Original article

Development and validation of a computer-based learning module for wrist arthroscopy

Développement et validation d'un module d'enseignement informatique pour arthroscopie du poignet

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Abstract

The objective of this study was to develop and validate a computer-based module for wrist arthroscopy to which a group of experts could consent. The need for such a module was assessed with members of the European Wrist Arthroscopy Society (EWAS). The computer-based module was developed through several rounds of consulting experts on the content. The module's learning enhancement was tested in a randomized controlled trial with 28 medical students who were assigned to the computer-based module group or lecture group. The design process led to a useful tool, which is supported by a panel of experts. Although the computer based module did not enhance learning, the participants did find the module more pleasant to use. Developing learning tools such as this computer-based module can improve the teaching of wrist arthroscopy skills.
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Keywords: E-learning; Computer based learning; Wrist arthroscopy; Teaching; Validation; Randomized trial

Résumé

L'objectif de cette étude était de développer, puis de valider un module d'enseignement informatique d'arthroscopie du poignet (CBL) grâce à un panel d'experts. L'intérêt pour la réalisation de ce module émanait d'un projet de la société européenne d'arthroscopie du poignet (EWAS). Le contenu du module d'enseignement informatique a été obtenu à partir des réponses de plusieurs séries de questionnaires rédigés sur les conseils d'experts. La qualité de l'enseignement par le module été testée lors d'un essai contrôlé randomisé avec 28 étudiants en médecine, en comparant les résultats d'un groupe enseigné par le module d'enseignement informatique à un groupe enseigné par lecture de documents papier. Le processus de conception a conduit à un outil intéressant de l'avis d'un panel d'experts. Bien que le module d'enseignement informatique n'améliore pas l'apprentissage, les participants ont trouvé le module plus agréable à utiliser que les documents papier. Développer des outils d'apprentissage comme ce module d'enseignement informatique peut améliorer l'enseignement de l'arthroscopie du poignet.
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Mots clés : Enseignement informatique ; Arthroscopie du poignet ; Apprentissage ; Validation ; Essai contrôlé randomisé

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1. Introduction

Mastering a new skill usually starts with acquiring the basic theoretical knowledge about the skill of interest. In medicine, this generally means studying the relevant anatomy and physiology. For training in endoscopic skills, such as wrist arthroscopy, knowledge needs to be acquired about the indications, complications, therapeutic possibilities, entry points, positioning of the patient and use of arthroscopic instruments. Traditionally, such knowledge is acquired in lecture courses, through oral briefing by the supervisor in the operating room (OR) and from books. Textbooks offer ample information, illustrated with images. However, they lack the possibility of showing videos or animated pictures. Furthermore, the residents of today's search strategy for information are not likely to start inside a library building – they typically start on the Internet [1,2]. Getting information from computers, being able to interact with the proposed information and the addition of videos or animations suit the present generation of residents very well. When looking for information on the Internet, residents use search patterns familiar to them, leading them to popular content-rich Websites such as YouTube and high-ranking sites in Google. Novices are unable to differentiate between more and less valid contents since they inevitably lack experience regarding the information they are looking for. It is important to guide these residents in their search strategy, starting by offering them information that is easy to find, valid and relevant. To link up with this modern way of education, a variety of sources have become available for acquiring the basic knowledge on the performance of arthroscopy. These include Web-based sources, such as electronic books or articles, and Web portals acting as multimedia training platforms, such as Websurg (http://www.websurg.com).

Websurg offers the advantage of placing peer-reviewed lectures and step-by-step instructions from renowned colleagues. The disadvantage is that it is a one-way portal for the transfer of information, meaning that the information is transferred to the user in a passive way; there is no interaction with the content.

Medical professional societies have realized the potential advantages of Web-based learning and are developing or have developed Web-based educational programs [3]. In fact, some of these societies use Web-based learning to prepare residents for exams or internships. These Websites are usually only available to members and contain interactive E-learning modules, sometimes with the possibility of self-examination or self-assessment (e.g. BAPRAS, LFH, RCSENG, RCSI). In a review by Kleinpell et al. in 2011, a list six pages long identifies various Web-based resources for critical care education, indicating the enormous amount of information available [4]. After searching Medline from 1980 to 2013 using the search terms e-learning, computer-based learning and arthroscopy, we found no evidence of computer-based learning modules for wrist arthroscopy.

