

# Time Management of Open Lower-Leg Fractures in Morocco

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## Abstract

**Background:** It is recommended that the management of open lower-leg fractures should occur within six hours to avoid complications affecting both prognosis and functionality. This study aimed to evaluate the time taken for each step of management, identify causes of delay, and propose solutions to reduce the rate of complications. **Patients and methods:** This was a prospective study involving 153 patients treated from January 2011 to December 2012. Standardized data collection forms documented the times taken for each management step from the accident until surgical intervention. **Results:** For patients admitted directly to our institution, median time to surgical debridement from arrival was 5 hours. Median time for bone fixation was 24 hours. External fixation was used in 119 patients. There were several causes of delay; lack of financial resources was the most common. Certain causes of delay were significantly correlated with time to debridement. However, although 86.7% of patients who developed an infection had a time from injury to debridement greater than six hours, there was no statistically significant association between infection and delay beyond six hours ( $p = 0.403$ ). **Conclusion:** By identifying causes of treatment delay, we hope to be able to avoid complications, and therefore reduce the socio-economic impact of these important surgical emergencies.

## Keywords

Open Fracture, Lower-Leg Fracture, Chu Ibn Rochd, Casablanca

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## 1. Introduction

Open fractures of the lower-leg are an orthopaedic emergency. Ideal management includes antibiotics and pro-

phylaxis against tetanus and thromboembolic disease, debridement and irrigation within six hours, followed by operative fixation [1]-[3]. However, this is not always achieved in the central university hospital (CUH) of Casablanca; Non-availability of fixation material in our hospital requires us to prescribe the required equipment for the patient, and delay bone fixation pending purchase of that equipment. In 1987 a series of 70 patients treated at the orthopedic trauma service of the University Hospital of Casablanca reported times to bone fixation from one week to one month [4]. It is not known whether this has improved since.

Many authors, especially in similar contexts to our own, have addressed the issue of open lower-leg fractures and their complications, but the actual times of each management step and potential causes of therapeutic delay have not yet been elucidated.

This study aimed to evaluate the time taken for each step of management, identify causes of delay, and propose solutions to reduce the rate of complications.

## 2. Materials and Methods

This was a prospective study of 153 patients treated at Orthopaedic Trauma Department of Casablanca, over a period of 24 months (January 2011 to December 2012). During this time, 765 extremity fractures were received. (Open lower-leg fractures made up 20% of the traumatic pathology in our orthopedic department during the period of study). We included all patients aged at least 15 years with open lower-leg fracture, admitted directly to our institution or transferred from a regional hospital without prior care, who received surgical treatment. Exclusion criteria: patients with lower-leg fractures treated conservatively; open-from-within fractures that had been closed on arrival to hospital; patients who died before surgery.

### 2.1. Normal Flow of Patients in CUH

The normal flow of patients in our institution involves the patient being transported into the closest hospital to the accident scene. Once in hospital; the patient receives necessary first aid treatment and is either admitted there or transferred to CUH. If CUH is the closest hospital, the patient gets admitted directly without having to go through another health centre. If the patient is transferred or evacuated from another health centre to the CUH, his admission into CUH is described as indirect. Once in CUH, patients are assessed by the general physician on duty, and prioritized for diagnostic imaging and further management according to clinical urgency. Occasionally imaging needs to be repeated if of insufficient quality on first attempt. Once adequate imaging is achieved, the physician refers the patient for review by relevant specialists before admission and definitive management as appropriate. If present, the patient's family and friends will assist him throughout his hospital stay. If bone fixation is required, the necessary materials are prescribed (intramedullary nail or external fixation) and the patient is admitted pending operation, until the materials have been purchased. Nursing staff work in eight hour shifts with handovers at 2 pm, 7 am and 8 pm. During Ramadan work is nearly completely suspended between 7 - 8 pm while the fast is broken.

In Morocco the cost of fixing depends on the type of fixation material: Hoffmann: 500 Euros; Ilizarov: 1200 Euros; Orthofix: 3000 Euros; intramedullary nail: 200 Euros.

