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Original research

A comparison of primary and delayed wound closure in severe open tibial fractures initially treated with internal fixation and vacuum-assisted wound coverage: A case-controlled study

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ABSTRACT

The ideal timing of wound closure for open tibial fractures is debatable. This study aimed to compare outcomes of primary and delayed wound closure in severe open tibial fractures initially treated with internal fixation and vacuum-assisted wound coverage (VAC). Data of 80 patients with Gustilo–Anderson type IIIA and IIIB open tibial fractures treated with primary internal fixation, VAC, either primary wound closure (PWC) or delayed wound closure (DWC), and external fixation were reviewed retrospectively, and outcomes and complications compared. Patients were divided into three groups, including a PWC group ($n = 27$), DWC group ($n = 22$), and a control group ($n = 31$) that had received external fixation. Among all patients, the median age was 38 years (IRQ 32–47 years), and 67.5% were male. Injuries included 33 Gustilo–Anderson type IIIA and 47 type IIIB. Among injuries, 83% (66/80) were high-energy trauma, 63.8% were contaminated and median injury severity score (ISS) was 14 points. Significant differences were found between groups in fixation methods ($p < 0.001$). No significant differences were observed between groups in rates of deep infection, osteomyelitis, amputation and nonunion at 6 and 12 months (all $p > 0.05$), although all rates were markedly lower in the PWC group. The outcomes of PWC performed in conjunction with primary internal fixation and VAC for the treatment of Gustilo–Andersen type IIIA and IIIB open tibial fractures are similar to or better than those of DWC with primary internal fixation and VAC.

1. Introduction

Gustilo–Anderson Type III open tibial fractures are almost always the result of high-energy injuries and are associated with a high incidence of complications and morbidity [1,2]. Delayed and late amputations have been reported to occur in 9%–40% of cases [3,4]. Treatment includes administering intravenous antibiotics, meticulous wound debridement, surgical stabilization of the bone injury and early soft tissue coverage [1]. However, even though consensus appears to favor early stabilization, orthopedic surgeons and scholars continue to debate whether immediate wound closure or delayed closure is the most effective treatment for type III fractures [4]. Some authors oppose immediate wound closure on the basis that bacterial organisms remain at the site of the injury and increase risk of infection [5]. In fact, fear of infection has led to the prevailing accepted opinion that immediate internal fixation, or for that matter, *any* internal fixation of open fractures is contraindicated [6]. However, this attitude has changed markedly. Growing evidence supports early wound closure as an effective method to prevent infections [1,4,7], especially in carefully selected patients [8,9].

Recently, the development of negative-pressure wound therapy has altered the treatment of open fractures. Use of a non-adherent sponge and intermittent suction via a vacuum-assisted closure (VAC) creates a closed environment and rapidly promotes granulation tissue formation [10,11]. In addition, VAC has been shown to effectively reduce bacterial counts in wounds until definitive bony coverage can be achieved [4,11,12]. For the treatment of open tibial fractures, primary wound coverage has been considered to be critical to achieving favorable outcomes [1,7,13]. Other studies have shown that primary VAC and delayed definitive wound coverage also results in favorable outcomes [4,9,14].

It is still unknown whether primary wound closure combined with VAC can achieve improved outcomes. In addition, it is still unclear whether open wounds should be closed immediately or if

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closure should be delayed when VAC is applied immediately after internal fixation. Considering these options in the treatment of open tibial fractures, we hypothesized that the outcomes and complication rates of PWC with internal fixation and VAC would be non-inferior to those of DWC with internal fixation and VAC, and could possibly be superior. To assess the potential safety and efficacy of primary closure of severe open tibial fracture wounds, this study aimed to evaluate the outcomes of patients treated with internal fixation and VAC who received either primary wound closure performed at the time of internal fixation or delayed wound closure.

2. Patients and methods

We retrospectively reviewed the medical records of 122 patients with open tibial fractures treated at our institution between April 2005 and January 2011. The criteria for inclusion in this study were: 1) Gustilo–Anderson type IIIA and IIIB tibial shaft fractures (Orthopedic Trauma Association code 42); 2) Age $\geq$ 18 years; 3) Associated soft tissue wounds were treated with VAC; 4) Fractures were treated with internal fixation as well as external fixation methods. The exclusion criteria were: 1) Patients who received immediate amputation before any attempt at soft tissue management; and 2) patients with peripheral vascular disease, diabetes, immune dysfunction and other diseases conducive to infection. This study was approved by the Institutional Review Board of our hospital, and because patient identity was protected in this retrospective study, the requirement of informed consent was waived.

Of the 122 patients who were recruited, 80 who met the inclusion criteria were enrolled. The patients were divided into a primary wound closure (PWC) group (n = 27), delayed wound closure (DWC) group (n = 22) and a control group that had been treated with external fixation (n = 31). PWC refers to direct tension suture, skin grafting or flap transplantation together with negative pressure therapy (NPT) as an auxiliary measure performed based on soft tissue status around the wound after one-stage debridement and internal fixation. DWC refers to direct coverage of the wound using a non-adherent sponge and intermittent suction via a vacuum-assisted closure (VAC) after one-stage debridement and internal fixation; coverage is changed once every three days and final wound coverage (tension suture, skin grafting or flap transplantation) is applied about one week later depending on soft tissue status, as with primary wound coverage. External fixation involves three steps: 1) debriding necrotic tissue, 2) performing external fixation and finally 3) applying wound coverage with vacuum-assisted coverage (VAC).

