Face-to-face versus remote synchronous instruction for the teaching of single-interrupted suturing to a group of undergraduate paramedic students: a randomised controlled trial

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Face-to-face versus remote synchronous instruction for the teaching of single-interrupted suturing to a group of undergraduate paramedic students: a randomised controlled trial

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Abstract

This post-test randomised controlled trial (RCT) aimed to explore whether readily accessible videoconferencing technology can be used to effectively teach a complex psychomotor skill (in this case single-interrupted suturing) to a group of undergraduate paramedic students who have no prior experience of the technique, and to ascertain whether there is any difference in performance between a group taught via this method, and a group taught via traditional face-to-face (F2F) methods. Despite a small sample size (n24), findings suggest that this process of instruction may be effective, and that participant performance will be at least as good as a group taught via F2F methods. The design of this study allows a degree of confidence when generalising from these results; incorporating a skill which is unfamiliar to all participants; experiential equivalence within and between both groups; and the adoption of validated objective assessment criteria. Participant opinion was also explored in relation to this method of instruction. Should such online synchronous methods of instruction prove viable, they will allow a greater opportunity for clinicians to access training which requires the acquisition of complex psychomotor skills.

Keywords: remote instruction; synchronous;online education; video conferencing; psychomotor skills; clinical skills; web conferencing; paramedic

Introduction

For many authors, e-learning represents a credible solution to the difficulties experienced by emergency medical practitioners in terms of engagement with desired or mandatory clinical training. These difficulties encompass problems with attending traditional face-to-face (F2F) training, such as obtaining release from working schedules, or where travelling to the location of training

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is impractical (Curran *et al.,* 2005; Weeks & Molsberry, 2008; Roe *et al.,* 2010).

These difficulties may be experienced by paramedics, who are obliged by the Health and Care Professions Council (2007) to maintain their "fitness to practice" through ongoing career–long learning. For this group, e-learning may prove particularly fruitful, as according to the Quality Assurance Agency (2004), paramedics are required to demonstrate, "an ability to engage with technology, particularly the effective and efficient use of information and communication technology ", and maintain their continuing professional development through educational programmes which adopt an innovative approach (College of Paramedics, 2008).

Whilst e-learning methods have already been adopted within many areas of heath education, they predominantly tend to focus upon asynchronous applications, with less attention given to synchronous methods such as live videoconferencing (Morrison *et al.,* 2009**;** Chen *et al.,* 2005). However, acknowledged advantages of synchronous methods include being "more akin to face-to-face contact" and the allowance of immediate corrective feedback from the instructor (Chen *et al.,* 2005). Such immediacy is considered to be of particular importance for the acquisition of complex psychomotor skills, and one of the key reasons why it is generally deemed inappropriate to teach such skills purely via e-learning (Roe *et al.,* 2010).

Synchronous e-learning studies involving psychomotor skills

In an RCT conducted by Haney *et al.* (2012), a comparison was made between a conventional lecture and an online synchronous method for the teaching of wound closure techniques (including suturing) to a group of 89 novice paramedics. This method incorporated live video footage of the conventional (control) group lecturer being transmitted to the online (experimental) group classroom, with provision for participants to seek clarification. Post-test comprehension was assessed via a multiple-choice question (MCQ) paper, and a skills test was used to evaluate their practical techniques. No significant difference was found between the groups for either the comprehension test, or for any aspect of the practical skills techniques, although participants in the control group did rate the "effectiveness of the teaching" as superior.

Although this study adopted an experimental design and was determined to include a sufficient sample size, there are some limitations which should be considered. Whilst the authors suggest that this online synchronous technique could be at least as effective as traditional F2F methods, they do state that

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without using validated assessment criteria, there is the potential for the results to be affected by subjective bias.
It was also not apparent how much practice the participants were allowed to undertake (or how it was scheduled) following the educational delivery, or indeed whether the experimental group were offered any practice time at all. Internal validity may have also been affected by a proportion of the experimental group (29%) having prior suturing experience, although the authors state that even with this variable removed the results were unaffected.

