The Use of an Algorithm for Classifying Acetabular Fractures

A Role for Resident Education?

Thuan V. Ly MD, Michael D. Stover MD,
Stephen H. Sims MD, Mark C. Reilly MD

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Abstract

Background The Letournel and Judet classification system is commonly used for classifying acetabular fractures. However, for orthopaedic surgeons with less experience with these fractures, correct classification can be more difficult. A stepwise approach has been suggested to enhance the inexperienced observer's ability to properly classify acetabular fractures, but it is unclear whether this actually improves one's ability.

Questions/purposes We asked (1) whether the use of a step-by-step algorithm improves residents' ability to classify acetabular fractures, (2) whether resident experience

influenced ability to correctly classify acetabular fractures, and (3) which acetabular fractures were the most difficult to classify?

Methods Forty-six residents reviewed 15 sets of plain radiographs of 10 acetabular fracture patterns. Residents used the Letournel and Judet classification with only a diagram for reference. Three weeks later they were asked to classify the fractures a second time with the use of the algorithm. We then compared the number of correct responses from the two sessions and determined whether resident experience and use of the algorithm influenced correct classification.

Results We found an improvement in the number of correctly classified fractures between the first (348/690 [50%]) and second (409/690 [59%]) sessions. Thirty-two of 46 participants improved their score with the use of the algorithm. There was a tendency for participants with more residency training to correctly classify the fractures.

Conclusions The algorithm provided modest improvement to the residents' ability to classify acetabular fractures. This or other such algorithms could provide residents with a basic tool to better evaluate standard radiographs and classify acetabular fractures.

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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T. V. Ly
Regions Orthopaedic Department, St Paul, MN, USA

M. D. Stover (✉)
Department of Orthopaedic Surgery,
Loyola University Medical Center,
2160 S. First Avenue, Maywood,
IL 60521, USA
e-mail: mstover@lumc.edu

S. H. Sims
Carolinas Medical Center, Charlotte, NC, USA

M. C. Reilly
University of Medicine & Dentistry of New Jersey,
Newark, NJ, USA

Introduction

The Letournel and Judet acetabular classification [4–6] is widely used and accepted for classifying acetabular fractures, communicating with others, selecting surgical approach, and reporting results [7–10, 12]. This classification, based on plain radiographs, is associated with high interobserver ($\kappa = .63$) and intraobserver ($\kappa = .75$) reliability when used by orthopaedic surgeons with experience in treating acetabular fractures [2]. The classification is

based on the review of three standard plain radiographs: AP view, obturator oblique view (OOV), and iliac oblique view (IOV) [2]. However, for orthopaedic surgeons with less experience treating acetabular fractures, correctly classifying acetabular fractures is more difficult [2, 11].

There are 10 acetabular fracture patterns that are separated into five elementary and five associated fracture types. To correctly classify acetabular fractures, it is important to identify certain radiographic landmarks and fracture lines on each of the three specific pelvic radiographs. CT scans and three-dimensional reconstructions may improve the understanding of these fractures, but classification can be accomplished from review of the plain radiographs [2, 3].

Saterbak et al. [13] reported an approach to recognizing and understanding acetabular fractures. They believed using a stepwise approach would enhance an inexperienced observer's ability to properly classify acetabular fractures into one of the 10 fracture patterns of the Letournel and Judet classification, but it is unclear whether the use of this approach actually improves one's ability to classify acetabular fractures.

We therefore addressed these questions: (1) Does the use of a step-by-step algorithm that allows characterization and diagnosis based on radiographic landmarks and fracture lines improve residents' ability to identify acetabular fractures? (2) Does resident experience influence the ability to correctly classify these fractures? (3) Which acetabular fractures were the most difficult to classify?

