

# Open Tibial Fractures Part I: A Narrative Review of Initial Treatment and Potential Applicability to the Southern African Context

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**Abstract:** Treatment guidelines for open tibial fractures are well established in high-income countries, but their implementation in low-resource settings remains challenging. To date, only one African country has attempted to formulate national, consensus-based guidelines that cover key aspects such as antibiotic administration, initial stabilization, surgical debridement, wound management, and definitive fixation. This narrative review summarizes current principles for the initial management of open tibial shaft fractures and evaluates their relevance in the Southern African context, particularly in rural and resource-constrained environments. Given the limited availability of advanced imaging, specialized implants, and soft-tissue coverage expertise, clinicians must adapt existing protocols to local capacities. This review highlights areas where treatment recommendations from high-income settings may not be feasible and identifies practical considerations for applying initial management principles in Southern Africa. The need for context-specific, resource-appropriate guidelines is emphasized.

**Keywords:** open tibial fractures, initial management, low-resource countries, Southern Africa, review

## Introduction

The treatment of open tibial shaft fractures presents a significant challenge due to limited soft tissue coverage and compromised blood supply.<sup>1</sup> Due to its close proximity to the skin, the tibia is particularly vulnerable to becoming an open fracture with significant soft tissue damage, often resulting in complications such as infection and non-union.<sup>2</sup> The primary goals of treatment are to promote an optimal environment for fracture healing, minimize complications, and restore limb function as effectively as possible.<sup>3</sup> Achieving these goals can pose significant challenges for both patients and healthcare systems.<sup>3</sup>

The healthcare system in Southern Africa consists of both public and private sectors, with marked inequalities in access and quality of care.<sup>4,5</sup> Public healthcare, largely financed by government funding, serves the majority (particularly those in rural and economically disadvantaged areas) but often suffers from resource limitations, including staff shortages, inadequate infrastructure, and irregular medication supply.<sup>4,5</sup> In contrast, private healthcare is supported by insurance or out-of-pocket payments and delivers superior services, though it is primarily accessible to wealthier, urban populations.<sup>4,5</sup> In South Africa, for example, a dual healthcare model exists where approximately 80% of the population depends on the public sector, while the majority of resources are concentrated in the private sector, which caters to just 20% of citizens.<sup>4,5</sup> Therefore, the management of open fractures in low to middle-income countries of Africa presents unique challenges, including limited early access to specialist care, delays in the administration of intravenous antibiotics, difficulties with choosing appropriate methods of fixation and wound closure, as well as patients' health-seeking behaviours prior to accessing formal orthopaedic care.<sup>6</sup> In addition, access to healthcare remains a significant issue, particularly in rural areas outside urban centres.<sup>7</sup>

Open fractures should be managed using a standardized care pathway that includes the prompt administration of antibiotics, surgical debridement to remove all contaminated and devitalized tissue, thorough irrigation of the wound in the operating theatre, and fracture stabilization using either internal fixation, such as intramedullary nailing, or external fixation.<sup>8–11</sup> While these guidelines are universally applicable, their implementation may not be practical or feasible in low-income countries. The Malawi Orthopaedic Association/AO Alliance has published a national consensus statement, outlining revised standard principles that consider the country's unique circumstances.<sup>12</sup> The authors recommended the following procedures: adherence to ATLS principles, administration of antibiotics, assessment for neurological and vascular injuries, immediate transfer of a threatened limb to a referral hospital, preliminary realignment and splinting, formal debridement only for gross contamination, no irrigation outside the operating theatre, debridement under anaesthesia, lavage with at least 5 litres of water before draping, photographic documentation, primary closure for clean wounds, fracture stabilization using external fixation or definitive fixation if appropriate soft tissue coverage is achieved, and amputation should only be performed for life-threatening injuries.<sup>12</sup>

The purpose of this study was to conduct a narrative review of contemporary treatments for open tibial shaft fractures and assess their applicability to the South African context.

## Methods

This study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines<sup>13</sup> and the updated recommendations provided in the Cochrane Handbook.<sup>14</sup>

## Eligibility Criteria

This project incorporated all Level I–IV evidence-based clinical studies addressing open tibial shaft fractures. Reviews, systematic reviews, and meta-analyses were excluded from the analysis; however, their references were screened to identify relevant studies meeting inclusion criteria. Abstracts and conference proceedings were also excluded from the study.