Many different terms are used to describe the use of computer technology for teaching purposes. In this paper, the term computer-based learning (CBL) will be used. CBL is considered to be instruction that is dependent on the use of a personal computer without guidance or tuition from a teacher or facilitator [5].

A CBL module for teaching wrist arthroscopy would be useful as wrist arthroscopy is a complicated skill to teach. The complexity lies in the facts that access to the wrist needs to be achieved partly blindly through the creation of portals, the tissue is indirectly visualized on a 2D monitor as opposed to a 3D direct view during open surgery, and tissue manipulation takes place solely indirectly via instruments. Furthermore, the creation of portals is performed in an area with many neurovascular structures at risk, which requires extensive knowledge of the anatomy of the wrist to avoid complications.

The purpose of this study was to develop a valid CBL module for wrist arthroscopy which had to meet two criteria: its content had to be tested and approved by an international panel of experts in the field of wrist arthroscopy (thus securing the level of content) and the module had to be validated by comparing the results with those of a traditional teaching method.

Our hypothesis was that a CBL module could be built for wrist arthroscopy to which a large group of wrist arthroscopy experts would consent. Such a CBL module would improve the learning results compared with those of traditional teaching.

2. 2–Methods

2.1. Phase 1: survey

A survey was required to determine the need to develop the proposed CBL module for wrist arthroscopy. As an expert group, members of the European Wrist Arthroscopy Society (EWAS) were surveyed. The questions and answers are given in Table 1. They were invited to elaborate on their expressed opinions.

2.2. Phase 2: building the first version of the CBL module

A list was drawn up to serve as a template for the topics to be addressed in the CBL module. The content of the module was built with the use of digital images from different experts (C. Mathoulin, A. Atzei, M. Garcia-Elias). A panel of novices reviewed these images and made comments and suggestions (residents from the Department of Plastic Surgery at our hospital). Their remarks were used to improve the content and subsequently the images were used to construct an interactive CBL module. The interactivity consists of supplementary information that can be viewed by clicking on parts of the image. Furthermore, two animations with voice-over were added to clarify the positioning of the patient in the OR and the entry procedure into the wrist.

2.3. Phase 3: Testing and improving the CBL module

A variation of the Delphi method was used to achieve consensus among a group of wrist arthroscopy experts. The Delphi method is based on the assumption that group judgments

Table 1
Demographic data and experience of the six participants.

Comments from the survey given by members of the EWAS	
Question: do you think a computer program to learn the basics of wrist arthroscopy would be an asset?	
No, it would not be an asset	Yes, it would be an asset
Getting inside the joint is the essential	Introduction to the general principles
Indications and portal placement cannot be taught in 2D	Useful for the first steps: understanding the working area
Future lies in 3D simulators	Supports anatomical knowledge
	Theory before practice
	Could give good visual impression of normal and pathological anatomy
	It is a difficult joint to explore
	Yes, but only as an adjunct to a course

are more valid than individual judgments. Experts are asked to give their opinion on different subjects. The process is repeated several times until a consensus emerges (wikipedia.org/wiki/ Delphi method).

The CBL module was presented to a panel of experts (faculty at the wrist arthroscopy course of the EWAS). The panel was asked to fill in a questionnaire on the content and structure of the CBL module and these comments were used to improve the CBL module. A second panel of experts re-evaluated the amended CBL module and their comments were employed to perform a second round of improvement. This procedure was repeated a third time after altering the CBL module based on the comments from the second round.

Finally, the CBL module was presented to the panel of novices for a last round of comments and suggestions on the content and structure of the module. These evaluations were also used to make further adjustments. The participants were also asked to indicate how they would rate the CBL module. The content of the final CBL module is summarized in Table 2.

