Injury, Int. J. Care Injured 46 S3 (2015) S13–S18

Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Standards of external fixation in prolonged applications to allow safe conversion to definitive extremity surgery: the Aachen algorithm for acute ex fix conversion

Klemens Horst[a,b], Hagen Andruszkow[a,b], Christian Weber[a], Thomas Dienstknecht[a], Frank Hildebrand[a], Ivan Tarkin[c], Hans-Christoph Pape[a]*

[a] Department of Orthopaedic Trauma at Aachen University Medical Center
[b] Harald Tscherne Lab for Orthopaedic Trauma, Aachen Germany
[c] Division of Orthopaedic Trauma, University of Pittsburgh Med. Ctr., Pittsburgh, USA

KEYWORDS

External fixation
Conversion
Definitive stabilization
Algorithm
Standard
Infection
Complication

ABSTRACT

External fixation has become an important tool in orthopedic surgery. Technology has improved the design and material as well as the construct of the fixator. As most patients are converted from external fixation to definite stabilization during later clinical course, prevention of complications such as infection is of high importance. Based on the current literature, principles of temporary external fixation were summarized. We focused on minimizing the risk of infection and introduce a standardized algorithm how to proceed when converting from external to internal fixation, which also was examined for effectiveness.

Introduction

External fixation has a long history; it was first documented by Hippocrates when he used a splint for tibial fractures [1]. The development of external fixation devices that were directly attached to the bone started in the mid-19th century [2-6]. Langenbeck was the first to describe a technique that offered sufficient stability to the fracture site in 1851 [7,8]. At the turn of the century, the concept of unilateral external fixation was invented [7,9,10]. In 1928, the swiss surgeon Raoul Hoffmann introduced an external fixation system concept that was able to provide length, alignment and rotational control in a rigid construct [11-14].

Today we encounter many clinical scenarios, where external fixators are kept in place for a prolonged time, thus increasing the risk of local infection [15,16]. The extended use of external fixation is associated with specific complications, among which pin tract infection and pin loosening are key [17-19]. As most patients are converted to definitive stabilization during further clinical course, surgeons should be familiar with a standardized algorithm to prevent possible infection from spreading to definitive stabilization.

Due to its wide range of indications, such as peri-articular fractures (i.e. pilon fractures), articular dislocation (e.g. knee/elbow) and polytrauma [20-25], external fixation stands out by its simplicity in regard to initial treatment [26] (Figure 1). Recently, an increasing rate of primary fracture treatment with spanning external fixation was observed [26] and was explained by changes in logistics, economic aspects, or an increased use of damage-control techniques [26].

For safety purposes, namely to avoid infections complications, our group developed a standardized Algorithm. Based on findings from the recent literature [27-33], the standardization of conversion from external fixation to definitive surgery was performed and the principles were summarized in an Algorithm (Figures 2 and 3)

This manuscript summarizes principles of temporary external fixation and focuses on minimizing the risk of infection. The standardized algorithm for converting from external fixation to definitive surgery was also examined for effectiveness.

Material and methods

A pilot study was performed to compare local and systemic clinical changes following the use of standardized algorithm for conversion of external fixation into definitive fracture stabilization.

Furthermore, a literature search was carried out on Medline, Embase, and Cochrane for studies on topics related to external fixation, material and design, biomechanics as well as infection and complications.

* Corresponding author at: Department of Orthopaedic Trauma at Aachen University and Harald Tscherne Laboratory, University Hospital Aachen, Pauwelsstraße 30, 52074 Aachen, Germany. Tel.: +49 241 80 89350; fax: +49 241 80 82415.
E-mail address: hpape@ukaachen.de (H.-C. Pape).

0020-1383/$ – see front matter

Fig. 1. Hoffmann® Fixator (Fa. Stryker) for spanning of a fracture dislocation of the ankle joint.

