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Clinical Outcomes of Hyperplantarflexion Variant Compared With Supination External Rotation Ankle Fractures: A Matched-Cohort Analysis

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ABSTRACT

Recent literature has reported an uncategorized hyperplantarflexion variant ankle fracture characterized by a posteromedial fragment separate from the posterior or medial malleolar fragments. The current study sought to determine whether the outcomes for surgically treated hyperplantarflexion variant fractures are similar to the more common supination external rotation (SER) IV fractures. A prospective registry of operatively treated ankle fractures was queried to create 2 age- and gender-matched cohorts: hyperplantarflexion variant and SER IV fractures. Each cohort had 23 patients (18 females), and matched pairs were within 2 years of age at the date of surgery. Patient demographics, comorbidities, and Foot and Ankle Outcomes Scores at minimum 12 months after the index surgery were compared. The cohorts were similar with respect to body mass index, the length of the clinical follow-up, medical comorbidities, dislocation rate, and postoperative articular incongruity ($p > .05$). Patient-reported outcomes demonstrated no statistically or clinically significant differences within any domain and were as follows: symptoms (70.8 versus 77.8, $p = .11$), pain (80.7 versus 85.0, $p = .33$), activities of daily living (83.7 versus 89.2, $p = .23$), sports (67.4 versus 73.4, $p = .33$), and quality of life (57.3 versus 63.9, $p = .24$) for the hyperplantarflexion and SER IV groups, respectively. No significant differences were found in the rang`e of motion for dorsiflexion (17.7° versus 18.1°, $p = .52$) or for plantarflexion (48.6° versus 47.1°, $p = .71$). Patients treated surgically for hyperplantarflexion variant ankle fractures have similar 1-year clinical outcomes when compared with the more common SER IV fracture patterns, provided that the injury is correctly identified preoperatively and treated appropriately.

The Lauge-Hansen classification system provides a systematic method for categorizing ankle fractures by the pattern of osseous and ligamentous injuries. However, not all ankle fracture patterns fit into the defined categories, which increases the potential for misdiagnosis or mistreatment (1–3). Reports in the recent literature have described one such ankle fracture variant that cannot be categorized by the Lauge-Hansen or any other described classification system. This hyperplantarflexion variant comprises between 6% and 8% of all ankle fractures and consists of a fibula fracture along with a characteristic fracture of the posteromedial tibial rim that generates separate posteromedial and posterolateral fragments (4–6) (Fig. 1). Although the exact mechanism of this fracture pattern is still unknown, the ligamentous injuries present with this fracture pattern suggest a rotational injury caused by the initial external rotation, followed by forceful plantarflexion of the foot (4,5).

Previous studies have reported clinical outcomes following the fixation of this fracture pattern (7–13); however, whether these outcomes are comparable to the more traditional ankle fracture patterns is unknown. The purpose of this study was to determine if fragment-specific anatomic reduction of the hyperplantarflexion variant yields similar clinical results to the more common supination external rotation (SER) pattern. An age- and gender-matched cohort of SER IV fractures (Fig. 2) was chosen specifically for comparison, because the SER IV injury is thought to share a rotational mechanism and fibular fracture pattern with the hyperplantarflexion ankle variant (5). We hypothesized that patients who sustain hyperplantarflexion variant fractures could achieve equivalent outcomes to those with SER IV fracture types if the fracture pattern is identified correctly and treated using a fragment-specific anatomic reduction.