## Literature Search

A systematic review of the literature was performed to identify all publications in English and German, screening the databases Medline, Embase, Scopus, and Google Scholar. These databases were screened using the following terms and Boolean operators: “tibial fractures” AND/OR “open” AND/OR “compound” AND/OR “tibial shaft”; AND/OR “complications” AND/OR “treatment” AND/OR “management”. For the Medline search the MeSH term “tibia” was used with the following qualifiers: “fractures, bone” and “compound fractures”. One reviewer conducted independent title and abstract screening. Disagreements between reviewers were resolved by consensus, and if no consensus was reached, they were carried forward to the full-text review. All eligible articles were manually cross-referenced to ensure that other potential studies were identified. The search period was restricted to studies published between 2000 and 2025 to ensure a contemporary review of current treatment approaches for open tibial shaft fractures.

## Data Extraction and Quality Assessment

An electronic data extraction form was employed to systematically collect information from each article, including the level of evidence, study location, patient age, and sex. The key areas documented include incidence and epidemiology, fracture classification, treatment principles, antibiotic use, debridement, surgical timing, primary skin closure, temporary wound dressings, soft tissue management, large fragment management, and the applicability of these guidelines in resource-limited settings such as Southern Africa.

## Results

### Incidence – Epidemiology

In the United Kingdom, open fractures of the lower extremity constitute approximately 12% of all open fractures, with an estimated incidence of 3.4 cases per 100,000 individuals annually.<sup>15</sup> These injuries demonstrate a bimodal distribution, with high-energy trauma being the predominant cause in younger populations, while low-energy trauma is more common in

older individuals, often attributable to decreased bone density.<sup>15</sup> In the Netherlands, the estimated incidence of open fractures is approximately 1.1 per 100,000 person-years, with a notable increase observed in individuals over the age of 70.<sup>16</sup> The German Trauma Registry reported nearly 3,000 open tibial fractures within a patient cohort of 148,000 over a ten-year period.<sup>17</sup> Weiss et al reported an annual incidence of 2.3 per 100,000 person-years for open tibial fractures in Sweden and observed a decline in the overall incidence between 1998 and 2004.<sup>18</sup> In a 15-year study analyzing 2,386 open fractures, the authors reported that 70% occurred in males, with only 22% resulting from road traffic accidents or falls from a height.<sup>15</sup> However, when stratified, road traffic accidents accounted for 34% of lower extremity open fractures.<sup>15</sup>

Unfortunately, there is a lack of comprehensive data published from the African continent. Existing studies only report the total number of treated cases, without providing information on the overall trauma burden or the proportion of open fractures among admitted trauma cases. For instance, Mwafurirwa et al reported that 72 open tibial fractures were managed at a tertiary hospital in Malawi during 2019.<sup>19</sup> Almost all of these were caused by road traffic accidents (63%), assaults (18%), and falls (17%), with males accounting for the majority of cases (82%).<sup>19</sup> Adesina et al reported similar findings, with motorcycle riders, artisans, and farmers accounting for 63% of open fractures, of which 75% occurred in male patients.<sup>20</sup> While Clelland et al reviewed 1016 orthopaedic inpatients admitted in Northern Tanzania, their results demonstrated 143 had open tibia fractures.<sup>21</sup>

## Classification Systems

The two most commonly utilized classification systems for open fractures are the Gustilo-Anderson scheme<sup>21,22</sup> and that of the Orthopaedic Trauma Association (OTA). The Gustilo-Anderson system categorizes open fractures into three grades based on wound size, extent of skin loss, and muscle damage.<sup>21,22</sup> Generally, Type I fractures involve a clean wound less than 1 cm in length, Type II fractures feature a laceration greater than 1 cm without significant soft tissue damage, flaps, or avulsions, and Type III fractures are characterized by open segmental fractures, extensive soft tissue damage, or associated vascular injury. This classification is widely accepted due to its ability to correlate severity grades with complication rates.<sup>23</sup> However, it has been criticized for demonstrating poor to moderate inter-observer reliability.<sup>24</sup>

