

# CALCANEAL FRACTURES: IS SURGEON'S TRAINING MORE IMPORTANT THAN INJURY PATTERN IN DETERMINING OPERATIVE VERSUS NON-OPERATIVE TREATMENT?

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## ABSTRACT

**Purpose:** There appears to be a general lack of consensus in treating calcaneus fractures. Calcaneus fractures are unique in that many different patient-based variables such as smoking, diabetes, or occupation, may influence treatment decisions possibly more so than the nature of the injury itself. Indications for operative versus non-operative treatment are often unclear. The goals of this study are to: 1) determine if lack of consensus truly exists, 2) determine which factors most influence orthopaedic surgeons in choosing treatment algorithm and 3) determine if there are differences in treatment algorithm based on fellowship training and exposure to these injuries.

## METHODS

Practicing orthopaedic surgeons of various backgrounds and training were administered an electronic survey. The survey consisted of clinical vignettes and questions regarding fellowship training, demographics, and exposure to calcaneus fractures. Orthopaedic surgeons were asked to weigh the importance of patient-based variables in determining operative versus non-operative treatment.

## RESULTS

375 orthopaedic surgeons responded to our survey: 183 foot & ankle fellowship-trained (F&AT), 75 trauma fellowship-trained (TFT), and 117 neither foot & ankle/trauma fellowship-trained (NFT). F&AT surgeons ranked calcaneal deformity as statistically significantly more important than did NFT surgeons, and ranked peripheral vascular disease (PVD)/diabetes mellitus (DM) statistically significantly more important than did both TFT and NFT surgeons. There was no significant difference in choosing operative versus non-operative treatment for surgeons treating more calcaneus fractures (>4/month) versus those who see less (<1/month). For patients with

uncomplicated medical history there is general consensus on treatment as guided by the Sanders classification. For those with complex medical history, there is less consensus on management despite fracture pattern.

## CONCLUSION

The results suggest that there is general agreement in terms of which factors surgeons believe are the most important for determining management of calcaneus fractures. However, how this information is utilized varies according to practitioner and leads to varying consensus. In cases where there was anatomic deformity at either end of the spectrum of severity (Sanders 1 or 4), there was generalized consensus amongst our polled surgeons regarding management. When additional confounders were added, the agreement between surgeons declined only in the presence of factors considered to be of moderate importance. These data suggest that practitioners may first evaluate the fracture characteristics as a primary factor in terms of operative versus non-operative management, with consistency noted between surgeons. As confounding factors are added, there is less agreement between practitioners about the importance of these variables and, consequently, less consensus in regards to management. There were differences in assignment of importance of certain patient-based factors in determining treatment algorithm based on fellowship training.

## INTRODUCTION

The treatment of calcaneus fractures is one of controversy in the literature. Historically, the pendulum has swung between conservative and surgical treatment. As early as 1916, Cotton and Henderson recognized poor outcomes from calcaneus fractures when stating, "The man who breaks his heel bone is done"<sup>1</sup>. However in the early 1930's Bohler advocated open reduction internal fixation but recognized technical problems and associated poor outcomes secondary to poor anesthetics, limited radiography/fluoroscopy, as well as a poor understanding of principles of internal fixation.<sup>2</sup> The advent of better anesthetics, widespread use of antibiotics, and advancement in imaging and fixation principles/instrumentation has advanced our ability to achieve improved outcomes from surgery. However, the controversy regarding treatment of calcaneus fractures remains. Unlike other fractures that have more clearly defined indications for operative treatment, calcaneus fractures are unique in that many patient-based variables such as smoking, diabetes, occupation, and worker's compensation have been shown to effect outcomes.<sup>3 4</sup> For example, in a large, pro-

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**KEYWORDS:** calcaneus fracture, operative calcaneus, non-operative calcaneus.