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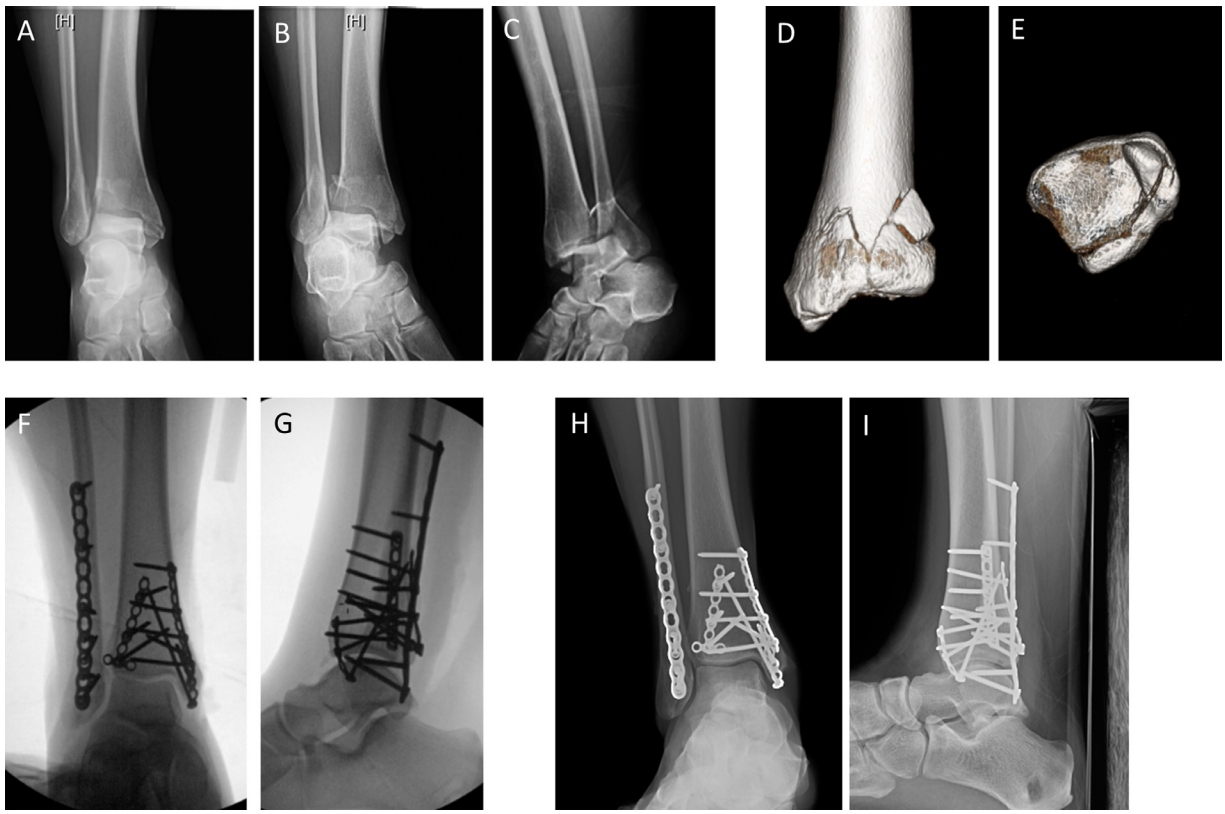

Fig. 1. Case example of a hyperplantarflexion variant fracture–dislocation. Injury anteroposterior (*A*), mortise (*B*), and lateral (*C*) radiographs. Three-dimensional computed tomographic reconstructions of the posterior malleolus (*D*) and articular surface (*E*). Intraoperative anteroposterior (*F*) and lateral (*G*) fluoroscopy images. Six-month postoperative anteroposterior (*H*) and lateral (*I*) radiographs.

Case Series

Methods

After approval from the institutional review board, a clinical database of ankle fractures treated operatively by a single surgeon (D.G.L.) was reviewed. A total of 753 patients aged ≥18 years were initially identified as having undergone operative fixation between January 2004 and September 2013. Study inclusion criteria consisted of either a hyperplantarflexion variant or an SER IV ankle fracture, as assessed by a combination of preoperative radiographs, preoperative axial imaging (computed tomography [CT] or magnetic resonance imaging), and intraoperative observations by the senior surgeon (D.G.L.).

Initially, 43 variant and 543 SER IV ankle fracture patients who met the initial inclusion criteria were identified from our database. We excluded 20 variant and 352 SER IV ankle fracture patients for the lack of at least 12 months of Foot and Ankle Outcome Scores (FAOS) and/or at least 6 weeks of radiographic follow-up**.** In total, 23 variant and 191 SER IV ankle fracture patients ultimately met the final inclusion criteria. Using the age and gender of the 23 patients in the variant cohort, we constructed an age- and gender-matched cohort of 23 patients with SER IV fractures from our list of 191 fractures. Each group had 18 females and 5 males, and all pairs of ankle fractures within the variant and SER IV cohorts were within 2 years of age at the date of surgery. The average age of patients in the variant and SER IV cohorts were 58 years and 59 years, respectively. Registry data were then reviewed for these 2 cohorts to obtain the following: mechanism of injury; fracture side; open or closed nature of the fracture; the presence of a dislocation; tobacco and alcohol use; and medical comorbidities, including hypertension, peripheral vascular disease, and diabetes. Range of motion data, postoperative complications, and FAOS scores were also reviewed from outpatient records.

