Open fracture classification – the need to modernise

Introduction

It is well known that the clinical outcome of open fractures is, in part, dependent on the injury severity and specifically on the extent of any soft tissue disruption. In order to collect meaningful data, and to offer guidance that is easy to follow, there must be reproducible means of classifying these injuries. With a robust classification system, there should come a sensible management algorithm that is user friendly and not open to misinterpretation. Accuracy of such data supports meaningful research and allows evolution in fracture care. Currently, the most commonly (mis)quoted classification system for open fractures is that of Gustilo and Anderson [1] [2]. However, there has been some loss in translation from the original articles [3]. Furthermore, the original Gustilo-Anderson system has several limitations when applied to open fracture management in the current clinical era.

Many healthcare systems around the world have algorithms and recommendations for treatment of open fractures. These serve to help achieve predictable outcomes for patients and to set standards against which performance can be measured, often with financial incentives. These algorithms suggest management strategies dependent on the grade of the open fracture as defined in the original Gustilo-Anderson classification.

Here, we challenge the validity of the original grading systems and discuss the concept of an ideal system, based on patient reported outcomes and resource consumption in the 21st century.

Why classify?

A classification system is a language. It is a means of describing individuals or groups of individuals according to certain characteristics or traits. In medicine, classification systems generally assess severity / grade of an injury or clinical condition, serve to provide treatment and management guidelines, identify risk profiles and proffer prognosis or outcome. Classification systems have been used in research to help account for differences in outcomes seen between patient groups and can be used as in audit as a descriptor against which performance measures can be calibrated. Classification data needs to be accurate to enable audit, research and epidemiological assessment, allowing for improved resource allocation and planning of healthcare provision on a network / geographical basis.

Ideal classification systems

A well-designed system should enable two different physicians to identify the appropriate group or class to which each fracture/injury should be assigned, in other words the system should be reproducible with low inter and intra-observer error. It should be simplistic but inclusive, allowing for all injury patterns, and mutually exclusive, creating only one category for each pattern [4]. There should be a natural hierarchy that reflects either outcome / prognosis or treatment burden.

Evaluation of existing classification systems

The validity of a classification system changes over time: most becoming obsolete with advances in surgical techniques or changes in our approach to management and understanding of injuries. There are several historic open fracture classification systems in the published literature. Here we review and discuss their limitations.

Gustilo-Anderson

The Gustilo-Anderson classification of 1975 [5] was the first of its kind; a system through which clinicians could classify open fractures of the tibia with some degree of reliability. The original article defined type I fractures as those <1cm in length and clean, with type II involving lacerations >1cm but without extensive soft tissue damage, flaps or avulsions. Type III were defined as either segmental, with extensive soft tissue damage or amputations. Special consideration was given to those secondary to gunshot or farmyard injury or those requiring vascular repair. It mandated that 'Primary closure is indicated for Type I and II open fractures but delayed primary closure, including split thickness skin grafts or appropriate flaps, should be used for Type III fractures. This was based on their pooled data analysis of both prospectively and retrospectively included patients, and their incidence of infection.

It is clear that while the original description has stood the test of time, the way in which the classification was created and validated is scientifically unsound. The pooling of retrospective and prospective data, the use of a single outcome measure as defined by infection, and the highly subjective descriptors for each group highlight the significant limitations with the original system. Furthermore, the original system suffered from grouping too many types together – the original group III covered a huge spectrum of injury. In 1984 Gustilo, expanded the most severe grade for fractures, grade III, into three further subgroups due to it previously having been "too inclusive" [6]. It was noted that there was an increase in the infection rate with certain fracture types and overall a worse prognosis in many. Almost all were noted to have complex fracture patterns. IIIa were defined as having severe crushing soft tissue injuries, high degrees of contamination, yet were still closable. IIIb had a loss of soft tissue

coverage and typically required a soft tissue flap, and IIIc had an arterial injury requiring repair.

These subdivisions are widely misquoted and have become lost in translation from the original articles, with significant use of subjective language. Does a Type IIIB apply to a 'free or rotational flap' but not to a split thickness skin graft? With both Type II and IIIA referring to 'extensive soft tissue damage', these have become difficult to distinguish. In addition, what definitively differentiates a Type IIIB from a Type IIIC? These are questions which have created a system with questionable levels of reliability to perform as the standard for clinical practice [7]. Terms such as 'severe' and 'typically' risk being considered differently between individuals and institutions. In 1990, in his own review article, Gustilo again evolves the original descriptions from his first paper, and adds yet more subjective detail [8]. Offerings such as 'extensive' stripping of periosteum, and 'massive' contamination appear. It is impossible to quantify these terms and again use of this classification system is let down by differences subjective interpretation between. So much so, the inter-observer reliability of the Gustilo-Anderson system has been shown to be poor having demonstrated only 'moderate agreement' (kappa 0.59)[9], and average agreement of 60% [10].

