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Technical skills teaching to MD students: a blinded, randomized controlled trial investigating video assistance in the education of the single-handed knot tie

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Received: 18 October 2023 / Accepted: 7 February 2024
Published online: 25 March 2024

Abstract

Background The COVID-19 pandemic has brought significant changes to medical education, particularly for procedural and surgical skills, which inherently require face-to-face education. The utility of adding an instructional video remains uncertain. To guide future curricula, our aim was to assess whether the addition of an optional instructional video improves the acquisition and retention of one-handed surgical knot-tying.

Methods Naïve year one medical students were randomised to video before face-to-face instruction versus face-to-face instruction only. Blinded surgeons assessed their performance at the end of a workshop and 4 weeks later by counting the number of knots tied in 1 min and a global Likert score assessing knot quality. The students also completed surveys for qualitative assessment and feedback.

Results Students with access to the video tied significantly more knots in 1 min than the control group (median ± IQR: 15 ± 4 N = 14, vs 12.5 ± 10 N = 15, p = 0.012). After 4 weeks, the intervention group showed a non-significant trend towards being able to tie more knots (16.5 ± 6 N = 6, vs 3.5 ± 16 N = 8, p = 0.069), and the knots tied were of significantly better quality (global score: 3 ± 1.4 vs 1 ± 1.8, p = 0.027). Compared to the control group, the intervention group expressed greater confidence in their ability to retain their skills after the workshop and at follow-up (p = 0.04). Additionally, they experienced significantly less stress during the workshop (p = 0.028).

Conclusion A non-interactive video can improve learning and retention of single-handed knot tying. As medical education continues to evolve, supplementary videos should be considered an important part of new surgical skill curricula.

Keywords Surgical skills education · Digital education · Curriculum design · Skill retention · Blinded randomized control trial

1 Introduction

There are reports on both the negative impact and the development of innovative clinical teaching initiatives in response to the COVID-19 pandemic [1, 2]. Most reference the significantly increased use of technology to improve access to didactic sessions. While these didactic components of medical education may well be permanently transformed into virtual platforms, conducting physical examinations and performing procedures will remain inherently

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personal and face-to-face. As human teaching resources are increasingly reduced, there is a need for high-quality, standardised virtual resources to augment what remains of face-to-face teaching [3]. With this accelerated technological innovation, the educational implications of platforms like YouTube need to be closely examined. This study aims to extend the theoretical foundations surrounding the integration of video-based education, exploring its effectiveness alongside traditional face-to-face teaching methods.

Knot tying is essential for any surgeon and is a basic procedural skill. However, the current evidence around teaching this essential skill, comparing non-interactive and interactive video-based education to face-to-face teaching, is heterogeneous and difficult to interpret [4]. Furthermore, literature that has addressed this often included other skills or students with prior knowledge of knot tying, which confounds results. Nonetheless, three conclusions may be drawn from current studies. Firstly, no studies show face-to-face education as inferior to non-interactive video-based education alone. Secondly, non-interactive videos perform poorly compared to human interaction, either virtually or face-to-face [5, 6]. Thirdly, the availability of video education improves skill retention by facilitating opportunities to practice and providing an individualised pace of learning [7, 8].

Therefore, we hypothesise that future education models combining face-to-face and non-interactive video-based education may improve learning for knot tying, manifesting as improved quality of knot tying and durability of skill retention. Thus, in this study, we aimed to conduct a blinded, randomised control study to evaluate the utility of non-interactive video-based education as an adjunct to face-to-face live teaching amongst knot-tying-naïve, first-year medical students.

2 Methods

2.1 Subject selection

Year one Doctor of Medicine (MD) students at the University of Sydney across all affiliated teaching hospitals were invited to participate in this study. Participants with previous exposure to surgical knot tying by vocation or education were excluded. This study was performed in line with the principles of the Declaration of Helsinki. All participants gave written informed consent for the study. This protocol was approved by the University of Sydney Human Research Ethics Committee [2021/628] in accordance with the National Health and Medical Research Council (NHMRC) regulations.