2.4. Phase 4: Validation of the CBL module

The effectiveness of the wrist arthroscopy CBL module was tested in a randomized controlled trial. Twenty-eight medical students were enrolled. All students received an invitation via e-mail and a VARK questionnaire that they were asked to complete and return. VARK is a questionnaire that provides users with a profile of their learning preferences [6] (www.vark-learn.com). These relate to their preferred strategy for information uptake, which can be through visual, audible, written or action cues. The students were randomized into two groups using manual covariate adaptive randomization, trying to achieve a balance between the groups with respect to age, gender and VARK score [7]. Group A contained students who were assigned to use the CBL module and Group B contained students who were assigned to listen to a pre-recorded lecture. The demographic features of the 28 participants and their VARK scores are given in Table 3.

All participants performed the experiment in a 30-station computer laboratory within our hospital. Every student received a headphone. The participants were asked to take a pre-test containing 12 multiple-choice (MC) questions on wrist arthroscopy. Group A went through the CBL module and Group B watched the pre-recorded lecture on wrist arthroscopy, made

by the same authors who constructed the CBL module and containing the same information. Compared with the pre-recorded lecture, the CBL module contained animations and interactive elements, and offered the possibility to go through the presented material at the participants' own pace. They were also able to go backwards and forwards through the presented material. Directly after the learning instruction, both groups completed a knowledge post-test containing 12 MC questions. All participants were invited back after one week to repeat the test, but with slight changes to the 12 MC questions. By asking the participants to take an immediate post-test and another test one week later, we were able to analyze the short-term and the medium-term effects of both teaching modalities. Every correct answer to the knowledge test was counted as 1 point; consequently, a maximum of 12 points per test could be obtained by each of the participants. The post-test also contained three questions about the satisfaction rate with the proposed method of learning (on a 0–10 nominal rating scale). The results of the tests were processed using the Mann-Whitney U test for the test results and for the pleasantness score, and the Chi-Square test for the comprehensibility score.

3. Results

The response rate to the electronic survey that was sent using Google Docs to 185 members of the EWAS was 35% (65 out of 185). One reminder was sent. Fifty-five of the 65 respondents (85%) indicated that they felt a computer program could be an asset for teaching wrist arthroscopy skills. The participants' remarks and suggestions are summarized in Table 1.

The CBL module was designed as described in the Methods section.

The feedback received from the panel of novices is summarized in Fig. 1. The results show a high satisfaction rate and 100% of the participants indicated that they would advise their fellow residents to use this CBL module if it was available in their hospital.

The validation study showed that the results of the post-test immediately after the intervention (CBL or lecture) were significantly better than the results of the pre-test (Mann-Whitney U test, $p = 0.021$). The second post-test did not show a significant difference (Mann-Whitney U test, $p = 0.194$).

Group A performed significantly better (Mann-Whitney U test, $p = 0.044$) on the post-test directly after the intervention

Table 2

Summary of the computer-based E-learning module for wrist arthroscopy.

Récapitulatif du module d'enseignement électronique de l'arthroscopie du poignet.
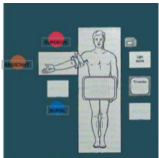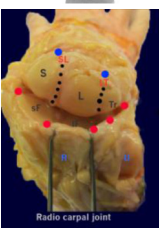
Chapter	Subjects	Example of a slide
Indications	Diagnostic Therapeutic	
Patient positioning	Patient positioning on the table Animation of the positioning in the OR	
Traction	How do you prepare the patient? Why is traction necessary? How can traction be applied?	
Instruments	Which instruments do we use? How do you prepare the instrument table?	
Portals	Which portals can we use? What are the most frequently used portals? Which anatomical structures should we take care of?	
Entry procedure	Creation of the portals (Animation) Use of the instruments	
Radio-carpal anatomy	Identification of the intra-articular anatomy of the wrist	

Table 3

Demographic features of the students in the validation study.

Données démographiques concernant les étudiants de l'étude de validation.

	VARK score[a]				Gender[b]		Age
	V	A	R	K	M	F	Mean
CBL module	0	4	4	6	3	11	24.4
Lecture	1	4	3	6	4	10	24.2

V: visual; A: aural; R: read/write; K: kinesthetic; M: male; F: female.

