Correlating Injury Mechanism with Fracture Patterns of the Ankle: Challenging Long-Standing Orthopaedic Dogma Using Injury Videos from www.YouTube.com

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INTRODUCTION

Our understanding of the deforming mechanisms which cause fracture patterns has historically relied on various levels of evidence. Some authors have deduced mechanisms from patient histories,[1, 2] while others have used details from written reports,[3] observed deformation of rigid attire, e.g., steel-lined shoes,[4] documented their abstractions after looking at x-rays when history was unclear,[2] and executed cadaveric fracture analysis.[5-7] The inherent deficiency in our understanding of the biomechanics of fractures is the reliance on these models due to the prohibitive ethical and practical considerations of conducting injury studies in live participants. This creates a scientific divide as we extrapolate from controlled cadaveric biomechanical studies an understanding of how fractures occur dynamically in "real life" injuries under physiologic loading. The present technique of video analysis may help to bridge this divide.

With the advent of websites such as www.YouTube.com (YouTube.com), there exists a virtually unlimited and ever-increasing number of videos publicly available through the internet.[8] Many of the videos contain events during which individuals sustain orthopedic trauma. These videos can be a valuable resource since they demonstrate individuals sustaining injuries under physiologic loading during various recreational activities. 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. Whereas previously injuries may have been captured on video tape serendipitously, websites such as YouTube.com offer researchers the potential to gain access to a large number of in-vivo injury videos which can be analyzed to make validated claims regarding live injuries. This methodology can further the understanding of injury mechanisms and will allow researchers to challenge established dogma on how injuries occur.

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Videos from www.YouTube.com.

In the case of ankle fractures Lauge-Hansen's work from the 1950 Archives of Surgery still stands as the seminal work for our understanding of fracture mechanisms and its correlation with fracture patterns despite subsequent works which have challenged its validity.[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 methodology.[6] In addition, Michelson found the relationship between the described soft tissue injuries and fracture pattern could not be reproduced. Gardner et al. evaluated ankle fractures using magnetic resonance imaging and found poor accuracy of the predicted injury sequences involving the soft tissues as predicted by Lauge-Hansen.[9] Other studies have shown poor reproducibility as well poor intra- and inter-observer reliability.[10-12] 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.

We describe a novel technique for studying injury mechanisms using in-vivo injury videos obtained from Youtube.com demonstrating injuries as they occur in real time. We also present the results of a case series using this methodology as it pertains to ankle fractures as an example of the application of this technique and its potential to challenge long-standing dogma in orthopedic trauma.

METHODOLOGY

Patient selection

Videos of potential study candidates sustaining ankle injuries were reviewed on YouTube.com which is an on-line site on the World Wide Web where users can download and view videos. A user can customize a video search by specifying criteria. A video search was performed by including key words in combination such as "ankle, tibia, fibula, break, fracture, broken, snap, dislocation" and revealed over 1000 entries. Each video was assessed for clear visualization of the mechanism of injury including the foot position and deforming force. Candidate videos were selected if the mechanism of injury was classifiable by those described by Lauge-Hansen and there appeared to be a significant mechanism to likely cause fracture. The individuals posting these videos were then offered participation in the study.

Each potential study candidate was contacted via YouTube.com's email server regarding the purpose of the study.

Candidates who verified that they sustained a fracture were sent the IRB-approved consent form as well as a short demographics form either via regular mail or as attachments to their personal email address. A mailing address or personal email was required as documents cannot be attached via YouTube.com's email server.

Our inclusion criteria were:

1. Video demonstrating clear visualization of the mechanism of injury including foot position and deforming force
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 US dollars or equivalent gift certificate for participation.

Video review

Videos demonstrating the mechanism of injury for each study participant were reviewed by 4 reviewers: 2 fellowship-trained orthopaedic traumatologists as well as 2 senior orthopaedic 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.