The Orthopaedic Trauma Association (OTA) classification system evaluates open fractures based on five components: skin injury, muscle injury, arterial injury, contamination, and bone loss. Each component is assessed using predefined criteria and rated on a scale from 1 (mild) to 3 (severe).<sup>25,26</sup> Compared to the Gustilo-Anderson classification, the Orthopaedic Trauma Association system demonstrated moderate to excellent inter-observer reliability. Additionally, it has been shown to outperform the Gustilo-Anderson system in predicting post-operative complications and clinical outcomes.<sup>27</sup> The OTA classification system was recently updated to include a category for classifying post-traumatic bone defects.<sup>28</sup>

Although the OTA open fracture classification is more complex, it is not necessarily superior to the Gustilo-Anderson system in predicting fracture-related infections.<sup>29</sup> Given that the Gustilo-Anderson classification is easier to remember and more widely recognized, it may be the preferred choice for assessing fracture severity in resource-limited settings such as Southern Africa.

## Principles of Treatment

### Antibiotics

Antibiotic prophylaxis is widely recognized for reducing infection rates and particularly in preventing early infections. Mundy et al provided comprehensive recommendations for antibiotic prophylaxis in open fractures.<sup>30</sup> For Gustilo-Anderson Type I and Type II injuries, primary coverage against gram-positive organisms is advised, typically using a first-generation cephalosporin. Prophylaxis should not extend beyond 24 hours following wound closure.<sup>30</sup> For Type III injuries, both gram-positive and gram-negative coverage is recommended. This is achieved with a combination of a first-generation cephalosporin and an aminoglycoside. Antibiotic administration should continue for 72 hours but should not exceed 24 hours after wound closure.<sup>30</sup> In cases of farm injuries, additional anaerobic coverage is necessary, typically using penicillin. The same timelines for antibiotic administration as those outlined for Type I–III open fractures are applicable in these cases.<sup>28</sup> The German guidelines recommend first- or second-generation cephalosporins for Type I–III fractures, with gram-negative coverage using ampicillin/sulbactam, piperacillin, or tazobactam.<sup>10</sup> If Clostridia is suspected, penicillin or clindamycin should be added. Antibiotic administration should begin promptly, with a duration of no

more than 24 hours for Type I and II fractures, and 72 hours for Type III fractures, but no longer than 24 hours post-wound closure.<sup>10</sup> The Orthopaedic Trauma Association (OTA) recommends using cefazolin, clindamycin, or vancomycin for Type I and II fractures, with the addition of an aminoglycoside for Type III fractures. Alternatively, a combination of piperacillin and tazobactam is suggested for Type III fractures. Importantly, antibiotics should be administered within one hour of injury, and continued for no more than 24 hours for Type I and II injuries, and 72 hours for Type III injuries.<sup>31</sup> The current AAOS guidelines on the prevention of surgical site infection after major extremity trauma give a moderate strength of recommendation for the administration of initial and preoperative antibiotics.<sup>32</sup>

The only guidelines established through a consensus project have been published for Malawi.<sup>12</sup> They recommend administering intravenous antibiotics as soon as possible, ideally within one hour of presentation.<sup>12</sup> The guidelines suggest using ceftriaxone or a combination of doxycycline and gentamicin, with the addition of metronidazole for grossly contaminated wounds.<sup>12</sup>

The use of local antibiotics remains unclear, though it offers the potential advantage of higher antibiotic concentrations compared to intravenous delivery.<sup>33</sup> A meta-analysis has demonstrated a 12% reduction in risk with the use of local antibiotics.<sup>34</sup> In a systematic review and meta-analysis, Craig et al demonstrated that the local administration of antibiotics significantly reduced the incidence of infection in Grade III fractures, from 31% to 9%.<sup>35</sup> The VANCO trial, which administered vancomycin powder directly to the fracture site, reported a 6.4% probability of deep infection by 182 days in the treatment group, compared to 9.8% in the control group, suggesting promising results.<sup>36</sup> Pesante and Parry demonstrated that the use of vancomycin and tobramycin powder reduced the rate of deep infections following open fracture treatment, thereby confirming the findings of the VANCO trial.<sup>37</sup> The current AAOS guidelines strongly recommend the administration of local vancomycin powder or tobramycin-impregnated beads for the prevention of surgical site infection after major extremity trauma.<sup>32</sup>

