

SURGICAL TREATMENT OF UNSTABLE PELVIC RING FRACTURE IN SKELETALLY IMMATURE PATIENTS

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ABSTRACT

Objectives: To present the outcomes from definitive surgical treatment for unstable fractures of the pelvic ring in children undergoing surgical reduction and stabilization. **Methods:** We studied 10 patients with immature skeletons who suffered unstable fractures of the pelvic ring and were treated between March 2004 and January 2008. The study was retrospective, based on clinical and radiographic evaluations. **Results:** The mean age at the time of the trauma was 8.8 years (2 to 13 years). Seven patients were female and three was male. There were eight cases of trauma caused by being run over, and one case each of a motorcycle accident and falling from a height. Five patients had other associated injuries such as fractures of the clavicle, femoral diaphysis, proximal humerus, lower leg bones, olecranon and bladder injury.

All the patients evaluated showed an excellent clinical outcome. The pelvic asymmetry before surgery ranged from 0.7 to 2.9 cm (mean 1.45 cm), and dropped to values between 0.2 and 0.9 cm (mean 0.39 cm) after reduction. In no case was any change observed in pelvic asymmetry measured in the immediate postoperative period and at the end of follow-up. **Conclusion:** Pelvic ring fractures in skeletally immature patients are rare and surgical treatment is unusual. Several authors have questioned conservative treatment because of the complications encountered. Bone remodeling does not seem enough to cause an improvement in pelvic asymmetry, and this justifies the choice of surgical treatment for reduction and correction of pelvic ring deformities.

Keywords – Fracture Fixation; Child; Pelvis

INTRODUCTION

Fractures of the pelvic ring in skeletally immature patients are relatively rare and represent less than 0.2% of all pediatric fractures and 1 to 5% of the admissions in tertiary centers for child trauma^(1,2). They are generally caused by high-energy trauma and are often associated with other organic lesions (genitourinary tract, abdominal viscera, central nervous system, neurovascular structures and musculoskeletal structures)⁽³⁾.

Despite their relatively low incidence, pelvic lesions in children give rise to high rates of morbidity and mortality⁽⁴⁾. One postmortem study that evaluated 66 trauma-related deaths among children found that pelvic fractures and severe hemorrhage occurred in 42% of the cases as the cause of death. Like in adults, retroperitoneal hemorrhage is the worst complication in unstable fractures of the pelvis⁽⁵⁻⁷⁾.

Compared with adults, children with pelvic ring

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fractures have greater survival when associated lesions are present, and this represents greater socioeconomic cost and long-term morbidity. In a prospective study on 95 children who suffered pelvic ring fractures, the locomotion capacity and dependence of these patients was assessed. The results showed that 80% of the patients had unstable fractures, and that 52% of the patients with stable fractures were dependent on help for locomotion⁽⁷⁾.

Conservative treatment for pelvic ring fractures in children, by means of rest, skeletal traction and plaster casts, has been recommended because of the potential for lesion correction through bone remodeling that occurs within this age group. However, many cases evolve unfavorably because of the potential complications, characterized by pelvic asymmetry, nonstructural scoliosis, lumbalgia, dysmetria of the lower limbs and claudication during gait. For some lesions in which significant displacements occur, especially the presence of sacroiliac dislocation due to vertical instability, or even in cases of accentuated horizontal instability, conservative treatment does not result in achieving satisfactory functioning. The presence of an open triradiate cartilage in children favors remodeling, but the literature still does not present any consensus regarding the best form of treatment for these severe lesions, and much controversy persists concerning which children might benefit from invasive treatment^(1,8). There is no doubt that in emergencies involving cases with hemodynamic instability, in the same way as among adults, the immediate treatment should consist of using an external fixator, with the aim of controlling the bleeding and saving the patient's life, even if this is just temporary treatment. In cases with disjunction of the sacroiliac joint, an anterior external fixator alone will not be sufficient to reduce and stabilize the poster ring^(4,5,9).

