

Today's Role of External Fixation in Unstable and Complex Pelvic Fractures

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Abstract

Introduction: The treatment of pelvic fractures has undergone a change over the past few years. As there seems to be a trend away from external towards internal fixation, the goal of this study was to investigate whether the use of an external fixator is still a standard procedure for the initial as well as – if necessary – for the definitive treatment of complex and unstable pelvic injuries.

Methods: During a period of five years at the Level I Trauma Center, an external fixator was applied in 28 (11%) out of 236 pelvic ring fracture cases. The common indications were open fractures, complex fractures and multiple injuries with hemodynamic instability. Hemorrhage control, fracture stabilization and infection prophylaxis in cases of open fracture were achieved by variable placement and fixation of Schanz screws. In some cases, the assembly of a hybrid combined with internal osteosynthesis was used to increase stability.

Results: Of the 28 patients, 20 survived, while eight (28.6%) died in the course of treatment due to fatal hemorrhage, craniocerebral trauma, multi-organ failure and sepsis. A satisfactory result (anatomical and functional outcome) was achieved in 16 of the 20 cases (80%). The remaining four (20%) suffered from serious complications, the majority of them caused by the initial type of injury.

Conclusions: The use of the external fixator for the initial and in some cases for the definitive fixation of unstable and complex pelvic injuries with hemodynamic instability is still a successful treatment of multiply injured patients.

Key Words

External fixator · Pelvic fracture · Severe pelvic injury · Bleeding control

Eur J Trauma Emerg Surg 2010;36:100–6

DOI 10.1007/s00068-010-1048-7

Introduction

On the one hand, the lives of patients with complex pelvic fractures are threatened by uncontrollable blood loss caused by the fracture itself and by injured vessels (presacral venous plexus, damaged arteries, organ injuries, etc.). On the other hand, lives are threatened by infections starting from injuries of the perineum, the urethra, the rectum, or the intestine in case of open fractures. The main goal of the initial and/or shock therapy is to achieve control over bleeding by minimizing the volume of the retroperitoneal space through the application of external compression (pelvic binder, pelvic clamp, external fixator) [1–4]. As a positive side effect, relative immobilization of the pelvic diaphragm is obtained.

Hemorrhage control, fracture stabilization and infection prophylaxis in cases of open fracture can be achieved by the variable placement and fixation of Schanz screws into the anterior superior iliac crest, supra-acetabularly starting ventrally and supra-acetabularly starting laterally, and occasionally through the additional usage of half-pins into the pubic bones if necessary. In order to increase stability, the assembly of a hybrid fixation with internal osteosynthesis (screw fixation, tension band) of one and external fixation of the other site is beneficial (see Figure 1). Furthermore, acute temporary or definitive treatment of complex unstable pelvic fractures with an external fixator offers convincing advantages and a decent success rate for severely injured patients. Nevertheless, the use of a pelvic fixator requires a mentally prepared and adequately skilled team as well as the techniques of packing, angiography and embolization. Further

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Received: February 25, 2010; revision accepted: March 11, 2010;
Published Online: March 31, 2010



Figures 1a to 1c. In order to increase stability, the assembly of a hybrid fixation with internal osteosynthesis (screw fixation, tension band) of one site and external fixation of the other site can be beneficial. Case study: type C fracture associated with rupture of the bladder. a) Preoperative X-rays, b) X-ray with contrast medium (rupture of the bladder), c) X-ray after healing.

therapeutic activities should not be performed. The relevant bleeding sources in this context are the fracture itself and ligamentous lacerations which occur regularly, the venous plexus (presacral, prevesical 80%), injured arteries (pudendal, obturator, iliolumbar, superior and inferior gluteal artery, and trunk vessels in 0.2–27%), as well as hollow viscous injuries and soft tissue damage (5%). In cases of bleeding from the fracture and ligamentous lacerations, hemorrhage control can be achieved by external compression. This seems to be a useful and target-oriented approach, at least until the diagnostic process is finished and the therapeutic procedure is chosen.