The timing of antibiotic administration appears to be a critical factor in preventing infection. Zuelzer et al demonstrated that administering antibiotics within 150 minutes of injury significantly reduces infection risk, even after adjusting for potential confounding factors such as age, diabetes, and smoking status.<sup>38</sup> Earlier, Patzakis and Wilkins identified timely antibiotic administration as crucial in reducing infection risk.<sup>39</sup> In their case-control study of over 1,100 open fractures, administering antibiotics more than three hours post-injury increased the odds of infection by 1.63 times compared to treatment within the first three hours.<sup>39</sup> Extending the duration of antibiotic prophylaxis beyond 24 hours has not demonstrated a significant benefit in reducing the risk of fracture site infections.<sup>40</sup> In contrast, the 2017 British Orthopaedic Association recommend administering antibiotics within one hour of injury, citing a 17% reduction in infection risk compared to those receiving antibiotics after 60 minutes.<sup>41</sup>

Antibiotic-coated nails were first described by Paley and Herzenberg for the treatment of intramedullary infections.<sup>42</sup> However, recent studies have highlighted their potential role in the primary treatment of open tibial fractures. A recent meta-analysis, which included only two studies, indicated a trend but no statistically significant differences toward reduced infection rates with the use of antibiotic-coated nails, identifying a 17% relative risk reduction in infection.<sup>43</sup> Similarly, De Meo et al, in a systematic review of eight studies, found no evidence of advantages associated with antibiotic-coated nails in terms of fracture-related infection, non-union, or healing in both primary and revision surgeries.<sup>44</sup> Given the current evidence, the use of an antibiotic-coated nail for primary fracture fixation in open tibial fractures cannot be recommended. Further high-quality randomized controlled trials are needed to clarify the potential benefits of this treatment option.

## Debridement

Debridement involves thoroughly cleaning the wound by excising necrotic and devitalized tissue and removing foreign materials. It is a critical factor in achieving optimal outcomes in the management of open tibial fractures.<sup>22</sup> Before surgical debridement, careful wound cleansing using a soft brush and a soap solution should be considered to reduce contamination.<sup>43</sup> Careful excision of wound margins to healthy tissue is essential; however, undermining soft tissues and preserving tenuous skin bridges should be avoided to minimize the risk of compromised healing.<sup>10</sup> Nonviable bone fragments should be removed, and any fragments that can be easily detached without resistance (using the “tug test”) should also be excised.<sup>10</sup> Fragments that remain attached to the periosteum, however, should be preserved.<sup>10</sup>

Contaminated bone fragments should be thoroughly cleaned, debrided, and decorticated if necessary. The routine use of a tourniquet during these procedures is generally discouraged.<sup>10</sup> If there is uncertainty about tissue viability, a second-look debridement should be considered, particularly in cases of small wounds with significant comminution, as the initial appearance may be misleading.<sup>3</sup>

The traditional approach of routinely debriding all open tibial fractures within 6 hours no longer appears universally applicable. The current NICE guidelines recommend immediate debridement for wounds with vascular compromise, debridement of high-energy or contaminated wounds within 12 hours, and debridement of low-energy open fractures within 48 hours.<sup>39</sup> These recommendations align with those of other established guidelines.<sup>10,31</sup> Interestingly, studies suggest that factors other than time to debridement play a more significant role in perioperative infection risk. Independent risk factors include smoking, diabetes, prolonged surgical time, and fracture severity. Type III injuries, in particular, are associated with higher rates of reoperation and infection.<sup>46,47</sup>

The Malawi guidelines recommend performing debridement in the operating room under general or spinal anaesthesia.<sup>12</sup> They advise immediate debridement for highly contaminated wounds or cases with vascular compromise, within 12 hours for Grade II and III fractures, and within 24 hours for Grade I fractures.<sup>12</sup>

## Irrigation

Wound irrigation is a crucial component of open tibial fracture management, effectively removing contaminants and reducing the risk of infection. Current controversies focus on the debate between high-pressure versus low-pressure lavage and the selection of the optimal irrigation fluid.