In a comparable study involving the teaching of neonatal resuscitation skills to qualified nurses, Jain *et al.* (2006) concluded that online synchronous methods offer a "feasible and effective alternative" to conventional F2F methods. Following a randomisation process which sought to balance qualifications and work experience between the groups, 26 students received online synchronous "tele-education", whilst 22 students received conventional classroom teaching; with both groups receiving identical educational material from the same instructors. An assessment of knowledge and skills (MCQ paper and 5 Objective Structured Clinical Examinations (OSCEs)) was conducted both pre and post-test by examiners blinded to the method of instruction, and a Likert scale questionnaire was used to ascertain levels of satisfaction with the teaching and learning experience. Although when pre-test scores were accounted for, underpinning knowledge results were found to be higher within the F2F group, post-test skills results were both significantly improved and comparable between the groups. Echoing the results of Haney *et al.* (2012) however, students rated the levels of participation and "delivery of subject" as superior in the F2F group. Whilst this study again suggests that synchronous e-learning methods are a viable means for psychomotor skills delivery, it should be noted that there were proportionately more students in the online group with prior experience of both handling a newborn, and newborn resuscitation (although not deemed statistically significant). The authors also acknowledge that external validity may be affected by the background of the participants, which may not reflect the experiences of those in rural areas.

Weeks and Molsberry (2008) sought to test the hypothesis that the "knowledge, psychomotor performance and confidence" of participants who were re-trained in Paediatric Advanced Life Support (PALS) techniques via synchronous videoconferencing would not be inferior to those taught via F2F methods. The sample for this study was deemed powerful enough to detect non-inferiority, consisting of 73 clinicians who were randomised into a F2F group and videoconferencing group according to their background and

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experience. The instruction process was in accordance with American Heart Association guidelines, which for the videoconferencing group consisted of interactive audio and video communication. The classroom instruction was delivered in the presence of the online instructor to help ensure that the educational content was identical for both groups, and an OSCE-style checklist was subsequently utilised to measure psychomotor skills performance. As hypothesised, no statistically significant post-test difference could be detected between the groups in terms of their psychomotor skills performance. The same result was also found in terms of the knowledge levels of each group, and their confidence in performing the skill.

As with Haney *et al.,* and Jain *et al.,* this study adopted a robust experimental design and suggests that online synchronous methods may provide a viable means of teaching psychomotor skills. However, the authors were obliged to focus upon retraining competent clinicians (rather than complete novices) owing to concerns about the potential need for remedial training should videoconferencing methods prove inferior.

Rationale and objectives for the current study

Although there are limitations which should be considered, the literature pertaining to the synchronous delivery of healthcare-related psychomotor skills suggests that it can be as effective as F2F teaching. However where it has been measured, student satisfaction with the educational delivery tends to be lower for the remote group.
This study is intended to contribute to what is known in relation to skills acquisition via remote synchronous delivery. It incorporates the teaching of a new skill to "novice" participants, the use of readily available webconferencing software (in this case "BigBlueButton" (BBB)), validated assessment criteria, and an exploration of student opinion. The methods mirror the post-test experimental fixed designs of previous studies and should provide results which may be of relevance to healthcare educators, and potentially provide the basis for a larger study with a similar group.

General research question:

- Can remote synchronous methods of instruction be effectively used to teach a complex psychomotor skill?

Specific question 1:

- Can readily accessible video conferencing technology be used to teach a complex psychomotor skill?

Specific question 2:

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- In comparison to traditional F2F teaching methods, can a group of paramedic students be effectively taught how to use a single-interrupted suturing technique via remote synchronous methods?

Specific question 3:

- What (if any) elements of deficiency (objective or subjective) become apparent either within or between each group?

Research design and method overview

Overview

A post-test RCT design was adopted to compare the efficacy of teaching a complex psychomotor skill via synchronous videoconferencing (experimental group) with traditional F2F classroom instruction (control group). Single-interrupted suturing was chosen as a proxy measure for some of the complex psychomotor skills which must be mastered by qualified paramedics. This technique was also chosen as it is currently beyond the scope of newly qualified paramedics, and would negate the need for subsequent equivalence of training in order to safeguard standards of patient care.

