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Influence of surgeon expertise on the duration of approach and closure during osteosynthesis of distal radius fractures

Laurine Cafarelli¹, Camille Graëff^{2,3}, Thomas Lampert¹, Nicolas Padoy^{1,2}, Nicolas Meyer⁴, Dabbagh Armaghan⁵, Laela El Amiri¹, Philippe Liverneaux^{1,3}

¹ Department of Hand Surgery, Strasbourg University Hospitals, FMTS, 1 avenue Molière, 67200 Strasbourg, France

² IHU, Institute of Image-Guided Surgery, Strasbourg University Hospital, FMTS, University of Strasbourg, Strasbourg, France.

³ ICube CNRS UMR7357, Strasbourg University, 2-4 rue Boussingault, 67000 Strasbourg, France

⁴ Department of Public Health, Strasbourg University Hospital, FMTS, GMRC, 67091 Strasbourg, France 67200, 1 avenue de l'hôpital, 67000 Strasbourg cedex, France

⁵ Faculty of Health Sciences, Western University, London, Ontario, Canada

Corresponding author:

Liverneaux Philippe

Department of Hand Surgery, Strasbourg University Hospitals, FMTS, 1 avenue Molière, 67200 Strasbourg, France

philippe.liverneaux@chru-strasbourg.fr

Ethical Approval:

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Strasbourg University Hospitals.

Consent to participate:

Informed consent was obtained from the patients included in the study.

Consent to Publish:

The authors affirm that human research participants provided informed consent for publication of the videos.

Authors Contributions:

All authors contributed to the study. Conception and design (Laurine Cafarelli, Thomas Lampert, Nicolas Padoy, Philippe Liverneaux). Material preparation, data collection and analysis were performed by Camille Graëff, Laela El Amiri. The first draft of the manuscript was written by Philippe Liverneaux, Laurine Cafarelli and Camille Graëff. Statistics (Nicolas Meyer). Language editing (Dabbagh Armaghan). All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Philippe Liverneaux has competing interests with Caresyntax®. None of the other authors have competing interest

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Abstract

Background

The aim of this study was to determine whether the duration of the approach (PII) and closure (PV) phases for minimally invasive osteosynthesis of distal radius fractures (MIPO) varied according to the surgeon's level of expertise.

The main hypothesis was that the PII or PV duration was inversely proportional to the level of expertise.

Methods

The method measured the duration of PII and PV for 50 videos of MIPO operated by one surgeon with level 3^E expertise, three with level 4^E and one with level 5^E. The videos were viewed to identify any technical errors.

Results

The average PII duration was 3min 8s for level 5^E, 4min 7s for 4^E and 6min 19s for 3^E. Average PV duration was 2min 12s for level 5^E, 2min 36s for 4^E and 2min 41s for 3^E. The average duration of PII+PV was 5min 20s for level 5^E, 6min 37s for 4^E and 9min for 3^E. These findings indicate that both PII and PV duration was the longest in the level 3^E surgeons' practice.

Six technical errors were identified for level 3^E and 4^E during PII (hemostasis control, multiple incisions, instrument handling, improper use of the fluoroscope, time-outs) and PV (intradermal reattachment).

Clinical relevance

The main hypothesis was verified since the duration of PII or PV was inversely proportional to the surgeon's level of expertise.

This study identified technical errors in hand surgery practices of new surgeons. By early identification and correcting these minor errors, it would be possible to speed up the learning curve. We recommend surgical videos to be systematically recorded and analyzed to improve hand surgery practices.

Type of Study/Level of Evidence: Therapeutic/Level IIIa

Key words: operative time; surgical video; approach; closure; expertise; distal radius fracture

Introduction

The duration of a surgical procedure depends on many factors, including the difficulty of the pathology [1] and the surgeon's expertise [2]. A surgical procedure can be divided into several phases [3]. The duration of some of these phases does not depend on the pathology or its difficulties, such as the approach and closure. Whereas it mainly depends on the surgeon's expertise [4].

Concerning minimally invasive osteosynthesis of distal radius fractures (MIPO), some authors have shown that there are 5 phases: installation (PI), approach (PII), fixation (PIII), verification (PIV), closure (PV) [5]. The duration of the PII and PV phases should not depend on the type of fracture.

