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IN BRIEF

Gustilo-Anderson Classification

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History

Open fractures usually are high-energy injuries. This, along with the exposure of bone and deep tissue to the environment, leads to increased risk of infection, wound complications, and nonunion [12, 28, 31]. Antibiotics, surgical débridement, and internal fixation have improved outcomes of open fracture management in important ways, but the underlying principles for treating open fractures have remained the same since World War I: primary asepsis, adequate debridement, immobilization, and protection of wounds against disturbance and reinfection [25, 26].

Despite the overall improvement in outcome after open fractures, the variable outcomes among different patterns of open fractures with differing severities prompted the development of grading systems that classify them based on increasing severity of the associated soft tissue injuries. These grading systems seek to help guide treatment, improve communication and research, and predict outcome. Such classifications have been in use for some time [29]; however, it is the Gustilo-Anderson classification that has become the most commonly used system for classifying open fractures. Early attempts by Veliskakis [29] at grading open fractures were refined by Gustilo and Anderson in 1976 [16]. After reviewing their initial classification of the most severe open injuries, Gustilo et al. subsequently modified their classification system into its current form in 1984 [17]. Ultimately, through their studies of prevention of infection in open long bone fractures [16, 17], Gustilo et al. outlined the general principles of management of open fractures, and helped define the contemporary approach to the treatment of open fractures.

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Purpose

Like many classification systems, the purpose of the Gustilo-Anderson schema is to provide a prognostic framework that guides treatment and facilitates communication among surgeons and clinician-scientists. Decades of research correlating the Gustilo-Anderson type with infection risk have helped refine surgical protocols, change antibiotic recommendations, and determine appropriate timing for interventions including débridement, internal fixation, and soft tissue coverage [14, 23, 24, 27, 31]. As a widely known and relatively straightforward system, which has become the standard of classifying open fractures, the Gustilo-Anderson classification also is useful for education of residents and other trainees in the treatment of patients with orthopaedic trauma [19].

Description of the Gustilo-Anderson Classification

At the time of the seminal paper [16], it already was common knowledge that open fractures required prompt débridement and irrigation, but there was considerable ambiguity regarding how different patterns of injury behaved in response to the treatments of that period. The original study [16] included an initial retrospective evaluation, followed by a prospective test of the system that Gustilo and Anderson developed.

The retrospective part of the study evaluated 673 open fractures of long bones in 602 patients to determine the impact of primary versus secondary closure, use of primary internal fixation, and routine use of antibiotics in the treatment algorithm of open long-bone fractures. The key findings were that primary closure without primary internal fixation and prophylactic antibiotics for Type I and Type II open fractures reduced the risk of infection as much as 84.4% [16], whereas acute internal fixation and primary closure after segmental fractures, extensive lacerations, avulsion, or traumatic amputation resulted in a greater likelihood of subsequent osteomyelitis.

Gustilo and Anderson then prospectively followed more than 350 patients. They categorized open injuries into the familiar three categories, based on wound size, level of contamination, and osseous injury, as follows: Type I = an open fracture with a wound less than 1 cm long and clean; Type II = an open fracture with a laceration greater than 1 cm long without extensive soft tissue damage, flaps, or avulsions; and Type III = either an open segmental fracture, an open fracture with extensive soft tissue damage, or a traumatic amputation. Special categories in Type III were gunshot injuries, any open fracture caused by a farm injury, and any open fracture with accompanying vascular injury requiring repair [16].

Type III open fractures proved the most difficult to classify and treat owing to the varied injury patterns, increased morbidity from associated injuries, massive soft tissue damage or loss over the fracture sites, compromised vascularity, wound contamination, and fracture instability. Infection in Type III open fractures was observed 10% to 50% of the time [17]. With ranges like that, it became evident that the variation in severity, etiology, and prognosis of Type III injuries made a single classification insufficiently specific for the task at hand; the frequency of these injuries (greater than 60% of open fractures are Type III, according to one epidemiologic study [10]), made that issue even more pressing. In response to that problem, these high-energy open fractures were further subclassified by Gustilo et al. into A, B, and C according to the severity of the soft tissue injury, need for vascular reconstruction, and worsening prognosis, as follows [17]: Type IIIA = open fractures with adequate soft tissue coverage of a fractured bone despite extensive soft tissue laceration or flaps, or high-energy trauma regardless of the size of the wound; Type IIIB = open fractures with extensive soft tissue injury loss with periosteal stripping and bone exposure. This usually is associated with massive contamination [17]; and Type IIIC = open fractures associated with arterial injury requiring repair [17].

