

The T-Shaped Fractures of the Acetabulum

Omar F Martín^{1*}, Patricia ZA², Miguel Ángel MF³, Aurelio VC³, Jose Antonio VG⁴ and María Ángeles DG⁵

¹Department of Orthopedic Surgery and Traumatology, Hospital de Avila, Avila, Spain

²Hospital Severo Ochoa, Leganes-Spain

³University of Valladolid-Spain

⁴Hospital of Avila, Sacyl-Spain

⁵Hospital Marques de Valdecilla- Spain

Introduction

The T-shaped pelvic fracture represents from 3%-12% 1 of all acetabulum fractures. It is defined as a transverse acetabulum fracture in combination with a vertical fracture that divides the posterior column from the anterior column (Figure 1). Although the T-type fracture affects both columns, it differs by definition from a fracture of both columns in that part of the acetabulum articular surface still remains stably attached to the iliac pelvic ring.

Depending on the height of the transverse fracture line, transtectal fractures (approximately 27%), yuxtatectal fractures (approximately 45%) and infratectal fractures are distinguished (approximately 28%). In most of the cases the vertical fracture goes through obturator foramen (approximately 62%) and only in some occasions anteriorly through the pubic inferior branch (approximately 18%), or posteriorly through the ischiatic tuberosity (approximately 20%) [1].

The management of acetabular fractures has improved greatly over the last 30 years [2]. Non-operative management was preferred by most orthopaedic surgeons until Judet et al. published their paper in 1964 which led to a better understanding of the different types of acetabular fractures [3].

A satisfactory result of the treatment of acetabular fractures requires anatomic reduction, stable internal fixation and early mobilization. The treatment of choice for acetabular fractures with an incongruity greater than 3 mm is open reduction and internal fixation [4].

Letournel reported good outcomes in 75% of operated fractures of the acetabulum observed for 2-21 years. This figure increased to nearly 90% of good or excellent results when the initial reduction was anatomic and maintained, but was only 55% when reduction was imperfect. Procedures using plates, lag screws or both have been advocated for fixation of anterior and posterior column fractures. Optimal position

and amount of internal fixation and the required surgical approach or approaches for both column fractures also are debated [5-8].

Despite the requirement of regaining and maintaining anatomic reduction is essential for the success of the procedure, few studies have been reported to evaluate techniques of fixation. No biomechanical studies *in vivo* have been carried out about the T-type acetabular fracture. In 1995 reports over cadaveric models the results in relation to stability of diverse types of internal fixation needing anterior, posterior or combined surgical approaches for the T-shaped acetabular fracture [4]. The evaluation regarding with did not show differences statistically significant. The anterior column plate provided the highest degree of added stability for the anterior column fracture line, although differences were not statistically significant. Same was found for the posterior column fracture line with the posterior column plate. Each plate or combination stabilized the inferior fracture line similarly. This study attempted to evaluate an unstable T-type acetabular fracture in a physiologic manner. The authors performed a load of approximately 10% of bodyweight. This is the load that might be anticipated during rehabilitation in the hip of a patient after open fixation of an acetabulum fracture. The displacements evaluated did not differ between the three types of fixation at each of the 3 fracture sites. These results suggest that either an anterior or posterior plate provides equivalent stability compared with a combination of anterior and posterior plates. Perhaps the fracture line that includes more of the articular surface or most displaced should influence what type of plate is used, if anterior or posterior. Therefore, the approach the surgeon is most familiar with should influence the decision to use and anterior or posterior plate.

We have to take into account that operative procedures carry risks of infection, deep vein thrombosis, nerve palsy, and heterotopic ossification among others. Specific problems associated with internal fixation include intraarticular penetration of screws or loss of fixation, which may lead to the rapid development of osteoarthritis or chondrolysis [9,10].

Treatments

Accuracy of the fracture reduction may be considered as the main problem of reduction of a displaced T-shaped fracture of the acetabulum. To show that approaching the pubo-acetabular fragment to reconstruct the pelvic brim is important for the reduction these kind of fractures

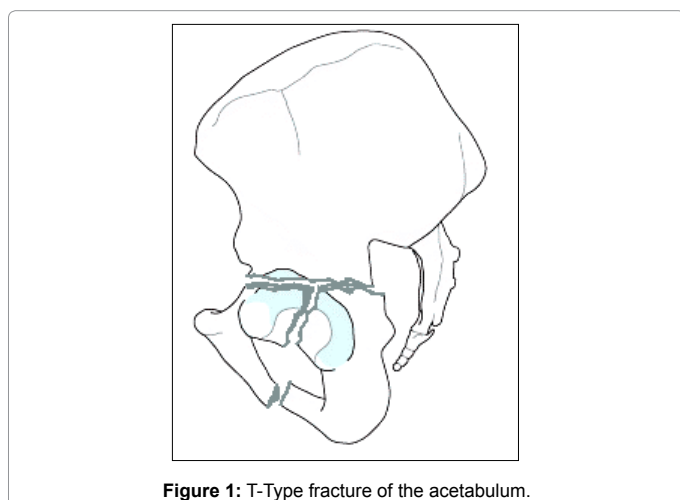


Figure 1: T-Type fracture of the acetabulum.

