fundamental skills, particularly visible in the results of OSATS M 2.0 (Table 5). The comparison between sessions 1 (pre-training or diagnostic) and 5 (post-training) with OSATS M 1.5 demonstrates significant progress in performance (Figure 2), which suggests its applicability in basic or initial training processes within academic programs. The high averages achieved reflect compliance with the established objectives, according to the required standards.

A key exercise in this process is the revascularization test or vascular patency check, included as item 14 in the OSATS M 1.5 evaluation. This task verifies the functionality of the intervened blood vessel, with no leaks or escapes, and represents the "gold standard" in this type of practice. Its execution requires residents to possess demonstrable and measurable technical skills. Passing this test indicates that the student is prepared to tackle more complex models and exercises. Therefore, it is essential to have objective evaluation systems based on observable and quantifiable parameters, such as those offered by the OSATS M 1.5 models.

The proposed methodology was based on constant support from the teacher or guide throughout the student's training process, who plays an essential role in the acquisition of competencies. Constructivist models in medical pedagogy emphasize the active role of the teacher (38), who is responsible for promoting spaces for active, independent, and self-directed learning. Furthermore, the teacher can identify students who are experiencing difficulties in a timely manner, allowing for the implementation of corrective strategies and specific reinforcement activities. This process is facilitated by the use of the OSATS scales, which structure learning into specific and clearly differentiated tasks. The student repeats these tasks continuously until the required level of competency is reached (39).

Additionally, several studies highlight the importance of including feedback sessions (debriefing) at the end of planned activities. These can be conducted between students or between students and the instructor, and are a key tool for consolidating practical knowledge. Debriefing allows for assessing the achievement of proposed objectives, identifying learning gaps, and promoting training focused on real-world results (40–41).

Previous research has identified limitations associated with the use of live models, primarily animals, during the initial stages of surgical training (2, 4–5, 8, 14, 32, 44). This approach poses serious bioethical restrictions because, although it has historically been used to develop basic competencies in residents and specialists, it often lacks validated simulated models to replace it. The methodological proposal of this study avoided the use of *in vivo* models, opting instead for synthetic and organic models. Specifically, an anatomical biomodel based on a chicken thigh was used for vascular skills testing due to its easy acquisition, low cost, adaptability to workstations, and absence of bioethical implications or biological risks. Furthermore, it does not require special preparation and is easy to store, making it an ethical and practical alternative for training processes (33, 42–43).

We hope that the results of this research will serve as a basis for future studies and that the proposed OSATS global grading model can be adopted and implemented in other laboratories and training programs, both in human and veterinary medicine, especially in vascular microsurgery. The methodological model and the materials used stand out for their accessibility, low cost, and ethical feasibility. It should be noted that some institutions have already developed their own scales inspired by the OSATS model for other surgical specialties (22, 44–52), which reinforces the importance of having effective training programs that allow new generations of surgeons to develop technical skills with high standards of quality, ethics, and professional responsibility, all for the benefit of patient quality of life.

However, it is important to recognize certain disadvantages associated with the use of OSATS scales. These include the costs associated with test design and implementation, as well as the need for training for both evaluators and those being evaluated. It is also necessary to standardize the exercises and establish uniform evaluation criteria to ensure consistency, efficiency, and reproducibility of the process (15).

Regarding the limitations of this study, we highlight the small sample size, due to the low number of residents in certain medical specialties, as well as the absence of a control group, which limits the generalizability of the results. However, these findings motivate the continuation and implementation of the model in various graduate and extension training programs, areas, and levels, with the goal of filling identified gaps and enriching the teaching-learning processes in microsurgery.

5. Conclusions

- The implementation of OSATS-type assessment scales, in conjunction with the proposed methodological plan, has proven to be a useful and applicable tool in medical-surgical specialty programs that include microsurgery as part of their curriculum. This proposal represents an innovative, practical, and cost-effective alternative that can be implemented in any laboratory, without bioethical implications or legal restrictions.
- The developed methodology is designed to cover the initial and fundamental stages of microsurgical training and allows for structured progression toward intermediate and advanced levels through the application of the OSATS M 1.5 model. Furthermore, its versatility allows for its extension to complementary studies in clinical settings in both human and veterinary medicine, consolidating it as a comprehensive training strategy for developing specific surgical skills.

