THE ORTHOPAEDIC FORUM

Open Tibial Shaft Fractures

Treatment Patterns in Latin America

Patrick D. Albright, MD, Madeline C. MacKechnie, MA, Heather J. Roberts, MD, David W. Shearer, MD, MPH, Luis G. Padilla Rojas, MD, Julio Segovia, MD, Jose Eduardo Quintero, MD, Rafael Amadei, MD, Fernando Baldy dos Reis, MD, Theodore Miclau III, MD, and the ACTUAR Open Tibia Study Group*

Investigation performed at the Institute for Orthopaedics and Traumatology, Orthopaedic Trauma Institute, Department of Orthopaedic Surgery, University of California, San Francisco, Zuckerberg San Francisco General Hospital, San Francisco, California

Background: Open tibial shaft fractures are an important source of disability in Latin America. High-income countries (HICs) worldwide have established standardized treatment protocols for open tibial fractures, but less is known about their treatment in middle-income countries (MICs) in Latin America. This survey of Latin American orthopaedic surgeons characterizes open tibial fracture treatment patterns.

Methods: Orthopaedic surgeons from 20 national orthopaedic societies throughout Latin America completed an online survey assessing their treatment of open tibial fractures. Demographic information was collected. Treatment patterns were queried according to 2 groupings of Gustilo-Anderson (GA) fracture types: treatment of type-I and type-II fractures (GA-I/II) and treatment of type-III fractures (GA-III). Treatment patterns were evaluated across 4 domains: antibiotic prophylaxis, irrigation and debridement, fracture stabilization, and wound management. Summary statistics were reported; analysis was performed using the Fisher exact test ($p < 0.05$).

Results: There were 616 survey participants from 20 Latin American countries (4 HICs and 16 MICs). Initial external fixation followed by staged internal fixation was preferred for GA-I/II (51.0%) and GA-III fractures (86.0%). Nearly one-third (31.5%) of GA-IIIB fractures did not receive a soft-tissue coverage procedure. Stratifying by country socioeconomic status, surgeons in MICs more commonly utilized delayed internal fixation for GA-I/II (53.3% versus 22.0%, $p < 0.001$) and GA-III fractures (94.0% versus 80.4%, $p = 0.002$). Surgeons in MICs more commonly used primary closure for GA-I/II (88.9% versus 62.8%, $p < 0.001$) and GA-III fractures (32.6% versus 9.8%, $p < 0.001$).

Conclusions: This survey reports Latin American orthopaedic surgeons' treatment patterns for open tibial shaft fractures. Surgeons in MICs reported higher delayed internal fixation use for all fracture types, while surgeons in HICs more routinely avoid primary closure. Soft-tissue coverage procedures are not performed in nearly one-third of GA-IIIB fractures because of a lack of operative personnel and training.

*A list of the ACTUAR Open Tibia Study Group members is included as a note at the end of the article.

Disclosure: This work was supported by a grant from the Wyss Medical Foundation. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/G100).

Musculoskeletal injuries contribute substantially to global disease burden, and open tibial fractures are a leading cause of morbidity[1]. Moreover, more than 90% of injury-related deaths occur in low and middle-income countries (LMICs)[1,2]. Latin America has a rising open tibial fracture burden due to road traffic accidents, with as many as 50,000 open fractures per year in some countries and complication rates as high as 20%[3,4]. Yet, little remains known regarding the true burden or treatment of these injuries in Latin America[5-7].

Open tibial fractures are traumatic injuries that require emergency orthopaedic treatment. The standard of care for open tibial shaft fractures includes early prophylactic antibiotics, surgical wound debridement, and fracture stabilization, all of which play a critical role in reducing long-term morbidity[6-11]. However, nationally recognized best practices and treatment patterns for open tibial shaft fractures across Latin America are less documented. A recent study found that 26% to 50% of middle-income countries (MICs) worldwide had formalized guidelines for open fracture treatment[12], but few Latin American countries had available guidelines[13-16]. While factors such as access to resources and the type of health-care system can determine treatment patterns, it is challenging to address orthopaedic care gaps without understanding current treatment patterns and how such preferences differ among the countries surveyed. Therefore, this study aims to provide insight into the treatment of open tibial shaft fractures in Latin America.

Materials and Methods

Survey Design and Distribution

We performed a cross-sectional survey of orthopaedic surgeons practicing in Latin America. We utilized a convenience sampling method of members of an academic orthopaedic research consortium[17] and members of Latin American orthopaedic societies. Institutional review board approval was obtained from the primary study institution.

The survey assessed surgeons' treatment preferences for open tibial fractures. Survey questions were developed based on the existing literature, with input from 3 United States fellowship-trained orthopaedic trauma surgeons and 3 Latin American orthopaedic surgeons. The English survey

Fig. 1

Map of survey respondents by country, demonstrating high-income and middle-income Latin American countries. (MICs include lower-middle-income and upper-middle-income countries; 13 respondents did not identify their country).

TABLE I Demographic Data

Characteristic	Total (N = 616)*
Sex (male)	565 (91.7)
World Bank profile	
High-income country	51 (8.5)
Middle-income country†	552 (91.5)
Practice environment	
Academic	35 (5.7)
Private practice	106 (17.4)
Public	89 (14.6)
Multiple	380 (62.3)
Practice location	
Urban (city)	588 (96.1)
Suburban	19 (3.1)
Rural	5 (0.8)
Years in practice	
0 to 5	112 (19.6)
6 to 10	121 (21.2)
11 to 15	87 (14.1)
16 to 20	77 (13.5)
>20	174 (30.5)
Fellowship in musculoskeletal trauma	
Yes	230 (37.6)
No	382 (62.4)
Number of open tibial fractures treated each year	
0 to 10	217 (36.2)
11 to 20	176 (29.4)
21 to 30	93 (15.5)
31 to 40	30 (5.0)
41 to 50	32 (5.3)
>50	51 (8.5)
Percentage of fractures presenting within 24 hours of injury	
<10%	71 (11.6)
10% to 25%	61 (10.0)
25% to 50%	71 (11.6)
50% to 75%	95 (15.5)
75% to 90%	133 (21.7)
>90%	181 (29.6)
Institution has a formal open fracture treatment protocol	
Yes	163 (26.5)
No	451 (73.5)