All variant and SER IV fractures were treated by a single surgeon, using similar surgical approaches. In the variant cohort, a posterolateral surgical approach was used in all patients through the interval between the peroneals and flexor hallucis longus to visualize fibular and posterior malleolus fractures. In 19 (83%) patients, a subsequent posteromedial or medial incision was performed to visualize medial malleolus or posteromedial fractures. No separate incision was performed on the remaining 4 patients, because no medial implants were indicated based on axial imaging studies (fracture fragment did not involve articular surface). In the SER IV group, a posterolateral approach was used in all 23 patients, of which 19 (83%) patients were followed by either a direct medial or anteromedial incision to address medial malleolar fragments or deltoid rupture. After surgery, patients were kept non-weightbearing for a period of 6 weeks. Two weeks following the surgery, all patients were transitioned from a below-knee lower-leg splint to a removable boot and were advised to begin range of motion therapy, including dorsiflexion, plantarflexion, inversion, and eversion. At the 6-week mark, patients were allowed to bear weight, as tolerated. Any syndesmotic screws that were placed were routinely removed 4 months after the index surgery as part of the standard protocol.

Postoperative CT imaging was examined for each fracture to determine articular congruency after anatomic reduction. For our study, we considered a joint to be incongruent if the postoperative CT demonstrated an articular step-off >2 mm, the existence of an articular gap of 2 mm or greater despite an anatomic reduction, or the presence of loose bodies within the joint (1).

Statistical analysis was conducted using either Fisher's exact test or chi-square test for goodness of fit to compare the categoric data of various event frequencies, including comorbidities and dislocation rates. All continuous data, including clinical follow-up time and functional outcomes, were assessed using a 2-sample, 2-tailed Student's *t* test. A *p* value of .05 was considered to be statistically significant.

Results

Final analysis included 23 variant ankle fracture cohorts and 23 age- and gender-matched SER IV fracture cohorts. These cohorts were similar with regard to body mass index and the presence of comorbidities (Table 1), as well as the length of follow-up (Table 2). Of the 23 patients with variant fractures, 21 (91%) were injured by a low-energy twisting mechanism such as a ground-level fall, 1 (4%) was injured in a motor vehicle accident, and 1 (4%) was injured while playing football. Within the SER IV cohort, 21 (91%) were injured by a ground-level fall or twisting mechanism and 2 (9%) were injured when struck by motor vehicles while walking. Thirteen (57%) patients in the variant group had dislocations versus 12 (52%) patients in the SER IV group. Both cohorts contained 2 (9%) open fractures.