Funding: No funding available.

Declaration of conflict of interest: The authors declare that they have no conflict of interest.

Author contributions : Study conception and design: MARG, AALR, ASPG. Data acquisition: MARG, AALR. Data analysis and synthesis: MARG, AALR, ASPG. Manuscript writing: MARG. Copyediting and critical revision: MARG, AALR, ASPG.

References

1. Tyagi S, Kumar S. Microsurgery: An important tool for reconstructive surgery a clinical review. *Surgery Curr Res*. 2014, 4(4), 1-4. <https://ijpbs.net/abstract.php?article=Mzkz>
2. Huentequeo-Molina C, Pino-Diaz Daniel, Moreno-Apablaza E, Alister JP Uribe F, Unibazo-Zuñiga A, et al. Microvascularized Flaps in Maxillofacial Reconstruction: Advances in Microsurgery. *Int. J. Odontostomat* . 2018, 12 (3), 309-319. <http://dx.doi.org/10.4067/S0718-381X2018000300309>
3. Camacho-García F, Rojas-Galvis M. Determining competency levels for basic microsurgery training. *Rev Colomb Cir*. 2016, 31, 240-7. <https://www.revistacirugia.org/index.php/cirugia/article/view/299/275>
4. Acland R, Raja S. *Acland's Practice Manual for Microvascular Surgery*. Missouri: Mosby; 1980 .
5. Lee Sang H, *Manual of Microsurgery*. St Luis, Ed. CRC Press; 1985 .
6. Camacho-García FJ, Rojas-Galvis MA, Ramírez-León JF, Cortés-Barré M. Basic course in microsurgery. Student guide. Bogotá: CLEMI Foundation Publishing; 2011 .
7. Camacho-García FJ, Rojas-Galvis MA, Ramírez-León JF, Cortés-Barré M, Cogua-Cogua LN. Microsurgery guide for training techniques in minimally invasive surgery. *Rev. colomb. ortop. Traumatol*. 2019, 33 (S2), 18-33 . <https://doi.org/10.1016/j.rccot.2019.07.007>
8. Samprón MN, Marqués SC. *Manual of neurovascular microsurgery*. Ed: OSI Communication. 2017, Donostialdea, pp. 6–9. ISBN: SS-108–2017
9. Valencia-Castro JL, Tapia-Vallejo S, Olivares-Olivares SL. Clinical simulation as a strategy for developing critical thinking in medical students. *Inv Ed Med*. 2019 ; 8 (29):13-22. <http://dx.doi.org/10.1016/j.riem.2016.08.003>
10. Guínez-Molinos S, Maragano-Lizama P, Gomar-Sancho C. Collaborative clinical simulation for the development of teamwork skills in medical students. *Rev. méd. Chile*. 2018, 146(5), 643–652. <http://dx.doi.org/10.4067/s0034-98872018000500643>
11. Díaz-Guio D, Cimadevilla-Calvo B. Simulation-based education: debriefing, its foundations, advantages, and difficulties. *Clinical Simulation*. 2019, 1, 95–103. <https://doi.org/10.35366/RSC192F>
12. Morales-Morgado E, García-Peñalvo F, Campos-Ortuño R, Astroza-Hidalgo C. Developing competencies through learning objects; *Journal of Distance Education (RED)*. 2013, (36). <https://www.um.es/ead/red/36/morales.pdf>
13. García-Perdomo H. Current surgical education as a tool for safer clinical practice. *Rev Colomb Cir*. 2016, 31, 237-9. <https://www.revistacirugia.org/index.php/cirugia/article/view/300/277>
14. Kania K, Chang DK, Abu-Ghname A, Reece EM, Chu CK, Maricevich M, Buchanan EP, Winocour S. Microsurgery Training in Plastic Surgery. *Plast Reconstr Surg Glob Open*. 2020, 8(7), 1-9. <https://doi.org/10.1097/gox.0000000000002898>
15. Rojas-Galvis MA, López-Ríos AA. Implementation of the OSATS formative assessment scales for applied technical skills in the microsurgery laboratory. *Rev Colomb Cir*. 2022, 37, 251-8. <https://doi.org/10.30944/20117582.1070>
16. Gaxiola-García Ma, Kushida-Contreras Bh, Sanchez-Mendiola M. Teaching surgical skills: relevant educational theories (part two). *Medical Educational Research*. 2022, 11 (42), 95-105. <https://doi.org/10.22201/fm.20075057e.2022.42.22433> .
17. Faulkner H, Regehr G, Martin J, Reznick R. Validation of an objective structured assessment of technical skill for surgical residents. *Acad Med*. 1996, 71, 1363-5. <https://doi.org/10.1097/00001888-199612000-00023>
18. Carsuzaa F, Payen C, Gallet P, Favier V. French translation and validation of the OSATS tool for the assessment of surgical skill, *Journal of Visceral Surgery*. 2023, 160 (6), 402-6. <https://doi.org/10.1016/j.jviscsurg.2023.08.001>
19. Martin JA, Regehr G, Reznick R. et al. Objective structured assessment of technical skills (OSATS) for surgical residents. *Br J Surg*. 1997 , 84(2), 273–278. <https://doi.org/10.1046/j.1365-2168.1997.02502.x>
20. Reznick R, Regehr G, MacRae H, Martin J, McCulloch W. Testing technical skill via an innovative “bench station” examination. *Am J Surg*. 1997 , 173(3), 226–230.