**\* 7. Please indicate the importance of the following variables when deciding to treat a patient with a calcaneus fracture operatively or non-operatively?**

Figure 1: Question #7 asking surgeons to indicate the importance of patient-based variables

	No importance	Little importance	Some importance	Moderately important	Very important	Extremely important
Age	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gender	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
History of smoking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
History of alcohol and/or substance abuse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Occupation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Work vs. non work related injury	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Articular involvement (or lack of)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Calcaneal deformity (or lack of)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diabetes and/or peripheral vascular disease (PVD)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Concerns for patient compliance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other medical comorbidities aside from Diabetes and PVD	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

spective, randomized multicenter trial, performed by Buckley et al., comparing operative with non-operative treatment of displaced intra-articular calcaneus fractures, findings were statistically significant for such patient-based variables. However, to our knowledge there is no established algorithm to effectively weigh these multiple patient-based variables to help orthopaedic surgeons determine the best course of treatment. As a result, it is our hypothesis that treatment of calcaneus fractures may be highly influenced by surgeon training, practice characteristics, and exposure to patients with calcaneus fractures. Despite Buckley's findings, to our knowledge there has been no study that has analyzed what variables surgeons actually assign more importance to and how this influences their management of patients with calcaneus fractures. The current study attempts to decipher how various patient, surgeon, and fracture variables influence the management of calcaneus fractures and whether differences in training account for this.

**MATERIALS AND METHODS**

Orthopaedic surgeons were sent an electronic survey through [www.surveymonkey.com](http://www.surveymonkey.com) which consisted of 22 questions including 5 clinical vignettes. Surgeons were asked various questions including those specific to: fellowship training, practice demographics, patient population, number of acute calcaneus fractures (as defined by injury < 2 weeks old) treated per month, as well as the importance of different patient-based variables that may influence treatment algorithm. Figure 1 demonstrates question #7 from the survey. Surgeons were asked to weigh the importance of the following variables in determining operative versus non-operative treatment: age, gender, smoking history, ETOH/substance abuse, occupation, worker's compensation, articular involvement, calcaneal deformity, peripheral vascular disease/ diabetes, compliance issues, and other medical comorbidities. Surgeons were also shown 5 clinical vignettes each of which included a short medical his-

tory, a lateral x-ray of the foot, and a single coronal CT scan of the hindfoot. The lateral radiograph was included in each vignette so that surgeons could assess Bohler angle, angle of Gissane, and heel shortening/loss of height. The single coronal CT image was included so surgeons could measure amount of articular displacement and classify each fracture per the Sanders classification.

The vignettes demonstrated patients of different gender, varying age, medical comorbidities, social histories, and calcaneus fractures with varying articular involvement/deformity. For each clinical vignette surgeons were asked various questions regarding their decision for operative versus non-operative management, need for referral, and factors influencing their decisions. Figure 2 demonstrates clinical vignette #4 and associated questions. Surgeons were given the option to opt out of participation. Results were tabulated by [SurveyMonkey.com](http://SurveyMonkey.com).

The clinical vignettes (without radiographs) are described below:

**Clinical vignette #1:**

HPI: 27 yo female s/p fall off ladder while painting her room  
 PMHx: none  
 SH: no toxic habits, works as accountant  
 Fx: Sanders 1 calcaneus fx

**Clinical vignette #2:**

HPI: 55 yo male s/p fall down stairs while inebriated  
 PMHx: un-treated diabetes mellitus  
 SH: + tobacco (1 PPD x 30 years), + ETOH (2-4 beers/night), hx of recent incarceration for assault  
 Fx: Sanders 3 calcaneus fx

**Clinical vignette #3:**

HPI: 50 yo male s/p MVA  
 PMHx: none  
 SH: no toxic habits, works in construction  
 Fx: Sanders 4 calcaneus fx



Clinical vignette #4:  
 HPI: 29 yo male s/p fall off scaffolding at work  
 PMHx: none  
 SH: social smoking (4 cigarettes/week), social ETOH (4-6 beers Friday night), works in construction  
 Fx: Sanders 2 calcaneus fx

\* 17. How would you treat this patient?