X-Ray review

Radiographs of each ankle fracture were independently reviewed and classified per the Lauge-Hansen classification by the 4 reviewers. Once again, final designation of the fracture pattern 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 radiographs were reviewed independent of the corresponding videos, and any patient identifiers were removed.

Previous work has shown that known inter-observer variability when classifying ankle fractures per the Lauge-Hansen classification can be reduced by specific instruction on this complex fracture classification.[4] In order to reduce any potential inter-observer differences between our reviewers they were given a ½ 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 stage II or IV (SER II or SER IV)
- Supination/Adduction stage I or II (SAD I or SAD II)
- Pronation stage I (P I)
- Pronation/Abduction stage III (PAB III)
- Pronation/External rotation stage III or IV (PER III or PER IV)

This gave eight possible fracture types. Fractures not classifiable by Lauge-Hansen were excluded from the analysis. There were several reasons for choosing the fracture classifications used in our study to categorize our radiographs. Previous work by Lauge-Hansen and others has demonstrated that stage I SER injuries often did not reveal any radiographic findings.5, 13 Similarly, those that involved a bony avulsion of the ATFL found at time of surgery were only evident radiographically on retrospective review 10 out of 29 times.13 Stage III SER injuries were excluded for similar reasons. Yde et al. showed that such injuries could progress to stage IV injuries without actual fracture of the posterior malleolus and a lack of radiographic findings.13 Stage V SER injuries (spiral fracture of the distal tibia) as described by Yde were also excluded. In his review of 488 ankle fractures, this type was found to make up only 0.7% of all SER injuries.13 Stage I PAB and PER fractures were combined in our study as P stage I injuries. According to Lauge Hansen's work, the fracture-causing mechanism in Stage I PAB and PER fractures is identical. Stage II PAB and PER fractures (rupture of the distal tibiofibular syndesmosis) were also excluded as they, too, are radiographically indistinguishable, may not be visualized radiographically at all, and often need clinical correlation.13

Correlation

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

Over 1000 videos were reviewed. 240 videos/candidates were selected for possible inclusion based on the above criteria of clear visualization of mechanism and the ability to classify their mechanism according to the Lauge-Hansen classification. These individuals were contacted to request participation. Of 96 positive responses, we have collected to date 15 videos with corresponding radiographs.

Of the 15 in-vivo injury videos reviewed, 8 had SAD deforming trauma and 7 had PER deforming trauma as appreciated in the videos. There was no SER or PAB deforming trauma appreciated in the videos. Injuries occurred as the result of skateboarding (n=8), bicycling (n=2), wrestling (n=2), martial arts (n=2) and trampoline injury (n=1). There was 1 study participant who demonstrated a likely subtalar dislocation based on photographic evidence sent with his post-reduction

Figure 1a

Figure 1b

Still shot of in-vivo injury video clip of study participant 8 sustaining a PER mechanism of injury with corresponding x-ray demonstrating SER II ankle fracture pattern

Table 1:
Results from 15 participants with significant ankle injuries as judged in video clips, resulting in 11 fractures, one subtalar dislocation, and two sprains without fractures.

Study Participant	Activity:	Mechanism of Injury from video:	Fracture Classification from x-rays received:	Correlation:
1	Skateboarding	SAD	SAD II	+ (positive)
2	Skateboarding	SAD	SAD I	+
3	Skateboarding	SAD	SAD II	+
4	Skateboarding	SAD	SAD II	+
5	Skateboarding	SAD	SAD II	+
6	Bicycling	PER	PER III	+
7	Skateboarding	PER	PER IV	+
8	Martial arts	PER	SER II	- (negative)
9	Wrestling	PER	SER II	-
10	Wrestling	PER	SER IV	-
11	Martial arts	PER	SER II	-
12	Skateboarding	PER	SER II	-
13	Bicycling	SAD	Subtalar dislocation	-
14	Trampoline	SAD	No Fracture sustained	-
15	Skateboarding	SAD	No Fracture sustained	-

x-rays with an SAD mechanism of injury but without fracture or dislocation. There were 12 true ankle fractures. When assessing ankle fractures, all 5 fractures judged by video to be SAD injuries resulted in corresponding SAD pattern radiographic ankle fractures. Of the 7 fractures judged by video to be PER injuries, only 2 resulted in PER pattern radiographic ankle fractures. Five PER injuries resulted in SER ankle fracture patterns. (Figure 1a, 1b). Despite demonstrating a significant mechanism 2 study participants had radiographs which did not reveal a fracture.