2.2 Intervention

Using simple randomisation, students were divided into the intervention group (IV) and the control group (CT). Regardless of group assignment, all participants were invited to attend a 1.5-h single surgical knot-tying workshop that included a live demonstration of the skill, individualised one-on-one tuition and feedback from expert faculty. Those assigned to the IV group were provided access to an instructional video they could optionally view prior to and after the workshop, whereas those in the CT group were not (Fig. 1).

The instructional video consisted of a narrated, slow-motion video demonstrating one-handed knot tying using the reversed 4 pattern [9] (https://youtu.be/NdUbhQ9ShdA). IV participants were provided with a link to this video 2 weeks before the workshop. Participants were allowed to access the videos freely. No additional instructions or resources, such as knot-tying materials, were provided. The review of the video was not monitored. The IV group retained access to the video after the workshop. CT students received access to the video when all evaluation, including follow-up, was complete. There were no restrictions placed on external content that either group could access prior to or after the workshop. This allowed the CT group to also prepare for the workshop freely.

2.3 Evaluation and outcome measures

Skill acquisition and retention were assessed at the end of this workshop and at 4 weeks after the face-to-face workshop. During the assessment, participants were asked to tie as many good-quality knots as possible for 1-min. Two experienced general surgeons, blinded to participant group assignment, assessed the quantity and quality of knot ties.

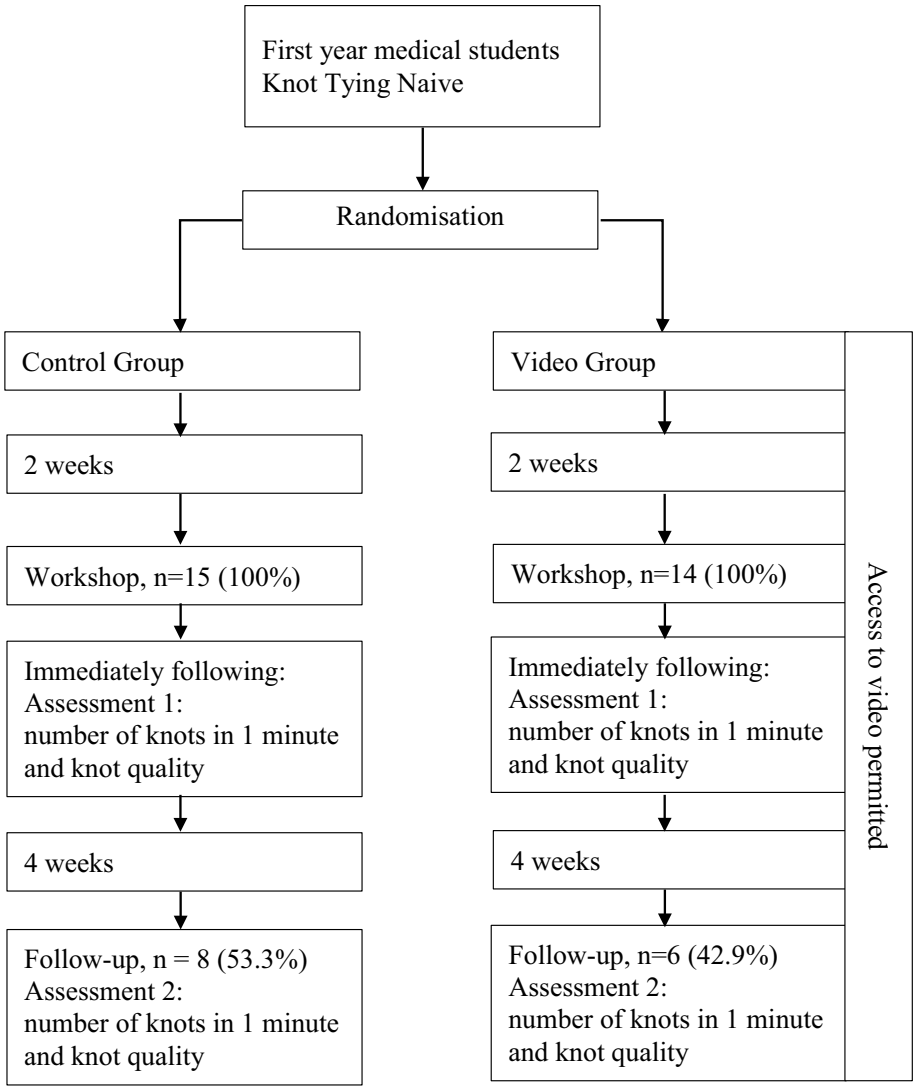

Fig. 1 Study flowchart describing randomisation, timeline, workshop, and assessments. [own elaboration]