*Various data were not reported by all respondents. All data are frequency of response: number (%). †Includes countries defined as upper-middle and lower-middle income countries.

was translated into Spanish by 2 bilingual Latin American orthopaedic trauma surgeons. Subsequently, the Spanish survey was reviewed after translation back into English and distributed to the authorship group for final review. The survey included demographic information about the treating surgeon and his or her practice, including sex, country, practice environment, and number of open tibial fractures that are treated per year. Open tibial fracture treatment was queried according to 2 groupings determined by the Gustilo-Anderson (GA) classification[18]: the first group included treatment of type-I and type-II fractures (GA-I/II), and the second group included treatment of type-III fractures (GA-III). The survey queried responses relating to 4 open fracture treatment domains: antibiotic prophylaxis, irrigation and debridement, fracture stabilization, and wound management (see Appendix).

To reach respondents, at least 1 board member of each Latin American orthopaedic society was contacted to request assistance with survey distribution to the members of his or her respective organization. In order to increase survey response, it was requested that board and society members distribute the survey to local orthopaedic surgeons who treat open fractures. In order to avoid duplicate responses and to make them identifiable, respondents provided their name and hospital. Additionally, each orthopaedic society reported if society or national guidelines exist for open fracture treatment. Follow-up emails were sent at 2-month intervals, and the survey was closed after 10 months. Responses were collected utilizing Research Electronic Data Capture (REDCap)[19].

Statistical Methods

Summary statistics were calculated, and responses were categorized according to World Bank data regarding country income status as either high-income countries (HICs) or MICs, where MICs include both upper-middle-income and lower-middle-income countries[20]. At the time of the writing of this paper, no Latin American country represented in this survey was classified as a low-income country. Comparisons among groups were performed using 2-tailed Fisher exact tests with $\alpha = 0.05$ as the significance level. All analyses were performed using STATA SE version 15 (StataCorp).

Results

There were 616 survey participants from 20 countries (4 HICs and 16 MICs; Fig. 1), with the majority from MICs (91.5%). The majority of respondents were men (91.7%), practiced in an urban setting (96.1%), and had not completed musculoskeletal trauma fellowships (62.4%) (Table I). Just over one-quarter (26.5%) stated that their institution has a formalized open tibial fracture treatment protocol. Of the 20 orthopaedic societies, 6 (30%) stated that either societal or national open tibial fracture treatment guidelines exist, while 14 (70%) either stated that no guidelines exist or did not respond (Table II). More than half of respondents treated >10 open tibial fractures per year. One-third reported that the majority of patients with

TABLE II Latin American National Orthopaedic Societies*

National Society	Country	Reported Membership Count	Estimated Survey Distribution	Surveys Completed
Asociación Argentina del Trauma Ortopédico (AATO)	Argentina	500	500	46
Sociedad Boliviana de Ortopedia y Traumatología (SBOLOT)	Bolivia	NR	NR	3
Sociedade Brasileira de Trauma Ortopédico (SBTO)/Sociedade Brasileira Ortopedia e Traumatología (SBOT)	Brazil	470/15,000	470/1,500	45
Sociedad Chilena de Ortopedia y Traumatología (SCHOT)	Chile	74	74	7
Sociedad Colombiana de Cirugía Ortopédica y Traumatología (SCCOT)	Colombia	1,411	1,411	62
Asociación Costarricense de Ortopedia y Traumatología (ACOT)	Costa Rica	85[39]	NR	7
Sociedad Cubana de Ortopedia y Traumatología (SCOT)	Cuba	2,284	1,142	10
Sociedad Dominicana de Ortopédia y Traumatología (SDOT)	Dominican Republic	703	21	14
Sociedad Ecuatoriana de Ortopédia y Traumatología (SEOT)	Ecuador	500	500	23
Asociación Salvadoreña de Ortopédia y Traumatología (ASOT)	El Salvador	55	55	12
Asociación Guatemalteca de Ortopédia y Traumatología (AGOT)	Guatemala	1,200	1,200	4
Asociación de Cirugía Ortopédica y Traumatología de Honduras (ACOTH)	Honduras	135	135	1
Federación Mexicana de Colegios de Ortopedia y Traumatología (FEMECOT)	Mexico	3,100	3,100	205
Asociación Nicaraguense de Ortopedia y Traumatología (ANOT)	Nicaragua	230	230	39
Sociedad Panameña de Ortopedia y Traumatología (SPOT)	Panama	180	180	10
Sociedad Paraguaya de Ortopedia y Traumatología (SPOT)	Paraguay	250	60	53
Sociedad Peruana de Ortopedia y Traumatología (SPOT)	Peru	500	400	9
Sociedad Puertorriqueña de Ortopedia y Traumatología (SPOT)	Puerto Rico	144[40]	NR	1
Sociedad de Ortopedia y Traumatología del Uruguay (SOTU)	Uruguay	358	358	33
Sociedad Venezolana de Cirugía Ortopédica y Traumatología (SVCOT)	Venezuela	2,003	1,200	19

*NR = not reported. Various data were not reported by all respondents.

open tibial fractures at their hospital present at >24 hours after injury.

