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# Open tibial shaft fracture management in Argentina: an evaluation of treatment standards in diverse resource settings

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## Abstract

**Background:** Argentina is a country with varying access to orthopedic surgical care. The Argentine Association of Trauma and Orthopedics (AATO) “Interior Committee” was developed to address potential regional differences and promote standardization of orthopedic trauma care. The paper assesses the level of national standardization of the management of open tibia fractures across 9 provinces in Argentina.

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

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**Methods:** Utilizing a matched-comparison group design, management of these injuries were assessed and compared between 3 groups: an “AATO Exterior Committee” consisting of surgeons that practice in Buenos Aires, and 2 “Interior Committees,” comprising surgeons that practice in outlying provinces, 1 of which is affiliated with the AATO, and 1 that is not affiliated with the AATO. The study was conducted in 2 phases: phase 1 assessed open tibia fracture management characteristics, and phase 2 evaluated the management of soft-tissue wound coverage following open fractures.

**Results:** Soft-tissue coverage procedures for Gustilo Anderson Type IIIB fractures were more commonly performed by orthopedic surgeons in Interior Committees than the AATO Exterior Committee. Greater rates of definitive wound coverage within 7 days post-injury were reported in both Interior Committees compared to the Exterior Committee. Plastic surgeons were reported as more available to those in the AATO Exterior Committee group than in the AATO Interior Committees.

**Conclusion:** While treatment patterns were evident among groups, differences were identified in the management and timing of soft-tissue coverage in Gustilo Anderson Type IIIB fractures between the Exterior Committee and both Interior Committees. Future targeted educational and surgical hands-on training opportunities that emphasize challenges faced in resource-limited settings may improve the management of open tibia fractures in Argentina.

**Keywords:** Argentina, Latin America, open tibial shaft fractures, soft-tissue coverage, treatment patterns

## 1. Introduction

Globally, trauma represents the leading cause of morbidity and mortality in patients younger than 40 years of age,<sup>[1]</sup> with musculoskeletal injuries, such as open fractures, most commonly contributing to significant disability.<sup>[2,3]</sup> Open tibia fractures are common injuries that require specialized surgical care and soft-tissue wound coverage treatment.<sup>[4–7]</sup> In particular, these injuries bear a disproportionate burden of musculoskeletal disease in low- and middle-income countries (LMICs), predominantly in Latin America, due to high rates of road traffic injuries.<sup>[8,9]</sup>

Argentina, similar to other Latin American countries, has varying access to orthopedic surgical care between its provinces; the Level I trauma hospitals are mostly concentrated in larger urban centers and its capital, Buenos Aires. In contrast, more resource-limited lower-level trauma centers are in the peripheral provinces with smaller, rural cities. Unequal access to care may occur, in large part, due to disparities in resource allocation between provinces.<sup>[10–12]</sup> In an effort to address potential regional differences, the Argentine Association of Trauma and Orthopedics (AATO), developed an “Interior Committee,” comprising orthopedic surgeons that practice in outlying provinces across Argentina. The Interior Committee sought to promote national standardization of orthopedic trauma care to achieve best practices.

This paper assesses the management of open tibia fractures across provinces in Argentina and provides insight into the level of standardized treatment of a challenging musculoskeletal injury. The findings may be used to address disparities in care through educational opportunities and further outreach efforts.

## 2. Methods

Argentinian orthopedic surgeons who treat open tibia fractures were invited to participate in the study. These surgeons consisted of 3 groups. The first group, an “AATO Exterior Committee,” included 19 orthopedic surgeons that practiced in Buenos Aires and who were active members of the AATO. The second group included an “AATO Interior Committee” of 20 orthopedic surgeons that practiced in provinces outside of Buenos Aires and who were active members of the AATO. The third group included a “Non-AATO Interior Committee” of 20 orthopedic surgeons that practiced in provinces outside of Buenos Aires and who were not affiliated with the AATO. A matched-comparison group design was utilized in this study to reduce confounding variables.<sup>[13]</sup> Participants in all 3 groups were selected based on their similar baseline characteristics including age, gender, and years in practice to better determine

treatment patterns and differences across cohorts in Argentina (Table 1). This study was conducted in 2 phases.