*Corresponding author: Omar F Martín, Department of Orthopedic Surgery and Traumatology, Hospital de Avila, Avila, Spain, Tel: +34630081151; E-mail: ofmartin@msn.com

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[11]. The interventions did not include restoration of the pelvic brim. The radiological assessment result showed a displacement of the pubo-acetabular fragment including the medial wall in all cases. In other prospective study the pubo-acetabular fragment was anatomically reduced and fixed to the anterior column of the acetabulum to restore a disrupted pelvic brim. A second surgical exposure confirmed the intraoperative x-rays appearances. A spontaneous reduction of the ischio-acetabular fragment was achieved in most of the patients and the hip was stable in all of them. A good reduction of the ischio-acetabular fragment to the posterior column was performed by ligamentotaxis and addressing the ischio-acetabular fragment was not necessary. No heterotrophic ossification or premature osteoarthritis of the hip joint was registered at 5 year follow-up showed that the fracture had healed without. Merle D' Aubigne's hip score showed a "very good" score in all patients. Authors concluded that reduction and fixation of the pubo-acetabular fragment to the anterior column is important for the reduction of a displaced T-shaped fracture of the acetabulum.

The analyzed three types of fixation for T-shaped acetabulum fractures: double column reconstruction plates, anterior column plate combined with posterior column screws, and anterior column plate combined with quadrilateral area screws were chosen for evaluation [12]. The fixation systems were assessed through effective stiffness levels, stress distributions, force transfers, and displacements along the fracture lines. Authors concluded that all three fixation systems can be used to obtain effective functional outcomes but the third one was the optimal method for T-shaped acetabular fracture.

A new clamp that can successfully pull the posterior column back to the anterior column and firmly maintain the reduction was introduced recently to treat three cases of T-shaped acetabular fractures [13]. This clamp's aiming plate can facilitate the insertion of long lag screws and the open reduction and internal fixation of acetabular fractures.

The study described that factors related to a poor outcome were age >40 years, development of avascular necrosis, T-shaped fractures and more of >3 mm residual displacement [12].

In relation to the surgical access, the Kocher- Langebeck approach is used for most of the T-shaped fractures [14,15]. Prone patient positioning on a table is preferred. The anterior column fracture is exposed with longitudinal traction and retraction of the posterior column. As for a transverse fracture the anterior column is reduced with a clamp and fixed with a lag screw. The traction is released, the femoral head is repositioned, and the posterior column is reduced. Palpation of the quadrilateral surface is used to confirm reduction surface. A lag screw is inserted across the posterior column. In order to complete the construct a plate is placed on the retroacetabular surface. When these steps do not make possible the reduction of the anterior column, the posterior column is reduced and fixed, and reposition of the patient would be required for a second-stage anterior approach (ilioinguinal approach) taking into account that the posterior column fixation must not cross into the anterior column.

A modification of the Stoppa approach involving an anterior intrapelvic (AIP) extraperitoneal approach. This exposure permits direct access to the quadrilateral surface, the pubic eminence, the posterior surface of the ramus, the infrapectineal surface, as well as the sciatic buttress, sciatic notch, and the anterior sacroiliac joint. On the other hand this approach, the so-called middle window of the ilioinguinal approach may be avoided, resulting in minimal dissection of the neurovascular structures. The AIP approach is particularly useful for fractures that involve the quadrilateral surface with or without

comminution and medial dislocation of the femoral head. General agreement exists for the use of the modified Stoppa approach for all fractures that can be managed with an ilioinguinal approach [16,17].

In 2010 the comparative results of the operative treatment of the T-shaped fractures of the Acetabulum via Stoppa approach or via surgical hip dislocation (Table 1). The authors considered the Stoppa approach with larger displacement of the anterior column and the surgical hip dislocation approach with larger displacement of the posterior column. A combined approach might be necessary with difficult reduction. Contraindications were fractures of more than 15 days, abdominal problems and suprapubic catheters [1].

The advantages and disadvantages described for each type of approach were:

Surgical hip dislocation approach:

Advantages

- Intermuscular approach low invasive.
- Direct view of articular surface.
- Approach of the superior aspect of the acetabulum.
- Approach of the entire posterior column.
- Additional approach of the anterior column.
- Additional approach of the anterior wall.
- Possibility of treatment of injuries of the femoral head.
- Possibility of primary total hip replacement by the same approach.
- Direct visual exclusion of an intraarticular torsion.