Regarding antibiotic prophylaxis, 92.6% reported administering intravenous antibiotics alone for patients with GA-I/II fractures, while 21.7% administered local antibiotics with intravenous antibiotics for GA-III fractures (Table III). The majority of respondents felt that the optimal time for antibiotic delivery is within 3 hours of hospital arrival for GA-I/II (89.0%) and GA-III (93.4%) fractures. However, respondents frequently encountered delays in antibiotic administration, with about one-third stating that antibiotics are typically delivered at >3 hours after patient arrival for GA-I/II (34.6%) and GA-III (31.5%) fractures. For GA-I/II fractures, most respondents administer first-generation cephalosporins alone (64.5%),

TABLE III Treatment Decisions by Domains of Open Fracture Management: Antibiotic Prophylaxis and Irrigation and Debridement*

	Gustilo-Anderson Type I or II	Gustilo-Anderson Type III
Antibiotic prophylaxis		
Route of antibiotic administration		
Intravenous only	560 (92.6)	468 (76.6)
Local antibiotics only	1 (0.2)	8 (1.3)
Intravenous with local antibiotics	44 (7.3)	132 (21.7)
Optimum time to antibiotic delivery		
<3 hours	544 (89.0)	570 (93.4)
3 to 6 hours	60 (9.8)	30 (4.9)
6 to 24 hours	6 (1.0)	8 (1.3)
>24 hours	1 (0.2)	2 (0.3)
Actual average time to antibiotic delivery		
<3 hours	399 (65.4)	417 (68.5)
3 to 6 hours	152 (24.9)	139 (22.8)
6 to 24 hours	57 (9.3)	50 (8.2)
>24 hours	2 (0.3)	3 (0.5)
Antibiotic regimen†		
First-generation cephalosporin	466 (64.5)	324 (31.8)
Third-generation cephalosporin	107 (14.8)	204 (20.0)
Aminoglycoside	106 (14.7)	324 (31.8)
Penicillin	23 (3.2)	51 (5.0)
Vancomycin	5 (0.7)	22 (2.2)
Piperacillin/tazobactam	1 (0.1)	3 (0.3)
Metronidazole	14 (1.9)	92 (9.0)
Irrigation and debridement		
Optimum time to definitive operative debridement		
<6 hours	484 (79.1)	554 (90.5)
6 to 24 hours	103 (16.8)	43 (7.0)
24 to 48 hours	3 (0.5)	8 (1.3)
Time to debridement is unimportant	22 (3.6)	7 (1.1)
Actual average time to definitive operative debridement		
<6 hours	239 (39.1)	290 (47.4)
6 to 24 hours	330 (53.9)	286 (46.7)
24 to 48 hours	31 (5.1)	23 3.8)
>48 hours	12 (2.0)	13 (2.1)
Reason for delayed debridement		
Surgeon choice/preference	15 (2.5)	13 (2.2)
Lack of available operative personnel or space	296 (50.3)	301 (51.1)
Patient cannot afford expenses	39 (6.6)	35 (5.9)
Lack of necessary equipment/implants	36 (6.1)	46 (7.8)
Delayed patient arrival	203 (34.5)	194 (32.9)

*All data are frequency of response: number (%). Various data were not reported by all respondents. †Multiple responses could be selected for the antibiotic regimen.

with some respondents adding third-generation cephalosporins (14.8%) or aminoglycosides (14.7%). The antibiotic administered to patients with GA-III fractures was variable, with first-generation cephalosporins (30.7%) and aminoglycosides (30.7%) most commonly reported.

Regarding irrigation and debridement, the majority felt that optimal definitive operative debridement should occur within 6 hours of presentation for GA-I/II (79.1%) and GA-III (90.5%) fractures (Table III). However, the reported time to operative debridement in practice differed considerably from the optimal

TABLE IV Treatment Decisions by Domains of Open Fracture Management: Fracture Stabilization and Wound Management*

	Gustilo-Anderson Type I or II	Gustilo-Anderson Type III	All Fracture Types
Fracture stabilization			
Treatment method			
Primary internal fixation	291 (47.7)	40 (6.6)	
Delayed internal fixation	311 (51.0)	524 (86.0)	
Definitive external fixation	6 (1.0)	45 (7.4)	
Definitive cast or splint	2 (0.3)	0	
Primary method of internal fixation			
Locking plate	38 (6.3)	68 (12.1)	
Nonlocking plate	37 (6.2)	20 (3.6)	
Unreamed intramedullary nail	262 (43.7)	228 (40.6)	
Reamed intramedullary nail	263 (43.8)	246 (43.8)	
Primary reason for using delayed internal fixation			
Infection risk	183 (59.2)	417 (79.9)	
Cost of implants	61 (19.7)	47 (9.0)	
Training/level of comfort	14 (4.5)	19 (3.6)	
Other	51 (16.5)	39 (7.5)	
Wound management			
Time of wound closure			
Primary closure at time of definitive fixation	534 (87.5)	184 (30.2)	
Delayed closure	76 (12.5)	425 (69.8)	
Surgical specialty responsible for the majority of flap procedures			
Orthopaedics			108 (18.4)
Plastic surgery			428 (72.9)
General surgery			3 (0.5)
Orthopaedics and plastic surgery			48 (8.2)
The majority of Gustilo-Anderson type-IIIB fractures are treated with flap procedures			
Yes			417 (68.5)
No			192 (31.5)
Reason for not using flap procedures in your hospital			
Surgeon training level/comfort		-	54 (23.7)
Surgeon preference		-	30 (13.2)
Lack of available operative personnel or space			22 (9.6)
Patient cannot afford expenses			10 (4.4)
Lack of necessary equipment/implants			17 (7.5)
Lack of plastic surgeons			95 (41.7)
Treatment used when wound cannot be closed primarily			
Negative-pressure wound therapy			331 (57.8))
Saline-solution-soaked dressings			226 (39.4)
Antibiotic bead pouch			16 (2.8)

*All data are frequency of response: number (%). Various data were not reported by all respondents.

time, with approximately half of GA-I/II (53.9%) and GA-III (46.7%) fractures reportedly treated between 6 and 24 hours after presentation to the hospital. Respondents most commonly cited a lack of available operative personnel or space and delayed patient arrival as the reasons for delayed definitive debridement.

