Quadrilateral plate fractures of the acetabulum: Proposition for a novel classification system


Trauma & Orthopaedic Surgery, Cairo University Hospitals, Egypt

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**Abstract**

Background: Currently, there is no definition or classification system for quadrilateral plate (QLP) fractures; the aim was to anatomically and radiologically characterise the QLP, propose a definition and classify QLP fractures.

Methods: This study included an anatomical component and a radiological component. The anatomical study aimed at defining the characteristics of the QLP; the QLP was identified using four articulating bony pelvic specimens. A titanium mesh was placed on the specimens’ quadrilateral surface; standard anteroposterior and oblique views were obtained, and axial CT images, to determine the radiological landmarks. The radiological study included the review of images of patients with QLP fractures; fractures involving the QLP were identified in a series of 609 consecutive patients with acetabular fractures.

Results: We considered QLP fractures where the QLP is separated from both columns of the acetabulum; this was found in 16% (98 cases). They were mostly encountered with associated both columns fractures (60 cases; 61%). Separation of the QLP could be complete or incomplete, or simple or comminuted, so QLP fractures were divided into three types: QLP1, simple with incomplete separation; QLP2, comminuted with incomplete separation; QLP3, comminuted with complete separation; QLP4, simple with complete separation.

Conclusion: The QLP was characterised, and a definition and classification system; Cairo University Hospitals (CUH) Classification was proposed for these fractures. We believe that this classification may prove useful in the future for the identification and management of these fractures.

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**Introduction**

Quadrilateral plate fractures of the acetabulum are a challenging group of acetabular fractures. The main difficulty lies in the fact that they are usually accompanied by medial subluxation of the femoral head and dome impaction, as well as a high degree of comminution [1–5]. One of the most confusing aspects of these fractures is the lack of a clear definition. Different authors define quadrilateral plate fractures differently, and there is no one clear or all-encompassing definition. Further, their studies have described different modalities of fixation for quadrilateral plate fractures based on different descriptions of quadrilateral plate fractures.

White et al. based their definition on a search of the Medline, Embase and Cochrane library databases for the term “Acetabular Fracture” and “Central Hip Dislocation” [3]. Their results and conclusions were dependent on these search criteria, and they considered it to be any acetabular fracture with medial subluxation of the femoral head [3]. We however believe that a central hip dislocation with an acetabular fracture does not necessarily indicate a separation of the quadrilateral plate, and that a fracture of the quadrilateral plate does not necessarily indicate a central hip dislocation.

Qureshi et al. considered it as a comminution in the quadrilateral plate accompanied with a medial displacement pattern [1]. They also described quadrilateral plate fractures as being accompanied with medial subluxation of the femoral head in the elderly, and they used infrapatellar plates for fixation of these fractures. Further, Sen et al. described a technique for buttress plating of quadrilateral plate fractures; their interpretation of quadrilateral plate fractures was fractures which involved
comminution in the quadrilateral surface of the acetabulum [5]. Yet another description was provided by Farid, who mentioned that the quadrilateral plate could be separated from the anterior or posterior column, and that this separation could be complete or incomplete [4]. Given these varying and confusing descriptions, in this study, we have tried to anatomically and radiologically characterize the quadrilateral plate and define the fractures based on these characteristics.

The lack of sufficient guidelines in the current literature makes it difficult to deal with these fractures. There is considerable debate around this fracture type, to the extent that even at the same institute, surgeons use different methods to treat these fractures. Some surgeons advocate the use of dedicated approaches or specific methods of fixation, while others believe that reduction of these fractures is mainly dependent on reduction of the acetabular columns and that they are not associated with hip joint stability or the development of posttraumatic arthritis. In this study, we have attempted to establish a classification system for these fractures, which could later be used to develop definite guidelines for the management of this particular group of fractures. This study tries to anatomically and radiologically characterize the quadrilateral plate, propose a definition for quadrilateral plate fractures, and classify them. This is the first time a classification system is being proposed for this type of fracture, and we believe that it will have strong implications for the diagnosis and treatment of these fractures.

