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Management of soft-tissue coverage of open tibia fractures in Latin America: Techniques, timing, and resources☆

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ABSTRACT

Purpose: This study examined soft-tissue coverage techniques of open tibia fractures, described soft-tissue treatment patterns across income groups, and determined resource accessibility and availability in Latin America.

Methods: A 36-question survey was distributed to orthopaedic surgeons in Latin America through two networks: national orthopaedic societies and the Asociación de Cirujanos Traumatólogos de las Américas (ACTUAR). Demographic information was collected, and responses were stratified by income groups: high-income countries (HICs) and middle-income countries (MICs).

Results: The survey was completed by 469 orthopaedic surgeons, representing 19 countries in Latin America (2 HICs and 17 MICs). Most respondents were male (89%), completed residency training (96%), and were fellowship-trained (71%). Only 44% of the respondents had received soft-tissue training. Respondents (77%) reported a strong interest in attending a soft-tissue training course. Plastic surgeons were more commonly the primary providers for Gustilo Anderson (GA) Type IIIB injuries in HICs than in MICs (100% vs. 47%, $p<0.01$) and plastic surgeons were more available (<24 h of patient presentation to the hospital) in HICs than MICs (63% vs. 26%, $p = 0.05$), demonstrating statistically significant differences. In addition, respondents in HICs performed free flaps more commonly than in MICs for proximal third (55% vs. 10%, $p<0.01$), middle third (36% vs. 9%, $p = 0.02$), and distal third (55% vs. 10%, $p<0.01$) lower extremity wounds. Negative Pressure Wound Therapy (NPWT or Wound VAC) was the only resource available to more than half of the respondents. Though not statistically significant, surgeons reported having more access to plastic surgeons at their institutions in HICs than MICs (91% vs. 62%, $p = 0.12$) and performed microsurgical flaps more commonly at their respective institutions (73% vs. 42%, $p = 0.06$).

☆ Investigation performed at the University of California, San Francisco; Zuckerberg San Francisco General Hospital.

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Conclusions: The study demonstrated that most orthopaedic surgeons in Latin America have received no soft-tissue training, HICs and MICs have differences in access to plastic surgeons and expectations for flap type and timing to definitive coverage, and most respondents had limited access to necessary soft-tissue surgical resources. Further investigation into differences in the clinical outcomes related to soft-tissue coverage methods and protocols can provide additional insight into the importance of timing and access to specialists.

Introduction

The burden of musculoskeletal disease poses a significant global health challenge, with low-and middle-income countries (LMICs) being particularly affected, resulting in approximately 90% of trauma-related deaths worldwide [1–3]. Open tibial shaft fractures are one of the most frequently reported traumatic injuries, and are associated with high rates of infection, nonunion, and malunion [1]. Road traffic accidents have contributed to the rise in the incidence of open tibia fractures, which has led to over 50,000 open fractures per year in some Latin American countries, with complication rates reaching as high as 20% [4,5].

Due to the high-velocity trauma associated with many open tibia fractures, these injuries are often complicated by soft-tissue damage, which can be exacerbated by poor and untimely wound coverage that can lead to further complications including infection, amputation, and death [6,7]. In high-income countries (HICs), these soft-tissue interventions are often delegated to the expertise of plastic surgeons. However, in LMICs there is a dearth of plastic surgeons available to treat soft-tissue injuries, and therefore these wounds are managed by orthopaedic surgeons or other healthcare providers who often lack sufficient training [8].

Multiple measures have been suggested to address this gap in the management of soft-tissue injury following open tibia fractures, such as standard of care protocols, academic partnerships, and international soft-tissue coverage training courses [9]. However, these measures are not well documented across Latin America. In a recent study, it was reported that few middle-income countries (MICs) had standard of care protocols or guidelines in place for open fracture treatment in Latin America [10,11]. The current paucity of literature on soft-tissue management for open traumatic wounds in this region poses a significant challenge in identifying needs, comparing treatment strategies, and determining effective solutions across a diverse economic landscape. Thus, the purpose of this study was to examine soft-tissue coverage techniques of open tibia fractures, describe soft-tissue treatment patterns across income groups, and determine resource accessibility and availability in Latin America.