In this context, this study aimed to verify whether the duration of PII and PV varied from one surgeon's level of expertise to another or from one MIPO osteosynthesis to another.

This study aimed to explore whether the duration of PII and PV was different according to the surgeon's level of expertise or the type of MIPO osteosynthesis.

The primary hypothesis was that the approach or closure duration was inversely proportional to the surgeon's level of expertise during MIPO osteosynthesis. The secondary hypothesis was that it was possible to identify technical errors potentially responsible for the lengthening of these times.

Materials and methods

The local ethics committee approved the conduct of this study (CE-2021-159).

The material included 50 videos of five right-handed surgeons. The level of expertise of the five surgeons in MIPO osteosynthesis was 3^E for one surgeon, 4^E for three surgeons and 5^E for one surgeon [4]. Fracture fixation was performed using a minimally invasive plate osteosynthesis (MIPO) technique, which allows the pronator quadratus to be respected by sliding the plate underneath [6]. The 50 MIPO osteosynthesis videos were viewed on a dedicated software platform (qvident[®], Caresyntax[™], Boston, Massachusetts, United States). Videos were recorded by an HD camera integrated into the scalytic (TruVidia[™] Wireless[®], TRUMPF Medizin Systeme GmbH + Co. KG[™], Saalfeld, Germany). The 50 MIPO osteosynthesis videos were divided into 5 phases by a surgeon level 5^E [5], the boundaries of which were defined in Figure 1. The PII began as soon as the scalpel appeared in the operating field and ended as soon as the plate appeared in the operating field [5].

The assessment method consisted of two main parts, which were 1) measuring the duration (in minutes) of the surgical approach (PII) and closure (PV) phases, and 2) observing the videos to identify technical errors qualitatively.

The statistical analysis compared the mean durations of phases II, V and II+V as a function of the surgeons' level of performance. Given the small size of our sample, the old "frequentist" methods, expressed as p-values, have little power. In this work, Bayesian analysis methods were used, as they are more powerful in detecting the probability of observing a difference. Bayesian analysis yield a probability ranging from 0 to 1, which is more precise than a binary answer of $p < 0.05$ or $p > 0.05$. A probability of difference of confidence

intervals between two groups of more than 90% corresponds to a small difference, of more than 95% to a large difference, and of more than 97.5% to the equivalent of a very large difference. All analyses were performed using R software version 3.1.0 and JAGS.

Results

Quantitative results are presented in Figures 2 and 3, and Table I.

The mean PII time was 3min 8s for the level 5^E surgeon, 4min 7s for the level 4^E surgeons and 6min 19s for the level 3^E surgeon. In almost all cases in the sensitivity analysis, the procedure times were longer in levels 3^E and 4^E than in level 5^E since the probability of the time being longer is high in almost all cases. On the other hand, the two levels, 3^E and 4^E, are almost equal. The probability of the duration being longer in level 3^E than in level 4^E is low, even though the durations are in the expected order.

The mean PV time was 2min 12s for the level 5^E surgeon, 2min 36s for the level 4^E surgeons and 2min 41s for the level 3^E surgeon. In all cases of sensitivity analysis, we can see a low probability that the average time to complete phase 5 is longer in one of the 3^E and 4^E levels than in the 5^E levels. Similarly, there is a low probability that the average duration will be longer in level 3^E than in level 4^E. On the other hand, the averages are in the expected order, with the duration being lowest for the level 5^E surgeon and longest for the level 3^E surgeon, with an intermediate value for level 4^E surgeons.

The average duration of PII+PV was 5min 20s for the level 5^E surgeon, 6min 37s for the level 4^E surgeons and 9min for the level 3^E surgeon. In all cases of sensitivity analysis, there is a very high probability (or high in one case) that the time taken to complete the two phases is longer in levels 3^E and 4^E than in levels 5^E. The average duration of level 3^E is not always distinguishable from the average duration of level 4^E, as the probabilities are generally low.

On the qualitative side, viewing the video identified six technical errors that increased the duration of PII and PV. During PII, the least-experienced surgeons lost time hemostasizing peripheral veins, did not incise the skin or fascia in one go but did so several times, regularly changed instruments, misused the fluoroscope, and paused for a few seconds. During PV, the less experienced surgeons sometimes repeated the intradermal overjet several times.

