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Review Article

Systematic Review of Literature on Timing of Conversion from External Fixator to Definitive Fixation in Closed Adult Long Bone Fractures

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Abstract

Little is known about the safety in terms of timing of conversion from external fixation to definitive fixation for diaphyseal fractures of the femur and tibia in patients with multiple trauma. The timing of conversion is determined by various factors such as the patient's general condition, inflammatory response, status of soft tissue and the expertise of surgeon. The aim of this study is to review the available literature focusing on the timing of conversion from temporary external fixation of long bone fractures in multiply injured patients to definitive fixation. Our search strategy identified 30 citations in English literature of which 7 met our inclusion criteria.

Our study concluded that the ideal window for conversion from external fixation to definitive fixation is between 5 - 14 days. However, future studies are required and should comprise adequate number of patients, prospective, and compare predefined protocols with varying lengths of external fixation and interval times on clinically important outcomes.

Keywords: *Adult; Long Bone Fractures (Femur or Tibia); Closed Fracture; Conversion; External Fixation; Definitive Fixation; Intramedullary Nailing*

Introduction

Early stabilisation of closed fractures of long bones has become a major component of acute care and is a well-established practice in many trauma centres [1-4]. It has not only improved the overall functional results, but also greatly reduced mortality due to multiple-organ failure. When stabilising long bone fractures in multiple injured patients, one should preferably use minimal intervention [1]. Occasionally, diaphyseal fractures of the tibia and/or femur in the multiple injured require expeditious fixation to avoid the physiologic insult that may accompany a delayed surgical intervention [3]. At times, this may lead to the use of an external fixator as a means of stabilising the fracture to tide over this acute phase.

External fixation is associated with complications such as loss of reduction, malunion, non-union and pin tract infection [5]. If external fixation is chosen in the acute period for long bone stabilization, it is necessary to decide whether the external fixators should be kept in

place until bone has healed or whether there is scope for replacement with definitive fixation to reduce pin tract problems such as infection and loosening. The use of a definitive surgical reconstruction or fracture stabilisation must be decided based on the type of fracture and the general condition of the patient. There is no universally accepted consensus regarding the appropriate timing of conversion from external fixation to definitive operative procedures. The timing of conversion is decided based on the physiological factors and local soft tissue status of the patient [3].

Objective of the Study

The objective of this review is to examine the available evidence regarding the timing of conversion from external fixation to definitive fracture stabilization in femur and tibia shaft fractures.

Methodology

Data sources

A comprehensive literature search was undertaken to identify publications relating to the current study. The initial search was carried out on the Medline database from 1980 to the present, using the Ovid interface using the terms (long bones or femur or tibia) and (time or conversion or external fixation or definitive fixation or intramedullary nailing). These terms were searched under medical subject heading (MeSH) and text words were limited to 'Human and English language'. This was then cross-referenced with the Pub Med database. Further articles were obtained from the references list of articles already identified from the above search. Other databases including Google scholar, and Cochrane database were searched.

The systematic review was conducted as per PRISMA guidelines and is shown in figure 1.

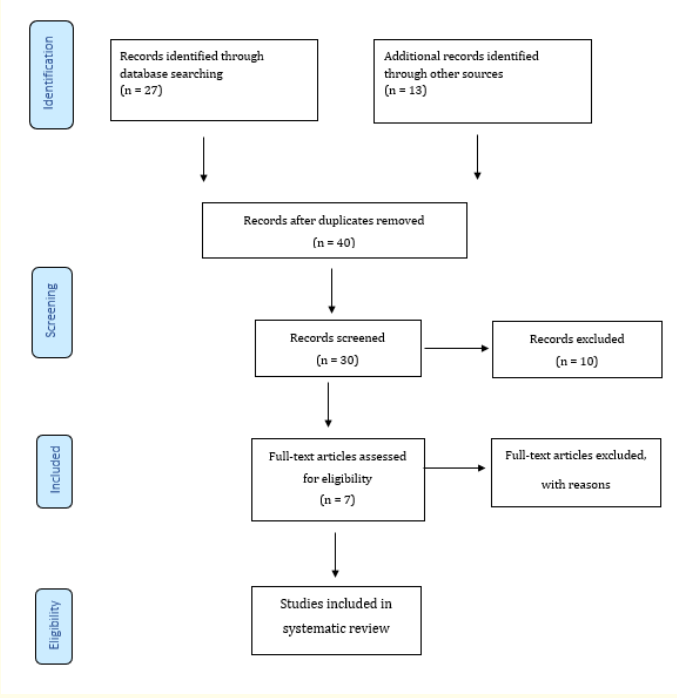

Figure 1: *The systematic review was conducted as per PRISMA guidelines.*

Study selection

Out of the 30 citations identified only seven studies were eligible to be included in the current study (Table 1).