Studies suggest that high-pressure pulsatile lavage is more effective at removing bacteria and debris compared to low-pressure lavage.<sup>48</sup> The main concern with high-pressure lavage is the potential to push contaminants deeper into tissues, which may increase infection rates and cause further damage to soft tissues and bone.<sup>49</sup> The FLOW trial has provided clarity, demonstrating that warm normal saline with low-pressure irrigation should be the primary and safest choice for wound lavage.<sup>50</sup> Conversely, Omar et al concluded that there is a lack of evidence to warrant discontinuing the use of pulsatile high-pressure lavage and recommended its continued implementation.<sup>10</sup> Regarding irrigation volume, there is general agreement that 3 litres are sufficient for Type I injuries, 6 litres for Type II, and 9 litres for Type III injuries. However, it is generally accepted that highly contaminated wounds may require larger volumes until they are adequately cleansed of contamination.<sup>10,31,41,45</sup> Irrigation fluids containing surfactants and antiseptics are no longer recommended, as they can cause secondary injury to the wound, increasing the risk of soft tissue necrosis.<sup>10,48</sup> Furthermore, antimicrobial agents such as bacitracin have been shown to be associated with higher rates of wound healing complications.<sup>45</sup> The AAOS guidelines strongly recommend irrigating wounds with saline without additives for initial wound management.<sup>32</sup>

The Malawi guidelines advise against performing washouts outside the operating room and recommend that lavage be done in conjunction with debridement.<sup>12</sup> They suggest using at least 5 litres of tap water followed by a minimum of 2 litres of sterile fluid.<sup>12</sup>

## Timing of Surgery and Surgical Implant Options

The treatment of open tibial fractures should adhere to the general principles of orthopaedic trauma management, and the presence of an open fracture should not justify the departure from established osteosynthesis guidelines.<sup>10</sup> Primary treatment is largely determined by the fracture characteristics, with both internal and external fixation techniques being viable options.<sup>10,51</sup> An exception occurs when bone defects are present, which necessitate the use of appropriate reconstruction techniques.<sup>10</sup> In general, Type I and II open fractures can be treated primarily with definitive osteosynthesis.<sup>10,52</sup> Most Type III injuries can also follow this approach, except in cases with large or segmental bone defects, significant soft tissue damage requiring flap coverage, severely contaminated farm injuries, or cases involving vascular injuries that necessitate urgent vascular reperfusion surgery.<sup>10,52</sup> For primary fixation, options include intramedullary fixation, plating, and external fixation methods such as ring fixators, hexapods, and static frames.<sup>10,52</sup> Intramedullary nailing is generally considered the primary treatment option for most open diaphyseal and extra-articular metaphyseal fractures, although alternative fixation methods may be necessary in certain cases.<sup>31</sup> Yokohama



et al demonstrated that immediate reamed or unreamed nailing for Grade 3B and 3C fractures results in higher infection rates and should be avoided.<sup>53</sup> However, the authors also concluded that other factors, such as early debridement, timely conversion of external fixation to nailing, and prompt skin closure, are critical in reducing the risk of deep infection.<sup>53</sup> Intramedullary nailing can also be considered to be an effective bridging device for open fractures with bone loss.<sup>31</sup> If definitive skeletal stabilization is not feasible for any reason, temporary spanning external fixation is an effective alternative.<sup>2,10,41</sup> Temporary external fixation should be particularly considered in cases of severe contamination, extensive soft tissue involvement, or in unstable patients.<sup>3</sup> Furthermore, the Ganga Hospital Open Injury Score (GHOIS) can aid in decision-making, with definitive fixation typically being appropriate when the score is below 9.<sup>54</sup> The current AAOS guidelines on preventing surgical site infections after major extremity trauma provide a moderate-strength recommendation for definitive fracture fixation at the initial debridement, along with primary wound closure when appropriate. They also suggest that temporary external fixation remains a viable option.<sup>32</sup>

