



SICOT PIONEER (Programme of Innovative Orthopaedic Networking Education and Research): Re-inventing global orthopaedic education, training and research

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Introduction

The outburst of SARS-CoV-2 infection, known as coronavirus disease 2019 (COVID-19), posed an unprecedented impact on the global health care system. It was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 [1]. Several precautionary steps were undertaken to control the spread of the virus throughout the globe such as nationwide lockdowns, social distancing protocols, use of masks and personal protective equipment (PPE). These restrictions, especially lockdowns and social distancing, continue to impact the workflow patterns and pose several challenges for all the medical specialties, not barring the orthopaedic community, including orthopaedic surgeons and trainees [1–3].

Impact of COVID-19 on orthopaedic departments, organizations and training

Since the evolution of the pandemic, reduced number of clinical cases have been observed in the orthopaedic outpatient departments (OPDs) along with the cancellations of elective surgeries resulting in lesser orthopaedic patient admission to hospitals [1, 4]. Moreover, the task forces employed to manage the pandemic in various countries called for a delay or cancellation of all non-essential or elective surgeries. These

decisions were taken to conserve healthcare resources (e.g., PPE, gloves, intensive care unit (ICU) beds, ventilators), reduce the risk of contagion transmission, reduce hospital admissions and enhance the capacity to support patients with COVID-19 [4, 5]. Furthermore, one of the early studies conducted after the COVID-19 restrictions revealed a 32% reduction in trauma cases due to people remaining indoors during this period [6].

These unprecedented changes have affected orthopaedic training and fellowships in a very complex and colossal manner. Orthopaedic training, fellowships, conferences and meetings have waned at the expense of management of the viral spread [7]. Most face-to-face lectures, academic activities, teaching and other didactic activities, clinical ward rounds and case presentations conducted for the trainees were cancelled. Furthermore, majority of the teaching activities (lectures, case presentations, bedside teaching) were virtually transformed virtually, thereby significantly altering the clinical and surgical learning experience [1]. With the diminished number of elective or non-emergency procedures and trauma cases along with increased virtual outpatient clinics, orthopaedic surgeons got to spend less time managing emergency cases [7]. Even the roles of the fellows, residents and trainees were changed to share the burden of the pandemic in multiple capacities [1, 5]. Reallocation of the orthopaedic surgeons as well as trainees occurred at many hospitals to manage the overwhelming challenge of increased COVID-19 patient load [2, 5, 7]. This impacted the learning curve of the orthopaedic trainees in an unprecedented manner [1].

Moreover, the limited number of procedures executed was recommended to be performed by consultant orthopaedic surgeons without involving the trainees to reduce the operation times and the spread of infection. Consequently, the surgical exposure for trainees was radically diminished. The impact of these reductions had resulted in some residents and fellows not being able to meet the minimum

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requirements of surgical training necessary to advance as an independent surgeon or consultant. Prolonging training has had to be considered by some in order to hone their subspecialty skills [5, 8, 9]. Additionally, international travel restrictions added to the complexity of access to training and significantly impacted international fellowship programmes. These restrictions led to the uncertainty among many fellows who had to cancel their training and/or visiting fellowship programmes [9, 10].

The nationwide lockdown measures and other restrictions compelled changes in the approach to patient care. Various sectors of healthcare shifted to virtual clinics and telemedicine to reduce social contact. Concurrently, educational delivery also evolved, employing virtual methodologies like online lectures, e-learning tools, webinars and 3D-simulation techniques. Most conventional classroom teaching shifted to online group video platforms (e.g. Zoom, Cisco Webex, Microsoft teams) and pre-recorded lectures which has now pretty much become the new normal. This aimed to maintain some of the interaction orthopaedic trainees had with their mentors while keeping the didactic activities ongoing in a time of crisis. However, many other surgical training modalities such as cadaveric hands-on training and clinical postings in subspecialties (like paediatrics and elderly care) were either switched to teleconferencing or completely cancelled [2, 10]. Reduction in the volume of elective and non-essential operations in addition to redeployment of the surgical residents to non-orthopaedic departments limited their clinical and surgical exposure, leaving them behind in their utmost required skill.

A similar pattern was also observed in other specialities as well such as gastroenterology, neurosurgery and urology [2]. Furthermore, the pandemic restrictions also impacted the exit exams of residents and trainees in many countries due to difficulty with conducting exams or postponements [10].

