Teaching Letournel classification: systematic analysis of x-rays using algorithm versus 3D computed tomography scan

Hammad AS[a], Abu-Sheasha[b]

[a]Assistant Professor of Orthopaedic Surgery and Traumatology. Elhadarah University Hospital, Faculty of Medicine, Alexandria University, [b]Lecturer of Biomedical Informatics and Medical Statistics, Medical Research Institute, Alexandria University, Alexandria, Egypt

Correspondence to Hammad AS, MBCCh, MCh, MD, Fleming Tram Station.37 Alfateh Street. Alkarnak Building No 2, Appartment 1201, Alexandria, Egypt.
Tel (Home): 002-035852555;
Mob: 002111056406;
fax: 002033302083;
e-mail: Drhammadab@gmail.com

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Background
The aim of Letournel classification was to identify accurately the pathological anatomy of the fractured acetabulum. For orthopedic residents, this classification system is somewhat cumbersome. An important objective is to facilitate the understanding of this classification system among the junior residents. The aim of this study was to compare two educational tools, namely the systematic analysis of the plain films and the 3D computed tomography (CT) scans in improving the diagnostic performance of orthopedic residents.

Patients and methods
Twenty x-rays set for acetabular fractures, including A/P, iliac, and obturator view, were selected from our hospital database. These sets were prepared in a quiz form. Thirty residents were asked to diagnose the given fracture using x-rays only. Then, the residents were randomly allocated to two groups. Group I was asked to repeat the same quiz with the addition of 3D CT-reformatted images (A/P and obliques). Group II was asked to analyze the same x-rays using an algorithm. Data collected included the training period of the resident, the answers in pre- and post-tests together with the subjective assessment of how difficult each diagnosis was.

Results
While the two groups showed a significant and similar improvement in reaching the right diagnosis, using the algorithm was significantly easier.

Conclusion
Compared with the advanced imaging technology, plain x-ray film if analyzed systemically is an easier way to understand Letournel classification when educating junior orthopedic residents.

Keywords:
3D computed tomography scan, Letournel classification, x-rays

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Introduction

The most commonly used and widely accepted classification system for acetabular fractures is that of Letournel. In its final version, Letournel included five elementry and five associated types. The aim of Letournel classification was to identify accurately the pathological anatomy of the fractured acetabulum and to determine the right surgical approach [1]. For orthopedic residents, this classification system is somewhat cumbersome [2]. An important objective is to facilitate the understaning of this classification system among the junior residents. This will reflect on trainee's ability to understand the personality of every individual fracture and to get confident when discussing the treatment plans with experts in the field.

Depending on plain film is a logic option. Plain A/P film is a part of trauma survey, a cheap and effective tool for diagnosis of acetabular fractures for decades. Besides diagnosis of the fracture type, it allows rapid diagnosis of dislocation, the associated potentially life-threatening pelvic injuries, or proximal femoral fractures [3].

In the setting of trauma, the quality of x-ray films, and correct position of the patient for special views may be questionable. This is especially true in obese patients. Repeating the x-rays to get better quality exposes the patient to more radiation and is cost-ineffective [4].

It may be difficult for an orthopedic trainee to get confident with the diagnosis using plain films alone. The use of 3D computed tomography (CT) scan for diagnosis of acetabular fractures was a proven tool for diagnosis, especially for less-experienced surgeons. 3D CT scans allow the conception of the 3D complex anatomy of the fracture, especially when comminuted with fragments' overlapping. 3D CT also allows the diagnosis of transitional fractures, which is not easily identified on the plain films even for experienced surgeons. With the use of 3D CT, the above-mentioned limitations of the plain films are solved.

Moreover, the need for Judet oblique views could be eliminated [5–8].

The value of 3D CT scans against the plain film is a debatable issue, especially when junior orthopedic surgeons are concerned. Several algorithms were developed to systematically analyze the x-rays in order to help junior orthopedic surgeons correctly diagnose an acetabular fracture [9–13]. The aim of this study was to compare two educational tools, namely the systematic analysis of the plain films and the 3D CT scans in improving the diagnostic performance of orthopedic residents.