Discussion

The greater the surgeon's expertise, the better the clinical results [7], the greater the precision of the gestures [8-11] and the shorter the operating time [12-14]. Our results are in line with those reported in the literature regarding operative time. Overall, the approach or closure duration was inversely proportional to the surgeon's level of expertise during minimally invasive osteosynthesis of distal radius fractures. Authors have shown the opposite: there was no correlation between the surgeon's level of expertise and the total duration of osteosynthesis of distal radius fractures [15]. This study was biased because the types of fractures were very heterogeneous. However, other studies have shown that the difficulty of the surgical procedure increases the operative time [1].

Differences in phase duration between surgeons were more marked in PII than in PV. One reason could be that the number of technical errors was greater in PII (n = 5) than in PV (n = 1). The level 3^E surgeon did not make several incisions, whereas the other surgeons made a single incision. The level 5^E surgeon respected the vascularity, which may explain why he didn't waste time on haemostasis, unlike less experienced surgeons. Incision of the antebrachial fascia requires an infracentimeter incision with a scalpel, followed by proximal and distal sectioning with scissors. Only the level 5^E surgeon did not change hand instruments during this maneuver. In addition, the level 3^E surgeon incised and cut the fascia in several movements. Unlike the level 5^E surgeon, the others regularly paused for a few seconds, which is impossible to explain from the videos. Furthermore, unlike the level 5^E surgeon, the others sometimes used the fluoroscope when it was unnecessary during PII. It should only be used during the fixation (PIII) and verification (PIV) phases to check fracture reduction, plate position and screw length (add reference). Less-experienced surgeons sometimes had to repeat the intradermal overlay several times, probably because of imperfect contact between the skin edges.

From a methodological point of view, the present study had some limitations. For example, not all operators had the same number of videos; in particular, the level 5^E surgeon had only one. The total number of videos was not large enough to obtain consistently significant results, although there was a trend in favor of the level 5^E surgeon. The videos were annotated by a single person who was not a surgeon. Some authors have shown that there is inter-individual variability in video annotation [16]. Not all expertise-level groups included the same number of surgeons.

The primary hypothesis was verified since the approach or closure duration was inversely proportional to the surgeon's level of expertise during minimally invasive osteosynthesis of distal radius fractures. The secondary hypothesis was also verified since it was possible to identify technical errors responsible for these lengthened times.

In conclusion, whatever the distal radius fracture type, the approach and closure duration is inversely proportional to the surgeon's expertise. This study identified the technical errors that need to be corrected in less experienced surgeons to facilitate the learning curve. Surgical videos should be systematically captured and analyzed to improve surgical practices.

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Legend of figures

Figure 1. Phases with their beginning and their end for the 50 videos of distal radius fracture fixation.

Figure 2. Videos of minimally invasive osteosynthesis of distal radius fractures (abscissa) versus duration (ordinate) for 5 surgeons (ABCDE).

(a) Phase PII.

(b) Phase PV.

(c) Phases PII+PV.

Figure 3. Percentage of mean duration of minimally invasive osteosynthesis of distal radius fractures by 4 surgeons (BCDE) versus level 5^E surgeon (A).

(a) Phase PII.

(b) Phase PV.

(c) Phase PII+PV.