Methods

A cross-sectional, multi-national survey was conducted between January to July 2021 to identify orthopaedic surgeons' standards of soft-tissue wound care for open tibia fractures and determine areas for further study and improvement. Inclusion criteria included orthopaedic surgeons that treat traumatic injuries in Latin America. There were no exclusion criteria.

The survey consisted of 36 questions and was designed based on a literature review, and further assessed by two fellowship-trained orthopaedic and plastic surgeons (NL and MT). It was then translated into Spanish and Portuguese by three bilingual Latin American orthopaedic surgeons using the back translation method (MG, CSV, and VG) [12]. Demographic information was collected, including country of practice, years of experience, subspeciality training, practice environment, and soft-tissue training level. In addition, a needs assessment gauged orthopaedic surgeons' access and availability to various wound care and microsurgical operating room resources and instruments. To optimize the number of survey responses across the region, the survey was distributed through two networks: national orthopaedic societies across Latin America and the Asociación de Cirujanos Traumatólogos de las Américas (ACTUAR) [13], an academic consortium of Latin American orthopaedic trauma surgeons interested in collaborating on clinically-important and regionally-relevant investigative work.

In addition, survey responses were stratified by income groups (HICs and MICs) categorized by the 2021 World Bank Country and Lending Groups [14] data to further evaluate patterns and differences in soft-tissue management of open tibia fractures. Analy-

Table 1
Demographic Data of Survey Respondents.

	Total n (%)
	469 (100)
Male	416 (88.7)
Years in practice	
0-5	69 (14.7)
6-10	88 (18.8)
11-15	70 (14.9)
16-20	67 (14.3)
>21	175 (37.3)
Residency training	448 (95.7)
Fellowship in musculoskeletal trauma	333 (71.3)
Practice setting	
Public-Private (Combination)	212 (45.2)
Public hospital	126 (26.9)
Private practice	102 (21.7)
Academic practice	28 (6)
Practice location	
Urban	439 (93.6)
Suburban	25 (5.3)
Rural	5 (1.1)
Supervise Residents	285 (60.8)
Received soft-tissue training	
Yes	207 (44.2)
No	262 (55.8)
Type of soft-tissue training	
Surgical mentorship	108 (52.7)
Formal training course	97 (47.3)
Number of open tibia fractures personally treated each year	
0-10	173 (38.1)
11-20	93 (20.5)
21-30	61 (13.4)
31-40	28 (6.2)
41-50	34 (7.5)
51-60	15 (3.3)
61-70	8 (1.8)
71-80	3 (1)
81-90	1 (.2)
91-100	16 (3.1)
>100	8 (1.8)

*Various data not reported by all respondents

Fig. 1. Map of survey respondents by country and identification of income groups (HICs and MICs) as determined by the 2021 World Bank Country and Lending Groups data.

sis was performed utilizing Fisher's exact tests with $p \leq 0.05$ as the significance level with STATA SE version 17 software (StataCorp). The survey was distributed electronically through REDCap (Research Electronic Data Capture) and the study was deemed exempt from review by the University of California, San Francisco Institutional Review Board.

Results

The survey was completed by 469 orthopaedic surgeons. Respondents represented 19 countries in Latin America (Fig. 1), two of which were designated as HICs and 17 as MICs. Most survey respondents were male (89%), completed residency training (96%), and were fellowship-trained (71%). The majority of orthopaedic surgeons practiced in an urban environment (94%), most commonly in a public-private dual practice setting (45%). Most survey respondents (59%) personally treated 20 or fewer open tibia fractures each year. Overall, only 44% of the survey respondents had received soft-tissue training, obtained through surgical mentorship (53%) or formal training courses (47%). Seventy-seven percent of respondents reported a strong interest in attending a soft-tissue training course (Table 1).

