Original Article

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Significance of quadrilateral plate in surgical treatment of complex bi-columnar acetabular fractures: descriptive analysis through three cases.

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Abstract

Complex acetabular fractures affecting both columns remain one of the hardest challenges to trauma orthopaedic surgeons with high morbidity and often poor outcomes. Treatment dilemmas arise especially in both column fractures where the fracture line dissociates acetabulum in different directions and sizes resulting in quadrilateral plate (Quad) fragments of various sizes. This plate serves as a vertical girder-wall structure for the acetabulum. Order of fixation along with selection of its associated surgical approach are the cornerstones of operative strategy in such injuries and are driven by various factors one of the most important being quadrilateral plate involvement. A traditional rule of thumb dictates to first fix the column that can be addressed easier and more directly. Then the second column can be addressed. As the quad is the connection girder between the two columns, the fragmental condition of this plate, is one of the most decisive factors influencing decision making. The fracture line which crosses the quad plate is crucial and if there is a multifragmentary component it dictates the chosen plate. We will try to illustrate, discuss and explore this topic exemplifying three difficult cases dealt with three approaches: Ilioinguinal (ILO), Stoppa-Anterior Intrapelvic (AIP)-ILO modification and Kocher-Langenbeck (K-L) either in isolation or combined. Pearls, pitfalls and lessons learned are offered in a vivid illustrative way.

Keywords: quadrilateral, plate, column, acetabulum, approach

Introduction

Both column acetabular fractures can be classified according to Young and Burgess classification as CM type (Combined Mechanism)[1], according to Tile classification as C2 or C3[2] and according to AO/OTA modification of the Letournel-Judet classification as C2.2, or C2.3, or C3.2, or C3.3[3] Typical mechanisms causing pelvic disruption are: traffic injuries (60%), falls from height (30%) and crush injury under heavy weights (10%).[4] Armamentarium of surgical approaches utilized in surgical fixation of such fractures includes: Stoppa or Anterior Intrapelvic

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Approach (AIP), Ilioinguinal (ILO), AIP-ILO modification (the AIP in conjunction with the first or the two lateral windows of ilioinguinal) and Kocher-Langenbeck (K-L) approaches. Commonly presenting problem in such cases is how to efficiently reduce the posterior column along with the quadrilateral plate, which both relate directly to the proper sequence of approaches and selection of the component to be reduced first. The role of quadrilateral plate has recently started to be an area of interest.[5] However its significance had been recognized since 1997 when Perry et al. stated that it functions as a third column rather than a connection between anterior and posterior columns.[6] We have realised that the key role of the Quad gives partially or sometimes entirely, the answer from where to start and how (which exposure). Apart from that, it is well known that pelvic stability depends on the ability of osseoligamentous structures to withstand physiologic stress without abnormal deformation. Posterior Sacroiliac ligaments are a key vertical stabilizer maintaining the sacrum in its normal position in the pelvic ring.[7]

In this short case series we illustrate the reduction and fixation sequence of complex bi-columnar acetabular fractures striving to extract useful conclusions, lessons and recommendations about this difficult topic.

Case 1

A seventy-two-year-old man fell from height and presented with a both column-fracture (Figure 1). Further workup revealed a complex bi-column acetabular fracture with posterior wall involvement and more specifically a transtectal fracture because the fracture line crossed the superior weight bearing surface into the acetabulum, comprising the fracture with the worst prognosis (Figures 2 and 3).[8] Ideally complex pelvic and acetabular fractures should be addressed through one single exposure; therefore as the major lesion is posteriorly we tried to rectify the problem utilizing Kocher-Langenbeck (K-L) approach. We planned to fix the posterior column firstly and secondly the Quad. In figure 4a is shown how with an asymmetric clamp we reduced from posteriorly the Quad holding in place with a Schanz screw the posterior column. Notice how the two long screws in Fig 5, (red arrows) keep in place the anterior column from posteriorly. Trochanteric osteotomy was very helpful in order to provide access to placing two screws in the upper portion of the acetabulum wall.

Case 2

A forty-five-year-old man fell from height sustaining a two-column acetabular fracture with posterior wall divided in three major pieces (Figure 6). CT scan showed that quad was detached and that we had to deal with a transverse transtectal fracture, high anterior column fracture with multifragmentary iliac wing and that quad fracture line did not extend into major sciatic foramen (Figures 7,8).