### 2.1. Phase 1: open tibia fracture management

An initial survey was distributed to orthopedic surgeons to assess the management of open tibia Gustilo Anderson Classification (GA) Type III and Type III fractures.<sup>[14]</sup> The 65-question self-reported survey was designed in Spanish and evaluated the timing and treatment strategies for antibiotic prophylaxis, irrigation and debridement, fracture stabilization, and wound management. Demographic information including years in practice, specialty training, and treatment preferences was also collected. Survey questions were designed based on a review of the literature and further evaluated by 3 independent, trauma fellowship-trained orthopedic surgeons. The survey was deemed exempt by the Institutional Review Board at the University of California, San Francisco.

### 2.2. Phase 2: management of soft-tissue wound coverage

Based on the responses from the phase 1 survey, a second survey was distributed to the same orthopedic surgeon-participants. This 36-question self-reported survey was designed by 2 independent microvascular fellowship-trained orthopedic and plastic surgeons. The survey evaluated their management of wound coverage following open fractures and queried the availability of wound care and operating room resources. The survey was deemed exempt by the local Institutional Review Board.

### 2.3. Statistical method

The data were analyzed using Fisher exact tests with  $P = .05$  as the significance level to assess for significant differences in

**Table 1**  
Characteristics of matched cohorts.

	AATO exterior committee (n = 19)	AATO interior committee (n = 20)	Non-AATO interior committee (n = 20)
<i>Total</i>			
Mean age	40.1	40.3	41
Gender (male) (%)	94.7	95	95
Years in practice (mean)	10.6	10.3	10.4

treatment techniques between the 3 cohorts. Analysis was conducted using STATA SE Version 17 (StataCorp).

### 3. Results

#### 3.1. Demographic information

The phase 1 and phase 2 surveys were completed by 59 orthopedic surgeons, representing 9 provinces across Argentina: Buenos Aires, Chaco, Córdoba, Chubut, Neuquén, La Rioja, Santa Cruz, Santa Fe, and Tucumán (Fig. 1). Overall, 95% of the participants were male with a mean age of 40.5 years and 45% of participants held a resident-teaching position. All participants (100%) completed residency training of which 42 (72%) were fellowship-trained. When stratified by groups, the AATO Exterior Committee group had a higher percentage of fellowship-trained colleagues than the Non-AATO Interior Committee group (95% vs 45%,  $P=.001$ ). This significant difference in training was also observed between the AATO Interior Committee group and the Non-AATO Interior Committee group (78% vs 45%,  $P=.048$ ). Practice experience ranged among participants, with the most commonly reported timeframe being 6 to 10 years (32%). Less than half (41%) of the participants had received soft-tissue coverage training in some capacity, either through formal training or mentorship from a colleague. The majority of survey participants (88%) most commonly treated between 0 and 10 open tibia fractures annually (Table 2).

#### 3.2. Phase 1: open tibia fracture management

In phase 1, all 3 groups demonstrated consistent treatment protocols for GA Type III fractures regarding irrigation and debridement, fracture stabilization, wound closure, and antibiotic prophylaxis (Table 3). Most of the AATO Exterior Committee (95%), AATO Interior Committee (100%), and Non-AATO Interior Committee (100%) groups performed operative irrigation and debridement within 24 hours of injury. Further, the AATO Exterior Committee, AATO Interior Committee, and Non-AATO Interior Committee most commonly utilized delayed internal fixation for fracture stabilization (84% vs 85% vs 90%) and opted for primary wound closure (95% vs 100% vs 95%), respectively. In addition, most participants across all groups administered antibiotics within 3 hours of hospital presentation (74% vs 70% vs 65%).

A statistically significant difference was identified, however, in the performance of soft-tissue coverage procedures by orthopedic surgeons for GA Type IIIB fractures between the AATO Exterior Committee and the AATO Interior Committee (0% vs 35%,  $P=.004$ ) groups. This discrepancy was also observed between the AATO Exterior Committee group and the Non-AATO Interior Committee group (0% vs 50%,  $P<.001$ ).

#### 3.3. Phase 2: management of soft-tissue wound coverage

All groups commonly reported patient arrival to the operating room within a 6-hour timeframe. Regarding soft-tissue coverage timing between the AATO Exterior Committee and the AATO Interior Committee, the latter group reported greater rates of definitive wound coverage within 7 days (32% vs 74%,  $P=.009$ ). This difference was also identified between the AATO Exterior Committee group and the Non-AATO Interior Committee group (32% vs 75%,  $P=.007$ ).

