An Update on Assessing the Validity of the Lauge Hansen Classification System for *In-vivo* Ankle Fractures Using YouTube videos of Accidentally Sustained Ankle Fractures as a Tool for the Dynamic Assessment of Injury

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The understanding of the deforming mechanisms which result in fractures has primarily relied on cadaveric fracture analysis. However, extrapolating from controlled cadaveric biomechanical studies an understanding of how fractures occur dynamically in "real life" injuries under physiologic loading, is itself subject to limitations. In the case of ankle fractures, Lauge-Hansen's[1] original work describing a mechanistic system to classify ankle fractures has been challenged at different levels.[2-5] Michelson, et al. attempted to duplicate Lauge-Hansen's findings using modern biomechanical techniques and showed the proposed mechanism of injury for the most common injury pattern, supination/external rotation was not reproducible according to Lauge-Hansen's described methodology .[2] Furthermore, the relationship between the described soft tissue injuries and fracture pattern could not be reproduced . Gardner, et al. evaluated ankle fractures using MRI and found poor reproducibility of the expected soft injury sequences as predicted by Lauge-Hansen.[3] Other studies have shown poor reproducibility as well poor intra and inter-observer reliability.[4-6] Despite these challenges and methodological shortcomings in his original paper, Lauge Hansen's work still stands as the basis for our understanding of the patho-mechanics of ankle fractures.

In 2010, we described a method for the dynamic assessment of injury in which we correlated radiographic images of ankle fractures sustained accidentally that were also recorded on live video clips. With the development of websites such as www.YouTube.com (YouTube.com), there is an ever-increasing number of videos publicly available through the internet that shows injuries of various types. Many of the videos contain events during which individuals sustain orthopedic trauma. The ability to correlate these in-vivo injury videos with the actual injury radiographs of the individuals sustaining these injuries allows for a valuable instrument to further the understanding of fracture mechanisms. We previously published the results of 12 ankle fractures using this technique in the Journal of Orthopaedic Trauma, August 2010. We now present our finalized case series consisting of 30 participants and their corresponding radiographs.

Participant Selection

Videos of potential study candidates sustaining ankle injuries were reviewed on YouTube.com. A video search was performed by including key words such as: "ankle, tibia, fibula, break, fracture, broken, snap, dislocation". The individuals posting these videos were then offered participation in the study. Potential participants were only contacted after it was determined that their YouTube posted videos were of sufficient quality to classify the injury mechanism and demonstrated sufficient trauma to likely have sustained an ankle fracture. Each potential study candidate was contacted via YouTube's email server regarding the purpose of the study. Candidates were sent our IRB-approved consent forms as well as a short demographics form. A mailing address or personal email was required as documents cannot be attached via YouTube.com's email server. After 2010, our IRB required notarized parental consent for participants who were less than 21 years of age, and limited participation to US residents. These restrictions hindered us from completing our initial goal of obtaining 50 participants.

Inclusion Criteria

1. Video demonstrating clear visualization of the mechanism of injury including foot position and deforming forces

2. Candidates who sustained a fracture or dislocation

3. X-rays of adequate quality revealing a fracture of the ankle

Candidates were asked to send their injury x-rays to the authors and upon receipt of the above materials were paid a stipend of $100-125 US dollars in gift card form for participation.

Video Analysis

Videos demonstrating the mechanism of injury for each study participant were reviewed by 4 reviewers: 2 fellowship-trained orthopedic traumatologists as well as 2 senior orthopedic surgery residents. Each mechanism of injury was classified independently into 4 categories by each reviewer: Supination/external rotation (SER); Supination/adduction (SAD); Pronation/external rotation (PER); Pronation/abduction (PAB)

Classification of the mechanism of injury was determined by consensus of at least 3 out of the 4 reviewers. If consensus could not be reached then the patient was excluded from our analysis. All videos were reviewed independently of the corresponding radiographs and free of any patient identifiers. Video enhancing with slow motion and magnification was used as needed.

X-Ray Review

Radiographs of each ankle fracture were independently reviewed and classified per the Lauge-Hansen as well as by the AO classification. All radiographs were reviewed independent of the corresponding videos and any patient identifiers were removed. In order to reduce any potential inter-observer differences between our reviewers they were given a half-hour instruction in the Lauge-Hansen classification prior to evaluating the radiographs and videos. This consisted of a review of fracture pattern, associated mechanism and radiographic findings as described by Lauge-Hansen.

