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Acetabular both-column fractures: Essentials of operative management

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ABSTRACT

Acetabular both-column fractures are challenging articular injuries. They usually require operative treatment. We report on fundamental elements of pathoanatomy and radiology that are reviewed as far as they may influence treatment planning and surgical intervention. Surgical strategy, choice of the most suitable approach, reduction manoeuvres and fixation techniques are presented, together with some tips and tricks that are worth knowing in the surgical reconstruction of these difficult fractures.

Introduction

Both-column acetabular fractures are complex lesions characterised by lines developing on several planes.[3,4,7,10] The detachment of the whole acetabulum[15] (divided into anterior and posterior column fragments) from the sacroiliac joint is truly pathognomonic of this injury: therefore, the term "floating acetabulum" is more meaningful.

In this study, we aim to provide the orthopaedic surgeon with simple rules for the operative management of such a challenging injury and to present some tips and tricks facilitating reduction of the fracture.

Elements of pathoanatomy

Precise knowledge of fracture morphology and mechanism is essential to plan the adequate reduction manoeuvres.

Both-column fractures are T- or Y-shaped fractures determined by two converging lines, the former originating from the greater sciatic notch, the latter from the superior or anterior border of the ilium. Those lines merge just above the roof (supra-acetabular groove), from where a vertical tract descends and separates the articular surface and the ischio-pubic branch in two parts, anterior and posterior.

Thus three main fragments can be identified and defined as follows[21]:

- First part: posterior iliac fragment, well fixed to the sacroiliac joint, that does not have any connection to the hip joint.
- Second part: iliopubic fragment (anterior column), in contact with the femoral head, that includes the central third of the fossa acetabuli and the anterior horn (this fragment can be subdivided in two parts).
- Third part: ischiadic fragment (posterior column), in contact with the femoral head through the posterior horn of the fossa acetabuli.

The anterior line, which separates parts 1 and 2, may have an almost horizontal direction and, reaching the posterior line, may determine a split from the grater ischiadic notch to the iliac notch between the anterior superior iliac spine (ASIS) and the anterior inferior iliac spine (AIIS). In this case the fracture pattern is similar to a supra-acetabular "T" and is defined a type I fracture of both columns (Fig. 1).

In other cases, the anterior line may descend almost vertically from the iliac crest. This is so called type II fracture and looks like a supra-acetabular "Y"[7] (Fig. 2).

Fracture dislocation is dictated by the femoral head penetration and by the anatomical connections between each fragment and the surrounding skeleton. As the first fragment is linked to the ipsilateral sacroiliac joint and has no connection with the femoral head, it is the only element of the injured hemipelvis that keeps its anatomical location.

On the contrary, second and third fragments are pushed medially by the femoral head and dislocate according to their intrinsic stability and to the magnitude and direction of femoral head penetration. While translations are usually small and easy to identify, rotations are critical, and often difficult to recognise and to correct.

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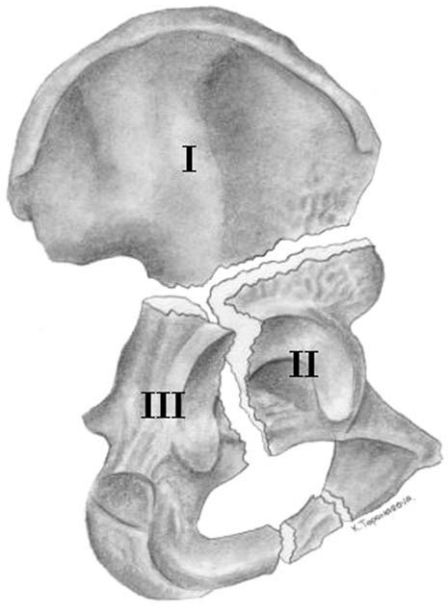

Fig. 1. Type I both-column fracture, with bifocal interruption of the lower pubic ramus.

