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ORIGINAL RESEARCH

Unstable Ankle Fractures in Older Patients: A Consecutive Series with Modern Internal Fixation Techniques

Nicholas A Viens MD, **E Grant Sutter** MS, **Daniel S Mangiapani** MD, **Samuel B Adams** MD, **Robert D Zura** MD

ABSTRACT

Background: Ankle fractures are among the most common injuries sustained by older patients. Management of these fractures remains both controversial and challenging. Clinical outcomes from a series of older patients treated surgically for unstable ankle fractures were reviewed to determine the effects of patient, injury and fixation factors on postoperative outcomes.

Materials and methods: A retrospective series of 58 consecutive patients age 60 years and older with 63 unstable ankle fractures treated surgically by a single surgeon over a 5-year period was reviewed. Forty-seven females (81.0%) and 11 males (19.0%) with a mean age of 72.6 (range, 60 to 88.4) years made up the sample.

Results: The most common injuries were OTA type 44-B2 (66.7%) or Lauge-Hansen supination-external rotation type-4 (76.2%) fractures. Forty-seven (74.6%) fractures were due to a low energy mechanism. Nineteen (30.6%) injuries were fracture-dislocations and seven (11.1%) fractures were open. Augmented techniques were used in 31 (49.2%) cases overall. Ten (17.2%) patients experienced postoperative complications. Males, patients with fracture dislocations, high energy fractures, and open fractures experienced significantly worse outcomes ($p < 0.05$). Age, fracture type and the use of augmented technique were not predictive of clinical outcomes.

Conclusion: Overall in this series, older patients treated surgically for ankle fractures experienced good clinical outcomes. Further investigations are required in order to find patient and injury factors that can assist preoperative planning and predict outcomes.

Keywords: Ankle fracture, Elderly, Osteopenia, Augmented fixation, Locked plating.

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INTRODUCTION

Ankle fractures are among the most common fractures that occur in older patients, yet their management remains controversial.[1,2] Approximately 18% of the United States population (over 56 million people) is age 60 or older with a projected increase to 25% by the year 2050.[3] Previous literature reported an increased risk of postoperative complications and an equivalent or inferior outcome following surgical management of ankle fractures in older patients when standard techniques were used.[4-6] Likewise, older patients tend to experience prolonged recovery compared to a younger cohort.[7-15]

Despite not being true 'fragility fractures' linked directly to osteoporosis, ankle fractures are common in the elderly patient population and increasingly common in older white females, in whom osteoporosis is most prevalent.[16-20] Decreased bone mineral density in many of these patients may result in more severe injury patterns and decreases the ability to obtain sufficient fixation intraoperatively with standard open reduction and internal fixation (ORIF) techniques.[9,21] Multiple techniques of augmented fixation for ankle fractures in older patients, including locked plates, hook plates, tibia-pro-fibula screws, bicortical medial malleolar screws, intramedullary implants, and bone void fillers, have been described.[22-31]

The goals of this investigation were to review the clinical and radiographic outcomes of ankle fracture ORIF in an older patient population and compare them to the somewhat limited literature focusing on this group of patients using the most current surgical techniques and implants. No previous studies have investigated if preoperative patient or injury factors can predict the need for, or efficacy of augmented fixation techniques in older patients.

MATERIALS AND METHODS

After obtaining approval from the institutional review board, we retrospectively reviewed the clinical records of all patients age 60 years and older at the time of surgery who underwent ORIF for unstable ankle fractures at an academic level I trauma center from July 2005 through June 2010. An experienced fellowship-trained orthopaedic trauma surgeon (RDZ) performed the definitive surgeries and directed postoperative clinical follow-up for this cohort. Co-morbidities, Charlson index, American Society of Anesthesiologists (ASA) grading, and body mass index (BMI) were determined from the medical records.[32,33] Specific attention was paid to current tobacco smoking, diabetes mellitus, peripheral neuropathy, peripheral vascular disease, and dementia. The use of preoperative mobility aids was also recorded.