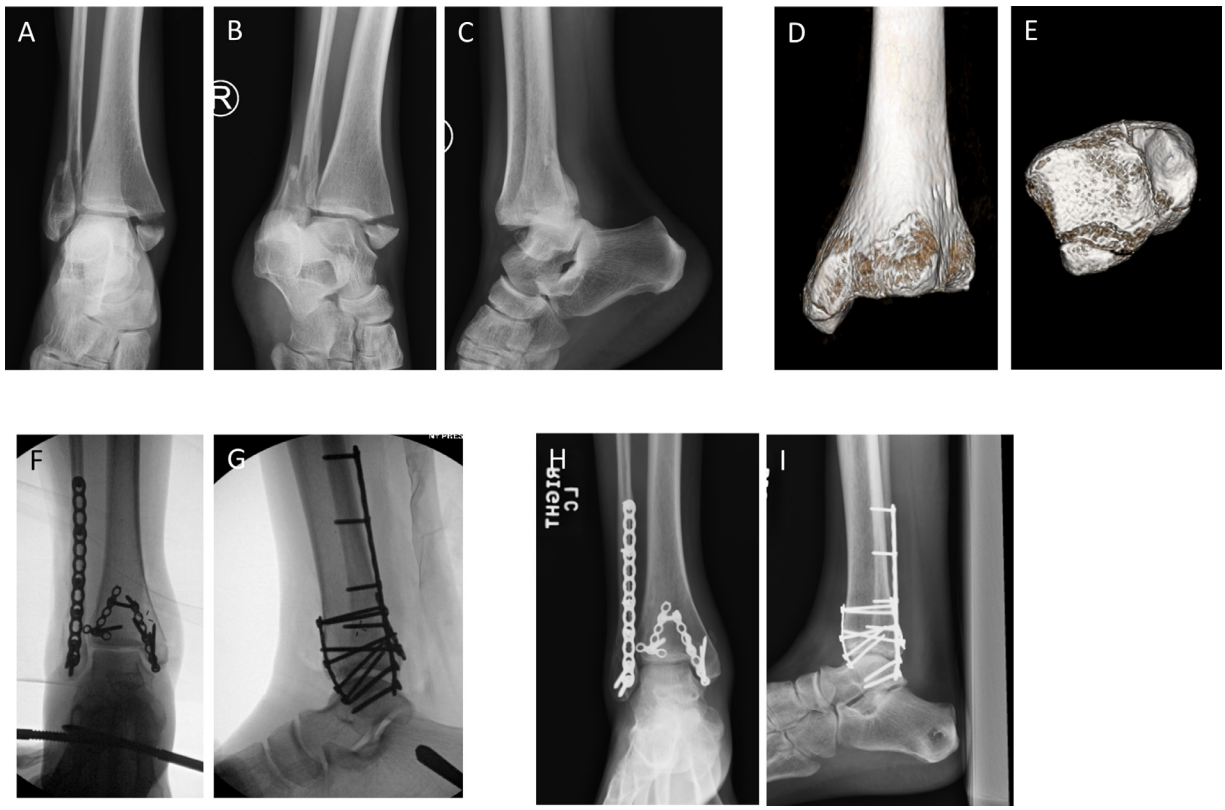

Fig. 2. Case example of a supination external rotation IV fracture–dislocation. Injury anteroposterior (*A*), mortise (*B*), and lateral (*C*) radiographs. Three-dimensional computed tomographic reconstructions of the posterior malleolus (*D*) and articular surface (*E*). Intraoperative anteroposterior (*F*) and lateral (*G*) fluoroscopy images. Six-month postoperative anteroposterior (*H*) and lateral (*I*) radiographs.

Table 1
Demographics data of the variant and supination external rotation IV cohorts

Demographics	Variant Cohort	Supination External Rotation IV Cohort	*p* Value
Male, n (%)	5 (18)	5 (18)	1
Age, y (mean [range])	57.7 (18 to 75)	58.8 (18 to 73)	1
Body mass index, kg/m^2 (range)	27.8 (20.1 to 39.1)	25.6 (18.0 to 34.9)	.30
Diabetes mellitus, n (%)	4 (17)	3 (13)	.29
Peripheral vascular disease, n (%)	2 (9)	1 (4)	.38
Smokes tobacco, n (%)	6 (26)	7 (30)	.74
Hypertension, n (%)	5 (22)	6 (26)	.73
Hyperlipidemia, n (%)	6 (26)	6 (26)	1
Dislocation Rate, n (%)	13 (57)	12 (52)	.77

In the variant group, 3 (13%) patients developed postoperative wound complications, including 2 (9%) who developed partial-thickness epidermolysis. All 3 patients were treated with local wound care, and 1 patient required oral antibiotics for a superficial infection. In the SER IV cohort, 4 (17%) patients had wound complications. Three (13%) patients developed superficial skin infections that were treated with antibiotics and local wound care. One (4%) patient had delayed healing of medial incision. No patient in either cohort required return to the operating room for wound complications or infection.

Within the variant cohort, a total of 13 (57%) patients returned to the operating room for implant removal: 4 for the routine removal of syndesmotic screws and 9 for the removal of syndesmotic screws and/or posteromedial plates secondary to posterior tibial tendon symptomology. Within the SER IV group, a total of 13 (57%) patients returned for implant removal: 7 for the routine removal of syndesmotic screws and 6 for the removal of syndesmotic screws and/or plates. Overall, no difference was seen in implant removal rates between the 2 cohorts

Table 2
Postoperative data and functional outcomes comparing hyperflexion variant with supination external rotation IV ankle fractures