Initial external fixation followed by staged internal fixation was most commonly reported for GA-I/II (51%) and GA-III (86%) fractures (Table IV). Definitive external fixation was infrequently reported, but more often for GA-III (7.4%) than GA-I/II fractures (1.0%). When performing internal fixation,

TABLE V Comparison of Treatment Preference by HIC Versus MIC*

	Gustilo-Anderson Type I or II			Gustilo-Anderson Type III		
	HIC (N = 51)	MIC (N = 552)	P Value*	HIC (N = 51)	MIC (N = 552)	P Value
Average time to antibiotic delivery						0.059
<3 hours	41 (80.4)	350 (63.4)	0.014	41 (80.4)	368 (66.7)	
>3 hours	10 (19.6)	202 (36.6)		10 (19.6)	184 (33.3)	
Average time to operative debridement						0.062
<24 hours	50 (98.0)	508 (92.0)	0.244	51 (100.0)	513 (93.4)	
>24 hours	1 (2.0)	41 (7.4)		0 (0.0)	36 (6.6)	
Utilize primary versus delayed internal fixation						0.002
Primary	39 (78.0)	247 (44.7)	<0.001	10 (19.6)	30 (6.0)	
Delayed	11 (22.0)	294 (53.3)		41 (80.4)	474 (94.0)	
Utilize primary versus delayed closure						<0.001
Primary	32 (62.8)	491 (88.9)	<0.001	5 (9.8)	178 (32.6)	
Delayed	19 (37.3)	56 (10.1)		46 (90.2)	368 (67.4)	
Use soft-tissue coverage procedures for Gustilo-Anderson type-IIIB fractures						0.270
Yes				39 (76.5)	374 (68.5)	
No				12 (23.5)	172 (31.5)	

*All data are frequency of response: number (%). Various data were not reported by all respondents. All tests of significance were completed with the Fisher exact test ($\alpha = 0.05$). HIC = high-income country, and MIC = middle-income country.

intramedullary nailing was the preferred strategy for GA-I/II (87.5%) and GA-III fractures (84.4%). The most commonly cited reason for delayed internal fixation for all fracture types was infection risk.

Regarding wound management, most reported primary closure for GA-I/II fractures (87.5%) and delayed closure for GA-III fractures (69.8%) (Table IV). However, nearly one-third did not use soft-tissue coverage procedures to treat GA-IIIB fractures. The most commonly cited reasons for not using these procedures included lack of plastic surgeons, surgeon preference, and surgeon training level. When primary closure was not possible, the majority reported using negative-pressure wound therapy (57.8%) or saline-solution-soaked dressings (39.4%).

When comparing respondents from MICs with those from HICs, surgeons from MICs more frequently reported time to antibiotic administration as >3 hours after patient presentation than surgeons from HICs for GA-I/II (36.6% versus 19.6%, p = 0.014) and GA-III (33.3% versus 19.6%, p = 0.059) fractures (Table V). Furthermore, surgeons from MICs reported utilizing delayed internal fixation more commonly for GA-I/II (53.3% versus 22.0%, p < 0.001) and GA-III (94.0% versus 80.4%, p = 0.002) fractures. Surgeons from MICs also more commonly reported attempting primary closure for GA-I/II (88.9% versus 62.8%, p < 0.001) and GA-III (32.6% versus 9.8%, p < 0.001) fractures. Finally, when comparing by surgeons' years in practice, there was decreased primary closure use for GA-III fractures with increasing practice years (0 to 5 years, 38.2%; 6 to 10 years, 35.0%; 11 to 15 years, 32.2%; 16 to 20 years, 27.6%; and >20 years, 21.4%; p = 0.020).

Discussion

To our knowledge, this cross-sectional study is the first to examine the preferred open tibial fracture treatment methodology in a cohort of Latin American orthopaedic surgeons. We have identified differences in treatment patterns among Latin American HICs and MICs, particularly pertaining to antibiotic prophylaxis, fracture stabilization, and wound coverage. Furthermore, we have identified potentially modifiable factors that may be addressed to improve open fracture treatment.

This study's strength is in the novelty of the data that are included and the diversity of the countries that are represented, particularly given its focus on a world region where collaborative and multicenter studies are limited[17,21]. The results are consistent with previous studies. In an international survey that included orthopaedic surgeons from each continent, Bhandari et al. queried tibial shaft fracture treatment; among 444 respondents, they found that internal fixation is commonly used across open fracture types (type I, 95.5%; type II, 88.1%; and type IIIA, 67.6%)[22]. They did not, however, distinguish between index internal fixation and external fixation followed by delayed internal fixation, or evaluate the reasons for the potential treatment differences. Furthermore, the majority of the respondents were from North America (51.7%), with only 65 responses (14.6%) from South America. A Canadian survey with 268 respondents found that 83% of respondents preferred to use intramedullary nailing for all open tibial fractures, but they did not distinguish implant choice by open fracture type or the choice between primary and delayed internal fixation[23]. Studies specific to Latin America are composed of small analyses from single institutions. A study from Guanajuato, Mexico, prospectively recorded the frequency and fracture type encountered over 1 year at their institution, in which they reported 66 open tibial fractures[24]. A similar study from Mexico City reviewed case logs over 4 years and identified 82 tibial fractures but did not specify whether they were open or closed[25]. Furthermore, neither study noted treatment protocols or fracture stabilization strategies. Thus, our study provides novel insights into the current standards of care in Latin America. These results highlight a need for the development of treatment guidelines at an orthopaedic society or national level. These guidelines should be specific for patients who present acutely and for those who present in a delayed manner. The guidelines developed by organizations such as the American Academy of Orthopaedic Surgeons or the Orthopaedic Trauma Association may not be generalizable to Latin American countries because of the high delayed patient presentation rate. Globally, there are few countries that have developed formal treatment guidelines for these injuries[12].