- Operative
- Non-operative

\* 18. Would you treat this patient:

- Yourself
- Refer to another specialist

\* 19. What 3 factors in order of importance most influenced your decision to treat operatively or non-operatively? (select only 3)

Age	<input type="text"/>
Gender	<input type="text"/>
History of smoking	<input type="text"/>
History of alcohol and/or substance abuse	<input type="text"/>
Occupation	<input type="text"/>
Work vs. non work related injury	<input type="text"/>
Articular involvement (or lack of)	<input type="text"/>
Calcaneal deformity (or lack of)	<input type="text"/>
Diabetes and/or peripheral vascular disease (PVD)	<input type="text"/>
Concerns for patient compliance	<input type="text"/>
Other medical comorbidities aside from Diabetes and PVD	<input type="text"/>

Figure 2: Clinical Vignette #4 with associated questions

Clinical vignette #4:

HPI: 29 yo male s/p fall off scaffolding at work  
 PMHx: none  
 SH: social smoking (4 cigarettes/week), social ETOH (4-6 beers Friday night), works in construction  
 Fx: Sanders 2 calcaneus fx

Clinical vignette #5:

HPI: 56 yo male s/p fall off ladder  
 PMHx: CAD s/p CABG 5 years ago, hx of mild stroke  
 SH: no toxic habits, works as lawyer  
 Fx: Sanders 2 calcaneus fx

	Sample N = 375	Non-F&A/trauma Fellowship Trained		Fellowship Trained		p-value
		N = 117	Foot and Ankle N = 183	Trauma N = 61	Both N = 14	
<b>Practice Characteristics</b>						
Solo	27 (7.2)	13 (11.1)	11 (6.0)	2 (3.3)	1 (7.1)	0.22
Group						
< 5	43 (11.5)	17 (14.5)	21 (11.5)	2 (3.3)	3 (21.4)	0.09
≥ 5	167 (44.5)	39 (33.3)	110 (60.1)	14 (23.0)	4 (28.6)	< 0.001
Academic	138 (36.8)	41 (35.0)	47 (25.7)	43 (70.5)	7 (50.0)	< 0.001
Rural	18 (4.8)	8 (6.8)	8 (4.4)	2 (3.3)	0 (0.0)	0.54
Suburban	40 (10.7)	12 (10.3)	24 (13.1)	1 (1.6)	3 (21.4)	0.05
Urban	45 (12.0)	16 (13.7)	23 (12.6)	5 (8.2)	1 (7.1)	0.68
Non-Trauma Center	45 (12.0)	17 (14.5)	25 (13.7)	1 (1.6)	2 (14.3)	0.06
Level II or Level III Trauma Center	60 (16.0)	18 (15.4)	34 (18.6)	6 (9.8)	2 (14.3)	0.44
Level I Trauma Center	29 (7.7)	4 (3.4)	15 (8.2)	8 (13.1)	2 (14.3)	0.09
<b>Patient Population</b>						< 0.001
General Orthopedics	91 (24.3)	55 (47.1)	27 (14.8)	8 (13.1)	1 (7.1)	
Foot and Ankle	180 (48.0)	14 (12.0)	152 (83.1)	4 (6.6)	10 (71.4)	
Orthopedic Trauma	64 (17.1)	11 (9.4)	3 (1.6)	48 (78.7)	2 (14.3)	
Other Orthopedic Subspecialty	40 (10.6)	37 (31.6)	1 (0.5)	1 (1.6)	1 (7.1)	
<b>Fracture Exposure</b>						< 0.001
< 1	149 (39.7)	74 (63.2)	63 (34.4)	10 (16.4)	2 (14.3)	
1-4	211 (56.3)	39 (33.3)	114 (62.3)	46 (75.4)	12 (85.7)	
>4	15 (4.0)	4 (3.4)	6 (3.3)	5 (8.2)	0 (0.0)	
Difficulty Accessing a Specialist? (Yes)	13 (3.5)	11 (9.4)	1 (0.5)	1 (1.6)	0 (0.0)	< 0.001
Does availability of specialists influence your treatment decisions? (Yes)	5 (1.3)	4 (3.4)	0 (0.0)	1 (1.6)	0 (0.0)	0.45

Table 1: Summary Statistics for Study Population

## STATISTICAL METHODS

Survey data were entered into a statistical database (SPSS v.11.0, © SPSS Inc., Chicago, IL) for analysis. Descriptive statistics were computed to provide a general description of the sample and for the various subgroups, which included F&AT surgeons, TFT surgeons, and NFT surgeons. Given the lack of confirmed normality within the dataset, non-parametric methods were used to compare the different study groups. For multiple comparisons, the Bonferroni procedure was used. For all analyses, a p-value  $\leq 0.05$  was considered statistically significant.