Postoperative Data	Variant	Supination External Rotation IV	*p* Value
Length of clinical follow-up, mo (mean [range])	24.9 (12 to 72)	29.5 (12 to 73)	.43
Rate of removal of hardware, n (%)	13 (57)	13 (57)	1
Reoperation rate (excluding routine syndesmotic screws), n (%)	9 (39)	6 (26)	.35
Articular incongruity (out of 23), n (%)	4 (17)	6 (26)	.47
Step-off (out of 23), n (%)	1 (4)	3 (13)	.25
Gap or impaction (out of 23), n (%)	2 (9)	1 (4)	.38
Loose bodies (out of 23), n (%)	0 (0)	1 (9)	.50
Step-off and Loose Bodies (out of 23), n (%)	1 (4)	1 (4)	1
Foot and Ankle Outcomes Score			
Symptoms, y (mean [range])	70.8 (28.6 to 100)	77.8 (25.0 to 100)	.11
Pain, y (mean [range])	80.7 (38.9 to 100)	85.0 (47.2 to 100)	.33
Activities of daily living, y (mean [range])	83.7 (25.0 to 100)	89.2 (35.3 to 100)	.23
Sports, y (mean [range])	67.4 (0 to 100)	73.4 (15 to 100)	.34
Quality of life, y (mean [range])	57.3 (0 to 100)	63.9 (25 to 100)	.24

Table 3
Range of motion data comparing hyperflexion variant with supination external rotation IV ankle fractures*

Range of Motion	Variant	Supination External Rotation IV	*p* Value
Dorsiflexion (°)	17.7 (15 to 20)	18.1 (5 to 20)	.51
Plantarflexion (°)	48.6 (45 to 50)	47.1 (25 to 50)	.71

*Data presented as mean (range), unless otherwise noted.

when including or excluding the routine removal of syndesmotic screws (Table 2).

There were no statistically significant differences in body mass index, with a mean of 27.8 for the variant cohort and 25.6 for the SER IV cohort (Table 1), or in the length of follow-up, with a mean of 25 months for the variant group and 29 months for the SER IV group (Table 2). The 2 sets of patients had no significant differences in comorbidities or dislocation rate (Table 1), and a comparison of all 5 FAOS outcome domains revealed no statistically significant differences between the 2 cohorts (Table 2). In addition, no statistically significant differences were discovered in the range of motion at the last follow-up visit (Table 3).

Evaluation of postoperative articular incongruity was similar between the 2 groups, as measured using postoperative CT imaging. Four (17%) of the 23 patients in the SER IV group and 6 (26%) of the 23 patients in the variant group demonstrated articular incongruity ($p = .47$). Of the 4 patients in the variant group with articular incongruity, 2 (9%) had an articular gap >2 mm, 1 (4%) had an articular step-off >2 mm, and 1 (4%) had both an articular step-off and the presence of a loose body within the joint. Within the SER IV group, 1 (4%) patient had an articular gap >2 mm, 3 (13%) had an articular step-off, 1 (4%) had a loose body in the joint, and 1 (4%) had both an articular step-off and a loose body (Table 2). On mean radiographic follow-up of 17.3 (range 1.6 to 90) months, all fractures showed radiographic evidence of fracture healing.

Discussion

The hyperplantarflexion variant ankle fracture pattern has been described previously along with clinical outcomes (4,5). This injury pattern is complex and consists of a combination of a rotational ankle fracture and a posteromedial plafond impaction injury. Based on the available literature, it is not clear whether treating surgeons and patients can expect patients with this injury to experience clinical outcomes similar to the more common rotational ankle fractures. In this age- and gender-matched comparison, we found that fragment-specific reduction performed for hyperplantarflexion variant ankle fractures led to similar FAOS clinical outcomes when compared with an age- and gender-matched SER IV group. We also found that implant removal is similar between the 2 cohorts; however, we anticipated a higher removal rate in variant patients, because fixation of this fracture pattern often requires plating directly beneath the posterior tibial tendon. It is likely that larger numbers would be needed to show a difference with respect to this variable.

Weber (14) stated that the inherent instability in this fracture pattern and potential for negative outcomes if treated conservatively were enough to “warrant a more aggressive approach and to reconstruct the entire posterior tibial lip in these fractures.” Studies such as this suggest that open reduction and internal fixation with the aim of achieving an anatomic reduction may be crucial for the maintenance of reduction and long-term stability when the variant fracture pattern exists, regardless of the severity of articular involvement. We believe that careful identification of the fracture pattern and the use of a second posteromedial or medial incision when necessary allow for appropriate fracture fixation and an improved chance at maintaining joint congruity until fracture union. This approach was supported by another recent series that demonstrated the importance of CT for correct identification of fracture pattern in variant fractures, as well as the use of a posteromedial and posterolateral incision, when necessary, to improve exposure and reconstruction of the joint surface (15).