Primary outcome measures were the number of valid knots tied in 1 min and a global subjective quality score. The latter was a Likert score between 1 to 5 (5 being best) for each candidate's knot-tying ability and the quality of their knots. Secondary outcome measures related to participants' subjective experience of the learning process and learning success were collected through a standardised survey. In this survey, participants self-assessed their confidence with knot tying and were asked about the utility of the instructional video.

2.4 Statistical analysis

Collected data were analysed using SPSS (PASW) Statistics, version 22 for Windows (IBM v28.0.0.0 (190)). Descriptive statistics used include median, interquartile ranges and proportions. Mann–Whitney U was used for the difference of means testing; this data is reported as mean and standard deviation. Paired difference of means testing was used to compare number of knots initially and at 4-week follow-up. Two-by-two table analysis was used to examine dichotomous variables, using Chi-square and Fisher exact tests, as appropriate. Statistical significance was attributed to a p-value less than 0.05, with a two-tailed probability. Missing data were treated with listwise deletion.

Table 1 Participant characteristics; shows the demographic data of the study population

	Intervention (n = 14)	Control (n = 15)	p-value
Age (years; mean, SD)	23.9 (3.5)	23.8 (4.5)	0.922
Gender: M (n, %)	4 (29%)	8 (53%)	0.176
Interest in surg (n, %)	3 (21%)	3 (20%)	0.924
Attendance at follow-up (n, %)	6 (43%)	8 (53%)	0.437

No difference in mean age, gender distribution, or interest in surgery between the intervention (n-14) and control group (n = 15) [own elaboration]

Table 2: Assessment of performance

Assessment of performance	Intervention		Control		Difference
	N	Median	N	Median	p-value
Initial Assessment					
Initial number of knots	14	15 (11–19)	15	12.5 (3–23)	**0.012**
Average global score of 2 assessors	14	3.5 (2–5)	15	3.5 (2–13)	0.286
Follow-up session					
F/U number of knots	6	16.5 (11–23)	8	3.5 (0–20)	0.069
F/U Average global score of 2 assessors	6	3 (2–4)	8	1 (0–3)	**0.027**
N of participants who tied ≥ 1 Knot (Total N, N, % of total)	6	6 (100%)	6	5 (62.5%)	0.091
Difference between initial assessment and follow-up					
Number of knots	6	2 (– 4 to 8)	8	– 6 (18)	0.093
Global quality score	6	– 0.5 (3)	8	– 2 (3)	0.080

Table 2 shows the difference in the performance of the intervention group compared to the control at initial assessment and 4 week follow-up (F/U). [own elaboration]

3 Results

29 students participated in the study. 14 students were in the intervention group (IV), and 15 were in the control group (CT). Participant demographics are displayed in Table 1. There was equal interest in surgery as a career and a non-significant difference in gender distribution between the two groups. Approximately half of the students in each group attended follow-up at 4 weeks. All students who participated in the workshops completed feedback surveys.

Interventional group students tied more knots than the control group during the initial assessment with a similar global quality score (Table 2). At four weeks, there was weak evidence that the intervention group had better-retained knot-tying ability than the control group (Median (IQR) 16.5 (10.5–22.5) vs 3.5 (0–19.5), p = 0.093), with a statistically significant effect on global quality scores (Median (IQR) 3 (1.62–4.38) vs 1 (0–2.75) p = 0.027). The global scores of both assessors were similar, with a mean difference of 0.24 (SD 0.69) p = 0.071 at the initial session and – 0.07 (SD 0.27) p = 0.317 at follow-up.

