Validation of a Task-Specific Scoring System for a Microvascular Surgery Simulation Model

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Objective/Hypothesis: Simulation models can help develop procedural skills outside the clinical setting while also providing a means for evaluation of trainees. Objective Structured Assessment of Technical Skills (OSATS) have been developed for several procedures. The purpose of this study was to demonstrate the construct validity of an OSATS for microvascular anastomosis performed on a simulation model using chicken thigh vessels.

Study Design: Validation study.

Methods: An expert panel constructed a task-specific checklist for an OSATS for microvascular anastomosis. Twenty surgical staff and trainees performed a microvascular anastomosis of a chicken ischiatic artery. Training level and microsurgical experience were assessed by questionnaire. The performances were recorded and scored by two experts using the task-specific and global scales of the OSATS.

Results: Analysis of variance revealed a significant effect of training and microvascular experience for both the task-specific score and global rating scale score ($P < .005$). Interrater reliability was 0.7. Experience level demonstrated a logarithmic relationship with task time.

Conclusions: The microvascular OSATS applied to the chicken thigh simulator model differentiated between levels of microvascular experience. It demonstrated construct validity and reliability for the assessment of procedural competence using a cost-effective and easily accessible model.

Key Words: Microvascular surgery, microsurgery, simulation model, objective structured assessment, Objective Structured Assessment of Technical Skills, scoring system.

Level of Evidence: 2c.

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INTRODUCTION

Medical educators are under increasing pressure to assess skills and competence. Case logs have been the conventional methods used to assess progress in surgical training. Participation in cases, however, does not necessarily predict the trainee's ability to perform the procedure independently. Challenges in the assessment of surgical skills include access to a uniform and testable situation, as well as a uniform and objective assessment method. Simulation models can be utilized for this purpose.

Microsurgery has become an essential technique in many surgical specialties. Microsurgery requires hand-microscope-eye coordination; respectful handling of the delicate tissues with the microsurgical instruments; and steady, fast, and fluid surgical technique. The learning curve is steep, especially in these complex and time-consuming cases. Training in the laboratory on simulation models can develop familiarity with handling of microinstruments and suturing under the microscope. This may optimize trainees' experience in the operating room and also provide a means for assessment of their technical skills.

Several high- and low-fidelity models for microvascular anastomosis have been previously described, including the chicken thigh,[1] wing,[2] and carotid.[3] The chicken thigh model utilizes the chicken ischiatic neurovascular bundle, the anatomy of which was demonstrated on an angiographic study performed by Galeano and Zarabini.[4] The chicken ischiatic artery approximates the caliber of arteries used for anastomosis in the human head and neck, which have a mean inner diameter of 2.5 to 3 mm. The smaller distal vessels in the leg may also be used to simulate perforator vessels. After the anastomosis, the sutured segment can be opened to assess the adequacy of the sutures, and the process can be repeated multiple times on the same chicken specimen.

To improve the preclinical experience for trainees in microvascular surgery, we adapted the Objective Structured Assessment of Technical Skills (OSATS) scoring system to the microvascular arterial anastomosis task. The OSATS was originally described by Reznick et al.[5] as
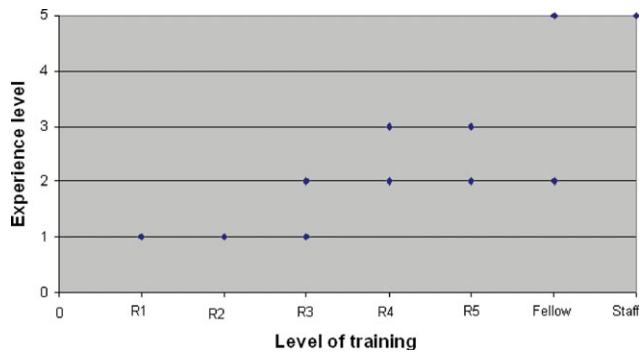
Fig. 1. Level of training versus experience level. Twenty participants were recruited from surgical staff, fellows, and residents. Self-reported experience level 1 was deemed "novice," level 2 to 3 "intermediate," and level 4 to 5 "expert."

an objective alternative to the previous, traditional assessments of surgical skills, which were based on subjective ratings by experts. By establishing set criteria, objective scoring systems have better interrater reliability and construct validity than subjective ratings. The OSATS is comprised of two parts: the task-specific score (TSS), a series of items scored in a binary fashion designed for the procedure being practiced; and a global rating scale (GRS), a five-item list, identical for all OSATS scales, containing items scored on a 1 to 5 Likert scale.