The Malawi guidelines recommend that definitive internal stabilization should only be performed when it can be immediately followed by definitive soft tissue coverage.<sup>12</sup> They also suggest that Grade IIIA and IIIB fractures be stabilized with an external fixator at the time of debridement.<sup>12</sup> However, no specific recommendations were made regarding other surgical fixation methods.<sup>12</sup>

### Primary Skin Closure – Temporary Wound Dressings

Historically, immediate primary closure of open fractures was thought to increase the risk of wound infection and fracture non-union.<sup>55</sup> However, recent published literature has challenged this long-standing assumption. Hohmann et al reported no significant difference in infection rates between patients who underwent primary closure, with an average infection rate of 4%, and those who underwent delayed closure, which had an average infection rate of 2% when primary closure was performed.<sup>56</sup> Moola et al demonstrated that primary closure for all open fractures is safe and does not increase the risk of postoperative infection.<sup>55</sup> Their study identified no significant correlation between fracture classification, trauma velocity, or time to wound closure and the occurrence of infection, delayed union, or non-union.<sup>50</sup> Scharfenberger et al demonstrated that primary wound closure in Grade I–IIIA open fractures resulted in lower rates of infection (4% vs 9%) and nonunion (13% vs 29%) compared to delayed closure.<sup>57</sup> Rajasekaran reported that primary wound closure is safe when performed under specific conditions: debridement is completed within 12 hours, there is no significant skin loss, skin approximation is achievable without tension, and there is no evidence of vascular insufficiency.<sup>54</sup> Riechelmann et al confirmed that primary soft tissue closure is safe for Grade I–IIIA open fractures, provided that debridement is thorough, the skin margins are bleeding and viable, and appropriate antibiotics are administered.<sup>58</sup> It is noteworthy, and perhaps counterintuitive, that re-exploration of the wound during definitive fracture fixation does not appear to be associated with an increased risk of complications.<sup>59</sup> Reynolds et al reported no significant difference in complication rates between patients with open tibia fractures who underwent staged fixation.<sup>59</sup>

Primary closure is generally recommended for Type I to Type IIIA tibial fractures when sufficient viable soft tissue is available to achieve tension-free closure. This approach is contingent on meticulous debridement of the injury and the timely administration of prophylactic antibiotics.<sup>60</sup> The current AAOS guidelines on preventing surgical site infections after major extremity trauma strongly recommend the use of negative pressure therapy, as it may reduce the risk of revision surgery and superficial site infections.<sup>32</sup> However, silver-coated dressings are generally not recommended, with only a moderate-strength recommendation.<sup>32</sup> Regarding primary wound closure, the guidelines strongly recommend closure when feasible and when there is no significant gross contamination.<sup>32</sup>

The Malawi guidelines recommend primary closure for clean Grade I fractures, leaving Grade II fractures open with closure within 72 hours, and keeping Grade III fractures open.<sup>12</sup> For Grade III fractures, patients should be referred to the nearest specialized hospital for further management.<sup>12</sup>

### Soft Tissue Management

For fracture wounds that cannot be closed primarily and may require flap coverage, the injury location, defect size, and zone of damage must be carefully assessed to determine whether rotational or free flap coverage is the most suitable option.<sup>30</sup> Fractures in the proximal two-thirds of the tibia are typically treated with rotational muscle flaps, while those in

the distal third generally require free flaps.<sup>30</sup> Soft tissue management should aim to achieve flap coverage within 72 hours to minimize the risk of deep infection.<sup>10</sup> Lack et al reported that delaying soft tissue closure beyond 5 days doubles the infection rate.<sup>61</sup>