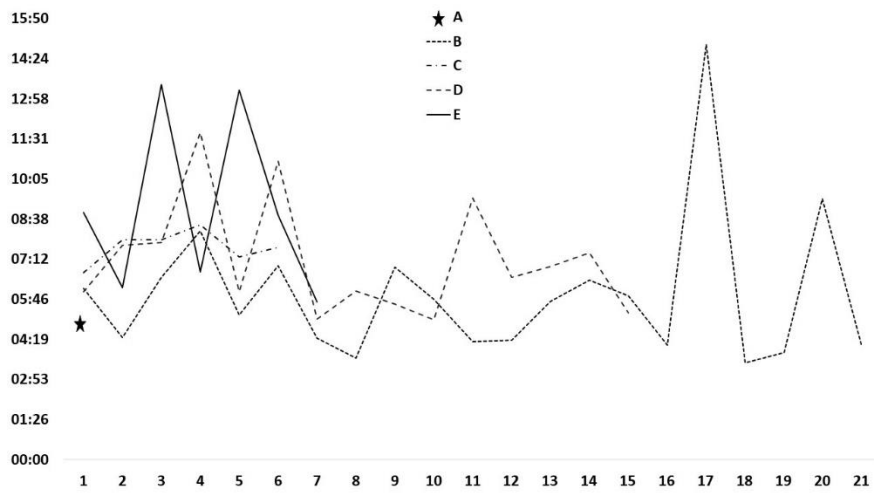
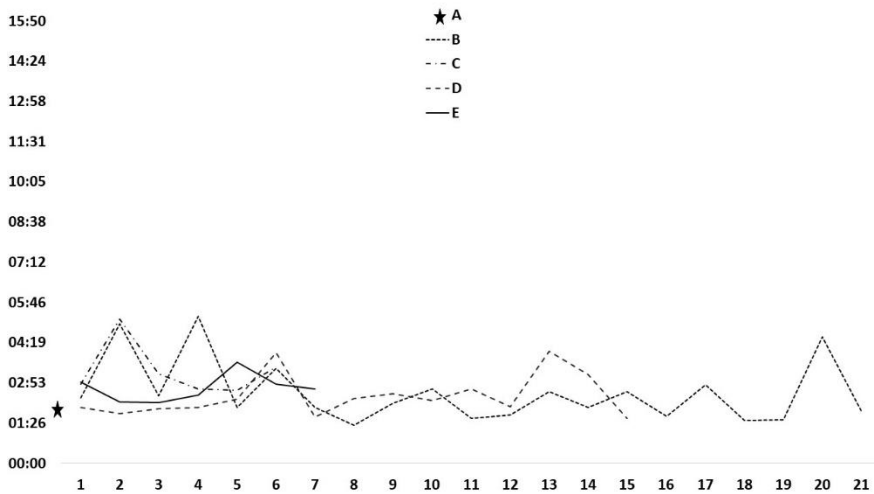
Phase	Image	Beginning	End	
I	Installation		Beginning of the video	Beginning of the approach phase
II	Approach		Apparition of the scalpel	Beginning of the fixation phase
III	Fixation		Beginning of the introduction of the plate subphase	Beginning of the verification phase
IV	Verification		First image, after the last moment when the surgeon touched the proximal screws, where neither surgical instruments nor operator's hands are visible	Beginning of the closure phase
V	Closure		Apparition of the Adson-forceps and the needle with the needle holder	Section of the last suture with the scissors

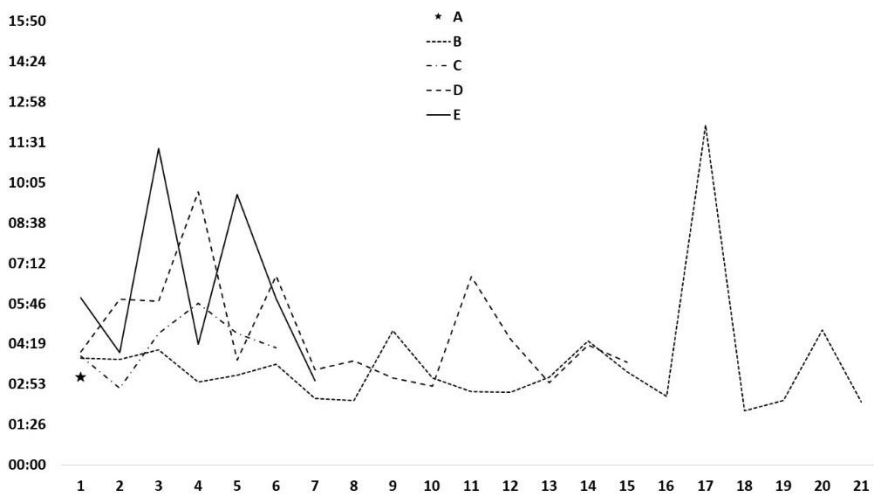
Figure 1. Phases with their beginning and their end for the 50 videos of distal radius fracture fixation.



a



b



c

Figure 2. Videos of minimally invasive osteosynthesis of distal radius fractures (abscissa) versus duration (ordinate) for 5 surgeons (ABCDE). (a) Phase PII. (b) Phase PV. (c) Phases PII+PV.