### 2.2. Data Collection

Data were collected using a standardised survey form, documenting the times taken for each management step from patient arrival to each stage of treatment. In addition, time to debridement was also calculated from the time of injury. Eight time-points were studied: arrival, request for radiography, completion of radiography, hospitalization, debridement, prescription of fixation material, purchase of fixation material, bone fixation.

### 2.3. Ethics

Patients or their relatives gave informed consent to be part of the study.

### 2.4. Statistical Analysis

Data were entered and analyzed using SPSS 16.0 and  $p < 0.05$  was considered significant. Chi-squared test, t-test, analysis of variance (ANOVA), and nonparametric tests as appropriate, were used to determine the factors

influencing the time taken to debridement and bone fixation. Multivariate analysis was performed by binary logistic regression.

### 3. Results

#### 3.1. Age, Sex and Etiology

Patients were aged between 15 and 75 years, with a median age of 26.92.2% were male. The most common etiology was public road accident (86.7%), followed by high-level falls 10.6% and assaults 2.7%.

#### 3.2. Mode of Transportation and Time of Admission

39.9% of patients were admitted directly to the emergency room without going through another health facility. Non-paramedic ambulances were the most frequent method of attendance (90%). Other means of transportation included private cars. Median time of arrival was two hours from injury scene (range 0.25 to 17 hours). Median time for direct arrival at our institution was 0.75 hours (range 0.25 to 2.5 hours).

All patients were admitted through the emergency room. Haemodynamic shock requiring ICU admission was present in 3.6% of our patients.

Grades of wound according to the Cauchoix and Duparc classification [5] are detailed in **Table 1**. 60/153 patients had associated injuries: other fractures (9 cases), head injuries (40 cases) and chest injuries (11 cases).

Radiological assessment included anteroposterior and lateral radiographs of the lower-leg, including both knee and ankle. Pelvic and chest x-rays were routinely performed following road traffic accidents. Other radiological assessments depended on the injuries identified. Median time to initiation of diagnostic imaging was 0.5 hours (range 0.25 to 3 hours). Median time to completion of diagnostic imaging was 2 hours (range 0.5 to 3 hours).

#### 3.3. Treatment

Median time to admission to the orthopaedic unit was five hours (range 1 to 22 hours). Median length of hospital stay was five days (range 3 to 53 days). Initial debridement consisted of washing with antiseptic solution and saline. Surgical exploration defined the grade of injury, removed debris, foreign bodies, and excised devitalized bruised areas. Median time of debridement was five hours (range 1.5 to 6.5 hours). Median time of debridement from the injury scene was seven hours (range 2 to 22 hours). Median time to prescription of fixation material was 24 hours (range 1 to 72 hours). Median time to purchase fixation material was 24 hours (range 0.5 to 144 hours). Median time for bone fixation was 24 hours (range 20 to 168 hours).

External fixation (EF) was used in 119 patients (77.8%) intramedullary nailing (IN) in 34 (22.2%). Median time for bone fixation using an external fixator was 24 hours, and median time of fixation using intramedullary nailing was also 24 hours.

#### 3.4. Causes of Delay in Care

There are multiple factors associated with surgical delay including both patient and system-specific variables. Patient factors include the presence of haemodynamic instability, associated traumatic injuries, and lower-leg skin condition. System factors include timing of arrival to the definitive treatment center, and hospital efficiency and protocols for management including: unavailability of care givers, team changeovers, radiographic equipment breakdown, striking by medical staff, breaking the fast during Ramadan, needing to repeat radiography, and lack of financial resources. In our study, lack of financial means was the leading cause of delayed care for patients (**Figure 1**).

Statistical analysis showed significant associations between the time from injury to debridement and patient flow ( $p < 0.05$ ); unavailability of medical staff ( $p < 0.05$ ); and type of material used ( $p < 0.05$ ). There were no other statistically significant associations with debridement or bone fixation times (**Table 2**).