Moreover, the AATO Exterior Committee group more commonly reported plastic surgeons as the primary providers for soft-tissue coverage flaps in comparison to the Non-AATO Interior Committee group (74% vs 40%,  $P=.043$ ). In addition, plastic surgeons were reported as more available to those in the AATO Exterior Committee group than in the AATO Interior Committee group (84% vs 35%,  $P=.005$ ). This was also evident between the AATO Exterior Committee group and the Non-AATO Interior Committee group (84% vs 30%,  $P=.003$ ) (Table 4). No significant differences existed in the number of orthopedic surgeons who received soft-tissue training among the AATO Exterior Committee (42%), the AATO Interior Committee (45%), and the non-AATO Interior Committee (35%) groups.

Regarding wound care and operating room resources, a needs analysis showed that most institutions have access to Negative Pressure Wound Therapy (85%). Other instruments, such as wall suction outside the operating room (42%), Humby blades, and other manual blades for harvesting skin graft (37%) were less common. Microsurgery instruments (15%), skin graft meshers (13%), and handheld dopplers (12%) were the least accessible resources. Further, occlusive dressings were most commonly available in the operating room (85%), with less than half of the participants (45%) citing access to saline-moistened sterile gauze dressings and antimicrobial dressings (28%), including antibiotic ointments and betadine/iodine-based dressings (Table 5). Finally, for lower extremity wounds with exposed bone that cannot primarily be closed, participants in all 3 groups reported performing muscle flaps most commonly for proximal third and middle third defects. Regarding a lower extremity distal third defect, participants in the Exterior Committee and the AATO Interior Committee most commonly performed fasciocutaneous flaps, and the Non-AATO Interior Committee most frequently used direct wound care (Fig. 2).

### 4. Discussion

This study evaluated the management of open tibia fractures between surgeons affiliated and nonaffiliated with the national trauma and orthopedic society (AATO) throughout 9 Argentinian provinces. The Interior Committee was developed by the AATO to promote national standardization of orthopedic trauma care across Argentina. Common reasons for nonstandard management of these musculoskeletal injuries in LMICs include limited resources, level of surgeon expertise, knowledge deficits, and lack of specialized training.<sup>[15-18]</sup> Educational courses are offered at the annual AATO conference on a variety of topics in orthopedic trauma, including the management of open tibia fractures, and the type and timing of soft-tissue coverage. Soft-tissue wound coverage surgical techniques, however, have not been specifically targeted.

Though the Non-AATO Interior Committee had potential for inconsistent reporting given its greater geographic separation and nonaffiliated status with the AATO, as well as lower rates of fellowship-trained colleagues, there were more similarities than differences in the management of open tibia fractures reported across all study groups. Many of the results in this study are consistent with treatment patterns previously identified across Latin America, particularly pertaining to timing of antibiotic administration, irrigation and operative debridement, and utilization of delayed internal fixation and primary closure.<sup>[19,20]</sup> In these aspects, the Argentinian orthopedic surgeon groups demonstrate standardization in the management of open tibia