Patients and methods

This study took place at the Department of Orthopedic Surgery and Traumatology at Alexandria University, Egypt. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Alexandria University, Egypt. It involved 30 orthopedic residents with different levels of experience. All participating residents read and signed an informed consent detailing the study protocol and purpose. All residents were asked to fill in a form, including details about their age and level of experience and period of training. Each resident was given a number to be used for allocation to one of two groups. Twenty sets of complete radiographs, including A/P, iliac, and obturator views, were selected from the database of acetabular fractures and delivered as a powerpoint presentation in a quiz format.

The first session was a pretest for the whole cohort. Beside selecting the answer about the fracture type, the trainee had to grade every question on a scale of difficulty and to state how much he was confident about his answer. The answer sheets were collected.

After completion of the pretest, a computer-based randomization allocated the thirty residents into two groups (I, II). The description of the two groups is demonstrated below (Table 2). Group I included 15 residents who moved to another room. They were given the post-test using the same x-rays with the addition of 3D CT images in the A/P and oblique projections. A diagrammatic illustration of Letournel classification was given with the answer sheet as a guide for classification.

Residents allocated to group II solved the post-test using an algorithm for systematic reading of the x-rays as suggested by Prevezas *et al.* [9]. It entails breaking the 10 fracture types into three groups, depending on the integrity of the two major lines, namely the iliopectineal and the ilioischial lines. The first category includes only the posterior wall type in which both iliopectineal and ilioischial lines are intact. The second category has only one line broken. In posterior types, the ilioischial line is broken and the iliopectineal line is intact. This includes the posterior column and posterior column/posterior wall types. On the contrary, anterior wall or column fractures have only the iliopectineal line broken while the ilioischial line is intact. The third category includes five fractures when both principal lines are broken. This group is further classified by the integrity of the obturator foramen. In transverse/posterior wall fractures, the obturator ring is intact. In the T-shaped, anterior column and anterior column posterior hemitransverse, the obturator ring is broken. The T-shape had no fractures extending to the iliac wing as seen in the iliac oblique view. Anterior column posterior hemitransverse is distinguished from both columns' fracture by the absence of the spur sign in the obturator view.

Statistical methods

After completion of the second session, data were collected, tabulated, and analyzed using SPSS software (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0; IBM Corp., Armonk, New York, USA).

Qualitative data were summarized using number and percentages. The number of correctly classified fractures per resident were summarized using median (Mdn) and interquartile range (IQR). χ^2 and Mann–Whitney (U) tests were used to compare the qualitative and quantitative variables between groups I and II.

Logistic regression model was used to study the effect of using either diagnostic tool together with the effect of duration of residency training on the correct diagnosis of acetabular fractures. Ordinal regression model was used to study the effect of the same factors on the difficulty perceived when classifying the given acetabular fracture. In the two models, generalized estimating equations were used to adjust for the correlations among observations from the same resident and the correlations among the observations of the same fracture.

Results

With the use of x-ray only, the total number of correctly classified fractures were 153 (26%). With the use of CT or algorithm, we observed an improvement in the total number of correctly classified fractures (n=184, 31%). Regarding the CT group, the total number of correct classifications was 72 (24%) without the use of CT, and improved to 87 (29%) with the use of CT. In the algorithm group, the total number of correct classifications was 81 (27%) without the use of algorithm and improved to 97 (32%) with the use of algorithm.

Of the 30 residents, 18 (60%) showed an improvement in the number of the correct classification with the use of CT or algorithm and seven residents (23%) had the same number. There were five residents (17%) who performed worse, that is, the number of correct classifications they made decreased when they use CT or algorithm. These figures were similar, regardless of the classification tool (χ^2_{Linear}=0.56, P=1.000, Table 1).

Table 1 Change of the residents' scores of classification of acetabular fractures after the educational session by the classification tool

Performance after training	CT group (n=15)	Algorithm group (n=15)
Improved	9 (60)	9 (60)
Stayed the same	3 (20)	4 (27)
Worse	3 (20)	2 (13)

Values are number and (percentages).

The median number of correctly classified fractures per resident improved from 4 (IQR=5) to 5 (IQR=5) among the CT group and from 5 (IQR=6) to 7 (IQR=5) among the CT group.

