Transcondylar traction as a closed reduction technique in vertically unstable pelvic ring disruption

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Abstract Little information is provided in the literature describing an efficient reduction technique for pelvic ring disruption. The aim of this study is to assess the use of the transcondylar traction as a closed reduction technique for vertically unstable fracture-dislocations of the sacro-iliac joint. Twenty-four pelvic ring disruptions were treated with attempted closed reduction followed by percutaneous screw fixation. Transcondylar traction was used as a closed reduction technique. Closed reduction to within 1 cm of residual displacement was obtained in all cases. No incidence of infection, digestive, cutaneous, or vascular complications occurred. We observed secondary displacement in three patients. Correction of the vertical displacement is better achieved when performed within 8 days after the trauma. Two posterior screws and a complementary anterior fixation is typically required to avoid further displacement in case of sacral fractures. However, an open approach should be preferred in both cases of crescent iliac fracture-sacroiliac dislocation and transforaminal fracture associated with peripheral neurological deficit. A vertical sacral fracture should make the surgeon more wary of fixation failure and loss of reduction.

Résumé Introduction: peu d'informations sont données dans la littérature sur les techniques de réduction des ruptures de l'anneau pelvien. Le but de cette étude est d'évaluer l'utilisation d'une traction transfémorale pour les

fractures-luxations instables de l'articulation sacro-illiaque. Matériel et méthode: 24 ruptures de l'anneau pelvien ont été réduites par traction transcondylienne puis synthésées par vissage percutané. Résultat : une réduction a été obtenue avec un déplacement résiduel maximal de 1 cm dans tous les cas. Il n'y a pas eu de problème d'infection, de complication digestive, cutanée ou vasculaire. Nous avons observé trois déplacements secondaires. Discussion: la correction des fractures luxation verticales donne un meilleur résultat si elle est réalisée avant huit jours. Deux vis postérieure et une fixation antérieure complémentaire sont typiquement nécessaires pour éviter des déplacements secondaires, dans les cas de fractures sacré. Cependant un abord chirurgical peut être préféré dans certains cas associant une disjonction sacro iliaque associée à une fracture iliaque ou en cas de fracture sacrée transforaminale associée à des troubles neurologiques. Une fracture sacrée verticale est à haut risque d'échec de fixation et de perte de réduction.

Introduction

Displaced fractures of the pelvic ring associated with either a vertical fracture of the sacrum or disjunction of one or both sacro-iliac joints represents challenge for reduction and fixation [5, 18, 20]. These fractures are better managed by internal fixation with open reduction under direct vision [7, 18]. However, this type of approach is rarely possible in an emergency and percutaneous insertion technique is an alternative treatment that offers several advantages with benefits of lower blood loss and reduced infection rates [12, 16]. Stable and safe internal fixation can be achieved only after an accurate reduction [13, 17]. However, achieving a reduction in difficult cases without opening the fracture site can be problematic, thus limiting the possibility of using the

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percutaneous technique [18]. Little information is provided in the literature describing an efficient and reproducible reduction technique. Aware of the potential advantages this technique would offer, we propose a reduction method for displaced pelvic ring fractures that avoids an open approach or the use of an external pelvic fixator. This technique produces anatomical reductions in severe displaced fractures, therefore increasing the indications for percutaneous screw usage.

Surgical procedure

It is well known that a percutaneous screw can be inserted safely only when the displacement is completely reduced [12, 13]. Reduction is the first and most important step. The patient was brought to the operating theatre and placed in the supine position on a standard radiolucent table. Muscle relaxation is a necessity during surgery. We attached a traction system laterally to the standard table (Fig. 1). This traction system must not interfere with the fluoroscopy and care must be taken to ensure that the table pedestal does not prevent the fluoroscopic C-arm from accessing the outlet views with the patient in the supine position. Depending on the table, the patient may need to be moved down to obtain good images, even for taller patients whose feet extend beyond the table. Reduction is obtained by traction along the femoral axis while blocking the trunk and the contralateral leg. The trunk and contralateral foot are blocked, so the traction is able to reduce the pelvis fracture without the use of a perineal post. The only mobile part

should be the ipsilateral lower limb. Transcondylar traction with slight knee flexion (30 to 45°) is necessary to obtain a correct reduction. In some cases, a small amount of hip flexion (10 to 30°) can further improve the reduction.