Concomitant injuries, mechanism of injury, and energy of the injury were determined from the clinical histories and imaging obtained upon presentation. High energy injuries occurred from motor vehicle collisions (MVC) and falls from elevated heights, whereas low energy injuries were sustained during falls or twisting injuries from standing

or seated heights.[34,35] Fractures were categorized according to the Orthopaedic Trauma Association (OTA) fracture classification based upon retrospective review of radiographs and CT scans (when available) obtained at the time of injury.[36] Fractures were also classified according to the Lauge-Hansen system.[37] Patients with unimalleolar, bimalleolar, and trimalleolar ankle fractures (OTA type 44) were included in the analyses. Patients with distal tibia metaphyseal fractures and tibial pilon fractures (OTA type 43) were excluded. Open fractures were classified according to the modified Gustilo-Anderson system.[38]

Fixation techniques and implants were used at the discretion of the senior author based on fracture patterns and subjective assessments intraoperatively of each patient's bone quality and stability of fracture fixation as the case progressed. The use of augmented fixation techniques, including locking constructs, hook plates, tibia-pro-fibula screws across the syndesmosis regardless of syndesmotic stability, bicortical medial malleolar screws, intramedullary implants, bone void fillers, as well as external fixation was catalogued after detailed review of operative records, intraoperative fluoroscopic images saved to the medical record, and postoperative radiographs. Patients were typically placed into a short leg splint immediately postoperative and converted to a short leg cast in clinic at the time of suture removal 2 to 4 weeks following ORIF. Patients were kept nonweight bearing on the operative ankle until signs of radiographic healing were seen after at least 6 to 8 weeks from surgery. Patients were then advanced into a walking boot and subsequently progressed with the assistance of physical therapy as needed. The primary study outcomes included postoperative complications and radiographic union.

Statistical analysis was performed using SAS/STAT software (SAS Institute Inc, Cary, NC). Chi-squared analysis was used to determine the effect of discrete variables on discrete outcomes; Pearson correlation analysis was used to determine the effect of continuous variables on continuous outcomes; Student t-test and ANOVA analyses were used to determine the effect of discrete variables on continuous outcomes. Logistic regression was performed to determine odds ratios. A p-value of < 0.05 was considered significant.

RESULTS

The study population consisted of 58 consecutive patients with 63 unstable ankle fractures. There were 47 females (81.0%) and 11 males (19.0%) with a mean age of 72.6 (range, 60-88.4) years. Comorbidity data for the study sample is summarized in Table 1. Sixty-two percent of patients were categorized in the surgical record as ASA grade 3, signifying a patient with severe systemic disease. No patients were considered ASA grade 1 (i.e. normal healthy patient). Nineteen (33.3%) patients had a Charlson comorbidity index of zero, with a mean Charlson index of 2.1 (range, 0-9) for sample. The mean BMI was 31.4 (range, 19.4-59.8) kg/m^2. Only two (3.4%) patients required a mobility aid before sustaining the ankle fracture: One due to prior cerebrovascular accident and one due to a complex seizure disorder.

Forty-seven (74.6%) fractures were due to a low energy mechanism. High energy fractures occurred due to MVC in 11 cases and blunt trauma in five cases. Nineteen (30.6%) injuries were fracture-dislocations and seven (11.1%) fractures were open injuries (Fig. 1) (one Gustilo Anderson type II, four type IIIA, two type IIIB). Concomitant injuries were suffered by 17 (29.3%) patients. The frequencies of fracture patterns by patient age are presented in Tables 2 and 3.

Definitive fixation occurred an average of 8.2 (range, 0-34.5) days after the initial injury and was performed at the discretion of the senior author once soft tissue swelling and concomitant injuries (when applicable) had appropriately stabilized. External fixation was utilized for temporary fracture stabilization before definitive fixation in seven (11.1%) cases. One or more plates were used during fixation in the majority of fractures (92.1%). Transsyndesmotic screws were used in 14 (Fig. 2) (22.2%) fractures.

Augmented techniques were used in 31 (49.2%) cases overall, as shown in Table 4. External fixation was used in addition to internal fixation in nine (14.3%) fractures, and was removed an average of 48 (range, 15-74) days after the definitive fixation procedure. Patients in whom definitive external fixation was used were 0.75 times as likely to exhibit fracture healing at final follow-up ($p < 0.05$). Additionally, the use of external fixation showed a longer

Table 1: American Society of Anesthesiologists (ASA) grading and comorbidity data for 58 consecutive patients age 60 years and older

ASA grade	
Grade 2	15 (25.9%)
Grade 3	36 (62.1%)
Grade 4	7 (12.1%)
Specific comorbidities	
Smoking	13 (22.4%)
Diabetes mellitus	25 (43.1%)
Peripheral neuropathy	8 (13.8%)
Peripheral vascular disease	1 (1.7%)
Dementia	1 (1.7%)
Charlson index	
0	19 (32.8%)
>0	39 (67.2%)

Fig. 1: Representative anteroposterior radiograph of an open OTA type 44-B2 (trans-syndesmotic bimalleolar) fracture

Fig. 2: Representative anteroposterior radiograph of an ankle fracture treated with augmented fixation. The fibula was fixated with a 10-hole tubular plate with a tibia profibular screw. A 6-hole 1/3 tubular plate, with two tibia profibular screws, was also used for the additional fibular fragment

healing time of 8.7 ± 3.0 *vs* 6.2 ± 3.3 months in patients without external fixation ($p < 0.05$). With the numbers available, a significant effect of augmented fixation on time to radiographic union could not be detected.