- [https://doi.org/10.1016/S0002-9610\(97\)89597-9](https://doi.org/10.1016/S0002-9610(97)89597-9)
21. Navarro-Subiabre F, Gabrielli-Nervi M, Varas-Cohen J. Objective assessment of technical skills in surgery. *ARS Med.* **2018** ; 43: 6–14. <http://dx.doi.org/10.11565/arsmed.v43i3.1112>
 22. Ezra DG, Aggarwal R, Michaelides M et al Skills acquisition and assessment after a microsurgical skills course for ophthalmology residents. *Ophthalmology.* **2009** , 116(2),257–262. <https://doi.org/10.1016/j.ophtha.2008.09.038>
 23. Manzini JL. Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *Acta Bioeth.* **2000** , 6, 321–34. <http://dx.doi.org/10.4067/S1726-569X2000000200010>
 24. Republic of Colombia. Ministry of Health. Resolution 8430 of 1993 <https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/DE/DIJ/RESOLUCION-8430-DE-1993.PDF>
 25. Muñoz-Cano J, Maldonado-Salazar T, Albarrán-Melzer J, Estrella-Gómez R. Constructivism in medical education: teaching perspectives. **2008** , 36, 31-39. ISSN-e 0188-3313.
 26. Bujan VK, Rekalde RI, Aramendi JP. The evaluation of competencies in higher education. Bogotá: Editions of the U, **2011** . p. 87-96. ISBN 978-958-762-027-6.
 27. Cruz-Rodríguez AM. The Integrated Professional Competencies Model as an Educational Paradigm. *Hipoc Rev Med.* **2011**, 6(24), 2-3 . <http://www.medigraphic.com/pdfs/hipocrates/hip-2011/hip1124a.pdf>
 28. Salas Perea RS. Proposed strategy for the evaluation of physicians' job performance in Cuba. *Cuban Journal of Higher Medical Education.* **2010** , 24(3), 387-417. <http://scielo.sld.cu/pdf/ems/v24n3/ems11310.pdf21412010000300011&lng=es&nrm=iso&tlng=es>
 29. Zambrano-Jerez L, Ramírez-Blanco M, Alarcón-Ariza D, Meléndez-Flores G, Pinzón-Pinilla L, Rodríguez-Santos M. Novel and easy curriculum with simulated models for microsurgery for plastic surgery residents: reducing animal use. *European Journal of Plastic Surgery.* **2024** , 47:36. [doi:10.1007/s00238-024-02177-2](https://doi.org/10.1007/s00238-024-02177-2)
 30. Sirimanna P, Boyce S, Gunanayagam P, Gladman M, Naganathan V. Development of a rating scale for objective assessment of performance in laparoscopic appendectomy surgery *ANZ J Surg.* **2022** , 92, 1724–30. <https://doi.org/10.1111/ans.17601>
 31. Díaz-Guio D, Cimadevilla-Calvo B. Simulation-based education: debriefing, its foundations, advantages, and difficulties. *Clinical Simulation.* **2019** , 1, 95–103. <https://doi.org/10.35366/RSC192F>
 32. Aoun SG, Ahmadiéh TY, Teclé NE, Daou MR, Adel JG, Park CS, Batjer, Bendok RB. A pilot study to assess the construct and face validity of the Northwestern Objective Microanastomosis Assessment Tool. *J Neurosurg.* **2015** , 123, 103–109. <https://doi.org/10.3171/2014.12.jns131814>
 33. Pehlivanovic B, Dina F, Emina A, Ziga Smajic N, Fahir B. Animal models in modern biomedical research. *Eur J Pharm Med Res.* **2019**,6 (7), 35–8. <https://www.researchgate.net/profile/Belma-Pehlivanovic/publication/334169930>
 34. Anderson DD, Long S, Thomas WG, Putnam MD, Bechtold EJ, Karam DM. Objective structured assessments of technical skills (OSATS) does not assess the quality of the surgical result effectively. *Clin Orthop Relat Res.* **2016** , 474, 874–81 <https://doi.org/10.1007/s11999-015-4603-4>
 35. Aoun SG, El Ahmadiéh TY, El Teclé NE, Daou MR, Adel JG, Park CR, et al. A pilot study to assess the construct and face validity of the Northwestern objective microanastomosis assessment tool. *J Neurosurg.* **2015** , 123, 103-9. <https://doi.org/10.3171/2014.12.JNS131814>
 36. Camacho-García F, Rojas-Galvis M. Ergonomic errors in a basic microsurgery training course. *Rev. Fac. Med.* **2020** , 68(4), 499-504 . <http://dx.doi.org/10.15446/revfacmed.v68n4.77256>
 37. Lakhiani, C, Fisher, SM, Janhofer, DE, Song, DH. Ergonomics in microsurgery. *J Surg Oncol.* **2018** , 118, 840-844. <https://doi.org/10.1002/jso.25197>
 38. Vargas K, Acuña, J. Constructivism in teachers' pedagogical and epistemological conceptions. *Innova Educación Journal,* **2020** , 2(4), 555–575. <https://doi.org/10.35622/j.rie.2020.04.004>
 39. Abreu-Hernandez L, Infante-Castañeda C. Medical education facing the challenges of the knowledge society. *Gac Med Mex* **2004** , 140-4. <https://www.scielo.org.mx/scielo.php?>