Despite the borderline-significant findings on statistical analysis, Fig. 2 demonstrates that students in the CT group who deteriorated between initial and follow-up assessments all demonstrated steep declines in efficiency and quality, whereas students in the IV group showed relatively stable performance over time. The proportion of students with declining/improving performance also differed. Over the four-week period between initial and follow-up assessments, all individuals except for two in the IV group improved the number of knots tied. In contrast, all individuals except for two in the CT group deteriorated in their knot-tying efficiency (Fig. 2a).

All students, 100%, in the intervention group tied at least one knot at follow-up compared to 62.5% of the control group (p = 0.091).

Student's subjective experience of the education delivery were also more favourable in the CT group (Table 3). Students who did not have access to the video found the workshop to be more stressful (33.3% vs 0%, p = 0.028). Students in the intervention group thought they were more likely to retain their knot-tying skills (100% vs 50%, p = 0.04) and reported it could not be taught any better. The vast majority (92.9%) of IV students believed the video

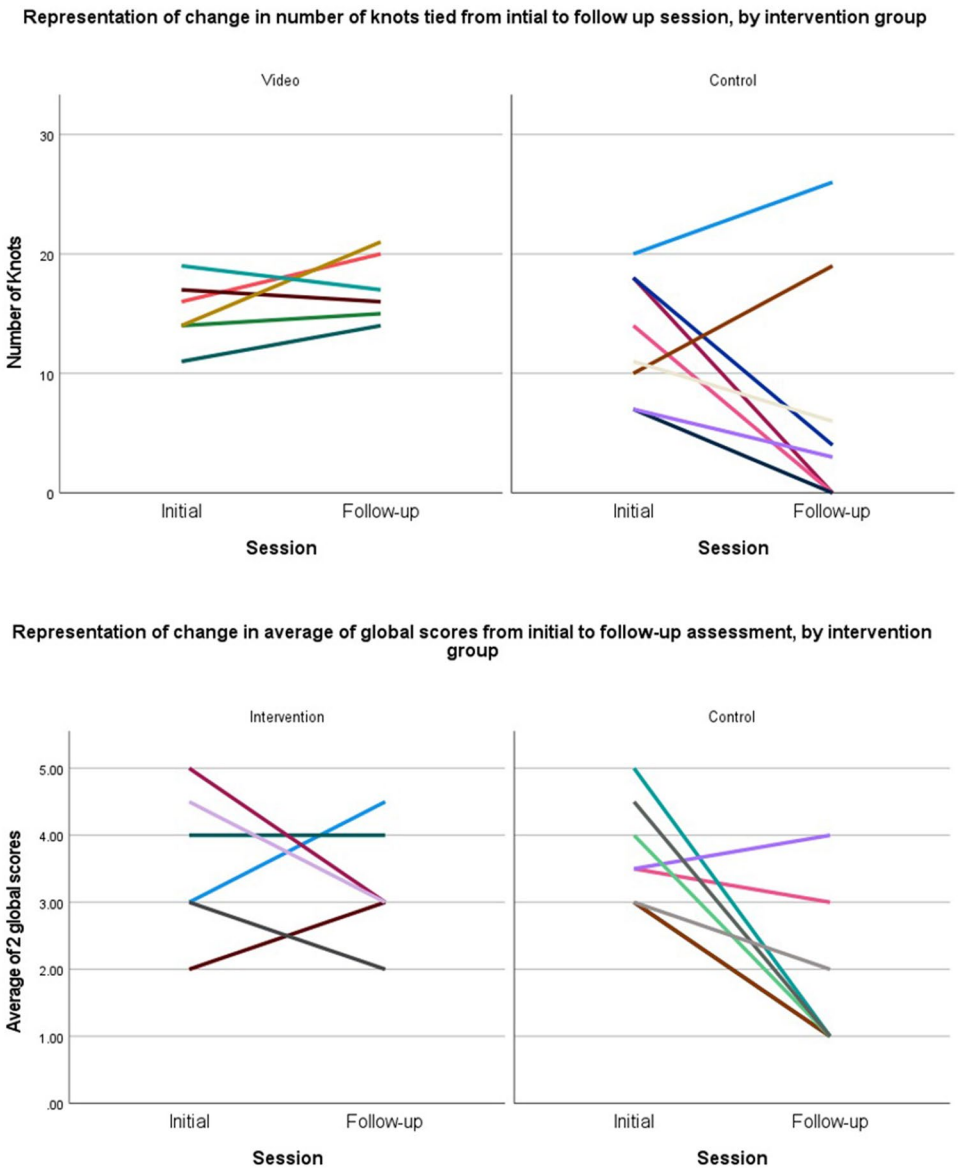

Fig. 2 Graphs representing change from the initial session to follow-up for the intervention group (left) and control group (right). N = 6 for the video group, N = 8 for the control group. [own elaboration]. Top: Number of knot. Bottom: Average of 2 global scores

would help them retain their new skills (n = 13 of 14). 100% of them agreed it did help retain their skill at the 4-week follow-up, and 100% of them agreed that the video enhanced their learning in the workshop (n = 6).

4 Discussion

In times of increasingly digitalised medical education, we sought to compare the efficacy of supplementing face-to-face surgical knot-tying education by video. We found strong evidence that students with access to the video (IV) tied more knots initially and were of higher quality at the 4-week follow-up. We discuss the improvement in learning performance as well as an improvement in perceived learning efficiency that may correlate with reduced stress of learning. This is the first study to utilise the novel reverse 4 method of teaching single-handed knot tying [9], and we discuss qualities of the video that are likely to have impacted the outcome.