Factors affecting the classification of acetabular fractures

The generalized estimating equation (GEE) logistic regression (which adjusts for the previous training among residents) showed a significant improvement in classification of acetabular fracture with the use of either CT or the algorithm (χ^2_{Wald}=5.1, P=0.024); however, this improvement did not differ significantly with the use of the algorithm compared to the use of CT (χ^2_{Wald}=0.596, P=0.440). Additionally, residents with a longer duration of orthopedic residency were more likely to correctly classify fractures (χ^2_{Wald}=21.3, P<0.001), regardless of using CT or algorithm in classification (Table 2).

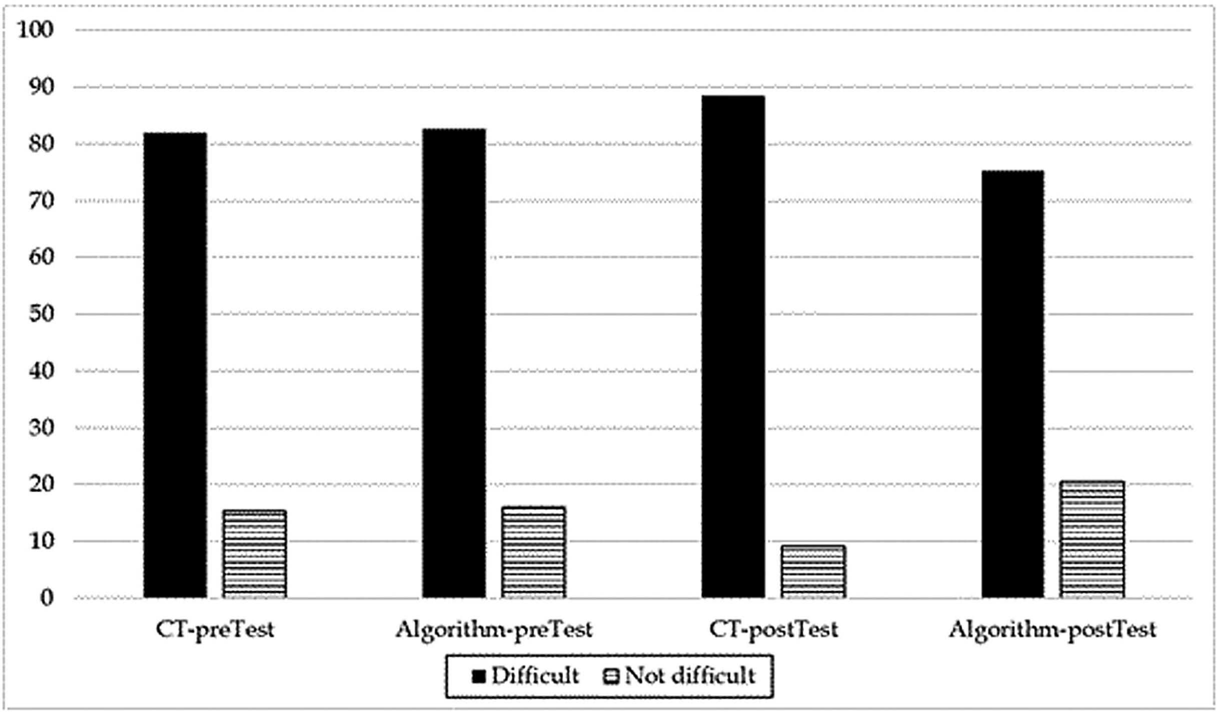
Residents reported that using the algorithm as a classification tool was easier. For the correctly classified fractures, the perceived difficulty among the algorithm group was lower than among the CT group (P=0.036) (Fig. 1).

Table 2 Residents' characteristics and their baseline performance before the education session

	CT group	Algorithm group	P value
Number of residents	15	15	
Training period (months) [n (%)]			
<12	6 (40)	3 (20)	χ^2=207 (0.147)
12 –	4 (27)	2 (13)	
24–49	5 (33)	10 (67)	
Using x-ray only			
Number of fractures per group	300	300	
Number of fractures per resident	20	20	
Correctly classified fractures [n (%)]			
Total number	72 (24)	81 (27)	
Mdn number per resident (IQR)	4 (5)	5 (6)	U=100 (0.624)
Perceived difficulty[a]			
Little difficulty	11 (16)	13(16%)	
Moderate difficulty	24 (34)	46(58%)	
Very difficult	35 (50)	21 (26%)	
Using CT or algorithm			
Number of fractures per group	300	300	
Number of fractures per resident	20	20	
Correctly classified fractures [n (%)]			
Total number	87 (29)	97(32)	
Mdn number per resident (IQR)	5 (5)	7 (5)	U=94 (0.461)
Perceived difficulty[b]			
Little difficulty	8 (9)	20 (22)	
Moderate difficulty	30 (35)	57 (61)	
Very difficult	47 (55)	16 (17)	

