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Effectiveness of synchronous vs asynchronous faculty aid in learning how to diagnose, plan and perform a 44C ankle fracture osteosynthesis in a synthetic bone model

Eficacia de la ayuda docente sincrónica frente a la asincrónica en el aprendizaje del diagnóstico, la planificación y el desempeño de una osteosíntesis de fractura de tobillo 44C en un modelo de hueso sintético

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ABSTRACT. Introduction: COVID-19 pandemic has disrupted educational activities since 2020. AO Trauma Latin American courses took place in a blended modality during 2021 and participant's feedback was positive. In this study, we aim to identify if there was any difference in learning, planning, and executing an osteosynthesis on a bone model with synchronous or asynchronous faculty support during an online asynchronous learning program. **Material and methods:** we designed an online asynchronous course designed for teaching about trimalleolar ankle fractures. We randomized twenty participants into two groups: the control group had synchronous faculty support and the intervention group had asynchronous faculty support. Participants were evaluated with initial and final quizzes, preoperative planning, and execution of an osteosynthesis on a bone model. Comparisons of scores between CG and IG were performed using the Mann-Whitney U test for non-parametric variables. A two-tailed $p < 0.05$ was considered statistically significant. **Results:** we did not find a significant difference between synchronous or asynchronous faculty

RESUMEN. Introducción: la pandemia de COVID-19 ha interrumpido las actividades educativas desde 2020. Los cursos de AO Trauma Latinoamérica se realizaron en modalidad semipresencial durante 2021 y la retroalimentación de los participantes fue positiva. En este estudio, nuestro objetivo es identificar si hubo alguna diferencia en el aprendizaje, la planificación y la ejecución de una osteosíntesis en un modelo óseo con el apoyo sincrónico o asincrónico de la facultad durante un programa de aprendizaje asincrónico en línea. **Material y métodos:** diseñamos un curso asíncrono en línea para la enseñanza de las fracturas trimaleolares de tobillo. Se distribuyó aleatoriamente a 20 participantes en dos grupos: el grupo de control tuvo apoyo docente sincrónico y el grupo de intervención tuvo apoyo docente asincrónico. Se evaluó a los participantes con cuestionarios iniciales y finales, planificación preoperatoria y ejecución de una osteosíntesis en un modelo óseo. Las comparaciones de las puntuaciones entre GC e GI se realizaron mediante la prueba U de Mann-Whitney para variables no paramétricas. Una p de dos colas < 0.05

Level of evidence: II

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support during our asynchronous learning program in quiz results, preoperative planning, global rating scale or the result of the osteosynthesis as compared to the preoperative plan. **Conclusion:** there appears to be no difference in participant learning with synchronous or asynchronous faculty support during an online, asynchronous course. Asynchronous activities appear to be effective teaching methods and should be considered in continuous medical education in orthopedics. Larger studies are needed to identify differences in participant learning outcomes between synchronous and asynchronous faculty support models.

Keywords: continuous medical education, synchronous and asynchronous education, faculty support, discussion, orthopedic education.

se consideró estadísticamente significativa. **Resultados:** no encontramos diferencia significativa entre el apoyo del profesorado síncrono o asíncrono durante nuestro programa de aprendizaje asíncrono en los resultados de los cuestionarios, la planificación preoperatoria, la escala de valoración global o el resultado de la osteosíntesis en comparación con el plan preoperatorio. **Conclusión:** no parece haber diferencias en el aprendizaje de los participantes con el apoyo sincrónico o asincrónico del profesorado durante un curso en línea asincrónico. Las actividades asíncronas parecen ser métodos de enseñanza eficaces y deberían tenerse en cuenta en la formación médica continua en ortopedia. Se necesitan estudios más amplios para identificar las diferencias en los resultados de aprendizaje de los participantes entre los modelos de apoyo docente síncrono y asíncrono.

Palabras clave: educación médica continua, educación sincrónica y asincrónica, apoyo del profesorado, debate, educación ortopédica.

Highlights: there is no difference between synchronous or asynchronous faculty support during an online, synchronous course.