Initially, the Anterior Intrapelvic Approach (AIP)-Ilioinguinal modification (AIP-ILM), more specifically the Stoppa approach with the two lateral windows of the IL approach, were used. There was great difficulty, reducing the quad from anterior because the posterior column (with the quad on it) was displaced far posteriorly, too deep into the true pelvis and neither the colinear, nor other clamps could pull the posterior column back to its original position to the pelvic brim. We decided not to make any more attempts to reduce the quad with the posterior column to its initial place from anterior due to fear of uncontrollable bleeding. We succeeded only at an almost 2 cm reduction of the posterior column, with the quad on, and compromised accepting a 2 cm gap. A suprapectineal plate was applied and a screw from anterior to posterior was used to stabilize the posterior column to its new position (red arrows in Figure 9). Also, from the 1st window of the IL approach, a big plate applied to the iliac wing. The distance from the pelvic brim to the quad was left almost 2 cm "open" and fresh frozen allograft was applied. Then, the patient was switched to a lateral decubitus position and via K-L approach we attempted to address posterior wall and column. Now even though the posterior wall was fixed easily with two spring plates the posterior column was found "locked" due to the anterior fixation and did not permit the any posterior column movement at all. The gap of the unreduced column

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***Figure 1**: Case 1 Xray AP view depicting a left both column acetabular fracture*

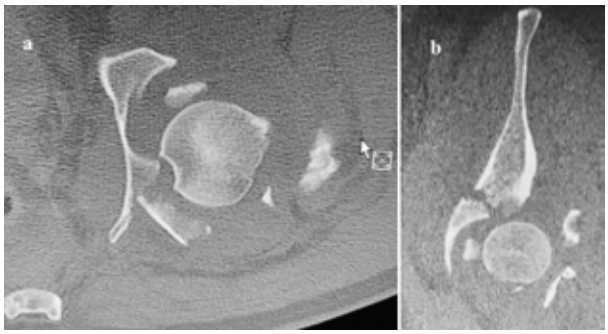

***Figure 2**: Case 1 CT scan. **a)** axial view showing bi-columnar fracture with significant comminution and head posterior dislocation, **b)** Sagittal view showing transverse fracture*

***Figure 3**: Case 1 3D Recon. **a)** Transverse transtectal acetabular fracture, **b)** Fracture line posteriorly through Quad up to major sciatic foramen*

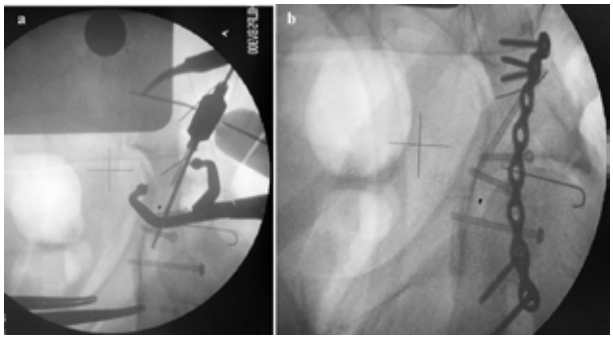

***Figure 4**: Case 1 Intraoperative c-arm views. **a)** asymmetric clamp reducing Quad from posteriorly plus Schanz screw holding it in place, **b)** satisfactory reduction of Quad and fixation with posterior column plate. Very small piece of cartilage fixed in situ with a needle*

(with the quad on it) could be palpated also from posteriorly and fresh frozen allograft was interposed. This combined approach procedure took approximately 6 hours surgical time. Despite our initial reservations radiographic and clinical follow up six months post-op showed a good outcome with a happy and fully functional patient (Figure 10).

Case 3

A 27-year-old woman was involved as passenger in a motorcycle accident when their motorbike crushed on the concrete fringe of the pavement. Contrary to case 2 now we had to deal with a transverse juxtatectal fracture (fracture line crossed the top of cotyloid fossa) along with a high anterior column fracture and comminuted iliac wing (Figure 11). Quadrilateral plate was disrupted in two pieces but in continuity with iliac bone near major sciatic foramen as the fracture juxtatectal. Sacroiliac joint was indeed affected but with intact posterior elements hence we decided not to apply any treatment to the sacrum. Quad surface was totally separated from anterior and the posterior columns and was lying as an independent piece in the middle of the

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***Figure 5**: Case 1 Post-op AP Xray. Red arrows showing independent screws from posterior to anterior column. Notice that trochanteric flip osteotomy was restored with 3 cannulated screws*