Under fluoroscopy, the reduction is achieved by applying increased traction along the femoral axis. The amount of the reduction is assessed on the anteroposterior view and also on the inlet and outlet views. When reduction is obtained, the pelvis is draped after bandaging, following the technique described by Routt [12]. Traction is maintained during the entire procedure. The portal is better managed with a lateral view by applying the drill on the iliac bone. The screw should be directed perpendicular to the outer surface of the table from this entry point. Advancement of the drill is checked in the inlet and outlet views. When reduction is maintained with the screws, the traction is removed and AP X-rays with two Pennal views are obtained.

Materials and methods

Between 1995 and 2003, 24 C-type pelvic fractures were treated consecutively using the closed reduction technique. The series comprised 12 women and 12 men with a mean age of 32 years (range: 16–70 years). All cases resulted from a high-velocity injury. Using the AO criteria for fracture classification, the series contained 10 C-1-2, 11 C1-3, 3 C-2. The lesion was isolated three times. Of the cases with multiple injuries, six included a femoral fracture, three included a fracture of the shank, six included a foot fracture, five

Fig. 1 Reduction technique by transcondylar traction. The contralateral foot is blocked with a distal foot rest. Above the thigh, a U inverse rest prevents knee flexion. When the contralateral leg is firmly fixed to the table, the trunk must be immobilised with two thoracic rests on

each side. The only mobile part should be the ipsilateral lower limb under the pelvic fracture. Hip and knee flexion is helpful in obtaining reduction of the fracture

included a spinal fracture (two neurological, three non-neurological), and five included upper extremity fractures. With regard to urological lesions, there was one sub-Interstitial bladder rupture, one ureter rupture, one urethra rupture, and two bladder ruptures. In six patients, neurological sacral injuries were noted at the beginning of treatment.

Total operating room time for percutaneous stabilisation of the pelvic fractures was 56 min on average (range: 32–80 min). On average, the operation was performed on the fourth day (range: 0–17). We used isolated percutaneous screws in 15 cases and percutaneous screws associated with an anterior fixation in nine cases. The screws were inserted first and then the pubis symphysis was stabilised when necessary. The anterior fixation method included four and six hole plates on the pubis.

The type of screws used included non-cannulated screws at the beginning (Venable screws), then we used the 6.5-mm ASNIS screws (Howmedica, Rutherford, NJ, USA) in 18 cases. A single screw was used in 11 cases and two screws were inserted into S1 body in 13 cases. Twenty-two of the patients were followed up and the mean follow-up was 4 years (range 10–96 months). Two were lost at the last follow-up but pre- and post-operative X-rays were available. Functional results were evaluated following the criteria from the Majeed score [6].

Displacement patterns based on the imaging studies were multiplanar. The inlet, outlet, and AP views were studied and the displacement was quantified according to the greatest deformity (Fig. 2). The greatest deformity was typically cephalad migration, more than flexion deformities or posterior translation. Therefore, the analysis was performed only on the vertical displacement, which was measured in the radiographic evaluation on the anteroposterior view. Three landmarks were considered on each half part of the pelvis. The right and left landmarks were measured from a central line, determined from the spine axis, and reported in millimeters on the preoperative, postoperative, and at the last follow-up. The landmarks were the iliac crests, sacro-iliac feet, and U radiological feet. The differences in height between the right and left sides for the three landmarks were averaged. This composite measurement was statistically compared between preoperative, postoperative, and follow-up states. As with the pre-operative deformities, the same imaging studies (AP views) were used post operatively to evaluate the reduction critically.

A linear regression analysis was used to measure the relative association between the Mageed score and the final displacement and between the Mageed score and the surgical delay. A Fisher exact test was used to compare the difference between preoperative, postoperative, and follow-up states.

Fig. 2 Measurements technique. Using an anteroposterior view for the vertical displacement (a) and an inlet view for the posterior displacement (b), right and left landmarks were measured from a central line, determined from the spine axis, and reported in millimeters of displacement on the preoperative, postoperative, and

the last follow-up evaluation. The landmarks were the iliac crests, sacro-iliac feet, U radiological feet. The differences in height between the right and left sides for the three landmarks were averaged and compared

Results were considered significant at 95% confidence interval (CI) level for all statistical analyses.

