Eye Tracking Assessment as an Educational Tool for the Lauge-Hansen Ankle Fracture Classification System

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Statement of Purpose and Literature Review

The contemporary literature has demonstrated that medical students often lack the confidence, accuracy and efficiency in the interpretation of radiographs possessed by their more senior colleagues [1-3]. Jeffrey et al. found that most medical students diagnosed chest radiographs with less than 50% certainty, and that only 4% of medical students felt they were competent at interpreting chest radiographs [1]. Other surveys have provided evidence that medical students often feel that the amount of direct radiology teaching they receive is too little, and request an increased volume of teaching with respect to image interpretation within their curriculum [2, 3]. As a result, there has been a recent push for the development of different learning modalities in allopathic and osteopathic medicine so that medical students might feel more prepared for residency and clinical practice.

Within the scope of foot and ankle surgery, the evaluation of and treatment recommendations for ankle fractures represents an important component of podiatric medical education. Ankle fractures are common injuries of the lower extremity that tend to occur most frequently in young men due to high-energy trauma, and in older women secondary to osteopenia and osteoporosis [4]. The Lauge-Hansen classification system is one of the most widely utilized and accepted classification systems used in the diagnosis of ankle fractures [5,6]. This classification system was developed based on the mechanism of the trauma, and is useful for guiding the treatment of different types of ankle fractures.

The purpose of this study was to evaluate gaze pattern differences between experienced foot and ankle surgeons and fourth-year podiatric medical students during the radiographic evaluation of ankle fractures with eye-tracking software. This technology has previously been utilized to evaluate clinical reasoning and medical decision-making differences between experts and relative novices [7,8]. The primary objective was to compare the total time needed to classify a radiographic series of ankle fractures. The secondary objectives were to evaluate for any consistent gaze patterns of anatomic structures and radiographic projections in the groups that might be useful in the development of teaching protocols with respect to this classification system.

Methodology

A total of 8 participants were recruited and consented to take part in the study (4 foot and ankle surgeons who take call at a Level-1 trauma center and 4 fourth-year podiatric medical students). Participants independently evaluated a series of 10 ankle fracture radiographs on PowerPoint slides and were asked to classify each fracture using the Lauge-Hansen system. Each slide consisted of an AP and Lateral ankle projection of the same ankle fracture. For each ankle fracture in the series, the AP and Lateral ankle views were randomly assigned to be on either the left or right side of the screen. Once participants classified the fracture using the Lauge-Hansen system, they proceeded to the next slide until they completed the entire radiographic series. During this evaluation, eye-tracking and gaze recognition software (Gazepoint©, Clemson, South Carolina) was utilized to provide an objectification of the specific anatomic structures of interest focused on by the participants [Figures 1, 3 and 4].

The primary outcome measure was considered the total length of time needed to classify the entire radiographic series of 10 ankle fractures as measured in seconds. Descriptive statistics were calculated and included the mean, standard deviation and range, and differences were compared between groups with an unpaired t-test.

The secondary outcome measures were collected utilizing the eye-tracking and gaze recognition software. We first evaluated whether the participant initially looked at the AP projection or the Lateral projection. We then evaluated how many times the participants switched their focus between the AP and Lateral projections, as well as the last projection evaluated. We then objectified which distinct anatomic structures were evaluated on each projection [Figure 2]. For the AP ankle projection, the anatomic structures considered were as follows: Medial malleolus/medial clear space, tibial-fibular overlap, distal fibula, fibula at the syndesmosis, and the proximal fibula. For the Lateral ankle projection the anatomic structures considered were as follows: Anterior tibia/medial malleolus, posterior tibia/posterior malleolus, distal fibula, fibula at the syndesmosis and the proximal fibula. The total number and sequence of the distinct anatomical structures focused on was obtained and recorded for each fracture the participants evaluated in the series [Figure 2]. These comparisons were performed with the Fisher's exact test.

Results

Figure 1: Computer setup with Gazepoint© eye-tracking and gaze recognition software.