Disadvantages

- It is only possible to achieve a partial reduction of the anterior column.
- A greater trochanter osteotomy is needed.
- A minimum risk of avascular femoral head necrosis exists.

Stoppa approach

Advantages

- Earlier rehabilitation.
- Surgical requirement of this approach is relatively easy and secure.
- Less invasive than the classic ilioinguinal approach or than the extended iliofemoral approach.
- Easy closing of the wound.
- Very reduced tendency to develop heteropic ossifications.
- There is no risk of damaging the sciatic nerve or the lateral femoral cutaneous nerve.
- The risk of damaging the great iliac vessels is low.
- Change to a classic ilioinguinal approach.
- Low bleeding.

Disadvantages

- The internal fixation may be difficult.
- It is only possible to achieve a limited reduction of the posterior column.

Authors	Year	Patients	Follow-up period	Type of Fracture	Treatment	Surgical approach	Methods of evaluation	Results	Complications
Wang et al. [13]	2015	3 patients	Not specified	T-type fractures	Plate and screws.	Ilioinguinal approach	Technical evaluation of new clamp Simple X-ray	Good reduction and stable fixation	None
Fan et al.	2015	3 pelvic model	Not specified	T-type fracture	Double column reconstruction plates, anterior column plate combined with posterior column screws, and anterior column plate combined with quadrilateral area screws (P+QS)	None	Biomechanical evaluation in experimental models	Effective functional outcomes. The third fixation system was the optimal method: anterior column plate combined with quadrilateral area screws	None
Bath et al.	2014	5 patients	2-5 years	T- type fracture	Plate and screws	Not specified	Simple X ray evaluation and Merle functional score	3 fair and 2 poor results	Not specified
Lao et al. [21]	2011	Case report	2 years.	Anterior hip subluxation following fixation of a T-shaped acetabular fracture	Ilioischiatric screw and an AO reconstruction plate in neutralization.	Extended iliofemoral approach	Simple X ray evaluation and CT	Fracture union 7 months after the initial accident as well as absence of a joint congruence defect and heterotopic ossifications.	Lateral subluxation. post-traumatic osteoarthritis 2 years after the initial accident.
Tannast et al.[1]	2010	17 patients	3,2 years	Displaced acetabular T-type fractures. 3 cases with central hip dislocation	Plate and screws.	Surgical hip dislocation: 10 patients. Stoppa approach: 2 patients Combined approach: 5 patients	Simple X-ray evaluation according to Matta's criteria	Anatomic reduction was achieved in ten of the twelve patients (83%) without primary total hip arthroplasty.	One delayed trochanteric union, one heterotopic ossification and one loss of reduction. There were no cases of avascular necrosis. In two patients, a total hip arthroplasty was performed due to the development of secondary hip osteoarthritis.
Porter et al	2008	323 patients, 20 of them with T-Type acetabular fractures	4-8 years	20 T-type displaced acetabular fractures	Not specified	Not specified	Evaluation of the visceral organ injuries.	-Vascular 10% -Upper Extremity fracture 15% -Spleen 15% -Spine fracture 30% -Retroperitoneal Hematoma 35% -Lung 30% -Liver 5% -Low extremity fracture 40% -Kidney 5% -Brain 5% -Bowel 5% -Bladder 5%	Evaluation of the visceral organ injuries.
Hirvensalo et al. [16]	2007	14 patients of a total of 164 patients with acetabular fractures	3,9 years	14 T-type acetabular fractures	Open reduction and internal fixation with plates and screws	Standard Anterior approach (most of the cases) / and posterior approach combined.	Harris Hip Scale and CT evaluation.	Not specified for T-Type fractures; good reduction in 84% of all patients, with a Harris Hip Score "Good" in 75%.	Not specified
Stökle et al.	2000	50 patients, 2 of them with T-Type acetabular fractures.	2 years	2 T-type displaced acetabular fractures	Open reduction and internal fixation; with cortical screws of 5.5 mm.	Not specified	Simple X ray and clinical evaluation and CT scan evaluation	Anatomic reduction (< 1mm) for the T-Shaped fractures.	Not specified