DISCUSSION

Lauge-Hansen's classic study is the current basis for our understanding of the mechanisms which produce fractures of the ankle.[5] However subsequent studies have demonstrated poor reliability and reproducibility and have challenged the validity of his work.[9-12] Our study is the first and only case series that scientifically correlates dynamic in-vivo injury mechanisms by analyzing video of actual injuries as they occur in real time with their resulting fracture patterns. To our knowledge, only one other group of researchers has used video to evaluate injuries. Giza et al. evaluated game footage to determine the mechanisms and weight bearing status that placed soccer players at risk for foot and ankle injuries.[14] However, no previous studies have used internet available pubic access home video clips of patients sustaining inadvertent injuries to assess mechanisms of injury.

The use of the internet is a promising means for studying orthopaedic trauma mechanisms. Statistics reveal that 73% of the population of the United States and 23.5% of the world's population utilize the internet in some form.[15] YouTube.com is the largest provider of online videos in the US[16] and allows users to upload, view, and share video clips they have taken.[17] YouTube.com was established by Chad Hurley and Steve Chen and officially launched in December of 2005.[18] In November 2006, ownership was purchased by Google Inc. for $1.65 billion. Prior to the purchase by Google Inc., YouTube.com announced that more than 65,000 new videos were being uploaded every day and 100 million videos were viewed each day. In January of 2009, YouTube.com stated that more than 6 billion videos were viewed during that one month.[16]

We have encountered several challenges when using this novel approach. For the present case series, which was our initial test of the method, we experienced a relatively low recruitment rate of only 40% of the potential study candidates responding and with only 14.5 % of the positive responders actually following through with full participation thus far. Unlike most other clinical studies where patients are recruited in clinical settings, our study participants were recruited exclusively via on-line by means of email, as other contact information was not readily available through YouTube.com. This lack of face-to-face interaction and reliance on email communication may have contributed to a relatively low recruitment rate as potential study candidates may have been wary of the authenticity of our research endeavors. Although we encouraged potential candidates to discuss the study with us via phone conversation, few accepted this offer. Even those that were interested in participating limited their contact to email only. Some potential study participants asked for credentials before consenting to the study while others posted their questions of legitimacy of the study on blogs, message boards, and other popular social networking websites looking for advice on how to proceed with the study. Some of these participants who consented to the study subsequently posted updates on the web of how the study was proceeding. After viewing these websites we became aware that any questions of legitimacy or delay in payment would be posted for other potential study participants to view, which could severely impair future recruitment if any concerns from participants were not addressed promptly and to their satisfaction.

In regards to payment for participation The Committee on Clinical Investigations at our institution requires a US social security number be obtained at the time of payment to a research subject. The US social security number and name of each participant is required prior to payment for the completion of our institution's Internal Revenue Service (IRS) Form 1099-Misc as required by US tax law. When contacted for this information and other general demographic data, many potential study participants were hesitant to supply this information. Potential study participants feared that supplying their social security number put them at risk for credit fraud. This became a difficulty as well for international study participants as they do not have US social security numbers. Fearing a delay in payment and a negative image of the study, the authors paid the initial participants using cash money orders at personal expense. Our international participants were also contacted to select payment in this manner using US currency, or in the form of a gift certificate. After the initial group of study participants were renumerated, we agreed a gift certificate to be the best method to compensate individuals in the US and abroad thus bypassing the requirement for a US social security number. We also requested participants whom we renumerated to state in their blogs, message boards, and social networking sites that our study is indeed legitimate, hoping it would facilitate future recruitment.