Introduction

During most of 2020, orthopedic residency and fellowship programs worldwide were disrupted. Many programs were forced to decrease or stop clinical, surgical, and academic activities and reroute orthopedic residents to aid in the treatment of patients during the first year if COVID-19 pandemic. Some residency programs in the United States started educational online activities with both synchronous and asynchronous activities.[1] After that, during the second half of 2020 and 2021, educational events took place in a virtual or blended way, mixing synchronous and asynchronous activities, face-to-face activities, and virtual simulation.[2]

Despite the increment of online activities and resources,[3,4] there is no clarity on which is the most effective educational method. Few studies explore the advantages, disadvantages, and effectiveness of online synchronous or asynchronous activities in educational programs for residents. The existing studies are appreciative and are mostly focused on undergraduate education and the student's perspective. A Russian study from 2020 showed that medical students preferred to maintain hybrid modules with online activities.[5] There is some evidence supporting the fact that participation on online synchronous sessions can improve performance during an asynchronous course.[6] The role of faculty support has not been the object of research so far.

During 2021, AO Trauma Basic and Advanced Principles courses took place in a blended modality all over Latin America. There were pre-recorded lectures and face-to-face activities, with workshops and clinical case discussions. Overall, participants' feedback was positive. Regarding the asynchronous component of the courses, participants mentioned that it was valuable to have more time to learn and understand the pre-recorded lectures. This apparently helped participants take better advantage of face-to-face activities.

The main objective of this study was to identify if there was any difference in learning, planning, and executing an osteosynthesis on a bone model after an online asynchronous learning program that did not include hands-on training with either synchronous or asynchronous faculty support during the course.

Material and methods

Educational program overview

For 15 days, 20 participants were enrolled in a virtual course where they learnt about the diagnosis and treatment of malleolar ankle fractures. They had to prepare a preoperative plan to treat a trimalleolar ankle fracture. All participants performed the planned osteosynthesis on a synthetic bone model with an AO type 44C1.3 fracture. Online program in *Figure 1*.

Participant recruitment and selection

PGY2-PGY4 residents or orthopedic surgeons graduated until February 2022 in Mexico City were recruited through an invitation delivered to AO Trauma Mexico members via email from AO Latin America office and social media posts. Applicants who were previously enrolled in the upcoming Basic Principles course and foreigners were excluded.

Participants who were not authorized by the hospital program to participate in the face-to-face activity, were not available to participate in synchronous activities, did not complete online activities, did not demonstrate willingness to participate in the learning experience, and did not sign the informed consent were excluded from the study.

The first twenty participants to complete all activities were accepted as the main participants and the remaining participants were selected as backup. They were invited to participate in the study and complete all online activities. They were also invited to face-to-face activity as attendees. If any of the main participants did not complete one of the activities, they were excluded and immediately replaced by one attendee.

Faculty recruitment

The project was presented and approved by the AO Trauma Mexico board. Active faculty in AO Trauma Mexico were invited to participate as evaluators and as assistants during the face-to-face activity. For the online activities, the Chairperson of AO Trauma Latin America (RP) was invited to participate, together with the Chairperson of AO Trauma Mexico (PJ).