***Figure 6**: Case 2 Xray AP view. Comminuted both column acetabular fracture*

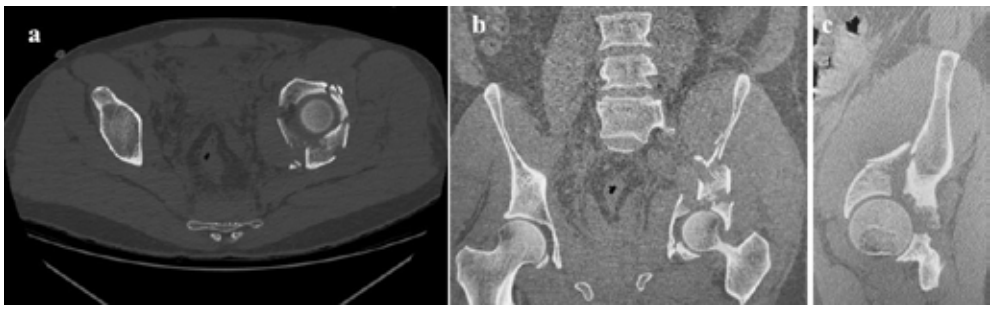

***Figure 7**: Case 2 CT scan. **a)** axial view-quad is detached, **b)** coronal view-transtectal transverse fracture. iliac wing is also fractured, c) sagittal view*

upper and lower pelvis. In Fig.11 b-c, CT/scan reveals that the anterior ligamentous complex is torn but the posterior one is stable. Nevertheless, the gap of the SIJ isn't more than 2 mm anteriorly. The multifragmentary of the sacral makes the SIJ plating inappropriate and on the other hand SIJ screws would have yielded a small advantage to the overall patient condition.

We opted to fix the posterior column via K-L approach first, contrary to previous case number 2. The fracture seemed to be Juxtatectal which means that the fracture line crosses the top of the cotyloid fossa of the acetabulum. In this way, it cut the quad almost in the middle in a transverse plane. So it appeared to be easier to reduce the posterior column from behind. Two plates applied at the posterior column (Fig 12a) via K-L approach for better stability. When we realized that quad and anterior column were displaced (red arrows in Fig. 12a) we turned the patient supine to fix them through ilioinguinal approach (ILA) and the iliac wing from its 1st window. In post-operative x-rays the femoral head did not appear to be concentrically located in the acetabulum and further investigation with CT scan revealed that although metalwork was appropriately applied, part of the quad was malreduced resulting in a spur entering the cotyloid fossa and preventing the femoral head from sitting normally (Figure 13). Six weeks later, the patient was brought again to theatres for further exploration of the acetabulum. Using modified Hardinge approach, (anterolateral) we performed hip dislocation and smoothened the residual quad bone from the acetabulum. In one year follow up (Figure 14) x-rays in multiple views

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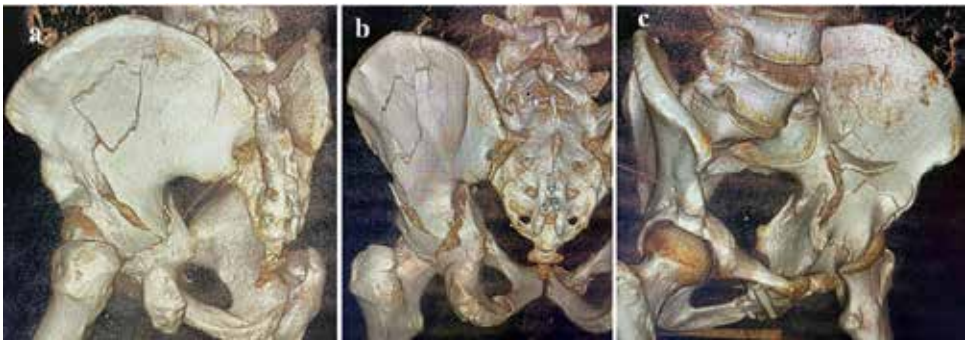

***Figure 8**: Case 2 3D Recon. **a)** High anterior column fracture. Iliac wing multifragmentary starting from acetabular roof to iliac crest, **b)** quad fracture line does not extend into major sciatic foramen, **c)** posterior column completely separated from ilium with part of Quad*

***Figure 9**: Case 2 Post-op Xray. **a)** AP view. 2 spring plates for posterior wall, a plate in ilium and suprapectineal plate in quad from Stoppa approach, **b)** Obturator oblique view. Red arrow shows screw from anterior to posterior column, **c)** Iliac oblique view, **d)** clinical photo showing both approaches K-L and AIP-ILM*

prove that the fracture is healed without osteoarthritis and that the patient enjoys a fully pain-free sporting lifestyle.