These data may provide an opportunity for the standardization and modernization of treatment protocols in Latin America. Based on data primarily from resource-rich settings, primary intramedullary nailing is the preferred management for low-energy and some high-energy open tibial shaft fractures[26-28]. Some meta-analyses have corroborated this treatment preference[29,30]. However, our study demonstrated a high delayed internal fixation rate, particularly among MICs. This could be due to a number of factors, including surgeon education, resource limitations, patient factors, or concern that the local environment differs from resource-rich environments.

For example, one-third of respondents in this study indicated that the majority of patients at their institution presented to the hospital at >24 hours after injury, which increases infection risk. Respondents reported that their primary reason for using delayed internal fixation was infection risk. These findings are consistent with the previous open tibial fracture literature from Latin America. One Brazilian study found that 44% of patients with open tibial fractures were treated at >24 hours after injury, which they attributed to late presentation, lack of hospital beds, extended transport time, and operating room unavailability[31]. A study in Mexico found that 80% of their cohort was treated with delayed internal fixation, commonly because of fracture severity or lack of implant availability at the initial debridement[32]. Additional studies are needed to explore the rationale for performing delayed internal fixation for open tibial fractures and to find solutions to reduce delayed presentation. There has been a notable lack of prehospital care and resource availability in non-trauma-designated hospitals in Latin American LMICs, and recent evidence suggests that the adoption of well-coordinated trauma systems is critical for improving musculoskeletal trauma care, including open fractures[12]. Indeed, the most recent edition of *Essential Surgery: Disease Control Priorities* from the World Bank Group has incorporated open fracture care into its essential trauma care guidelines for primary level hospitals[33]. Furthermore, training rural surgeons in basic open fracture care, as is being done by Mexican and Argentinian national orthopaedic societies, and developing guidelines for acute and delayed open fracture presentation may address the issue of delayed care.

Finally, our study found higher delayed closure rates among Latin American respondents from HICs and similar primary closure rates among Latin American respondents from MICs as compared with recent North American studies. A study of 119 open fractures at a single institution in the United States found that primary closure was frequently used for type-I (88%), type-II (86%), and type-IIIA (75%) fractures[34]. In 2 separate Canadian studies, the overall primary closure rate for type-I to type-IIIA open tibial fractures was 70% and 77%, respectively, and the majority of type-I (92% and 93%, respectively) and type-II (79% and 95%, respectively) fractures in each study were closed primarily[35,36]. Finally, in a 2007 survey of current open fracture teaching among United States orthopaedic residencies, respondents frequently utilized primary closure for type-I (88%) and type-II (86%) fractures[37]. However, the higher delayed closure rate among Latin American respondents from HICs may be due to increased delays in patient presentation to the hospital as compared with the United States and Canada. Thus, direct comparisons of our data to HIC data from other countries may be difficult. Further work is necessary to explore this issue. Additionally, the higher primary closure rate among surgeons in Latin American MICs compared with HICs may be because of concern about their ability to return to the operating room due to the lack of personnel, operating room capacity, or patient ability to pay. Thus, rather than performing multiple take-back operations, they may opt to primarily close wounds at the initial debridement and fracture stabilization.

Our study demonstrated that soft-tissue flap procedures are not performed in nearly one-third of GA-IIIB tibial fractures, a finding that was evident among surgeons in MICs. This likely represents limited access to plastic surgeons, as 40% of respondents attributed lack of flap coverage to lack of access to plastic surgeons and 23% cited their own training level or comfort with flap procedures. These findings support the investment into increasing plastic surgery capacity or training orthopaedic surgeons to perform flap procedures to address this treatment gap[38].

While this study provides novel insight into open tibial fracture treatment by Latin American orthopaedic surgeons, it has several limitations. We were unable to obtain a response rate for this survey given how it was distributed to orthopaedic societies, the ACTUAR Open Tibia Study Group network[17], and Latin American orthopaedic surgeons. We sought to maximize responses by encouraging respondents to distribute the survey to their colleagues and encouraging orthopaedic societies to distribute the survey to their membership roster. Members of the boards of directors or their delegates were responsible for survey distribution. Some individuals distributed the survey to their membership roster, while others distributed the survey within their organization to a targeted audience of orthopaedic trauma surgeons known to treat open tibial fractures. We attempted to determine survey penetrance and provide contextual evidence for the number of orthopaedic surgeons in each country by retrieving data regarding the number of practicing orthopaedic surgeons in each society and an estimate of the number of surgeons who received the survey. However, we were ultimately unable to determine if a survey was received by society members. Furthermore, given the chain-referral sampling methodology and the possibility that individuals providing surveys may have been contacted outside of a national society, we were unable to accurately calculate response rate. Nonetheless, the number of respondents to this survey is small relative to the number of practicing orthopaedic surgeons in Latin America. Therefore, the results may not be generalizable. We also recognize that the majority of respondents were urban surgeons. It is possible that urban surgeons were more likely to receive or complete the survey, or a disproportionate concentration of orthopaedic surgeons in urban Latin America may be reflected. While the treatment protocols assessed in this survey are based on the available literature and the input of subject matter experts, the survey that we used is not validated, and psychometric properties such as the Cronbach alpha and eigenvalues are unknown as they were not assessed during survey piloting.