A number of series to this point have discussed the outcomes of variant fractures treated with open reduction and internal fixation. Gardner et al (7) reported a median of 84 on the American Academy of Orthopaedic Surgeons’ lower extremity score for a series of 7 patients with hyperplantarflexion variant fractures who had undergone operative fixation.. This study suggested an overall positive outcome for patients who undergo surgery for variant fractures, but the study possessed a small sample size and a limited average follow-up time of 8 months.

A separate series also reported positive clinical outcomes for 12 patients who had undergone operative fixation of an ankle fracture that involved the entire posterior plafond (9). The mean Short Form-36 physical component summary score and mental component summary score were 45.3 and 46.9, respectively, for their cohort, and the mean American Academy of Orthopaedic Surgeons’ lower extremity score was 85.7. This study categorized the variant fracture into 2 separate subtypes, depending on the types of the posterior malleolus fragments present. The first type included a spiral fracture of the high fibula, a vertical shear fracture of the posteromedial plafond, and a posterolateral malleolar fragment. The second subtype included a fracture of the posteromedial plafond that remained intact to the medial malleolus.

A different study described a range of clinical outcomes for 11 patients treated for a fracture of the posterior tibial lip, most of whom reported below-average scores in multiple different categories of the RAND-36 assessment. Furthermore, they reported that patients in their cohort would not be expected to obtain equivalent quality-of-life scores 2 years after surgery, when compared with healthy controls (8). We felt that the variability in the reported outcomes to date for the hyperplantarflexion variant warranted a clinical comparison with more common ankle fractures such as the SER pattern.

Our study has several strengths, including the fact that all patients were treated by a single surgeon at a single institution. Perioperative protocols were therefore consistent, including surgical approaches, implants utilized, and postoperative rehabilitation. In addition, all posterior malleolus fragments were reduced and fixed, regardless of their size. This approach limited potential confounding variables that could be attributed to fixation strategy and surgical technique. Any developmental changes over the course of time were temporally true for both groups, for instance, the move toward syndesmotic stabilization through the posteroinferior tibiofibular ligament, which has been shown to generate equivalent radiographic and clinical outcomes to syndesmotic screw fixation (16,17).

All patients received preoperative 3-dimensional imaging, which allowed the senior surgeon (D.G.L.) better visualization of the fracture fragments prior to surgery and increased accuracy in preoperative planning and anatomic reductions. Our selection of age- and gender-matched cohorts that were similar with respect to dislocation rate, articular incongruity, implant removal rate, and comorbidities strengthens our study by limiting potential variability in outcomes owing to these parameters.

There are a number of limitations to this study. First, although we used all the available cases contained within our prospective ankle database, this study comprised a relatively small number of hyperplantarflexion variant ankle fractures, owing to the rarity of this specific pattern of injury. Further, although the differences in the functional outcomes of both the variant and SER IV cohorts were neither clinically nor statistically significant, all scores within each of the 5 domains for the variant cohort were lower than the those for the SER IV group. It is possible that a larger cohort of patients might yield differences within 1 or

more of these domains. Another limitation was the retrospective nature of the study, which prevented successive patients from being considered and could have led to selection bias. We attempted to control for any potential biases and confounding variables by selecting 2 age- and gender-matched cohorts from the variant and SER IV groups. Our clinical outcomes were subject to the self-reporting nature of the FAOS clinical outcome score, which can make it difficult to assess a patient's true outcome without sufficient baseline scores for comparison.

In conclusion, as many as 79% of hyperplantarflexion ankle variants present with a "spur sign" on preoperative radiographs, a signal for a displaced posteromedial fragment, and an indicator of the specific fracture pattern (5). Our study demonstrates that accurate identification of the fracture pattern can lead to clinical outcomes similar to the common SER pattern when treated with fragment-specific anatomic reduction. Although we did observe that functional outcomes scores were lower overall within each of the 5 domains of the FAOS for the variant cohort, none of these differences were statistically significant. Further series are necessary to evaluate the long-term outcomes for the variant pattern, particularly to assess if it leads to increased rates of post-traumatic arthritis owing to the increased involvement of the articular surface. Other studies are needed to investigate how our approach of surgical fixation for all fracture fragments, regardless of size, compares to more conservative treatment. Enhanced knowledge of the mechanism behind this variant fracture could help to guide future recognition and treatment of this difficult injury pattern.

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