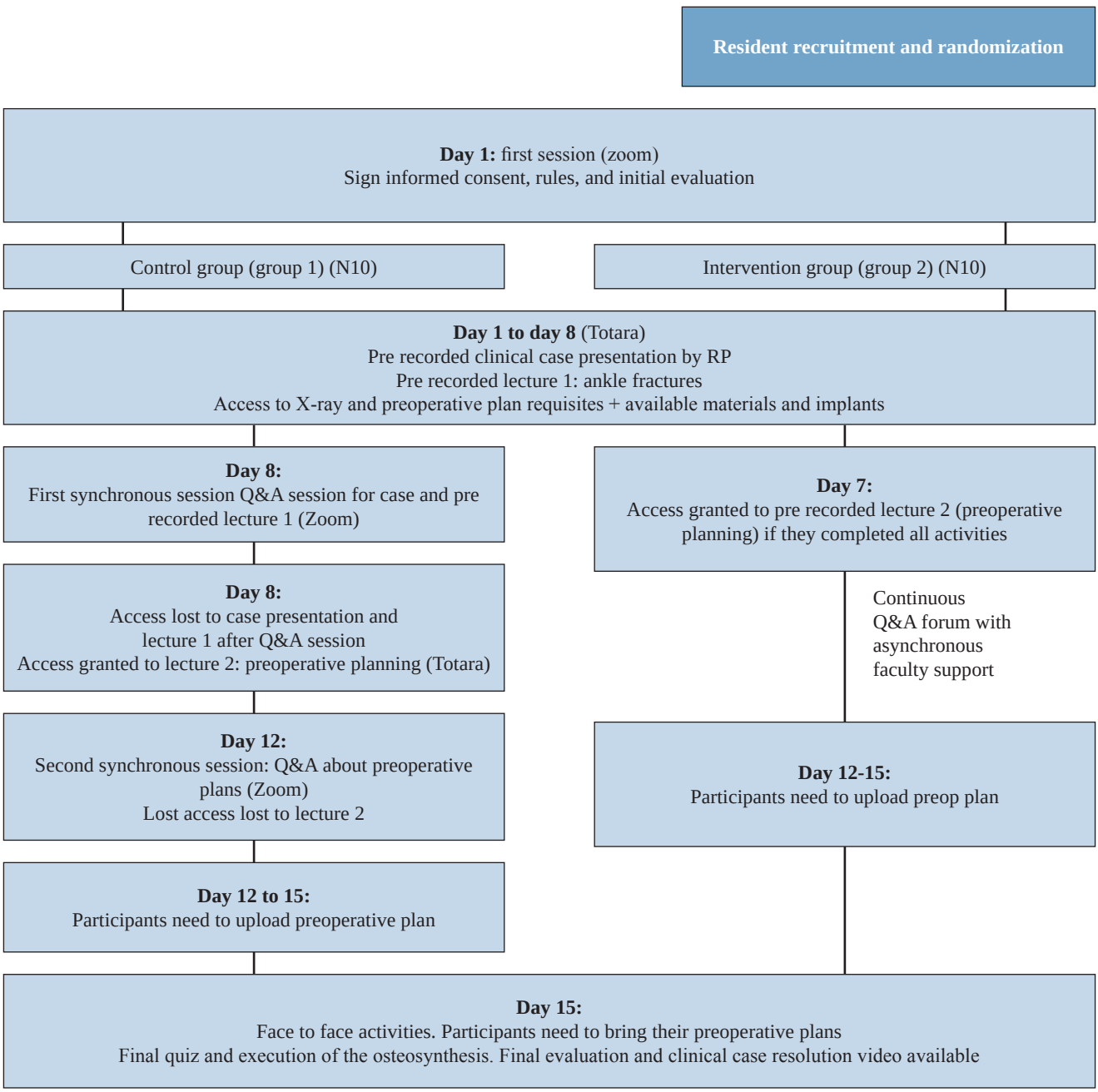

Figure 1: Asynchronous educational program for ankle fractures on Totara. Synchronous and asynchronous activities described for each group.

Figure 2: A) Material setup for evaluators and participants. **B)** Station setup. **C)** Comparison of preoperative evaluations with osteosynthesis.

Randomization

All enrolled participants were randomized into two groups using an online program http://www.jerrydallal.com/random/random_block_size_r.htm (seed: 17492). The backup attendees were randomized separately using the same software (seed: 22514). They were also assigned an individual ID for the blinding of the study. The control group (CG) had synchronous faculty support and the intervention group (IG) had asynchronous faculty support during the online course.

Course design

A virtual course based in Totara, the platform used for the organizational courses, was designed. There was no interaction between the participants on the platform at any time. The course varied depending on the control or intervention group. On the first day, instructions were given to all participants to sign an informed consent and answer an initial quiz about malleolar ankle fractures.

It consisted of two modules: module 1 included the pre-recorded lecture on malleolar ankle fractures used for the blended courses in Latin America since 2021 and a prerecorded clinical case presentation on a trimalleolar 44C fracture. An X-ray with the same fracture pattern as the ankle malleolar fracture synthetic bone model that they would have during the face-to-face activities was available for preoperative planning. A list of the available implants for the skill exercise so they could plan their osteosynthesis. Instructions detailing the elements the preoperative plan should include were also available. Module 2 included the prerecorded lecture on preoperative planning used for the blended courses in Latin America. *Figure 1* for differences between CG and IG.