**Patients and methods**

This study was approved and registered in our local institutional review board.

**Cadaveric study**

The first part of this study is an anatomical study, using four cadaveric bony pelvises (two male and two female), we identified the quadrilateral plate of the acetabulum as the trapezoidal-shaped area that is bound by the greater sciatic foramen posteriorly, the obturator foramen anteriorly, and the pelvic brim superiorly, with a horizontal line joining the ischial spine and the obturator foramen inferiorly (Fig. 1). These boundaries were based on our understanding of the quadrilateral plate and from previous descriptions by Bircher and Tile [6] and Guyton and Perez [7].

To identify the radiological landmarks corresponding to the anatomical landmarks mentioned in the previous subsection, we used a male dry articulating pelvis. A titanium mesh was placed on the quadrilateral surface of the acetabulum, based on the same landmarks mentioned previously. The dry pelvis was then fixed in position, and the anteroposterior and oblique views were obtained.

In the anteroposterior view, the quadrilateral plate was found to be the area between the iliopectineal and ilioischial lines, which extends superiorly to the area just above the anterior inferior iliac spine and inferiorly till the lower end of the tear drop. In the iliac oblique view, the quadrilateral surface was seen from the anterior end, extending to the ilioischial line, and from the greater sciatic notch down till the upper end of the lesser sciatic notch. In the obturator oblique view, the quadrilateral plate was found to be the area extending from the anterior column anteriorly till the beginning of the posterior wall posteriorly, and from above the anterior inferior iliac spine superiorly till above the obturator foramen inferiorly. The tear drop is seen overlapping this area in the obturator oblique view (Fig. 2).

To identify the quadrilateral plate on CT images, an axial CT scan of 3-mm sections was obtained for the specimen with the titanium mesh fixed in position. The quadrilateral plate was found to be the area corresponding to the medial wall of the acetabulum: from the level of the anterior inferior iliac spine till the appearance of the obturator canal (Fig. 3).

**Radiological study**

Using the database of a level one trauma center university hospital, we retrospectively reviewed the records of 609 patients who presented between January 2009 and January 2012. Using the previously mentioned axial CT sections, we identified all the fractures involving the quadrilateral plate of the acetabulum. Out of the 609 fractures, 470 involved the medial wall of the acetabulum. These 470 fractures were divided into two main groups: Group A, fractures where the quadrilateral plate was separated from the anterior and posterior column (n = 98); Group B, acetabular fractures with a fracture line passing through the quadrilateral plate, but not separating the plate from the anterior and posterior column (n = 372).

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**Fig. 1.** Anatomical landmarks of the quadrilateral plate. The quadrilateral plate extends from the pelvic brim superiorly till a line joining the ischial spine and obturator foramen inferiorly, and is bound by the greater sciatic notch posteriorly and the obturator foramen anteriorly.
Group B included a heterogeneous group of fracture patterns, all of which seemed to require no special approach or fixation for the quadrilateral plate, they included transverse, transverse posterior wall fractures, T-fractures, anterior column posterior hemi transverse fractures and both column fractures. All these fractures had a fracture line that was merely passing through the quadrilateral plate but not separating the quadrilateral plate from the columns of the acetabulum. In this group, reduction of the quadrilateral plate was dependent on reduction of either the anterior or posterior column, as the QLP was directly connected to one of them. On the contrary, in Group A, the quadrilateral plate was separated from the columns and seemed to require a special approach or dedicated fixation technique. The separation of the quadrilateral plate was either complete or partial. Partial separation meant that the QLP was completely separated from one column and partially attached to the other column.

