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PŮVODNÍ PRÁCE

Does Convergent Placement of Interlocking Iliosacral Screws into the Body of Vertebra S1 Prevent Screw Migration?

Je konvergentní umístění vzájemně propojených iliosakrálních šroubů do těla obratle S1 prevencí migrace šroubů?

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ABSTRACT

PURPOSE OF THE STUDY

To compare the outcomes of parallel and convergent iliosacral screw insertion into the body of vertebra S1 in the treatment of posterior pelvic arch injuries.

MATERIAL AND METHODS

Radiographs of 120 patients (43 women, 77 men), aged between 14–79 years, treated with iliosacral screw fixation for posterior pelvic ring fractures between 1.1.2009 and 31.12.2019 were reviewed for inclusion in the study. In each case two screws were inserted into the body of vertebra S1. The screws were inserted in either parallel or convergent orientation. Convergent orientation allows the threads of both screws to be interconnected. In this technique, the first screw is inserted into the centre of the body of vertebra S1 as a compression screw. The second screw is inserted as a positioning screw and is placed so that the threads of both screws lock together. We believe that the interlocking of the threads of both screws and contact of the second screw with three cortices (two of the iliac bone and one of the sacrum) increase the stability of the fixation. Migration of loosened screws was measured on radiographs of the pelvis obtained at six weeks and at three, six and twelve months postoperatively. Migration of five millimetres or more within the first six weeks was considered to be clinically significant. Only patients after primary fracture treatment and with a complete one-year follow-up were included in the study. Cases of non-union and failure of osteosynthesis of the anterior pelvic arch and patients with incomplete follow-up were excluded. The incidence of significant screw migration between the two techniques was compared using Fisher's exact test with a 5% level of significance.

RESULTS

Sixty-three patients (23 women, 40 men) aged 17 to 79 years were included in the study. Parallel screws were used in 24 patients (8 women, 16 men) and convergent screws were used in 39 patients (15 women, 24 men).

Clinically significant migration occurred in nine (38%) patients after parallel insertions. In two of these cases there was unstable fixation of the anterior pelvic arch. Migration of convergently placed iliosacral screws occurred in four (10%) cases. In three of these cases this was due to unstable fixation of the anterior pelvic arch. The difference in screw migration between the two groups was shown to be significant ($p = 0.0219$).

DISCUSSION

Iliosacral screws ensure sufficient stability of the posterior arch in type B and C pelvic fractures provided that the anterior pelvic arch is stable. Convergent insertion of iliosacral screws may increase the stability of fixation. Minimally invasive surgery with sufficient stability may be advantageous for early treatment of patients after multiple trauma and in elderly patients.

The weaknesses of this study are its relatively small number of patients, which prevented reliable statistical analysis of screw migration according to the type of pelvic fractures. The second main limitation is the failure to perform densitometric examination of the skeleton in patients with X-ray proven screw migration for confirmation of osteoporosis as one of the possible causes of fixation failure.

CONCLUSIONS

The results of the study suggest that convergent insertion of iliosacral screws into S1 is associated with a lower risk of screw migration and subsequent failure of fixation of the posterior pelvic arch.

Key words: pelvic fracture, pelvic injury, iliosacral screw, parallel screws, convergent screws, migration of iliosacral screws.

INTRODUCTION

Good functional results of the treatment of unstable pelvic fractures rely upon adequate reduction and stable fixation of both the anterior and posterior pelvic arches (3, 16, 23). Minimally invasive osteosynthesis techniques are advantageous for treating such fractures, particularly in high-risk patients, such as elderly and polytraumatised patients (2, 4, 8, 18). One such minimally invasive techniques used for unstable pelvic ring fractures is the insertion of iliosacral screws under fluoroscopic or other methods of guidance (4, 7, 11, 12, 21, 24, 28). If stability of these screws is not achieved, as may happen in cases of large comminuted fractures affecting the lateral parts of the sacrum or if screws are placed in osteoporotic bone, there is a risk of screw migration, which results in loss of fixation of the pelvic fracture and development of the non-union or healing in an inadequate position (1, 6, 18, 26, 29). The aim of this study was to compare the risk of early screw migration after parallel (Fig. 1) and convergent (Fig. 2) insertion of iliosacral screws.