The purpose of this study was to describe an OSATS specific to microvascular anastomosis and demonstrate its construct validity and reliability when applied to the chicken thigh model.

MATERIALS AND METHODS

OSATS

Three experienced microvascular surgeons (K.E.C., G.F.F., N.A.P.) collaborated on creating a task-specific checklist specific to microvascular anastomosis. The starting point was an OSATS checklist developed for urologic vasovasostomy (E. Grober, personal communication). Items were added to and removed from the checklist by consensus in a collaborative process until the list was as short as possible. The final list contained 14 items, each scored in a binary fashion. The standard OSATS five-item GRS was also used.
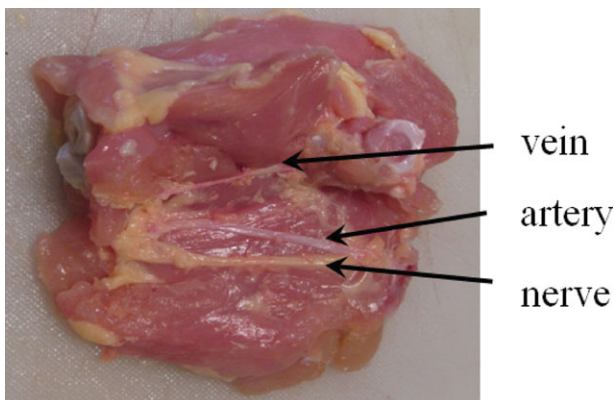

Fig. 2. The ischiatic neurovascular bundle utilized in the chicken thigh model.

Subjects

Twenty participants were recruited from surgical staff, fellows, and residents at our institution. There were two to four participants at each level of training. All except one, a neurosurgery fellow, were from the otolaryngology department. Institutional review board approval was obtained. Participants reported their level of clinical training and microsurgical experience using a web-based questionnaire (Fig. 1). Self-assessment of level of microsurgery experience was determined by Likert scale score, ranging from "novice" (no prior microsurgical experience) to "expert" (perform microsurgery independently at least once a month). Subjects who had performed microsurgery at the expert level in the past but were no longer performing it regularly were asked to indicate the years since they stopped. Subjects were also asked whether they had microvascular experience in particular. This distinction was made because it was unlikely for any resident to have significant microvascular experience, but residents may have gained microsurgical skills from other disciplines, such as otology and laryngology. These skills were expected to translate to microvascular techniques. Participants were then stratified into three experience cohorts, where level 1 was deemed "novice," level 2 to 3 "intermediate," and level 4 to 5 "expert."

Model

The model used chicken thighs purchased from a grocery store. The ischiatic artery, vein, and nerve were identified under the iliotibialis and iliofibularis muscles (Fig. 2). Microvascular instruments and an operative microscope with recording capability were provided. The shared instrument set used was a Synovis S&T Microset F Basic Lab Set (Synovis, Neuhausen, Switzerland) and contained a needleholder (14 cm), dissecting scissors (15 cm), adventitia scissors (15 cm), forceps (11 cm straight, 12 cm straight), vessel dilator (11 cm), clamp applying forceps, and vessel approximator clamp. Operative microscopes were obtained from the operating rooms and clinic. Syringes of water were also provided to moisten the tissue.