Gustilo and Anderson initially recommended surgical débridement and irrigation for all open fractures, with primary closure for Types I and II fractures, and secondary closure for Type III fractures but no primary internal fixation for patients [16]. Gustilo et al. modified these recommendations by incorporating fixation devices for Type III injuries that have more massive soft tissue injuries [17].

Confirmation/Validation

Because much of the literature on the subject of open fractures uses the Gustilo-Anderson classification or a variant of it, it is important to know whether the classification is reliable. Brumback and Jones [5] and Horn and Rettig [19] have examined the reliability of the Gustilo-Anderson classification system [16, 17]. One study of 245 orthopaedic surgeons who were asked to classify 12 different open fracture wounds of the tibia, using videotape and photographs, found that interobserver agreement was only 60% [5], representing moderate to poor agreement. In another study [19], 10 patients with open fractures had photographic slides of their wounds and radiographs taken before and after debridement and stabilization. These slides subsequently were evaluated by 22 orthopaedic surgeons (eight attending orthopaedic surgeons and 14 orthopaedic residents). The kappa value [9, 20] in this study was 0.53, indicating moderate agreement overall with no difference between the ability of either attending staff or residents to use the Gustilo-Anderson classification system reliably [19]. The fact that these two studies [5, 19] on the subject found only moderate reliability of the Gustilo-Anderson classification system among different observers is an important clinical limitation of this schema. Another limitation of the classification schema can be further emphasized by the lack of primary internal fixation and short-term followup (1 month in retrospective study and 6 weeks in prospective study) [16] in the original study. This is in contrast to the subsequent study that had adequate followup with use of internal fixation in more than ⅓ of their 87 patients [17].

The variability among individuals and their interpretation of the Gustilo-Anderson classification [16] results in a spectrum of injuries having too much overlap [5], possibly owing to the observer error [19]. Despite this, the Gustilo-Anderson classification has prognostic implications [6, 10] with complication rates increasing as the severity of the injury increases [6, 18]. Given that the classification system [16, 17] is easy to use and has prognostic and therapeutic implications, it is of value, but treatment recommendations based on the classification [16, 17] should be interpreted with caution owing to its limitations regarding interobserver reliability [5, 19].

There is general agreement that more severe open fractures have a worse clinical prognosis for infection, nonunion, and other complications, although the magnitudes of these findings vary depending on numerous clinical factors [7, 18]. Multivariate analysis of 146 patients with 162 fractures found that the Gustilo-Anderson classification predicted infection and was applicable to identifying increased risk of infection in patients with comorbid medical illnesses, but this study was limited by a minimum followup of 90 days [4]. A study of 422 open fractures showed an overall infection rate of 4.3%, with patients with Type II fractures having a deep infection rate of 4%, and patients with Type III fractures having a 5.7% infection rate [21]. In the original study by Gustilo and Anderson, an overall infection rate of 2.4% was observed in Type II fractures representing less than 1%, but with Type III fractures infection rates were as much as 44% in the entire study [16]. Type III fractures, however, are not a homogeneous group; another study found a considerable range of infection rates among the subtypes of Type III injuries, with 1.8% of Type IIIA, 10.6% of Type IIIB, and 20% of Type IIIC fractures having infections develop [21]. Caudle and Stern [6] had a similar finding in a study of 62 tibial shaft fractures; Type IIIA fractures had a 27% risk of nonunion, Type IIIB fractures had a 43% risk of nonunion (with 29% of them having deep infections develop), and Type IIIC had a 100% complication rate (78% were treated with amputation and the remaining either had chronic osteomyelitis or chronic pain). Long-term functional results for patients with Type IIIB fractures can be bleak. Giannoudis et al. reported on patients with Type IIIB tibial fractures treated with successful limb salvage and found they had delayed time to full weightbearing, used handheld aids for ambulation, had more postoperative complications, and were more disabled compared with patients who received early amputations [13].

Limitations

The Gustilo-Anderson classification is widely used [6], and is the basic language with which many investigators communicate the results of open fracture treatment [5]. However, the Gustilo-Anderson classification is limited because it seeks to contain an almost limitless variety of injury patterns, mechanisms, and severities with a small number of discrete categories [32].