MATERIAL AND METHODS

Patient cohort

This was a retrospective study designed to evaluate iliosacral screw migration after osteosynthesis of the posterior pelvic arch. The patient cohort consisted of 63 patients (23 women, 40 men), who underwent unilateral fixation of posterior pelvic arch with iliosacral screws between 01.01.2009 and 31.12.2019. An overview of the types of fractures is given in Table 1.

Surgical technique

Type B and C fractures according to the AO/ASIF classification were indicated for fixation of the posterior pelvic arch with iliosacral screws (9). All procedures were performed in general anaesthesia with the patient in a supine position with the sacrum slightly raised. The anterior segment was always treated first, by one or two plates or by pubic screws.

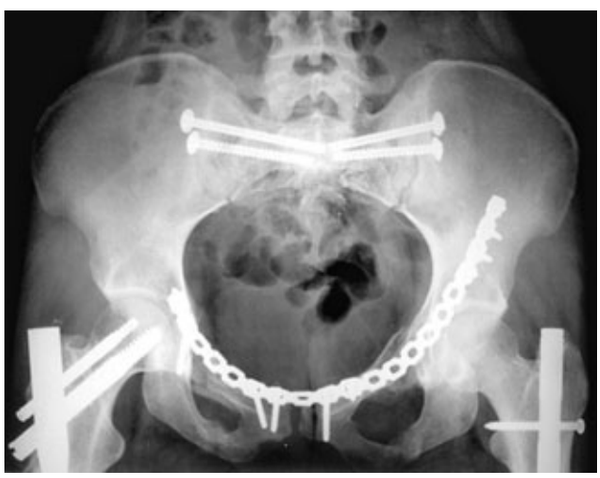

Fig. 1. Follow-up X-ray three months after fixation of a type B3.2 pelvic fracture in a 30-year-old woman after a traffic accident. The posterior pelvic arch was treated bilaterally with parallel iliosacral screws inserted into the body of vertebra S1.

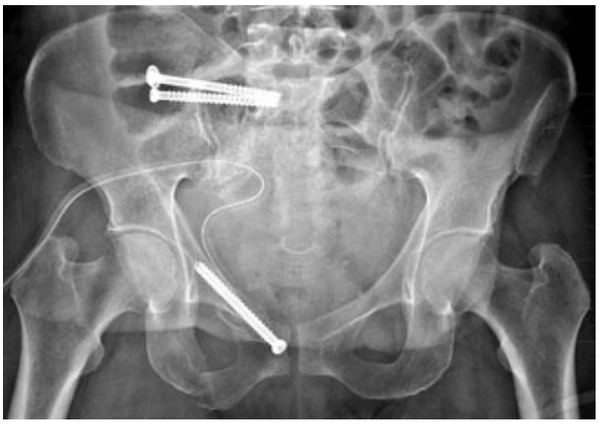

Fig. 2. Postoperative X-ray after fixation of a type B2.1 pelvic fracture in a 48-year-old woman occurring after falling off a bicycle. The posterior pelvic segment on the right was treated with two convergent iliosacral screws placed into the body of vertebra S1. The entry point for inserting the guide wire of the second screw is right next to the edge of the washer of the first screw so as to allow both screw heads to press on one washer. Alternatively, two washers can be used. The second screw is placed convergently, so that it reaches the thread of the first screw about 2 cm from its end. The second screw thus "locks" between the threads of the first compression screw.

Iliosacral screws were inserted under fluoroscopic control using inlet and outlet projections according to Pennal (23) through two mini-incisions into the body of vertebra S1 safely above the sacral foramina S1/S2 (4–7). In all cases 6.5-mm cannulated titanium screws (DePuy Synthes, Oberdorf, Switzerland) were used.

