Considerations in Surgical Timing for Femoral Shaft Fractures

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ABSTRACT

Femoral shaft fractures are a common orthopaedic injury. They are generally treated with intramedullary nailing. The optimal timing of operative treatment is variable and debated. Relatively simple femoral shaft fractures can be successfully treated in less than 24 hours in most health care systems. Femoral shaft fractures can be more complicated owing to various factors, such as multiple traumatic injuries, associated conditions, etc. These more complicated femoral shaft fractures benefit from stabilization within the first 6 hours to minimize complications. Stabilization of the long bones helps achieve an upright chest position and improves pulmonary, circulatory, and musculoskeletal function. Some patients with multiple severe traumatic injuries may suffer worsening of their general condition and pulmonary status. This article reviews concepts for selecting optimal timing of intramedullary fixation of femoral shaft fractures and reviews relevant current literature.

Keywords: Femur, Intramedullary, External Fixator, Diaphyses

INTRODUCTION

The timing of fracture fixation in patients with multiple traumatic injuries is complex. Many factors play a role in the trauma team's decision-making process, specifically for the operating surgeon. The trauma team must keep in mind the risks and benefits of definitive fixation of various fractures. Numerous studies have shown that relatively simple femoral shaft fractures can be treated successfully in less than 24 hours in most health care systems (Figure 1). The literature supports either early fixation or the damage control orthopaedics (DCO) approach depending on the overall severity of the patient's presentation. Other factors influencing the optimal time for surgical fixation are the associated injuries that occur with femoral shaft fractures. This article aims to review the literature and provide guidance in the timing of fixation of femoral shaft fractures.

TIMING OF INTERNAL FIXATION

A large part of deciding the surgical timing of fixation of femoral shaft fractures depends on the associated injuries sustained during the patient's mechanism of injury. The injury severity score (ISS) is a scoring system often used to quantify the overall severity of an individual's total injury. ISS may be low in a patient with an isolated femoral shaft injury or very high (>25) in the critically injured patient with multiple traumatic injuries. The more severely injured patients have higher ISS scores. Multiple studies have attempted to examine the consequences and outcomes of early fixation of femoral shaft fractures in high and low ISS situations.

Cantu et al[1] retrospectively examined the relationship between time to definitive fixation of femoral shaft fractures, ISS score, and in-hospital mortality. In patients with an ISS score of less than 25, they found a considerably increased risk of mortality if definitive fixation was delayed beyond 48 hours. This increased risk was especially evident in patients older than 65 years.[1] Similarly, when looking at pulmonary complications and increased mortality of patients, the risk of mortality increased at the window of time between injury presentation and definitive fixation.[2] This is a risk even in patients with an ISS score above 18.[2]

DAMAGE CONTROL ORTHOPAEDICS

In the more critically injured patient, the focus needs to shift from definitive fixation, where the ultimate goal is to get patients mobilized as quickly as possible, to stabilizing the patient's major injuries quickly to allow for aggressive resuscitation. It is with this mindset that the concept of DCO was developed. DCO can often be applied when treating femoral shaft fractures in patients with higher ISS scores. This strategy aims to balance various means of fixation while respecting the patient's total level of systemic inflammation. It also aims to avoid what is often referred to as a "second-hit phenomenon," where lengthy surgical intervention introduces additional inflammatory mediators to the patient's already compromised system. A DCO approach often involves acute application of external fixation and rapid temporary stabilization in the setting of femoral