The anterior column (part 2) includes the pubic symphysis that behaves as anterior fulcrum. Consequently, it rotates externally around this hinge, virtually moving towards an almost coronal position.

The posterior column has no skeletal connection; thus it translates medially and partly intrarotates, often loosing the articular relation with the femoral head and causing the ovalisation of the socket. This pathomechanism explains the definition of the "false congruency".

Rather common variants of those typical patterns are characterised by accessory fragments of the iliac wing, due to iliac fracture line splitting, or by an isolated fragment of the ischio-pubic fragment, due to a bifocal ramus fracture.

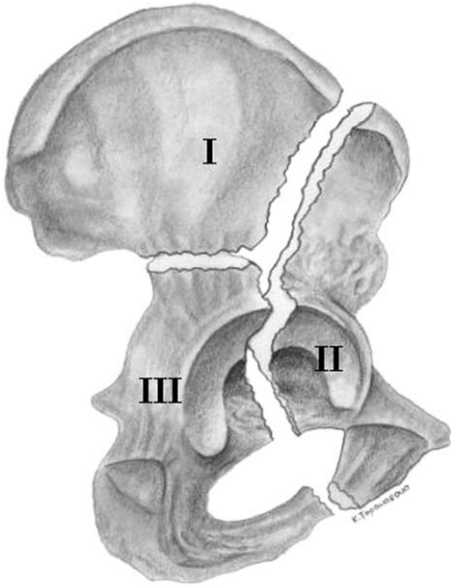

Fig. 2. Type II both-column fracture.

Elements of radiology

Only the surgeon who is skilled in pelvic radiology can understand the fracture pattern, plan the proper reduction, and evaluate the results of his manoeuvres.

The most relevant issues to be considered are described below.

I level: standard X-rays

Three radiological views are needed to evaluate and classify any acetabular fracture: the anteroposterior view, the iliac view and the obturator view.

In the standard pelvis anteroposterior view of a both-column fracture all the fundamental landmarks of the acetabulum are involved somehow (iliopubic line, ilioischial line, anterior rim, posterior rim, roof and teardrop).[5] Furthermore a diagnostic sign known as the "curved line", firstly described by Judet and Letorunel, can be easily recognised. It is an arciform image created by the interruption of the greater sciatic notch. Usually the femoral head is displaced medially (if no attempts to reduction are performed) with a variable protrusion into the pelvis (Fig. 3a).

The iliac view permits to evaluate the fracture of the posterior column (with the interruption of the greater sciatic notch) and of the iliac wing.

The obturator view shows a typical image called "spur sign"[13] that is generated by the external rotation of the second part, whose inferior shard projects as a spur above the acetabulum (Fig. 3b). Moreover the fracture of the ischio-pubic ramus is seen.

II level: CT-scan

A CT-scan is a compulsory investigation in all both-column fractures. The axial slices allow to estimate fragments rotation around the femoral head and the consequent "secondary congruency". CT findings justify the overcoming of this definition in favour of the more correct "false congruency", as the injured acetabulum offers a narrowed opening with interfragmentary gaps of the articular surface and frequent loss of articular relation between the femoral head and the posterior horn.

Two dimensional reconstructions in a coronal plane quantify the involvement of the roof, its comminution or impaction, and thus have an important prognostic value.

Three dimensional reconstructions are extremely useful for the preoperative planning, as they show the three main fragments dislocation, helping to plan the proper reduction (Fig. 3c).

Preoperative planning

The most convenient approach for open reduction and internal fixation of a both-column fracture is the extended iliofemoral. Unfortunately, the high rate of associated complications (heterotopic ossifications, deep haematoma, delayed union, avascular necrosis of bony fragments) leads us to discourage from using this exposure.

Alternative options are the Kocher–Langenbeck approach[8,9,18] and the ilioinguinal approach,[14] both appropriate to deal just with one column, respectively, the posterior and the anterior one. This limit makes often a second procedure needed to complete the surgical treatment on the other side (Fig. 3).