Participants

A volunteer participant sample of 29 students was drawn from the available undergraduate paramedic population (*n*64) at the author's educational institution. Whilst prior experience of single-interrupted suturing would have led to exclusion, none of the participants declared prior experience of this (or a similar) technique. No differentiation was made on the basis of gender or age.
The random allocation of participants to either control or experimental group conditions took place at the study launch. Participants were also blindly allocated a unique identification number to be used as their sole means of identification during the post-test OSCE assessment.

The creation of an assessment criterion

The OSCE is used extensively within the current paradigm of paramedic education, and also within other health-care related professions which utilise similar psychomotor skills. For the purposes of this study, the *Royal Marsden Hospital Manual of Clinical Nursing Procedures 7th ed.* (Dougherty and Lister, 2008) was used as a guide for single-interrupted suturing, along with the contributions from a panel of twelve experts who were asked to take part in a Delphi Survey. The experts were all colleagues of the author, with either direct experience of teaching the procedure, and/or experience of writing

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OSCE criteria. During the four rounds of the survey, a consensus was reached in relation to the assessment components, and having a pass/fail criterion on key psychomotor skills. Adjustments were however anticipated following the study pilot.

Study pilot

It was deemed important to implement a pilot for this study owing to the novel use of non-specialist videoconferencing software and untested assessment criteria. As the F2F teaching of clinical psychomotor skills with a post-test OSCE is a fairly established mode of instruction and assessment, it was only considered necessary to pilot the remote learning group. Volunteers without prior suturing experience were drawn from the pool of lecturers working within the author's educational faculty. Lecturers were chosen so as to avoid the "pre-testing" validity threat which might be caused by utilising the same student participants for both the pilot and the main study.

During the instructional element, issues were highlighted concerning the physical on-screen space required for the webcam images and the simultaneous observation of multiple participants. It was therefore determined that no more than 5 participants would be taught at any one time, and that for instructional consistency, this limitation would also be imposed upon the control group. Key areas for revision highlighted within the OSCE element of the pilot included the clarification and expansion of certain criteria, and the inclusion of a "free text" area for the examiner to "qualify" the overall global rating.

Procedure

The study began with an explanatory launch event during which a participant information sheet was issued, consent obtained, pre-reading material issued and participants randomised. All participants were then given several days to study the same pre-reading booklet, which outlined the relevance of the procedure, and gave a descriptive and pictorial breakdown of the surgical instruments involved and the technique which would be taught. (Figure 1).

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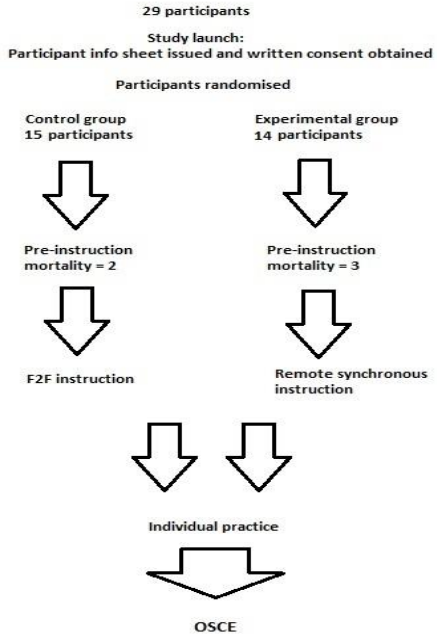
Figure 1: Study overview



A couple of days following the launch, the first two control groups received their instruction via traditional F2F classroom-based methods. On the afternoon of the same day, the first two experimental groups were provided with identical training resources and received remote synchronous instruction utilising the videoconferencing platform BBB (the morning/afternoon group order was reversed for the subsequent day of instruction). The online participants were also allocated an individual computer work station with their own screen, headset with built-in microphone, and 6.0 megapixel USB "plug-in and play" webcam. This allowed each online participant to see the procedure and allowed the instructor (using identical equipment) to offer instant feedback upon their attempts. Each participant could also see the webcam images and hear the audio output of the other participants. This allowed them to witness how their peers were performing, and hear the feedback given to them (in order to replicate the experience of independent study, participants were not allowed to converse outside of the videoconferencing forum). All groups received tuition from the same instructor, who had also taught the pilot group.

