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Open knot-tying skills: Resident skills assessed

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Abstract

Aim: Open knot-tying and suturing skills are fundamental surgical skills, founding many alternative knot-tying techniques. It is therefore mandatory for residents to possess adequate basic open knot-tying skills. The aim of this study was to compare an objective assessment of open knot-tying skills by residents to a resident's own estimation of his or her knot-tying skills, before and after a knot-tying course.

Material and Methods: A prospective observational cohort study was performed. At baseline level, after 1 training day in the Advanced Suturing Course (ASC) in the Netherlands and Belgium and after 6 weeks of autonomous practice (i.e. self-practice), 99 residents' open knot-tying skills were objectively evaluated using the Objective Structured Assessment of Technical Skills (OSATS). The resident's own confidence in these skills was also evaluated.

Results: The ASC substantially and significantly improved residents' knot-tying skills according to the OSATS between baseline and post-measurement. The observed improvement after 1 training day decreased after 6 weeks of autonomous practice. Self-confidence increased directly after the training program and was maintained 6 weeks later. Residents having completed the first 3 years of residency displayed an overall greater self-confidence than residents not having completed the first 3 years of residency, although the increase in self-confidence was significantly larger in the latter after 6 weeks' autonomous training.

Conclusion: There is a divergence between residents' objectified open knot-tying skills and self-confidence in these skills. The ASC improved open knot-tying skills according to the OSATS, however this improvement decreased after a 6-week period of autonomous practice. Self-confidence, in contrast, was maintained or increased. Further research is needed to correlate validated training programs with clinical outcomes and to determine whether residents' open knot-tying skills and self-confidence are retained beyond 1 year.

Key words: basic technical skills, knot-tying and suturing curriculum, self-confidence, skill acquisition, skills training/assessment.

Introduction

Despite the importance of technical skills, less than 1% of all surgical residents are tested on their open knot-tying techniques.[1] Open knot-tying and suturing skills are fundamental and critical to ensuring safe performance of all operations.[2] Training in basic surgical skills should be a primary component in the education of a surgical resident. Considering patient safety, working-hour restrictions and budgetary constraints, many hospitals have developed laboratory-based training programs using bench models and simulators to provide surgical skills. Several structured proficiency-based curricula for the education and assessment of

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basic surgical skills have since been evolved, validated and implemented.[3–6] Detailed curricula training in open knot-tying skills have not been extensively evaluated. To our knowledge, two prior studies focused on the utility of bench models for open knot-tying skills.[2,7]

However, these programs are provided during a medical student's surgical rotation, not surgical residency.[8,9] The assessment of open knot-tying and suturing skills is typically performed at the end of a rotation and mostly based on a recollection of the student's performance during that rotation. This assessment has been proven to have poor reliability and validity and is often biased by factors other than technical skill.[10] The gap between a medical student's training and implementation of knot-tying skills during surgical residency results in a loss of skills during this time. Goova *et al*. assessed the baseline proficiency of primary-year surgical residents before and after participation in an open knot-tying and suturing training program, using the modified Fundamentals of Laparoscopic Surgery scoring system.[11] They found a significant score-increase during the course.[12] It may be important for trainees to rate their own personal skills and to assess the effect of training on these skills.

This subsequently encourages a trainee's own responsibility for professional skill and competence development.[13,14] The implementation of self-assessment moments within supervised training programs has been demonstrated to improve self-confidence.[15,16] The aim of this study was to evaluate residents' self-confidence in open knot-tying techniques and compare this self-confidence with an objective measurement of these skills using the Objective Structured Assessment of Technical Skills (OSATS) assessment. The effect of an open knot-tying course was evaluated.

Methods

A prospective observational cohort study was conducted in the Netherlands and Belgium between 1 February and 30 April 2011.

Study group

A total of 99 surgical, gynecological and urological residents voluntarily participated in the Advanced Suturing Course (ASC), a laparoscopic and open knot-tying course organized by the VU Medical Center in Amsterdam, the Netherlands. Residents were allowed to enroll in this training program after having completed the first 1.5 years of their residency program, as basic open and laparoscopic knot-tying trainings are then completed.

Training program

The ASC consists of 1 training day followed by 6 weeks of voluntary autonomous training at home. The first training day entails an extensive repetition of open, square, surgeon's and slipping knot-tying techniques. Training in these techniques was carried out using a knot-tying board and cotton thread. Training was intensively supervised by at least two senior (gynecological) surgeons providing instructions and feedback. The resident–supervisor ratio during the course was 4:1. All equipment and supervisors were kept identical during both training days.