To our knowledge, this study is the first to date describing open tibial fracture treatment patterns by orthopaedic surgeons across Latin America. We determined that there are significant differences pertaining to fracture stabilization and wound management among Latin American HICs and MICs. Future research is needed to clarify the reasons for these discrepancies and to establish setting-specific guidelines.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/G101). ■

NOTE: We would like to thank each of the following members of the ACTUAR Open Tibia Study Group and their respective Boards of Directors for their participation in this study:
Asociación Argentina del Trauma Ortopédico (AATO): F. Bidolegui, MD (Hospital Sirio Libanés de Buenos Aires); B. Dello Russo, MD (J. P. Garrahan Hospital Nacional de Pediatria Ciudad Autónoma de Buenos Aires); G. Garabano, MD (Hospital Británico de Buenos Aires); S. Pereira, MD (Hospital Sirio Libanés de Buenos Aires); and C. Pesciallo, MD (Hospital Británico de Buenos Aires).
Sociedad Boliviana de Ortopedia y Traumatología (SBOLOT): R. Gutierrez Escobar, MD (Clínica Aranjuez). Sociedade Brasileira de Trauma Ortopédico (SBTO): W.D. Belangero, MD, PhD (Universidade Estadual de Campinas); M.T. Caiero, MD (Instituto de Ortopedia e Traumatologia); S.T. Fischer, MD, MSc (Hospital do Trabalhador); V. Giordano, MD, PhD, FBCS (Hospital Municipal Miguel Couto); J.O.S. Hungria, MD (Hospital da Irmandade de Misericórdia da Santa Casa de São Paulo), K. Kojima, MD, PhD (University of São Paulo); L.H. Penteado da Silva, MD (Instituto de Ortopedia e Traumatologia de Passo Fundo); and R. Pires Esteves, MD, PhD (Universidade Federal de Minas Gerais). Sociedade Brasileira de Ortopedia e Traumatologia (SBOT): G. Baldy (Universidade Cidade de São Paulo); J. Klay Machado, MD (Porto Dias Hospital and Adventist Hospital of Belém); and J. Matheus Guimarães, MD (Instituto Nacional de Traumatologia e Ortopedia).
Sociedad Chilena de Ortopedia y Traumatología (SCHOT): E. Fuentes Morales, MD (Clínica Ciudad del Mar).Sociedad Colombiana de Cirugía Ortopédica y Traumatología (SCCOT): J.L. Osma, MD (Universidad Industrial de Santander); M.A. Triana, MD (Fundación Cardioinfantil); R.A. Vargas, MD (Universidad Nacional de Colombia); and M. Zuluaga, MD (Centro Medico Imbanaco).
Sociedad Cubana de Ortopedia y Traumatología (SCOT): R. Balmaseda Manent, MD (Hospital Fructuoso Rodriguez); A. Ceballos Mesa, MD (Universidad Medica de La Habana); and H. Tabares Neyra, MD (Universidad Medica de La Habana).Sociedad Dominicana de Ortopédia y Traumatología (SDOT): J. Landrón, MD (Hospital Ney Arias Lora).
Sociedad Ecuatoriana de Ortopédia y Traumatología (SEOT): G. Merchan, MD (Hospital de la Policia Nacional). Asociación Salvadoreña de Ortopédia y Traumatología (ASOT): M.A. Durán Sánchez, MD (Instituto Salvadoreño del Seguro Social); R.A. Gómez González, MD (Hospital Jose Rosales); and C.A. Romero Guerra, MD (Centro de Cirugía de Mínima Invasión Escalón).
Asociación Guatemalteca de Ortopédia y Traumatología (AGOT): R. Bolaños, MD (Hospital Centro Medico); M. Cahueque, MD (Hospital Centro Médico); C. Davila Mohr, MD (Hospital Nuestra Señora de El Pilar); E.Fabian, MD (Hospital Centro Médico); and J. Xicara, MD (Hospital Nacional de Occidente).Asociación de Cirugía Ortopédica y Traumatología de Honduras (ACOTH): O.E. Bueso, MD (Hospital del Instituto Hondureño de Seguridad Social); W. Caraccioli, MD (Hospital Regional del Instituto Hondureño de Seguridad Social); G. Hernandez, MD (Hospital Regional del Instituto Hondureño de Seguridad Social); and T. Minueza, MD (Hospital Fundación Ruth Paz).
Federación Mexicana de Colegios de Ortopedia y Traumatología (FEMECOT): J.M. Gomez Acevedo, MD (Hospital de Especialidades, San Francisco de Asís); L. López Almejo, MD (Universidad Autonoma de Coahuila); and S. Quintero, MD (Universidad de Guadalajara).Asociación Nicaraguense de Ortopedia y Traumatología (ANOT): N. Castro, MD (Hospital Carlos Roberto Huembes); D. Aguilar, MD (Hospital Metropolitano Vivian Pellas); J. Garcia Rizo, MD (Hospital Viviam Pellas); and V. Gutierrez, MD (Hospital Salud Integral).Sociedad Panameña de Ortopedia y Traumatología (SPOT): M. Garuz, MD (Hospital Punta Pacífica).
Sociedad Peruana de Ortopedia y Traumatología (SPOT): I. Salce, MD (Clínica Delgado AUNA); and A. Velit, MD (Hospital Central de la Fuerza Aerea del Peru).Sociedad de Ortopedia y Traumatología del Uruguay (SOTU): J.L. Etchegoyen, MD (Mutualista Medica Uruguaya); P. Filomeno, MD (Instituto Nacional de Ortopedia y Traumatología, Hospital de Clínicas); J.C. López, MD (Banco de Protesis); M.E. Pérez, MD (Universidad de la República); and E. Vilensky, MD (Hospital Policial).
Sociedad Venezolana de Cirugía Ortopédica y Traumatología (SVCOT): A.J. Serrano Fermin, MD (Hospital Vargas de Caracas).

Members of the the ACTUAR Open Tibia Study Group include: D.A. Estrada Tellez, MD, Hospital Civil de Guadalajara; A. Flores Biard, MD, Hospital Ángeles del Carmen, Guadalajara; F. Medina, MD, Instituto Mexicano del Seguro Social, Hospital de Traumatología, Ortopedia y Rehabilitación Magdalena de las Salinas UMAE DVFN; E. Mercado Salcedo, Instituto Mexicano de Seguro Social; M.A. MacKechnie, MD, CM, FRCSC, MaineGeneral Medical Center, Geisel School of Medicine, Dartmouth College; R. Madrigal Gutierrez, MD, Tecnológico de Monterrey, Hospital Puerta de Hierro; S. Morshed, Orthopaedic Trauma Institute, Zuckerberg San Francisco General Hospital, University of California, San Francisco; and C. Ramirez Guevara, Puerta de Hierro Norte.