In cases where primary wound closure is not possible and temporary wound management is needed, negative pressure wound therapy is an effective option.<sup>10</sup> Kim and Lee demonstrated in a meta-analysis that negative pressure wound therapy, compared to conventional management, resulted in lower rates of soft tissue infections, non-union, flap necrosis, and the need for revisions.<sup>62</sup> Stannard et al reported in a randomized controlled trial that negative pressure wound therapy significantly reduced the total infection rate (acute and late combined) compared to saline-soaked dressings, although the estimate lacked precision.<sup>63</sup> In a similar study, Kumaar et al demonstrated that negative pressure wound therapy significantly reduced infections and enhanced the healing of open fracture wounds.<sup>64</sup> However, both the WHIST and WOLFF trials found no evidence that negative pressure wound therapy (NPWT) reduced infection rates compared to open solid foam or gauze dressings.<sup>65,66</sup> However, the WOLFF trial was conducted in the UK, and all open fractures in their cohort underwent definitive soft tissue management within 72 hrs from injury, perhaps negating any benefit NPWT may have provided. Regardless of the wound management method, five-year results from the WHIST trial still reported high levels of persistent disability and reduced quality of life, with minimal evidence of improvement over this period.<sup>67</sup> The current AAOS guidelines on preventing surgical site infections after major extremity trauma provide a moderate-strength recommendation for wound closure within seven days.<sup>30</sup> However, they note that the current evidence supporting the use of an orthoplastic team or hyperbaric oxygen therapy is limited.<sup>32</sup>

## Large Bone Fragments

The presence of large bone fragments, whether devitalized, extruded, or attached to viable soft tissue, remains a significant challenge and a subject of ongoing debate.<sup>68</sup> Traditionally, the standard approach has been to discard devitalized or extruded cortical fragments; however, this practice has recently been questioned. In cases of severe contamination or comminution, such as ballistic injuries, retaining bone fragments is not feasible, and discarding them may be the most logical and often only option for the surgeon.<sup>68</sup> If large bone fragments remain attached to the periosteum or pass the tug test (showing substantial resistance when attempting to remove them), they may be preserved and reduced if possible.<sup>10</sup> Devitalized and extruded fragments can be retained if thoroughly debrided and disinfected to reduce bacterial load before being incorporated into the fracture site.<sup>69</sup> Mechanical scrubbing followed by a five-minute immersion in povidone-iodine or chlorhexidine appears to be a safe and effective time interval.<sup>70</sup> Another author has suggested soaking the fragment in a vancomycin solution for an additional thirty minutes to further reduce the risk of infection.<sup>71</sup> The Bristol experience demonstrated that incorporating mechanically relevant, debrided devitalized bone fragments into the definitive reconstruction of Type IIIB open diaphyseal tibial fractures is a safe approach.<sup>69</sup> In addition, two case reports demonstrated the successful reimplantation of extruded bone fragments.<sup>71,72</sup>

## Conclusions

The initial treatment of open tibial fractures remains controversial and lacks robust recommendations. Key steps include early administration of intravenous antibiotics, timely debridement and lavage of open wounds, primary wound closure when tissue is viable and closure can be achieved without tension, and early flap coverage within 72 hours if needed. Preferred definitive stabilization for Grade I–IIIa fractures is intra-medullary nailing, with temporary external fixation used when necessary. Early conversion to definitive treatment is also essential.

In low-resource countries in Southern Africa, only one guideline has been developed, which recommends the administration of early intravenous antibiotics, timely debridement and irrigation in the operating room, and management based on fracture severity. The guideline advises primary closure for Grade 1 fractures, delayed closure for Grade 2 fractures, and no closure for Grade 3 fractures, with referral to a specialist hospital for further management of Grade 3 injuries. In this context, further exploration is needed regarding the applicability of early simple oral antibiotics as an alternative to intravenous administration, the use of locally administered antibiotics, and temporary fixation with homemade antibiotic nails. Furthermore, optimal timing for both initial and definitive surgery, the use of temporary or permanent wound dressings,

and soft tissue management when referral is not possible or significantly delayed require further investigation. The management of large bone fragments at the time of debridement also warrants further investigation.

Ultimately, the absence of general recommendations and context-specific guidelines for the initial management of open tibial fractures in Southern Africa highlights the need for further work. Specific issues to address include how to evaluate and treat these injuries in low-resource settings that are by staff shortages, inadequate infrastructure, and inconsistent medication supply.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Funding

This research did not receive any funding.

## Disclosure

Professor Kevin Tetsworth is an unpaid consultant for AO Foundation, personal fees for speakers bureau and design consultant from Smith and Nephew, personal fees for speakers bureau from Johnson and Johnson MedTech, scientific advisory board for and shares and stock options from OrthoDx and VitaClot Medical, outside the submitted work. The authors report no other conflicts of interest in this work.

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