

# Early versus Delayed Surgical Treatment in Open Hand Injuries: A Paradigm Revisited

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## Abstract

**Background** To date it remains unclear if a delayed surgical treatment of open hand injuries after more than 6 h may be detrimental to outcome. Previous investigations by McLain et al. (J Hand Surg Am 16:108–112, 1980 [9]), Nylen and Carlsson (Scand J Plast Reconstr Surg 14:185–189, 1991 [10]) could not find statistical proof of correlation between infection rate and delayed surgical treatment after open hand injuries up to 18 h. The current study was designed to investigate the outcome of early versus delayed surgical treatment after open hand injury.

**Patients and methods** A retrospective data analysis of all patients sustaining an open hand injury between January 1 and December 31 2006 was performed. Patients with

incomplete data records were excluded. Patients were stratified according to time delay of surgical treatment and injury complexity. Complications, revision rate, and functional outcome were also investigated.

**Results** Between January 1 and December 31 2006 a total of 458 patients with open hand injuries were treated at the University Hospital of Berne, Switzerland. The records were retrospectively analyzed and a subgroup of 100 patients were randomly determined for standardized follow-up evaluation. There were no significant differences regarding infection, complication, and revision rate between early (<6 h) and delayed (6–24 h) surgical treatment of open hand injuries. Independently from the time point of surgical treatment, patients with complex injuries and longer operative times had an increased infection rate ( $p = 0.05$ ) and revision rate ( $p = 0.003$ ).

**Conclusions** Delayed surgical treatment (6–24 h) of open hand injuries did not increase infection or revision rates in open non-devascularizing hand injuries.

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## Introduction

Will the delayed surgical treatment of open hand injuries after more than 6 h influence the outcome in a negative manner? In the historical literature [1] general surgical treatment was requested within 6 h after trauma to prevent wound infections. However, this standard was established before the introduction of prophylactic antibiotic therapy [2]. In general trauma studies, investigations of open lower limb fractures showed no correlation between infection rate and delayed surgical treatment up to 24 h [3–8]. In more recent hand injury related literature, McLain et al. [9] reported 11% infection rates in open fractures of the hand, but they found no differences between early and delayed treatment. Neither did Nylen

and Carlsson and McLain et al. [9, 10], who reported an overall infection rate of 16% when investigating tidy and untidy hand injuries. As a consequence, an overall outcome assessment of both simple and complex hand injuries with a delay to surgery of up to 24 h appears necessary.

The goal of the present study was to retrospectively investigate the outcome of early versus delayed surgical treatment after open, non-devascularizing hand injuries up to 24 h post-trauma.

## Patients and methods

Analysis of all patients treated for open hand injuries at the University Hospital of Bern, Switzerland, between 1 January and 31 December 2006 was performed according to regulations of the Institutional Review Board. Exclusion criteria were incomplete records, amputation or devascularizing injuries, and minor age patients. Records were retrospectively analyzed and a prospective, standardized telephone lead patient survey, relying on Patient-Rated Wrist Evaluation (PRWE) [11], was conducted in 100 randomly determined patients.

The following parameters were recorded: demographic data, injury localization and type, number of injured structures, time point of trauma and start of operation, operative time, infections, complications, number of revisions, and follow-up period. “Simple injuries” were defined by injury of the skin and just one additional structure (i.e., tendon or nerve); “complex injuries” were defined by two or more injured structures. Patients were stratified according to time delay of surgical treatment, injury complexity, and causes of injury.

**Table 1** Number of patients in dependency of time delay of surgical treatment and injury severity

Time delay (h)	All patients <i>n</i> = 100	Simple injuries <i>n</i> = 41	Complex injuries <i>n</i> = 59
<6	52	23	29
>6–12	28	11	17
>12–24	14	4	10
>24	6	3	3

**Table 2** Infection and wound healing disorder rate in dependency of time delay of surgical treatment and injury severity

Time delay (h)	<i>p</i> Value, all patients <i>n</i> = 100 (%)		<i>p</i> Value, simple injuries <i>n</i> = 41 (%)		<i>p</i> Value, complex injuries <i>n</i> = 59 (%)		<i>p</i> Value, simple vs complex
<6	8 (15.4)		4 (17.4)		4 (13.8)		ns
>6–12	2 (7.1)	ns	1 (9.1)	ns	1 (5.9)	ns	ns
>12–24	2 (14.3)	ns	0 (0)	ns	2 (20.0)	ns	ns
>24	2 (33.3)	ns	1 (33.3)	ns	1 (33.3)	ns	ns