Authors	Sample size	Design	Pin Tract Infections (%)	Time of conversion	Intervention	Outcomes
Broos PL [1]	10	Retrospective, Case series	0	21 days	Reamed Nail	FO, INF, OT, UR
Nowotarski P [3]	59	Retrospective, Non-randomized	Superficial (6.8) deep (1.8)	7 days	Nail	INF, REOP,
Scalea T [4]	43	Retrospective	2.3	4 days	Nail	INF, REOP, BL
Pape HC [6]	42	Prospective cohort study	1	5-8 days	Nail	ARDS, PI, OSM, INF
Taeger G [7]	75	Retrospective case series	6.6	13.4 days	Nail	OT, BL
Harwwod PJ [13]	98 (111 fractures)	Retrospective, Non-randomized	12.6	14.1 (median 12, Range 1-61 days)	Nail	SIRS, ARDS, MODS
Bhandari M [8]	T -125 (230), F-70 (166)	Review	36.4 (6.8 to 100)	F- 6 T- 24	Nail, N/S	INF, NU, Time of conversion

Table 1: *FO: Functional Outcome; INF: Infection, OT: Operating Time; BL: Blood Loss; REOP: Reoperation; ARDS: Acute Respiratory Distress Syndrome, MOD: Multi Organ Dysfunction Syndrome; UR: Union Rate; PI: Pin Tract Infection, NU: Nonunion; T: Tibia; F: Femur; N/S: Not Supplied; SIRS: Systemic Inflammatory Response Syndrome; OSM: Osteomyelitis.*

All the references were imported to Endnote, studies relating to paediatric long bone fractures and open fractures were excluded from this study.

Broos., *et al*. [1] treated nine patients with 10 femoral shaft fractures using an external mono-fixator device as primary fixation. All fractures were stabilized within hours of arrival at the emergency department. The average theatre time was 21 min. In eight of nine patients, the external fixator was removed an average of 21 days later and subsequently replaced by an intramedullary nail. Timing and type of device depended on the general condition of the patient and local soft tissue disorders. The average theatre time to perform the second operation was 43 minutes. In one patient, the second operation was postponed due to soft tissue complications, which resulted in a below-knee amputation. In this case, intramedullary nailing was performed 27 weeks after injury by which time an aseptic delayed union was present.

Nowotarski., *et al*. [3] reviewed 59 femoral shaft fractures managed with external fixation followed by conversion to IM nailing at an average of 7 days. Forty fractures (68%) were closed injuries. Fifty-five fractures underwent conversion to IM nailing in a single procedure. The infection rate was low (1.7%), and the 6-month union rate was high (97%). The authors concluded that immediate external fixation with early conversion to closed nailing is safe in select multiple injured patients with femoral shaft fracture.

Scalea., *et al*. [4] compared 43 patients treated initially by external fixation with 284 treated by primary intramedullary nailing of the femur. The first group was more severely injured than those treated by primary intramedullary nailing. They had a significantly higher

injury severity score (26.8 v 16.8) and a lower Glasgow coma scale (11 v 14.2 1) and required significantly more fluid (11.9 v 6.2 1) and blood (1.5 v 1.01) in the initial 24 hours. In the external fixation group, the median operating time was 35 minutes with an estimated blood loss of 90 ml compared with 130 minutes and 400 ml of blood loss in patients having intramedullary nailing. Intra Medullary nailing (IMN) was performed in 35 of 43 patients at a mean of 4 days after external fixation. The authors concluded that external fixation was a safe, viable procedure to achieve temporary rigid stabilisation in patients with multiple injuries at risk of an adverse outcome and mean period of conversion to definitive fixation was 4 days.