Other contributing factors to a low recruitment rate included difficulty in contacting the individual in the video. The individual submitting the video to YouTube.com was often not the individual sustaining the injury. YouTube.com only allows for email contact via their server to the individual submitting the video and no other personal information is offered aside from that which is entered by the submitter. The submitter then had to notify the actual injured participant. Another factor is also the young demographics of our potential study candidates who may be less inclined to participate in our research endeavors despite the monetary incentive. In order to improve our recruitment for our ongoing video analysis study of ankle fractures, as well as for future applications of the proposed method, we are in the process of establishing an IRB-approved advertisement through YouTube.com with a link to our institution's website describing the nature of our study. We feel that these efforts will not only improve recruitment but will also help legitimize our study to potential candidates who may question the purpose of our contact.

Many potential study candidates expressed difficulty in obtaining their x-rays despite understanding the process of contacting the hospital or clinic where they were evaluated and signing a medical release form. In order to improve our yield of radiographs we drafted a generic medical release form based on our institution's current form and offered to obtain the radiographs ourselves if the candidates would sign our release form. This form was poorly accepted by outside institutions which often required the candidates signing their institution-specific form. Those that were able to obtain their radiographs either sent them to us as hardcopies, CDs or via attachments in email. We have found that jpeg images sent as attachments were often of good quality and sufficient to classify the fracture pattern. This avoided the need to mail the actual hardcopies and associated mailing fees. This also increased the yield of collected radiographs as many participants initially requested that their x-rays be returned or were cautious about sending them in the first place.

In regards to the usage of the in-vivo injury videos for research purposes we were concerned with potential copyright issues. YouTube.com's Terms of Service clearly describes that the individuals uploading the video clips are the sole owners of the work.[19] When subjects were consented to take part in our study we made it clear in our IRB approved consent form that the videos will be used for our study and that the videos may be viewed by others in the orthopaedic or medical field. No participants had issues in regards to releasing their video clip to us. Many of the participants acknowledged that the reasoning for uploading the clips in the first place was to allow people from around the world to view what had happened to them.

Another issue not only for our study but for the medical community in general is use of the internet to transmit personal medical information. The Health Insurance Portability and Accountability Act (HIPAA) has established specific guidelines regarding the transmission of private medical information via the internet and email.[20] Increasingly many patients have turned to personally controlled online medical records in order to improve communication with their physician.[15] Google Health and other private websites have password protected options so the general public cannot access personal information.[15] A number of institutions such as ours have acknowledged the technology available and have utilized the internet in this fashion. Beth Israel Deaconess Medical Center in Boston, MA utilizes a custom "patient portal" called PatientSite.[16] This website allows patients to view certain portions of their medical record.[16] As we contacted potential study candidates we were surprised to find the amount of personal medical information that many subjects had posted on the internet. One study participant had posted a full catalog of their radiographs including pre-operative and post-operative films while another had explained on a message board a detailed history of their course of treatment as well as their difficulties with postoperative complications. Individuals are increasingly using blogs as well to anonymously post stories and questions regarding medical issues. Medical information including radiographs are often freely available on the internet and there are no current guidelines or protocols that we are aware of regarding the use of this publicly available medical information for research purposes such as ours. To absolve any potential HIPPA violations all study participants were required to sign our IRB approved consent form recognizing that we will utilize their information despite the fact that the necessary radiographs were at times available on the internet.

Our case series, although limited by a small number of participants, 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 . We recognize that substantial claims cannot be made given the small number of participants and that not all of Lauge-Hansen's fracture patterns were represented in our short case series.

Despite these shortcomings 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. Not only can this technique be used to study other fracture types but it can be used to establish a compendium of videos for educational purposes. In our present study we report findings from a case series with 15 participants and a challenge to our understanding of the patho-mechanics of ankle fractures. Future direction includes continued recruitment to statistically assess the validity of the Lauge-Hansen classification as applied to in-vivo injuries and use of this methodology to study other injury mechanisms.

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