The purpose of this study was to present the results from definitive surgical treatment for unstable fractures of the pelvic ring in children who underwent surgical reduction and stabilization on an elective basis, after initial attendance provided at an emergency service.

METHODS

After receiving approval from the research ethics committee, we evaluated 10 skeletally immature patients who had suffered unstable fractures of the pelvic ring and had undergone surgical treatment at the National Institute of Traumatology and Orthopedics of the

Ministry of Health (INTO/MS) between March 2004 and January 2008. The patients selected underwent outpatient clinical assessment and analysis of the pre and postoperative radiographs. All the patients had received their first attendance in other emergency service and had been referred to our institution because of the complexity of the injury, in order to receive definitive treatment. The criteria for including patients in this study were that they should present an unstable lesion in the pelvic ring and radiographic signs of skeletal immaturity, as defined by the presence of the triradiate cartilage of the iliac. Patients with a stable lesion or with a fracture pattern without displacement, either of the ilium or of the sacrum, were excluded from this sample.

The surgical technique used was based on the principle of reduction and stabilization of the anterior and posterior parts of the pelvic ring. The anterior component, whether consisting of fractures of the pubic rami or disjunction of the pubic symphysis, was reduced indirectly through emplacing an assembly consisting of an AO tubular external fixator composed of just two Schanz pins in the supra-acetabular region of each ilium, with the aid of radioscopy, using by means of iliac obturator and wing views. The diameter of the Schanz pins used was chosen according to the patient's bone size. In three cases, the diameter was 5.0 mm, while it was 3.5 mm in the others, because of the dimensions of the pelvis in question, with the corresponding connections and bars for anterior assembly of the external fixator. In just one case was there a need to make an anterior access to the pubic symphysis, in order to carry out direct reduction of the dislocation, because of the length of time over which the lesion had evolved. For this reason, in this case, a plate of one third of the tube of 3.5 mm was used for the bone fixation. With regard to posterior lesions on the ring, the indirect reduction technique by means of anterior manipulation using the pins of the external fixator, in association with longitudinal traction of the lower limb, made it possible to use a cannulated screw that was placed percutaneously into the injured sacroiliac joint. In six cases, the diameter of this screw was 4.0 mm, because the safety margin for its placement was smaller due to the dimensions of the immature bone. In three cases, the cannulated screw presented a diameter of 7.0 mm, since these were older children in whom the size of the pelvis would support this dimension. In just one case, in which the posterior lesion was a "growing" fracture of the iliac wing, anterior fixation with

the supra-acetabular assembly of the external fixator was used on its own, with bone consolidation occurring without loss of the reduction that had been obtained. The assembly of the anterior external fixator was removed after six to eight weeks, after obtaining radiological proof that fracture consolidation had been achieved. In all the nine cases in which a cannulated screw was used for posterior stabilization of the sacroiliac joint, this implant was not removed.

This was a retrospective study based on evaluating the medical files and carrying out clinical and radiographic assessments on the patients after a mean follow-up interval of 808.83 days after the initial trauma. The outcome from the study was based on radiographic quantification of the residual pelvic asymmetry after the surgical treatment, through using the method of Keshishyan *et al*⁽⁵⁾ (Figure 1) to compare the pre and postoperative findings. In this method, the pelvic asymmetry is determined as the difference in centimeters between two diagonal lines traced out from the edge of the sacroiliac joint to the contralateral triradiate cartilage. From these measurements, asymmetry of up to 4 mm is considered to be within the normal anatomical variation, which might occur because of rotation of the pelvis at the time of producing the radiograph. However, variation of more than 5 mm should be considered to be an abnormality⁽⁶⁾. The pelvic asymmetry was also correlated with the deformity index, which is the difference between the two diagonals divided by their sum, in order to ensure that the error due to rotation of the pelvis on the anteroposterior radiograph was a minimum.

The patients were analyzed clinically by means of interviews and physical examinations. We evaluated the range of motion and abducting strength of the hip joint, displacements of the spine, neurological sequelae, gait characteristics and the existence of reported pain or pain on palpation of the pelvis. These data were correlated with the radiographic findings from the patient.