Discussion

Increased controversy regarding the optimal way of treatment of complex associated bi-column acetabular fractures exists. Traditionally as an effective way it is suggested to deal with the posterior column first via a posterior approach and use a clamp from the back to the front to reduce and hold in position the anterior column before the final fixation with screws.[9] That is what we have done in case number 1. Summarising our approaches we have used K-L approach alone in case 1, AIP-ILA modification and then K-L approach in case 2 and K-L and then ILA alone in case number 3. In all three cases we treated transverse fractures (Juxtatectal or transtectal) and fractures of posterior and anterior column. Quadrilateral surface has been highlighted as an important factor in such fractures and some authors attempted to understand these fractures by classifying quad fractures into in two categories relating to two areas formed by an imaginary line from iliopubic eminence to ischial tuberosity.[10] Again this does not assist too much when we have to deal with such horrific injuries. In case 2 we also had fracture of the posterior wall of the acetabulum and we had the expectation that if we could reduce the quad from anteriorly first, then the posterior column would come closer to acetabulum and especially the posterior wall pieces would follow so that the pieces of the wall and the posterior column could be fixed in a more accurate manner. Unfortunately this hypothesis was not proven true. Even though the anterior approach is the approach of choice for the quad (and the anterior column), it was not possible to grasp the quad because it had fallen very deep to the minor pelvis, almost near to the retroperitoneal area, very deep beside the bladder. All attempts with the collin-

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***Figure 10**: Case 2 6-months post-op. **a)** AP view, **b)** Outlet view **c)** Obturator oblique view, **d)** Iliac oblique view, **e)** patient walking independently without crutches, **f, g)** good hip ROM*

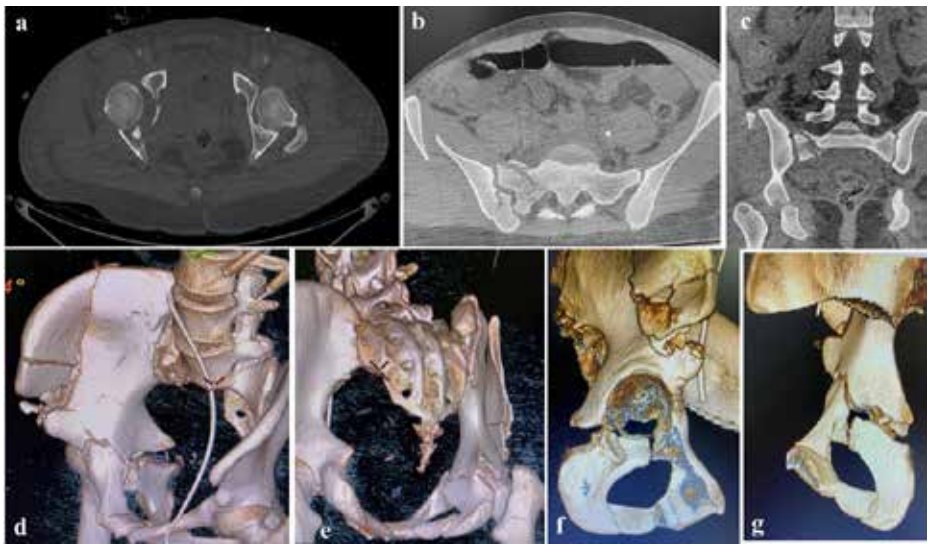

***Figure 11**: Case 3 CT scan. **a)** axial view- Quad is floating, **b)** comminuted SIJ with intact posterior elements and fractured ilium, **c)** coronal view showing SIJ disruption and posterior column displacement, **d)** 3D Recon quad in 2 major pieces, **e)** posterior column with part Quad, **f)** Juxtatectal fracture-quad near major sciatic foramen stable in continuity with comminuted iliac bone, **g)** quad in a large piece but has lost its continuity with iliac bone, acetabular brim in front and ischial tuberosity-posterior column behind*

ear clamp, asymmetric forceps etc. were ineffective. Only a small reduction was achieved. Then, at the posterior exposure it was difficult to reduce the posterior column because the osteosynthesis which proceeded from the front prevented any movements. Only the posterior wall was able to be fixed easily. In cases 1 and 3 starting from posteriorly with K-L approach the overall obstacle of the unreduced posterior column was surpassed. In case 3 especially where an anterior approach

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***Figure 12**: Case 3. **a)** Intra-op c-arm views. With K-L posterior column was fixed but red arrow shows unreduced anterior column & quad, **b)** Post-op AP view, **c)** Post-op obturator oblique view, **d)** Post-op iliac oblique view. Multiple plates through both (K-L + ILA). Femoral head seems non-congruent inside acetabulum*