When inserting interlocking convergent iliosacral screws in the body of the S1 vertebra we place the first screw approximately into the centre of the body of vertebra S1 as a compression screw. We use screws with either short or medium threads according to the location of the fracture of lateral part of the sacrum. To insert the second screw, it is important to position the guide wire precisely. It should be inserted convergently so that the

Table 1. Overview of the types of pelvic fractures

Type of pelvic fracture	Patients in study group	
	Number	Percent
B1	11	18%
B2	12	19%
B3	7	11%
C1	17	27%
C2	9	14%
C3	7	11%
Total	63	100%

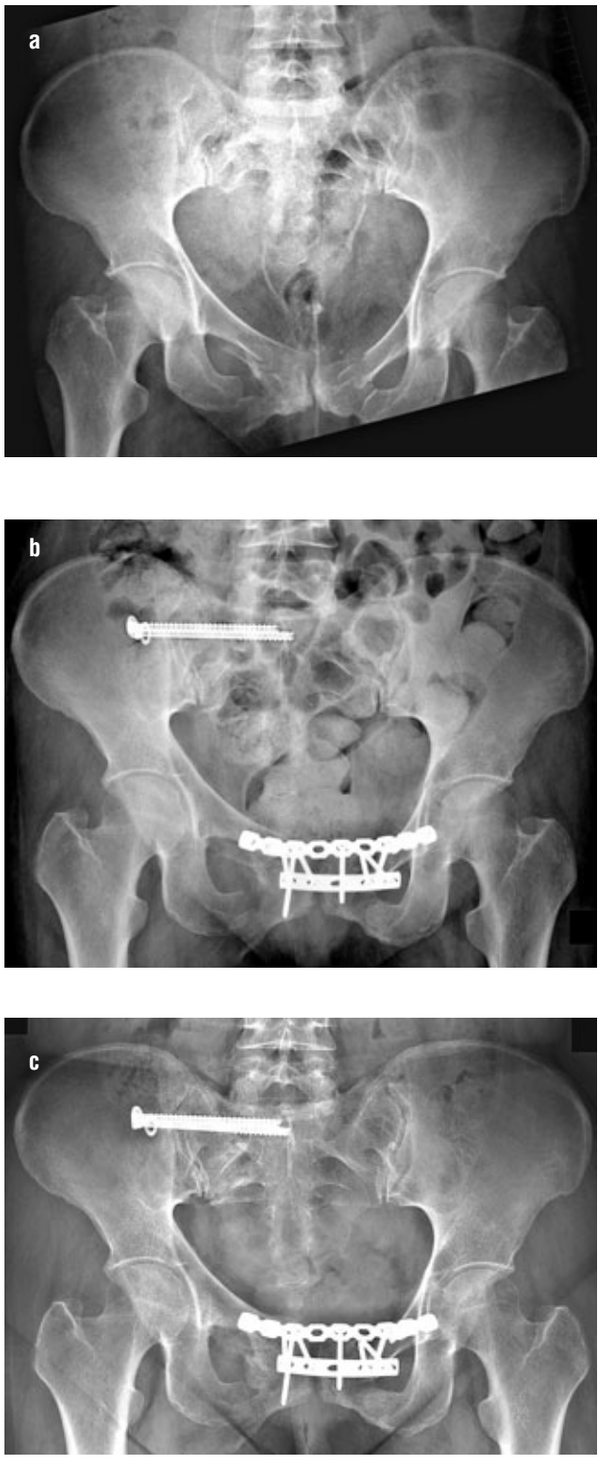

Fig. 3. X-ray documentation of a 47-year-old woman with a type C1.3 pelvic fracture occurring after a traffic accident: a – fracture of the lateral part of the sacrum on the right and bilateral fracture of the pubic rami with proximalisation of the right hemi-pelvis by 1 cm;
b – follow-up X-ray 6 weeks after fixation with migration of one screw by 3 mm;
c – follow-up X-ray at three months with screw migration by 5 mm (at this time the patient did not have any pain and there were radiological signs of fracture healing).

tip of the guide wire touches the thread of the first screw approximately 2 cm before its end. The second screw is always full-threaded to allow it to be fixed in the three cortices (two cortices of the ilium and one cortex of the sacrum). During the final tightening of the second screw, it is possible to feel a slight resistance at the moment when it interconnects with the thread of the first screw. We always use a washer for the first screw. We do not use a washer for the second screw if the guide wire is located close enough to the washer of the first screw so that the head of the second screw can be placed on the edge of the washer of the first screw. In this case the single washer is pressed against the cortex of the ilium by the heads of both screws (Fig. 2). If the guide wire of the second screw is located further than this, we use a washer for the second screw as well. In these patients, the heads of both screws are supported by washers (Fig. 3).