Evaluation

On day 15, face-to-face activities took place *(Figure 2)*. The twenty participants were divided in groups of five. Each participant had to bring their preoperative plan to perform the osteosynthesis on a synthetic bone model (malleolus right with fracture, bone model LD3119 Synbone AG, Tardisstrasse, Switzerland**)**. For logistical reasons, they had 30 minutes to perform the osteosynthesis according to their preoperative plan. Participants had access to the small fragment set used on the Basic Principles course (small fragment set with cortical and cancellous bone screws, partially threaded screws, 1.6-mm K-wires, 1.6-mm cerclage wire, and a 7-hole one third tubular plate). Each participant had an assistant and was randomly assigned to a faculty to be evaluated. The faculty were blinded to the participant's allocation group (CG or IG).

Three different evaluations took place: faculty members evaluated the participants' motor skills using a previously published global rating scale (GRS) (**supplemental digital content 1**), a checklist was used to compare the result of the skill exercise on the synthetic bone model with the

preoperative plan (**supplemental digital content 2**), and preoperative plans were evaluated by a different faculty member using a separate checklist (**supplemental digital content 3**). https://bit.ly/3PZJWP4 If participants did not complete the osteosynthesis in 30 minutes, they were not allowed to continue and comparison between the preoperative plan and the osteosynthesis was done with what the participant achieved.

After completing the osteosynthesis, participants could access the prerecorded video for module 1's clinical case resolution. They also had to complete the final online quiz and a general survey about the course.

Statistical analysis

All the information was gathered and coded in an excel sheet database by the principal investigator (CA) who did not take part in the course as a faculty at any time. Survey results were not differentiated between groups, the main researcher received anonymous pooled data from all participants. Data was analyzed by a statistician blinded to the group allocation. The analysis was done in Minitab 19. Quantitative parametric variables were described as medians continuous variables are reported as medians (standard deviation [SD]). Categorical variables are presented as absolute numbers and percentages (n = 20). Comparisons of scores between CG and IG were performed using the Mann-Whitney U test for non-parametric variables. A two-tailed $p < 0.05$ was considered statistically significant.

Results

A total of 70 applications were received. Forty applicants were excluded because they did not fulfill inclusion criteria. Thirty applicants could potentially attend the face-to-face activities. Two applicants were excluded because they didn't present a signed authorization letter from their hospital. Twenty-eight participants were randomized. After randomization, there was a homogenous distribution between both groups. Of the 28 participants, three did not complete the initial quiz and were excluded, leaving 25 participants.

Participants were mainly young individuals (median age 29.35 years), mostly male (85%), 70% were residents and 30% were recent graduates. Out of all residents, 15% were PGY-2, 40% were PGY-3, and 15% were PGY-4. During the face-to-face activity, 20 participants completed an osteosynthesis on a bone model and the other five were attendees. In the CG, only seven participants logged in to the first synchronous session and eight logged in to the second synchronous session.

Overall, scores for the initial and final quiz, for the global rating score (GRS), and preoperative planning checklist presented asymmetrically in a non-homogeneous distribution.

Quiz results

There was no statistically significant difference between groups for both the initial and final quiz results. The median score for the initial quiz was 7.75 for the CG and 8.00 out of 10.00 for IG ($p = 0.734$). The median score for the final quiz results was 8.50 for the CG and 8.75 for the IG ($p = 0.734$).

There was no statistically significant difference in the time to complete both the initial and final quiz between groups. The median time to complete the initial quiz for the control group was 10.21 minutes and 19.44 minutes for the intervention groups ($p = 0.186$). The median time to complete the final quiz was 9.23 minutes for the control group and 8.45 minutes for the intervention group ($p = 0.521$).

Global rating scale results

The GRS scores five domains that sum the final score. These domains are: time and movement, instrument handling, knowledge of instruments, flow of operation and forward planning, and knowledge of specific procedure. Each domain is graded between one and five, five being the highest possible score for each category, with a possible final score of 25. The GRS did not require participants to finish the exercise to be evaluated.