Materials and Methods

This was a multicenter study that involved orthopaedic residents from five different orthopaedic surgery residency programs. Forty-six residents participated. The residents were subcategorized as those with 12 (PGY-2), 24 (PGY-3), 36 (PGY-4), and 48 (PGY-5) months of orthopaedic training. There were six residents with 12 months, six with 24 months, 18 with 36 months, and 16 with 48 months of training. All participating residents read and signed an informed consent detailing the study protocol and purpose. All residents were able to complete both sessions of the study. Fifteen sets of AP (Fig. 1), IOV (Fig. 2), and OOV (Fig. 3) plain radiographs from patients who sustained acetabular fractures were selected. These radiographs were considered to be diagnostic and of good quality by the senior authors (MS, SS). They represented classic patterns and were confirmed intraoperatively to be these patterns. We selected one of each fracture type and repeated the five most commonly encountered acetabular fracture patterns. Thus, there were two posterior wall, two associated both column, two transverse/posterior wall, two anterior

T-Type Acetabular Fracture (Anteroposterior View)

Fig. 1 The AP view radiograph shows a t-type acetabular fracture.

T-Type Acetabular Fracture (Iliac Oblique View)

Fig. 2 A t-type acetabular fracture is seen on this iliac oblique view radiograph.

column/posterior hemitransverse, and two T-type fractures, and one each for the anterior column, anterior wall, posterior column, posterior column/posterior wall, and transverse fracture. The repeated fracture patterns were different cases. These 15 cases were put on a PowerPoint display and copied to CD. Although CT scans provide additional information, we elected not to use them because they reportedly do not improve accuracy of classification [2].

All residents classified each set of pelvic radiographs on the CD. The residents were given no specific education or training on the interpretation of pelvic radiographs and classification of acetabular fractures other than the information that they had been exposed to during their residency education and patient care. They were asked to classify the

T-Type Acetabular Fracture (Obturator Oblique View)

Fig. 3 A t-type acetabular fracture is shown on this obturator oblique view radiograph.

acetabular fracture into one of the 10 fracture patterns according to the Letournel and Judet classification. The only resource given to them was a diagram of the Letournel and Judet classification that depicted the 10 fracture patterns. They were instructed that each of the 10 fracture patterns may be used more than once or not at all and they were given approximately 1 hour to complete the test. After completion of the first session, they returned their answer sheets and CD to their respective site research coordinator. They were specifically asked to refrain from using textbooks, discussing the radiographs with other observers, or studying the classification between the two sessions.

In the second session, the residents were provided with a simple algorithm (Fig. 4) to assist them in classifying the acetabular fractures. This algorithm was developed by the senior authors (MS, SS) to systematically evaluate and classify the fracture. It directed the user to look at the anatomic landmarks and certain fracture lines that are characteristic of the 10 fracture patterns. They then were

Fig. 4 The algorithm designed for this study is shown.

asked to review and classify the same set of radiographs 3 weeks later. After completion of the second session, residents returned the answer sheets and CD to their respective site coordinator. Forty-six residents attempted to classify 15 fracture patterns at each session, making 690 (46×15) the total possible number of fractures classified for each session.

The data were compiled and analyzed. The scoring between the two sessions was accomplished anonymously to protect privacy. The resident's year of training was recorded. We evaluated the number of fractures correctly classified by each individual, each group of residents as defined by year in training, and the whole group of residents for each of the sessions. We calculated how many scores improved, stayed the same, or worsened between the two sessions. For fracture patterns that the majority of the residents (greater than 75%) classified incorrectly, we carefully looked at the specific radiographs, applied the algorithm, and tried to determine where difficulties in interpretation could have occurred.

We determined whether the total number of fractures classified correctly improved with use of the algorithm. We evaluated whether resident experience (ie, year in training [YIT]) influenced the number of correct responses. The dependent variable, correctly classified fracture, (1 = yes, 0 = no) was regressed on the independent ordinal variables YIT (PGYs 2-5) and use of the algorithm (1 = yes, 0 = no). For analysis we used SAS for Windows 9.1.3 (SAS Institute, Cary, NC, USA).