Parallel screw insertion was used more frequently at the beginning of the study. In the later years the convergent technique was used more frequently. No criteria were set that would prefer or limit the use of any of these techniques, and the choice of how to insert the iliosacral screw was left to the surgeon.

Radiological follow-up

We reviewed immediate postoperative X-rays as well as follow-up X-rays at 6 weeks and 3, 6 and 12 months after surgery for iliosacral screw migration. We arbitrarily chose migration of 5 or more milimetres in the first 6 weeks after surgery to be a significant risk for impaired fracture healing and in these cases, we indicated re-osteosynthesis. Full weight bearing on the injured side without significant pain was considered a clinical sign of healing. Presence of a callus and disappearance of the fracture line without dislocation or migration of the iliosacral screws were taken as radiological signs of healing (23).

Patient selection

Iliosacral screws have been used in our department since the year 1999. The convergent screw technique was introduced in 2008. Therefore, we included in the study patients treated between 2009 and 2019 who met the following inclusive criteria: unilateral iliosacral screw fixation during primary treatment of pelvic fractures and complete clinical and radiological follow-up for at least one year after the procedures. We excluded cases of osteosynthesis of non-unions, cases of failure of fixation of the anterior pelvic segment within the first six weeks after the surgery and patients with incomplete follow-up (including patients who underwent postoperative rehabilitation in another facilities and patients who died within the first 12 months after the surgery).

Statistical analysis

Fisher's exact tests were used to compare differences in the extent of screw migration between screws inserted in parallel and screws inserted convergently. P-values less than 0.05 were considered significant.

RESULTS

In total 63 patients (23 women, 40 men) were included in the study. The mean age was 45.9 years (range 17–79). The classic method of parallel iliosacral screw insertion was used in 24 patients (8 women, 16 men, mean age 42.9, range 17–71) and the new method of convergent iliosacral screw insertion was used in 39 patients (15 women, 24 men, mean age 47.7, range 21–79).

Significant iliosacral screw migration (5 mm or more) within six weeks from the surgery occurred in nine patients (38%) who underwent parallel iliosacral screw insertion. In two cases we noted insufficient postoperative stability of the anterior pelvic segment (change in position of the pubic screws or screws fixing the plates, without significant changes in the position of the anterior arch and without failure of the fixation).

In the patients who underwent convergent screw insertion significant iliosacral screw migration occurred in the first six weeks in a total of four patients. In three cases this was associated with instable fixation of the anterior pelvic arch (Fig. 3).

The results show that convergent screw insertion is significantly associated with a lower number of cases of migration than parallel iliosacral screw insertion ($p = 0.0219$).

DISCUSSION

The aim of the treatment of unstable pelvic fractures is to achieve good functional results after healing in the correct position, with a maximum tolerated fragment dislocation of 10 mm *ad latus* and 3 mm of distraction (3, 16, 23). Iliosacral screws ensure sufficient stability of the posterior arch in pelvic fractures type B and C provided that the anterior arch is stable after its treatment (1, 2, 8, 18, 22). Insufficient stability of fixation of the pelvis often leads to poor healing and necessitates reoperation – this was noted at the beginning of the era of modern pelvic surgery by its main protagonists (16, 17, 19, 23). Despite this, it is always necessary to consider the general state of the patient and the quality of the pelvic bones on one hand with the extent of the planned procedure on the other hand. It is advantageous for internal fixation of the pelvis to be performed soon after the injury, ideally within the first week. In the first days after the fracture occurs it is usually relatively easy to reduce the main fragments and therefore it is possible to select closed reduction and minimally invasive osteosynthesis as the treatment strategy. This procedure is more suitable to perform shortly after polytrauma, as such patients would poorly tolerate extensive procedures with large open or multiple approaches. However, minimally invasive osteosynthesis should not be performed at the expense of sufficient stability (15, 17, 23). This has been shown in recent studies devoted to the correct insertion of iliosacral screws in the terrain of dysplastic changes in the sacrum and sacroiliac joint (10, 25, 27).