Patients and Methods

During a period of five years (1995–2000), 236 patients with pelvic ring fractures were admitted to the Level I Trauma Center of the Medical University of Vienna. One hundred fifty-six (66%) were polytraumatized, 18 (7.6%) additionally suffered local and/or concomitant organ injuries of the small pelvis, and were therefore defined as having complex pelvic injuries.

In 28 cases (11.9%) an external fixator was used. In 27 of these the fracture was closed, and in the remaining case the fracture was open. A combined pelvic–acetabular fracture was diagnosed nine times (36%). The injuries were caused by a car accident (9 cases), a fall from a significant height (7), a motorcycle accident (7), an overroll trauma (3), a car collision with a pedestrian (1), and a train collision with a pedestrian (1) (Table 1). In 21 cases (75%) the pelvic injury occurred bilaterally, in four cases (14%) the injury was located solely on the right side, and in three

Table 1. Mechanisms of injury (n = 28).

Mechanisms of injury	n (%)
Motor vehicle crash	9 (32.1)
Fall from a great height	7 (25)
Motorcycle crash	7 (25)
Overroll injury	3 (10.7)
Pedestrian–automobile collision	1 (3.6)
Pedestrian–train collision	1 (3.6)

Table 2. Associated injuries in unstable/partially unstable pelvic ring fractures treated with external fixation (n = 28).

Associated injuries	n (%)
Retroperitoneal hematoma	8 (28.6)
Rupture of the bladder	3 (10.7)
Rupture of the urethra	2 (7.1)
Lesion of the iliac artery	1 (3.6)
Perineal laceration	1 (3.6)
Rupture of the ovary	1 (3.6)
Rupture of the kidneys	1 (3.6)

cases (11%) it was only on the left side. According to the AO/ASIF classification, ten fractures were classified as type B and 18 as type C. Twenty-four (85%) of the patients were at least multiply injured. The associated injuries that were diagnosed and their frequencies are presented in Table 2.

Results

Twenty-six (11%) out of the 236 of the patients with pelvic ring fractures died immediately upon their

Table 3. Operative management of pelvic fractures (n = 20 survivors).

Stabilization methods	n (%)
External fixation (only)	12 (60)
External fixation + internal fixation of the dorsal pelvic ring (plate/screws)	4 (20)
External fixation + internal fixation of the ventral pelvic ring (tension band wiring)	4 (20)

Table 4. Complications (n = 20 survivors).

Complications	n (%)
Heterotopic ossifications	3 (15)
Nerve lesions	2 (10)
Infections	2 (10)
Urinary/rectal incontinence	2 (10)
Osteoarthritis (sacroiliac + coxarthrosis and hip)	1 (5)
Femoral head necrosis	1 (5)
Leg length discrepancy	1 (5)

arrival or shortly after admission. Of the 18 complex pelvic injuries, the most frequent cause of death was fatal hemorrhage followed by craniocerebral trauma and secondary multi-organ failure.

Eight (28.6%) patients out of the 28 who were treated with an external fixator died during the course of treatment induced by fatal hemorrhage, multi-organ failure and sepsis. The different stabilization variants utilized for the surviving 20 patients and their frequencies are presented in Table 3. The type of complications that occurred and their frequencies are displayed in Table 4.

A satisfactory result (anatomical and functional outcome) was achieved in 16 of the 20 cases (80%). The remaining four patients (20%) suffered from serious complications, the majority of them caused by the initial type of injury.

