



Fig. E-1

World map highlighting the nationalities of the respondents. Those countries that had surgeons who participated in the study are highlighted in red.

TABLE E-1 Characteristics of Respondents

	No. (%) of Respondents
Sex (n = 335)	
Male	320 (95.5)
Female	15 (4.5)
Age (n = 335)	
<30 years	1 (0.3)
30 to 40 years	127 (37.9)
41 to 50 years	120 (35.8)
51 to 60 years	62 (18.5)
>60 years	25 (7.5)
Country (n = 334)*	
United States	81 (24.3)
United Kingdom	41 (12.3)
Netherlands	26 (7.8)
Germany	22 (6.6)
Canada	14 (4.2)
France	11 (3.3)
Turkey	11 (3.3)
India	10 (3.0)
Other	118 (35.2)
Role in health care (n = 335)	
Surgeon or consultant	309 (92.2)
Surgical trainee	26 (7.8)
Completion of trauma fellowship training (n = 335)	
Yes	217 (64.8)
No	118 (35.2)
Years in practice (n = 335)	
<3	31 (9.3)
3 to 5	33 (9.9)
6 to 10	69 (20.6)
11 to 15	76 (22.7)
16 to 20	44 (13.1)
21 to 25	40 (11.9)
>25	42 (12.5)
Academic and/or community-based practice (n = 335)	
Academic	141 (42.1)
Community	68 (20.3)
Both academic and community	126 (37.6)
Supervision of residents (n = 335)	
Yes	293 (87.5)
No	42 (12.5)

\*A denominator of <335 reflects missing data.

TABLE E-2 Annual Number of Patients Treated and Percentage Treated Operatively by Respondents According to Fracture Types

	Fracture Type (no. [%] of respondents)					
	Tibia	Femoral Shaft	Pelvic Rami	Scaphoid	Hip	Open
Fractures treated annually						
0	25 (7.5)	31 (9.3)	70 (20.9)	93 (27.8)	30 (9.0)	13 (3.9)
1 to 5	64 (19.1)	84 (25.1)	87 (26.0)	103 (30.7)	22 (6.6)	85 (25.4)
6 to 20	131 (39.1)	130 (38.8)	119 (35.5)	111 (33.1)	56 (16.7)	130 (38.8)
21 to 50	76 (22.7)	72 (21.5)	44 (13.1)	21 (6.3)	118 (35.2)	67 (20.0)
>50	39 (11.6)	18 (5.4)	15 (4.5)	7 (2.1)	109 (32.5)	40 (11.9)
Fractures treated operatively						
0% to 20%	37 (11.1)	29 (8.7)	253 (75.5)	169 (50.4)	29 (8.7)	14 (4.2)
21% to 40%	13 (3.9)	5 (1.5)	41 (12.2)	65 (19.4)	2 (0.6)	5 (1.5)
41% to 60%	42 (12.5)	11 (3.3)	25 (7.5)	60 (17.9)	3 (0.9)	4 (1.2)
61% to 80%	98 (29.3)	13 (3.9)	10 (3.0)	21 (6.3)	15 (4.5)	22 (6.6)
81% to 100%	145 (43.3)	277 (82.7)	6 (1.8)	20 (6.0)	286 (85.4)	290 (86.6)

TABLE E-3 Defining Delayed Union and Nonunion

	No. (%) of Respondents		No. (%) of Respondents	
	Delayed Union	Nonunion	General Definition	Clinical Definition
The definition of a “delayed union” or “nonunion” in the orthopaedic surgical literature is standardized with a consensus existing among orthopaedic surgeons.				
Strongly agree	18 (5.4)	32 (9.6)		
Agree	73 (21.8)	119 (35.5)		
Uncertain	67 (20.0)	42 (12.5)		
Disagree	122 (36.4)	98 (29.3)		
Strongly disagree	55 (16.4)	44 (13.1)		
A delayed union may be defined as “the lack of progression of fracture-healing beyond the time expected for a similar fracture to heal (typically beyond 3 months).”				
Yes			285 (85.1)	253 (75.5)
No			50 (14.9)	82 (24.5)
A nonunion may be defined as “failure of progression of fracture-healing for at least 3 consecutive months (and at least 6 months following the fracture) accompanied by clinical symptoms of delayed/nonunion (pain, difficulty weight-bearing).”				
Yes			296 (88.4)	286 (85.4)
No			39 (11.6)	49 (14.6)
In a clinical trial, a reoperation may be defined as “any event requiring a secondary surgery to promote fracture-healing in delayed unions, nonunions, or infections of the bone implant interface.”				
Yes				304 (90.7)
No				31 (9.3)