The two procedures may be performed consecutively during the same operative session, or separated by 5–6 days. The decision should be made by the anaesthesiologist in the light of the duration of the first procedure, of the severity of associated injuries, of the amount of blood loss. The typically poor general conditions of those high-energy trauma patients make us prefer the delayed treatment of the opposite side.

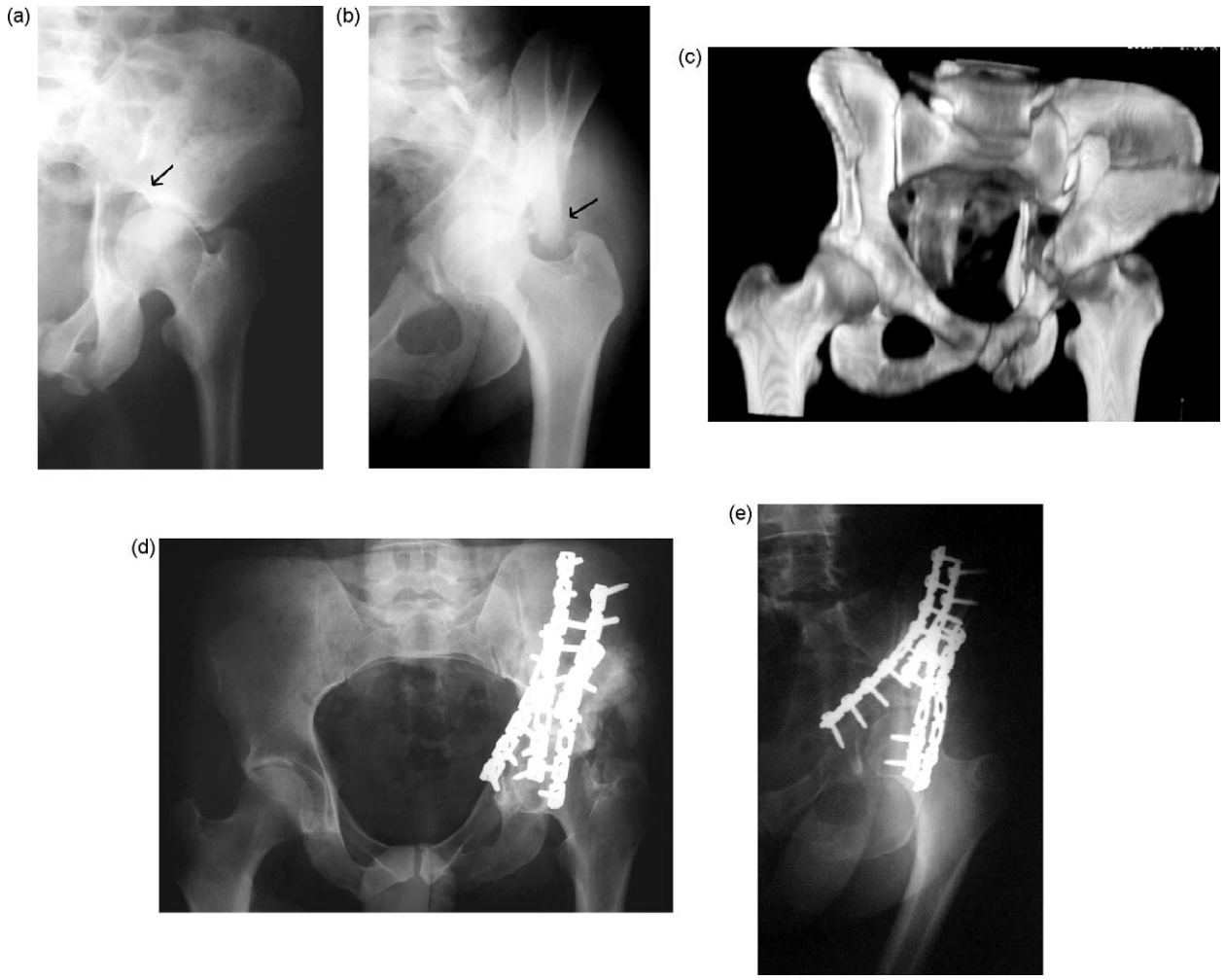

Fig. 3. Type II both-column fracture, with split of the second fragment on the origin of the iliopubic branch. Surgical treatment with posterior step first (double plate) and delayed anterior step (iliac and iliopubic plate). (a) Preoperative anteroposterior view (the arrow indicates the "curved line"); (b) preoperative obturator view (the arrow indicates the "spur sign"); (c) 3D CT reconstruction that clearly shows the fragments and their displacement; and (d and e) anteroposterior and obturator X-ray 3 years after surgery.

The choice of the first surgical approach depends on the fracture pattern, as the more dislocated column is conveniently reduced and fixed before the other one.

Surgical technique

Posterior step first

If the third part is more dislocated, a posterior approach is often the more convenient first step of the surgical management.

The reduction of the third fragments requires external rotation and lateralisation. This is usually accomplished placing a Schanz screw or a Steinmann pin into the ischial tuberosity. If more than 2 weeks passed from the day of injury, scar tissue may impede fragments manoeuvrability. In this case, the sacrospinus ligament might be released or the ischial spine osteotomised.

The penetration of the femoral head in between the two columns usually obstructs the reduction until manual traction is applied along the cervical axis. This requires to place a hook around the calcar or a Schanz screw along the femoral neck.