RESULTS

Among the patients evaluated, seven were female and three were male. Their mean age at the time of the trauma was 8.8 years (range: two to 13 years). The patients underwent the operation on average 11.9 days after the fracture occurred (ranging from four to 29 days). In eight cases, the initial trauma was caused by being run over, while there was one case each of a motorcycle accident and falling from a height. The osteoarticular

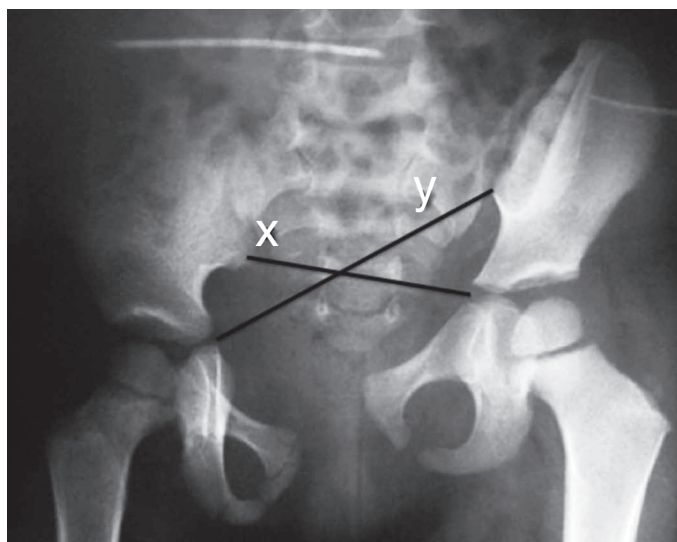


Figure 1 – Method for measuring pelvic tilt described by Keshishyan *et al*⁽⁵⁾, in which the pelvic asymmetry is the difference between the diagonals ($X - Y$ cm). The deformity index corresponds to the difference between the diagonals ($X - Y$ cm) divided by the sum of the diagonals ($X + Y$ cm).

lesions encountered in the pelvic ring were divided into anterior and posterior types. Disjunction of the pubic symphysis was present in five patients, fractures of two pubic rami in three and fractures of four rami in two. In six cases, the posterior lesions corresponded to unilateral dislocation of the sacroiliac joint; in one, there was a unilateral fracture of the posterior ilium; in one, there was unilateral anterior opening of the sacroiliac joint; in one, there was dislocation of the sacroiliac joint on one side and compression on the other, resulting from lateral compression; and in one, there was bilateral dislocation of the sacroiliac joints. The trauma mechanism was considered to be lateral compression in three cases, anteroposterior compression in two and vertical shearing in five. The AO-OTA classification⁽¹⁰⁾ was used to evaluate the patients, with the following distribution: 61 B1 (one case); 61 B2 (one case); 61 C1 (six cases); 61 C2 (one case); and 61 C3 (one case) (Table 1). All the patients received their initial attendance in another healthcare unit and were transferred to our hospital after clinical stabilization had been achieved. Five patients presented other associated lesions, among which there was one case of fracture of the clavicle that was treated without surgery involving external immobilization. One patient presented a diaphyseal fracture of the femur that was treated with flexible intramedullary rods. One patient presented a fracture of the proximal humerus and fractures of the bones of the lower leg ipsilateral to the pelvic lesion: the upper limb was treated conservatively

and the tibia was fixed with flexible intramedullary rods. A fracture of the olecranon in the patient who suffered a fall from a height was treated by means of osteosynthesis using a tension band. A patient who presented a concomitant lesion of the bladder that was diagnosed by means of exploratory laparotomy during the initial attendance evolved to a urinary infection during the hospitalization.

The main complication from the method was the presence of three cases of superficial infection along the path of the Schanz pins in the anterior assembly of the external fixator, which completely regressed after the pins had been removed. The patients kept the external fixator for an average of 40.5 days (range from 28 to 48 days). The length of hospital stay ranged from two to 14 days, with a mean of 3.8 days. All the patients evaluated presented excellent clinical evolution, which was observed during the control consultations. None of the cases evolved with pelvic pain, gait abnormalities, discrepancy between the lower limbs or scoliosis, in

the physical examinations. No vascular or neurological lesions resulting from the use of a cannulated screw in the sacroiliac joint were detected.