Digital education for surgical skills ranges from passive video supplementation to active one-on-one online education with a tutor. These have been heterogeneously examined in literature for various surgical skills, including wound closure, suturing, and instrument ties. Specifically for knot-tying, there is only one study that assessed single-handed ties. Lwin et al., in Myanmar, compared video education against face-to-face education to find there was an improvement in skill by

Table 3 Survey outcomes from workshop 1

	Intervention (n = 12) n	Control (n = 12) n	Difference p -value
Survey outcomes from workshop 1			
Workshop useful? yes [insert one row here above this one. It should say "Survey outcomes from workshop 1" like the one below for workshop 2. and merge it also]	12 (100%)	12 (100%)	–
Workshop enjoyable? yes	12 (100%)	12 (100%)	–
Workshop stressful? yes	0 (0%)	4 (33.3%)	**0.028**
Can it be taught better? yes	0 (0%)	4 (33.3%)	**0.028**
Comfortable during assessment? yes	10 (83.3%)	11 (91.7%)	0.537
Did workshop content align with assessment? yes	12 (100%)	12 (100%)	–
Assessment stressful? yes	2 (16.7%)	4 (33.3%)	0.346
Survey outcomes from workshop 2			
Workshop useful? yes	6 (100%)	8 (100%)	–
Did the workshop help retain your skill? yes	6 (100%)	4 (50%)	**0.04**
Can current skill be retained? Yes	6 (100%)	4 (50%)	**0.04**
Can it be taught better? yes	1 (16.7%)	3 (37.5%)	0.393
Comfortable during assessment? yes	6 (100%)	5 (62.5%)	0.091
Assessment stressful? yes	2 (33.3%)	6 (75%)	0.119

Outcomes from a survey of students at initial assessment (top half) and follow-up assessment (bottom half) [own elaboration]

both methods without a significant benefit between them based on objective assessment only [10]. Similar findings are demonstrated for two-handed knot tying [7, 11]. Nathan et al. conducted a randomised control trial and discovered that interactive education was superior to self-learning [6], consistent with the findings of Tejos et al. for suturing and tying square knots [5]. At the same time, some found it to be not inferior [12, 13]. We uniquely assessed video supplementing face-to-face teaching for single-handed knot tying, which has not been addressed previously. Our study confirms that there are objective benefits to having this additional online component. This highlights the benefit of including videos in the teaching–learning process.