Participants were asked to complete two microvascular anastomoses of the chicken ischiatic artery using 8-0 or 9-0 nylon suture, one using the "back-wall-first" method and one using the method of their choice (Fig. 3). In the back-wall-first method, the back wall is sutured first, followed by the front wall, and no approximator micro clamp is used. A video demonstrating the back-wall-first method and instructions for the
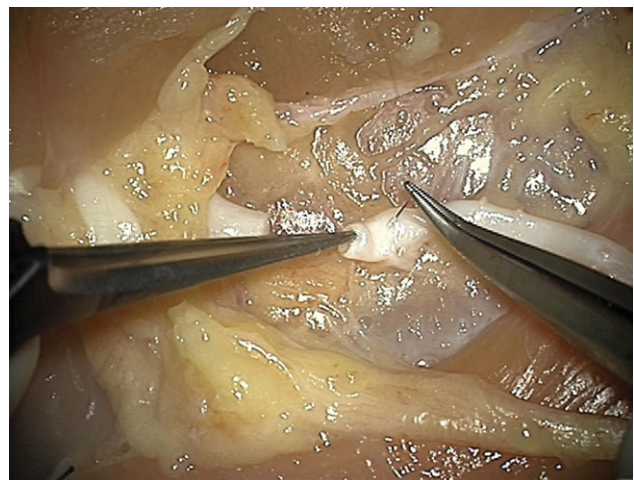

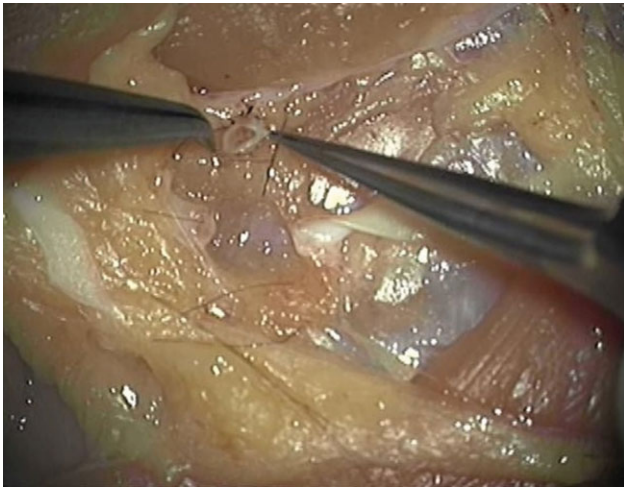Fig. 3. Example of arterial anastomosis through the operative microscope.

Fig. 4. After completing the anastomosis, the segment is excised and lumen patency is demonstrated to the camera.

study protocol are available on the Iowa Head and Neck Protocols at [http://wiki.uiowa.edu/display/protocols/Microsurgical+chicken+thigh+model+study]. After completing each anastomosis, participants were asked to cut out the sutured segment and show the lumen to the camera (Fig. 4).

Assessment and statistical analysis

The video-recorded performances were independently scored by two experienced microvascular staff surgeons using the adapted OSATS. Time taken to complete the anastomosis was measured independently. Statistical analysis was done

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TABLE I.
Microvascular Objective Structured Assessment of Technical Skills (OSATS)-Task Specific Score.

	Correct	Incorrect
Passing needle through tissue		
1. Loads needle in drive 1/2 to 2/3 from needle tip		
2. Needle does not wobble in driver		
3. Needle enters tissue perpendicularly		
4. Forceps handle vessel adventitia to provide counter traction		
5. Dilator is appropriately used		
6. Needle is pulled through tissue following its curve		
7. Suture is pulled out parallel to the tissue		
8. Suture tails are left at the correct length		
9. Appropriate depth tissue bite on each side		
10. Sutures are spaced appropriately		
Knot tying		
11. Three or more square throws are tied		
12. Efficient handling of suture while tying		
13. Appropriate tension on suture while tying		
14. Tissue well-approximated but not strangulated		
Total correct		/14

*Tasks are scored as "correct" if done correctly >75% of the time.

TABLE II.
Microvascular OSATS-Global Rating Scale.

	Worst				Best
Economy of motion	1	2	3	4	5
Instrument handling	1	2	3	4	5
Respect for tissue	1	2	3	4	5
Flow of operation	1	2	3	4	5
Overall result	1	2	3	4	5

using SAS 9.2 (SAS Institute, Inc., Cary, NC). Construct validity was assessed using one-way analysis of variance models with an α level of 0.05.

RESULTS

The adapted OSATS checklists are shown in Tables I and II. When grouped by experience level, experts performed significantly better than novices and intermediate microsurgical experience participants ($P < .0001$) (Fig. 5). Novices included postgraduate year (PGY) 1 to PGY3 residents, and intermediate participants included PGY3 to PGY5 residents and a fellow, based on self-reported experience. Training level was also predictive of TSS. Although the difference between PGY4 and PGY5 residents and fellows/staff was not statistically significant, there was a significant difference between PGY1 to PGY3 and fellows/staff ($P = .002$). Microvascular experience was also predictive of TSS ($P < .0001$).