Discussion

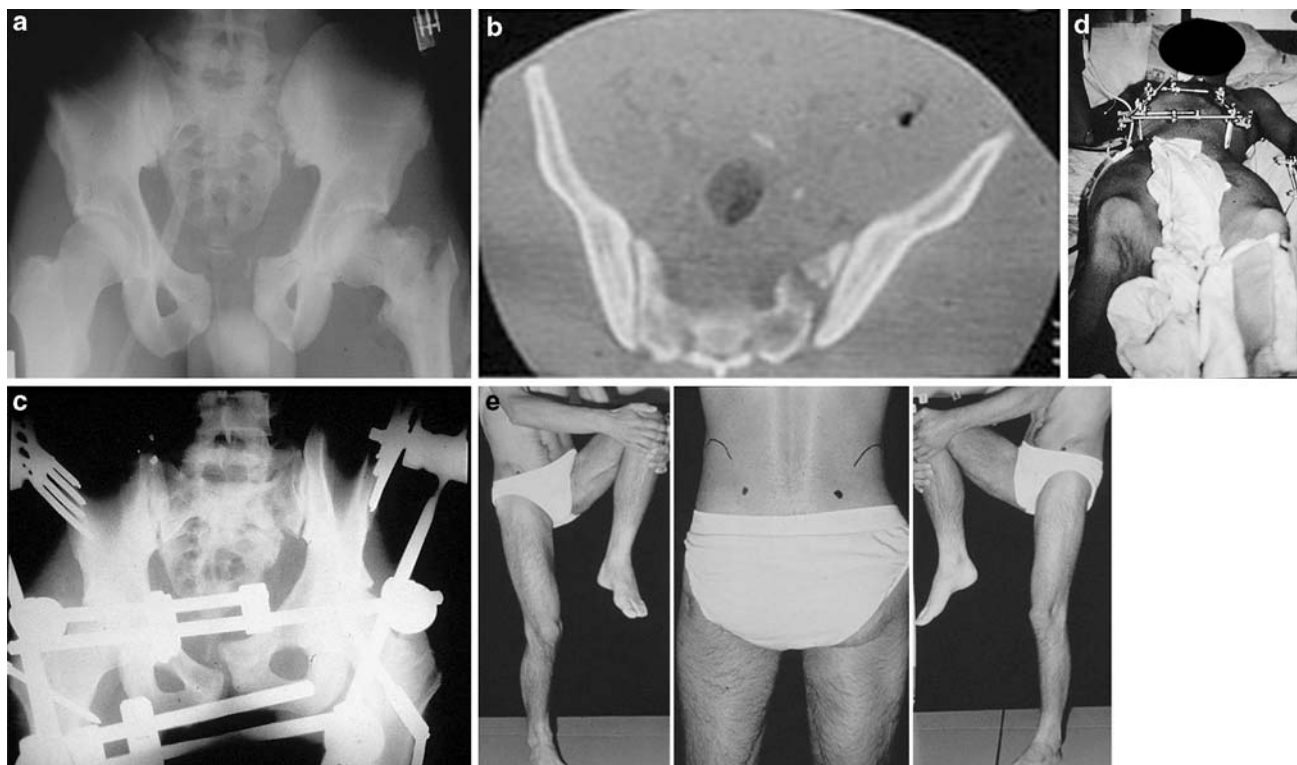
A consensus exists regarding the present therapy of unstable pelvic fractures with threatening or manifest hemodynamic instability. It includes a gentle and target-aimed volume substitute therapy and blood loss control. The latter is achieved by diminishing the enlarged holding capacity of the unstable pelvis, especially the retroperitoneal space due to the fracture, and ligamentous lacerations, using pelvic binders, a pelvic clamp or an external fixator. Other goals are to sup-

press the pain afferents induced by the instability, and to decrease the risk of infection by immobilizing the pelvic diaphragm and soft tissues.

In our opinion, a gentle fluid and volume therapy is the target-aimed substitution of crystalloids, plasma expanders and blood products in balanced proportions. The systolic blood pressure should be >100 mmHg, the heart rate ≤ 100/min, hemoglobin ≥ 8.6 g%, hematocrit ≥ 26%, and urine output > 50 ml/h. Restraint or excessive volume therapy have a negative impact on prognosis. The contribution of the lax retroperitoneal space without fascia, septa and/or bony counterfort for tamponade as an important factor in bleeding limitation has repeatedly been questioned. The retroperitoneal space can incorporate 3–6 l (or even more) of blood [5–9]. Undoubtedly, external fixation, packing and angiography with selective embolization are gaining ground, whereas acute closed or open reduction with subsequent osteosynthesis – eventually under CT guidance – are the exception. However, concepts may change in the near future.