## RESULTS

The survey was sent electronically to 2471 orthopedic surgeons, and responses were received from 375 surgeons, resulting in a 15% response rate. The study sample was composed of 183 foot & ankle fellowship-trained (F&AT) orthopaedic surgeons, 75 trauma fellowship-trained (TFT) orthopaedic sur-

geons, and 117 neither fellowship-trained (NFT) orthopaedic surgeons. There were 14 participants who reported fellowship training in both trauma and foot & ankle surgery.

In regards to practice demographics, the majority of surgeons reported participation in a group practice (92.8%). Approximately 37% of respondents stated that at least part of their practice was in an academic center. Even though a minority of respondents reported affiliation with level 1 (7.7%), level 2 or level 3 (16.0%) trauma centers, 56.3% reported seeing between 1 and 4 calcaneus fractures per month. Descriptive statistics for the population are summarized in Table 1. While F&AT surgeons were significantly more likely to work in groups with  $\geq 5$  surgeons ( $p < 0.01$ ), TFT surgeons were more likely to be found in academic centers ( $p < 0.01$ ). As expected practice patterns differed significantly between surgeons with the practice patterns noted to be consistent with the corresponding fellowship training (i.e. F&AT surgeons had significantly

	Sample	Fellowship Trained				p-value
		Non-F&A/trauma Fellowship Trained	Foot & Ankle	Trauma	Both	
	N = 375	N = 117	N = 183	N = 61	N = 14	
Age	2.7 ± 1.1	3.0 ± 1.2	2.6 ± 1.1	2.5 ± 1.2	2.5 ± 1.3	0.07
Gender	0.6 ± 0.9	0.65 ± 0.9	0.5 ± 0.9	0.8 ± 1.0	0.6 ± 1.0	0.11
Smoking History	3.3 ± 1.4	3.1 ± 1.4	3.5 ± 1.2	3.0 ± 1.5	2.8 ± 1.5	0.01
Alcohol or Substance Abuse History	2.8 ± 1.3	2.8 ± 1.4	2.9 ± 1.2	2.7 ± 1.4	2.8 ± 1.0	0.55
Occupation	2.4 ± 1.3	2.6 ± 1.3	2.4 ± 1.2	2.4 ± 1.3	2.3 ± 0.9	0.56
Work vs. Non-Work Related Injury	1.3 ± 1.3	1.2 ± 1.2	1.4 ± 1.3	1.6 ± 1.3	1 ± 1.0	0.16
Articular Involvement	4.2 ± 0.9	4.2 ± 0.9	4.2 ± 0.9	4 ± 1.0	4.1 ± 0.8	0.41
Calcaneal Deformity	4.3 ± 0.8	4.1 ± 0.8	4.4 ± 0.7	4.3 ± 0.9	4.1 ± 0.9	0.01
Peripheral Vascular Disease or Diabetes	4.0 ± 1.0	3.8 ± 1.1	4.2 ± 0.9	3.9 ± 1.2	3.9 ± 0.8	< 0.001
Compliance Issues	3.5 ± 1.1	3.5 ± 1.1	3.6 ± 1.0	3.3 ± 1.3	3.5 ± 0.5	0.29
Other Medical Comorbidities	3.2 ± 1.1	3.2 ± 1.1	3.2 ± 1.0	3.1 ± 1.1	2.8 ± 1.1	0.39

Table 2: Comparison of Relative Importance Rankings Which Characteristics are the Most Important When Treating Calcaneus Fractures? (0 = No Importance - 5 = Extremely Important)  
 Note: F&AT surgeons ranked calcaneal deformity as statistically more significant than NFT surgeons.  
 Note 2: F&AT surgeons ranked PVD/DM statistically more significant than both TFT and NFT surgeons.