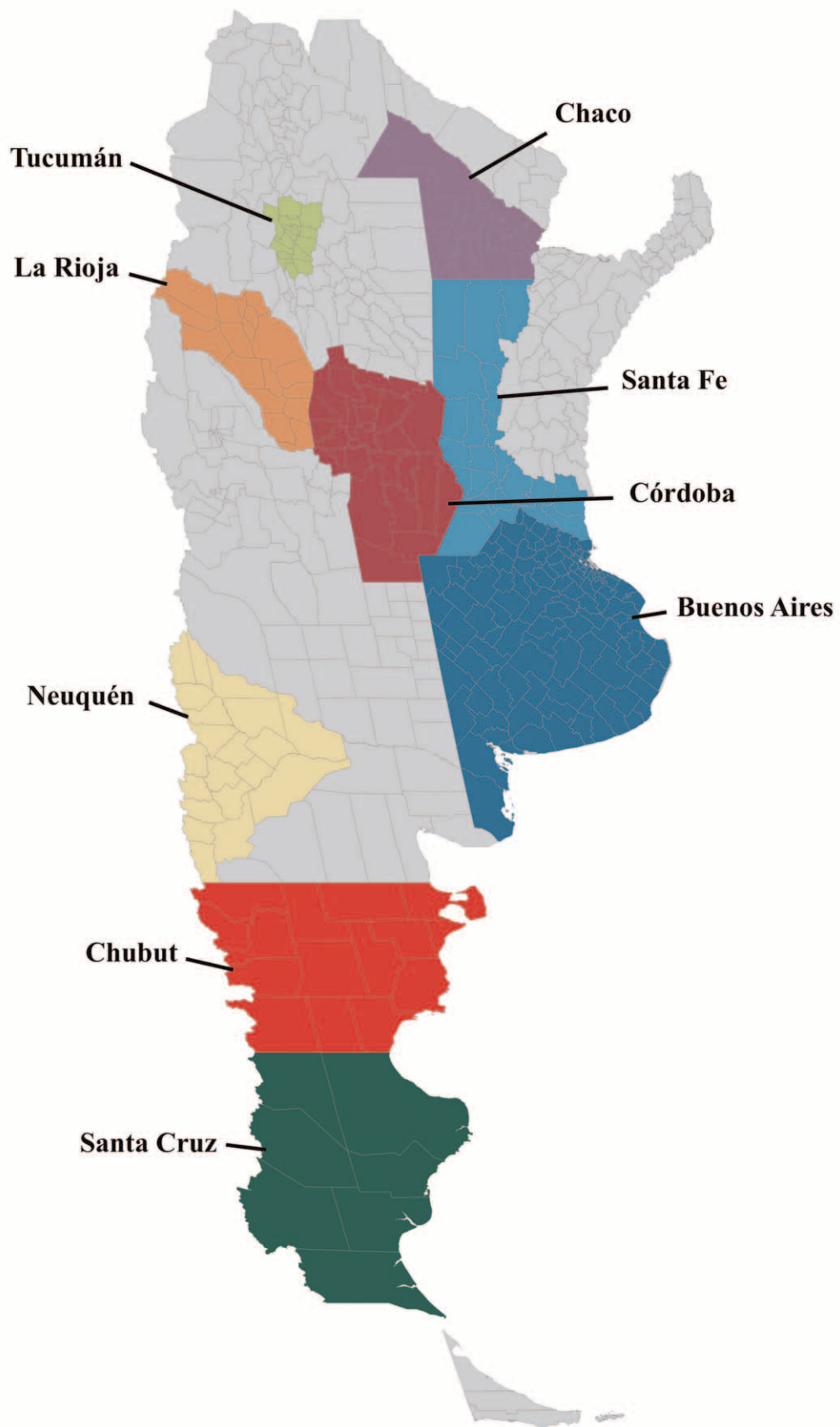


Figure 1. Map of survey participants by province in Argentina.



**Table 2**  
**Demographic data of survey respondents.**

	Total n (%) 59 (100)
Male	56 (95)
Years in practice	
0–5	14 (23.7)
6–10	19 (32.2)
11–15	17 (28.8)
16–20	7 (11.9)
>21	2 (3.4)
Residency training	59 (100)
Fellowship in ortho trauma or plastic surgery	42 (72.4)
Practice setting	
Combination	25 (42.4)
Private practice	24 (40.7)
Public practice	7 (11.9)
Academic practice	3 (5)
Supervise Residents	27 (45.8)
Received soft-tissue training	24 (40.7)
Number of open tibia fractures personally treated each year	
0–10	51 (87.9)
11–20	7 (12.1)

\*Various data not reported by all respondents.

fractures. Yet, differences in the management of soft-tissue defects in GA Type IIIB fractures were evident between the orthopedic surgeons based in the urban group (AATO Exterior Committee), and those in more remote settings (AATO and Non-AATO affiliated Interior Committees).

Notably, the AATO Exterior Committee reported performing soft-tissue coverage less frequently within a 7 day post-injury standard than the Interior Committee surgeons.<sup>[21–24]</sup> The AATO Exterior Committee also reported having more access to plastic surgeons at their institutions, in contrast to the AATO and Non-AATO Interior Committee groups that cited a lack of available plastic surgeons to provide definitive coverage. This discrepancy in access to multidisciplinary management is well-documented in LMICs worldwide.<sup>[15,16,18,25–27]</sup> This might also be observed in resource-rich countries, and merits further evaluation. The reported increased delay to definitive coverage by the AATO Exterior Committee surgeons seems counter-intuitive, as greater access to specialist coverage should likely lead to fewer delays to definitive soft-tissue coverage. One possible explanation for these findings is that despite access to plastic surgeons, reliance on their availability may result in greater delays relative to timelier coverage performed by orthopedic surgeons. Further examination into the reasons for these differences in coverage treatment and timing is necessary.