TABLE E-4 Importance of Clinical and Radiographic Factors in Defining Delayed Union and Nonunion

	No. (%) of Respondents				
	Agree	Fracture Pain	Palpation	Pain on Weight-Bearing	Weight-Bearing Status
Factors on which definition of delayed union and nonunion can be based (n = 335)					
Radiographic criteria only	30 (9.0)				
Clinical criteria only (i.e., weight-bearing and patient function)	3 (0.9)				
Both radiographic and clinical criteria	295 (88.1)				
Other	7 (2.0)				
Clinical factors					
Delayed union (n = 335)					
Most important		125 (37.3)	21 (6.3)	139 (41.5)	53 (15.8)
Important		136 (40.6)	114 (34.0)	140 (41.8)	107 (31.9)
Less important		57 (17.0)	101 (30.1)	54 (16.1)	82 (24.5)
Least important		17 (5.1)	99 (29.6)	2 (0.6)	93 (27.8)
Nonunion (n = 335)					
Most important		128 (38.2)	25 (7.5)	147 (43.9)	82 (24.5)
Important		119 (35.5)	101 (30.1)	134 (40.0)	90 (26.9)
Less important		67 (20.0)	104 (31.0)	51 (15.2)	78 (23.3)
Least important		21 (6.3)	105 (31.3)	3 (0.9)	85 (25.4)
Radiographic factors on which definition of delayed union and nonunion can be based (n = 335)					
Lack of callus formation (bridging bone across fracture ends)					
Delayed union	210 (62.7)				
Nonunion	169 (50.4)				
Persistent fracture lines					
Delayed union	125 (37.3)				
Nonunion	166 (49.6)				

TABLE E-5 Prognostic Patient-Related Factors for Delayed Union and Nonunion

	No. (%) of Responses						
	Age	Sex	Smoking History	Alcohol Consumption	Diabetes	Vascular Injury	Osteoporosis
Delayed union (n = 335)							
Major contributor	103 (30.7)	5 (1.5)	279 (83.3)	127 (37.9)	207 (61.8)	255 (76.1)	57 (17.0)
Minor contributor	184 (54.9)	87 (26.0)	52 (15.5)	180 (53.7)	114 (34.0)	75 (22.4)	190 (56.7)
Not a contributor	48 (14.3)	243 (72.5)	4 (1.2)	28 (8.4)	14 (4.2)	5 (1.5)	88 (26.3)
Nonunion (n = 335)							
Major contributor	91 (27.2)	10 (3.0)	272 (81.2)	131 (39.1)	198 (59.1)	250 (74.6)	52 (15.5)
Minor contributor	184 (54.9)	81 (24.2)	55 (16.4)	182 (54.3)	126 (37.6)	77 (23.0)	185 (55.2)
Not a contributor	60 (17.9)	244 (72.8)	8 (2.4)	22 (6.6)	11 (3.3)	8 (2.4)	98 (29.3)

TABLE E-6 Prognostic Factors Related to Fracture and Injury Characteristics

	No. (%) of Responses				
	Mechanism of Injury	Fracture Morphology	Degree of Soft-Tissue Injury	Amount of Cortical Continuity	Fracture Type (OTA, AO Classification)*
Delayed union (n = 335)					
Major contributor	212 (63.3)	204 (60.9)	316 (94.3)	177 (52.8)	127 (37.9)
Minor contributor	102 (30.4)	124 (37.0)	17 (5.1)	150 (44.8)	181 (54.0)
Not a contributor	21 (6.3)	7 (2.1)	2 (0.6)	8 (2.4)	27 (8.1)
Nonunion (n = 335)					
Major contributor	214 (63.9)	203 (60.6)	307 (91.6)	163 (48.7)	115 (34.3)
Minor contributor	102 (30.4)	125 (37.3)	27 (8.1)	158 (47.2)	183 (54.6)
Not a contributor	19 (5.7)	7 (2.1)	1 (0.3)	14 (4.2)	37 (11.0)

\*OTA = Orthopaedic Trauma Association.