Stress and anxiety due to COVID-19 and its impact

The protracted nature of COVID-19 restrictions and constantly changing protocols has had a substantial impact on orthopaedic residents globally. Inadequate surgical exposure, safety concerns, the uncertainty of the exit exams, the ambiguity of completing fellowships on time, the fear of getting infected or transmitting the virus to their loved ones and so forth have led to an upsurge of mental health issues such as development of discomfort, stress, anxiety and poor sleep quality among the residents and trainees [1, 11, 12]. However, such stressful situations have not been limited to the orthopaedic community. Most other educational fraternities, businesses or employments worldwide have had to grapple

with increased mental health issues [11, 13]. A study conducted among university students (medical and non-medical) revealed that anxiety levels had increased during the pandemic with medical students having higher anxiety levels compared to non-medical student before the introduction of online teaching [11].

Increased stress amongst workers, induced due to the pandemic across different industries, affected productivity and thus led to an adverse economic growth. This has proven to be a motivator for many employers to embrace newer work approaches and promote a safer work culture. Changes in work practices aim to shield employees from the undesirable effects of COVID-19 at the workplace and help improve their performance. The flexibility provided to workers and introduction of newer technologies to access and collate information has helped workers perform better without the stress of COVID-19 [12]. Thus, several organizations in industries such as banking, information technology, education and finance have accepted virtual working as the new normal possibly the future work trend.

Several surveys were conducted in different countries to assess the online teaching methodologies being employed during the pandemic. The residents and trainees who participated in such surveys reported online-based teaching methods to be easier. However, many highlighted difficulties with online case presentations, in-patient clinical evaluation, pre-operative planning, post-operative care, clinical education at the patient's bedside and were thus unsatisfied with the online teaching methods compared to traditional learning methods [1, 2, 14–17]. Furthermore, the surgical skills required by residents were lacking given the deprived exposure to surgeries or even cadaveric training. In a survey on 327 orthopaedic residents spread across 23 countries in Europe, 58.6% of trainees experienced difficulties in the execution of operations [2]. Henceforth, delivering didactic activities virtually may prove to be helpful to some extent but is certainly not conducive to all, of the needs of a surgical resident or trainee. This gap necessitated the evolution of a new era of education and training which utilizes modern tools like e-learning modules, virtual reality (VR), surgical simulations in surgery and learning management systems (LMS).

Integrating educational theories for the training of future orthopaedic surgeons

Many educational theories have been proposed for improving the learning curve in surgical disciplines. The traditional model of learning was true apprenticeship; however, over a period with the reduction of hours spent in surgical residency, this has moved on to competency-based training. It

has also been observed that learning of psychomotor skills (mental and motor skills) required by a surgeon could be facilitated by simulations. The simulations can provide a safe learning zone without the pressure of operating theatres as well as ease of repetition for practice and achieving competence. Therefore, the understanding and application of educational theories such as the Fitts and Posner theory and the Ericsson theory might be beneficial to improving the learning curve of surgeons and to develop a training model for them [18, 19].

The Fitts and Posner theory depicts a three-stage model to achieve motor skills involving trainees' performance at each stage. The first stage is the cognitive stage, which includes intellectualizing the task by demonstration and explanation; however, one may not be able to perform the task without errors. This level of attainment can be learned by a surgical trainee with the help of books, journals or lectures. The second stage, the associative stage, includes a translation of the acquired knowledge into proper motor skills. This stage can be achieved with repeated practice and feedback on performing the skill. In the third stage, the autonomous stage, the trainee surgeon may be able to perform the task smoothly and independently without any errors and with least mental effort, almost as an expert. However, achieving this stage requires continuous feedback and direct observation of the learner's skill in an operating room (OR) [19]. Regular repetitive practice, feedback and reinforcement play a major role in developing a skill to the level of an expert. Ericsson's theory is based on the principles of deliberate practice and allows for retention of the skill as an expert. Thus, it becomes a mandate for a surgeon to keep on performing a particular skill, frequently, to master it [18–20].

Both theories suggest the initial levels of competency may be attained by theoretical knowledge but the transition to expertise requires deliberate practice. Hence, simulation-based training must be an integral part of medical training to minimize any harm to patients. It is of utmost importance that following training, immediate formative feedback is provided based on the comparison of the trainee's performance to an established standard. Such a teaching model can be employed to optimize the training of surgical skills of the trainees or residents [19]. Simulation based training can be categorized as VR, physical or hybrid [21]. Integration of these models into the training curricula of young surgeons along with controlled supervision is essential in the pandemic situation.