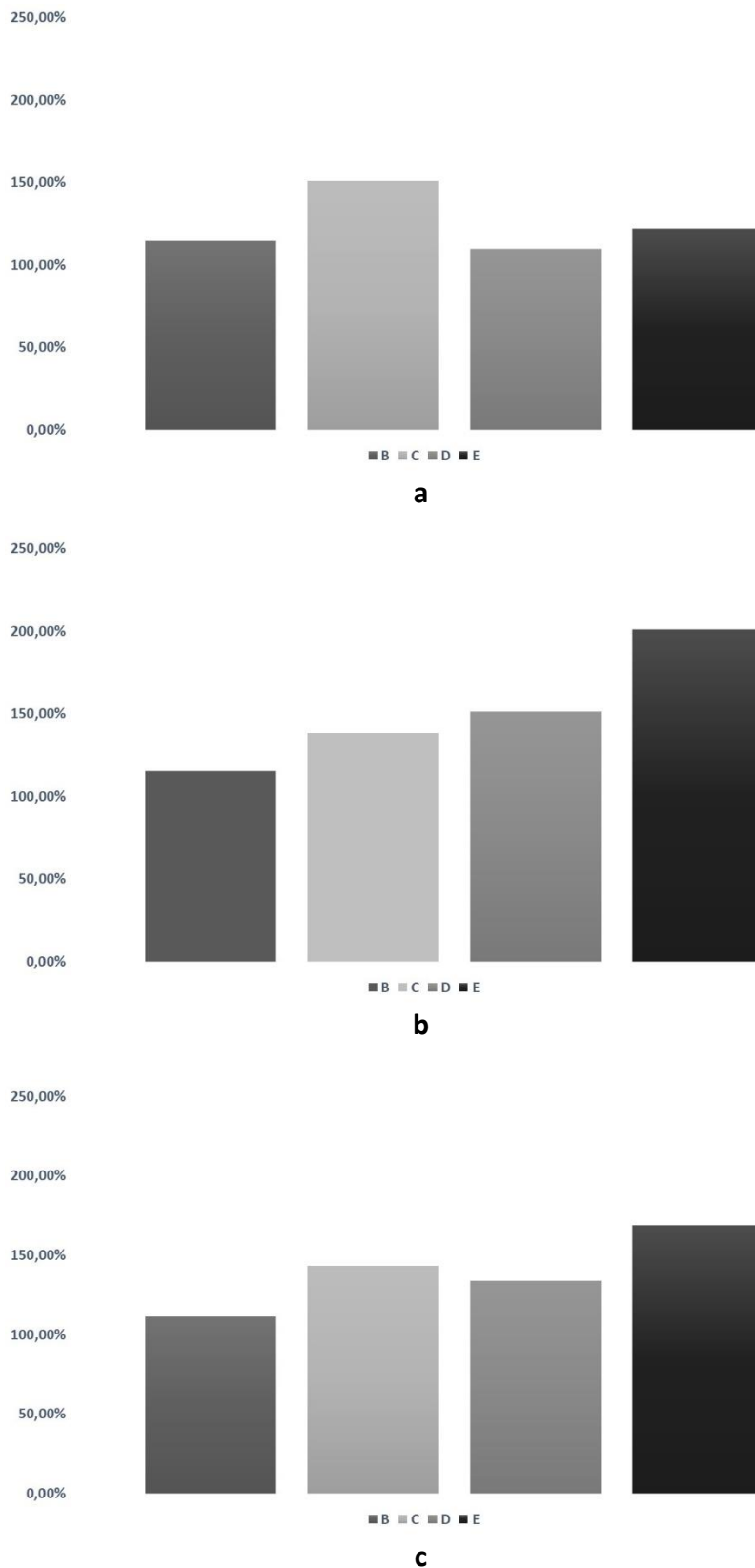


Figure 3. Percentage of mean duration of minimally invasive osteosynthesis of distal radius fractures by 4 surgeons (BCDE) versus level 5^E surgeon (A). **(a)** Phase PII. **(b)** Phase PV. **(c)** Phase PII+PV.