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The tuition itself followed a "staged process", broadly reflecting the development of learning according to the taxonomy of the psychomotor domain (Bullock, 2000; George and Doto, 2001). These stages were broken down into; an overview (provided by the pre-reading booklet); a "real speed" demonstration of the procedure by the instructor; a breakdown of the procedure into key steps; a repeat demonstration guided by the participants (with the opportunity to ask questions/seek clarification); the performance of the procedure by each participant with reinforcement and feedback from the instructor (George and Doto, 2001; Bullock, 2000; Grantcharov and Reznick, 2008).

Although 29 students agreed to participate at the "study launch", 3 participants from the experimental group and 2 from the control group failed to attend their instructional training sessions. This left 11 participants for the experimental group, and 13 for the control group. Fortunately, there was no further "mortality" during the study and all of the remaining participants went on to undertake the practice and OSCE assessment elements.

In the 2-3 days following the instructional element for both groups, all participants were given a period of self-directed practice, with equipment issued for that period of practice only. Although it was only possible to facilitate one period of practice for the participants, it did follow the recommended "distributed" pattern (Magill, 2011) in that it allowed a period of consolidation between periods of instruction and practice. Participants were also asked not to consult external sources of reference so as not to introduce any additional factors which may distort or override the instruction provided for them.

The OSCE assessment followed a predetermined assessment structure, with just one assessor who was "blinded" to how each participant had been instructed. Data regarding the similarities/differences in performance within and between groups was collected via the individual allocation of a "pass" or "fail/omitted" score against 24 separate criteria, and a "global assessment" score which utilised a progressive scale from 1 to 5 as a representation of the participant's overall competence. A 5-point Likert scale (with free-text box) was used to collect qualitative feedback from the experimental group.

The OSCE and Likert scale data was subsequently coded and entered into Statistical Package for the Social Sciences (SPSS), version 19.

Findings

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According to the separate OSCE criteria there were 7 areas in which the Control group performed better than the Experimental group, and 11 areas where the reverse was true. The worst performing areas for the Control group (9 "passes") represented a mean of 0.69, whilst the worst area for the Experimental group (7 "passes") represented a mean of 0.64. There was no apparent inter-group correlation between the worst performing areas, although the lowest "pass" rate for both groups was recorded for the variable, "*The needle is grasped in the needle holder at an appropriate distance…. ".* The biggest proportional difference between the groups was within the variables: "*Care is taken to ensure that the needle is not blunted by incorrect handling… "*, and "*Care is taken to ensure that the depth of the wound is accounted for… "*. In both cases the Experimental group were superior, with a mean of 0.91 (10 "passes") against the Control group mean of 0.69 (9 "passes") (Table 1).

Table 1: Outline of the OSCE pass/fail performance of each group

	Control group criteria scores			Experimental group criteria scores		
Dependent variable – OSCE criteria	N	Pass achieved	Mean	N	Pass achieved	Mean
The needle holder is held appropriately in the dominant hand	13	12	.92	11	8	.73
The needle is grasped in the needle holder at an appropriate distance from the "cutting" edge and from the "thread end"	13	10	.77	11	7	.64
Care is taken to ensure that the needle is not blunted by incorrect handling (throughout the procedure)	13	9	.69	11	10	.91
An appropriate tissue location is chosen to start suturing (eg. centre of wound)	13	13	1.00	11	9	.82

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The needle is inserted at 90 degrees to the tissues	13	13	1.00	11	11	1.00
The needle is inserted at an appropriate distance from the wound edge	13	10	.77	11	9	.82
Care is taken to ensure that the depth of the wound is accounted for, leaving no internal "dead space"	13	9	.69	11	10	.91
The needle is brought up between the wound edges and the suture thread is pulled up through the centre of the wound	13	9	.69	11	9	.82
The needle is reinserted at an appropriate angle to the internal base of the wound and the suture is pulled through the tissue on the opposite side of the wound	13	13	1.00	11	10	.91
The needle exits the tissues at the same distance from the wound edge as the initial insertion site (on the opposite side)	13	12	.92	11	11	1.00
A short "tail" is left once suture is placed	13	12	.92	11	11	1.00

