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Original article

# Design and evaluation of a new synthetic wrist procedural simulator (Wristsim®) for training of distal radius fracture fixation by volar plating

## *Évaluation d'un simulateur synthétique 3D (Wristsim®) pour l'entraînement à l'ostéosynthèse par plaque antérieure des fractures de l'extrémité distale du radius*

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A B S T R A C T

Legislation concerning workload of surgical trainees and pressure to reduce learning curves have forced us reconsider surgical training. Our goal was to evaluate a synthetic procedural simulator for teaching open reduction and internal fixation (ORIF) of distal radius fractures (DRF). Twenty surgeons used a synthetic procedural simulator (Wristsim®) made by 3D printing for ORIF of DRF with a volar plate (Newclip Technics®). The evaluation consisted of grading the simulator's realism compared to the surgeons' own experience with surgery on cadavers. The Wristsim® was graded 5.10/10, compared to 8.18/10 for the cadaver specimen for introduction of the plate under pronator quadratus. For fracture reproduction, Wristsim® scored 6.40/10, with the cadaver specimen scoring 7.15/10. For fracture reduction, Wristsim® scored 5.62/10, with the cadaver specimen scoring 7.38/10. Plate application was scored 7.05/10 for Wristsim® and 8.23/10 for the cadaver. Drilling was scored 6.60/10 for the Wristsim® and 8.23/10 for the cadaver. Screw fixation was scored 7.40/10 for the Wristsim® and 8.12/10 for the cadaver. Our results demonstrated that Wristsim® is still inferior to a cadaver specimen for teaching ORIF by volar plating of DRF. A new model of Wristsim® is being developed that will address shortcomings in pronator quadratus thickness, passive ROM in flexion/extension and bone size.



*Mots clés :*
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R É S U M É

La réglementation sur la diminution du temps de travail des internes et la pression assurancielle sur la diminution de la durée de la courbe d'apprentissage incitent à revoir la formation chirurgicale. Le but de ce travail était d'évaluer un simulateur chirurgical pour l'apprentissage de l'ostéosynthèse des fractures de l'extrémité distale du radius (EDR). Vingt chirurgiens ont utilisé un simulateur chirurgical synthétique (Wristsim®) issu de la technologie d'impression 3D pour ostéosynthéser une fracture de l'EDR par plaque antérieure (Newclip Technics®). L'évaluation consistait à noter de 0 à 10 le réalisme du simulateur par rapport à l'expérience des chirurgiens sur cadavre. Le réalisme moyen de l'introduction de la plaque sous le carré pronateur était de 5,10/10 avec le Wristsim® et de 8,18/10 avec le cadavre. Le réalisme moyen de la fracture était de 6,40/10 avec le Wristsim® et de 7,15/10 avec le cadavre. Le réalisme moyen de la réduction de la fracture était de 5,62/10 avec le Wristsim® et de 7,38/10 avec le cadavre. Le réalisme moyen de l'application de la plaque était de 7,05/10 avec le Wristsim® et de 8,23/10 avec le cadavre. Le réalisme moyen du forage du radius était de 6,60/10 avec le Wristsim® et de 8,23/10 avec le cadavre. Le réalisme moyen de la fixation des vis sur la plaque était de 7,40/10 avec le Wristsim® et de 8,12/10 avec le cadavre. Les résultats de notre étude montraient que le Wristsim®

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utilisé pour l'apprentissage de l'ostéosynthèse à foyer ouvert d'une fracture de l'EDR par plaque antérieure était inférieur au cadavre. Une nouvelle version du Wristsim® est à l'étude, corrigeant notamment l'épaisseur du carré pronateur, la mobilité passive du poignet en flexion/extension, et la taille de la cartouche.



## 1. Introduction

During the second half of the 20th century, surgical training was most often delivered by buddy learning at the patient's bedside or in the operating room (OR). Since the beginning of the 21st century, regulations on the workload of trainees [1] and pressure to reduce their learning curve [2] have modified our views on training. Dupuytren's famous quote "see a lot, do a lot, read little" [3] is no longer adequate and is replaced by the following concept: "never on a patient the first time" [4].

Theoretical learning for our trainees is mostly computerized [5,6], while practical training is performed in labs using simulators [7–10]. Numerous simulators have been developed for general and bowel surgery [11] but a few only for orthopedic surgery [12–18] (Table 1). For wrist surgery, only arthroscopy teaching has been tested both theoretically [19] with computers and practically with simulators [20].