Patrick D. Albright, MD[1,2]
Madeline C. MacKechnie, MA[2]
Heather J. Roberts, MD[2]
David W. Shearer, MD, MPH[2]
Luis G. Padilla Rojas, MD[3]
Julio Segovia, MD[4]
Jose Eduardo Quintero, MD[5]
Rafael Amadei, MD[6]
Fernando Baldy dos Reis, MD[7]
Theodore Miclau III, MD[2]

[1]Department of Orthopaedic Surgery, University of Minnesota Medical School, Minneapolis, Minnesota

[2]Institute for Global Orthopaedics and Traumatology, Orthopaedic Trauma Institute, Department of Orthopaedic Surgery, University of California, San Francisco, Zuckerberg San Francisco General Hospital, San Francisco, California

[3]Hospital Puerta de Hierro, Guadalajara, México

[4]Hospital Central Instituto de Previsión Social, Asunción, Paraguay

[5]Fracturas y Fracturas, Pereira, Colombia

[6]Hospital Interzonal General de Agudos, San Martín de la Plata, La Plata, Argentina

[7]Federal University of São Paulo, São Paulo, Brazil

Email address for T. Miclau: theodore.miclau@ucsf.edu

ORCID iD for P.D. Albright: 0000-0001-7141-9245
ORCID iD for M.C. MacKechnie: 0000-0001-6619-9778
ORCID iD for H.J. Roberts: 0000-0002-2576-1338
ORCID iD for D.W. Shearer: 0000-0002-9065-1725
ORCID iD for L.G. Padilla Rojas: 0000-0001-6658-4123
ORCID iD for J. Segovia: 0000-0001-5760-9413
ORCID iD for J.E. Quintero: 0000-0001-6197-2565
ORCID iD for R. Amadei: 0000-0002-0032-3016
ORCID iD for F. Baldy dos Reis: 0000-0003-2431-2634
ORCID iD for T. Miclau III: 0000-0003-1975-2061

References

1. Mock C, Cherian MN. The global burden of musculoskeletal injuries: challenges and solutions. Clin Orthop Relat Res. 2008 Oct;466(10):2306-16. Epub 2008 Aug 5.

2. Moroz PJ, Spiegel DA. The World Health Organization's action plan on the road traffic injury pandemic: is there any action for orthopaedic trauma surgeons? J Orthop Trauma. 2014;28(6)(Suppl 1):S11-4.

3. Fraser B. Traffic accidents scar Latin America's roads. Lancet. 2005 Aug 27;366(9487):703-4.

4. Orihuela-Fuchs VA, Fuentes-Figueroa S. [Infection rate in open fractures adjusted for the degree of exposure]. Acta Ortop Mex. 2013 Sep-Oct;27(5):293-8. Spanish.

5. INORMUS Investigators. INternational ORthopaedic MUlticentre Study (INORMUS) in fracture care: protocol for a large prospective observational study. J Orthop Trauma. 2015 Oct;29(Suppl 10):S2-6.

6. Kohlprath R, Assal M, Uçkay I, Holzer N, Hoffmeyer P, Suva D. [Open fractures of the tibia in the adult: surgical treatment and complications]. Rev Med Suisse. 2011 Dec 21;7(322):2482: 2484-8. French.

7. Mundi R, Chaudhry H, Niroopan G, Petrisor B, Bhandari M. Open Tibial Fractures: Updated guidelines for management. JBJS Reviews. 2015;3(2):e1.

8. Cross WW 3rd, Swiontkowski MF. Treatment principles in the management of open fractures. Indian J Orthop. 2008 Oct;42(4):377-86.

9. Duyos OA, Beaton-Comulada D, Davila-Parrilla A, Perez-Lopez JC, Ortiz K, Foy-Parrilla C, Lopez-Gonzalez F. Management of open tibial shaft fractures: does the timing of surgery affect outcomes? J Am Acad Orthop Surg. 2017 Mar;25(3):230-8.

10. Clelland SJ, Chauhan P, Mandari FN. The epidemiology and management of tibia and fibula fractures at Kilimanjaro Christian Medical Centre (KCMC) in Northern Tanzania. Pan Afr Med J. 2016 Sep 29;25:51.

11. Giannoudis PV, Papakostidis C, Roberts C. A review of the management of open fractures of the tibia and femur. J Bone Joint Surg Br. 2006 Mar;88(3):281-9.

12. Miclau T, Hoogervorst P, Shearer DW, El Naga AN, Working ZM, Martin C, Pesántez R, Hüttl T, Kojima KE, Schütz M; International Orthopaedic Trauma Study Consortium. Current status of musculoskeletal trauma care systems worldwide. J Orthop Trauma. 2018 Oct;32(Suppl 7):S64-70.

13. Nogueira Drummond JM, Braga GF, da Cunha FM. Tratamento primário das fraturas expostas. 2009 Dec 18. Accessed 2020 Jul 20. http://saudedireta.com.br/protocolos.php?busca=exposta&x=0&y=0

14. Instituto Guatemalteco de Seguridad Social. Guia de práctica clínica basada en evidencia (GPC-BE) no. 70. Manejo de fracturas expuestas. 2016. Accessed 2020 Jul 20. https://www.igssgt.org/wp-content/uploads/images/gpc-be/traumatologia-y-ortopedia/GPC-BE-No-70-Manejo-de-las-Fracturas-Expuestas.pdf

15. Rodríguez MI, Menjívar V, Espinoza Fiallos E. Guías clínicas de ortopedia. 2012 Feb. Accessed 2020 Jul 20. http://asp.salud.gob.sv/regulacion/pdf/guia/Guias_Clinicas_de_Ortopedia.pdf

16. Centro Nacional de Excelencia Tecnológica en Salud. Guía de práctica clínica. Diagnóstico y tratamiento de fractura de la diáfisis de tibia. 2009. Accessed 2020 Jul 20. www.cenetec.salud.gob.mx/descargas/gpc/CatalogoMaestro/139_GPC_DIAFISIS_TIBIA/GpcER_diafisis_de_tibia.pdf.