Regarding the radiographic evaluation, the pelvic asymmetry before the surgical procedure ranged from 0.7 to 2.9 cm (mean of 1.45 cm), and it fell to values between 0.2 and 0.9 cm (mean of 0.39 cm) after the reduction. The minimum evolution period assessed was 210 days and the maximum was 1,896 days (Table 2). In no case was there any change in pelvic asymmetry measured, between the immediate postoperative period and the end of the follow-up, thus showing that insufficient bone remodeling to change this measurement had occurred, over the period studied (Figure 2).

DISCUSSION

Unstable fractures of the pelvic ring in children are relatively rare and result from high-energy trauma. In our sample, being run over on public roads was the main

Table 1 – Clinical data on the patients.

Case	Age (years)	Sex	AO-OTA classification	Trauma mechanism	Posterior lesion	Anterior lesion	Cause of accident	Associated lesions
1	2	Fem	61 C1	Vertical shearing	Sacroiliac dislocation	Disjunction of symphysis	Run over	None
2	13	Fem	61 B1	Anteroposterior compression	Anterior sacroiliac opening	Fracture of four rami	Motorcycle accident	None
3	8	Fem	61 B2	Lateral compression	Sacroiliac dislocation	Fracture of two rami	Run over	None
4	4	Fem	61 C1	Vertical shearing	Sacroiliac dislocation	Disjunction of symphysis	Run over	Fracture of femur
5	7	Male	61 C1	Vertical shearing	Sacroiliac dislocation	Disjunction of symphysis	Run over	Fracture of clavicle
6	6	Fem	61 C1	Vertical shearing	Sacroiliac dislocation	Disjunction of symphysis	Run over	None
7	13	Male	61 C2	Lateral compression	Sacroiliac dislocation +anterior compression (bilateral)	Fracture of two rami	Run over	Lesion of bladder
8	10	Male	61 C1	Vertical shearing	Posterior iliac fracture	Fracture of two rami	Run over	None
9	12	Fem	61 C3	Lateral compression	Sacroiliac dislocation (bilateral)	Fracture of four rami	Run over	Fracture of humerus + fracture of tibia
10	13	Fem	61 C1	Vertical shearing	Sacroiliac dislocation	Disjunction of symphysis	Fall from height	Fracture of olecranon

Table 2 – Results from treatment instituted.

Case	Time between accident and surgery (days)	Surgery performed	Preoperative pelvic asymmetry(cm)	Postoperative pelvic asymmetry (cm)	Preoperative deformity index (Keshishyan)	Postoperative deformity index (Keshishyan)
1	16	Symphysis plate + sacroiliac screw	1.7	0.2	0.2	0.02
2	5	External fixator + sacroiliac screw	0.7	0.3	0.06	0.02
3	11	External fixator + sacroiliac screw	1.8	0.3	0.17	0.04
4	6	External fixator + sacroiliac screw	1.2	0.5	0.15	0.04
5	14	External fixator + sacroiliac screw	1.2	0.2	0.09	0.03
6	14	External fixator + sacroiliac screw	1.5	0.6	0.09	0.05
7	29	External fixator + sacroiliac screw	2.9	0.9	0.15	0.09
8	12	External fixator	0.8	0.2	0.12	0.01
9	8	External fixator + bilateral sacroiliac screws	1.5	0.5	0.07	0.03
10	4	External fixator + sacroiliac screw	1.2	0.2	0.09	0.03