Comparison of soft-tissue management between income groups

The majority of respondents from both HICs (55%) and MICs (56%) had not received any form of soft-tissue coverage training. Average timing between injury and presentation to the hospital was most commonly reported within 6 h among HICs and MICs (82% vs. 60%, $p = 0.63$), demonstrating no significant difference between income groups. Similarly, timing between presentation to the hospital and the operating room was most commonly reported within 6 h for both HICs and MICs (64% vs. 63%, $p = 0.69$). Plastic surgeons were identified as the primary providers for soft-tissue coverage for Gustilo Anderson (GA) Type IIIB fractures in HICs significantly more often than in MICs (100% vs. 47%, $p<0.01$). While not statistically significant, respondents in HICs had access to plastic surgeons more commonly than in MICs (91% vs. 62%, $p = 0.12$). Additionally, orthopaedic surgeons in HICs reported increased availability to soft-tissue specialists within 24 h of patient presentation to the hospital in comparison to MICs (63% vs.

Table 2
Comparison of Soft-Tissue Management in Open Tibia Fractures between Income Groups.

	High-Income Countries n (%)‡	Middle-Income Countries n (%)‡	P Value
Total	*11 (100)*	*458 (100)*	
Average time between injury and patient presentation to hospital			
<6 hours	9 (81.8)	274 (60)	0.63
24 hours	2 (18.2)	173 (37.9)	
48 hours	0 (0)	10 (2.1)	
Average time between patient presentation and the OR for fracture stabilization			
<6 hours	7 (63.7)	281 (62.5)	0.69
24 hours	4 (36.4)	142 (31.6)	
48 hours	0	27 (6)	
Average time to provide soft-tissue coverage after presentation of injury			
<7 days	6 (60)	194 (48.7)	0.48
>7 days	4 (40)	204 (51.3)	
Primary soft-tissue coverage provider for GA-IIIB fractures			
Plastic surgeon	11 (100)	213 (46.9)	<0.01
Orthopaedic surgeon	0 (0)	205 (45.1)	
No available surgeon	0	36 (7.9)	
How often is a plastic surgeon available at your institution?			
Always	10 (90.9)	282 (61.7)	0.12
Sometimes	1 (9.1)	69 (15.1)	
Never	0 (0)	106 (23.2)	
How available is your soft-tissue coverage provider?			
Inpatient (initial hospitalization) <24 hours	7 (63.6)	118 (26.2)	0.05
Inpatient (initial hospitalization) <1-3 days	3 (27.3)	134 (29.7)	
Inpatient (initial hospitalization) >3 days	1 (9.1)	139 (30.8)	
Transfer or outpatient follow-up only	0	60 (13.3)	
Are microsurgical flaps performed at your institution?			
Yes	8 (72.7)	192 (42.1)	0.06
No	3 (27.3)	264 (57.9)	
Have you received soft-tissue coverage training?			
Yes	5 (45.4)	202 (44.2)	1
No	6 (54.5)	255 (55.8)	
Are you interested in attending a soft-tissue training course?			
Very interested	7 (63.6)	353 (77.2)	0.13
Moderately interested	2 (18.2)	82 (18)	
Not interested	2 (18.2)	22 (4.8)	

*Various data not reported by all respondents
*Tests of significance completed with Fisher's exact test ($p \leq 0.05$)
‡2021 World Bank Country and Lending Groups

26%, $p = 0.05$). Definitive soft-tissue coverage was performed more commonly within seven days in HICs than in MICs (60% vs. 49%, $p = 0.48$) and microsurgical flaps were used more frequently at institutions in HICs than in MICs (73% vs. 42%, $p = 0.06$), although these differences were not statistically (Table 2).

Preference for soft-tissue management of lower extremity wounds following open tibia fractures were treated significantly differently between income groups. Respondents from HICs performed free flaps more often than in MICs for proximal third (55% vs. 10%, $p<0.01$), middle third (36% vs. 9%, $p = 0.02$), and distal third lower extremity defects (55% vs. 10%, $p<0.01$) (Fig. 2).