17. Miclau T, MacKechnie MC, Shearer DW; ACTUAR Group. Asociación de Cirujanos Traumatólogos de las Américas: development of a Latin American research consortium. J Orthop Trauma. 2018 Oct;32(Suppl 7):S8-11.

18. Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma. 1984 Aug;24(8):742-6.

19. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009 Apr;42(2):377-81. Epub 2008 Sep 30.

20. The World Bank. Data: country and lending groups 2020. Accessed 2020 Apr 10. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

21. Moraes VY, Belloti JC, Faloppa F, Bhandari M. Collaborative multicenter trials in Latin America: challenges and opportunities in orthopedic and trauma surgery. Sao Paulo Med J. 2013;131(3):187-92.

22. Bhandari M, Guyatt GH, Swiontkowski MF, Tornetta P 3rd, Hanson B, Weaver B, Sprague S, Schemitsch EH. Surgeons' preferences for the operative treatment of fractures of the tibial shaft. An international survey. J Bone Joint Surg Am. 2001 Nov;83(11):1746-52.

23. Busse JW, Morton E, Lacchetti C, Guyatt GH, Bhandari M. Current management of tibial shaft fractures: a survey of 450 Canadian orthopedic trauma surgeons. Acta Orthop. 2008 Oct;79(5):689-94.

24. Domínguez GLG, Orozco VSL. Frecuencia y tipos de fracturas clasificadas por la Asociación para el Estudio de la Osteosíntesis en el Hospital General de León durante un año. Acta Med Grupo Ángeles. 2017;15(4):275-86.

25. Díez GMP, Macías HSI, Ramírez PE, Chávez ADD, Soria BMÁ, Granados RR, Ballesteros RF. Características epidemiológicas de pacientes adultos atendidos por fracturas en el Instituto Nacional de Rehabilitación. Investig En Discapac. 2013;2(2):51-4.

26. Court-Brown CM, McQueen MM, Quaba AA, Christie J. Locked intramedullary nailing of open tibial fractures. J Bone Joint Surg Br. 1991 Nov;73(6):959-64.

27. Bone LB, Kassman S, Stegemann P, France J. Prospective study of union rate of open tibial fractures treated with locked, unreamed intramedullary nails. J Orthop Trauma. 1994;8(1):45-9.

28. Henley MB, Chapman JR, Agel J, Harvey EJ, Whorton AM, Swiontkowski MF. Treatment of type II, IIIA, and IIIB open fractures of the tibial shaft: a prospective comparison of unreamed interlocking intramedullary nails and half-pin external fixators. J Orthop Trauma. 1998 Jan;12(1):1-7.

29. Bhandari M, Guyatt GH, Swiontkowski MF, Schemitsch EH. Treatment of open fractures of the shaft of the tibia. J Bone Joint Surg Br. 2001 Jan;83(1):62-8.

30. Foote CJ, Guyatt GH, Vignesh KN, Mundi R, Chaudhry H, Heels-Ansdell D, Thabane L, Tornetta P 3rd, Bhandari M. Which surgical treatment for open tibial shaft fractures results in the fewest reoperations? A network meta-analysis. Clin Orthop Relat Res. 2015 Jul;473(7):2179-92. Epub 2015 Feb 28.

31. Almeida Matos M, Castro-Filho RN, Pinto da Silva BV. Risk factors associated with infection in tibial open fractures. Rev Fac Cien Med Univ Nac Cordoba. 2013;70(1):14-8.

32. Ruiz-Martínez F, Caldelas-Cuéllar E, Sánchez Sánchez M. Epidemiología y resultados clínicos de las fracturas expuestas de la tibia. Acta Ortop Mex. 2001;15(6):288-95.

33. McCord C, Kruk M, Mock C, Cherian M, von Schreeb J, Russell S, English M. Organization of essential services and the role of first-level hospitals. In: Debas HT, Donkor P, Gawande A, Jamison DT, Kruk ME, Mock CN, editors. Disease control priorities: essential surgery. 3rd ed, vol 1. World Bank Group; 2015. p 213-31.

34. DeLong WG Jr, Born CT, Wei SY, Petrik ME, Ponzio R, Schwab CW. Aggressive treatment of 119 open fracture wounds. J Trauma. 1999 Jun;46(6):1049-54.

35. Moola FO, Carli A, Berry GK, Reindl R, Jacks D, Harvey EJ. Attempting primary closure for all open fractures: the effectiveness of an institutional protocol. Can J Surg. 2014 Jun;57(3):E82-8.

36. Jenkinson RJ, Kiss A, Johnson S, Stephen DJG, Kreder HJ. Delayed wound closure increases deep-infection rate associated with lower-grade open fractures: a propensity-matched cohort study. J Bone Joint Surg Am. 2014 Mar 5;96(5):380-6.

37. Lavelle WF, Uhl R, Krieves M, Drvaric DM. Management of open fractures in adult patients: current teaching in ACGME accredited residency programs. J Surg Orthop Adv. 2007 Fall;16(3):111-7.

38. Albright PD, Mackechnie MC, Jackson JH, Chopra A, Holler JT, Flores Biard A, Padilla Rojas LG, Morshed S, Miclau T, Shearer DW, Terry MJ. Knowledge deficits and barriers to performing soft-tissue coverage procedures: an analysis of participants in an orthopaedic surgical skills training course in Mexico. OTA Int. 2019 Dec;2(4):e044.

39. Feoli E, Badilla V, Bermudez M, Mendez E, Badilla X. Surgery in Costa Rica. Arch Surg. 2002 Dec;137(12):1435-40.

40. Sociedad Puertorriqueña de Ortopediay Traumatología. Directorio. Accessed 2020 Apr 10. http://spot.ortopediapr.org/directorio