This investigation had participants classify a series of ankle fractures using the Lauge-Hansen classification system. A dual-screen computer set-up was utilized so that the participant looked at the radiographs on a larger computer monitor in front of an eye-tracker, while a second laptop computer recorded the eye-tracking and gaze recognition results. A comparison was performed between experienced foot and ankle surgeons and fourth-year podiatric medical students.

Outcome Measure	Data		p Value
Total Time to Evaluate the Radiographic Series of 10 Ankle Fractures	Mean (seconds)	Range (seconds)	0.7518
Surgeon	138 ± 49	89-206	
Student	128 ± 35	96-175	
First Radiographic View Evaluated	Total Number (AP View)	Total Number (Lateral View)	0.1793
Surgeon	16 (40.0%)	24 (60.0%)	
Student	23 (57.5%)	17 (42.5%)	
Last Radiographic View Evaluated	Total Number (AP View)	Total Number (Lateral View)	0.6001
Surgeon	29 (72.5%)	11 (27.5%)	
Student	32 (80.0%)	8 (20.0%)	
Number of Distinct Anatomic Structures (AP View)	Mean	Range	0.2893
Surgeon	7.15 ± 3.76	2-22	
Student	8.15 ± 4.58	3-24	
Number of Distinct Anatomic Structures (Lateral View)	Mean	Range	0.6568
Surgeon	4.73 ± 2.61	0-14	
Student	4.43 ± 3.36	1-16	
Number of Focused Transitions Between AP and Lateral Views	Mean	Range	0.1072
Surgeon	4.63 ± 2.55	1-13	
Student	3.68 ± 2.66	0-13	

Figure 2: Example of gaze timeline and summary of anatomic structures focused on during evaluation of each ankle fracture slide.

We attempted to objectify the radiographic projections and anatomic structures most utilized while attempting to classify ankle fractures. This figure demonstrates an example of an assessment with respect to which views and structures were evaluated, and in what order.

Slide	Order	Timeline: AP View Structure	Timeline: Lateral View Structure	Summary	
1	1		Proximal Fibula	First Radiographic View Evaluated	Lateral
	2	Proximal Fibula		Last Radiographic View Evaluated	AP
	3		Proximal Fibula	Total Number of Distinct Anatomic Areas Focused On (AP View)	3
	4	Medial Malleolus / Medial Clear Space		Total Number of Distinct Anatomic Areas Focused On (Lateral View)	5
	5		Post. Tibia / Posterior Malleolus	Total Number of Focused Transitions Between Views	5
	6		Distal Fibula		
	7		Ant. Tibia / Medial Malleolus		
	8	Proximal Fibula			

Table 1: Outcome measure results

First, no difference was observed in the time it took experienced surgeons and fourth-year podiatric medical students in the classification of the 10 ankle fractures (138 ± 49 vs. 128 ± 35 seconds; p=0.7518).

Second, a trend was observed for experienced surgeons to first evaluate the Lateral projection during their assessment when compared to the students (60.0% vs. 42.5%; p=0.1793). Both experienced surgeons and students tended to end their assessment with the AP projection.

Third, experienced surgeons and students both evaluated a similar number of anatomic structures on the AP and Lateral radiographic projections, and both groups evaluated more structures on the AP projection vs. the Lateral projection.

Finally, a trend was observed for experienced surgeons to transition their focus between the AP and Lateral projections more frequently than students.