To perform an open knot, a valve-tube imitating a blood vessel put around an upside-down valve tightened to a board was used. A surgical clamp was held by the supervisor on the tube to enable participants to perform a square knot ligature around the valve-tube.

Evaluation of skills

The open knot-tying skills of each participant were evaluated immediately before and after the first course day, and again after the 6-week autonomous training period. This evaluation included an evaluation of self-confidence using a VAS of 0–100 and an objective assessment using the OSATS by senior laparoscopic surgeons of the department of surgery or gynecology.

Regehr *et al*. demonstrated that a global rating scale, such as the OSATS, demonstrates a high inter-observer reliability between surgeons of different skill (construct validity).[17] The OSATS consists of five scoring items covering the fundamental aspects of open knot-tying techniques (Appendix 1). A score of 1–5 is given for each item, resulting in a total score between 5 and 25. We did not score time as an indicator for performance as this is not necessarily a good surrogate for ability.[18] Seventy-five percent of the maximum OSATS score was used as a cut-off value.[19,20] Trainees were given 5 min to complete an open knot.

Statistical analysis

Data were analyzed using SPSS 15.0 for Windows. Data were tested for assumption of parametric testing, which revealed it is safe to perform parametric tests. Differences between the evaluation points in mean confidence scores and mean OSATS scores were assessed by using multilevel analysis statistics. A comparison was made between baseline measurement and

post-measurement (effect of the training program) and between post-measurement and follow-up measurement (long-term effect of the training program after 6 weeks of self-practice). Additionally, differences between residents with fewer than 3 years of residency and residents with 4–6 years of residency and differences among residents from gynecology, urology and surgery were analyzed. The relation between self-confidence and OSATS scores was assessed using Pearson correlation analyses comparing difference scores between baseline measurement and post-measurement (effect of the training program) and between post-measurement and follow-up measurement (long-term effect of the training program after 6 weeks of self-practice). Results are reported as mean (±SD) and all *P*-values reported are two-sided; a significance level of less than 0.05 was considered statistically significant.

Results

Out of 99 residents, 57.6% ($n = 57$) had completed less than 3 years of residency and 42.4% ($n = 42$) were between the 4th and 6th year of residency. Specializations included 81.8% ($n = 81$) in general surgery, 10.1% ($n = 10$) in urology and 7.1% ($n = 7$) in gynecology (one resident did not mention his or her specialization).

Objective assessment

Out of 99 residents, 70.7% ($n = 70$) were evaluated at the start of the training program (baseline), 67.8% ($n = 67$) after the first training day (post) and 48.5% ($n = 48$) after 6 weeks of autonomous training (follow up). OSATS scores are presented in Figure 1.

OSATS scores increased significantly between baseline and post-measurement ($P = 0.002$); however, the objective evaluation of surgical technique OSATS scores did not change significantly between post-measurement and follow-up measurement ($P = 0.824$). Overall, the changes in OSATS scores were similar for residents in their first 3 years of residency and residents after their first 3 years of residency ($P = 0.841$; $P = 0.223$). Overall, residents with 4–6 years of resident training demonstrated slightly higher mean OSATS scores compared to residents with 1–3 years of resident training, yet this was not statistically significant ($P = 0.144$). Overall, there was no significant difference in OSATS scores between residents from different specializations ($P = 0.414$). The changes in OSATS scores between baseline and post-measurement and between post-measurement and follow-up measurement were similar for residents from different specializations ($P = 0.866$, $P = 0.866$).

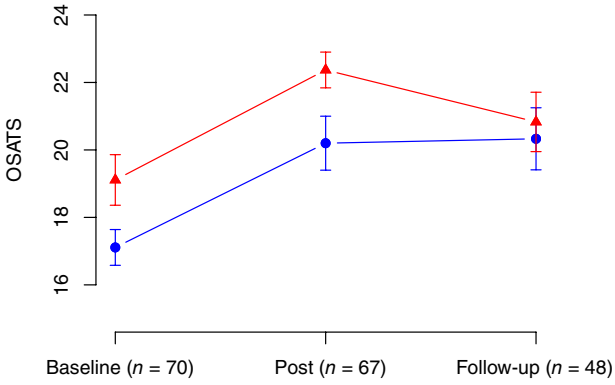

Figure 1 Means and standard errors of Objective Assessment of Surgical Techniques (OSATS-scores) for both experimental groups separately. (–●–), 1–3 years of residents training; (–▲–), 4–6 years of residents training.