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The first "throw" is placed effectively: grasping the needle end of the suture, two clock-wise loops around the needle holder are made. the "tail" of the suture is grasped with the needle holder and pulled through the two clockwise loops	13	13	1.00	11	11	1.00
The knot is tightened until the tissues are approximated	13	13	1.00	11	11	1.00
If necessary, the student is able to "lock" the first throw in place	13	13	1.00	11	11	1.00
The second "throw" is placed effectively: an anti-clockwise loop is made around the needle holder	13	13	1.00	11	11	1.00
At least one further "throw" is placed	13	13	1.00	11	11	1.00
Closure of skin – 2 sutures minimum, correctly performed	13	10	.77	11	10	.91
The knot lies flat across the wound	13	13	1.00	11	10	.91
Knot "tails" are cut to approx 5-6mm in length	13	11	.85	11	10	.91
Skin edges do not overlap and a "step" is avoided	13	12	.92	11	11	1.00
Appropriate tension: sutures are not too tight or too loose	13	11	.85	11	8	.73

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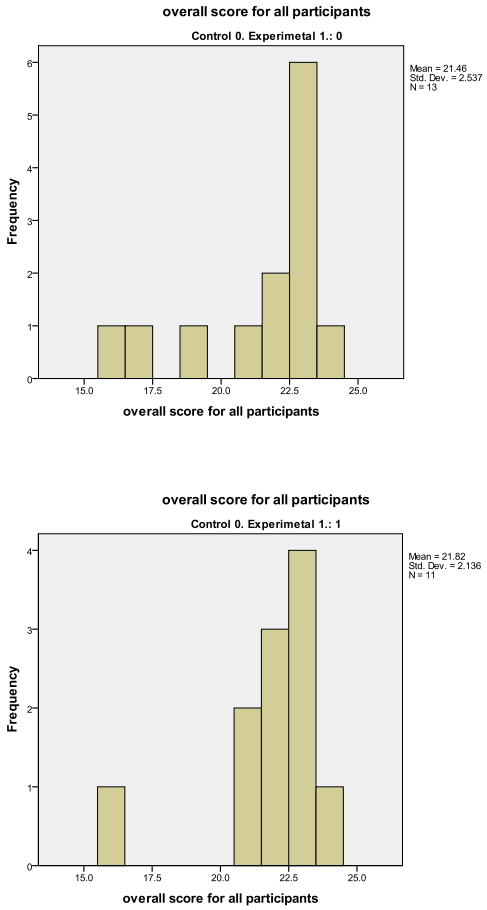
The edges of the wound are suitably opposed	13	12	.92	11	11	1.00
Sutures are appropriately spaced	13	11	.85	11	11	1.00
Suitable care is taken to avoid a potential "sharps" injury and "sharps" are disposed of	13	12	.92	11	9	.82
Valid N (listwise)	13			11		

In terms of a comparison between the overall scores between groups, the Control and Experimental group means are similar, at 21.46 and 21.82 (with a similar standard deviation of 2.537 and 2.136) (Figure 2).

Figure 2: Comparison of overall score for all participants



The distribution of "global rating" marks displays a difference between the groups. Within the Control group marks of 4 and 5 are equally distributed between 8 of the 13 participants (61.6%), whilst within the Experimental