Results

We observed an improvement in the total number of correctly classified fractures between the first and second sessions. After the first session, without using the algorithm, the total score was 348 (50%), whereas with the use of the algorithm in the second session, the score improved to 409 correct responses (59%). The logistic regression suggested an overall classification improvement ($p < 0.001$) with use of the algorithm. Of the 46 residents, we found 32 of 46 (70%) showed an improvement in their score between the first and second sessions. There were nine residents (20%) who had the same score between the first and second sessions (Table 1). There were five residents (11%) who scored worse with use of the algorithm.

The six PGY-2 residents improved from 46% to 58%, the six PGY-3 residents improved from 43% to 58%, the 18 PGY-4 residents improved from 52% to 58%, and the 16 PGY-5 residents improved from 53% to 62%. We found a trend suggesting residents with a higher level of training were more likely to correctly classify fractures ($p = 0.08$). Stratifying by session, this was more pronounced in the

Table 1. Individual resident scores

Performance	Number of residents	Percentage
Improved	32	69.50%
Stayed the same	9	19.60%
Worsened	5	10.90%
Total	46	100%

Posterior Column + Posterior wall (Anteroposterior View)

Fig. 5 A posterior column/posterior wall fracture is seen on this AP view radiograph.

first session (no algorithm used, $p = 0.11$) than in the second (algorithm used, $p = 0.40$).

The fracture patterns that the residents had the most difficulty classifying with and without the algorithm were: posterior column/posterior wall (Fig. 5), anterior column/posterior hemitransverse, and anterior column. Thirty-eight residents (83%) answered incorrectly for the posterior column/posterior wall. There were two anterior column/posterior hemitransverse radiographs for this study. With respect to the first anterior column/posterior hemitransverse fracture pattern, 40 residents answered incorrectly. For the second anterior column/posterior hemitransverse pattern, 45 residents answered incorrectly. The other specific fracture pattern that the residents had a tendency to answer incorrectly was the anterior column. Thirty-eight (82.6%) residents answered incorrectly both times.

Discussion

The pelvis is a complex, three-dimensional structure that makes displaced fractures of the acetabulum difficult to understand. The contributions of Letournel and Judet have provided orthopaedic traumatologists with a better concept

Table 2. Six fundamental radiologic landmarks for AP view of pelvis

Radiologic landmarks	Anatomic portion
Iliopectineal line	Anterior column
Ilioischial line	Posterior column
Posterior rim	Posterior column or wall
Anterior rim	Anterior column or wall
Roof of acetabulum	Superior articular surface
Tear drop	Columns relationship

of classifying and treating acetabular fractures [6]. With few exceptions, surgical approaches for operative treatment can be selected based on correctly classifying the fracture pattern. Classification of an acetabular fracture into one of the 10 fracture patterns is based on an AP pelvic view (Table 2) and two 45° Judet oblique views. Correctly understanding complex fracture patterns and classifying them into one of the five elementary or five associated fracture types described by Letournel and Judet have proved difficult for those who do not regularly examine these radiographs. For surgeons with experience in treating these injuries, substantial agreement exists for classifying these fractures [2, 11]. However, the classification is only the first step in the treatment of acetabular fractures. More training and experience are required to determine how treatment of the fracture should be approached. This study sought to answer these three questions: (1) Does the use of a step-by-step algorithm that allows one to diagnose and characterize based on radiographic landmarks and fracture lines improve residents' ability to identify acetabular fractures? (2) Does resident experience influence the ability to correctly classify these fractures? (3) Which acetabular fractures were the most difficult to classify?