Ten (17.2%) patients experienced complications in the postoperative period. Wound complications occurred in six (10.3%) patients: four requiring additional surgery and two treated with local wound care and antibiotics. Hardware was ultimately removed in five (8.6%) patients: due to pain in two patients, deep infection in two patients, and nonunion in one patient. One patient with a Gustilo-Anderson grade IIIB open ankle fracture developed an infection that could not be adequately treated with debridement and antibiotics alone and, therefore, required a below knee amputation (BKA). One patient with diabetes, peripheral neuropathy, and end-stage renal disease developed an ankle fracture nonunion treated with tibiotalocalcaneal arthrodesis using an intramedullary nail. This patient's course was subsequently complicated by infection that required BKA as well. One patient with bilateral ankle fractures died during the index hospitalization after surgery due to concomitant injuries sustained from a MVC. Fifty-seven (98.3%) patients

Table 2: OTA fracture classification frequencies subdivided by age at surgery

		Age at surgery (years)						
		60-64	*65-69*	*70-74*	*75-79*	*80-84*	*85-89*	*Total # fractures*
OTA fractures classification	44-A2	0	0	0	0	0	1	1 (1.6%)
	44-B2	12	4	8	7	9	2	42 (66.7%)
	44-B3	3	1	1	4	2	1	12 (19.0%)
	44-C1	0	0	1	0	0	0	1 (1.6%)
	44-C2	0	1	2	0	2	1	6 (9.5%)
	44-C3	1	0	0	0	0	0	1 (1.6%)
	Total # fractures	16	6	12	11	13	5	63

Table 3: Lauge-Hansen fracture classification frequencies subdivided by age at surgery

		Age at surgery (years)						
		60-64	*65-69*	*70-74*	*75-79*	*80-84*	*85-89*	*Total # fractures*
Lauge-Hansen fracture classification	SA-2	0	0	0	0	1	1	2 (3.2%)
	SER-3	0	0	0	1	0	0	1 (1.6%)
	SER-4	15	4	9	10	7	3	48 (76.2%)
	PER-2	0	1	0	0	3	0	4 (6.3%)
	PER-3	1	1	3	0	2	0	7 (11.1%)
	PER-4	0	0	0	0	0	1	1 (1.6%)
	Total # fractures	16	6	12	11	13	5	63

SA: Supination-adduction; SER: Supination-external rotation; PER: Pronation-external rotation

Table 4: Augmented fixation techniques subdivided by age at surgery

		Age at surgery (years)											
		60-64		65-69		70-74		75-79		80-84		85-89	
	Total # fractures	16		6		12		11		13		5	
		# Fractures	%	#	%	#	%	#	%	#	%	#	%
Surgical techniques	Locked plates	14	87.5	5	83.3	12	100.0	11	100.0	12	92.3	4	80.0
	Hook plates	0		0		0		0		1	7.7	0	
	Trans-syndesmotic screws*	6	37.5	1	16.7	5	41.7	4	36.4	1	7.7	2	40.0
	Tibia-profibula screws	1	6.3	1	16.7	0		1	9.1	1	7.7	1	20.0
	Bicortical medial malleolus screws	2	12.5	0		0		4	36.4	8	61.5	2	40.0
	Intramedullary implants	1	6.3	0		0		0		1	7.7	0	
	Bone void fillers	0		0		0		0		0		0	
	Definitive external fixation	2	12.5	0		1	8.3	1	9.1	3	23.1	2	40.0

*Includes trans-syndesmotic screws used for syndesmosis instability and screws used as augmented fixation technique

and 61 (96.8%) fractures were ultimately available for outpatient follow-up. One patient died 27.2 months after ankle ORIF from a myocardial infarction after completing ankle fracture follow-up. This was not recorded as a complication of ankle fracture treatment, and the patient's data were included for analysis.