We began using the technique of convergent iliosacral screw placement with closed reposition in patients after severe trauma, in order to be able to treat these patients as soon after the injury as possible with the hope that closed reduction would be successful. Both our experience and the literature show that with a delay of two weeks even open reduction of pelvic fractures is not easy and may not bring satisfactory results (14, 20). To achieve ideal reduction an extensive surgical approach is necessary, which increases the surgical stress inflicted on the patient.

The second group in whom we used the technique of convergent screws were elderly patients. The increased surgical stress associated with the more extensive open surgical approaches is more detrimental to the elderly patient, for whom minimally invasive approaches can bring a great benefit as they are associated with faster rehabilitation and earlier verticalization (4, 18, 26). On the other hand, inserting screws into osteoporotic bone is problematic, and this is true not only for iliosacral but also other pelvic screws, such as pubic screws (5, 6, 13, 18). We believed that the use of two iliosacral screws inserted convergently will increase the likelihood stable anchoring in osteoporotic bone, of course in conjunction with a stably treated anterior arch (2, 8, 29). Recently, for cases of advanced osteoporosis we have begun to instil small amounts of bone cement into the affected bone before inserting the screws to further increase the stability of the osteosynthesis (19). However, these cases were not included in the current study.

Years of experience has shown us that in cases where screw migration of 5 mm or more within the first postoperative six weeks, i.e., while the fracture is not yet healed, leads to further migration of the screws and to non-union. Therefore, we currently indicate reoperation in cases of migration larger than 5 mm. Thus, we chose this value as a cut-off for significant migration of the iliosacral screws in this study. Measuring screw migration by only using X-ray images may seem to be influenced by the subjective error of the evaluator, but due to the fact that the washers always remained in contact with the external cortex of the ilium during screw migration, we do not standardly indicate CT scans in these patients. We indicate CT scans only in cases where there is obvious re-dislocation of the fracture on the follow-up X-ray images when compared with the immediate postoperative X-ray image.

During the study period we used the technique of convergent screws for all cases of non-unions and for re-osteosynthesis. Healing occurred in all of these patients, but we excluded these cases from the study group so as not to positively distort the results, which focused on assessing the stability of parallel and convergently inserted iliosacral screws for the primary osteosynthesis of fractures of the posterior pelvic arch. We also omitted patients with bilateral fixation, so as not to distort the results.

Regarding surgical technique, we want to note that raising the sacrum by placing a pillow under it facilitates the reduction of fractures of the posterior pelvic arch. If this is not done then manipulation of the injured half of the pelvis by using traction of the extremities is difficult

and in the anteroposterior direct impossible. Raising the sacrum further simplifies the insertion of iliosacral screws as it reduces the layer of soft tissues because the gluteal muscles and subcutaneous tissue do not lie on a mat, but instead „hang" from the ilium (16).

We believe that the convergent introduction of iliosacral screws increases their stability, firstly by mutual locking of the threads of both screws into each other, and then by anchoring the full-threaded screw to the three cortices. We did not find any cases of convergently inserted iliosacral screws in the literature that confirmed this. We believe a comparative study on pelvic models would be able to confirm our initial clinical experience.

We are aware of several limitations of our study. First of all, the study is retrospective, non-randomised and has a relatively small number of patients. The small number of patients may be the reason why the differences in parallel and convergent screw insertions were not significant for fractures type B and C, individually. Another problem is the failure to perform densitometric examination in patients with X-ray proven screw migration to investigate osteoporosis as one of the possible causes of fixation failure. To confirm the results of this pilot study, we plan to perform a multicentre prospective randomized study.

CONCLUSIONS

By comparing the results of the two patient groups, we believe that the technique of convergent insertion of iliosacral screws is associated with a lower risk of screw migration and subsequent failure of osteosynthesis of the posterior pelvic arch. This expands the possibilities of early mini-invasive treatment of unstable pelvic fractures, which can benefit especially patients in severe conditions after polytrauma and elderly patients, in whom an open procedure performed soon after the injury may present a serious surgical risk and a delayed procedure may lead poor functional results. Further biomechanical and clinical studies are clearly needed to confirm the efficacy of this technique.

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