Wound care and operating room resources

The majority of participants (70%) had access to a Negative Pressure Wound Therapy (NPWT or Wound VAC). Less than half of the participants had access to the following items: magnifying loupes (43%), wall suction outside the OR (41%), manual blade for harvesting skin grafts (Humby blade) (40%), power dermatome (39%), microsurgery instruments (31%), operating microscopes (28%), handheld doppler (22%), and skin graft mesher (19%). Participants reported access to multiple types of dressings, including saline-moistened sterile gauze dressings (76%), occlusive dressings (71%), and anti-microbial dressings (62%). Regarding anti-microbial dressings for wound care, antibiotic ointments were the most commonly accessible (71%), followed by Silvadene (67%), Betadine/Iodine-based dressings (56%), Dakins/Dilute bleach (22%), honey-based dressings (17%), and other supplies (13%) (Table 3).

Discussion

Determining the ideal protocol for open fracture treatment in Latin America is considered one of the top health research priorities in musculoskeletal care [15], with timeliness and method of treatment being critical to the function and outcome of these injuries [16,17]. This study adds to recent research on open tibia fracture management in Latin America by identifying soft-tissue coverage techniques, timing, and available resources across HICs and MICs.

Countries in Latin America have large disparities in healthcare expenditures in relation to their Gross Domestic Product (GDP) per capita, ranging from 3.5%−11.2%, resembling similar percentages to those observed in low, middle, and high-income countries [18,19]. Socioeconomic factors, as well as diverse national healthcare systems in this region, contribute to the uneven distribution of musculoskeletal trauma care across centers, disproportionately impacting those in resource-limited settings [6,20–24].

In this study, plastic surgeons in HICs were more commonly cited as the primary providers responsible for performing soft-tissue coverage than in MICs. Of note, a small percentage of respondents reported no access to orthopaedic or plastic surgeons to provide soft-tissue coverage for GA Type IIIB open tibia fractures, likely requiring the patient to be referred to a more well-equipped hospital with specialists and resources. Plastic surgeons