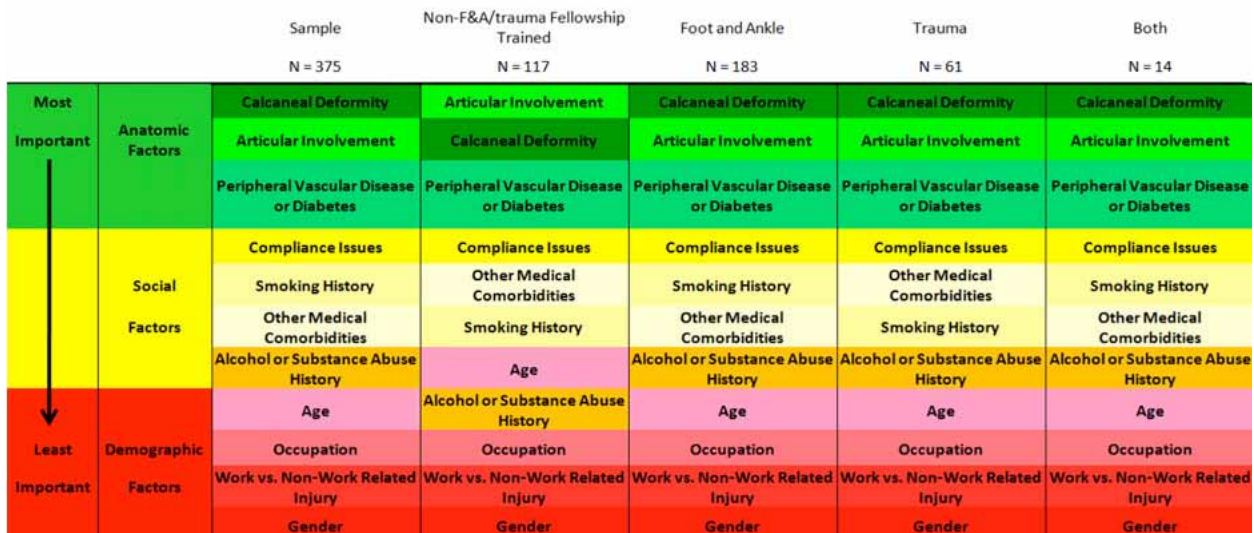


Figure 3: Relative Importance Rankings by Training Level  
 The figure above shows the relative importance of various factors in determining treatment planning for calcaneal fractures, sorted by type of training. Anatomic factors (listed in green), or those directly related to anatomic disruption or impaired wound healing were uniformly considered the most important factors in determining treatment, regardless of the type of specialist. Conversely, demographic factors (listed in red) were generally considered the least important factors in determining treatment.

higher proportions of their practice dedicated to foot and ankle problems). TFT surgeons were significantly more likely to see acute calcaneus fractures than F&AT surgeons, who, in turn were more likely to see calcaneus fractures than NFT surgeons ( $p \leq 0.02$ ).

Table 2 provides a summary of the relative importance of various contributing factors in determining operative versus non-operative management of calcaneal fractures. Factors associated with anatomic deformity (calcaneal deformity or articular involvement) were rated the most important in terms of determining treatment for the group as a whole and within each training subgroup. Gender and injury setting (work-relat-

ed versus non-work related) were consistently reported as the least important factors for determining treatment course. The relative rankings of factors are shown graphically in Figure 3.

Table 3 summarizes the treatment decisions of the various groups by clinical vignette, along with the pertinent case characteristics. For clinical vignette #1, the vast majority of respondents (96%) stated that they would manage this injury non-operatively, with no significant differences noted based on level of training ( $p = 0.37$ ). For clinical vignette #2, 59% of the sample stated that they would manage the fracture operatively, with F&AT surgeons statistically significantly more likely to suggest non-operative management than NFT surgeons



Treatment Recommendation						Features									
Case	Sample	Non-Fellowship Trained	Foot and Ankle	Trauma	Both	Age	Gender	DM	PMH	Smoke	ETOH	Sanders	Comply	Work	
	N = 375	N = 117	N = 183	N = 61	N = 14										
Case 1						27	F	No	No	No	No	1	No	No	
Operative	3.2%	5.1%	2.2%	1.6%	7.1%										
Non-Operative	96.8%	94.9%	97.8%	98.4%	92.9%										
Case 2						55	M	Yes	No	Yes	Yes	3	Yes	No	
Operative	40.8%	47.0%	32.2%	42.6%	42.9%										
Non-Operative	59.2%	53.0%	67.8%	57.4%	57.1%										
Case 3						50	M	No	No	No	No	4	No	No	
Operative	92.5%	88.0%	94.0%	95.1%	100.0%										
Non-Operative	7.5%	12.0%	6.0%	4.9%	0.0%										
Case 4						29	M	No	No	Yes	Yes	2	No	Yes	
Operative	96.8%	94.0%	99.5%	93.4%	100.0%										
Non-Operative	3.2%	6.0%	0.5%	6.6%	0.0%										
Case 5						56	M	No	Yes	No	No	2	No	No	
Operative	30.7%	32.4%	27.9%	37.7%	21.4%										
Non-Operative	69.3%	67.6%	72.1%	62.3%	78.6%										