The goal was to verify whether a procedural simulator (Wristsim®) for practical training in open reduction and internal fixation (ORIF) by volar plating of the distal radius fractures (DRF) was comparable to fresh cadavers.

## 2. Material and methods

Twenty surgeons from 11 countries (Austria, Columbia, France, Iran, Ireland, Poland, Russia, Turkey and UK) took part in the study. There were 16 males and 4 females.

A 3D synthetic procedural simulator (Wristsim®, Biomodex™, Paris, France) was used to fix DRF A2.2 or C1.2 in the AO classification [21]. The procedural simulator was produced using 3D printing techniques with different tissues, each with realistic mechanical properties, to create a model wrist based on wrist MRI and CT scans (Fig. 1). The Wristsim® model corresponded to the distal fourth of the forearm and hand; it was secured by a jack that could be locked in any given plane to a tablet laying on an OR table (Fig. 2). The illumination fixed to the tablet reproduced normal OR lighting. The forearm model was hollow and could accommodate a cartridge reproducing the fractured distal radius and surrounding tissues. The distal radius was radio-opaque (Fig. 3).

A single-use volar DRF plate and its instrumentation (InitialR®, Newclip™, Haute Goulaine, France) was used to fix the fracture in the Wristsim®.

The operation was performed the same way by all surgeons. Everyone had an assistant to fix A2.2 or C1.2 fractures by open reduction through an anterior Henry approach. After fixation, AP and lateral X-rays were obtained with a fluoroscope (Orthoscan®, Ziehm-EU™, Nürnberg, Germany).

All participants had to grade the Wristsim®'s realism and their own experience with cadaveric surgery on a scale of 0 to 10 (where 0 = not at all realistic to patient situation and 10 = identical to patient situation). The following six steps had to be graded:

- ease of introducing the plate under pronator quadratus (PQ);
- perceived reproduction of the fracture according to the AO;
- perceived performance of final reduction;
- perceived performance during plate application to the radius;
- perceived performance during distal radius drilling;
- perceived performance during screw fixation to the plate.

Statistical analysis compared the means of the six unpaired discontinuous variables. Given the small size of our sample, older measurements of *P* values were not reliable. We thus turned to newer methods of Bayesian analysis. These measure the distribution of the T coefficient and then calculate the probability of observing a difference. This method defines with greater power a probability between 0 and 1, which is more precise than a binary response with a *P* value larger or smaller than 0.05. If the interval of the T coefficient did not contain 0 and the probability was superior to 97.5%, the difference was considered significant.

## 3. Results

Analytical results are presented in Tables 2 and 3.

Overall, mean perceived reproduction during plate introduction under the PQ was 5.10/10 with the Wristsim® and 8.18/10 with the cadaver. The T coefficient interval did not contain 0 and the probability that plate introduction was better in the cadaver was 100%.

Mean fracture reproduction based on the AO classification was 6.40/10 with the Wristsim® and 7.5/10 with the cadaver. The T coefficient interval contained 0 and the probability that the fracture reproduction was better in the cadaver was 79%. The probability was not sufficient to conclude to that one group was superior to the other.

**Table 1**
Simulators used for general and orthopedic surgery training.

| General surgery | Orthopedic surgery |
|---|---|
| Surgical Education Platform (SEP®; SimSurgery™, Oslo, Norway) | Knee Arthroscopy Surgical Trainer, ArthroSim®, (Touch of Life Technologies™, Aurora, CO, USA) |
| Robotic Surgical System (RoSS®; Simulated Surgical Systems™, San Jose, CA, USA) | Sheffield Knee Arthroscopy Training System, SKATS® (Smith & Nephew™, London, UK) |
| dV-Trainer (Mimic™, Seattle, WA, USA) | VirtaMed ArthroS® (VirtaMed™, Zurich, Suisse) |
| da Vinci Skills Simulator (dVSS®; Intuitive Surgical®, Sunnyvale, CA, USA) | Arthro Mentor® (Sibionix™, Cleveland, Ohio, USA) |
| RobotiX Mentor (3D Systems®, Simbionix Products™, Cleveland, OH, USA) | Simendo Arthroscopy® (Simendo™, Rotterdam, the Netherlands) |
| ProMIS simulator (CAE Healthcare™, Montréal, Canada) | Trauma Vision simulator® (Swemac Orthopaedics™, Linkoping, Sweden) |
| | Toltech Knee Arthroscopy Simulator® (Touch of Life Technologies™, Aurora, CO, USA) |
| | InsightArthroVR® Arthroscopy Simulator (GMV™, Madrid, Spain) |

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