Results

Radiological results

The average preoperative displacement was 16.7 mm (range:1.6–42.6 mm, SD:10.2). The average amount of reduction gained was 13 mm (range:0–42 mm). There was a significant decrease in the displacement ($p < 0.001$), which was maintained in time (Fig. 3). All 24 of the patients who underwent a preoperative traction had an excellent postoperative reduction on the posterior lesion. There was a statistical correlation between the quality of reduction and the surgical delay using a linear regression test (Fig. 4). The functional outcome according to the Mageed score decreased with the vertical displacement at the last follow-up but it was not statistically significant (Fig. 5).

Clinical results

The average score of Mageed was 80 (range:48–98; SD:16). Two patients were lost during follow-up. Nine patients are pain-free and ten have mild or intermittent pain with normal activities. Two patients also have pain when seated for an extended period of time. Six patients experienced occasional hardware pain. They underwent hardware removal at least 9 months after the injury. Each time an improvement of this pain was noted by the patient.

Fig. 3 Pre-operative, postoperative and last follow-up vertical displacement measured on AP views. Values are means+standard deviations

Fig. 4 Variation of post-operative vertical displacement (mm) compared to the variation of surgical delay (days) using the linear regression model. The procedure is dependent on early operative intervention, especially in patients with severe posterior pelvic deformities. Early operative intervention improves the reduction accuracy

Of the 22 patients who were followed-up until fracture union and who were working before their injury, 19 have returned to work. Six of these have returned to less strenuous jobs, and 13 have returned to their previous employment. Nineteen patients are ambulatory without assistive devices. Normal gait was observed in 18 patients, one walks with a slight limp, and one uses crutches.

Although preoperative and post-operative neurological examination was accomplished for all patients, peripheral neurological examination was difficult to quantify in those

Fig. 5 Variation of functional outcome (Mageed score) compared to the variation of the last follow-up vertical displacement (in mm) using the linear regression model. The functional outcome decreased with the amount of vertical displacement at the last follow-up

patients with cranio-cerebral or spinal cord trauma (ten patients). With regard to mobility, one patient was paraplegic due to a spinal cord trauma, one had a complete plexus paralysis preoperatively which did not recover neurologically after surgery. A laminectomy was performed 2 days later to explore and decompress nerve roots that were sectioned. The others patients recovered only partially (three sensory loss, five sexual or urological problems).

Complications

On postoperative CT scans, all the screws except two were intra-osseous. These two screws passed in front of the ipsilateral sacro-iliac joint. As the reduction was satisfactory and no complications occurred, no revision surgery was performed and the final result was good and no infective, digestive, cutaneous, or vascular complications were observed.

We observed varying amounts of displacement in three patients. In one case, the screws bent in spite of the presence of an anterior plate. Two patients fused with a final malunion. One patient underwent surgical revision 21 days after the initial failure and it was not possible to obtain an acceptable reduction. The loss of reduction was less important when the posterior osteosynthesis comprised two posterior screws ($p < 0.05$). All of the pelvic fractures had healed at last follow-up. There were no non-unions, and none of the patients showed evidence of sacroiliac joint arthritis on their last radiographs.

Discussion

The functional outcome, when it is not compromised by neurological sequelae or associated lesions, is directly correlated with the residual displacement [3, 4, 9, 11]. Closed manipulative reduction of the pelvic ring was attempted for all patients and the technique gave satisfying results each time. It was not necessary to perform open reduction and acceptable reduction was always obtained by this technique (less than 1 cm in fluoroscopic imaging). The traction seems to be the most reliable means of obtaining an accurate reduction whatever the importance of the initial displacement even in emergency cases. This procedure avoids stabilising the pelvic ring prior to definitive stabilisation with an external fixator or a sling or a c-clamp in the acute setting. We have found the hip and knee flexion to be very important in reducing rotational displacement in the sagittal plane. With the knee flexed, the hamstrings are slack, therefore the traction associated with tightening the quadriceps and sartorius muscles allows correction of the rotational component in the sagittal plane whereas the addition of internal rotation allows to achieve a reduction of the rotational component in a coronal plane and to close the

pubic symphysis. It has been shown that closed reductions are more successful in type-C sacral instabilities than for lateral compression fractures, which are especially difficult to reduce [19]. In this case, longitudinal traction will help reduce any proximal displacement of the ilium. However, fracture reduction usually requires external rotation of the affected hemipelvis and can be obtained either with manipulation of the ilium or by use of a Schanz pin placed in the iliac wing to use as a handle as shown by Starr [19].