TABLE E-7 Prognostic Factors Related to Treatment and Surgical Characteristics

	No. (%) of Responses					
	Surgical Delay	Steroid Use	Anti-Inflammatory Use	Anticonvulsant Use	Anticoagulant Use	Vasculopathy
Delayed union (n = 335)						
Major contributor	39 (11.6)	173 (51.6)	63 (18.8)	17 (5.1)	6 (1.8)	192 (57.3)
Minor contributor	180 (53.7)	153 (45.7)	226 (67.5)	156 (46.6)	132 (39.4)	129 (38.5)
Not a contributor	116 (34.6)	9 (2.7)	46 (13.7)	162 (48.4)	197 (58.8)	14 (4.2)
Nonunion (n = 335)						
Major contributor	45 (13.4)	166 (49.6)	70 (20.9)	18 (5.4)	8 (2.4)	178 (53.1)
Minor contributor	188 (56.1)	156 (46.6)	217 (64.8)	163 (48.7)	135 (40.3)	139 (41.5)
Not a contributor	102 (30.4)	13 (3.9)	48 (14.3)	154 (46.0)	192 (57.3)	18 (5.4)

TABLE E-8 Effect of Years of Experience and Trauma Training on the Use of “Smoking” as a Prognostic Factor

	No. (%) of Responses					
	Delayed Unions			Nonunions		
Years of practice (n = 335)	Major Contributor	Minor Contributor	Not a Contributor	Major Contributor	Minor Contributor	Not a Contributor
<3 (n = 31)	29 (93.5)	2 (6.5)	0 (0.0)	29 (93.5)	2 (6.5)	0 (0.0)
3 to 5 (n = 33)	28 (84.8)	5 (15.2)	0 (0.0)	30 (90.9)	3 (9.1)	0 (0.0)
6 to 10 (n = 69)	61 (88.4)	8 (11.6)	0 (0.0)	59 (85.5)	10 (14.5)	0 (0.0)
11 to 15 (n = 76)	62 (81.6)	14 (18.4)	0 (0.0)	59 (77.6)	16 (21.1)	1 (1.3)
16 to 20 (n = 44)	38 (86.4)	6 (13.6)	0 (0.0)	37 (84.1)	6 (13.6)	1 (2.3)
21 to 25 (n = 40)	31 (77.5)	8 (20.0)	1 (2.5)	29 (72.5)	9 (22.5)	2 (5.0)
>25 (n = 42)	30 (71.4)	9 (21.4)	3 (7.1)	29 (69.0)	9 (21.4)	4 (9.5)
Trauma training (n = 335)						
Yes (n = 217)	172 (79.3)	41 (18.9)	4 (1.8)	166 (76.5)	44 (20.3)	7 (3.2)
No (n = 118)	107 (90.7)	11 (9.3)	0 (0.0)	106 (89.8)	11 (9.3)	1 (0.8)

TABLE E-9 Predicting When Delayed Unions and Nonunions Are Likely to Occur

	No. (%) of Responses				
	Tibial Fracture	Femoral Shaft Fracture	Humeral Shaft Fracture	Pelvic Rami Fracture	Scaphoid Fracture
Delayed unions*	(n = 326)	(n = 325)	(n = 324)	(n = 314)	(n = 317)
Weeks 2 to 12	256 (76.4)	238 (71.0)	267 (79.7)	249 (74.3)	237 (70.7)
Weeks 14 to 24	60 (17.9)	77 (23.0)	52 (15.5)	52 (15.5)	74 (22.1)
Weeks 26 to 36	9 (2.7)	9 (2.7)	4 (1.2)	10 (3.0)	5 (1.5)
Weeks 38 to 52	1 (0.3)	1 (0.3)	1 (0.3)	3 (0.9)	1 (0.3)
Nonunions*	(n = 320)	(n = 325)	(n = 323)	(n = 312)	(n = 319)
Weeks 2 to 12	88 (26.3)	91 (27.2)	136 (40.6)	127 (37.9)	118 (35.2)
Weeks 14 to 24	186 (55.5)	180 (53.7)	153 (45.7)	143 (42.7)	156 (46.6)
Weeks 26 to 36	38 (11.3)	45 (13.4)	28 (8.4)	34 (10.1)	38 (11.3)
Weeks 38 to 52	8 (2.4)	9 (2.7)	6 (1.8)	8 (2.4)	7 (2.1)
Early signs of delayed unions*	(n = 314)	(n = 313)	(n = 311)	(n = 304)	(n = 311)
Weeks 2 to 12	264 (78.8)	251 (74.9)	268 (80.0)	242 (72.2)	256 (76.4)
Weeks 14 to 24	44 (13.1)	58 (17.3)	39 (11.6)	53 (15.8)	47 (14.0)
Weeks 26 to 36	4 (1.2)	2 (0.6)	2 (0.6)	5 (1.5)	6 (1.8)
Weeks 38 to 52	2 (0.6)	2 (0.6)	2 (0.6)	4 (1.2)	2 (0.6)
Early signs of nonunions*	(n = 313)	(n = 313)	(n = 310)	(n = 301)	(n = 312)
Weeks 2 to 12	140 (41.8)	138 (41.2)	175 (52.2)	161 (48.1)	157 (46.9)
Weeks 14 to 24	153 (45.7)	151 (45.1)	120 (35.8)	117 (34.9)	130 (38.8)
Weeks 26 to 36	16 (4.8)	17 (5.1)	11 (3.3)	18 (5.4)	18 (5.4)
Weeks 38 to 52	4 (1.2)	5 (1.5)	4 (1.2)	5 (1.5)	7 (2.1)