Each ankle fracture was classified as either:

Supination/External rotation (SER);
Supination/Adduction stage (SAD);
Pronation (P);
Pronation/Abduction (PAB);
Pronation/External rotation (PER)
AO classification

After the videos and radiographs were independently classified according to the Lauge-Hansen fracture classification, each participant's video and radiograph was examined together for correlation between mechanism of injury and expected fracture pattern.

Results

Of over 2500 videos reviewed, only 625 were of sufficient quality to show an injury that could be described using the LH system. Of the 116 responders who were asked to submit ankle x-rays associated with their injury, only 30 completed enrollment by submitting the radiographs corresponding to the injury seen in the video.

The average age of participants was 18 years and the range was 13-38 years. While initially we preferred skeletally mature patients, after the first year, we increased enrollment to skeletally immature patients with adult fracture patterns in order to increase our enrollment objectives. Patients who sustained true Salter Harris fractures not classifiable per Lauge Hansen's classification system were excluded.

Injuries occurred as the result of skateboarding (n=20), bicycling (n=3), wrestling (n=2), martial arts (n=2), rollerblading (n=1), running (n=1) and trampoline jumping (n=1). There was 1 study participant with an SAD mechanism of injury who demonstrated a likely subtalar dislocation based on photographic evidence of his pre-reduction injury sent to us with his post-reduction x-rays showing no fracture. Despite demonstrating a significant mechanism 3 other study participants had radiographs which did not reveal a fracture, both with SAD mechanisms. There were 26 true ankle fractures (87%).

Of the 30 video clips reviewed, 16 had SAD deforming trauma and 14 had PER deforming trauma. No SER or PAB deforming trauma was appreciated in the videos. Injuries were secondary to skateboarding (20), bicycling (3), wrestling (2), martial arts (2), rollerblading (1), running (1) and jumping (1). There were 3 non-fractures despite videos suggestive of fracture. There was 1 subtalar dislocation after an SAD mechanism, and there were 26 actual ankle fractures. When correlating videos to x-rays, 12 fractures judged by video to be SAD injuries had corresponding SAD pattern radiographic fractures. However, only 5 of the 14 fractures judged by video to be PER injuries had PER radiographic findings. Eight PER video injuries resulted in SER ankle fracture patterns and another resulted in a SAD ankle fracture pattern.

When in-vivo video injury clips of actual ankle fractures are matched to their corresponding x-rays, the LH system is only 53% overall accurate in predicting fracture patterns from deforming injury mechanism. All SAD injuries correlated, but only 36% of PER injuries resulted in a PER fracture pattern. We have no video evidence that PAB and SER injuries occur in real life as described by the LH system with the resultant expected injury pattern.

When using the AO classification, all 12 SAD type injuries that resulted in a fracture actually resulted in 44A type fractures while the 14 PER injuries resulted in nine 44B fractures, two 44C fractures, and three 43A type fractures, suggesting the AO system is more consistently related to live injury mechanism than the LH system despite its development as a purely radiographic system. All 100% of the SAD mechanisms resulted in 44A fractures and 64% of PER injuries resulted in 44B fractures, an overall 81% rate of consistency.

Discussion

Our case series suggests that Lauge-Hansen's mechanistic classification may not consistently produce the radiographic fracture pattern predicted for a given injury mechanism in actual patients sustaining live injuries. Our series shows that when in-vivo injury videos are matched to their corresponding x-rays, the Lauge-Hansen system is only 53% overall accurate in predicting fracture patterns from deforming injury mechanism as pertaining to SAD and PER injury mechanisms. All SAD injuries correlated, but only 36% of PER injuries resulted in a PER fracture pattern. We found no video evidence that PAB and SER injuries occur in real life as described by the LH system with the resultant expected injury pattern. The AO classification, despite not being develeoped as a mechanistic classification system, may be more consistently related to mechanism of injury with 100% correlation of SAD mechansims to 44A type fractures and 64% correlation of PER mechanisms to 44B type fractures. The poor correlation of PER injury patterns with PER radiographic patterns is consistent with recent work by Haraguchi et al[7] who demonstrated that PER mechanism could cause both distal, short oblique and high fibular fractures.

Despite our shortcomings in final recruitment numbers (30 participants out of 50 initially intended) we feel that we have developed a flexible and valuable methodology for studying injury mechanisms; a methodology with a wide array of potential future applications. In our published methodology study[8] we initially reported findings from a case series with only 15 participants (12 ankle fractures) that challenged the understanding of the patho-mechanics of ankle fractures. We have now doubled that initial series and our results have remained consistent. We do recognize the numbers of participants required to address with clinical significance the validity of the Lauge Hansen as applied to live ankle fractures, will have to be higher in any future study. Yet we feel the present case series illustrates a method of significant research potential.

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