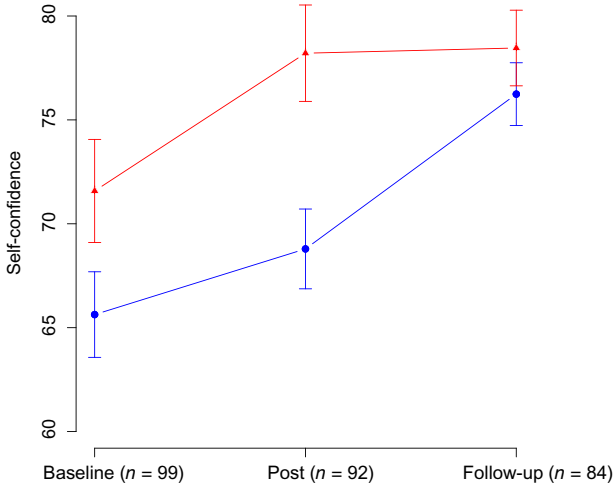

Figure 2 Means and standard errors of residents' confidence of surgical techniques for both experimental groups separately. (–●–), 1–3 years of residents training; (–▲–), 4–6 years of residents training.

Self-confidence

Of participating residents, 100% ($n = 99$) evaluated their own self-confidence in open knot-tying skills at baseline, 92.9% ($n = 92$) at post-measurement and 87.9% ($n = 84$) at follow-up measurement. Self-confidence scores are presented in Figure 2.

Mean confidence scores in open knot-tying skills increased significantly between baseline and

post-measurement ($P = 0.004$). Also, mean confidence scores increased significantly between post- and follow-up measurement ($P < 0.001$). The increase in mean confidence scores between baseline and post-measurement was similar for residents with different years of residency training ($P = 0.580$), but during the 6-week period of self-practice the increase in mean confidence scores was significantly greater for residents with fewer than 3 years of residency experience than for residents with 4–6 years of residency experience ($P = 0.010$). However, residents having completed 4–6 years of residency reported significantly higher mean confidence scores compared to residents with less than 3 years of residency ($P = 0.002$). Overall, there was no significant difference in self-confidence scores between residents from different specializations ($P = 0.430$). The changes between baseline and post-measurement and between post-measurement and follow-up measurement were similar for residents from different specializations ($P = 0.806$, $P = 0.779$).

Self-confidence and objective measurement relations

The increase in reported self-confidence in open knot-tying skills for both groups of residents between baseline and post-measurement was not significantly related to the increase in objective score of these skills ($r = 0.282$, $P = 0.172$; $r = –0.007$, $P = 0.972$). This relation was also not significant between post-measurement and follow-up measurement ($r = 0.237$, $P = 0.234$; $r = 0.332$, $P = 0.193$).

Discussion

Although it is known that basic skills acquired in a laboratory setting are transferable to the operating theatre,[21,22] there is a lack of longitudinal assessment with objective feedback regarding open knot-tying techniques.[8] To our knowledge, this is the first study comparing an objective assessment of open knot-tying skills to self-confidence in these skills. Proficiency-based training curricula that consist of structured practice, using performance-derived training end-points that provide constructive feedback, optimal learning, repetition and durable skill acquisition have not been widely reported.

Participating residents were relatively insecure regarding their open knot-tying skills at the start of the training program but did estimate their proficiency level in these skills as sufficient. The training program improved both residents' knot-tying performance and self-confidence. The increase in self-confidence over time was expected; experience in a procedure increases self-confidence.[23] Although self-confidence improved over time, the increase in self-confidence did not correlate to an objective improvement of performance. Residents were only minimally proficient 6 weeks post-training. Self-assessment scores have been shown to poorly correlate with the objective assessment of these skills[10] (as is shown in our study), and this essentially contributes to the motivation of trainees to improve their technical skill.[15] Although self-assessment helps to recognize deficiencies and create an awareness of deficiencies, these results emphasize the need for repeated practice to improve not only residents' self-confidence but also objective performance. Draycott *et al*. found in a retrospective observational study that the introduction of shoulder dystocia training improved management and neonatal clinical outcomes of births complicated by shoulder dystocia.[24] Further study is needed to determine whether residents' open knot-tying skills and self-confidence are retained beyond 1 year.

One training day induced only a temporary improvement in open knot-tying skills. The authors feel the initial improvement during day 1 may be caused by a refreshment and training of the resident's knowledge and techniques in open knot-tying skills during day 1. An absence in training or an absence of correction of skills during the 6-week autonomous training interval may explain unaltered scores on day 2.