\*Denominators of <335 reflect missing data.



TABLE E-10 Clinical Factors That Show Early Signs of Delayed Union and Nonunion\*

	Pain at the Fracture Site	Pain on Palpation	Pain on Weight-Bearing	Failure to Bear Weight	Failure to Return to Daily Activities	Infection	Wound-Healing Problem
Delayed unions (n = 335)							
Always	135 (40.3)	69 (20.6)	184 (54.9)	107 (31.9)	61 (18.2)	92 (27.5)	48 (14.3)
Sometimes	172 (51.3)	196 (58.5)	135 (40.3)	197 (58.8)	207 (61.8)	161 (48.1)	198 (59.1)
Rarely	18 (5.4)	54 (16.1)	6 (1.8)	19 (5.7)	55 (16.4)	68 (20.3)	66 (19.7)
Never	2 (0.6)	6 (1.8)	1 (0.3)	1 (0.3)	5 (1.5)	6 (1.8)	12 (3.6)
Unsure	8 (2.4)	10 (3.0)	9 (2.7)	11 (3.3)	7 (2.1)	8 (2.4)	11 (3.3)
Nonunions (n = 335)							
Always	137 (40.9)	75 (22.4)	178 (53.1)	131 (39.1)	79 (23.6)	94 (28.1)	57 (17.0)
Sometimes	176 (52.5)	210 (62.7)	138 (41.2)	177 (52.8)	205 (61.2)	168 (50.1)	202 (60.3)
Rarely	13 (3.9)	37 (11.0)	8 (2.4)	17 (5.1)	36 (10.7)	60 (17.9)	57 (17.0)
Never	2 (0.6)	5 (1.5)	1 (0.3)	1 (0.3)	7 (2.1)	6 (1.8)	8 (2.4)
Unsure	7 (2.1)	8 (2.4)	10 (3.0)	9 (2.7)	8 (2.4)	7 (2.1)	11 (3.3)

\*Values are given as the number of respondents, with the percentage in parentheses.

TABLE E-11 Radiographic Factors That Show Early Signs of Delayed Union and Nonunion\*

	Lack of Callus Formation	Persistent Fracture Lines	Large Fracture Gap	Limited Cortical Continuity	Poor Reduction	Inadequate Fixation
Delayed unions (n = 335)						
Always	166 (49.6)	169 (50.4)	158 (47.2)	88 (26.3)	51 (15.2)	98 (29.3)
Sometimes	160 (47.8)	145 (43.3)	186 (49.6)	223 (66.6)	233 (69.6)	208 (62.1)
Rarely	4 (1.2)	13 (3.9)	7 (2.1)	17 (5.1)	43 (12.8)	23 (6.9)
Never	1 (0.3)	4 (1.2)	1 (0.3)	1 (0.3)	4 (1.2)	2 (0.6)
Unsure	4 (1.2)	4 (1.2)	3 (0.9)	6 (1.8)	4 (1.2)	4 (1.2)
Nonunions (n = 335)						
Always	165 (49.3)	199 (59.4)	160 (47.8)	105 (31.3)	58 (17.3)	94 (28.1)
Sometimes	161 (48.1)	118 (35.2)	163 (48.7)	207 (61.8)	230 (68.7)	212 (63.3)
Rarely	4 (1.2)	12 (3.6)	8 (2.4)	19 (5.7)	39 (11.6)	23 (6.9)
Never	2 (0.6)	3 (0.9)	1 (0.3)	1 (0.3)	4 (1.2)	2 (0.6)
Unsure	3 (0.9)	3 (0.9)	3 (0.9)	3 (0.9)	4 (1.2)	4 (1.2)

\*Values are given as the number of respondents, with the percentage in parentheses.