It is a fact that the mechanical stability of an internal osteosynthesis is higher than that of a conventionally applied external fixator (see Figure 2). Furthermore, anatomical reduction under direct manipulation of the fracture fragments can be done more precisely [3, 10, 11]. Nevertheless, there are clear advantages to using an external fixator – for example for open fractures [12–14], perineal injuries (see Figure 3), rectal or vaginal injuries [15], and unstable pelvic ring fractures with threatening or manifest hemodynamic instability [16–19] – as an addition to retroperitoneal packing, and as a necessary positioning treatment during the intensive care period [20, 21].

To select the adequate assembly variant, the following recommendations must be considered [22–24]. Simple configurations in the acute situation are sufficient and are done to close the shattered pelvic ring [25]. If a laparotomy becomes necessary, the fixator should not hinder it. The stability and maneuverability depends on the position of the screws [19]. They can be screwed into the superior anterior iliac crest (as deep as possible), they can be applied ventrally in the supra-acetabular region in an open procedure in a sagittal direction, or they can be inserted above the acetabular roof in a frontal plane from lateral percutaneously (see Figure 4). Sometimes an insertion into the pubic bones may be indicated, but this procedure is only relevant in the case of a definitive treatment. As the pins are the weak point concerning stability during exercise, the number of pins is crucial. Several pins should be connected to each other as close to the skin as possible.



Figures 2a to 2e. Suboptimal fracture reduction in a 25-year-old multiply injured male. a) Preoperative X-ray; b) preoperative CT scan; c, d) fracture stabilization by external fixation; e) good functional outcome 8 months after injury.

After fixing the pins to the jaws, both sides can be linked with the bars and merged together. In order to prevent an infection, daily pin care with 0.9% saline solution or nonirritating sanitizing is recommended. Despite its bulky looking appearance, the mechanical stability of the external fixator should not be overestimated. Even relatively small loads can result in secondary dislocation, especially because of the conjunctions, which tend to loosen over time. Regular X-rays and occasional CT controls are necessary to detect changes that may need correction and/or secondary reduction. The probability of additional surgical treatment or even a change of procedure increases with the instability of the fracture configuration, because simple assembly configurations can easily be overstrained. The popular assemblies are primarily applicable to control the anterior pelvic ring.

