TECHNICAL NOTE

Technique for reduction and percutaneous fixation of U- and H-shaped sacral fractures

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Abstract  We describe an early reduction and percutaneous fixation technique for isolated sacral fractures. Strong manual traction combined with manual counter-traction on the torso is used to disimpact the fracture. Transcondylar traction is then applied bilaterally and two iliosacral screws are inserted percutaneously on each side. Open reduction and fixation, with sacral laminectomy in patients with neurological abnormalities, remains the reference standard. Early reduction and percutaneous fixation ensures restoration of the pelvic parameters while minimising soft-tissue damage and the risk of infection. Decompression procedures can be performed either during the same surgical procedure after changing the installation or after a few days. These complex fractures warrant patient referral to specialised reference centres.

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KEYWORDS

Sacral fracture; Reduction; Ilio-sacral screw fixation; Percutaneous sacral fixation; Surgical treatment

Introduction

Among the fractures that disrupt the posterior pelvic ring, 15% to 45% involve the sacrum [1,2] and 2% to 5% of these sacral fractures are isolated U- or H-shaped fractures [3,4]. The work reported by Roy-Camille et al. in 1985 improved the understanding of the mechanisms underlying U- and H-shaped sacral fractures. Typically, the fracture occurs when the patient lands after falling from a considerable height (e.g. suicide by defenestration) with the lumbar spine in exaggerated lordosis and the hips extended [5]. Roy-Camille et al. developed the first classification scheme with three types, and Strange-Vognsen et al. subsequently added another type characterised by a burst fracture of the body of S1 [6].

Surgical treatment involving lumbo-pelvic or trans-sacral fixation has not consistently been found effective compared to the conservative treatment [7–13]. Nevertheless, recent meta-analyses confirm the beneficial effects of surgical treatment, most notably regarding restoration of satisfactory alignment in the sagittal plane [14]. Open surgery can be followed by complications, such as disturbed wound healing and infection [15–18]. Percutaneous ilio-sacral screw fixation as described by Rottt et al. in 1996 decreases the morbidity of surgical treatment for sacral fractures [19,20].
Here, we describe a technique of early reduction followed by percutaneous screw fixation for U- and H-shaped fractures of the sacrum.

Reduction technique

The diagnosis should be obtained at the arrival of the patient. Disruption of the pelvic ring must be definitively ruled out. Computed tomography with sagittal reconstruction allows classification of the fracture according to Roy-Camille et al. and Strange-Vognsen et al. A neurological evaluation is indispensable at the admission and should be repeated during the immediate postoperative period then during subsequent follow-up. The findings should be recorded in the patient’s medical file.

At the early phase, in the operating room, bilateral transcondylar traction is set up. The patient is supine on a table slightly inclined in the Trendelenburg. After intubation and neuromuscular blockade, the surgeon applies rapid strong traction to both transcondylar traction stirrups while two assistants apply counter-traction to both armpits. Ideally, a cracking sound indicating fracture disimpaction is heard and felt. The strongest predictor of successful reduction is a short time to performance of the manoeuvre. The reduction is maintained by applying 15% of the patient’s body weight to each traction pin (Fig. 1). It is then possible to wait for the most appropriate time for performing the fixation procedure, according to the damage-control principle.

When the patient’s general condition is stable, the definitive fixation procedure can be performed. The patient is supine on a transparent surgical table with both transcondylar traction devices in place. A hard pad made from folded sheets to the size appropriate for the patient is placed under the lumbo-sacral junction (Fig. 2) to induce hyperlordosis, which completes the reduction of the sacrum. A method of last resort consists in placing the upper part of the table in Trendelenburg position and the lower part in proclivity. The quality of the reduction is assessed on lateral fluoroscopic views. We believe the best criterion is good alignment of the anterior sacral cortex (Fig. 3).

In our institution, we use bilateral percutaneous iliosacral screws to ensure fixation [19,20]. Ideally, two screws

![Figure 1](image1.png)

**Figure 1** Diagram of the full reduction technique performed on an emergency basis.

![Figure 2](image2.png)

**Figure 2** Patient installation on the operating table. Pad under the lumbar region to reduce the fracture via ligamentotaxis.

should be inserted through each longitudinal fracture to ensure rotational stability of the central sacral fragment. The patient is allowed to sit with the torso inclined no further than 45° starting on day 1. Weight bearing is resumed on day 45.

Results

We report the results obtained in three patients (2 females and 1 male). The fracture was due to a 3-m fall from a scaffolding (Fig. 3), a motorcycle accident (Fig. 4), and a 2-m fall while skiing (Fig. 5), respectively. All the three patients had neurological signs, which consisted in cauda equine syndrome in two patients and left S1 radicular pain in one patient. The first patient was managed with two-stage surgery involving early reduction and laminectomy in procubitus by a neurosurgeon then, implantation of four ilio-sacral screws. The other two patients had the same stage early reduction and strictly percutaneous fixation with ilio-sacral screws (two and four screws, respectively). In these two patients, reduction of the fracture ensured complete decompression of the sacral canal, obviating the need for laminectomy. The neurological evaluation was normal in the first patient after 7 months. In the second patient, anal sphincter contraction remained slightly impaired after 5 months. Follow-up duration was only 15 days in the third patient, at which point, the S1 pain was slightly improved.