There was no statistically significant difference for the GRS between groups. The CG scored a median of 14/25 points, while the IG scored a median of 12/25 points ($p = 0.94$). For time and movement, the CG scored a median of 3 points, while the intervention group scored a median of 3.5 points ($p = 0.94$); for instrument handling, the CG scored a median of 3 points and the IG scored a median of 2 points ($p = 0.406$); for knowledge of instruments, the CG scored a median of 3 points, while IG scored a median of 2 points ($p = 0.037$); for flow of operation and forward planning, the CG scored a median of 3 points and the IG scored a median of 3.5 points ($p = 0.427$); and for knowledge of specific procedure, the CG scored a median of 3.5 points, while the IG scored a median of 3 points ($p = 0.734$).

Regarding the time to complete the skill exercise (osteosynthesis), only nine participants completed the exercise. Eleven participants did not finish, five from the CG and six from the IG so we did not include the statistical analysis for this variable.

Preoperative planning checklist results

For the evaluation of the preoperative plan the maximum possible score was 13. There was no statistically significant difference between groups. The median score for the control group was 11.5 and 12 for the intervention group ($p = 0.94$).

Operative outcome compared to the preoperative plan

When comparing the outcome between the preoperative plan and the osteosynthesis the maximum possible score was

six. Bone models were evaluated even if the participant did not finish the osteosynthesis. There was no statistically significant difference between groups. The median score for the control group was 4 and 5.5 for the intervention group (p = 0.226).

Table 1 shows the comparisons between different variables and p values.

Post course survey

Post survey course results were reported anonymously for all participants and could not be analyzed according to their randomization group. The survey assessed preferences for learning and faculty support. Out of the 25 participants 24 found the asynchronous mode useful, and twelve preferred asynchronous learning modes. Twenty-three participants thought that having synchronous faculty support was helpful. The main reasons for preferring the asynchronous activities were the possibility to review the content at any time and the possibility to complete activities at their own pace.

Discussion

Overall learning outcomes

We did not find a significant difference between synchronous or asynchronous faculty support during our asynchronous learning program in quiz results, preoperative planning, GRS osteosynthesis outcome as compared to the preoperative plan, suggesting that asynchronous format can be an effective way to teach orthopedic residents. The only statistically significant difference we found was better knowledge of instruments in the GRS in the Control group (synchronous faculty support).

Other authors have demonstrated that both the synchronous and asynchronous format resulted in greater learner motivation, more positive attitudes towards learning, and improved outcomes.[7,8,9] Yadav et al. reported their experience in a synchronous and asynchronous course for teaching students of medical laboratory technology course during the height of the COVID-19 pandemic. They found no statistically significant difference between synchronous and asynchronous learning, favoring synchronous activities.[8] Abdollahi et al. compared traditional teaching with an asynchronous learning program with synchronous faculty support for medical students learning pathology in a non-randomized study. They found no statistically significant difference between learning methods.[10] Moridani et al. compared asynchronous video streaming with synchronous videoconference for teaching a pharmacogenetic pharmacotherapy course. They did not find any differences in course grades between groups.[9]

It seems that incorporating the advantages of both synchronous and asynchronous formats is an effective

Table 1: Statistical tests.

Variable	Group	Median	W	p
Time to complete Quiz 1	1	10.21	87	0.186
	2	19.445		
Time to complete Quiz 2	1	9.23	114	0.521
	2	8.485		
Quiz 1 score	1	7.75	100	0.734
	2	8		
Quiz 2 score	1	8.5	100	0.734
	2	8.75		
Time and movement	1	3	106.5	0.94
	2	3.5		
Instrument handling	1	3	116.5	0.406
	2	2		
Knowledge of instruments	1	3	132	**0.037**
	2	2		
Flow of operation and forward planning	1	3	94	0.427
	2	3.5		
Knowledge of specific procedure	1	3.5	110	0.734
	2	3		
GRS	1	14	115	0.473
	2	12		
Time to complete osteosynthesis	1	29	99.5	0.705
	2	30		
Preoperative plan checklist	1	11.5	103.5	0.94
	2	12		
Preoperative plan and osteosynthesis comparison	1	4	88.5	0.226
	2	5.5		

Table 1 shows the comparisons between different variables. The Mann – Whitney test was performed for non – parametric variables. p values < 0.05 were considered statistically significant and are highlighted in the table. W value: Mann – Whitney statistical significance. Group 1: control. Group 2: intervention group.

strategy to teach health-care students in general. Acaroglu et al. concluded that fully online blended courses could improve participant learning and that the asynchronous component contributed to the decrease in the learning gaps. They also found high faculty and participant satisfaction in three different spine courses.[11] Lindeman et al. also found superiority for online asynchronous activities during blended courses for undergraduate students.[12] Farros et al. focused on analyzing the effect of synchronous discussion sessions in an asynchronous in a non-medical course taught at a college in New England. They found a tendency for higher grades in participants of asynchronous discussion groups, although they do not report consistent differences between both groups.[13] Our findings are consistent with theirs.