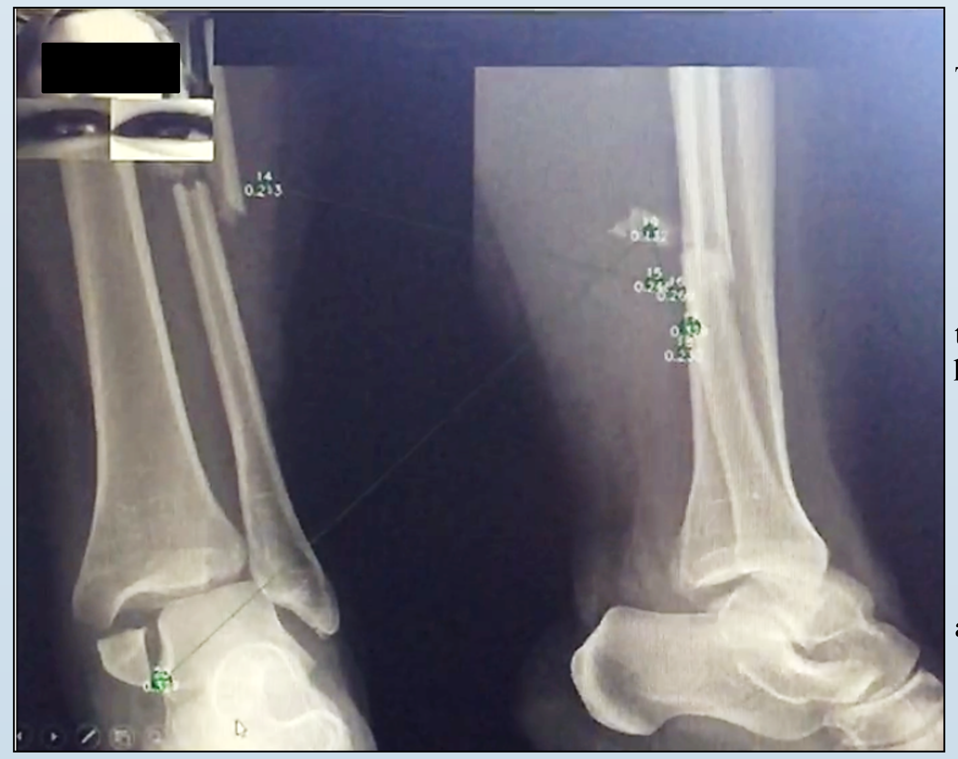
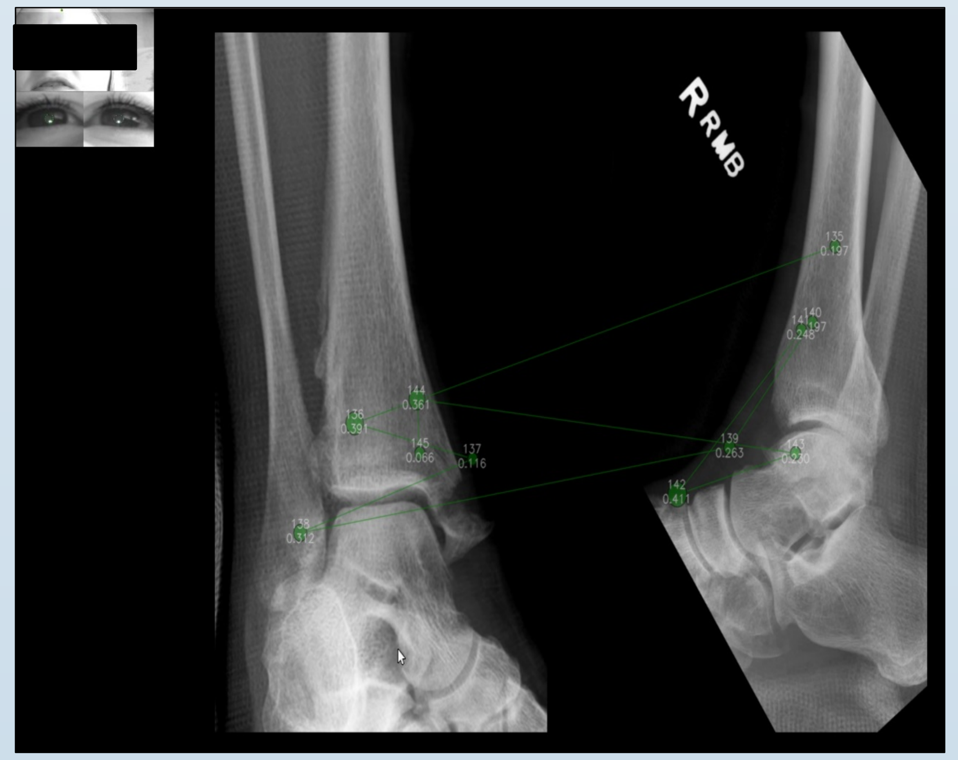