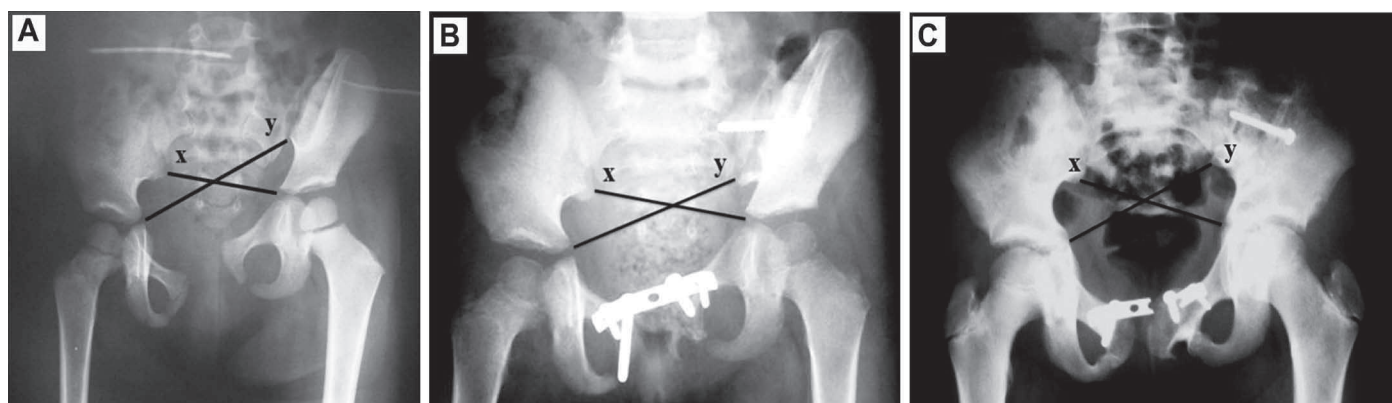


Figure 2 – Two-year-old girl presenting dislocation of the left-side sacroiliac joint and disjunction of the public symphysis. Panoramic AP radiographs of the pelvis: A) before operation, asymmetry = 0.7 cm; B) immediate postoperative period, asymmetry = 0.3 cm; C) after six years of evolution, showing consolidation and absence of abnormalities.

cause. Just as occurs with pelvic ring injuries in adults, they are accompanied by other lesions that present high morbidity and mortality^(8,11). Nonetheless, little is known regarding the long-term evolution of these lesions. The profile of the children studied was similar to what has been reported in the literature, except for the distribution according to sex. Although such lesions occur more frequently in boys, seven of our ten cases (70%) were in girls. The most frequent cause of the fracture was being run over on public roads, which is in agreement with what was reported by Signorino *et al*⁽⁴⁾, who found that the commonest causes were being run over and traffic accidents. They explained that high energy was needed to cause this damage to the pelvis in children, given that their bones are more plastic than those of adults and absorb more of the energy generated in the initial impact. This capacity among children is also reflected in the lower mortality following high-energy trauma that causes a pelvic ring injury: statistically fatal injuries occur in 5% of such cases in children and 17% in adults⁽⁹⁾.

Several studies⁽¹²⁻¹⁵⁾ have analyzed the long-term evolution of unstable and stable lesions of the pelvic ring that were treated conservatively. Schwarz *et al*⁽¹⁶⁾ reported that 47% of the cases presented poor results because of pelvic asymmetry and emphasized the importance of obtaining an anatomical reduction. They concluded that unstable fractures of the pelvic ring that were treated conservatively evolved with unacceptable functional results. Other authors^(3,13,17) presented cases of unstable fractures of the pelvic ring that were treated non-surgically and evolved with unsatisfactory results, with residual pain in the posterior region of the pelvis, discrepancy in the lower limbs, Trendelenburg sign and lumbar scoliosis, due to residual pelvic asymmetry.