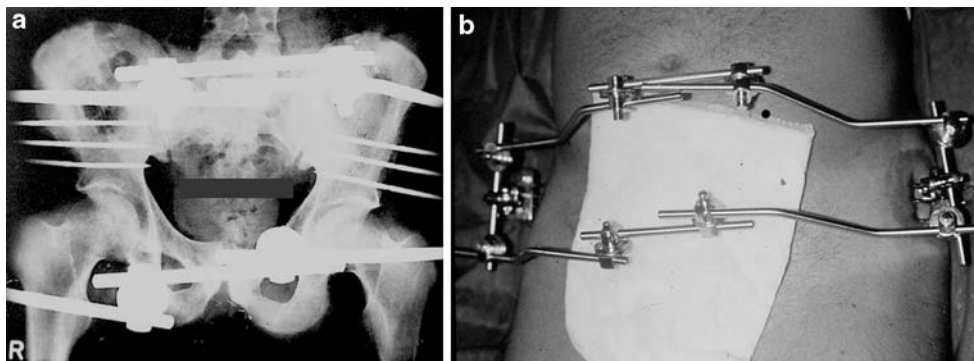
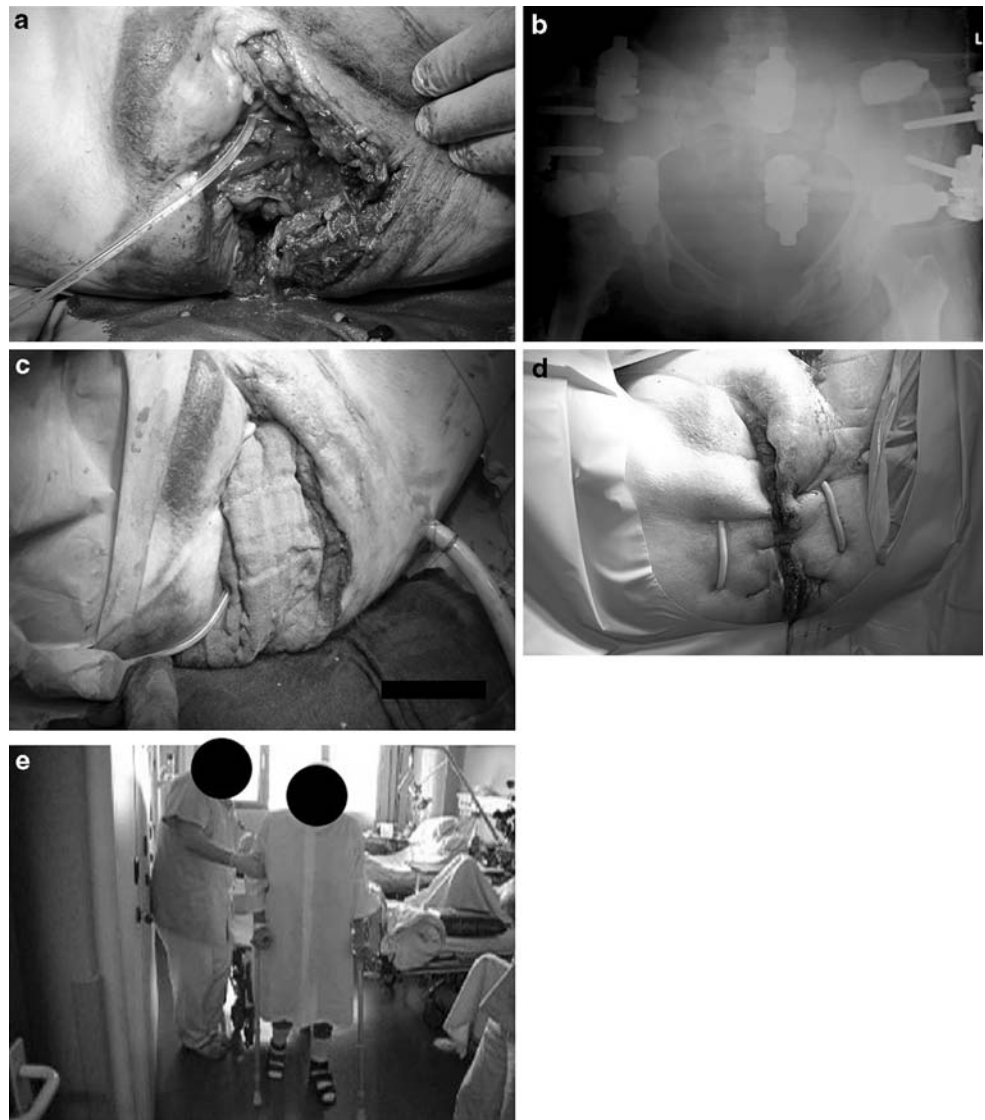
The method of Slatis and Karaharju [26–28] (see Figure 5) tries to solve this problem by connecting the pins inserted into the anterior superior iliac crest with long bars that are fixed in a 45° inclination towards the long body axes in front of the abdominal wall and then connected within a distance of 15–20 cm twice [29]. The first cross connection (the one closer to the pins) is

used for compression (anterior pelvic ring), the second one for distraction (posterior pelvic ring). Of course, these principles cannot be realized without certain companies making specific product lines available. It should be mentioned that fixators produced by different companies are neither exchangeable nor combinable. As the compression device is positioned clearly above the level of the pelvic inlet, the cranial part of the fracture surface is compressed and the caudal part is slightly distracted if the linkage of the left and right pelvis is disconnected. These details are barely an issue for type B fractures, whereas the consequences for type C fractures are clearly apparent. Therefore, the application of a pelvic fixator has its natural limits. Especially complex assembly variations are naturally able to take more loads but also require more space. In consequence, they cannot be used for the initial treatment and for the treatment of severely injured patients because they are a hindrance.