- [script=sci_serial&pid=0016-3813&lng=es&nrm=iso](#)
40. Cantrell MA. The importance of debriefing in clinical simulations. *Clinical Simulation in Nursing*. 2008 , 4, 19-23. <https://doi.org/10.1016/j.ecns.2008.06.006>
 41. Díaz-Guio D, Cimadevilla-Calvo B. Simulation-based education: debriefing, its foundations, advantages, and difficulties. *Clinical Simulation*. 2019 , 1, 95–103. <https://dx.doi.org/10.35366/RSC192F>
 42. Mukherjee P, Roy S, Ghosh D, Nandi SK. Role of animal models in biomedical research: a review. *Laboratory Animal Research*. 2022 , (38), 2-17. <https://doi.org/10.1186/s42826-022-00128-1>
 43. Matfield M. Animal experimentation: The continuing debate. *Nat Rev Drug Discov*. 2002 , 1, 149-52. <https://doi.org/10.1038/nrd727>
 44. Van Hove PD, Tuijthof GJ, Verdaasdonk EG, Stassen LP, Dankelman J. Objective assessment of technical surgical skills. *Br J Surg*. 2010, 97(7), 972–987. <https://doi.org/10.1002/bjs.7115>
 45. Swift SE, Carter JF. Institution and validation of an observed structured assessment of technical skills (OSATS) for obstetrics and gynecology residents and faculty. *Am J Obstet Gynecol*. 2006 , 195, 617–621. <https://doi.org/10.1016/j.ajog.2006.05.032>
 46. VanBlaricom AL, Goff BA, Chinn M, Icasiano MM, Nielsen P, Mandel L. A new curriculum for hysteroscopy training as demonstrated by an objective structured assessment of technical skills (OSATS). *Am J Obstet Gynecol*. 2005 , 193, 1856–1865. <https://doi.org/10.1016/j.ajog.2005.07.057>
 47. Ribeiro de Oliveira M, Mosso Ramos T, Ferrarez CE, MD, Machado CJ, Vieira-Costa PH, Alvarenga DL, et. to the. Development and validation of the Skills Assessment in Microsurgery for Brain Aneurysms (SAMBA) instrument for predicting proficiency in aneurysm surgery. *J Neurosurg*. 2020 , 133, 190–196. <https://doi.org/10.3171/2018.7.jns173007>
 48. Duarte-Pinto LO, Cunha-Silva R, Guerreiro de Barros L, Pampolha H, Bacelar H, Simone-Kietzer. Low-fidelity simulation models in urology resident's microsurgery training. *Acta Cir Bras*. 2023 , 38, 1 – 11. <https://doi.org/10.1590/acb386523>
 49. Choi J, Kim J, Shin J. Evaluation of quality and educational effect of microsurgery videos on YouTube: a randomized controlled trial. *Journal of plastic surgery and hand surgery*. 2022 , 56 (4), 242–248. <https://doi.org/10.1080/2000656X.2021.1990936>
 50. Szasz P, Bonrath EM, Louridas M, Fecso AB, Howe B, Fehr A, et al. Setting performance standards for technical and non-technical competence in general surgery. *Ann Surg*. 2017 ,266 (1),1–7. <https://doi.org/10.1097/SLA.0000000000001931>
 51. Acton RD, Chipman JG, Gilkeson J, Schmitz CC. Synthesis versus imitation: evaluation of a medical student simulation curriculum via objective structured assessment of technical skill. *J Surg Educ*. 2010,67 (3),173–8. <https://doi.org/10.1016/j.jsurg.2010.02.011>.
 52. Marcela Velásquez-Salazara M, Gaitán-Buitragob MA, Becerra-Cardona DA. Technical skills in suturing assessed with OSATS, comparing different instruction and support methods. *Medical Education*. 2024, 25, 1-8. <https://doi.org/10.1016/j.edumed.2024.100904>