Open fractures were determined when patients entered the operating room and/or *before* undergoing emergency surgery. Severity of open fracture was assessed by the Orthopedic Trauma Association (OTA) classification based on evaluation of skin injury, muscle injury, arterial injury, contamination and bone loss [15]. Gustilo–Anderson grades were determined based on wound size, depth, degree of contamination, extent of soft tissue contusion and defects, degree of crushing and peripheral circulation at the wound site. [16,17] Patients in the PWC group were treated with emergency internal fixation of fractures and single stage covering of open wounds with exposed bones using decompression suture methods (Fig. 1), or skin or flap grafts (Fig. 2). VAC (Fig. 3) was then used to provide additional coverage. VAC performed for severe open fractures included strict cleaning of the injury site and indwelling irrigation and drainage tubes; after surgery, negative pressure drainage was continuously applied and irrigation fluid used saline flush speed control of 30 drops per minute. Amount of flush was recorded and fluid was closely observed to reduce risk of serious infection for a fixed period of time. Patients in the DWC group were treated with emergency internal fixation of fractures and covering of open wounds with exposed bones by primary VAC, and delayed definitive wound coverage was performed with skin or flap grafts within two weeks.

Patients' demographic information was recorded, including age, gender, smoking habits, mechanism of injury, Injury Severity Score (ISS), OTA fracture classification [15], Gustilo–Anderson open

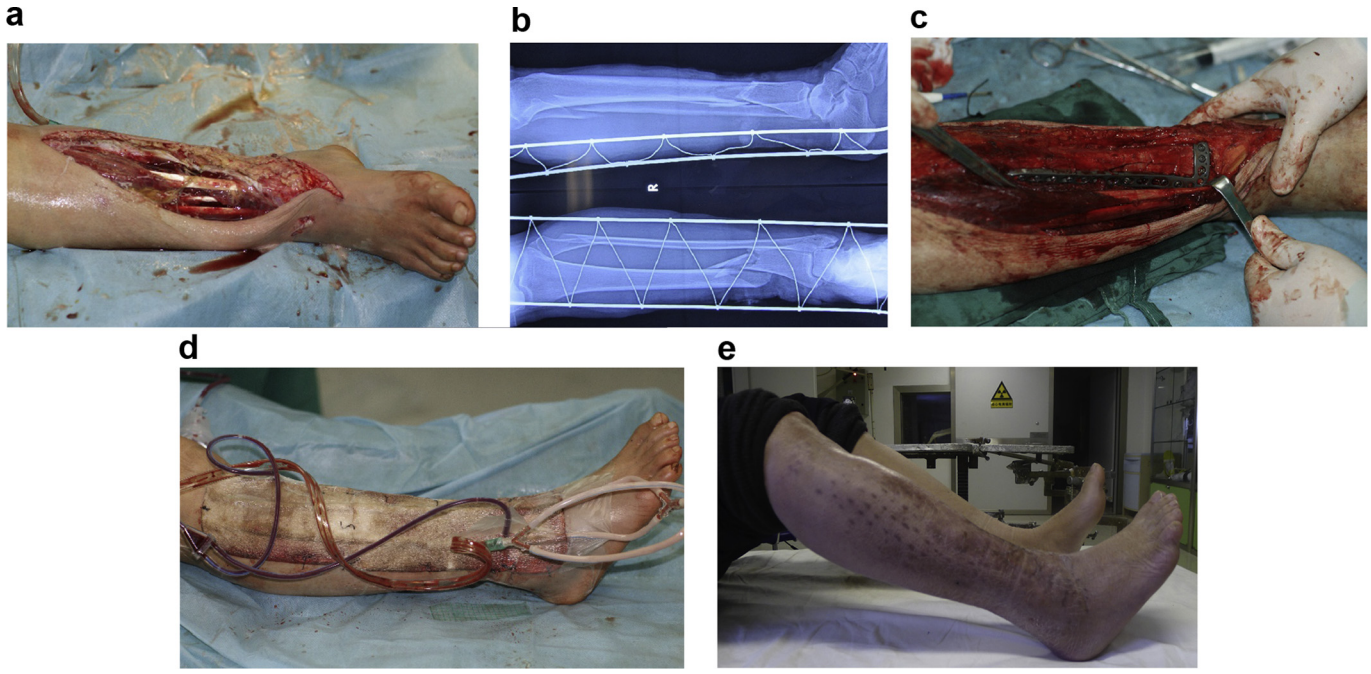

Fig. 1. A 56-year-old female with a Gustilo–Anderson type IIIB open tibial fracture caused by a traffic accident. Photo of injury (a) and radiograph (b). c, d) After debridement, the tibial fracture was fixed with a locking compression plate, primary wound closure was done with decompression suture and vacuum-assisted coverage was applied. e) The wound healed without complications.