Table 3: Decision Proportion by Clinical Vignette Characteristics

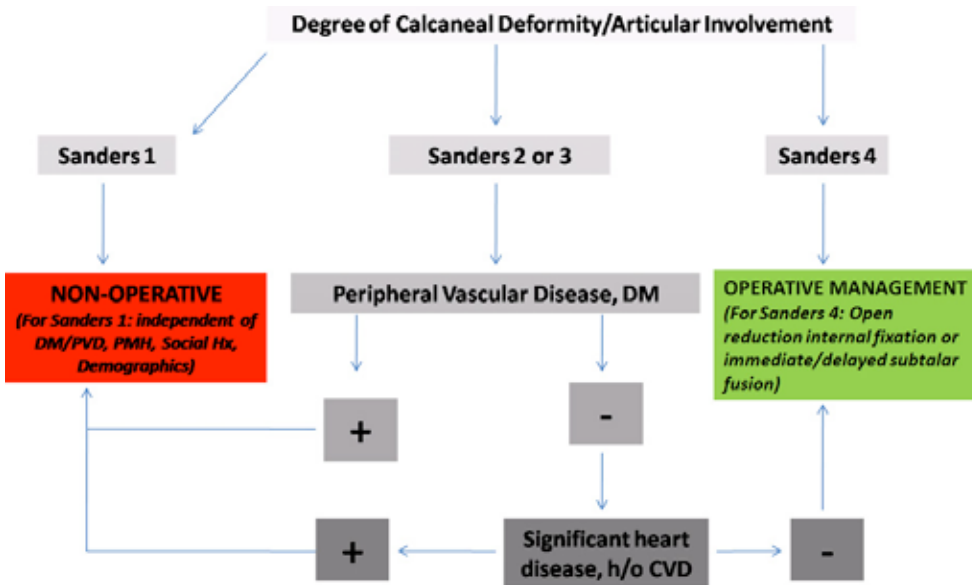


Figure 4 shows a simplified treatment algorithm based on interpretation of the responses of the polled surgeons to the above 5 clinical vignettes. The above figure outlines a potential treatment algorithm for the management of intra-articular calcaneal fractures, based on the responses to the clinical vignettes in this study. In general, fractures with Sanders 1 or 4 receive non-operative and operative management, respectively, with management of Sanders 4 fractures in either open reduction/internal fixation or an immediate or delayed (subtalar fusion) manner. For the management of Sanders 2 or 3 fractures, patients with diabetes (DM), peripheral vascular disease, significant heart disease, or history of cerebrovascular disease (CVD) should generally be treated non-operatively, whereas healthy patients should be offered operative management. It should be noted that these treatment decisions appeared to be independent of demographic (age, gender) and social factors (smoking, ETOH, substance abuse history, occupation, etc.), as these factors were listed as factors of intermediate or minimal importance by surgeons. However, given the limited number of clinical vignettes, we cannot definitively state that these factors have negligible influence on management.

(68% versus 47%, respectively,  $p = 0.01$ ). The majority of respondents (>90%) recommended operative management in clinical vignettes #3 and 4. Seventy percent of respondents recommended non-operative management for clinical vignette #5. Figure 4 shows a simplified treatment algorithm based on interpretation of the responses of the polled surgeons to the above 5 clinical vignettes.

### DISCUSSION

The results of this study suggest there is general agreement in terms of which factors orthopaedic surgeons believe are the

most important for determining management of calcaneal fractures. In general, surgeons consider those factors which cause anatomic disruption (calcaneus deformity and articular disruption) or impaired wound healing to the fractured area (diabetes mellitus or peripheral vascular disease) most important. These factors were generally followed in importance by social factors (smoking, substance abuse, compliance issues) and other medical comorbidities not including PVD/DM. Finally, the least important factors were demographic factors (age, gender, occupation and work vs. non-work related injury).