The benefits of video seem to be due to increased accessibility, engagement, and personalized learning experiences [7, 8]. These findings are interdisciplinary and have been shown to benefit the teaching–learning process, even in Mathematics. Having a video freely accessible through an easy-to-use service such as YouTube promotes improved accessibility, leading to better engagement [14]. The ability to pace the learning by pausing and rewinding a video is reported as a subjective benefit by our students and within the literature. All IV students who attended follow-up agreed that video-based learning helped them retain their skills and believed in their ability significantly more than CT students. This, alone, by the theory of self-efficacy, can lead to better performance [15]. This finding is present despite the video being only supplementary to face-to-face teaching, demonstrating the importance of this modality to student satisfaction and confidence. Qualitatively, we experienced that students who could not tie any knots at the 4-week follow-up could quickly regain their ability by being shown only 1 or 2 knots, emphasising the importance of accessibility and is likely a driver of the increased confidence, in turn producing higher satisfaction, engagement, and reduced stress.

Medical students face high levels of stress during their training with higher rates of depression than the general population [16]. Examinations, high self-expectations, and students' competitive nature contribute to this stress, which is also experienced in face-to-face surgical skill workshops [17]. This stress impedes both the learning and performance of surgical skills [18–20]. IV students found the workshop and assessment less stressful. This survey finding is significant in that the stress of face-to-face education can be reduced or removed simply by adding a pre-teaching video resource. This is a novel finding not established in literature specifically regarding surgical skills; however, it is known that reduced stress and encouragement/positive learning environment accelerates the acquisition of surgical skills [18, 21]. Video games have also been demonstrated to be a useful educational tool and would also lead to reduced stress and improved engagement [22]. This may explain some of the benefits of providing video as a supplement.

A novel aspect of this video teaching tool is a reference to the reverse 4 pattern, created with each component of the single-handed knot tie [9]. The video followed this with small and easily digestible instructions in a sequential structure

to improve its efficacy [23]. Reference to this technique was maintained for IV and CT students at the face-to-face workshop for consistency. A guiding pedagogical agent narrating a visual demonstration is considered ideal for expanding the visuospatial ability of students [24]. This is then directly demonstrated to improve the performance of a spatially complex surgical skill [25]. Subjectively, students highly regarded the ability to control the video's pace, both in literature and in our study, which has been shown to improve retention of knowledge [7, 26].

There are several strengths and limitations of our study. Our randomisation achieved a good distribution of students with similar demographics. By only including year 1 students with no prior exposure to knot tying or even suturing, we limited bias from previous experience. Our assessment was comprehensive, with blinded examiners ensuring integrity by utilising objective and subjective performance markers; we also included participant reviews and opinions of their performance. Our study is primarily limited by the small sample size. This was a result of our inclusion criteria which were required to limit bias. The number of participants at follow-up was small, and this reduced the power to detect differences. Methods to improve follow-up, such as financial incentives, were not utilised as they may have introduced bias. It was clear that IV students retained their skills better, but we could only produce weak statistical evidence to demonstrate this.

Future studies can address the same question across various procedural skills, with a larger cohort of participants to deliver generalisable findings applicable to multiple settings. Implications of our results are improved performance, confidence, and satisfaction for students even when the video is just supplementary to face-to-face teaching. This suggests that the broader implementation of this multimodal education is optimal.

5 Conclusion

Students with access to a supplementary video demonstrated better single-handed knot tying at initial assessment and follow-up than traditionally taught students. In addition, stress from the teaching environment was removed with prior video exposure. Although limited by a small sample size, the findings of this study are encouraging, and further research is required to improve the teaching of simple surgical skills to MD students. The authors recommend that such videos be considered a routine part of the future design of surgical skill education.

Author contributions All authors gave final approval for the submission of this paper. All authors met all four criteria for authorship. Their contributions are as follows: JHR, AH – Design, data acquisition, analysis, interpretation. Writing, drafting, and critical revision of the manuscript. TL, LY, CN - Design, data interpretation. Supervision and critical revision of the manuscript. TP, HP - Design, data acquisition and interpretation. Supervision and critical revision of the manuscript.

Funding This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability Raw excel files are available upon request.

Code availability Not applicable.

Declarations

Competing interests The authors have no competing interests to declare. The authors do not have any commercial or other associations to declare that impact the study.

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