Through observation of the different fracture patterns of Group A, we noticed that quadrilateral plate fractures maybe of the simple non-comminuted type or of the simple comminuted type; further, they may be completely separated from both columns of the acetabulum, or they may remain partially attached to one of the columns while being completely separated from the other column. Thus, we arrived at four different types of fractures: (1) An incompletely separated simple fracture or QLP1, where the quadrilateral plate is separated from the anterior column and partially attached to the posterior column; (2) An incompletely separated comminuted fracture or QLP2, where the main fragment of the quadrilateral plate remains partially attached to the one of the columns while exhibiting varying degrees of comminution; (3) A completely separated comminuted fracture or QLP3, where the quadrilateral plate is comminuted and completely separated from both columns of the acetabulum; (4) A completely separated non-
comminuted fracture or QLP4, where the quadrilateral plate is completely separated from both columns without comminution (we did not identify such a fracture pattern in our review of 98 cases) (Fig. 4).

Thus, we hypothesized that fractures of the QLP could be classified into one of four groups. To measure the intra-observer reliability of the suggested classification system, 40 QLP fractures were classified by the first author, then re-classified once again 4 weeks later. The fractures were also classified by an orthopaedic middle grade trainee, an orthopaedic consultant non-specialized in pelvic and acetabular fractures, and a consultant specialized in pelvic and acetabular fractures. Cohen's Kappa Index was measured to estimate the inter-observer agreement, where a kappa value of 0.8-1 indicates an almost perfect agreement according to Landis and Koch [8]. The Gamma correlation coefficient was also measured, which is a correlation coefficient to indicate the strength of correlation whereas kappa measures agreement.

Results

Based on our observations we defined quadrilateral plate fractures as fractures where the quadrilateral plate is partially or completely separated from the columns of the acetabulum. A partial separation was considered when the quadrilateral plate remained partially attached to one column and separated from the other column. In this case, it usually remains attached to part of the posterior column and completely detached from the anterior column. In our series, quadrilateral plate fractures accounted for 16% of the total number of acetabular fractures (98 out of 609). Quadrilateral plate fractures were mostly encountered in association with associated both columns fractures (60 cases; 61%), T-type fractures in 23 cases, anterior column fractures in 13 cases, and anterior column posterior hemi-transverse fractures in 2 cases. (Table 1).

Based on our classification, Cairo University Hospitals (CUH) classification; incompletely separated simple quadrilateral plate fractures (QLP1) accounted for 51 (52%) of the 98 cases; incompletely separated comminuted quadrilateral plate fractures (QLP2) accounted for 25 cases (25.5%); and completely separated comminuted fractures (QLP3) were found in 22 cases (22.5%). However, there were no cases of simple separated quadrilateral plate fracture (QLP4) identified in this series of patients. (Table 2) (Fig. 5).

The suggested classification system showed an intra-observer agreement of 95% (agreement in 38 out of the 40 cases) Kappa of 0.9 and Gamma 1.0. The agreement between the first author and the middle grade orthopaedic trainee was 85% (34 out of 40 cases), Kappa 0.7 and Gamma of 1.0. The agreement between the first author and an orthopaedic consultant was 90%, Kappa 0.9, and

**Table 1**

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Number of Fractures</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Fractures Associated with Both Columns</td>
<td>60</td>
<td>61%</td>
</tr>
<tr>
<td>T-Fractures</td>
<td>23</td>
<td>23%</td>
</tr>
<tr>
<td>Anterior Column Fractures</td>
<td>13</td>
<td>13%</td>
</tr>
<tr>
<td>Anterior Column, Posterior Hemitransverse Fractures</td>
<td>2</td>
<td>33%</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 2
Different types of quadrilateral plate fractures.

<table>
<thead>
<tr>
<th>Type of Quadrilateral Plate Fracture</th>
<th>Number of Fractures</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>QLP1: Incomplete, Simple</td>
<td>51</td>
<td>52.3%</td>
</tr>
<tr>
<td>QLP2: Incomplete, Comminuted</td>
<td>25</td>
<td>25.5%</td>
</tr>
<tr>
<td>QLP3: Comminuted, Complete</td>
<td>22</td>
<td>22.5%</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>100%</td>
</tr>
</tbody>
</table>

Gamma 1.0. The agreement between the first author and an orthopaedic pelvis and acetabular fracture consultant was 90%, Kappa 0.8 and Gamma 0.9.