#### 3.5. Infection Rates

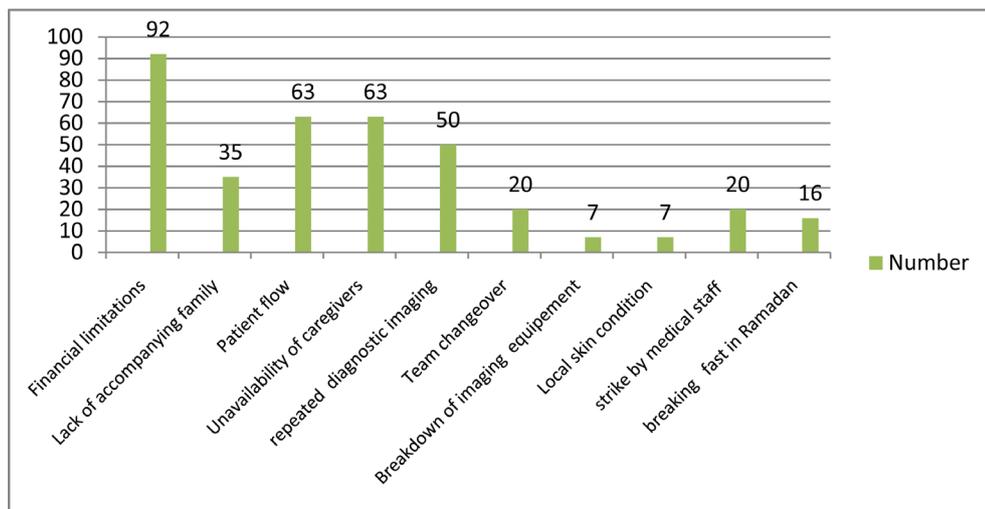
15 Patients were infected during hospitalization or within two weeks of operation; 86.7% of patients with infection had a time from injury to debridement greater than 6 hours (**Table 3**).

**Table 1.** Distribution of patients according to Cauchoix and Duparc grade.

Wound type	Clinical appearance	Number (%)	Percentage
TYPE I	Punctate or small linear wound, without peeling or bruising. Can be sutured without tension	98	64
TYPE II	Contused wound edges, or detached or bruised surrounding skin. Some risk of secondary necrosis	50	33
TYPE III	Significant skin loss. Unable to suture without tension. High risk of secondary necrosis.	5	3

**Table 2.** Statistical analysis (ANOVA 1) of factors associated with arrival to debridement time (ADT), with injury to debridement time (IDT) and with bone fixation time (BFT).

Factors	<i>p</i> values		
	ADT	IDT	BFT
Material use	0.695	0.000 230	0.097
Cutaneous opening type	<0.001	<0.001	0.876
Lack of financial	0.545	0.289	0.730
Unavailability of care givers	0.387	0.03	0.101
Radiographic down	0.368	0.615	0.546
Strike of medical staff	0.596	0.892	0.095
Repeat radiographic	0.750	0.180	0.975
Change of team care	0.683	0.496	0.494
Break fasting (ramadan period)	0.378	0.945	0.739
Lower-leg local cutaneous conditions	0.665	0.739	0.479
Absence of accompanying	0.115	0.885	0.566
Patients flow	0.387	0.03	0.101



**Figure 1.** Causes of delay in care.

However, the association of a greater than 6 hour delay from injury to debridement with infection was not statistically significant ( $p = 0.403$ ).

**Table 3.** Infection in relation to injury to debridement time (IDT).

	Number of patient	Percentage (%)
Time from injury to debridement < 6 h	2	13.3
Time from injury to debridement > 6 h	13	86.7

## 4. Discussion

### 4.1. Epidemiology

In a study from CUH Brazzaville [2] that included 122 open lower-limb fractures, more than half involved the lower-leg. Court-Brown [3] studied 2386 open fractures between 1995 and 2007, and found 267 open lower-leg fractures (11.2%). Open lower-leg fractures are frequent injuries.