The Gustilo-Anderson system also suffers with a lack of mutual exclusivity between grades. A wound <1cm, but with 'moderate' soft tissue damage has features of both grade I and II. The size of the wound relative the size of the patient is important as well – a 1cm wound in a child's tibia represents a greater relative percentage of the whole limb length, than a similar sized wound in a full-grown man. Grade IIIb wounds incorporate such a vast spectrum of injury, with such wholly different expected prognoses, that it has been described of limited use in providing guidelines for management given that injuries range from the easily manageable to the barely salvageable[11]. This was evidenced by the rates of infection corresponding to open fractures within this Grade III category, ranging from 10 to 50 per cent for Type IIIB and from 25 to 50 per cent for Type IIIC[8]. Such drastic overlap between categories diminishes the diagnostic capacity of the system, as well as the ability to provide guidelines for treatment. In addition, Grade IIIc was evaluated to demonstrate rate[s] of amputation of 50 per cent of more, indicating significant variation in outcomes for injuries within this class.

AO Classification

The AO/OTA Fracture Classification collaboration of 2007 was designed to place strict emphasis on the importance of a common language for surgeons [12]. It has incorporated the familiar AO-Müller system of alphanumeric code for classifications, to the open fractures scenario. It does describe all aspects of soft tissue trauma and does refer to all anatomical areas rather than just the tibia. The intricacy of the AO/OTA system has been criticised as carrying the inherent problems of the original AO-Muller system of being overly complex, and

difficult to apply in daily clinical practice. This type of system, while comprehensive, is best used for audit and data handling for research purposes [13,14,15].

OTA/OFSG classification system

In 2010, the Orthopaedic Trauma Association (OTA) open fracture study group (OFSG) published their classification system for open fractures[16]. This system is logical, taking into account 5 different aspects that characterise the pathoanatomy of an open fracture, irrespective of the anatomical site, for both adults and children. These 5 essential aspects refer to the condition of the skin, muscle, vasculature, bone and also the degree of contamination. The system was developed based on a literature review of 34 risk factors and a panel consensus opinion as opposed to a truly validated process.

Again, certain degrees of subjectivity prevail: "extensive degloving" "muscle loss" and "muscle function" are seen as descriptors. It also allows for multiple factors to be considered when classifying a fracture to a certain grade – leaving margin for error or misinterpretation. This system was proven superior to the Gustilo-Anderson system in regard to the detail of description of open fractures [18], or its prognostic value [19]. It has been reported to have moderate to excellent interobserver reliability [19,20], whilst in other comparative series it has been shown to have similar statistical qualities with the Gustilo-Anderson system [18].

GANGA

The Ganga Hospital Open Injury Severity Score (GHS) was proposed in 2006 [11]. Many of the shortcomings of both the Gustilo and the AO/OTA fracture classification systems are addressed. With these improvements, the Ganga Hospital Score is able to provide a clear prediction for outcomes in the most severe lower leg trauma cases. However the primary focus of the Ganga score has been that of a decision making tool in limb salvage versus amputation, more than a true classification system aiming to offer guidance for protocols for reconstruction[21]. The system has reported good specificity and sensitivity [22] and its ease of use, proving to be simple in application in a clinical context[23]. A framework, such as this, which draws direct parallels between class of injury and surgical treatment is, in theory, ideal.

While the clear advantage of the Ganga Hospital Score lies in its utility for help in decision-making in mangled extremities therein too lies its downfall. The system doesn't function as a generalized open tibial fracture classification system and nor was it designed to. The reason behind its creation was to pick up on the shortcomings of the Gustilo system in its poor sensitivity and specificity to predict salvage or outcome in Type IIIA and Type IIIB fractures [11]. It does not however, have the ability to provide guidelines for surgical management or rehabilitation estimates for those injuries deemed less severe. While it functions extremely well at one end of the spectrum, its use could prove convoluted and inconclusive in a number of trauma cases, as patient related and physiology response factors are missing from the equation of the GHS [24].

The limitations of current classification systems

Whilst on first inspection, these previous classification systems appear similar, there is significant variation in the nuances of their description for open fracture sub-type. The variable use of language and clinical parameters as descriptive tools renders each system open to misinterpretation. Having numerous subjective descriptors for each component of the injury – skin, muscle, bone, vascularity, allows people to stray from the original articles – each variable leads to an incremental increase in the margin for error. It invites potential performance bias whereby individuals or institutions may choose to upgrade or downgrade an injury in order to meet local standards.

It is noted that there is a large variance in the ability to meet performance targets for open fracture care around the United Kingdom according to TARN data [25] . Similarly, the published literature shows striking differences in outcomes for certain open fracture grades[26–28]. Is this solely down to differences in clinical set up, resource allocation and performance? Or is it possible there is a difference in the way treating centres classify and grade these injuries? If there is scope for different interpretations of a classification system, how can we be sure it is being used uniformly?