In summary, digital teaching methodologies, such as online lectures and seminars, instructional videos for surgical procedures, simulation-based training models and virtual web conferences for discussions, have the potential to bring a radical change to the future educational modalities for surgeons. This pandemic, thus, has provided a novel and accelerated opportunity to bring such models into practice.

These training models may also help to minimize the stress and anxiety among residents secondary to the pandemic.

Virtual reality in surgical training

Virtual reality and simulation have been introduced in the world of surgery in recent years with application in a wide range of specialities. One of the significant applications of VR technology in the medical world is in education and training [22]. VR simulation has been applied in several specialities such as laparoscopy, cataract surgery, psychiatric therapy, pain management and traumatic brain injuries. It is also establishing a role in pre-operative planning, intra-operative triangulations and surgical training in various orthopaedic surgical procedures (e.g. arthroscopy, arthroplasty, reconstruction of fracture malunion) [23, 24]. Currently, resident training involves arthroscopic simulators, fully immersive intra-operative simulators (trauma management and arthroplasty) and haptic simulators for bone drilling and reconstruction (fracture malunions) [23].

In recent years, orthopaedic surgery including arthroscopy and arthroplasty have advanced by leaps and bounds with more specialized techniques, specialized instruments and advanced navigation skills compared to routine arthroscopy. Given the learning curve of these orthopaedic surgery (knee and hip arthroscopy, arthroplasty, spinal surgery) with minimally invasive approaches is long and may be associated with complications, VR simulators can help to accelerate the learning curve. The use of VR technology for the training of residents in the early years can minimize the time required to develop complex surgical skills (including visuospatial, perceptual and psychomotor abilities) along with ensuring patient safety [25]. The VR technology can also provide an opportunity for the trainees to learn and master certain tasks involved in surgery by repetitive practice in an innocuous and benign environment. Furthermore, since all the movements of the trainees are recorded, formative feedback is possible that can enhance skill learning [26].

Moreover, a study conducted among 25 unsupervised medical students to assess whether their interest in orthopaedic surgery can be influenced by the use of arthroscopic simulator revealed that using VR simulators made the students more interested in orthopaedic, surgery and arthroscopy. Furthermore, the students reported improvement in their surgery quality even without expert supervision and suggested VR simulation to be a mandate for their surgical training [27]. Several studies have reported beneficial results in surgical performance when using VR during the training of young surgeons or surgical residents [23]. A study on 24 young surgeons demonstrated a better success rate for pedicle screw placement when performed by young surgeons trained by an immersive VR simulator compared to surgeons

exposed to the observation of spinal model and a teaching video of spinal surgery [24]. In addition, another study also reported improved intra-operative reconstruction surgeries of calcaneal fractures using computer-assisted pre-operative planning and virtual surgical technology [28]. Furthermore, a review of 31 articles evaluating the validity and efficacy of VR simulators showed improvement in performance in operating theatre as well as better skill acquisition due to repeated use of simulators [29].

However, the transferability of the trainees from VR-to-OR (from simulation-based training to improved clinical performance in operation theatres) is a long path to be navigated and needs a structured curriculum to be developed based on educational theories. The competence criteria for the required skill set in trainees can be set in the simulators. This competency can be achieved by following a step-wise method to acquire mastery over a skill [26]. At SICOT, we have progressively transitioned to innovate surgical training, incorporating VR technology while evolving the educational model during these difficult times.

SICOT PIONEER

SICOT PIONEER (Programme of Innovative Orthopaedic Networking, E-learning, Education & Research) was born out of the need to innovate. The COVID-19 pandemic pushed the orthopaedic community into a tight squeeze, leaving us with no option but to transform digitally and integrate technology into routine activities. SICOT's Education Academy adopted this digital transformation which paved the way for the birth of the PIONEER project in June 2020; a steppingstone towards the digital education journey in orthopaedics. The different virtual educational options launched under PIONEER include the SICOT Virtual Fellowship Program (SICOTVfellow), SICOT Virtual Education Program (SICOTVed), SICOT Virtual Examination Platform (SICOTVexam), SICOT Virtual Surgical Training Program (SICOTVtrain) and Surgical Techniques/Podcasts. It strives to facilitate knowledge exchange among the whole orthopaedic community worldwide, including the most experienced senior consultants to the trainees in their initial years of residency.