It is known that technical skills are better retained by residents when training is distributed over a number of training sessions.[25] Our results emphasize the requirement of repeated training of basic surgical skills, such as the open knot-tying technique in this study, to improve both confidence and objective performance of these skills.

Objective feedback might be crucial in the acquisition of clinical skills. Feedback induces motivation, supplies reinforcement for correct actions, dissuades incorrect actions and may provide information on errors as a basis for correction.[26] However, constant professional feedback outside the operating theatre is expensive and logistically infeasible. Thereby, feedback during operations is not always constructive as most of the current generation supervisors did not participate in an open knot-tying course themselves or assume residents to be suitably qualified. In contrast to our study, a self-practice format using video-based tutorials can minimize personnel resources and simplify scheduling issues.[8] We think that a validated basic

skills curriculum for open knot-tying techniques is needed to maintain a sufficient open knot-tying skill level.

The task used in this study was robust and there were no problems with our training model. Although more complex assessment strategies, including global ratings, video-based scoring systems, motion tracking devices or tensiometers, have been successfully used in other studies,[7,17,22,27–32] we used a simple scoring system using the elaborated validated OSATS. Cut-off values for OSATS have only been defined in a study by Bijen *et al*. (2009) at 75% of the maximum OSATS score.[19,20] Further studies are needed to establish a benchmark proficiency level for credential purposes. Several previous studies have demonstrated the reliability and validity of the OSATS,[17] therefore inter-rater reliability was not assessed in this study.

Our findings are limited for several reasons.

We only assessed residents participating in the ASC. As the ASC is designed mainly to train in laparoscopic techniques, residents might have spent most of their time practicing laparoscopic skills and not their open knot-tying techniques. To more accurately assess the influence of autonomous home training on open knot-tying techniques, future studies should investigate the time spent on training on this skill.

Second, objective evaluation of open knot-tying technique was by direct observation by a supervising surgeon. As such, observers were not blinded, introducing a possible risk of bias. A more objective – but expensive and time-consuming – form of evaluation could be video-guided assessment.

Third, in contrast to other studies, we did not use time as a performance indicator.[12] As there are limited studies available on open knot-tying techniques assessment, we could not set any evidence-based goals for assessment. However, we know that residents perform better if goals are set.[33]

Finally, we did not correlate this training with clinical outcome. Open knot-tying is considered a very important basic surgical skill, even though rates of complications associated with insufficient knot-tying skills are not known. The (surgical) consequences of poor knot-tying skills, and therefore procedural skill, seem obvious. Associating the implications of this study in a clinical setting would be compelling, however it is hard to relate a decline in clinical complications to participation in this course as many factors are associated with complications; it is also ethically challenging.

Conclusion

We emphasize the need for repeated training of basic surgical skills and continuous feedback on skills. The training program improved both residents' knot-tying performance and self-confidence. Residents appear to be unable to adequately estimate their open knot-tying skills. Further research is needed to correlate training programs with clinical outcomes and construct a validated basic skills curriculum, including certification. In our opinion, constructing a validated basic skill curriculum for open knot-tying techniques with predefined end-points, assessment and external feedback is mandatory to ensure adequate basic surgical skills.

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Appendix I

OSATS form, open suture around vessel using clamp

OSATS - open suture around vessel

Candidate name:……

Supervisor name:……

Time of assessment: baseline / post / follow-up

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1. Knowledge and handling of materials: **Correct position of suture around clamp**

1	**2**	**3**	**4**	**5**
Suture too far under clamp				Suture directly under clamp

2. Knowledge and handling of instrument: **Correct utilization of thread in hands**

1	**2**	**3**	**4**	**5**
No crossing of sutures at first knot *and* at second knot threads repacked		No crossing of sutures at first knot *or* at next knot threads repacked		Sutures crossed at first knot *and* at second knot threads not repacked

3. Use of assistants**: Order for removal of clamp delivered at correct time**

1	**2**	**3**	**4**	**5**
Removal of clamp too early		No or too late clamp removal		Clamp removed at correct time

4. Respect for Tissue: **Suture / hands movement towards tissue**

1	**2**	**3**	**4**	**5**
Tissue pulled towards hands during suture closure		During closure of suture tissue pulled partially towards hands		During suture closure hands moved toward tissue

5. Knowledge of specific procedure: **Square knots**

1	**2**	**3**	**4**	**5**
No square knots		Mostly square knots		Only square knots

6. Time: **Time to perform open suture around vessel using clamp:** … min … sec

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Advanced Suturing Course, VUmc Amsterdam