Pape HC., *et al*. [6] study concluded that the patients who demonstrated initial IL-6 values above 500 pg/dL, it might be advantageous to delay the interval between primary temporary fracture stabilization and secondary definitive fracture fixation for more than 4 days. In patients with blunt multiple injuries undergoing primary temporary fixation of major fractures, the timing of secondary definitive surgery should be carefully selected, because it may act as a second hit phenomenon and cause a deterioration of the clinical status.

Taeger G., *et al*. [7] conducted a study to prospectively evaluate the concept of damage control by immediate external fracture fixation (damage control orthopaedics [DCO]) and consecutive conversion osteosynthesis regarding timesaving, effectiveness, and safety. The duration of external fixation averaged 13.7 days (range, 3 - 46 days). According to the study more patients had bacteriologically proven pin-site infection without clinical significance in the damage control group (DCO) (12.6% vs. 3.7%, $P < 0.05$). This contamination rates was significantly higher within the DCO group where the external fixator was left in place for more than 2 weeks (comparing patients from the > 14 days group with those from the < 7 days and 7 - 14 days groups combined, 22.6% vs. 3.4%, $P < 0.01$). However, no such increase in the rate of clinically relevant infections was observed when comparing all three-time groups.

Bhandari M., *et al*. [8] performed an analysis of femur or tibial shaft fractures managed with planned conversion to IM nailing. Those studies in which intramedullary nails were used as salvage procedures for failure of external fixation were categorized as reconstructive procedures were excluded for the purpose of discussion. Only fifteen studies included acute femur [9] or tibial shaft fractures [10], with a total patient cohort of 453. Nine (six from tibia series and three from femur series) of the fifteen studies were excluded because of exclusion criteria. The remaining studies had a minimum of 52% and 45% open fractures in tibia and femur respectively. It is difficult to project the conclusions of these studies to patients with closed tibial shaft fractures because there were a high percentage of open fractures in all the cohorts. Nevertheless, there appeared to be a trend toward decreased infection rates in groups in which total external fixation time was ≤ 28 days, and a trend toward increased infection rates for intervals >14 days between external fixator removal and IM nailing. All but one study provided level IV evidence, and overall conclusions were graded as C, weak.

Discussion

The practice of delaying definitive fracture stabilisation to decrease the biological load posed by the operative procedure on the multiply traumatized patient is well established. The conversion from an external fixator to an intramedullary nail is a safe and viable procedure in both the femur and tibia if it is done by protocol and planned from the onset of treatment [11].

The conventional trans-osseous fixation with pins entering the medullary cavity is associated with problems such as pin loosening and pin tract infection. Together with limiting the duration of EF and associated pin tract infection, other authors achieved a high union rate and infection rate of less than 6% [12].

Literature on time of conversion from external fixation to intramedullary nailing is limited due to lack of prospective studies. Furthermore, published works focusing on a subject are also inadequate. However, the time of conversion from external fixation to intramedullary nailing has been reviewed in this study in relation to the different outcome measures as stated by the authors. In addition, it is important to understand that the issue of conversion from temporary fixation to definitive fixation arises in patients involved in poly trauma. Therefore, the time of conversion is determined by other factors such as patients' general condition, inflammatory response, status of soft tis-

sue and expertise. Nevertheless, future prospective large-scale studies are required to compare the effects of pre-defined protocols with varying lengths of external fixation and interval times on clinically important outcomes.

Conclusion

The most expedient technique for achieving temporary stability of fractured long bone is external fixation. In general, if the external fixation is in place for less than 1 to 2 weeks, conversion to an intramedullary nail appears to have low rates of associated infection. Early conversion in a single procedure appears to be associated with lower infection rates. However, with available evidence the ideal time for conversion is between 5 to 14 days. Decisions regarding the necessity of conversion, along with timing and method, should be made on a case-by-case basis. Therefore, more evidence is necessary to delineate the time of conversion from external fixation to definitive fixation and to thoroughly understand the risks and benefits involved with this conversion before definitive recommendations can be made. There is a need for a prospective, randomized, controlled trials evaluating the time of conversion from external fixator to definitive fixation.

Conflict of Interest

The authors have no conflict of interest to declare.

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