Discussion

In this study, we tried to provide a clear definition for the quadrilateral plate based on anatomical and radiological observations. We identified the borders of the quadrilateral plate on four cadaveric pelvises and outlined the radiological landmarks of the quadrilateral plate. We also proposed a classification system; Cairo University Hospitals (CUH) Classification for quadrilateral plate fractures based on the findings in 98 patients with QLP fractures of the acetabulum.

In order to anatomically characterize the quadrilateral surface of the acetabulum, we conducted a review of literature; we found that there was no consensus regarding its anatomical boundaries. Bircher and Tile considered it as an accessory structure, preventing medial displacement of the hip and described it a thin third column [6].

Guyton and Perez considered it to be the quadrangular area that is adjacent to the medial wall of the acetabulum, as depicted in an illustration in their book, and mentioned that it was located near the femoral head, which limits the options for its fixation [7]. We could not find any further description of this area in our search of the literature. Therefore, based on the few descriptions available and based on our perception, we considered it as the trapezoidal area that corresponds to the medial wall of the acetabulum. The trapezoidal area corresponded to the level of the anterior inferior iliac spine superiorly and the obturator canal inferiorly. In order to confirm the latter two landmarks and to identify the radiological boundaries of the quadrilateral plate, we placed a titanium mesh of the previously mentioned dimensions and obtained standard anteroposterior oblique radiographs and 3-mm axial CT scans. The imaging findings confirmed the anatomical boundaries identified earlier.

We then went to define Quadrilateral plate fractures as fractures where the QLP is partially or completely separated from the anterior and posterior columns of the acetabulum. The quadrilateral plate may remain partially attached to one of the columns (usually the posterior), and variable degrees of comminution maybe present.

Based on our observation of 98 such fractures, we defined four distinct types of plate fractures—QLP1, QLP2, QLP3 and QLP4—which cover different degrees of separation from the acetabular columns and different degrees of comminution. In this case series; we found that quadrilateral plate fractures were associated mostly with both column fractures (61%), and to a lesser extent with T-fractures, anterior column fractures and anterior column, posterior hemitransverse fractures. Hirvensalo also reported quadrilateral plate fractures being associated with the same types of acetabular fractures [9].

Although this is merely an anatomical classification, we believe that it also corresponds to the degree of initial trauma and the severity of the lesion. Laflamme published a case report of an isolated quadrilateral plate fracture, which is not classifiable with the Letournel and Judet classification [2]: however, it seems to meet the criteria for type QLP2 defined here. Thus, the classification proposed here could be used to identify and treat fracture types that were previously not clearly defined. However, in our case series, we did not find a completely separated quadrilateral plate fracture (QLP4), so we were unable to classify this type based on evidence.

The suggested classification system showed a high intra and inter observer reliability. There was good correlation between the authors’ perspective, along with the perspective of both experts and non-experts in the field of acetabular fractures.

![Fig. 5](image_url) A diagram explaining the different fracture groups identified.
The limitation of this study is the anatomical and radiological nature of the study. However, we believe that understanding the anatomical and radiological boundaries of the quadrilateral plate, together with a concise definition would facilitate further research in this field and validate the results. The proposed classification system would also facilitate communication when dealing with these fractures. Perhaps further studies are required to prove the efficacy of this classification system and the effect it would have on the management and outcomes of these fractures.

Conclusion

This anatomical and radiological study suggested a definition and a classification system for quadrilateral plate fractures, which present a challenging group of fractures. This classification groups quadrilateral plate fractures into three distinct groups according to their degree of separation from the acetabular columns and the degree of comminution of the quadrilateral plate.

Conflict of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Funding disclosure

The authors confirm that no funding was received for this study.

Ethics review committee

This study has been approved by the appropriate ethics committee (the Scientific Board of the Department of Trauma & Orthopaedic Surgery, Cairo University Hospitals). Details that might disclose the identity of the subjects in the study have been omitted.

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References