While these findings suggest a clinical paradigm for the management of calcaneus fractures, there were noticeable differences in how the information related to these factors was utilized across specialists with different levels of training. In cases where there was articular involvement with displacement at either end of the spectrum of severity (Sanders 1 or 4) there was generalized agreement between surgeons regarding management (>90% recommending the same treatment). When additional confounding variables were added, the agreement on management of the various fracture patterns between surgeons decreased. This was found to be the case only in the presence of factors considered to be of moderate or greater importance. For example clinical vignette #4 describes a patient with a Sanders 2 fracture but with confounding factors including smoking, alcohol use and workman's compensation. In this case, the confounding factors were those that were classified as having minimal to moderate importance, and there was still significant agreement between surgeons, with 97% suggesting operative management. This is in contrast to clinical vignette #5 which described a patient with a similar Sanders 2 calcaneus fracture but with a significant medical co-morbidity included (CAD). In this case, there was a majority opinion to offer non-operative management, but less agreement (70%). Finally, in clinical vignette #2, the presence of multiple confounding factors of varying importance (diabetes mellitus, smoking, alcohol use, and possible compliance issues) in the setting of a Sanders 3 calcaneus fracture led to significant discordance among practitioners. These data suggest that practitioners may initially evaluate characteristics of the fracture (articular involvement/calcaeneal deformity) and the corresponding Sanders classification as a primary factor in determining operative versus non-operative management as consistency was noted across practitioners with these being the most important variables. However, as confounding factors are added, there is less agreement between practitioners about the importance of the added variables and, consequently, less consensus in terms of management.

While there was no statistically significant difference between the group rankings for the importance of articular involvement in determining operative management, F&AT surgeons felt that calcaneal deformity was more important than did NFT surgeons. There may be several possible explanations for this difference. NFT surgeons who evaluate and treat these patients likely do so when taking trauma call and less so on a referral or elective basis. This accounts for our results that demonstrate that NFT surgeons see fewer patients with acute calcaneal fractures per month in their practice. One can extrapolate that this group, with no formal fellowship training in foot & ankle and with likely other subspecialty interests, may have less exposure to the long-term complications associated with either operative or non-operative calcaneus fracture treatment. The emphasis during general orthopaedic training often focuses on articular involvement and displacement as the principles that guide management. This explains why all groups ranked articular involvement as among the most important factors determining operative management. There

is likely less emphasis on the sequela of calcaneal deformity or non-operative treatment and its associated complications such as difficulty with shoe wear, gait problems, posterior tibial nerve impingement, subtalar arthritis, and tibia/fibular impingement. These long-term secondary complications from unresolved calcaneal deformity are likely treated more frequently by F&AT surgeons who receive specialized training in this domain and thus may explain why this group indicated calcaneal deformity as the most important factor over articular involvement relative to NFT surgeons. Our results, which indicate the importance of articular involvement, echo Buckley's findings. Buckley et al. showed that anatomic or near anatomic reduction of the posterior facet resulted in improved outcomes.<sup>iv</sup> However, aside from fracture classification (using systems developed by Sanders, Essex-Lopresti, Crosby and Fitzgibbons, and the Orthopaedic Trauma Association) he did not specifically address residual calcaneal deformity. While using post-operative CT scan to determine quality of reduction of the posterior facet he states that, "the reduction of the medial and the lateral wall and impingement of the peroneal tendon were not evaluated."<sup>iv</sup>

Although all groups ranked peripheral vascular disease and diabetes mellitus overall as the 3<sup>rd</sup> most important variable and smoking history as either 4<sup>th</sup> or 5<sup>th</sup> most important variable, there were statistical differences amongst the groups on the level of importance assigned on the scale utilized (i.e. assignment of moderately important versus very important versus extremely important). F&AT surgeons ranked PVD/DM statistically more important than did both TFT and NFT surgeons. The likely explanation for this difference is the degree of exposure that F&AT surgeons have to the complications associated with these comorbid conditions as they affect the lower extremity in general. Calcaneus fractures aside, F&AT surgeons manage a myriad of diabetic complications including ulcerations, infections, and charcot joints more frequently than a general practitioner or other subspecialty trained orthopedic surgeon who deals with trauma as a secondary practice interest.