Figure 3 (left) and 4 (right): These two figures demonstrate examples of eye tracking assessment during the classification of ankle fractures. The figure on the left demonstrates a relatively focused evaluation. The AP projection was evaluated first at the proximal fibula, then gaze and focus transitioned to the proximal fibula on the lateral view, and finally gaze transitioned again to the AP projection and medial malleolus. The figure on the right demonstrates a relatively unfocused evaluation. Gaze and focus transition multiple times between the AP and Lateral projections with multiple anatomic structures evaluated without an appreciable or systematic pattern.



Discussion

The objective of this investigation was to study how experienced foot and ankle surgeons and podiatric medical students evaluate ankle fracture radiographs using the Lauge-Hansen classification system. We observed some interesting trends which we think are potentially worthy of future investigation.

First, experienced foot and ankle surgeons were found to evaluate and classify ankle fracture radiographs in the same amount of time as the fourth-year podiatric medical students. We had originally suspected that experienced surgeons might arrive at the classification faster. However, this finding might indicate that classification determination requires careful evaluation of multiple specific structures and projections, as opposed to a more broad view of the fracture pattern. In other words, students should not attempt to rush when evaluating ankle fracture radiographs. It appears to take time and require a multipart evaluation. In a similar way, both groups transitioned between the AP and Lateral projections roughly the same amount of times and specifically focused on roughly the same number of anatomic structures. A review of the literature indicates that novices might be generally more likely to spend most of their time evaluating radiographs in a searching behavior, while surgeons tend to evaluate radiographs more systematically [9-11]. Van der Gijp et al. found that experts tended to fixate on radiographic abnormalities faster, while novices give more attention to salient structures regardless of their relevance [12]. Although we did not measure accuracy as an outcome in this study, other studies have shown how these behavioral differences may explain how increased levels of training are associated with accuracy in interpreting radiographs [11].

Second, previous studies have shown that eye-tracking and gaze recognition is useful in analyzing differences between experts and novices during the review of radiographs [7, 9, 12]. The ultimate goal of studies such as these and ours is to gather information that might lead to the development of educational tools to better guide students towards improved efficiency in reading radiographs. **We observed some interesting trends which might be utilized to develop radiographic protocols for the evaluation of ankle fractures**. For example, in the present study, we found that surgeons used the Lateral Ankle projection as their first area of focus 60% of the time, compared to only 42.5% of the time for students. We suspect that surgeons tended to use the Lateral Ankle projection first in order to initially determine the anatomic level of the fibular fracture relative to the ankle joint and syndesmosis, as well as determine the specific nature of the fracture (i.e. spiral oblique with a posterior spike vs. transverse or comminuted). In theory, this would quickly provide surgeons with broad information of the fracture category (i.e. SER vs. PER). Further, both groups tended to end their evaluation on the AP radiographic projection and specifically evaluated more distinct anatomic structures on the AP view. We suspect that the AP view was evaluated most often and last as participants looked for diastasis and medial clear space abnormalities which would further specify the classification (i.e. SERII vs. SERIV). Perhaps the adoption of these and other patterns by students might help them to approach viewing ankle fracture radiographs more systematically.

In conclusion, the results of this investigation provide original objective evidence on how ankle fracture radiographs are evaluated when attempting to determine Lauge-Hansen classification. It is our hope that this information might be used to develop evaluation protocols for the education of future generations of podiatric medical students.

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We would like to acknowledge Drs. Andrew J. Meyr, DPM FACFAS (TUSPM ACFAS student club faculty advisor) and Jenna Lohre, DPM (TUH Resident) for their advisory role with this project.