With only 40% of participants having had training in soft-tissue reconstruction and the lack of specialized care in more rural provinces, there is a need for Argentinian orthopedic surgeons with this specialized skill. In addition, of 17 wound care and operating room resources, Negative Pressure Wound Therapy was the only resource that was reported available to more than half of the participants. Given most of the participants' limited resources and lack of soft-tissue specialists, particularly for Interior Committee groups, a phase 3 study to create a specific didactic and hands-on wound coverage technique course could improve open tibia fracture management and treatment standardization.<sup>[28]</sup> Previous studies in LMICs have reported on the efficacy of such courses, including

**Table 3**  
**Comparison of orthopedic surgeons' management of open tibia fractures.**

	AATO exterior committee n (%)	AATO interior committee n (%)	P value	AATO exterior committee n (%)	Non-AATO interior committee n (%)	P value	AATO interior committee n (%)	Non-AATO interior committee n (%)	P value
Total	19 (100)	20 (100)		19 (100)	20 (100)		20 (100)	20 (100)	
Irrigation and debridement									
Average time to operative debridement									
≤24 hours	18 (94.7)	20 (100)	.487	18 (94.7)	20 (100)	.487	20 (100)	20 (100)	1
>24 hours	1 (5.3)	0		1 (5.3)	0		0	0	
Fracture stabilization									
Utilize primary versus delayed internal fixation									
Primary	3 (15.8)	3 (15)	1	3 (15.8)	2 (10)		3 (15)	2 (10)	1
Delayed	16 (84.2)	17 (85)		16 (84.2)	18 (90)	.661	17 (85)	18 (90)	
Wound closure									
Utilize primary versus delayed closure									
Primary	18 (94.7)	20 (100)	.487	18 (94.7)	19 (95)	1	20 (100)	19 (95)	1
Delayed	1 (5.3)	0		1 (5.3)	1 (5)		0	1 (5)	
Antibiotic prophylaxis									
Average time to antibiotics									
≤3 hours	14 (73.7)	14 (70)	1	14 (73.7)	13 (65)	.731	14 (70)	13 (65)	.736
>3 hours	5 (26.32)	6 (30)		5 (26.3)	7 (35)		6 (30)	7 (35)	
Soft-tissue coverage									
Perform soft-tissue procedures for IIIB fractures									
Yes	0	7 (35)	.004	0	10 (50)	<.001	7 (35)	10 (50)	.337
No	19 (100)	13 (65)		19 (100)	10 (50)		13 (65)	10 (50)	

\*Tests of significance completed with Fisher exact test (α=0.05).

**Table 4****Comparison of orthopedic surgeons' management of soft-tissue coverage following open tibia fractures.**

	AATO exterior committee n (%)	AATO interior committee n (%)	P value	AATO exterior committee n (%)	Non-AATO interior committee n (%)	P value	AATO interior committee n (%)	Non-AATO interior committee n (%)	P value
Total	19 (100)	20 (100)		19 (100)	20 (100)		20 (100)	20 (100)	
Average time to provide soft-tissue coverage									
< 7 days	6 (31.6)	14 (73.7)	.009	6 (31.6)	15 (75)	.007	14 (73.7)	15 (75)	.925
> 7 days	13 (68.4)	5 (26.3)		13 (68.4)	5 (25)		5 (26.3)	5 (25)	
Average time for arrival to OR									
< 6 hours	13 (68.4)	13 (65)	.614	13 (68.4)	16 (80)	.408	13 (65)	16 (80)	.425
6–24 hours	6 (31.6)	6 (30)		6 (31.6)	4 (20)		6 (30)	4 (20)	
24–48 hours	0	1 (5)		0	0		1 (5)	0	
Who primarily provides soft-tissue coverage to GA-IIIB fractures?									
Plastic surgeon	14 (73.7)	11 (55)	.263	14 (73.7)	8 (40)	.043	11 (55)	8 (40)	.547
Orthopaedic surgeon	5 (26.3)	7 (35)		5 (26.3)	8 (40)		7 (35)	8 (40)	
No available surgeon	0	2 (10)		0	4 (20)		2 (10)	4 (20)	
Do you have a plastic surgeon available at your institution?									
Yes	16 (84.2)	7 (35)	.005	16 (84.2)	6 (30)	.003	7 (35)	6 (30)	.765
No	1 (5.3)	9 (45)		1 (5.3)	8 (40)		9 (45)	8 (40)	
Sometimes	2 (10.5)	4 (20)		2 (10.5)	6 (30)		4 (20)	6 (30)	
Have you had soft-tissue coverage training?									
Yes	8 (42.1)	9 (45)	.855	8 (42.1)	7 (35)	.648	9 (45)	7 (35)	.519
No	11 (57.9)	11 (55)		11 (57.9)	13 (65)		11 (55)	13 (65)	