The median age of our patients and the age distribution were consistent with other studies [3] [5] [6]. Open fracture of the lower-leg particularly involves young people. Males are by far the most affected [3] [5] [7].

The most common etiology is public road accidents. Zryouil [4], 26 years earlier in the same department, also found public road accidents were the majority etiology with a rate of 71%. Similarly, Moyikoua [2] found that public road accidents were the main cause (56%), followed by assault (23%) and falls (6%) and other causes (15%). Be *et al.* [8] published rates for public road accidents (83%), sports injuries (7%), assault (7%) and falls (3%).

### 4.2. Type of Skin Incision

In our series the most common type of open fracture were Duparc and Cauchoix type I followed by type II and type III. Zryouil [4] found 18.5% type I, 37.1% type II and type III 44.2%. On the other hand, Moyikoua [2] found that type II were the majority (46 cases), followed by type I (21 cases) and type III (11 cases); Be [8] reported only Type II (42 patients). CM Leong [9] found similar numbers of type 1 and 2 (32 and 31 cases respectively) followed by type III (17 cases).

### 4.3. Collection and Admission

Non-paramedic ambulance was the most common mean of transportation (90%). By contrast, in a study conducted at the University Hospital of Brazzaville [2], most patients arrived at hospital by car, taxi, or motorcycle.

In France, it is usual practice for their pre-hospital service (SAMU, Service d'Aide Médicale Urgente) to stabilize patients at the accident site before transport to a health facility. SAMU mobilises units (SMUR, Service Mobile d'Urgence et Reanimation) to the scene of an accident. SMUR mobile units can be quick light vehicles, ambulances and helicopters [10].

In the United States, the priority is to evacuate the victim as early as possible to a hospital, using ambulances without a doctor, but with trained paramedics [10].

### 4.4. Time and Method of Admission

These parameters are linked to the mode of collection and admission [10]; they changed depending on the series. In Souna's series [11], 40% of patients arrived less than 6 hours post-injury. Namdari found that 58% of patients arrived less than 6 hours post-injury [12]. Kamat *et al.* [13] noted a median intake of 3.25 hours (62 cases). At the main hospital in Dakar [14], the median time for direct admission is 3.30 hours, with 70% arriving less than 4 hours after the accident.

### 4.5. Time Taken to Request Radiography

Hanhart [15] at the medical and surgical emergencies center in Neuchâtel, Switzerland found that median time to order an x-ray was 1 hour, this figure is less than that found in our study.

### 4.6. Time Taken to Completion of Radiographs

Likewise these parameters vary depending on the series. Time elapsed between request and completion of diag-

nostic imaging was 60 minutes at the Kremlin Bicêtre hospital [16]. In a study from CHU Farhat Hached in Tunisia [17], this period was 99 minutes.

#### 4.7. Debridement

Debridement influences the final outcome [18]-[21]. Debridement converts a dirty wound into a clean wound, removing devitalized tissue and possible foreign elements.

**The median time from injury** to debridement (IDT) is variable depending on the series and is linked with the mode of transportation and admission.

So in the series of Namdari [12], Bednar [22], Beltsios [6], Hohmann [5], Kamat [13], it was 4.9 h for 699 patients, 8.8 h for 82 patients, 10 h for 212 patients, 5.4 h for 46 patients and 4 h for 62 patients, respectively.

#### 4.8. Bone Fixation

In our study, we observed that there was time associated with prescribing the material, fixing the bone, and buying the required material after hospitalization. This was caused by the unavailability of the material used for bone fixation in our study, which consequently directly affected the time of fixation. Elsewhere in the literature, the price of bone fixation material, time of prescription, and time of purchase are not discussed. If necessary materials are immediately available in other hospital the problems we encounter will not be an issue.

Therefore the time median to bone fixation in the series of Be [8], Namdari [12], Hohmann [5], Beltsios [6] and Kamat [13] was 18 h; 4.9 h; 5.4 h; 10 h and 4 h respectively.

In comparison with other series, our time is the longest. However, this has improved slightly in 26 years since 1987 [4].