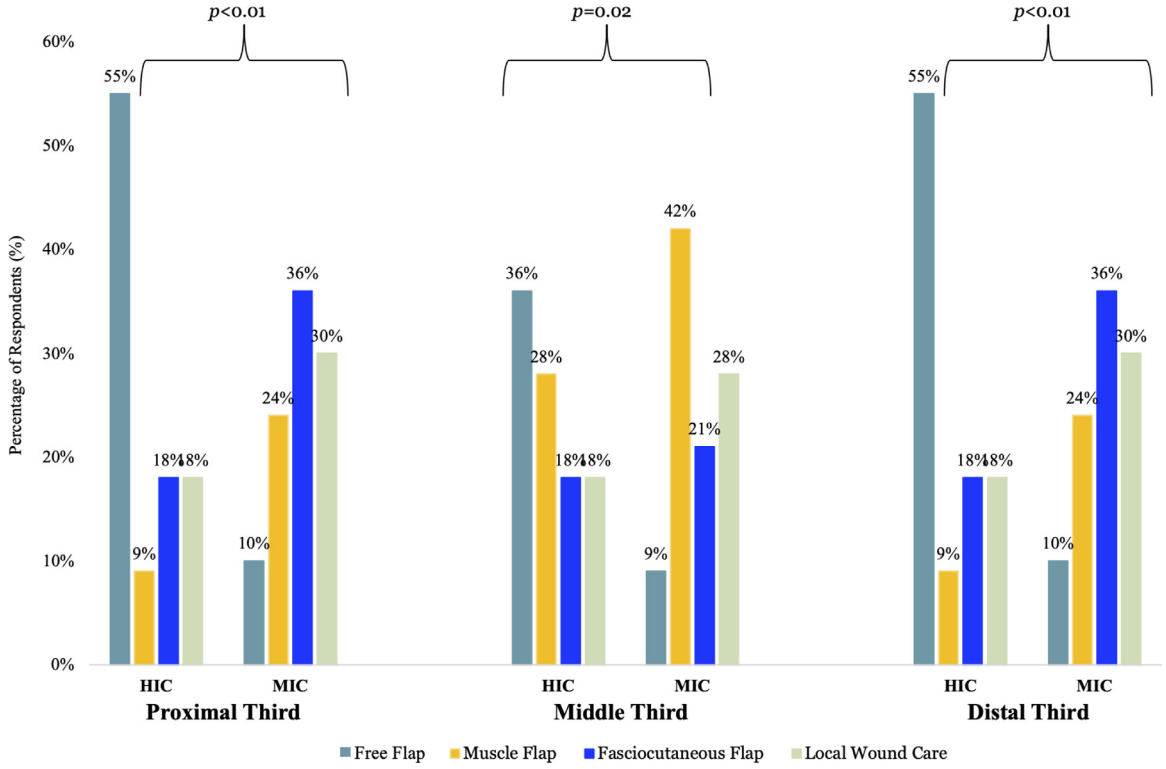

Fig. 2. Survey respondents' preference for treatment of lower extremity proximal, middle, and distal third defects stratified by income groups (HICs vs. MICs).

Table 3
Wound Care and Operating Room Resources.

	Total n (%) *469 (100)*
Which OR resources do you consistently have access to?+	
Negative Pressure Wound Therapy (NPWT or Wound VAC)	328 (69.8)
Magnifying loupes	201 (42.8)
Wall suction outside the OR	192 (40.8)
Manual blade for harvesting skin grafts (e.g Humby blade)	189 (40.2)
Power dermatome	184 (39.1)
Microsurgery instruments	147 (31.3)
Operating microscopes	130 (27.7)
Handheld doppler	103 (21.9)
Skin graft mesher	91 (19.4)
Which dressings do you consistently have access to?+	
Saline-moistened sterile gauze dressing	355 (75.5)
Occlusive dressing	332 (70.6)
Anti-microbial dressing	289 (61.5)
What type of anti-microbial dressings do you have access to?+	
Antibiotic ointments	333 (70.8)
Silvadene	315 (67)
Betadine/Iodine-based dressing	262 (55.7)
Dakins/Dilute bleach	102 (21.7)
Honey-based dressing	82 (17.4)
Other	61 (12.9)
What type of microsurgical instruments are available at your institution?+	
Not sure	270 (57.4)
8-0 suture (nylon, proline)	183 (38.9)
9-0 suture	131 (27.9)
Micro needle-holder	129 (27.4)
Curved micro dissecting scissors	126 (26.8)
Straight micro scissors	122 (26)
Micro-pickups	112 (23.8)
10-0 suture	107 (22.8)
Micro vessel dilator	99 (21.1)

*Various data not reported by all respondents
+ Participants were able to select multiple responses

were also reportedly more accessible in HICs than MICs, consistent with prior literature citing lack of access to specialists as a major barrier to performing wound coverage in LMICs [6,11,25–28]. Indeed, in Latin America, a prior study reported that soft-tissue flaps are not performed in nearly one-third of GA Type IIIB fractures due to these barriers [25]. Although the orthopaedic surgeon-respondents across HICs and MICs in this study received similar levels of soft-tissue training, the greater availability and access to specialist coverage in HICs was associated with timelier definitive treatment (within seven days) than in MICs, supporting the advantages of a combined orthoplastic team. Other barriers that may factor into time to definitive soft-tissue coverage between income groups include individual surgeon expertise, medical cost, implant and equipment availability, hospital resources, and infrastructure [29].

Multidisciplinary management between orthopaedic and plastic surgery teams is advantageous for the treatment of severe open tibia fractures, as it is associated with timelier treatment, quicker recovery, and less complications [30–33]. Plastic surgeons play a critical role in trauma centers performing limb-saving flap procedures, skin grafts, and microsurgery. Given these benefits, combined specialty teams are recognized in national open fracture treatment guidelines in Europe and North America [34–36]. Yet, many guidelines in Latin America are neither well-described nor standardized across the region [20,25]. Using evidence-based standardized guidelines, such as the British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS) [36], could help guide the development of regional protocols that include definitive soft-tissue coverage within seven days, “fix and flap” soft-tissue coverage with concomitant definitive fixation, and NPWT as an adjunct to open fracture management, all of which surgeons in HICs and MICs could work towards to improve outcomes and decrease complications [37]. Some principles of lower extremity management outlined in these guidelines, including wound debridement within 24 h of injury and antibiotic administration within 3 h of injury for GA Type I-III fractures, are already reported as common practice among orthopaedic surgeons in Latin America [25].