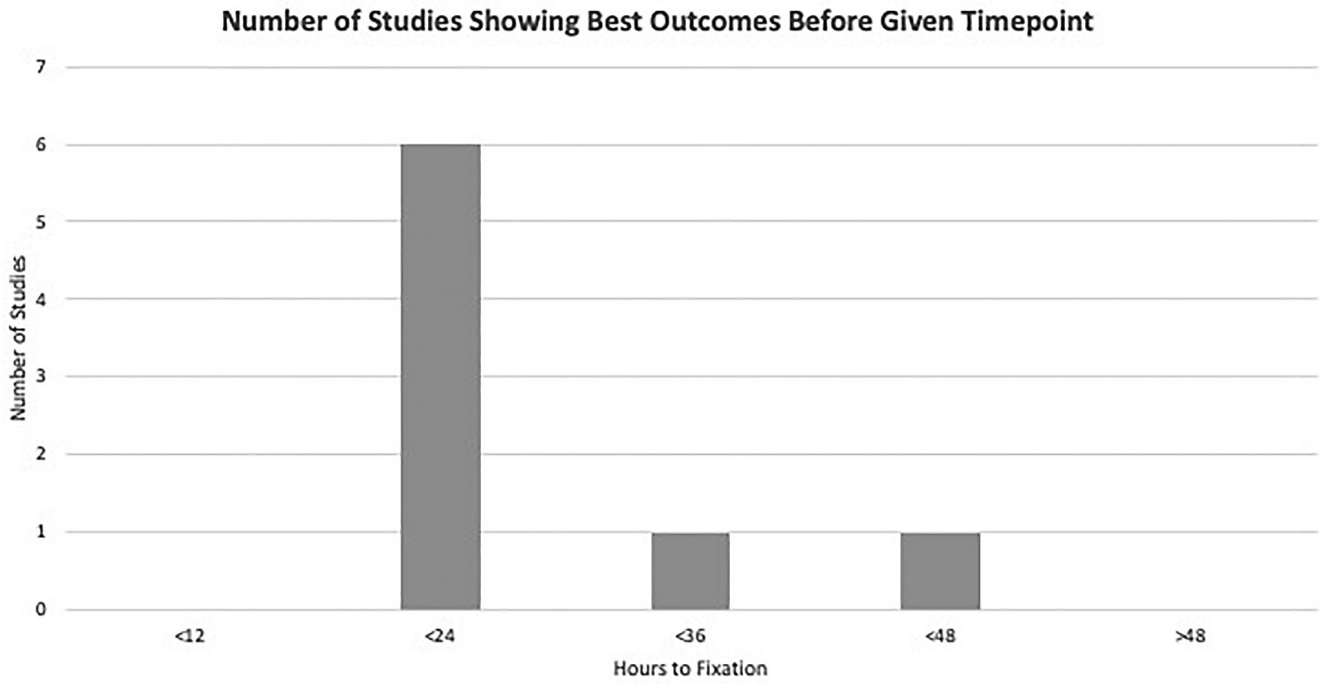

Figure 1. *Graph depicting results from a number of studies examining how much time (in hours) to surgical fixation of femoral shaft fractures resulted in the "best outcome." Note that a majority of the studies included had the best outcome with a time to fixation of less than 24 hours.*

shaft fractures. When applied appropriately, outcomes have shown to be improved in these circumstances of critical trauma.

When comparing DCO and early definitive fixation for femoral shaft fractures in patients with multiple injuries, DCO groups have considerably shorter operative times and less estimated blood loss for initial surgeries. One study showed no significant difference in the incidence of acute respiratory distress syndrome (ARDS), pneumonia, various lung scores, and total time on mechanical ventilation.[3] Although the initial fixation is often temporized in the DCO setting, the patient can be optimized to return to the operating room at a later time when they are more stable.

Delay in definitive fixation can allow time for aggressive resuscitation in the setting of more critical, systemic injury. It is difficult to quantify how much time between initial injury presentation to fixation is adequate. Morshed et al[4] published a retrospective study of over 3000 patients using data from a United States national trauma bank. They showed significant benefit when fixation was delayed at least 12 hours when compared to more immediate surgical interventions.[4]

FEMORAL SHAFT FRACTURES AND HEAD INJURY

Femoral shaft fractures often present with some degree of associated head injury owing to the high energy often associated with this fracture type. In more severe traumatic brain injury cases, surgical timing of the associated femoral fracture may be affected. A fine balance can be seen between early intervention and a delay in fixation to allow for a more adequate resuscitation. Wang et al[5] studied trauma patients that sustained a head injury and various orthopaedic fractures, including femoral shaft fractures. They found surgical intervention within 24 hours may lead to better neuropsychological outcomes at 6 months postoperatively.

Similarly, Nau et al[6] found that the presence of a head injury in patients with a femoral shaft fracture should not prevent surgical stabilization within the first 24 hours if the patient is otherwise cleared for surgery. Compared to patients with a head injury, patients without femoral shaft fractures received either a temporizing external fixator or an intramedullary nail within the first 24 hours did not have an increase in mortality, intensive-care unit stay, or total time requiring mechanical ventilation.