Many authors prefer nailing over external fixation for tibia fractures [23] [24]. However, there are still some absolute indications for external fixation [25] [26]: type III open fractures, those complicated by vascular damage, and those where treatment is delayed [27] [28]. In the series of Tripuraneni [29], he used external fixation in 78% of cases. This is comparable to our series.

#### 4.9. Related Injury

In Namdari's series [12] the most common associated lesions were closed head injury, thoracic injury and abdominal injury; these lesions are also found in our series.

#### 4.10. Causes of Delay in Case Management

Lack of financial resources was identified as the main cause of delay. This result is comparable to that observed in Libreville hospital center [30] where most patients were poor. Subsequent delay in purchasing equipment delays bone fixation for most poor patients. Najeb *et al.* [31] found similar results in their series. Be *et al.* [8] reported that the surgical management of trauma patients in hospitals is becoming more difficult due to the low socio-economic status of these patients and their growing numbers.

However the relationship between lack of financial resources and time to debridement or bone fixation did not reach significance ( $p > 0.05$ ). This was true too for staff unavailability, requests for repeated radiological assessment or referral for other specialist opinions.

Sima Zue [30] reported that the shortage and unavailability of staff (porters, nurses, and technicians) were frequent causes of delay. Jarrar *et al.* [17] in Tunisia showed that a large influx of patients was also a cause of delayed treatment; these two factors were also found in our series and had a statistically significant association with time to debridement and bone fixation ( $p < 0.05$ ).

Charalambous *et al.* [32] studied 383 cases with open lower-leg fractures presenting in seven hospitals in the north-west of England and found that delayed treatment of some fractures was due to the non-availability of an operating room or presentation of patients outside normal working hours when conditions may not be optimal. Namdari in the United States [12] found that the causes of delay are related either to patients (elderly patients, patients with head injury or severe chest trauma) or to the system of care (management protocol, availability of the surgeon, staff and operating room) and showed a statistically significant association between these factors and the time to debridement ( $p < 0.001$ ).

#### 4.11. Infection Rates

The infection rate in our series was not significantly related to a delay to debridement of greater than six hours. ( $p = 0.403$ ). The six-hour rule for debridement (debridement should be done within six hours of injury to avoid infection) has long been considered crucial to prevent infection [1]-[3], However it has been questioned by several authors [7] [13] [22] [33]. Twenty-one studies were reviewed by Yannascoli *et al.* [34]; three studies were found to support early debridement within 5 - 6 hours of injury, and the remaining eighteen studies found no correlation between time to debridement and rates of infection. Those series that found no association between early debridement and rates of infection suggest that lack of early administration of systemic antibiotics was the critical factor that may have impacted the need for urgent debridement within six hours.

We can then note in the series of Namdari [12], Bednar [22], Beltsios [6] and Hohmann [5] that the percentage of infection is 0% for a median time from injury to debridement [IDT] of 4.9 h; 14.6% for an IDT of 8.8 h; 17% for an IDT of 10 h and 4% for an IDT of 5.4 h, respectively.

#### 4.12. Proposed Solutions

Infection is the main complication of lower-leg fracture. The frequency of infection is estimated between 3% and 40% [9], and depends on several factors [35]-[37]. These factors include emergency management (antibiotic administration), the grade of open fracture, and the quality of debridement. In our study, we have identified several causes of delay. In view of these results we propose the following solutions: provide universal healthcare coverage; ensure the availability of emergency fixation equipment; increase staff numbers in the trauma centre; reserve blocks of operating theatre time exclusively for trauma management; raise public traffic awareness; better organization of mobile units for emergency rapid delivery of patients.

### 5. Conclusions

This study shows that delayed treatment of open lower-leg fractures at CUH is common, affecting a predominantly young and active population. Quicker intervention should be a priority. The Medical assistance scheme (RAMED), based on the principles of social assistance would be very helpful to the poor population and would participate in reducing our time delays. We need to repeat this study following implementation of these proposed solutions.

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