© 2025 University of Murcia. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 Spain license (CC BY-NC-ND) (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Table 1. OSATS M 1-5 Scale. Evaluation of performance in end-to-end revascularization in a biomodel.

Items to be evaluated	Description		
	1	3	5
1. Ergonomic balance (head, neck, back and legs).	Hunched back, flexed wrists, shrugged shoulders. Wide range of movements Excessive tremors in hands and fingers	Good initial posture and positioning but deteriorates at the end of the procedure. Rarely performs wide range of motion	Optimal ergonomic position, relaxed and correct posture. Short, fine and precise movements. The movements are centralized in your wrist and fingers
2. Use of the surgical microscope	He fails to adjust the microscope, continually positioning the focal length and working distance. He keeps it out of focus, and he doesn't use the appropriate lens, which affects his spatial navigation. He can't see clearly; his vision is blurred, which affects his visual acuity.	He keeps the microscope focused most of the time but readjusts the equipment on occasion. You are familiar with using the microscope but you are not yet able to adjust it with confidence.	Optimize zoom, lenses, and optical settings when starting tasks, getting the most out of each lens by efficiently adjusting it to your specific needs.
3. Use of the instruments	Repeatedly uses the wrong instruments to perform activities.	Use the correct instruments but with more time than usual. Quickly correct with correct instrumentation after error.	Perfect execution of the instruments in hand for each activity. Know the instruments and select the correct one according to surgical needs.
4. Handling of surgical instruments	Repeatedly makes unnecessary passes or awkward movements with instruments. Make unnecessary and clumsy movements.	He uses the instruments competently and stiff or awkward movements are rarely observed.	Perform movements of the instrument in a fluid and effortless manner. Exact and precise movements.
5. Handling the vessel and respecting the tissue	Frequent vessel injury due to inappropriate and excessive use of force. Vessel tear. Tear due to improper use of the needle or instrument when tying the knot.	Acceptable and occasional accidental damage that does not affect structural integrity. Sudden movements in the anastomotic line during tying.	The vessel remains intact until the end of the procedure. Absence of movements preventing vessel damage.
6. Dissection of the external tunic or adventitia	It ignores the dissection of adventitia.	It sections parts, a slight dissection but it does not do it completely.	Complete circumferential dissection in the working field for equidistant