Buckley et al. demonstrated with statistical significance that patients who are younger, female, non-worker's compensation cases, and with light or moderate workload do better with operative treatment.<sup>iv</sup> Despite this finding our polled surgeons, regardless of fellowship training, ranked (in order): gender, worker's compensation, occupation, and age as the least important variables they factor when determining operative versus non-operative treatment. It is unclear how Buckley's work has influenced our polled surgeons or the decision process orthopaedic surgeons use to determine management in non-fracture based variables.

Overall, there were no statistically significant differences between the groups with regard to percentage operative management based on fracture exposure for clinical vignettes #1, 2, 4, and 5, although for clinical vignette #3 surgeons who saw <1 fracture per month were statistically significantly less likely to choose operative management when compared to those who saw 1-4 fractures/month ( $p = 0.03$ ). This lack of significant results may be due to the fact that only 15 respondents reported

seeing > 4 calcaneus fractures/month, thus creating a significant sample size asymmetry between groups. The authors hypothesize that a larger sample size in this group may result in differential results as there was a trend toward significance in our study. Surgeons who see > 4 calcaneus fractures/month may have increased experience with the non-operative complications from unresolved deformity and articular involvement. Their increased exposure to patients with calcaneus fractures may also lead to increased skill and comfort regarding the technical issues for achieving proper reduction and fixation. These surgeons may also be more adept in dealing with the potential post-operative surgical complications including infection and subtalar degeneration. Similarly they may have increased resources and consultation services available to deal with potential complications from operative treatment (i.e. plastic surgery consultation for flap coverage).

We recognize several weaknesses in our study. The interpretation of our results is limited by Level V evidence and participation bias. Although we only achieved a 15% participation rate our distribution of NFT, F&AT, and TFT surgeons was acceptable for statistical analysis. Our results were formulated based on those that participated, and increased participation may have resulted in differential results.

In regards to worker's compensation, our rationale for inclusion of this variable in Question #7 was to investigate surgeon's attitudes given published data demonstrating that worker's compensation claims have generally worse outcomes following calcaneus fractures than cases involving non-compensation issues.<sup>5 6 7</sup> Our intention was to elicit how this published data might influence treatment management. However, we recognize that this question may have been interpreted differently based on financial issues given differential reimbursement for worker's compensation claims versus non-work injuries. This may have affected how this variable was weighed by our participants as determining operative versus non-operative treatment. The question was not formulated to assess the possible financial bias towards surgical treatment in a worker's compensation case.

In regards to clinical vignette #4 (Sanders 4 calcaneus fracture) there may have been ambiguity regarding operative treatment. Operative treatment for the purposes of our study was implied, but not explicitly stated, to be open reduction internal

fixation. However there is data advocating primary subtalar fusion for Sanders 4 type calcaneus fractures.<sup>8</sup> Respondents who chose operative treatment for this vignette may have done so considering fusion over ORIF and this distinction could not be elicited from our question format.

We feel that a scoring system, for example similar to The Mangled Extremity Severity Score, can and should be developed that would assist orthopaedic surgeons in determining the optimal treatment of calcaneus fractures. It was not the intent of the current study nor does our study design allow us to scientifically develop such a system based on statistical data. However, given the general consensus amongst 375 orthopaedic surgeons in ranking importance of the 11 variables we assessed, we feel that one can simplify decision processes by stratifying multiple patient-based variables into 3 categories:

Extremity specific factors: i.e. anatomic disruption (calcaneal deformity and articular disruption), concerns for impaired wound healing to the fractured area (diabetes mellitus or peripheral vascular disease).

Social factors (smoking, substance abuse, compliance issues) and those medical factors not directly associated with impairment of local wound healing.

Demographic factors (age, gender, occupation and work vs. non-work related injury).

Extremity specific factors, as they were indicated to be the most importance factors by our polled surgeons, would be given more weight in determining treatment. Social factors would be given less weight than extremity specific factors and demographic factors would hold the least weight.

Despite these shortcomings our study demonstrates that there are statistically significant differences in how patient-based variables are weighed and how these variables are interpreted in determining treatment of patients with calcaneus fractures based on fellowship training and exposure. Recognizing these differences is relevant in order to strive as a community of practitioners to offer our patients a more consistent recommendation. Improved rapid communication and consultation systems between general orthopedic surgeons and foot & ankle or trauma specialists may serve to address these differences. Appropriate referral to foot & ankle or trauma specialists by general orthopedic surgeons may be warranted in certain cases.

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