Conclusion

The pelvic external fixator is currently primarily used to treat severely injured patients, because their injuries

Figures 3a to 3e. Extended perineal laceration in a polytraumatized 70-year-old female with a type C pelvic fracture caused by an overroll trauma. a) Clinical aspect of the perineal laceration; b) stabilization of the pelvis with an external fixator; c) perineal tamponade; d) dynamic adaptation of perineal soft tissues, reconstruction of the vagina and anus; e) clinical picture 12 weeks after removal of the external fixator.



Figures 4a and 4b. Lateral percutaneous insertion of the Schanz screws cranial to the acetabulum. a) X-ray, b) clinical aspect.

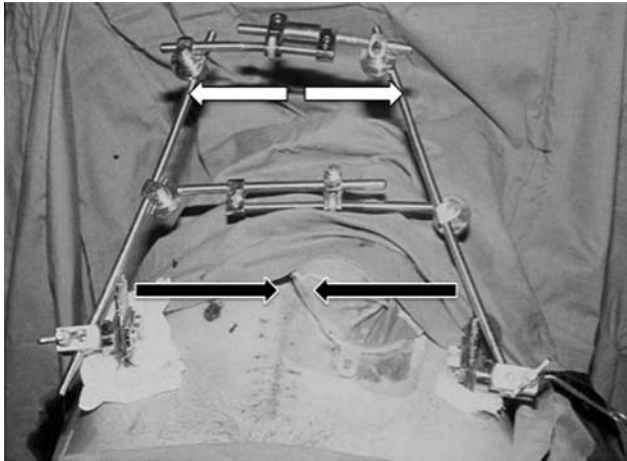


Figure 5. Trapezoid assembly of the pelvic external fixator (Slatik and Karharju): cranial distraction causes posterior compression (white arrows); caudal compression leads to anterior compression (black arrows).

may become, or already are, life-threatening. These patients form a group in which the stabilization of the circulatory system and of the pelvis, infection prophylaxis, and eventually additional acute surgical procedures must be performed. Because of the severity of their injuries, these patients suffer serious complications, such as sepsis, long-term urogenital effects, incontinence, nerve palsies, organ failure and death. The existing repertoire of treatment options cannot be chosen in its entirety. There is undoubtedly a high degree of individualization of the possible measures required. Under the circumstances presented and discussed above, the use of an external fixator for an unstable and complex pelvic fracture with hemodynamic instability is often a solution for the initial fixation, and in some cases for the definitive fixation if there are no alternatives. In conclusion, the use of this method remains justified in modern trauma surgery.