Some tasks showed a greater ability to differentiate between levels of experience (Fig. 6). Most participants, regardless of training or experience level, tended to load the needle correctly and without wobble, tie three or more square knots, use the appropriate amount of tension, and approximate the tissues without strangulating them. Tasks that experts tended to do better were handling the adventitia to provide counter traction; following the curve of the needle when pulling the needle through tissue; pulling suture out parallel to the tissue; taking an appropriate size bite on each side; and handling the suture efficiently while tying.

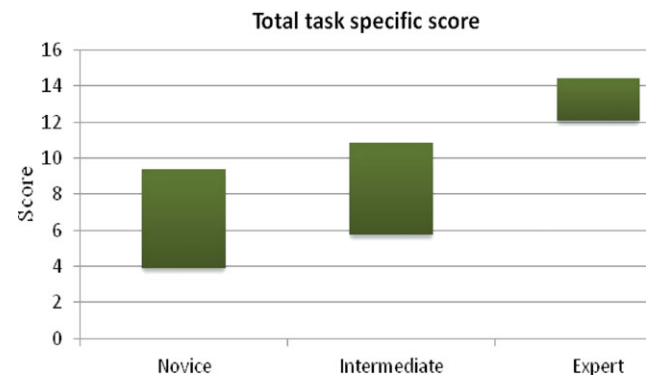Experience and training level were similarly predictive of GRS scores ($P < .0001$, and $P = .0045$,

Fig. 5. Mean total task-specific score based on experience. The box shows 1 standard deviation above and below the mean.
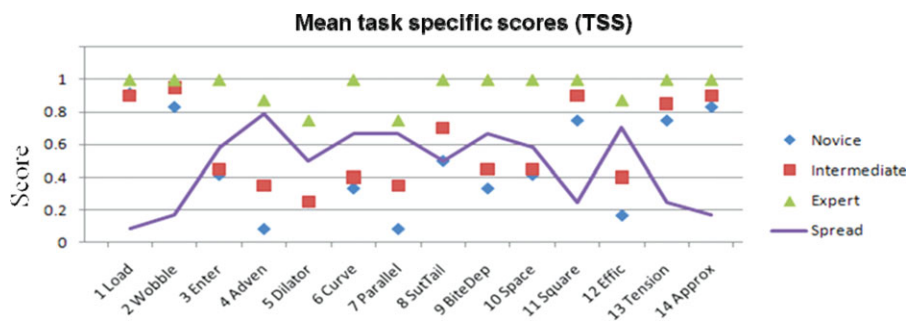
Mean task specific scores (TSS)

Fig. 6. Mean task-specific score based on experience. See Figure 5 for a key of the tasks. Spread is the difference between novices and experts. Based on these results, we will remove numbers 1, 2, 11, 13, and 14 from the task-specific assessment.

respectively). For all global elements—overall result, flow of operation, respect for tissues, economy of motion, and instrument handling—experts outperformed novices and intermediate participants (Fig. 7). For all levels of training and experience, both TSS and GRS showed good interrater correlation, with an intraclass coefficient of 0.69 and 0.72, respectively (Fig. 8).

Task time was also correlated with experience level. Advanced participants completed the task more quickly, with a plateau at 18 minutes (Fig. 9). Microvascular experience in particular, and not just general microsurgical experience, was associated with shorter task time.