			borders in both vessels.
7. Microsurgical efficiency with the needle	<p>Unnecessary movements. Multiple attempts required to catch and position the needle. Several attempts required to break through the fabric. Frequently loses the needle in the surgical field</p>	<p>Few unnecessary movements. 2 to 4 attempts to grasp the needle correctly. Few attempts are required to penetrate the tissue.</p>	<p>Grab the needle in one go. Movements, precise and efficient. With just one attempt it passes through the tissue efficiently.</p>
8. Needle handling	<p>Irreparable damage to the needle requiring new suture material until the anastomosis is completed</p>	<p>The needle is moderately damaged and deformed but remains functional.</p>	<p>The needle does not receive any damage or deformity until the procedure is completed.</p>
9. Vessel entry point 1 anterior border – needle exit point in vessel 2 posterior border (vascular approximation)	<p>The edges of the needle are very uneven between the two edges of the anastomosis. The needle entry/exit is very irregular. There is no input/output symmetry. It takes up too much fabric on either edge of the fabric.</p>	<p>Approximately 50% of needle bites are uniform and regular. Input-output symmetry but makes mistakes. Several attempts to enter and exit but the line remains symmetrical.</p>	<p>All the needle entry and exit bites are uniform and regular. Precise symmetry at the edges of the vessel allows for a safe approach. Closure of the stitches is precise and keeps the vessel intact</p>
10. Space between anastomosis sutures around the intervened vessel	<p>Irregular spaces. An excessive number of stitches are used to complete the anastomosis.</p>	<p>More than 50% accurate spacing between points, but still maintains slightly regular spacing between points.</p>	<p>Spaces are precise between periods. The number of stitches is appropriate to the size of the vessel.</p>
11. Knotted	<p>Knot is not firm and can come undone. The knots are tied so tightly that they tear and injure the vessel. It wastes too much suture and requires more suture material to complete the anastomosis.</p>	<p>Knots of acceptable clarity but are uneven and irregular. The knots are cut to an appropriate length. Requires only one additional suture to complete the anastomosis</p>	<p>Square knot made with sufficient tension and strength. Adequate suture length. Completely complete the anastomosis with just one suture material.</p>
12. Efficiency in microsurgical knot tying	<p>Unnecessary movements. Multiple attempts required to grasp the suture and tie the knot. Multiple ties and twists of the thread due to excessive force on the instrument.</p>	<p>Few unnecessary movements. Few attempts to grasp the suture thread. Minimal damage to the suture thread due to excessive force.</p>	<p>Precise and efficient movements. Just an attempt at tying the knot efficiently.</p>
13. Complete evaluation of the anastomosis	<p>Severe twisting, angulation, or torsion of the vessel Completely deformed glass Did not complete the anastomosis</p>	<p>Without vascular torsion Slight bending of the vessel</p>	<p>Symmetrical line of the vessel Fully functional anastomosis</p>

14. Vascular permeability test	Large leaks at the anastomosis Diffuse leaks without a specific point No flow through the vessel	Moderate or minimal leaks	It does not present leaks, guarantees a continuous intra-vascular flow
15. Complete evaluation of the anastomosis	70 to 100% stenosis Points on the posterior wall of the vessel	10 to 50% stenosis Overlapping vessel edges with minimal compromise	There is no stenosis that could compromise the vessel, maintaining its internal flow.

Table 2. OSATS M 2-0 Scale. Performance evaluation in training activities.