One thing that should be considered in this subset of patients is the possibility of increasing cerebral perfusion pressure if a reamed intramedullary nail is chosen as the mode of fixation for a femoral shaft fracture in the setting of an associated head injury. Anglen et al[7] studied 17 patients from a single center treated with intracranial pressure monitoring and a reamed femoral nail during the patients' hospital stay. They found a slight increase in intraoperative and postoperative cerebral perfusion pressure. However, the amount of increase measured was widely variable.[7] Intramedullary nailing of femoral shaft fractures has

become the gold standard and can still be used in the setting of a head injury. It has been shown that there can be an increase in cerebral perfusion pressure when reaming the medullary canal[7]. The insertion of an unreamed intramedullary nail can be considered a damage-control option if intracranial pressures are preoperatively elevated.

FEMORAL SHAFT FRACTURES AND PULMONARY INJURY

Patients sustaining femoral fractures because of higher energy mechanisms may also have some degree of thoracic/pulmonary injury. Physicians must also take this into account to not further worsen pulmonary inflammation in ARDS. They must also consider that not treating a femoral shaft fracture for an extended period poses its own pulmonary sequelae, including the risk of pneumonia and pulmonary embolism secondary to the patient being immobilized.

Nahm et al[2] retrospectively looked at 55 patients between 2010 and 2015 at a level-1 trauma center. They compared results of patients with femoral shaft fractures who received acute external fixator application versus skeletal traction application before being definitively fixated later. They found an overall shorter duration of mechanical ventilation required in the external fixation group and a 54.0% decrease in the incidence of ARDS. Likewise, Byrne et al[8] retrospectively looked at 17,000 patients with femoral shaft fractures across a national database of level-I and -II centers and found that centers that treated patients the earliest (<24 hours) had half the incidence of pulmonary embolism (1.3% versus 2.6%).

This relationship is further supported by a meta-analysis by Jiang et al[9], who looked at a total of seven retrospective studies investigating any relationships between early (<24 hours) and late (>24hours) intramedullary nailing of femoral shaft fractures and associated pulmonary complications in patients with an ISS score above 18. They found that there was no difference in the results in the incidence of ARDS, Pulmonary Embolism, pneumonia, multi-organ failure or mortality.

FEMORAL SHAFT FRACTURE PROTOCOL AND DAMAGE-CONTROL TECHNIQUES

When dealing with femoral shaft fractures, both the variability in treatment options available and the various associated injuries can complicate the timing of surgical fixation. Numerous authors have suggested implementing standardized protocols and novel techniques to deal with these complex and potentially life-threatening injuries. A more uniform treatment algorithm may be helpful to limiting unnecessary delay to fixation while taking the necessary steps to optimize and resuscitate the patient adequately in light of associated injuries.

Vallier et al[10] tested an early appropriate care protocol in which patients were treated based on the level of metabolic acidosis. Their findings showed that fractures fixed within the first 36 hours after presentation were associated with lower complications, fewer episodes of sepsis, and shorter intensive care unit length of stay. Only patients with the most severe chest injuries showed greater incidence of pulmonary complications. Overall, patients with mild chest injury still experienced fewer complications. It should be noted that this specific cohort included pelvic ring, acetabulum or spine fractures in addition to femoral shaft fractures. Byrne et al[8] also suggested that a standardized protocol in trauma centers would be beneficial in stabilizing these fractures early to prevent the pulmonary complications associated with a delay in fixation and ultimately mobilization.

As previously mentioned, the goal of DCO is to safely and effectively stabilize orthopaedic injury as quickly as possible to allow for further resuscitation. Higgins and Horwitz[11] suggested a novel attempt to combine DCO and definitive fixation with a suggested technique called “damage-control ailing.” The technique is described as inserting an unreamed nail in a retrograde fashion without proximally locking the nail. They executed this technique in five cases in which the patient was already making a trip to the operating room for accompanying injuries. They were able to stabilize the fracture in less than 30 minutes in all patients. When they deemed the patient as more stable, they returned to the operating room to either lock the proximal part of the nail or exchange the nail for a larger nail. Four of the five patients went on to heal without considerable limitation.

CONCLUSION

Femoral shaft fractures are a common orthoapedic injury occurring in roughly 10 per 100,000 patients per year.[12] Timing in surgical fixation of these fractures is complicated and influenced by many patient and institutional factors. It has been shown that early intervention should be the goal to minimize associated complications. However, multiple variables may direct the operating surgeon towards a damage-control approach, including associated head injuries, pulmonary injuries, and ISS scores. Standardized protocols similar to those already established for other injuries may aid surgeons and hospital systems to be more successful in treating femoral shaft fractures while minimizing complications as much as possible. When treated appropriately, most patients with femoral shaft fractures can be returned to mobilization within 24 to 48 hours, allowing them the best chance at a successful recovery.

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