DISCUSSION

The results demonstrate that the microvascular OSATS is able to differentiate between levels of microvascular ability, and scoring using the modified microvascular OSATS system showed good interrater reliability. Experienced microvascular staff surgeons outperformed novice and intermediate residents in time to complete the task as well as global and task-specific measures of skill. This demonstrates construct validity of the model. Training level was also correlated with scores, although TSSs were not significantly different between staff/fellows and PGY4 to PGY5 residents. The fact that experience level demonstrated more difference than training level underscores the unique nature of microsurgical skill and the need for directed learning, not just additional time in residency. A limitation of our study is that experience was subjectively reported, and no guidelines were given to the participants to ensure uniform judgment of experience level.
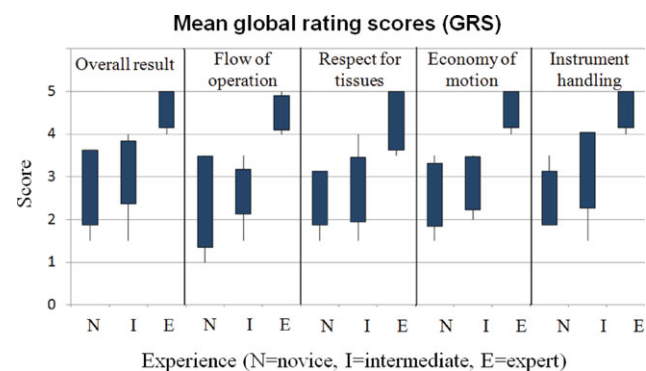
Experience level demonstrated a logarithmic relationship with task time, with novices taking exponentially longer and advanced participants showing incrementally less of a decrease in time. This is expected if one assumes that microvascular ability follows a typical S-shaped learning curve, with a slow beginning, steep acceleration, and eventual plateau. Experience level showed a greater correlation with task time than resident training level with task time, again highlighting the importance of directed microvascular experience rather than simply more years of general training.

Our results suggest that both task-specific measures and a GRS are useful. As with other described OSATS models, the GRS might be more useful for competency assessment, while the TSS might provide better feedback so learners might better focus their efforts. In future applications of the microvascular OSATS, tasks that did not demonstrate significant differences between experience groups in this study (i.e., loading the needle correctly, tying square knots, maintaining appropriate tension, and not strangulating tissues) can be eliminated to streamline scoring.

Mean global rating scores (GRS)

Fig. 7. Mean global rating scores based on experience. The box and whisker plots follow the same format as in Figure 6.
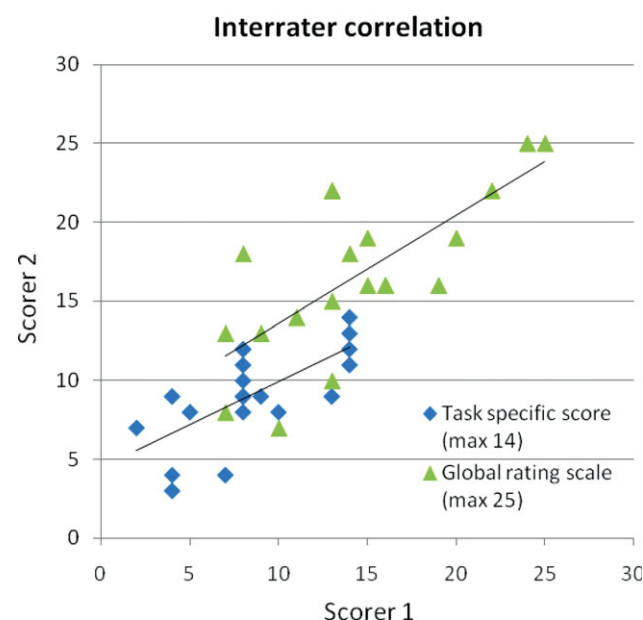
Interrater correlation

Fig. 8. Interrater reliability. Intraclass correlation coefficient for task-specific score and global rating scale between scorers were 0.69 and 0.72, respectively.
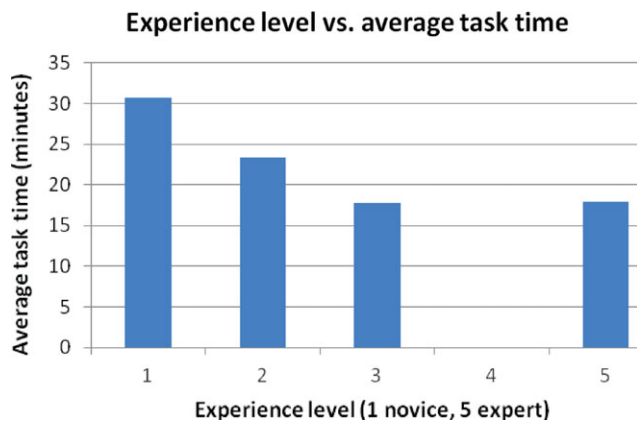
Experience level vs. average task time

Fig. 9. Experience level demonstrated a logarithmic relationship with task time.