PIONEER has hosted numerous webinars and podcasts (Tete-a-tete sessions) that have been live-streamed, incorporating a live discussion function for questions and comments. A custom-designed learning management system archives all the educational video content for the members to access anytime at their ease. Furthermore, video recordings of these e-events are also available on-demand as a feature item on the SICOT website. Moving forward, a wider constellation of e-events including interactive surgical demonstrations, panel-based discussions and accessibility

in multiple languages will be a feature. As part of VTrain, we have developed a structured module to conduct teaching modules, assessments and accreditation for trainees in specific areas of orthopaedic practice. This virtual training will culminate in a hands-on cadaveric training at the annual SICOT Orthopaedic World Congress. Feedback from the members or viewers of the educational content video is constantly sought for further improvement.

Under the aegis of SICOT PIONEER, we have hosted 36 webinars till November 2021 with 36,732 live viewers and 21,783 on-demand viewers. The high number of viewership suggests substantial change in the learning behaviour during the pandemic. To gain feedback for further improvement and its success, we conducted a survey involving 7,763 members spanning the whole community. The seniority of the viewers was also evaluated depicting maximum participation from consultants (46.4%) followed by trainees (28.1%) and lastly, senior consultants (25.5%). This data suggests virtual educational programs may not be only helpful for trainees but also for young consultants. Furthermore, the viewers were found to be scattered across the globe with maximum viewership achieved from Asia (40.4%), followed by Europe (26.9%), the Middle East (17.2%), Africa (8.3%), South America (5.6%) and North America (1.0%). The viewership based on the country is depicted in Fig. 1.

The survey was conducted to assess the acceptance among the viewers for the quality of the content and whether the educational content meets their expectations. It was found that 69.9% of the viewers rated the webinars as 'excellent' (Fig. 2). Intending to assess the faculty who are delivering the webinars, the survey rated the faculty as average, good and excellent. Most of the viewers (69.5%) found the faculty to be 'excellent' (Fig. 2). Furthermore, the format of the webinar and the tools used were also evaluated and 57.1% of the viewers rated this as 'excellent' (Fig. 2). This survey result will help us constantly evolve the format of webinars and other virtual programs to deliver the best possible content in a way that is most relevant and supportive of traditional systems of learning.

Finally, the primary aim of the virtual training programs was to bring a positive change into the routine practice of the orthopaedic community. These virtual educational activities aim to bridge the gaps in traditional methods of learning and help steepen the learning curve of complex surgical procedures. Furthermore, they aide in lowering the stress and anxiety among the trainees during these difficult times of pandemic by facilitating their learning, even with reduced exposure to surgery. The impact of the virtual programs in the routine practice was assessed by surveying the viewers with regard to any changes observed in their practice. Positive feedback was received from 51.7% of viewers, while 35.7% of viewers answered 'maybe' (Fig. 3). Thus, these virtual