CT, computed tomography; IQR, interquartile range. Perceived difficulty[a] per correctly classified fracture was available among 70 out of 72 and 80 out of 81 correctly classified fractures in CT and algorithm groups, respectively. Perceived difficulty[b] per correctly classified fracture was available among 85 out of 87 and 93 out of 97 correctly classified fractures in CT and algorithm groups, respectively.

Figure 1



Comparison of perceived difficulty among the correctly classified fractures between the two groups. In pretest, the percentage of difficult diagnosis was similar among the two groups. In post-test, the percentage of difficult diagnosis was lower with the use of algorithm.

The GEE ordinal regression showed that residents with longer duration of orthopedic residency reported less difficulty while classifying acetabular facture (χ^2_{Wald}=8.8, P=0.003), regardless of using CT or algorithm in classification. With adjustment for the previous training among residents, using an algorithm still showed a significant reduction in perceived difficulty (χ^2_{Wald}=4.9, P=0.024), when compared to using CT.

Discussion

Correctly classifying an acetabular fracture is the first step in successful treatment. Therefore, understanding of Letournel classification is an important learning objective, especially for junior residents and orthopedic surgeons who are not treating these fractures frequently. It is well documented in the literature that a substantial inter-/intraobsever agreement exists when experienced surgeons were asked to classify a given set of x-rays. The majority of these studies did not report a significant improvement of this agreement when 2D or 3D CT were added [14]. For young surgeons, the introduction of an algorithm to analyze the x-rays or the addition of 3D CT were associated with the increased number of correctly classified fractures [5–13].

To the best of our knowledge, this is the first study to compare the x-rays refined by using a systematic evaluation versus the 3D CT regarding resident education. Although we recruited a relatively few residents, we included residents of varying durations of training. This enabled us to the study the impact of the duration of residency on correctly classifying acetabular fractures and on the difficulty perceived as well. Moreover, by examining the performance of the residents on a set of 20 fractures twice, we could increase the sample size to 600 (300 with x-ray only, 150 with the use of CT, and 150 with the use of algorithm). The method of GEE was used to account for the correlations among observations from the same resident and the correlations among observations from the same fracture. The only drawback of the limited number of participating residents was that randomization did not succeed in balancing the duration of residency between the CT and algorithm groups. In the algorithm group, there were higher, yet not-statistically significant, percentage of residents with longer residency training. This is a common problem that could arise with randomization in a less-than-200 sample size. However, we could determine the unique effect of using CT or algorithm while adjusting for the training experience using regression analysis.

To have a ready-cooked food or to prepare your recipe? This is the essence of this study. Although we found no difference in the primary outcome, that is, improvement in the correctly classified acetabular fracture between the two methods, the perceived difficulty was less when using the x-rays and an algorithm. The reason behind this may be the ability of the x-rays to snapshot the complex 3D anatomy into a simpler 2D photo. If this photo is traced correctly following the two primary lines (iliopectineal and ilioischial), it will give a global identification of the fracture. Mauffrey *et al*. [15] stressed on the same concept of this mental conversion.

Although the 3D images look fantastic, they cannot give this spatial relation in one view. The resident has to link more than a 3D image in his mind to reproduce this relation. Adding to that, the computer software used in reconstruction may fail to differentiate between the important primary fracture lines and secondary ones, especially when fragments are overlapping.

This study has some limitations. First, there was an overall low diagnostic accuracy that could be attributed partially to the inclusion of x-rays with low quality together with lack of previous formal training for the most of study participants. However, this was intended to accurately report the level of performance of our residents according to the available resources. Second, the relatively small sample size may result in selection bias but this was adjusted by using the proper statistical techniques.

Conclusion

The use of an x-ray algorithm may be a better educational tool when teaching the classification of acetabular fractures. It was not inferior to the 3D CT regarding diagnostic accuracy and was perceived as an easier approach to understand the cumbersome classification from the perspective of junior orthopedic surgeons.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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