A critical limitation of the Gustilo-Anderson classification is its limited interobserver reliability, shown by Brumback and Jones to be only 60% [5] and Horn and Rettig to have a kappa value of 0.53 [19]. Another critical limitation is that the surface injury does not always reflect the amount of deeper tissue damage and the Gustilo-Anderson classification does not account for tissue viability and tissue necrosis, which tend to evolve with time after more severe injuries. Because open fractures may be underclassified on initial evaluation in the emergency department, many investigators agree that definitive classification (that is, the classification that will drive the eventual treatment decisions) of open fractures is best made in the operating room [3, 13, 22, 23]. Gustilo and Anderson [16] emphasized the importance of debridement but Pollak et al. reported time from injury to debridement was not an independent predictor of infection; rather admission to a definitive trauma center had a significant influence on the incidence of infection [28]. Furthermore, Webb et al., in a cohort study of 156 patients, showed that timing of debridement, timing of soft tissue coverage, and timing of bone graft had no effect on patient outcome [30]. Finally, Bowen and Widmaier found that the number of compromising comorbidities to be significant independent predictors of infection [4]. Studies such as these challenge the true prognostic ability of the Gustilo-Anderson classification.

Another limitation is the two studies [16, 17] were unbalanced in their numbers comparing the retrospective and prospective data without rigid statistical analysis; all long-bone open fractures were included despite different bones inherently having different risks of infection owing to their particular soft tissue envelope [16].

An area of controversy, at least earlier on [16, 17], pertained to the treatment of fractures in this spectrum of injury. Gustilo and Anderson originally recommended against early fracture fixation for many Type III injuries. Newer evidence shows that stabilization of many of these fractures—even with internal fixation—reduces the risk of infection and malunion, promotes fracture healing, restores function, and expedites rehabilitation [4]. Finally, the nonmutual exclusive nature of the criteria for Type IIIB injuries imposes inherent difficulty in using this classification schema to predict which injuries need a muscle flap for coverage [6].

Conclusions/Uses

The Gustilo-Anderson classification, despite its inherent limitations, is prognostically valuable for predicting orthopaedic infection [4, 16, 21]. It is widely accepted for research, communication, and training purposes, and its remains useful as a good, basic approach to manage open fractures. Goals of fracture treatment should be to prevent infection, promote fracture healing, and restore function. Open fractures are, by definition, contaminated; therefore, the use of antibiotics is therapeutic, not prophylactic, and is fundamental to the care of patients with these injuries [14]. Many of the principles outlined by Gustilo et al. remain applicable today, including early diagnosis and treatment with aggressive débridement of necrotic tissue and foreign debris, prompt and appropriate antibiotic therapy, fracture stabilization, and appropriate wound closure [17].

Although the Gustilo-Anderson classification is useful, its interobserver reliability is limited [5, 19] and it lacks the ability to comprehensively measure prognostic patient outcome [28, 30]; therefore, assessment of all open fractures should include the mechanism of injury, the appearance of the soft tissue envelope and its condition in the operating room [3, 13, 22, 23], the level of likely bacterial contamination, and the specific characteristics of the fracture [13, 31, 32]. Accurate assessment of an open fracture is best accomplished in the operating room after surgical exploration and débridement [3, 21–23], rather than the emergency room. To comprehensively measure prognosis, outcome measures such as the Sickness Impact Profile [2] can be used for more accuracy.

Earlier authors recommended against using internal fixation by plates or intramedullary nails in open fractures given the high infection rate of 19% [16], but this no longer applies to current standards of care.

The Gustilo-Anderson classification laid a foundation for management of open fractures, but the management of open fractures continues to evolve. Dellinger et al., in a prospective randomized study of 248 patients with open fractures, reported that a short course (1 day) of antibiotics was not inferior to prolonged use of antibiotics (5 days) [11]. Ostermann et al. reported that treating 845 compound limb fractures with systemic antibiotics and aminoglycoside-polymethylmethacrylate resulted in an overall infection rate of 3.7% compared with the 12% infection rate in patients treated only with systemic antibiotics [24]. Delayed primary closure historically has been used, especially for Type III fractures, but consideration for earlier closure has been reported. Choudry et al., in a retrospective study of Type IIIB midtibia fractures treated either with acute versus delayed closure, reported delayed soft tissue coverage resulted in 64% to 100% nonunion rates [8]. Finally, adjunctive therapies such as rhBMP-2 have been found to significantly reduce secondary interventions, lower hardware failure, and promote faster fracture healing [15], but more recently Aro et al. observed no significant difference in patients treated with rhBMP-2 with intramedullary fixation compared with patients treated only with intramedullary fixation for Type IIB tibia fractures [1].

The Gustilo-Anderson classification system remains the preferred system for categorizing open fractures. Despite its limited interobserver agreement [5, 19], good but imperfect prognostic ability, and somewhat dated treatment algorithms, no other classification is superior in terms of its popularity and common use, and because the Gustilo-Anderson schema correlates well with the risk of infection and other complications [5, 21, 23].

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