In our study, we chose to test all participants with the back-wall-first method because it was a new technique to everyone, including most of the experts. This created uniformity in the task and allowed assessment of whether prior microvascular experience was generalizable to an unfamiliar microsurgical task. It reduced the advantage that experts may have had just because they knew what the steps of a microvascular anastomosis entailed. Finally, it enabled us to teach novices how to perform one method of microvascular anastomosis. Leaving novices with no directions might be so discouraging that they might not attempt to complete the task. Although the goal of the study was to validate the model, a secondary goal was to provide practice and training for surgical trainees.

We have found the chicken thigh simulation model to be an excellent substitute for other low- and high-fidelity simulation models for microvascular anastomosis. It has the advantages of low cost and easy access, like silicone tubing and surgical gloves, while actually offering very similar qualities to human vessels, perhaps even more so than rat vessels. At our institution, this model has replaced all other training models for microvascular anastomosis. The chicken thigh model inherently has more face validity than the nonliving models and is also more widely available, maintainable, and cost-effective than animal models.

This study demonstrates the construct validity of the chicken thigh model for microsurgical competence assessment. Additional studies are necessary to show predictive ability with skills transfer to the operating room and improved patient outcomes. To the best of our knowledge, no microsurgical models have been tested for predictive validity. Furthermore, the model may also be useful as a tool for training, although this was not addressed by this phase of our study. A useful follow-up study would use the microvascular OSATS to assess improvement over time with practice on the simulator model.

There is an increasing body of research on the development of expertise which asserts that achieving superior performance requires vast experience—the "10,000-hour" rule first espoused by K. Anders Ericsson and popularized by Malcolm Gladwell. However, the length of experience alone is not systematically related to superior performance.[6] Indeed, reviews of the performance of doctors and nurses have shown that extended experience (beyond the first couple of years) after graduation is not associated with continued improvement but rather decrements in performance.[6] The critical variable for performance improvement is identifying areas of desired goals of achievement and engaging in effective training. This "deliberate practice" requires that the performer "be fully prepared for the initiation of the task, be given immediate feedback from the outcome, and then be allowed to repeat the same or similar task with gradual modifications. Performing the task under these optimal conditions is more effective than performing the associated task only when it occurs within the natural context of performance."[6] The chicken thigh provides a validated model for repeated practice, but the element of immediate feedback, which is critical for effective training, is missing. This feedback must come from the expert teachers, who may also find the OSATS task items we developed in the study to be a useful format to organize areas for directed training.

CONCLUSION

The chicken thigh model and microvascular OSATS can differentiate between levels of microvascular ability. Microvascular experts outperformed novices in task-specific measures, global ratings, and task time. Interrater correlation with the microvascular OSATS scoring system was good. This study demonstrates the construct validity and reliability of the chicken model and OSATS for assessing microvascular competence.

Additional studies would be necessary to show predictive ability of the model with skills transfer to the operating room for improved outcomes and to show that the model may also be useful as a tool for training. Given the task-specific results of this study, areas of focus for microvascular training could include learning to use vessel adventitia for counter traction and efficient handling of suture.

BIBLIOGRAPHY

1. Sucur D, Konstantinovic P, Potparic Z. Fresh chicken leg: an experimental model for the microsurgical beginner. *Br J Plast Surg* 1981;34:488–489.
2. Hino A. Training in microvascular surgery using a chicken wing artery. *Neurosurgery* 2003;52:1495–1498.
3. Govila A. A simple model on which to practise microsurgical technique: A fresh chicken. *Br J Plast Surg* 1981;34:486–487.
4. Galeano M, Zarabini A. The usefulness of a fresh chicken leg as an experimental model during the intermediate stages of microsurgical training. *Ann Plast Surg* 2001;47:96–97.
5. Reznick R, Regehr G, MacRae H, et al. Testing technical skill via an innovative "bench station" examination. *Am J Surg* 1997;173:226–230.
6. Enhancing the development of professional performance: implications from the study of deliberate practice. In: Ericsson KA, ed. *The Road to Excellence: The Acquisition of Expert Performance in the Arts and Sciences, Sports, and Games*. Mahwah, NJ: Lawrence Erlbaum Associates, 1996.