It is vital for research and audit purposes that the systems employed offer no opportunity for misinterpretation or confusion. As mentioned above, such examples include the variation in the difference between a Gustilo 3A and 3B or equivalent dependent on the system used. Specifically, it is the soft tissue component rather than the fracture pattern that causes consternation in classification. For example, some authors suggest there may be a need for plastic surgical input in a 3B, others mandate it yet none quantify what exactly that input should be.

If remuneration for treatment and regionalisation of care are to be determined by a classification system, is it right that the system, including the one most commonly used – that of Gustilo and Anderson – is open to misinterpretation?

The ideal open fracture classification system

We must ask ourselves if we are certain our current systems provide all we need for research, education, audit, resource planning, guiding management and predicting outcome in our modern era of healthcare? It is widely accepted that most were not developed or validated by rigorous scientific evaluation methods [29]. There is clearly a need for a new clear descriptive classification system. It needs to be simple such that there is only one clear objective descriptor defining each grade. The system should reflect current health care standards, outcomes, resource consumption and modern treatment options. Looking at complication rates should not be what defines a population in a classification system, but rather one should

look at functional outcome. PROMS, QALYs and functional return are far greater measures of success that the presence or absence of infection. Is someone unable to work for a year, with permanent loss in long term function but without infection, really a successful outcome? We must also consider the socio-economic burden and health care resource consumption: a free flap surgery takes significantly more time and resource than a split skin graft. A circular frame managing bone loss is a different beast to a tibia managed with an intramedullary nail.

Other factors need to be considered as well. Does as grade 1 open femoral fracture exist? Surely the energy required to deliver the femur from its soft tissue envelope mandates a high energy grading, irrespective of wound size. What of children's open fractures – a 1cm wound on a child's limb may represent a significant percentage of its soft tissue circumference relative to the bone. The system needs to move away from wound size as a defining parameter for grades, and similarly move away from energy – a rather subjective term. It is also well documented that soft tissue injury is best assessed by "potential for approximation rather than laceration length [30], as is done in the case of the Gustilo model.

In essence, open fractures fall into two distinct groups – those that are relatively simple to treat and those that have a degree of complexity to them either requiring increased levels of skill in their management, increased resource consumption, or predictably have a worse outcome. For all intents and purposes therefore, open fractures are either simple or complex. Simple behave much like a closed fracture and could be defined as those that can achieve tension free primary closure at the end of the first surgical wound excision (debridement). If the soft tissue envelope can be closed primarily then the outcome can be expected to be good and the likelihood of needing specialist techniques to manage the injury diminishes. By contract, complex fractures have a tortuous journey to recovery and clearly differ in their management and outcome. The functional outcome for complex fractures predictably worse, or the interventions needed to treat are considerably more complex than for simple fractures This distinction would allow for a simple binary system to group open fractures.

The binary system would make day to day application of open fracture grading simple and accessible. Naturally there may be a need for an objective subclassification of the more complex fractures depending on intervention, for research and audit purposes. The degree of plastic surgery reconstruction, vascular injury, and complex techniques for managing the skeleton would need consideration. The ideal system would be applicable to all open extremity fractures, both upper limb and lower limb, for both adults and children.

Discussion

With a robust classification system, there comes a sensible management algorithm that is user friendly and not open to misinterpretation. The aim of creating a framework which is not open to interpretation by individual clinicians, but instead classifies open lower leg fractures solely according to objective outcome or surgical procedure performed, is to minimise inter-observer variability while maintaining mutual exclusivity for each class.

Should a system consider the comorbid conditions of the patient? The host status, already has classification tools available [31]. Perhaps elderly patients need to be considered differently as it has been shown outcomes are worse in this cohort[32]. However, the risk of doing so is to potentially undermine the whole concept of developing a very simplistic grading system.

It may also be that an ideal open fracture classification system should include the limb with compartment syndrome that has undergone decompressive fasciotomies. Closed fractures with compartment syndrome consume significant resource via multiple trips to theatre and typically have adverse outcomes [33,34].

A new framework could provide an opportunity to depart from the inherent errors of a descriptive classification system and implement a system which has been validated through scientific methodology. The Gustilo-Anderson system clearly had value as it has been widely used, so this new system does not aim to dismiss it entirely but rather to build on what we have learnt since the original classification was proposed.

The original classification systems of Gustilo and subsequent revisions were created without functional outcomes in mind, and only looked at infection as an outcome. This was based on a single centre experience, with historic techniques in the surgical management and reconstruction of open fractures. Meanwhile, it has since been recognised that socio-economic burden of injury, including return to work, and quality of life are key factors from the perspective of the patient and the healthcare providers alike. A new system should be outcome-driven, removing subjectivity, creating a reproducible, and therefore reliable framework, representing modern standards in trauma care.

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