Following admission to the emergency department, all patients were treated with an immersion hand bath (50% Octenisept®, 50% normosaline). Furthermore, all patients except those with simple, clean cuts received antibiotic coverage: amoxicillin/clavulanic acid 2.2 g or cefuroxime 750 mg intravenously on admission, and that dose was repeated every 8 h until the operative procedure. A second dose was administered intravenously if the operative time exceeded 240 min, followed by oral therapy for 5–7 days. The affected hand was immobilized upon admission until surgery and postoperatively depending on the repaired structures. Depending on injury severity, the follow-up time varied between 3 and 6 months.

Statistical analysis was performed with SPSS (Release 18.0.03, 2010). Group differences were analyzed with Fisher’s exact test and Student’s *t* test, as appropriate. Pearson’s correlation coefficient or the Spearman correlation test and linear and logistic regression analysis were performed. A *p* value of 0.05 was deemed to be statistically significant throughout the study.

## Results

During the study phase 458 patients met the inclusion criteria. The included subgroup of 100 patients underwent standardized follow-up evaluation with no exclusion. The mean age of the patients was 52 years (range: 20–81 years). Eighty-two patients were men (82%) and 18 women (18%).

Among the recorded mechanism leading to open hand injury, sharp lacerations were the most frequent (35%), followed by 26 injuries with milling machines or saws (26%), 24 blunt traumata (24%), and 15 other injuries (15%). Neither the mechanism of injury nor the area of injury had an influence on any of the outcome parameters.

According to the above definition, 41 injuries were simple (41%) and 59 injuries were complex (59%); 52% of injuries were treated within 6 h (Table 1).

The overall observed infection rate including wound healing disorders was 14%. There was no significant difference in infection rate in early (<6 h) versus delayed (>6 h) surgical treatment of open hand injuries, both in simple and complex injuries (Table 2). Neither age nor number of injured structures influenced the incidence of

**Table 3** Revision rate in dependency of time delay of surgical treatment and injury severity

Time delay (h)	<i>p</i> Value, all patients <i>n</i> = 100 (%)		<i>p</i> Value, simple injuries <i>n</i> = 41 (%)		<i>p</i> Value, complex injuries <i>n</i> = 59 (%)		<i>p</i> Value, simple versus complex
<6	13 (25)		2 (8.7)		11 (37.9)		0.01
>6–12	6 (21.4)	ns	2 (18.2)	ns	4 (23.5)	ns	ns
>12–24	1 (7.1)	ns	0 (0)	ns	1 (10.0)	ns	ns
>24	1 (16.7)	ns	0 (0.0)	ns	1 (33.3)	ns	ns

infection. An increase in infection rate related to the duration of the operative procedure was observed in complex injuries but not in simple injuries ( $p = 0.02$ ).

There was no influence of early versus delayed surgical treatment on the incidence of revisions (Table 3) in both simple and complex injuries. The frequency of revision was, however, significantly higher in complex injuries than in simple injuries (17 of 59 = 28.8% vs. 4 of 41 = 9.8%;  $p = 0.03$ , OR 3.74 [confidence interval 1.16–12.13]). Longer initial operative times were associated with a higher number of revisions ( $p = 0.006$ ) in complex injuries but not in simple injuries.

The frequency of all complications (including infections and revisions) was higher in complex injuries than in simple injuries (22 of 59 = 37.3% vs. 9 of 41 = 22.0%), but this difference did not reach statistical significance. There was no influence of early versus delayed surgical treatment, nor injury localization, or causes of injury, or age on the incidence of complications. Complex regional pain syndrome was diagnosed in two patients (2%) and was unrelated to the treatment time point.

The recorded operative time was significantly longer in complex injuries than in simple injuries (156 vs. 52 min;  $p < 0.0001$ ) and was associated with the number of injured structures ( $p < 0.0001$ ,  $R^2 = 0.441$ ), but not with the time point of surgical treatment.