Fig. 1 Count of the country where the viewers of the webinars were based

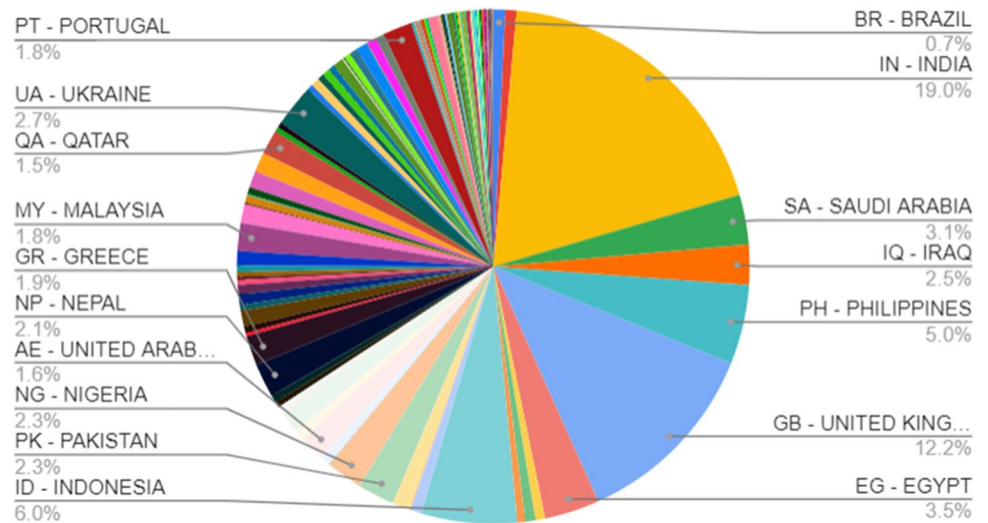
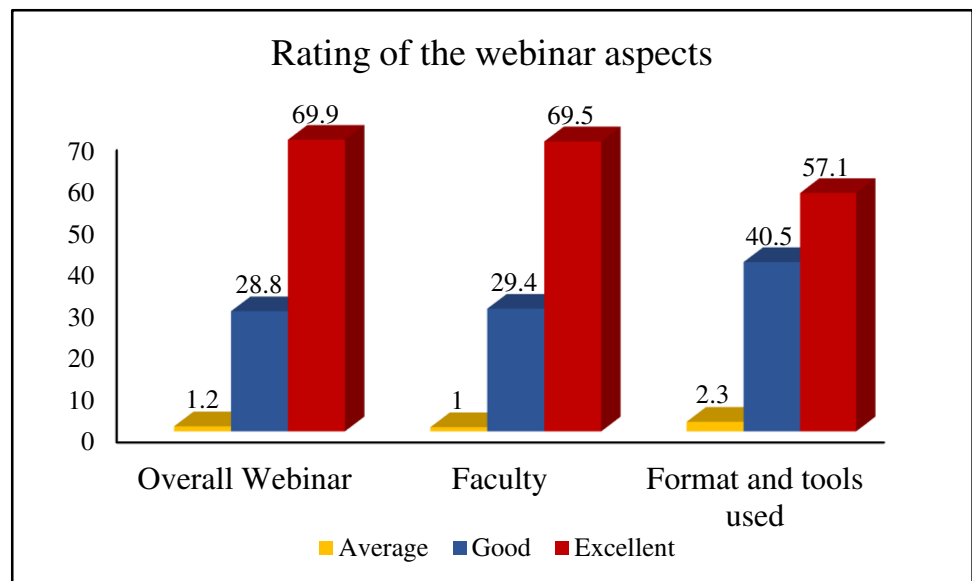


Fig. 2 Rating given by 7.763 webinar viewers for the overall content, faculty and the format and tools used in the webinars



educational programs may have a scope of improvement in their structure, delivery format or audience-engagement techniques in the future.

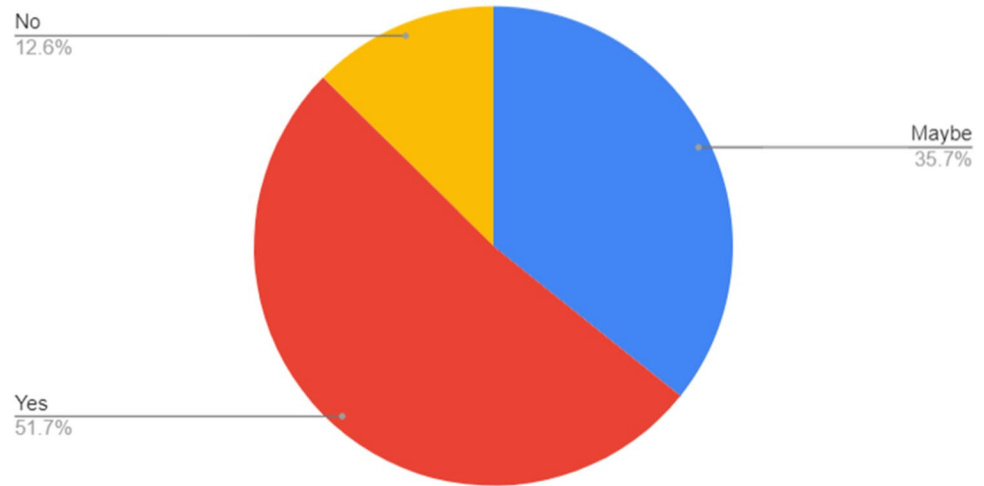
Futuristic plans of SICOT PIONEER include the development of a more structured and systematic e-learning ecosystem (learning management system) that can supplement the traditional methods of teaching and learning. The virtualization of these techniques may help to shorten the learning curve of several surgical procedures (e.g. knee/hip arthroscopy, ankle arthroscopy, ligament reconstruction). Thus, the progression from the cognitive stage to the autonomous stage (Fitts and Posner theory) for a trainee may be accelerated.