\*Tests of significance completed with Fisher exact test ( $\alpha=0.05$ ).

**Table 5****Wound care and operating room resources.**

	Total n (%)
	<b>59 (100)</b>
Which OR resources do you have access to? <sup>†</sup>	
Negative Pressure Wound Therapy (NPWT or Wound VAC)	51 (85)
Wall suction outside the OR	25 (42)
Manual blade for harvesting skin grafts (e.g., Humby blade)	22 (37)
Power dermatome	19 (32)
Magnifying loupes	15 (25)
Microsurgery instruments	12 (20)
Operating microscopes	9 (15)
Skin graft mesher	8 (13)
Handheld doppler	7 (12)
Which dressings do you have access to? <sup>†</sup>	
Occlusive dressing	51 (85)
Saline-moistened sterile gauze dressing	27 (45)
Antimicrobial dressing	17 (28)
What type of antimicrobial dressings do you have access to? <sup>†</sup>	
Antibiotic ointments	26 (43)
Betadine/Iodine-based dressing	26 (43)
Silvadene	11 (18)
Honey-based dressing	11 (18)
Dakins/Dilute bleach	5 (8)
Other	9 (15)
What type of microsurgical instruments are available at your institution? <sup>†</sup>	
Not sure	
8-0 suture (nylon, prolene)	20 (33)
9-0 suture	14 (23)
Micro needle-holder	13 (22)
Curved micro dissecting scissors	12 (20)
Straight micro scissors	12 (20)
10-0 suture	11 (18)
Micro-pickups	9 (15)
Micro vessel dilator	9 (15)

\*Various data not reported by all respondents.

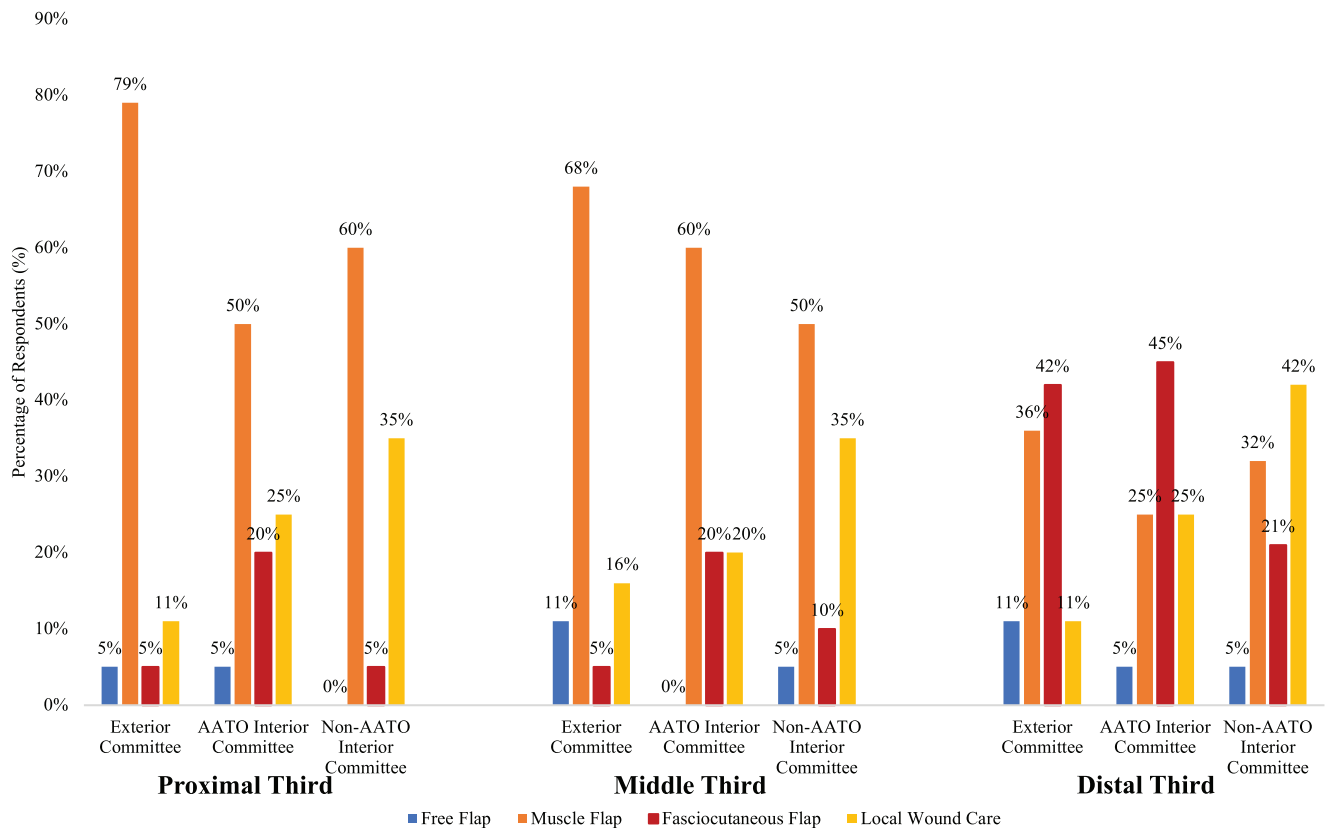
<sup>†</sup>Participants were able to select multiple responses.