The overall outcome, as measured by the PRWE score, was independent of early or delayed surgical treatment. Mean PRWE score was significantly lower in simple versus complex injuries (6.2 vs. 12.2;  $p = 0.03$ ). Operative time ( $R^2 = 0.231$ ), age ( $R^2 = 0.3$ ), and number of injured structures ( $R^2 = 0.380$ ) predicted the PRWE score ( $p < 0.001$ ). The semiquantitative analysis of hand function following open hand surgery revealed statistically an influence of operative time ( $p < 0.0001$ ,  $R^2 = 0.439$ ), age ( $p = 0.009$ ,  $R^2 = 0.208$ ), and number of injured structures ( $p < 0.0001$ ,  $R^2 = 0.240$ ).

## Discussion

The historically conveyed time limit of less than 6 h for surgical treatment of open injuries still has worldwide

acceptance [1]. However, routine prophylactic antibiotic therapy, improved suture and osteosynthesis material, as well as perioperative management and improved knowledge of soft tissue handling has decreased the infection rate dramatically [2, 4, 5]. Delayed treatment of open hand injuries may occur for a number of reasons, like delay in transportation to a tertiary treatment center, important co-morbidities in multiple trauma patients, or limitations of operating room availability, in which hand trauma has a lower priority than life-threatening conditions. Because these factors are unlikely to change in the future, current quality management concepts and patient safety require an investigation into the paradigm of 6 h limit to hand surgery. That was the basis for the current evaluation.

This retrospective single-center study revealed no outcome-disadvantage between the classical early surgical treatment (<6 h) and delayed surgical treatment (>6 h) in patients with open hand injuries in terms of infection rates, complication rates, and functional outcome. Unrelated to the delay of surgery, the outcome was found to be significantly influenced by the patient's age, number of injured structures, as well as duration of surgery.

The main features of the study population were comparable to other hand injury studies [9, 10]. The observed overall infection rate was 14% in this study and thus comparable to the above-reported infection rates (16 and 11%).

The current observations on time-dependent surgical treatment of open hand injuries paralleled the findings of Nylen and Carlsson, which showed no differences in infection rates by delayed surgical treatment up to 24 h post-trauma. Nylen and Carlsson [10] investigated delay-dependent bacterial counts and infection rates in tidy versus untidy hand injuries, but they did not stratify by injury complexity or examine the functional outcome. The investigations of McLain et al. [9] were limited to open hand fractures but did not include simple or complex soft tissue injuries, which occur more frequently. The potential "cut-off" point in the benefit/deficit calculation of delayed surgery could not be precisely deduced statistically because of the small number of patients in their study who were treated after 18 h, which is comparable to treatment after 24 h delay in the present study. The presented observations

are further supported by other studies on delayed treatment of open fractures [7, 8].

The additional value of the present study lies in the assessment of two important outcome parameters (revision rates and the functional outcome as measured by the PRWE score). These too, remained independent of the time-point of surgical treatment, showing thus no overall disadvantage in delayed surgical treatment. The clinical impact of the observed statistically significantly poorer outcome in three patients undergoing extremely delayed surgery (>24 h) is difficult to ascertain due to the very low patient numbers in this group. This result requires future in-depth, prospective investigation.

Further results of this study revealed a statistical correlation between poorer outcome and complexity of the injury, also reflected in the length of the operation. This was true also for the functional outcome measured by PRWE, which was significantly poorer in complex injuries than in simple ones, independent of the delay to surgery.

The limitations of the present study are the retrospective setting and the low number of patients—especially in the long delay treatment groups (>24 h). Both limitations affect the statistical power of observations made beyond 24 h post-trauma. Nevertheless, the results of this exploratory retrospective study are encouraging, showing so far no outcome disadvantage for patients undergoing delayed treatment of open, non-devascularizing hand injuries. These observations may well improve prioritization algorithms, avoid unnecessary rush, and allow patient transfer to centers where optimal therapeutic conditions are available and specialized surgeons can perform the necessary procedures.

## Conclusions

In the present study, the delayed surgical treatment of open, non-devascularizing hand injuries showed no disadvantage

in measured outcome variables including infection, revision and function as compared to early treatment. These observations support the concept of specialized center treatment for these injuries, for which an unavoidable delay of up to 24 h may be accepted. Further prospective investigations into the changing paradigm of the 6 h limit to surgery are warranted.

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