Other studies have found differences favoring traditional face-to-face learning.[8,14] Yadav et al. reported that 96.7% of their students understood well or fairly well the taught concepts, while only 56.7% had a clear understanding of the asynchronous content ($p < 0.001$).[14] Yadav they also reported that 93.5% of their students felt confident in solving questions during the subsequent examination after synchronous activities, while only 74.2% felt confident during the asynchronous activities ($p = 0.039$).[8]

Kunin et al. evaluated if the asynchronous format satisfied the educational needs of dental residents compared to traditional face-to-face lectures and synchronous formats.[7] They rated the face-to-face format as significantly more conducive to student-instructor and student-student interaction in terms of effectiveness and clarity of presentations.[7] Azi et al. found improvement in participant and faculty competencies in the treatment of fracture-related infections after an online course with both synchronous and asynchronous activities and faculty support during 2020.[14]

Preferences

Regarding preference, 96% of all our participants found the asynchronous course mode useful and effective. In our study, 50% of the participants preferred asynchronous learning modes, while Yadav et al. reported that only 12.9% of their students preferred the asynchronous modules. Young et al reported that 94% of an emergency medicine resident group found asynchronous activities during a flipped classroom model added to their knowledge and was a valuable use of time. However, 95% preferred traditional lecturing to flipped classroom modes.[15]

Eighty eight percent of our participants viewed the content more than once, while Young et al. reported that 60% or less of their residents viewed the online videos more than once.[15] Moridani et al. and Acaroglu et al. reported that participants considered an advantage of this learning modality to be able to review the material and better absorb the content during asynchronous activities.[9,11] This is also consistent with comments from our participants both at the study and during 2021 and 2022 blended Basic Principles courses in Mexico.

A meta-analysis on blended learning in health professionals showed that blended learning has a consistent positive effect on knowledge acquisition.[16] This is true when compared to non-blended learning (pure traditional or pure online learning).[16]

Asynchronous faculty support has proven to at least be non-inferior to synchronous faculty support. Farros et al. recommended that saving faculty time and resources and moving discussion to an asynchronous mode could be a more efficient use of faculty time.[13]

Our study presents clear strengths. To the best of our knowledge, this is the first randomized, longitudinal, double-blinded study that compares synchronous and asynchronous faculty support during an online learning course in orthopedics. Participants were from different experience levels and from different hospitals. They represented the target for AO Trauma Basic and Advanced Principles courses.

Study limitations include a small sample size, a small number of participants who completed the osteosynthesis during the hands-on evaluation, participants from one country, and no faculty facilitation during the online course or synchronous faculty support sessions. Also, faculty members during synchronous activities were not the same for both sessions. Because of logistics reasons, the participants had limited time to complete their osteosynthesis and most did not complete it. Many participants were very nervous during the osteosynthesis. Some participants had technical difficulties using and understanding the online platform. We evaluated a hands-on component, but we did not include hands-on training and the limited results on the hands on exercise do not allow a proper evaluation for the hands- on component. However, the main objective of the study was not to evaluate the hands on component.

There is still much to learn and understand to design the most effective continuous education activity. Further research should include larger studies, multicentric regional and international studies. Assessing participant performance with the educational method of their preference could help understand how to better implement asynchronous activities into the future of medical and surgical education. Hands-on training with simulation and faculty support should be explored. Finally, different modalities for hands-on training and assessment should also be explored.

Conclusion

There appears to be no difference in participant learning with synchronous or asynchronous faculty support during an online, asynchronous course. Asynchronous activities appear to be effective teaching methods and should be considered in continuous medical education in orthopedics. However, larger studies are needed to identify differences in participant learning outcomes between asynchronous and asynchronous faculty support models.

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Supplemental digital content