The average time from surgery to last follow-up was 7.8 (range, 0.1-24.8) months, at which time 44 (77.2%) patients experienced no ankle pain. Fourteen (24.6%) patients were lost to follow-up and therefore did not reach the final study outcome of radiographic union. The remaining 43 (75.4%) patients completed follow-up and were discharged from clinic after an average of 9.6 (range, 2.1-24.8) months from surgery. In these patients, 41 (95.3%) fractures were completely healed on radiographs, which occurred at an average of 6.6 (range, 2.1-19.3) months from surgery. Of the patients that completed follow-up, 36 (83.7%) patients ambulated unassisted, six (14.0%) patients required a mobility aid, and one (2.3%) patient was totally immobile due a contralateral above knee amputation performed for failed treatment of a periprosthetic proximal tibia fracture sustained after complete healing of the ankle fracture.

With the numbers available, a significant effect of age at the time of surgery on postoperative clinical or radiographic outcomes following ankle fracture ORIF could not be detected. Postoperative complications were 4.5 times more likely in males than females in this series ($p < 0.05$). In addition, males were 9.6 times more likely to undergo reoperation, 5.8 times more likely to require removal of hardware, and 3.9 times more likely to require a mobility aid at the final follow-up ($p < 0.05$).

Patients who suffered a high energy fracture were 3.4 times more likely to have postoperative complications and 4.6 times more likely to require a mobility aid at final follow-up ($p < 0.05$). Patients with open fractures were 0.67 times as likely to exhibit fracture healing at final follow-up ($p < 0.05$). Open fractures also had longer healing times of 9.5 ± 3.1 months compared to 6.2 ± 3.2 months for those with closed fractures ($p < 0.05$). Fracture-dislocations had augmented fixation 1.7 times more often than when the ankle was not dislocated at the time of injury ($p < 0.05$). Patients who suffered a dislocation in addition to fracture had slower fracture healing times of 8.3 ± 4.1 months compared to 5.7 ± 2.8 months for those with isolated ankle fractures ($p < 0.05$). Aside from the presence of dislocations, a significant effect of the specific fracture classification (OTA and Lauge-Hansen) on outcome or of the use of augmented fixation techniques could not be detected with the numbers available.

Patients in whom plates were used as a component of ORIF had 5.2 times less risk of experiencing postoperative complications, 8.7 times less risk of reoperation, and 7.7 less risk of requiring removal of hardware when compared to those in whom plates were not used ($p < 0.05$). With the numbers available, a significant effect of the use of augmented techniques on these outcomes could not be detected.

DISCUSSION

An improved understanding of ankle fractures in older patients and new treatment methods for taking care of this expanding patient population has occurred over the last several years. A detailed review of the literature on operative *vs* nonoperative treatment of ankle fractures in this patient

population is beyond the scope of this particular study and has been performed elsewhere.[27,39] Nevertheless, it is important to note, and encouraging to find, that patients in the current investigation similarly experienced favorable postoperative outcomes following ankle fracture ORIF, as demonstrated primarily by low postoperative pain, low rates of major complications, and very high rates of return to pre-injury function. Assal presented 100% fracture healing by 6 months in a series of 36 patients with mean age of 79 years and 90% return to preinjury functional status 1 year after surgery.[23] Shivarathre also reported 86% return to preinjury function after ankle fracture ORIF in a consecutive patient sample of 92 patients age 80 years and older.[13] Given the heterogeneity of both the patient populations and documentation of outcomes, direct comparisons of this investigation to prior studies are difficult.

Older male patients experienced worse overall outcomes following ankle fracture ORIF. Those who sustained high energy injuries, open fractures, and/or fracture-dislocations also had worse overall outcomes following surgery. Trans-syndesmotic fixation was associated with potentially mixed results given that it tended to elevate the risk of a negative outcome, yet was likely utilized in more challenging clinical scenarios overall and may be impacted by other confounding variables. Age, gender, and fracture pattern were not predictive of the fixation techniques that may be necessary for obtaining adequate fixation or of clinical outcomes for older patients with unstable ankle fractures presenting to our institution.