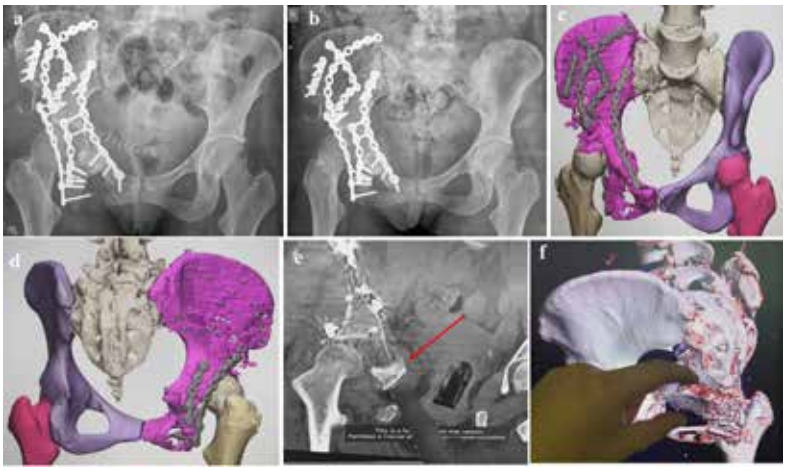

***Figure 13**: Case 3. **a, b**) malreduced hip was confirmed in serial views and xrays, **c, d**) metalwork found in good position, **e)** CT scan coronal view. Finger and red arrow showing spur of malreduced rotated Quad invading cotyloid fossa and narrowing joint forcing head to sit abnormally, **f)** 3D Recon finger showing quad malrotation*

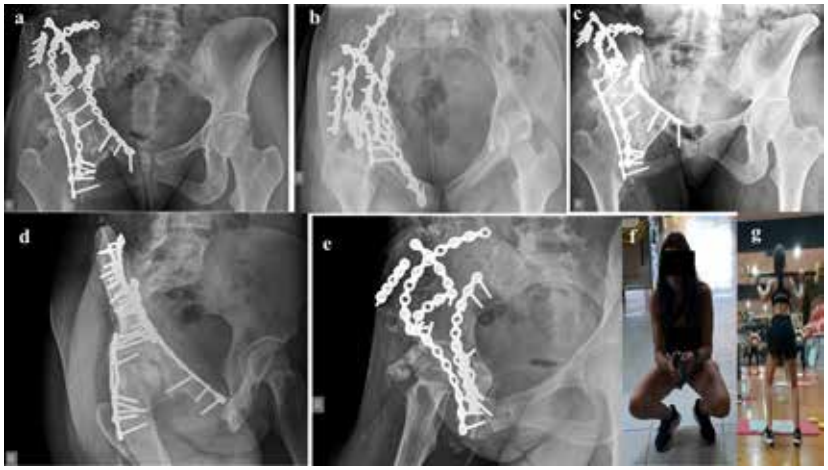

***Figure 14**: Case 3. 1 year clinical + radiological follow up. No signs of OA and head sits well **a)** AP Xray, **b)** Inlet, **c)** Outlet, **d)** Obturator oblique, **e)** Iliac oblique, f, g) fully functional patient doing sports*

was also needed, the quad was mobile and reduced more easily but it was not restored ideally. Therefore, it seems that we cannot safely offer a recipe "one size fits all" but rather a relevant recommendation. Our perceived algorithm that we want to share is: Operate as soon as possible, fix the posterior column first using your most familiar approach but especially when you have low or middle posterior column fractures use K-L approach without trochanteric osteotomy. Perform trochanteric osteotomy only if you have high posterior column fractures or the fracture line bisects the upper part of the acetabulum. Then, close and fix the quad and the anterior column using AIP-

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ILO modification or ILO approach alone. With combined approaches restrict initial fixation from posterior to a minimum to avoid any potential conflict when you go from the front. In case when posterior column is impossible to be reduced via posterior approach, then abandon it and switch to a fixation from anterior solely. Due to increased morbidity and risks, we do not advocate switching from posterior to anterior and then back to posterior to finalize the posterior column. Apart from infection risk, this approach does not seem to be cost-effective, is troublesome and only pelvic experts could potentially consider it in exceptional circumstances. In our hospital, the latest five years we perform two complex pelvic cases on a monthly basis utilizing a great variety of modern approaches and fixation methods and needless is to say that such complex injuries should only be dealt by specialized referral centers.

Conflict of interest

The authors declare no conflicts of interest.

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