While standard orthopaedic residency training typically does not include soft-tissue flap coverage techniques as part of their core curriculum, this study’s findings provide perspective on current training and practices in this region, which can aid in the development of solutions to address treatment gaps. Efforts to train orthopaedic surgeons that acutely manage open tibia fractures with wound defects has been shown to be a cost-effective way of addressing these complex injuries in lesser-resourced settings [38,39]. Specifically, hands-on reconstructive training courses in these environments, led by both orthopaedic and plastic surgeons, can augment surgeons’ knowledge and skill in managing rotational flaps, skin grafts, and wound management [9,29,40–42].

Less than half of the study participants reported having access to various instruments in the operating room, including magnifying loupes, wall suction, Humby blades, and power dermatomes. NPWT was the only resource available to the majority of orthopaedic surgeons. Though previously believed to decrease infection rates of severe open wounds, a 2018 Cochrane review and a large randomized controlled trial showed no clear differences in healing or infection rates in open fractures in comparison to conventional dressings [43,44]. While NPWT is widely available in the operating room, this method of wound coverage may not be an adequate substitute to soft-tissue coverage [45]. Further, this survey did not distinguish between industry manufactured and improvised NPWT devices, the latter of which is used in some public hospitals in Latin America and has an efficacy that has not been well described. Additional investigation on the differences between NPWT devices would be beneficial. In HICs, surgeons in Latin America were predisposed to treat lower extremity proximal third, middle third, and distal third defects more commonly with free flaps, likely due to the greater access to plastic surgeons at their institutions. Conversely, surgeons in MICs more commonly treated these injuries with various other methods, including fasciocutaneous flaps, local muscle flaps, or direct wound care. While there is evidence to support that free flaps can lead to less wound complications for fractures with high grade osseus injuries [46], Cho et al. reported no differences in healing or infection rates between fasciocutaenous and muscle flaps, describing both as suitable procedures for wound coverage [47,48]. Though the decision for type of flap coverage is dependent on the location and severity of the defect [37], further examination of the regional differences in soft-tissue treatment selection could help to identify areas of change to improve clinical outcomes.

This large-scale multi-national study describes orthopaedic surgeons’ soft-tissue coverage techniques of open tibia fractures in Latin America, with the intent to provide insight into region-specific knowledge gaps. Nineteen countries were represented in this study, providing a broad overview of regional treatment patterns and availability of wound care resources. The study demonstrated that most respondents had limited access to necessary soft-tissue coverage surgical tools and resources, most orthopaedic surgeons in this region have received no soft-tissue training, and HICs and MICs have different access to plastic surgeons and expectations for flap type and timing to definitive coverage.

This study had several limitations. First, a chain-referral sampling method was utilized to improve the number of responses, precluding the ability to estimate a survey response rate. However, this method allowed the survey to be distributed more widely and to a more diverse group of orthopaedic surgeons across the region. Second, the overall number of 469 survey responses was low in comparison to the actual number of practicing orthopaedic surgeons in Latin America, limiting the generalizability of the results. Though it is difficult to provide an absolute number of practicing orthopaedic surgeons across the region, a total of 30,000 orthopaedic surgeon-members have been estimated across 20 Latin American national societies. [25]. Nevertheless, the survey represented participants from 19 countries in Latin America, providing for a regional evaluation of soft-tissue treatment techniques . Third, there were few responses collected overall from the HICs, which may not adequately reflect the treatment practices across this entire income group and may affect statistical inferences. These fewer responses are due, in large part, to the fact that there are only two countries designated as HICs in Latin America (Chile and Uruguay); it is valuable, however, to include these data to fully understand management differences in the region.

In summary, this study’s findings support the need for soft-tissue training courses, including rotational flaps, skin graft, and wound management, as well as better allocation of surgical tools and resources for orthopaedic surgeons in this region. Further investigation into differences in the clinical outcomes related to soft-tissue coverage methods and protocols can provide additional insight into the importance of timing and access to specialists.

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Conflict of interest

No conflict of interest related to the research or manuscript for the listed authors.

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