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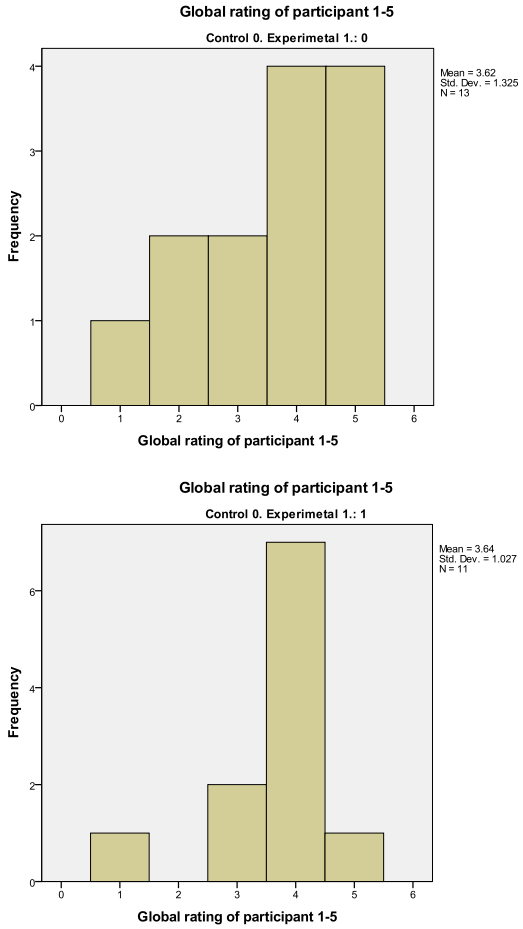
group a mark of 4 was given to 7 of the 11 participants (63.6%), and a mark of 5 given only once. Proportionately more participants within the Control group received the lower marks of either 1 or 2 – as opposed to 1 participant in the Experimental group (Figure 3).

Figure 3: Distribution of "Global rating" scores



The overall "pass" and "fail/omitted" results (for each criterion) for each participant from both groups were compared via Mann-Whitney U test. This generated a significance of p= .976, suggesting no statistically significant difference between the two groups. The mean scores for the "global assessment" were also similar, at 3.62 for the Control group, and 3.64 for the

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Experimental group (with a similar standard deviation). A Mann-Whitney U test generated a significance of p= .854, which also suggests that there is no statistically significant difference between the two groups in relation to their "global rating" scores.

For the Likert scale survey, only 8 responses were obtained (Table 2). The poorest feedback response can be seen within the variable pertaining to sound quality, with a mean of 3.13, and a fairly even distribution of opinion. Marginally better, with a mean of 3.5, were the variables relating to participant feedback during the session, and the value of the pre-reading material, although the latter did receive an overall higher score for the two top statement categories. The very highest rating of opinion (with a mean of 4.5) was given to the variable relating to the "good foundation" provided by the remote instructional method. This variable received no negatively orientated scores, and 5 within the "strongly agree" category. Other highly scoring variables (all with a mean of 4.38) include; *"There was adequate time to consolidate my learning between receiving the remote instruction and the OSCE"; "The period of consolidation/practice was necessary for me to pass the OSCE";* and *"Receiving feedback from the tutor during the session was helpful".* This last variable is interesting in that it received the most "strongly agree" scores (6), but was tempered by 1 vote in the "strongly disagree" category. The same participant also gave many of the other variables low scores, which was against the generally higher trend from the other participants.

Table 2: Likert survey results

	Frequency						
Likert variable	Strongly disagree	Disagree	Not sure	Agree	Strongly agree	mean	Std Dev
Remote instruction has provided me with a good foundation for learning how to suture	0	0	1	2	5	4.5	0.76
It was easy to follow the instructor's demonstrations	0	1	1	4	2	3.88	0.99
It was easy to demonstrate my own technique to others	0	0	3	2	3	4	0.92
Seeing what others were doing was beneficial	1	0	0	3	4	4.13	1.36
Receiving feedback from the tutor during the session was helpful	1	0	0	1	6	4.38	1.41
Receiving feedback from other participants during the session was helpful	0	2	1	4	1	3.5	1.07

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It was easy to clarify things that I was unsure of	1	0	1	4	2	3.75	1.28
The pre-reading material was essential for the remote learning of the skill	0	0	2	3	3	3.5	1.31
There was adequate time to consolidate my learning between receiving the remote instruction and the OSCE	0	0	1	3	4	4.38	0.74
The period of consolidation/practice was necessary for me to pass the OSCE	0	0	1	3	4	4.38	0.74
The quality of the remote video picture was adequate for the task	0	0	2	5	1	3.88	0.64
The sound quality was adequate for the task	1	2	1	3	1	3.13	1.36
Overall, the remote learning software was adequate for the task	0	1	0	7	0	3.75	0.71
The instructional content of the remote session was suitable	0	1	0	4	3	4.13	0.99
There was effective delivery of the instructional content within the session	0	0	1	2	5	4.5	0.76
It is possible to learn how to competently perform single-interrupted suturing via this method	1	0	1	1	5	4.13	1.46

Discussion

As one student in the Experimental (online) group achieved clinical "competency" according to the predetermined OSCE criteria, it would seem as though it is feasible to teach a complex psychomotor skill via readily available videoconferencing software.

