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Soft tissue reconstruction after compound tibial fracture: 235 cases over 12 years[☆]

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KEYWORDS

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Summary *Background:* Outcomes in management of compound tibial fractures are measured by the rate of infection and non-union. These are a function of many variables that interact in complex ways. Our aims are to describe changes in these injuries over the past decade, to determine which variables predict a poor outcome and to compare reconstructive options controlling for these variables.

Methods: All compound tibial fractures reconstructed at the Princess Alexandra Hospital from 1999 to early 2009 were reviewed retrospectively. The remainder of 2009 and 2010 were reviewed prospectively. Data were collected from departmental audits, medical records and imaging.

Results: 251 flaps were performed in 235 patients. Reconstructions within one week declined after 2000, which correlated with increasing Negative Pressure Dressings use ($R = 0.77$). Free flap use increased though the incidence of distal fractures did not ($R = 0.29$). Muscle flaps were consistently preferred. Injuries with a poor outcome had a greater delay or failed soft tissue reconstruction. A poor outcome was more likely in patients with a contaminated distal fracture ($p = 0.0038$). Outcomes in muscle and fasciocutaneous flaps were not significantly different.

Conclusions: Compound tibial fracture management has evolved to temporary followed by definitive fixation. Free flap use has increased, particularly in diaphyseal injuries. Delays in reconstruction should prompt aggressive surgical management. Injuries at risk of a poor outcome can be further characterised as being distal and contaminated. Reconstructive surgeons should not be discouraged from using muscle flaps. A management algorithm based on the evidence provided is presented.

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Background

Formal classification of tibial fractures was first undertaken in 1964 by Nicoll.¹ Twelve years later, Gustilo and Anderson were able to relate the prognosis of compound tibial fractures to wound length and soft tissue devitalisation, advising that soft tissue coverage should take priority over definitive bony stabilisation.² Their classification system was refined in 1984 to distinguish compound tibial fractures that remained satisfactorily covered (IIIa) from those that were not (IIIb). Limbs with a vascular injury were graded separately (IIIc).³ This classification system is still widely used⁴ despite its age, and the fact that it was designed on a population of patients treated over 30 years ago. Much has changed about the reconstruction of compound tibial fractures since then.⁵ Furthermore, the subclassification of grade III injuries – whilst useful to determine the need for soft tissue reconstruction – does not direct the way in which it should be performed. Also, the inter-observer reliability of the classification has been questioned.⁶ The experienced clinician knows that not all Gustilo IIIb fractures have the same prognosis and at present, there is no tool to assess and classify this subgroup according to severity of injury and prognosis. Other authors have highlighted the importance of such a tool in planning treatment and assessing results.^{7,8} An examination of the relationship between outcomes and variables in the presentation or management of compound tibial fractures must control for the severity of the injury. Failure to do so introduces bias.

Once it is decided that a soft tissue reconstruction is worthwhile, the next consideration is when this should be done. Whilst an 'early' reconstruction is preferred,^{9,10} this term has been variably defined; prior to the third day after injury,^{9,11} prior to the fourteenth day^{12–14} or any day in between.^{15–19} In 1986, Godina demonstrated poor outcomes (post-operative infection and time to union) in limbs reconstructed between three days and three months after injury. He hypothesized that the difference observed between the early and intermediate reconstruction groups was fibrosis in wounds of the latter and the effect of this on flow in recipient vessels.⁹ More recently, Gopal et al. re-emphasized the contention that Gustilo IIIB and C injuries reconstructed early fare better in their series of 84 patients.¹⁰ However, they recognized that treatment delays are inherent for patients transferred long distances from regional centers for tertiary care, or who are critically ill and unable to tolerate the physiological demands of a limb reconstruction. In these patients, an early reconstruction is either impossible or hazardous. More severely injured lower limbs may well not be suitable for a reconstruction within a given time interval where a lesser injury would be. This

means that the injuries pre-destined for a poor outcome by virtue of the severity of the injury alone may automatically be reconstructed later.

Muscle and fascio-cutaneous flaps have emerged as the most suitable options for soft tissue coverage of compound tibial fractures. Byrd and co-authors described lower infection rates in muscle only flaps.¹⁸ Possible reasons for this include a superior ability to fill the contour irregularities of a defect,^{4,20,21} higher tissue oxygen tension^{22,23} and higher blood flow when compared with fascio-cutaneous flaps,²⁴ notably in a canine model.²⁵ A series of experimental studies in murine models has shown better bone healing under muscle flaps when compared with fasciocutaneous flaps.²⁶ These and other studies affirm union as an outcome measure for the success of soft tissue reconstruction.²⁶ Superiority of muscle flaps in humans has not yet been demonstrated.

Flap selection also depends on the anatomical level of the injury. Compound fractures of the proximal third of the tibia can be covered with local muscle flaps whereas the distal third is classically regarded as free flap territory. Coverage of middle third injuries is less clear but no less important. Middle third injuries were most common (27.8%) in a recent review of 100 consecutive cases of lower limb trauma in Egypt.²⁷ These injuries create reconstructive equipoise, particularly if a loco-regional reconstruction is preferred on the basis of patient demographics or comorbidities. Fasciocutaneous perforator flap use has expanded for soft tissue defects of the middle and distal third,²⁸ but their use is only suitable in cases where the zone of injury is narrow.

The size of the defect also plays a role in flap selection. Historically, larger soft tissue defects demanded coverage with free transfer of muscle.²⁰ As experience with large fascio-cutaneous flaps increases, this may no longer be the case. Rather than simply presenting an alternative, fasciocutaneous flaps also have definite advantages. Flaps with a cutaneous component are more resistant to the minor trauma associated with daily lower limb function, offer a flow-through pattern of vascularisation for simultaneous wound coverage and reconstruction of the vascular tree²⁹ and may include small volumes of muscle. Conversely, the skin paddle of a composite muscle flap is typically unreliable and often adds ungainly bulk. Also, muscle flaps are reported to have higher revision rates, particularly when used in the region of the foot and ankle in paediatric patients.³⁰

A guideline of standards for the management of open fractures of the lower limb was published jointly by the British Orthopaedic and Plastic Surgery Associations in 2009.³¹ It made recommendations based on the best available evidence. These guidelines are extremely helpful

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