None of the cases treated surgically in our sample evolved with residual pain, gait abnormalities or any other abnormality on physical examination. Our study presents the limitation that the sample was relatively small in size, but because this is a rare fracture that affects around one in 100,000 children per year, we believe that the sample is relevant, since no large published series on surgical treatment for this lesion exist. Our results encourage us to continue to indicate surgical treatment for cases in which there is pelvic asymmetry greater than 0.5 cm and, especially, when associated dislocation of the sacroiliac joint is present, which would be unlikely to evolve satisfactorily without surgical measures. The decision to use posterior fixation together with a cannulated screw in the sacroiliac joint was based on the facts that this technique is noninvasive, provides adequate mechanical stability in the posterior part of the ring and has been shown to be a safe and reproducible method in children, since application of an anterior external fixator on its own is unable to control the posterior elements of the pelvic ring⁽¹⁸⁾ (Figure 3). Smith *et al.*^(1,3) showed in their sample that patients treated with combined anterior and posterior reduction and fixation presented smaller residual pelvic asymmetry than did the patients treated with anterior external fixation alone.

The dimensions of the screw and Schanz pins of the anterior assembly of the external fixator should be adapted to the dimensions of the bones of the child in question. A cannulated screw of 4.0 mm was shown to be sufficient to stabilize smaller pelvises, in which the safety margin for the sacroiliac joint was too small to use a diameter of 7.0 mm. In the same way, Schanz pins with a diameter of 3.5 mm made it possible to emplace the anterior assembly of the external fixation in the cases

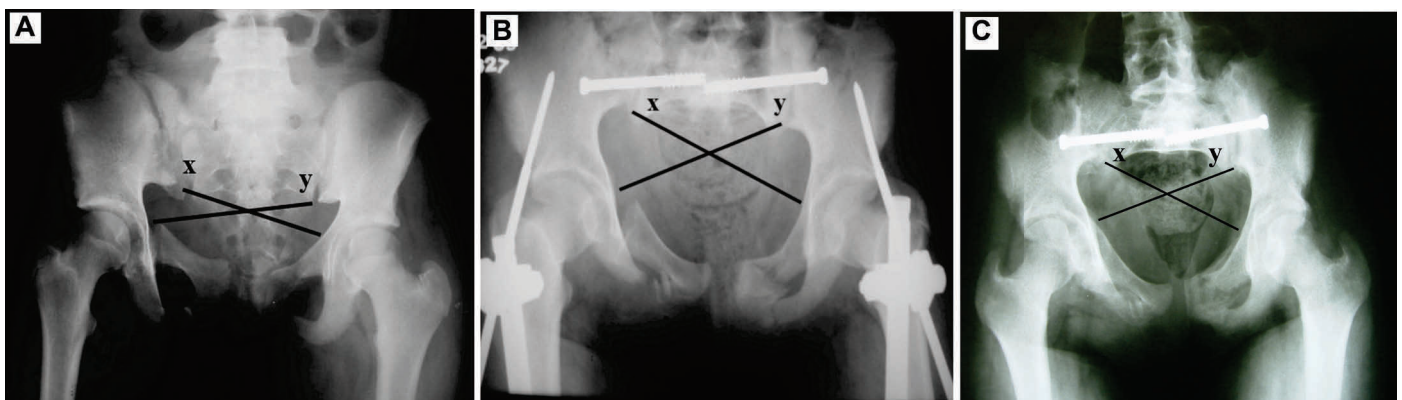


Figure 3 – Twelve-year-old girl who was a victim of being run over, presenting dislocation of the sacroiliac joint bilaterally and fractures of the pubic rami. Panoramic AP radiographs of the pelvis: A) before operation, asymmetry = 1.5 cm; B) immediate postoperative period, asymmetry = 0.5 cm; C) after three months of evolution, asymmetry = 0.5 cm.

in which the dimensions of the ilium did not allow a larger pin diameter in the supra-acetabular region.

CONCLUSION

Pelvic ring fracture in skeletally immature patients is a rare event, and an indication for surgical treatment is unusual. Several authors have questioned the use of conservative treatment, which has been recommended for treating these fractures for many years. Their

concerns relate to the complications encountered, especially discrepancy in leg length and residual pain in the sacroiliac joint. The bone remodeling that normally occurs in growing children does not seem to be sufficient for there to be an improvement in the pelvic asymmetry. This provides justification for the decision to use surgical treatment for reduction and correction of deformities of the pelvic ring at an early stage, at the time of the lesion.

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