Items	Description		
	1	3	5
Activity 1. 1. Quality of the cross-section of the wrapper	Messy, non-linear cutting. discontinuous	He maintains a slightly messy cut.	It maintains a straight and linear cut.
2. Distance of tobacco elements falling out of the Petri dish	>3 cm.	Between 1-3 cm.	A few fallen tobacco elements in <1cm
3. Take the elements of tobacco	Take several elements and move them with the clamp. > 5 elements fall outside the box.	Take a few items and move them on the same clamp. < 5 elements fall out of the box.	Take the tobacco elements one by one in the tongs. Few, < 3 items fallen out of the box.
Activity 2. 4. Writing on a blank sheet of paper	Writing the word in disorder. It does not maintain a neat vertical alignment.	Some letters are uneven but look for an order. Some words are out of order but maintain vertical alignment.	The words are in a structured order. Maintains a linear vertical order.
5. Decrease letters in descending order	Maintains the order of the letters without reducing the size.	It maintains a slight decrease in the letters.	It clearly decreases the size of the letters in descending order.
Activity 3. 6. Passing the thread through the gauze on the guide line	The strand moves away >5 mm from the guide line.	Keeps the thread on the guide line between 3 and 5mm.	The thread passes through < 3 mm of the guide line.
7. The strands of gauze	They are completely deformed and some are broken at the suture point.	The strands are in order but a few are deformed while maintaining their shape.	The strands are completely arranged without any deformity.
Activity 4.	It takes several attempts to take the sphere.	Few attempts to take sphere.	Grab the sphere safely in one

8. Sphere taking	Exceeds the pressure force with the clamp on the sphere. Changing the sphere from clamp to clamp fails on numerous attempts.	The pressure with the clamp on the sphere is just right with a few drops. Transfer the sphere from clamp to clamp with few drops.	attempt. The pressure of the clamp on the ball is just right. Efficiently transfers the sphere from clamp to clamp.
9. Sphere and suture material	Unable to insert the thread into the sphere It exerts overtension on the strand when taking it and it becomes deformed.	It takes only a few attempts to insert the thread into the sphere. The tension is necessary to take the thread with a few deformities.	Insert the suture strand into the sphere precisely. The tension on the thread is just right without deforming it.
10. Change of dominant and opposite hand in the exercise	Do not alternate hands while exercising.	Perform the exercise with your dominant hand more often than your opposite hand.	Alternate your dominant and opposite hands consistently when performing the exercises.
Activity 5. 11. Cutting the peel of organic material mandarin	Makes a messy cut, very deep or shallow, with several attempts at cutting. The cut is saw-like and uneven.	Make a cut the size of the bark, a few very deep cuts without altering its integrity. It maintains a linear cut in some areas, losing the guide line but maintaining uniformity.	Make precise cuts in the bark. The cut is linear and precise for removing the bark.
12. Capsule extraction	It does not separate the capsules that are attached to each other. During extraction, the capsules break due to excessive pressure and lack of precision.	He manages to separate most of the capsules, leaving some behind. Completely remove the capsules with a few broken ones.	Separate the capsules one by one with precision. Remove the capsules stuck together without breaking any.
Activity 6. 13. Alignment with the incision edges	Overlaps the edges of the incision creating.	Edges aligned with some overlapping.	Symmetry in completely aligned edges.
14. Needle entry and exit points in each segment (equidistant edges)	The relationship between income and output is unequal. It tears the material due to overtension when closing the stitches.	It maintains an input-output symmetry equal to the edge of the incision. There is little damage to the material in the tension and closure of the stitches.	Precise symmetry at the point entrance and exit with the edge at all points. There is no damage to the material due to over-tensioning of the points.
15. Symmetry in the distance between point and point	The distance between nodes is disordered, with wide and few spaces between them.	It maintains symmetrical spaces at most points.	Distance between points maintains uniformity with precise spaces.

	Loose knot and tends to come undone with errors in the knotting technique.	Firm knots with some irregular ones.	All knots are firm with good execution.
--	--	--------------------------------------	---

Table 3. Summary of scheduled activities.