With both groups receiving the same instructional content, the findings do suggest that as there is no significant difference in the results achieved by either group, single-interrupted suturing taught via remote synchronous methods may be at least as effective as F2F instruction. Indeed, in terms of the separate OSCE criteria, the Experimental group performed better in more areas, with the biggest differences between the group scores in favour of the Experimental group.

It could be argued however that as participants in both groups were exposed to the same pre-reading literature and were afforded the same amount of practice, they may have learned how to perform the technique from these methods alone. A factor which could also be deemed unrealistic is that the Control group were not afforded the opportunity to learn from each other

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during post-instructional group practice – something which usually occurs following most F2F training sessions. The biggest undermining factor however is the small sample size, which potentially weakens the reliability of the findings and restricts the sophistication of the statistical techniques which can be employed.

The findings from the Likert survey are similarly affected by the small sample size, made evident by the influence of one participant who scored against the general trend in some areas. They do however offer a unique contribution from the participants' perspective. For example, the question relating to the value of the pre-reading material received one of the overall lowest scores, which suggests that (from the participants' perspective) it did not act as an obvious substitute for the instructional method. The results also indicate that the participants were least impressed by the sound quality, which was expanded upon in the comments box by 2 students, who cited the slight (but disconcerting) delay between the video and the sound. However, the positive trend of answers for other questions, such as the one pertaining to remote instruction providing a good foundation, and the helpfulness of the tutor feedback lend support to the potential viability of teaching complex psychomotor skills via this method.

Limitations

Limitations of this study include the potential mismatch between the instructional methods and assessment criteria (as demonstrated by 22 of the participants failing to achieve "competency"). An explanation for such a low overall achievement of competence could be that greater adjustments were needed to the learning materials and teaching provision prior to the OSCE. According to Robson (2002:97) the piloting process for fixed designs is an important part of identifying potential flaws with the study design and data collection processes. Limitations to the pilot for this study included the low number of available participants, and technical issues (which were resolved for the main study) restricting the quality of communication between the participants and the instructor. However, one area of teaching which was revised following the pilot was clarification in relation to the needle insertion angle. This was an area in which all participants achieved a "pass" within the main study OSCE, and suggests that further indications for revision of the teaching processes (which may have been indicated by further piloting) is likely to have contributed to an improvement within the overall achievement of "competency".

A higher "pass" rate within each group would have allowed the employment of further statistical tests, which could also have been more sensitive if a

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larger sample were available. Greater alignment (and therefore comparison) with other studies could also have been achieved through surveying the opinions of the entire participant group.

Implications and conclusions

Despite the limitations, the results do suggest that it is possible to use remote synchronous methods of instruction to effectively teach a complex psychomotor skill, and that a group taught by this method will be able to perform at least as well in a validated OSCE assessment as a group who have been taught by F2F methods. The findings also mirror the results of other studies in terms of the efficacy of remote synchronous learning and its comparability with F2F methods. In addition, it has incorporated participants who are at the same academic and experiential level, an instructional design based upon pedagogic theory, and validated OSCE assessment criteria. These factors enhance its external validity and its applicability to other areas of "competency-based" clinical education.

Despite the general conception that complex clinical/psychomotor skills should only be taught in a F2F environment (Roe *et al.,* 2009), this study will hopefully add credence to this particular method of instruction. The adoption of such instructional techniques (even if initially as part of a blended approach) should offer a means of extending the scope of existing e-learning courses, and offer emergency clinicians a greater opportunity to advance their clinical skills.

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