Harrnon	2000	Group 1: 22 patients Group 2: 15 patients	Group 1: 10-25 years Group 2: 5 years.	37 T-type acetabular fractures	Open reduction and internal fixation Group 1: posterior column plate. The pelvic brim was not restored. Group 2: anterior column 3, 5 mm reconstruction plate. In 1 case, one additional plate at the anterior column. The pelvic brim was restored.	Group 1: posterior approach. Group 2: ilioinguinal approach-Kocher-Langenbeck approach.	Simple X ray and clinical evaluation (Merle D'Aubigne's hip score)	Group 1 Displacement of the pubo-acetabular fragment in all cases Group 2 : Fracture healed without heterotopic ossification or premature osteoarthritis. "Very good" clinical score	Group 1 Not described. Group 2. A broken plate at the anterior column.
Fica et al.[2]	1998	8 patients of a total of 84 patients with acetabular fractures.	5.5 years	Displaced acetabular T-type fractures.	Plate and screws.	Kocher-Langenbeck Extended iliofemoral Ilioinguinal	Clinical evaluation :Merle D'Aubigné's scale Simple X-ray evaluation according to Matta's criteria	Clinical outcome Poor: 6 patients Good: 2 patients X-ray evaluation: no described	T-shaped fractures having the worst clinical outcome. No complications specified
ChiBoub et al.	1998	52 patients	3.5 years	11 T type fractures. 41 transverse fractures. All of them associated with posterior column fracture	Open reduction and internal fixation: posterior plate in 17 cases and only screws in 5 cases. Conservative treatment in the rest of the patients	Kocher-Langenbach approach.	Simple X ray and clinical evaluation (Merle D'Aubigne's hip score)	Surgical treatment: Good or very good functional outcomes: 68, 2%. Anatomic congruence: 50% Conservative treatment: Good or very good functional outcomes: 63. 33%. Anatomic congruence: 47% The conservative and surgical results are the same without anatomic reduction	Surgical group: 2 infections, 1 iterative luxation of the femoral head, peroneal palsy in 2 cases. Conservative treatment: thrombophlebitis, 3 cases of superficial infection.
Simonian et al. [4]	1995	8 cadaveric hemipelvic specimens.	No data.	T-type acetabular fracture.	Plate and screws: -single anterior column plate - single posterior column plate -Both anterior and posterior column plates.	No needed: cadaveric hemipelvic specimens	Specimens were loaded 25 times in a cyclic manner to 150 N for each type of fixation evaluated.	No significant differences were founded in displacement of fracture fragments neither in the control of the inferior fracture line	Not described
Roffi and Matta	1993	three patients	18 months - 8 years	2 associated T-type posterior wall fractures 1 T-type fracture. Unrecognized posterior dislocation of the hip associated.	Open reduction and internal fixation; plate and screws.	Not described.	Simple X ray and clinical evaluation	Avascular necrosis of femoral head in one case. Good clinical and radiological outcomes in the other two cases	Total hip replacement in one case. Peroneal palsy (resolved) in one case. Partial sciatic nerve palsy (unresolved) in one case.

Table 1: summary of the main studies about the t-shaped fractures of the acetabulum.

- Visualization of the intraarticular damage is not possible.
- A simultaneous implantation of a total hip replacement is not possible through the same approach.

The case of an anterior hip subluxation following fixation of a T-shaped acetabular fracture through an extended iliofemoral approach. The substantial muscle exposure of the lateral aspect of the acetabulum and the circumferential capsulotomy related to the use of the iliofemoral approach were retained as factors promoting this complication. In case early postoperative mobilization is impossible, temporarily maintaining the limb in abduction and flexion can be recommended after an extended iliofemoral approach

with circumferential Capsulotomy [18-21].

Conclusion

Our literature review reveals that one of the main goals in the surgery of the fractures of acetabulum must be the anatomical reconstruction of the articular surface [22,23]. Not all complex fracture types have the same outcome, T-shaped fractures having the worst clinical results. Male gender, the use of an extensile approach, trochanteric osteotomy, presence of extensive cartilage injury, need of a complementary second approach, T-shaped fracture, or concomitant abdominal, chest, or head injury are associated with the formation of heterotopic ossification [12].

Surgical indications for acetabular fractures are: joint incongruency (>2 mm displacement), intrarticular fragments, hip joint subluxation or instability, posterior wall fracture with hip instability, roof arc measurement less than 45° on any simple Rx or progressive neurologic damage [24].

Nowadays, surgical indication with ORIF is the more frequently used. Non-surgical treatment is not preferred due to the longtime of weight bearing, inability to restore joint congruity surface and higher incidence of early hip osteoarthritis. In elderly patient, sometimes ORIF with percutaneous osteosynthesis is the main indication due to patients comorbidities although reduction of the fracture is not a perfect result [25,26].

ORIF allows surgeons to obtain anatomical reduction of the fracture, stable internal fixation and permit early mobilization of the joint. ORIF is more difficult as more complex is the fractures to reduce and this is the main reason of poor results in outcomes for beginners surgeons [26].

Trauma centres should designate a group of surgeons who will consistently treat these fractures in order to obtain more experience and better results. Acetabular surgery is demanding, and a high rate of complications can be expected.

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