Discussion

Reduction and fixation of isolated sacral fractures are often difficult procedures that must be performed on multiply injured patients who are usually vulnerable and require management in level 1 trauma centers, in particular to enable appropriate management of co-existing lesions and, if needed, emergency embolisation [1,6,21,22]. Non-operative management via bed rest is often advocated [4,7–14], based on the argument that neurological impairments due to sacral root avulsion or contusion result in a very low likelihood of functional recovery [4,10,11]. Kellam et al. suggested that non-operative treatment may be most useful in centers with little experience of sacral fracture surgery as, when well conducted, this approach may produce better
Percutaneous fixation of U- and H-type sacral fractures

Figure 3 A 37-year-old man. A. Preoperative computed tomography (CT), sagittal slice, showing a Roy-Camille type II sacral fracture. On the standard radiograph, pelvic incidence was 71°. B. Intra-operative lateral fluoroscopic view before reduction. C. Intra-operative lateral fluoroscopic view after reduction and placement of the lumbar pad: quality of the reduction is assessed based on alignment of the anterior sacral cortex. D. Postoperative CT, sagittal slice. On the standard radiograph, pelvic incidence was 63.6°. E. Postoperative CT, axial slice.

Figure 4 A 17-year-old woman. A. Preoperative computed tomography (CT), sagittal slice, showing a Roy-Camille type II sacral fracture. On the standard radiograph, pelvic incidence was 72.4°. B. Preoperative CT, axial slice: obstruction of the sacral canal due to posterior displacement of the proximal fragment. C. Preoperative 3D CT. D. Postoperative CT, axial slice: note the two ilio-sacral screws. E. Postoperative CT, sagittal slice: anatomic fracture reduction. F. Postoperative CT, axial slice: decompression of the sacral canal due to the anatomic fracture reduction.
Figure 5  A 22-year-old woman. A. Preoperative computed tomography (CT), sagittal slice, showing a U-shaped Roy-Camille type II sacral fracture. B. Preoperative CT, axial slice: narrowing of the sacral canal due to displacement of the proximal fragment. C. Intra-operative lateral fluoroscopic view, after the reduction manoeuvre and placement of the lumbar pad: anatomic fracture reduction. D. Postoperative CT, sagittal section: anatomic fracture reduction and visibility of two of the four ilio-sacral screws. E. Postoperative CT, axial slice: decompression of the sacral canal due to the anatomic fracture reduction.

results than a difficult surgical procedure performed by an inexperienced team [23].

However, the general consensus is that open surgical fixation is the best strategy [1,2,5,6,15–18]. The main complications are surgical-site infection and wound healing disturbances, seen in 16% of the patients in a study by Bellabarba et al. [23]. Pohlemann et al. cautioned against the major risk of infection, as well as the complexity of the constructs, which requires considerable experience on the part of the surgical team [24]. Percutaneous ilio-sacral screw fixation helps to minimise these complications. The advantages include the absence of decompression of the intra-pelvic haematoma and decreased postoperative bleeding [19,20]. This attractive technique, which decreases iatrogenic morbidity, seems of value for the management of isolated sacral fractures. Its use remains challenging, however, in patients with lumbo-sacral transitional abnormalities, such as lumbarisation of S1 or sacralisation of L5 [19,20]. König et al. described a very interesting technique involving fracture site distraction between four screws inserted percutaneously into the L5 and S1 pedicles, followed by trans-sacral fixation using two ilio-sacral screws [25].

The technique described here is a percutaneous fixation technique that can easily be combined with decompression sacral laminectomy, either during the same surgical procedure or later on depending on the patient’s condition. A study by Kim et al. [21] and a meta-analysis by Yi et al. [17] confirm the usefulness of laminectomy, chiefly for relieving pressure on roots that are undamaged, stretched, or minimally contused. However, the likelihood of recovery after root avulsion is minuscule. Yi et al. advocated same-stage laminectomy, before fracture reduction and surgical fixation, based on the argument that free fragments released by the reduction manoeuvre might put pressure on the roots entrapped in the canal. In our experience, good quality percutaneous reduction is usually sufficient to achieve decompression of the sacral roots (Figs. 4f and 5e). This strategy eliminates morbidity related to the posterior approach.

Conclusion

Isolated sacral fractures are serious lesions that must be managed in specialised centers. Displaced fractures require a surgical procedure, and additional sacral laminectomy may be required in patients with neurological deficits. Early reduction and percutaneous fixation reliably restores the physiological pelvic parameters, provided rigorous technique is used, and can be combined with laminectomy if the reduction fails to provide nerve root decompression. The well-known infectious and wound-healing complications of open surgery are far less common with the percutaneous technique, allowing early rehabilitation therapy and producing lower morbidity and mortality rates.
Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References