Scheduled Sessions	Activities	Aim
Session 1 (Pre-training or diagnosis)	End-to-end vascular anastomosis exercises on a biomodel	-Perform a diagnosis of technical competence in arterial revascularization exercises.
Sessions 2, 3 and 4. (Training activities)	Activity 1. Transfer of tobacco elements.	-Develop dexterity and manual skill in grasping and handling pressure with a watchmaker's pliers. -Build skill in triangulation and parametric movements.
	Activity 2. Writing on a blank sheet of paper.	-Promote skill in visual handling of surgical microscope magnifying lenses. -Generate visual precision through linear and angular drawings. -Build foundations for proper handling of microsurgical instruments.
	Activity # 3. Figures with gauze and suture thread.	- Improve the accuracy of watchmaker's tweezers and needle holders. - Develop suture thread handling skills.
	Activity # 4. Plastic spheres with holes and a strand of 7-0 monofilament suture (Nylon).	-Create precision in grasping the tip of the watchmaker's pliers. -Strengthen skills in handling nylon monofilament sutures.
	Activity # 5. Practice on organic plant material.	-Improve competence in the precise handling of organic tissue.
	Activity # 6. Suture in silicone synthetic material.	- Develop skill and dexterity in handling instruments used for microsurgical knot tying. - Precisely execute different types of sutures in microsurgery.
Session 5 (Post-training or final evaluation):	End-to-end vascular anastomosis exercises on a biomodel	-Evaluate technical competence in arterial revascularization exercises.

Table 4. Default score ranges.

	Low	Half	High
OSATS M 1-5 (session 1)	15 - 28 pts	29-55 pts	56 – 75 pts
OSATS M 2-0 (sessions 2, 3, 4)	15 - 30 pts	31-59 pts	60 – 75 pts
OSATS 1-5 (session 5)	15 - 28 pts	29 - 55 pts	56 – 75 pts

Table 5. Distribution of students according to the surgical specialty program.

Surgical specialty	Residency/Master's Year	Number of students	%
Neurosurgery	1st	1	3.45%
Plastic, reconstructive and hand surgery	3rd	4	13.79%
Orthopedic surgery and traumatology	4th	3	10.34%
General surgery	1st	7	24.13%
General surgery	2nd	6	20.68%
Otorhinolaryngology	3rd	3	10.34%
Transplant surgery (fellow)	1st	1	3.45%
Surgery in veterinary sciences	1st semester of Master's degree in Surgery	4	13.79%
Total		29	100%

Table 6. Resident performance in the diagnostic session, the training sessions and the post-training session (n=29).

OSATS M1-5 (Session 1 – pre-training/diagnosis)	OSATS M 2-0 (Sessions 2,3,4 - training)	OSATS M1-5 (Session 5 – post-training)
Low 13.79%	Low 0.00%	Low 0.00%
Half 86.21%	Half 31.03%	Half 24.14%
High 0.00%	High 68.97%	High 75.86%

Table 7. Relative and absolute frequencies of performance for the sessions and chi-square test.

Sessions	High performance range	Medium performance range	Low performance range	p – value χ^2
Session 1 (Pre-training/diagnosis)	0 (0.00%, 0.00%)	25 (43.10%, 86.21%)	4 (6.90%, 13.79)	0.0000
Session 5 (Post-training)	22 (37.93%, 75.86%)	7 (12.07%, 24.14%)	0 (0%, 0%)	

Table 8. Confidence intervals for scheduled sessions.

Session 1- Pre-training or diagnosis							
Classification	Count	Average	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Range
LOW	4	26.5	1.29	4.87%	25.0	28.0	3.0
HALF	25	44.24	6.64	15.02%	29.0	55.0	26.0
Total	29	41.79	8.76	20.97%	25.0	55.0	30.0
Session 2, 3, 4 Training							
HALF	9	52.67	1.93	3.67%	49.0	55.0	6.0
HIGH	20	62.45	3.08	4.94%	59.0	69.0	10.0
Total	29	59.41	5.36	9.024%	49.0	69.0	20.0
Session 5 – Post-training Evaluation							
HALF	7	52.85	2.41	4.56%	50.0	55.0	5.0
HIGH	22	65.54	3.86	5.89%	58.0	70.0	12.0
Total	29	62.48	6.55	10.49%	50.0	70.0	20.0