Our study has some limitations. First, while at the outset we chose what we believed were radiographs of good visual and diagnostic quality, after analysis of the incorrect answers we were able to discern possible difficulties in interpretation of the selected radiographic examples. We presume the incorrect answers resulted from minimally displaced or less visible fracture lines that may not be obvious to individuals with limited experience in evaluating radiographs of acetabular fractures. A more experienced observer may have scrutinized these areas more closely, owing to the likelihood these fracture lines may occur in conjunction with a certain displacement (ie, pattern recognition). Second, we did not have a control group (give half of the residents the algorithm on the second try and withhold the algorithm from the other half). With a control group we would have been able to better gauge how much of the improvement was attributable to the use of the algorithm versus how much was from memory recall. However, we

presumed that because the residents were asked not to study acetabular fractures in the interim between assessments, there would be no change in their knowledge base and a control group was not necessary. Third, our study was performed without any specific preparation, intervention, and approach to classification of acetabulum fractures, or instruction in using the algorithm before asking the residents to evaluate the radiographs during either session. In retrospect, we believe that with some formal education on reading radiographic landmarks, what areas to evaluate on each specific image, and providing a basic understanding of the terminology and function of the algorithm before its use, the residents would have shown greater improvements. Finally, it is difficult to prevent the residents from learning in the 3 weeks between the first and second sessions. We attempted to control this as best we could with removal of the radiograph CDs and instructions not to investigate acetabular fractures during this time. The inability to completely control this variable and the varying levels of preexisting acetabular fracture knowledge of the residents could have affected our final outcomes.

Algorithms are commonly used in patient care. Although many algorithms are not scientifically validated, algorithms often are used clinically to evaluate information in medical decision-making and to guide treatment [1]. Similar to Saterbak et al. [13], we have developed a systematic method to analyze the radiographic images most commonly obtained when characterizing an acetabular fracture. This algorithm should aid in helping residents to properly classify fracture types. It also may aid in improving the understanding and subsequent treatment of these fractures, and has potential as an important resident and surgeon education tool. Although the classification of Saterbak et al. is more reliant on "pattern recognition" [13], we use a different format to systematically identify, categorize, or eliminate certain patterns in the evaluation of the standard plain radiographic views, the radiographic lines, and their bony representation. Our approach is a true, step-by-step algorithm that allows one to diagnose and characterize based on disruption of the lines seen on the plain radiographs. Another difference between our study and that of Saterbak et al. is that we tested the algorithm on residents to objectively determine if it improves their ability to classify acetabular fractures. Our observations suggest the algorithm does help improve the accuracy with which a surgeon in training classifies acetabular fractures. As a group, there was improvement in the overall number of correctly classified fractures between the first and second sessions. We also looked at how each individual performed with and without the algorithm. Nearly 70% of the participating residents showed improvement in their score with the use of the algorithm. Approximately 20% of the residents showed no change and approximately 10%

did worse. Overall, residents with more training correctly classified more fractures. Despite the improved score on the second attempt, we found that the overall agreement with the correct answer was only 59%. This is in contrast to Beaulé et al. [2]. According to their study, they found an overall agreement of 74%. However, their participating surgeons had substantially more experience than our participating residents.

The fracture patterns that the residents had difficulty classifying were the posterior column/posterior wall, anterior column/posterior hemitransverse, and anterior column. It appears that residents have difficulty recognizing if there is a fracture involving the ilium or rami that is nondisplaced or minimally displaced. Although CT scans reportedly do not assist more experienced surgeons in classifying fractures [2], axial, three-dimensional, or surface rendered images may help the less experienced better define anatomic disruptions and they may have a role in classification according to this algorithm. Therefore, we agree with Saterbak et al. [13] that the use of CT scans can conclusively determine a minimally displaced fracture of the iliac wing and obturator foramen.

The use of this algorithm may have improved the resident's ability to classify acetabular fractures, but the true effect is confounded by our study design. We believe the algorithm can serve as an adjunct to teaching residents to classify acetabular fractures. We also suggest further study of this topic with the inclusion of a larger cohort, more radiographs to review, an educational session on the six main radiographic lines of the acetabulum between the resident testing sessions, and a control group for comparison.

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