After temporary fixation with Kirschner wires, the surgeon should check the continuity of the profile of the greater sciatic notch and of the surface of the quadrilateral area by inspection and palpation (the so-called "endopelvic finger"), inserted through the greater ischial foramen.[16] The lamina should be reduced not in reference to its anterior portion, that belongs to the second fragment and is supposedly dislocated, but in reference to the overlying posterior end of the pelvic brim, that belongs to the first fragment and thus represents a fixed landmark for reduction.

Furthermore, it is mandatory to obtain a set of fluoroscopic images to verify the disappearance of the "curved line" in the anteroposterior view and the restoration of the continuous posterior profile of the hemipelvis in the oblique iliac view.

An ilioischial bridging plate is able to fix the third fragment to the first one (stable, being constrained to the sacrum through the sacroiliac joint).[17] Care has to be taken to avoid screw penetration into the joint space. Moreover, it is advisable to avoid long screws (>30 mm) at the proximal end of the plate, as those might engage the second fragment and subsequently obstruct anterior column reduction. No screws should penetrate the second fragment, neither show up in the rim of the anterior fracture line.

Once the posterior column is permanently fixated, oblique views should be obtained to evaluate the residual anterior column displacement: disappearance of the spur sign in the obturator view and reduction of the iliac fracture line in the iliac view – both suggestive for dislocation of the second fragment – occur sometimes when the central dislocation is corrected.

In this rare favourable case, if the iliac fracture line is anterior enough to leave part of the supra-acetabular groove attached to the first fragment, it is possible to stabilise the anterior column with a

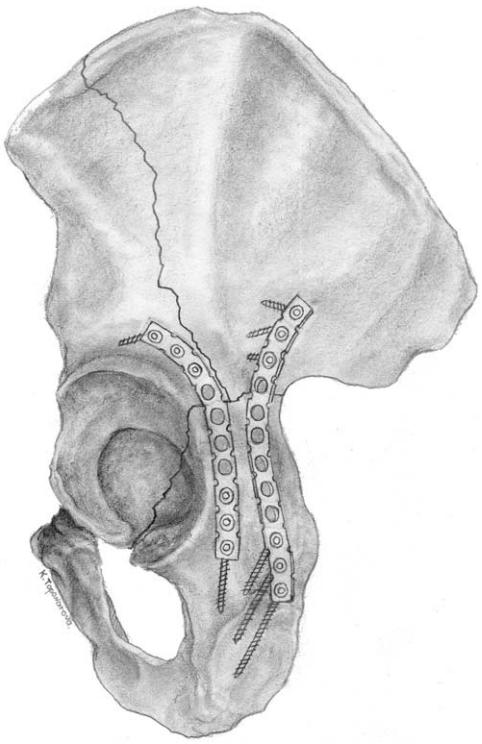

Fig. 4. Plate osteosynthesis of both columns through the posterior approach.