[a] Distribution of the students' learning preferences in the two groups.

[b] Distribution of the students' gender in the two groups.
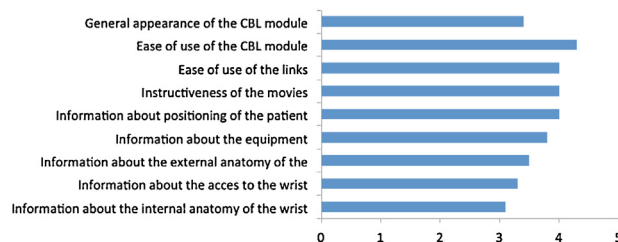

Fig. 1. Scores (mean) on the survey among the novices in the last round of comments. A 1–5-scale was used in which 1 meant a negative association and 5 meant a positive association.

Scores (moyens) de l'enquête auprès des novices dans la dernière série d'observations. Une échelle de 1 à 5 a été utilisée dans laquelle 1 signifie une association négative et 5 une association positive.
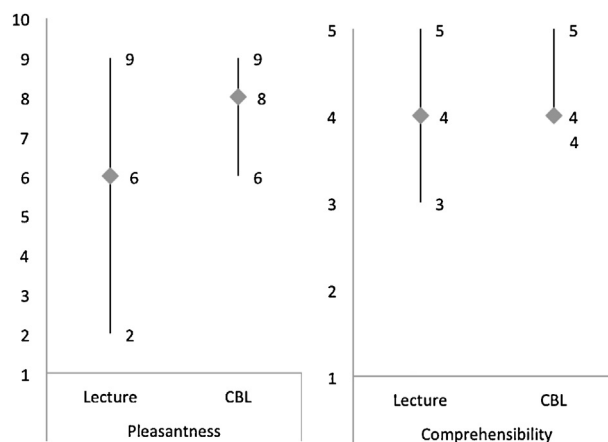

Fig. 2. Satisfaction scores (median, min and max) in the validation study among students. For pleasantness a 1–10-scale was used in which 1 was negative and 10 was positive. For comprehensibility a 1–10-scale was used in which 1 was negative and 5 was positive.

Scores de satisfaction (médiane, minimum et maximum) dans l'étude de validation parmi les étudiants. Pour la satisfaction, une échelle de 1 à 10 a été utilisée dans laquelle 1 était négatif et 10 était positif. Pour la compréhensibilité, une échelle de 1 à 10 a été utilisée dans laquelle 1 était négatif et 5 positif.

compared with Group B. After one week results were equal (Mann-Whitney U test, $p = 0.194$).

The participants of Group A indicated a significantly higher level of pleasantness when studying the material compared with Group B (Mann-Whitney U test, $p = 0.015$). Furthermore, the CBL group scored significantly higher on the score for comprehensibility (Chi^2 test, $p = 0.045$). Both scores are shown in Fig. 2. The students in the lecture group rated the duration of the lecture as too long, whereas in the E-learning group the time was rated as adequate.

4. Discussion

By using a modification of the Delphi method, consensus could be established between experts concerning the content of a CBL module for wrist arthroscopy. The future users, i.e. the residents, were positive about their satisfaction rating of the CBL module. This CBL module did improve the learning outcomes in the immediate post-intervention test. However,

this knowledge level was not maintained after one week. As in many other studies, the superiority of one modality over the other is not supported [8–10].

The results of the survey among the EWAS members showed a high percentage of respondents who felt that a CBL module would be an asset. However, we realize that the low response rate (35%) could have introduced a bias. Possibly the surgeons who are interested in education or in introducing new technologies would have been more inclined to respond to the questionnaire.

To achieve our goal of developing a module that would be supported by a group of experts, a variation of the Delphi method was used. The advantage of this way of developing a CBL module is that users can rely on the contents and the module has already been endorsed by a group of experts who can promote its use among their fellow workers.