Conflict of interest statement

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

- Mears DC, Fu F. External fixation in pelvic fractures. *Orthop Clin North Am* 1980;11:465–79.
- Mears DC, Fu FH. Modern concepts of external skeletal fixation of the pelvis. *Clin Orthop Relat Res* 1980;151:65–72.
- Mears DC, Rubash HE. External and internal fixation of the pelvic ring. *Instr Course Lect* 1984;33:144–58.
- Simpson T, Krieg JC, Heuer F, Bottlang M. Stabilization of pelvic ring disruptions with a circumferential sheet. *J Trauma* 2002;52:158–61.
- Trojan E. Vascular and nerve injuries in fractures and luxations in the pelvic region. *Hefte Unfallheilkunde* 1979;140:44–8.
- Moreno C, Moore EE, Rosenberger A, Cleveland HC. Hemorrhage associated with major pelvic fracture: a multispecialty challenge. *J Trauma* 1986;26:987–94.
- Ben-Menachem Y, Coldwell DM, Young JW, Burgess AR. Hemorrhage associated with pelvic fractures: causes, diagnosis, and emergent management. *AJR Am J Roentgenol* 1991;157:1005–14.
- Goins WA, Rodriguez A, Lewis J, Brathwaite CE, James E. Retroperitoneal hematoma after blunt trauma. *Surg Gynecol Obstet* 1992;174:281–90.
- Rieger H. Das instabile Becken: Diagnostik, Therapie und Prognose der Beckenringfraktur. New York: Zuckerschewdt, 1996.
- Rieger H, Winckler S, Wetterkamp D, Overbeck J. Clinical and biomechanical aspects of external fixation of the pelvis. *Clin Biomech (Bristol, Avon)* 1996;11:322–7.
- Egbers HJ, Draijer F, Havemann D, Zenker W. Stabilizing the pelvic ring with the external fixator. Biomechanical studies and clinical experiences. *Orthopade* 1992;21:363–72.
- Brenneman FD, Katyal D, Boulanger BR, Tile M, Redelmeier DA. Long-term outcomes in open pelvic fractures. *J Trauma* 1997;42:773–7.
- Birolini D, Steinman E, Utiyama EM, Arroyo AA. Open pelvis-perineal trauma. *J Trauma* 1990;30:492–5.
- Richardson JD, Harty J, Amin M, Flint LM. Open pelvic fractures. *J Trauma* 1982;22:533–8.
- Davidson BS, Simmons GT, Williamson PR, Buerk CA. Pelvic fractures associated with open perineal wounds: a survivable injury. *J Trauma* 1993;35:36–9.
- Bonnel F. Biomechanical observations of pelvic injuries and use of the fixateur externe in ruptures of the symphysis and sacroiliac joint. *Hefte Unfallheilkunde* 1975;124:161–3.
- Gylling SF, Ward RE, Holcroft JW, Bray TJ, Chapman MW. Immediate external fixation of unstable pelvic fractures. *Am J Surg* 1985;150:721–4.
- Havemann D, Egbers HJ. External fixators in treatment of severe fractures of the pelvis. *Langenbecks Arch Chir Suppl II Verh Dtsch Ges Chir* 1989;445–9.
- Buhren V, Marzi I, Trentz O. Indications and technique of external fixation in acute management of polytrauma. *Zentralbl Chir* 1990;115:581–91.
- Wild JJ, Hanson GW, Tullos HS. Unstable fractures of the pelvis treated by external fixation. *J Bone Joint Surg Am* 1982;64:1010–20.
- Riener BL, Butterfield SL, Diamond DL, et al. Acute mortality associated with injuries to the pelvic ring: the role of early patient mobilization and external fixation. *J Trauma* 1993;35:671–5 (discussion 676–7).
- Vécsei V. Results of biomechanical studies of various external fixation devices of the pelvis. *Aktuelle Traumatol* 1988;18:261–4.
- Vécsei V, Kuderna H. Therapy and results in pelvic fractures with the use of an external fixation device. *Hefte Unfallheilkunde* 1979;129–42.
- Burgess AR, Eastridge BJ, Young JW, et al. Pelvic ring disruptions: effective classification system and treatment protocols. *J Trauma* 1990;30:848–56.
- Brown TD, Stone JP, Schuster JH, Mears DC. External fixation of unstable pelvic ring fractures: comparative rigidity of some current frame configurations. *Med Biol Eng Comput* 1982;20:727–33.

26. Slatis P, Eskola A. External fixation of the pelvic girdle as a test for assessing instability of the sacro-iliac joint. *Ann Med* 1989;21:369–72.
27. Slatis P, Karaharju EO. External fixation of the pelvic girdle with a trapezoid compression frame. *Injury* 1975;7:53–6.
28. Slatis P, Karaharju EO. External fixation of unstable pelvic fractures: experiences in 22 patients treated with a trapezoid compression frame. *Clin Orthop Relat Res* 1980;151:73–80.
29. Lansinger O, Karlsson J, Berg U, Mare K. Unstable fractures of the pelvis treated with a trapezoid compression frame. *Acta Orthop Scand* 1984;55:325–9.

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