long 4.5 mm-cortical screw inserted through the groove (1° fragment) into the superior branch of the pubis (2° fragment) under fluoroscopic guidance. The modest diameter of this column makes this procedure extremely difficult and potentially dangerous, unless appropriate navigation systems are available.[12] Often however, the supra-acetabular region remains attached to the roof and therefore to the second fragment, and screw fixation cannot be achieved.

An easier opportunity to perform the anterior column fixation through a posterior approach is offered in case of fracture type II with an extremely posterior iliac rim. In this situation the second fragment is directly approachable elevating the glutei muscles subperiosteally from the external iliac fossa. In such a situation, fragment 2 may be fixated by a second ilioischial plate, proximally bent forward to reach the supra-acetabular bone of the fragment 2 with at least two screw holes (Fig. 4).[17]

In most cases, at the end of the posterior surgical stage, the spur sign and the iliac line remain unaltered, that means that the second fragment is still rotated and medialised. Thus one has to proceed with an anterior second step, as described further on.

Anterior step first

If the second part is more dislocated, it is useful to start through an ilioinguinal approach.

The second fragment, usually externally rotated and medialised, may be manipulated through the lateral and the intermediate window of the exposure.[6,20]. The surgeon should insert a lever (e.g. a Hohmann retractor) and contemporaneously the assistant should apply an adequate distraction to the lightly abducted limb, in order to disengage the iliac fracture line.

The second fragment is strongly connected to the femoral head, since it actually contains most of the articular surface. Then, in case of a central dislocation, the proximal femur ought to be extracted from the fractured socket with hook or a Schanz screw before any attempt of reduction. If the head is not repositioned, there is no possibility to reduce the second fragment.

Pushing the lateral side of the ilium with a squared impactor or a Letournel picador will subsequently allow to rotate inward the second fragment, thus correcting the malrotation.

A lag screw placed in the internal iliac fossa just above the pelvic brim and directed from the second fragment towards the first one, allows us to fix the anterior column temporarily.

Before definitive fixation, three fundamental points have to be checked:

- Palpate the crest (type II) or the notch between ASIS and AIIS (type I), making sure that the profile is continuous and anatomic.
- Palpate the internal iliac fossa, making sure that no irregularities alter the concave surface.
- Verify the disappearance of the spur sign in the obturator view and the reduction of the iliac fracture line in the iliac fluoroscopic view.

In case of favourable results, the lag screw can be maintained, and a short accessory plate (4–5 holes) should be contoured on the internal iliac fossa, close to the iliac crest. This prevents from secondary dislocations due to imperfect contouring of the main plate. Even though it is possible and described to position the accessory plate straight onto the convexity of the iliac crest, we recommend its implantation on the concave side to avoid local problems due to the superficial position of the hardware.

Neutralisation of the fracture site is achieved mainly by a long reconstruction plate along the pelvic brim, from the posterior end of the ilium, close to the sacroiliac joint, towards the iliopectineal eminence (type II) or even to the pubis (type I).[2] In the unexceptional case of accessory iliac fragment, included in the bifurcation of the iliac fracture line, this part should be immediately stabilised to the first or to the second fragment, in order to facilitate further manipulation. Fixation can be achieved with a short plate on the concavity of the internal iliac fossa. Then, the injury will be treated as a regular three-fragment fracture.

At the end of the anterior fixation, if the third fragment is well approachable (that means the posterior fracture line is quite high), an attempt to reduce it should be made.

The manoeuvre consists of pushing laterally the posterior margin of the quadrilateral lamina. A picador or the surgeon's finger may obtain the derotation of the distal fragment (normally internally rotated and medialised), if the fragment is mobile enough and the displacement is minimum.