improving patient outcomes and reducing long-term disability. These courses educate orthopedic surgeons on the basic principles and techniques of open fracture management and lower extremity flap reconstruction procedures, with an emphasis on challenges faced in resource-limited settings.<sup>[16,29,30]</sup> Improvement in competency scores, skill acquisition, and comfort in performing rotational and free flaps have been documented as a result of these courses.

To our knowledge, this study is the first to evaluate the level of standardization of open tibia fracture management across Argentina's diverse resource settings. The Interior Committee is an effective method that can be used as a model by other national professional societies interested in developing best practice protocols in resource-limited environments. The results of this study can help to advocate for better allocation of wound care resources, operative personnel, and hands-on training opportunities needed to improve care for patients with musculoskeletal injuries.

This study has several limitations. This 2-phase study was conducted through self-reported assessments, potentially allowing for participants to respond to the perceived optimal treatment standards, rather than those practiced. The sample size is small and represents 9 of 23 provinces across Argentina. Nevertheless, the 9 provinces represented in the study were socioeconomically diverse,<sup>[31]</sup> equally spread geographically across the country, and demonstrated fairly uniform treatment patterns. Study participants were also selected by the authors to match age, gender, and years in practice among groups, and thus, were subject to selection bias. However, matching variables a priori is a standard method for the match-comparison study design and allowed for a clearer examination of treatment preferences and differences across a diverse landscape.

Additionally, there may have been differences in the way the participants classified GA Type IIIB fractures, as this classification system was not specifically reviewed with the participants, and it has been shown to have only moderate agreement among surgeons.<sup>[32]</sup> Nevertheless, the GA classification is the most



**Figure 2.** Orthopaedic surgeons' preferences for soft-tissue management of lower extremity proximal third, middle third, and distal third defects, stratified by groups.

commonly used system in Argentina and GA Type IIIB injuries are a smaller subset of injuries that involve extensive soft-tissue damage.<sup>[14]</sup> Finally, this study focused on treatment patterns and not related patient outcomes. Treatment outcomes secondary to differences in practices is a subject that warrants future investigation.

In summary, the formation of an Interior Committee by the AATO sought to improve the quality of musculoskeletal care in Argentina. A difference in the use of soft-tissue coverage following GA Type IIIB fractures was identified between the orthopedic surgeons in the Exterior Committee and Interior Committee groups, with the latter performing these procedures more often and in a timelier manner (<7 days). Further investigation behind the reason for this discrepancy in treatment is necessary. Future targeted surgical educational interventions that emphasize challenges faced in resource-limited settings may improve the management of open tibia fractures, representing a potential area for examination.

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