The risk factors for sustaining an ankle fracture, including elevated BMI, smoking, polypharmacy, and prior fractures, provide useful information for determining why certain older patients may have good or poor outcomes following surgery, as undoubtedly the factors that put older patients at risk for fracture also place them at elevated risk of complications.[39,40] Obesity and smoking in particular both add to the difficulties inherent in the surgical and postoperative management of these patients due to the effects on general health, physiologic reserve, and ability to tolerate the prolonged periods of postoperative immobilization that may be necessary to allow for fracture healing in a challenged healing environment.[21,41] Other frequent comorbid conditions in older patients, while perhaps not risk factors for sustaining ankle fractures themselves, such as diabetes and osteoporosis, also must be considered when investigating prognostic variables and attempting to create treatment recommendations and algorithms.[42] Similar to the present study, Pagliaro reported good overall results from ORIF for unstable ankle fractures in 23 patients age 70 and older with 100% healing, but emphasized the importance of specific comorbidities in light of two amputations that were required due to failed treatment of the two patients with wound necrosis and underlying infection.[43] These circumstances were similar to an amputation suffered by one of our patients due to multiple comorbidities leading to nonunion and infection. The other amputation in our study resulted from an infected open fracture that failed surgical debridement and antibiotic treatment.

Multiple small clinical and cadaveric series discussing the use of augmented fixation techniques have demonstrated their utility in this patient population and have provided ideas to consider when faced intraoperatively with a difficult fracture in the setting of osteopenic bone and/or diminished overall healing potential. For example, Koval described positive clinical results and improved resistance to bending in a cadaveric model utilizing intramedullary Kirschner wires to augment standard screw fixation with a 1/3 tubular plate on the fibula.[27] Describing cadaveric data from an elderly cadaver fracture model, Dunn also demonstrated improved stiffness, strength, and resistance to axial deformation when using tibia-pro-fibula screws to further augment 1/3 tubular plating combined with intramedullary K-wires.[24] Additionally, Lemon treated fractures in osteoporotic women with a retrograde calcaneotibial nail and showed good healing and functional outcomes.[44]

The present study included a variety of augmented fixation techniques chosen intraoperatively based primarily upon the senior author's clinical experience and subjective assessment of bone quality and fixation strength. The lack of strict criteria for choosing one surgical technique over another in any specific situation and the lack of objective bone mineral density data are potential weaknesses of this study. Conversely, the heterogeneity of this consecutive series may be considered a strength since it provides a real life sample of older patients with a variety of ankle fractures and multiple surgical techniques used based on subjective intraoperative assessments, rather than focus on a single technique or smaller subset of older patients with a specific fracture pattern in a more artificial or experimental setting. Despite the use of numerous augmented fixation techniques in half of the patients in the sample, other techniques that some authors have shown clinical and biomechanical success using in older ankle fractures, such as the addition of bone void fillers to enhance screw purchase, were not used in these patients.[9,30] Perhaps the addition of techniques such as these in the future will further improve our patients' outcomes following ORIF and can be the subject of upcoming investigations.

This study is limited by its retrospective nature, lack of a comparison group, and lack of prospectively collected validated outcome measures. Clinical outcomes of pain, postoperative mobility compared to preinjury mobility, postoperative complications, and radiographic assessments of healing are perhaps more relevant to older patients due to their typical expectations and goals of avoiding major problems and of maintaining or gaining some degree of independence following an injury.

By reporting a consecutive series of older patients who presented to our institution and received care by the same orthopaedic trauma surgeon, the effects of confounding variables from multiples providers' intraoperative decision-making and outpatient management preferences are ideally decreased. Aside from male gender, open fractures, and fracture-dislocations, no clear patient or injury factors were determined to be statistically significant predictors of outcome. Although we report the results of over 50 patients treated during a 5-year period, the relatively low numbers in subsets of the sample likely limited the ability to detect subtle differences in outcomes. Increasing patient numbers with future investigations may allow us to better understand the hidden factors driving patient outcomes for this growing part of the population.

CONCLUSION

Despite the current inability to create a specific set of treatment recommendations, the results of this investigation reinforce that surgical management of ankle fractures in older patients is a relatively safe and effective option for most patients. Open reduction and internal fixation can allow the majority of older patients to remain mobile after their ankle fractures have healed.

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ABOUT THE AUTHORS

Nicholas A Viens

Resident, Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, USA

E Grant Sutter

Medical Student, Department of Orthopaedic Surgery, Duke University School of Medicine, Durham, NC, USA

Daniel S Mangiapani

Resident, Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, USA

Samuel B Adams

Assistant Professor, Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, USA

Robert D Zura (Corresponding Author)

Assistant Professor, Department of Orthopaedic Surgery, Duke University Medical Center, Box-3205, Durham, NC 27710, USA
Phone: (919) 668-0291, Fax: (919) 668-0272, e-mail: robert.zura@duke.edu