Discussion

The COVID-19 pandemic has overturned education, medicine and training, especially affecting the training of the surgeons to a great extent [30]. Restrictions such as social distancing, national lockdowns and international travel bans that have been put into practice to lessen the spread of the virus have greatly impacted the elective orthopaedic surgery being conducted globally [1–3]. This has resulted in a drastic reduction in the training activities of young surgeons and residents. Though these tough times are taking a toll on all of us, we at SICOT chose to innovate and

Fig. 3 Feedback from 7,763 webinar viewers concerning change observed in the practice due to these webinars or virtual educational activities

Has this webinar/educational activity affected/changed your practice?



continue to deliver the best quality education to our members. The education and training of budding orthopaedic surgeons cannot be overlooked for a better future. This was the impetus that nurtured the conception of an innovative educational platform—PIONEER, to continue with the educational and teaching activities amidst challenging pandemic restrictions.

The virtual and e-learning methods employed at present have several advantages over traditional methods of learning. It is more cost-effective as learning can occur with minimum infrastructure and equipment. Furthermore, no travelling is required as it can occur in the comfort of a home. Interactive features such as chat or messaging during the live sessions can actively initiate doubt clearing sessions for the learners. Pre-recorded demonstration videos of the surgeries can help the residents and junior doctors to learn surgery at their own pace. It also reduces the learning curve for complex surgical procedures. This model allows learners to learn from experts in their field rather than just the faculty in their respective institutions [30]. Hence, self-learning can also be improved. However, this could be applicable only for theoretical purposes and demonstration of videos on surgery. Integrating VR technology along with the e-learning modules can take the learning to the next level adding to the many advantages of this educational model.

Simulation-based learning models provide an opportunity to learn the steps involved in a surgery in a risk-free environment, thus ensuring patient safety. Moreover, the trainees can rehearse the surgical steps repeatedly at any time without any ethical concerns. The human feedback (visual and physical) provided to the residents on the surgical steps using VR simulators can accelerate the process of learning along with patient safety. The competence achieved by the trainee in surgical steps can also be assessed with

pre-defined criteria in a reproducible and dependable manner. Furthermore, emerging technology will also be able to validate reconstructive/fracture constructs as well as affirm the VR-to-OR experience for residents [23].

However, this technology is still naïve and in its infancy. Some of the simulators provide low fidelity, while high-fidelity simulators are expensive and limited at present. Moreover, there is limited evidence for the success of VR in the resident training curriculum and more detailed studies are still awaited. Furthermore, VR simulators are available for limited procedures and cannot be generalized across different surgery in orthopaedics. In addition, the coordination/interaction required among the intra-operative team in an OR is a crucial skill to be mastered which is lacking in the presently available VR stimulators [23]. A lot of challenges still need to be dealt with before implementing this technology widely. One such challenge involves mimicking a real patient situation in a virtual patient, since precise replication of complicated human anatomy and physiology (bleeding vessels, leaking structures, etc.) is difficult. Moreover, haptic feedback, an integral component of surgery, is very limited in VR simulators. Some of the newer simulators may be able to mimic and provide haptic feedback but they are expensive. Thus, these prominent limitations of VR technology need to be negated in order to make it successful [23, 26].

Overall, the future of integrating e-learning and VR technology holds high hopes for training of orthopaedic residents even after the COVID era. One of the studies evaluated the effectiveness of a five week structured virtual course teaching orthopaedic trauma via weekly online lectures and virtual interactive sessions to third year medical students. The average rating of the educational course was reported to be 4.98 out of 5. It was proven to be effective in providing the knowledge and preparation for basic skills required for fresh

orthopaedic interns and this can be considered as a reasonable alternative to traditional clinical orientation [31]. In conclusion, the virtual learning model could be employed as a useful tool for the supplemental training of acquiring basic skills in the OR settings. SICOT PIONEER is budding in this space and developing many virtual spokes encompassing not only conventional teaching and training modules but also surgical techniques, examinations and also virtual interactive forums for discussion and learning.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by both authors, with each one of them researching, referencing and formulating their caption. The first draft of the manuscript was written by Gowreeson Thevendran and both authors commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

Data availability Not applicable to this article type

Declarations

Ethical approval This is a survey study and therefore ethical approval is not applicable

Consent to participate Not applicable

Consent to publish All authors have given their consent to publish

Conflict of interest Gowreeson Thevendran is the Current Chair of the Education Academy of SICOT and Founder Member of SICOT PIONEER. Vikas Khanduja is the Past Chair of the Education Academy of SICOT and Founder Member of SICOT PIONEER

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