The basis for a valid CBL module is a successful merging of content and design. The content of the CBL module was secured as described above. The importance of design was shown by Levinson's group. They showed that a higher degree of learner control may in fact reduce the effectiveness of learning and that the presentation of multiple views to the learner may impede learning, particularly for those with relatively poor spatial ability [11]. For our CBL module we chose for a flexible system with chapters that allows users to go backwards and forwards in the content, as this was suggested by the residents during the evaluation, but with one strategy in order to avoid misconceptions by the learner. Furthermore, animations with voice-over illustrating skills such as the positioning of the patient and the introduction of the trocart were provided. Ridgeway et al. showed the addition of aural files enhances an application's face validity, and user results upon modular examination increased significantly [12].

We evaluated the concept of the CBL module by testing it within our user group, who were residents in training for either plastic or orthopedic surgery. This evaluation yielded mostly minor changes to both the content and design of the module. The high satisfaction rate that was found appears to be in concordance with that of other studies [13–15]. Lee found that all of the students endorsed CBL and participants preferred CBL, in most cases without providing any data to support this preference [5].

This study shows that the CBL module does improve the learning outcomes in the immediate post-intervention test, but it appears that these differences in outcome were not sustained longer than one week. Apparently, the fact that students are in a more actively engaged learning mode stimulates information uptake. However, as with much new knowledge, it does not remain if the tested population does not employ this knowledge through further practice to stimulate memorization and concept building. We did not find any literature analyzing the long-term effect of CBL learning. The advantage of a CBL module is that it can be instantly available, allowing the residents to go through the information just before using it in clinical practice. This will improve the memorization of the proposed information.

We concede that many confounding factors can influence the results of such a comparative study, but most of the critical points were addressed in the study design. Firstly, we chose medical students at the same level of their studies to ensure that they had the same level of knowledge of wrist arthroscopy (level 0). Because the groups were small, the participants were matched on those criteria that could influence the results of the test (age, gender, learning type). Participants completed both a pre-test and a post-test. The pre-test was used to validate the test itself. If the score on the pre-test was higher than the expected score based on gambling odds, it would mean that the answers to the questions were too obvious. However, not one of the questions was answered correctly by all participants.

In this study, the control group received the same information as the CBL group but presented in a more passive way, through a pre-recorded lecture. The use of a pre-recorded lecture avoids the bias introduced by the interaction between the presenter and the audience.

In the post-test for the medical students, we did include three questions about the satisfaction rate with both the content and presentation of the CBL and the lecture, and with the adequacy of the time available for completion. The satisfaction rate was higher in the CBL group. Interestingly, the students in the lecture group rated the duration of the lecture as too long, whereas in the E-learning group the time was rated as adequate. Both the E-learning group and the lecture group received the same amount of time for the intervention, and the same amount of information was presented to both groups. Perhaps students feel that time moves slowly when they are passively involved compared with active involvement. Several authors have tried to confirm the superiority of E-learning over more conventional ways of teaching. In a meta-analysis Sandars found that E-learning had a greater impact on learning than no intervention, but a wide variation was present when E-learning was compared with more traditional approaches [16], as there are a lot of different forms of E-learning as well. Hugenholtz et al. found no significant difference between two groups of occupational physicians comparing E-learning with lecture-based learning [17], similar to what we found in the second post-test. In a review performed by Letterie, 210 papers were identified on the subject of computer-based learning but only 23 of those reported on comparative studies. In the 12 studies comparing traditional learning with computer-based learning, five showed an improved test performance after CBL and seven studies showed no difference [18].

In the relevant papers, E-learning seems to follow from computer technology developments instead of being developed to fill a void. As Cook and McDonald describe it: ''Shortly after the advent of the computer, educators began using this powerful tool to facilitate learning'' [19]. Arguments in favor of E-learning were found to support the development of E-learning facilities [20]. As Cook and McDonald state: ''E-learning is only a tool – a powerful tool indeed, but not an end in itself'' [19]. As such it will not replace face-to-face education. In order to elevate E-learning above the level of ''information behind glass'', interactive and multimedia elements should be used. Furthermore, the information should be easily accessible worldwide and should be easy to update [21].

5. Conclusion

Starting from the assessment of the necessity for such a tool, via the gathering of information for the content, a CBL module for wrist arthroscopy was designed. This design process led to a useful tool, which is supported by a panel of experts.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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