If fluoroscopy shows good reduction of the posterior column, without curved line in the anteroposterior view and with restoration of the greater sciatic notch contour in the iliac view, screw osteosynthesis should be performed.

It is less difficult to insert a long screw into the posterior column from the anterior one than vice versa. The screw (4.5 mm-cortical screw) has to be introduced approximately 2.5 cm above the posterior aspect of the innominate line and has to be directed towards the ischial tuberosity. As this tuberosity is hardly detectable from the endopelvic side, it is recommended to orient the drill to the midpoint of the virtual line that connects the ischial spine with the posterior profile of the obturator foramen (Fig. 5).[19] Attention is paid not to penetrate the greater sciatic notch, to avoid lesions of the sciatic nerve and the gluteal artery. Fluoroscopic assistance is therefore mandatory in the iliac view during drilling. Alternatively it is possible to perform the fixation with two shorter and converging screws, the former directed from an entry point medial to the iliopectineal eminence towards the ischial spine, the latter converging to the previous one from the very posterior part of the internal iliac fossa (sometimes this screw may pass through a hole of the iliopubic plate). The first of those screws is directed to the quadrilateral lamina and might violate the fossa acetabuli.

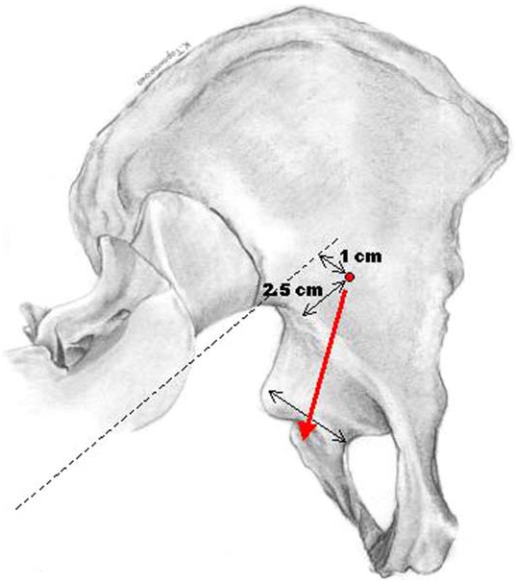

Fig. 5. Landmarks for screw fixation of the posterior column through the ilioinguinal approach. The drill entry point is about 2.5 cm above the pelvic brim and 1 cm anterior to the coronal plane passing through the anterior aspect of the sacrum. The drill should head for the midpoint between the ischiadic spine and the posterior margin of the obturator foramen.

A fluoroscopic view perfectly coaxial to the screw can exclude any true joint line penetration.

Surgeons should remember that in the common case of an unfeasible one-step management of the whole injury, long screws should be avoided, otherwise the manipulation of the posterior fracture line might be difficult in the second procedure.

Conclusions

Both-column fractures are the most complex acetabular lesions. For this reason many surgeons in the past preferred the conservative treatment, convinced that no surgical procedure could really restore the joint anatomy after such a severe injury.[11]

The "secondary congruency" supported this therapeutic orientation, at least until the development of the modern computerised tomography with 2D and 3D reconstructions demonstrated that the fractured acetabulum does not achieve any new congruency. Rotation of the fragments adjacent to the protruded femoral head actually determines a significant interfragmentary gap in the depth of the socket, while the rim is narrowed around the femoral neck like in a "coxa profunda".

The combination of an irregular articular surface with a multidirectional femoro-acetabular impingement justifies poor outcome of the conservative management.

Furthermore, the anatomical disruption of the entire hemipelvis makes future total hip arthroplasty extremely challenging, more than it could be in presence of metal hardware, but with a normal skeletal morphology.[1] For this reason we recommend surgical treatment of all both-column fractures, because a correct procedure can obtain good clinical results and facilitate future prosthetic replacement.

Conflict of interest

None.

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