TABLE E-12 Effect of Years of Experience and Trauma Training on the Use of “Pain on Weight-Bearing” as a Prognostic Factor

	No. (%) of Responses									
	Delayed Unions					Nonunions				
Years of practice (n = 335)	Always	Sometimes	Rarely	Never	Unsure	Always	Sometimes	Rarely	Never	Unsure
<3 (n = 31)	12 (38.7)	17 (54.8)	1 (3.2)	0 (0.0)	1 (3.2)	16 (51.6)	13 (41.9)	1 (3.2)	0 (0.0)	1 (3.2)
3 to 5 (n = 33)	18 (54.5)	14 (42.4)	1 (3.0)	0 (0.0)	0 (0.0)	19 (57.6)	12 (36.4)	2 (6.1)	0 (0.0)	0 (0.0)
6 to 10 (n = 69)	42 (60.9)	23 (33.3)	1 (1.4)	0 (0.0)	3 (4.3)	35 (50.7)	31 (44.9)	0 (0.0)	0 (0.0)	3 (4.3)
11 to 15 (n = 76)	38 (50.0)	33 (43.4)	2 (2.6)	0 (0.0)	3 (3.9)	37 (48.7)	33 (43.4)	2 (2.6)	0 (0.0)	4 (5.3)
16 to 20 (n = 44)	28 (63.6)	15 (34.1)	0 (0.0)	0 (0.0)	1 (2.3)	25 (56.8)	16 (36.4)	2 (4.5)	0 (0.0)	1 (2.3)
21 to 25 (n = 40)	27 (67.5)	12 (30.0)	0 (0.0)	0 (0.0)	1 (2.5)	26 (65.0)	13 (32.5)	0 (0.0)	0 (0.0)	1 (2.5)
>25 (n = 42)	19 (45.2)	21 (50.0)	1 (2.4)	1 (2.4)	0 (0.0)	20 (47.6)	20 (47.6)	1 (2.4)	0 (0.0)	1 (2.4)
Trauma training (n = 335)										
Yes (n = 217)	134 (61.8)	73 (33.6)	5 (2.3)	1 (0.5)	4 (1.8)	123 (56.7)	83 (38.2)	5 (2.3)	1 (0.5)	5 (2.3)
No (n = 118)	50 (42.4)	62 (52.5)	1 (0.8)	0 (0.0)	5 (4.2)	55 (46.6)	55 (46.6)	3 (2.5)	0 (0.0)	5 (4.2)

TABLE E-13 Impressions Regarding Clinical Trials\*

Interest in a proposed trial evaluating a novel treatment of fracture nonunions (n = 335)	Agree	Nonunion Rate	Delayed Union Rate	Reoperation Rate	Complication Rate	Return to Work	Return to Activities of Daily Living	Level of Pain	Weight-Bearing Status
Very interested	117 (34.9)								
Interested	117 (34.9)								
Moderately interested	33 (9.9)								
Somewhat interested	26 (7.8)								
Not interested	42 (12.5)								
Important outcomes in clinical trial practice (n = 335)									
Very important		217 (64.8)	136 (40.6)	203 (60.6)	194 (57.9)	100 (29.9)	124 (37.0)	104 (31.0)	132 (39.4)
Important		103 (30.7)	134 (40.0)	106 (31.6)	116 (34.6)	166 (49.6)	154 (46.0)	162 (48.4)	163 (48.7)
Moderately important		11 (3.3)	52 (15.5)	21 (6.3)	23 (6.9)	53 (15.8)	46 (13.7)	58 (17.3)	33 (9.9)
Little importance		1 (0.3)	9 (2.7)	2 (0.6)	0 (0.0)	14 (4.2)	10 (3.0)	10 (3.0)	4 (1.2)
Unimportant		3 (0.9)	4 (1.2)	3 (0.9)	2 (0.6)	2 (0.6)	1 (0.3)	1 (0.3)	3 (0.9)
Minimum acceptable reduction in complication that would be meaningful in a clinical trial (n = 335)									
5%		72 (21.5)	40 (11.9)	66 (19.7)					
10%		103 (30.7)	108 (32.2)	108 (32.2)					
15%		50 (14.9)	64 (18.2)	55 (16.4)					
20%		71 (21.2)	71 (21.2)	61 (18.2)					
25%		39 (25.0)	55 (16.4)	45 (13.4)					

\*Values are given as the number of respondents, with the percentage in parentheses.