The transcondylar traction should not be attempted in two cases: In cases of crescent iliac fracture-sacroiliac dislocation, the stable posterior iliac fracture fragment, which is crescent-shaped when viewed laterally, remains stable. Closed manipulative reductions and percutaneous fixation of these injuries are rarely possible [1] and open reduction accomplished either anteriorly using an iliac exposure or posteriorly using a paramedian exposure should be preferred. If the patient demonstrates a peripheral neurological deficit associated with transforaminal sacral fractures, closed reduction may injure the nerve root and, therefore, open sacral reduction after fracture debridement is advocated [11].

The procedure is dependent on early operative intervention, especially in patients with severe posterior pelvic deformities [14]. The closed manipulative reduction should be done before the maturation of the haematoma and the fibrosis of the soft tissues. In our series, the quality of reduction is directly correlated to the surgical time. Thus, the use of the traction does not allow the surgical procedure to be delayed. Operative delays greater than 5 days after injury [10] are associated with poorer closed reduction accuracy [14]. If the reduction is not obtained, percutaneous screws should not be used since screws placement with residual displacement of 10 mm or more can endanger adjacent neural and vascular structures.

The weak point of this study is that measurement of pelvic fracture displacement on radiographs is difficult, unlikely to be precise, and potentially fraught with error (the inevitable changes in radiographic technique, patient positioning, magnification, and measurement error all combine to lessen the validity of a method for describing the amount of displacement). The routine use of inlet and outlet views allowed us to assess displacement in both vectors, and posterior displacement is often associated with vertical displacement. However, the analysis was only carried out on the vertical displacement because it was always found to be the major component of the global displacement and it provides a simple and reproducible measure of the reduction.

The most frequent complication was failure defined as at least 1 cm of combined vertical displacement of the posterior pelvis compared with immediate postoperative position [14]. Consequently, we now attempt to complete, by a second posterior screw the synthesis, as recommended by biome-

chanical studies [22]. This is especially recommended when the posterior injury is a vertical fracture of the sacrum (C1-3), which is more likely to fail after closed reduction and percutaneous iliosacral screw fixation than fixation with dislocation or fracture-dislocation of the sacroiliac joint [2]. More recently, all patients who underwent this fixation method had good post-operative radiographic results and no displacement occurred. A vertical sacral fracture should make the surgeon more wary of loss of reduction and alternative methods of fixation, such as open reduction and long sacral plates should be considered, especially when the fracture is transforaminal, to avoid additional nerve root damage by reduction and compression.

We did not cause vascular or nervous lesions although a screw misplacement occurred two times. Nevertheless, most of the literature recognises the advantages of preoperative CT scans and electromyography or navigation of the drilling as it limits the risk of vascular and nerve injuries [8, 21]. We think the CT scan control can be helpful for some patients with anatomical variation of the sacrum [15], when considering possibilities for reduction. However, the best asset for the surgeon is a good knowledge of anatomy, excellent radiographic imaging, and the hand feeling of the drill progressing in the bone.

Conclusions

The percutaneous screw procedure seems to be a reliable and reproducible technique. The treatment of vertically unstable sacro-iliac dislocations (type C1-2 AO) is the best indication. The surgery was done on a radiolucent table in the supine position. Reduction of the lesion before fixation is of the utmost importance, and the technique is simple and efficient. The surgery should be done as soon as possible, ideally within the first 5 days. However, an open approach should be chosen in both cases of crescent iliac fracture-sacroiliac dislocation and transforaminal fracture associated with peripheral neurological deficit. A vertical sacral fracture should make the surgeon more wary of fixation failure and loss of reduction.

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