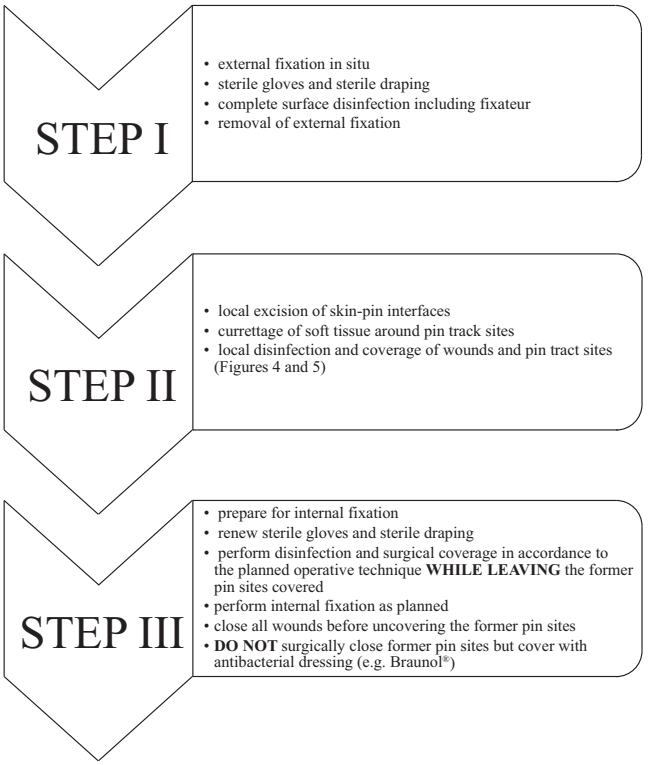

Fig. 2. Aachen Algorithm "Triple A ex fix conversion" for Acute Conversion of external fixators (Aa –A ex fix conversion).

Inclusion criteria

- Age >18 years
- Acute fractures of the extremity and pelvis requiring stabilization
- Application of external fixation

Exclusion criteria

- Age <18 years
- Amputation after extremity fracture
- Patients not amenable to surgical fixation
- Patients not cleared for conversion to definitive fixation

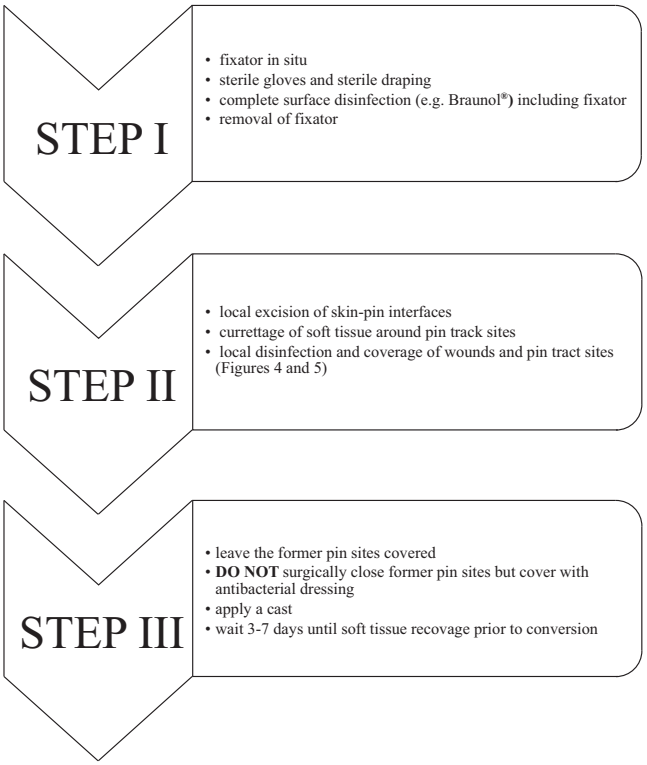

Fig. 3. Aachen Algorithm for Staged Conversion of External fixators.

Clinical documentation

Consecutive patients were documented from two different time periods.

All patients admitted to our department between the first of January 2009 and 31th of December 2009 that were treated with external fixation because of an acute injury were enrolled in this study. This group served as a historical control (group Pre-Algorithm).

The second group consisted of all patients treated with external fixation because of an acute injury between 1.1.2014 and 31.12.2014 (group Post-Algorithm).

Demographics and clinical data were drawn from the hospitals information system as follows:

- Age, gender, time of admission, surgical treatment and time of discharge
- Injury severity (Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS))
- Pre-existing immunodeficiency (i.e. cancer, HIV) or medication that negatively influences the immune system (i.e. Methotrexate®)
- Pre-existing systemic or local infection

The following complications were analyzed:

- Pin tract infection
- Local complications (i.e. wound infection, pin loosening)
- Injury to nerves and vessels
- Impaired bone healing/fracture dislocation
- Systemic complications (i.e. sepsis)
- Major complications (i.e. thrombosis, amputation, death)

Statistics

Statistical evaluation was conducted using Microsoft EXCEL® (Version 14.0, Microsoft Corporation, Redmond/USA) and