Slovenian Medical Journal

Methods of internal sacroiliac fixation – Literature review and case series analysis of iliac screw fixation

Metode notranjega fiksiranja križnice na črevnico – Pregled literature in analiza serije primerov fiksiranja z iliakalnim vijakom

Janez Mohar

Abstract

In order to achieve bone fusion between the mobile lumbar spine and the immobile sacrum, surgical techniques have been developed along with the development of instrumentation systems for internal fixation of the thoracolumbar spine that allows the extension and fixation of such systems to the structural elements of the pelvis. The term sacroiliac fixation encompasses all instrumentation systems and surgical techniques for fixation of the lumbosacral spine to the ilium. Nowadays, prevention of pseudarthrosis of the bone fusion at the lumbosacral region, the border between two different structures (mobile lumbar spine and static pelvic ring), is one of the main challenges of surgical treatment of adult lumbar spine deformities. Biomechanically, the lumbosacral junction represents an axis of rotation extending in the lateral plane through the posterior longitudinal ligament at the height of the intervertebral disc of the moving segment L5-S1. The flexion torque arm's size depends on the number of instrumented movable spine segments. Counter-torque is required for system stability, which, due to the short lever arm, depends mainly on the implant's attachment strength to the pelvic ring's bony elements. Sacroiliac fixation systems prevent the formation of pseudoarthrosis of the bone fusion of the lumbosacral junction. Its occurrence, with the exclusion of biological causes (i.e., infection), depends solely on the strength of the instrumentation system (the brittleness of the material) and the quality of attachment of the instrumentation to the pelvic ring (loss of fixation at the bone-implant interface).

Indications for sacroiliac fixation are lumbosacral fusion above the third lumbar vertebra, osteotomies of the lumbar vertebra, fractures of the sacrum with spinopelvic dissociation, partial or complete sacrectomy, lumbosacral fusion in the face of osteoporotic bone, spondylolisthesis grade III or more of Meyerding classification, correction of kyphotic or scoliotic deformity of the lumbar spine and pelvic obliquity in the frontal plane in neuromuscular deformities of the lumbar spine.

This review article aims to describe the spinopelvic junction's biomechanics, present the developmental history of implants and surgical techniques, and describe the modern sacroiliac fixation methods.

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Key words: spine deformity; pseudoarthrosis; lumbosacral junction; iliac screw; S2-alar-iliac screw

Ključne besede: deformacija hrbtenice; psevdoartroza; ledveno-križnični prehod; iliakalni vijak; S2-alarni iliakalni

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Izvleček

Da bi dosegli zatrditev med gibljivo ledveno hrbtenico in negibljivo križnico, so se ob razvoju instrumentacijskih sistemov za notranje fiksiranje prsno-ledvene hrbtenice razvijale kirurške tehnike, ki omogočajo podaljšati take sisteme na kostne elemente medenice. Izraz sakroiliakalno (SI) fiksiranje zajema vse instrumentacijske sisteme in kirurške tehnike za notranjo učvrstitev ledveno-križničnega predela hrbtenice na črevnico. Preprečevanje psevdoartroze kostne fuzije ledveno-križničnega prehoda, ki nastane na meji med dvema različnima strukturama (gibljivo ledveno hrbtenico in statičnim medeničnim obročem), je dandanes eden glavnih izzivov kirurškega zdravljenja deformacij ledvene hrbtenice pri odraslih. Ledveno-križnični prehod je biomehansko os vrtenja, ki v stranski ravnini poteka skozi posteriorni longitudinalni ligament v višini medvretenčne ploščice gibljivega segmenta L5-S1. Velikost ročice fleksijskega navora je odvisna od števila instrumentiranih ravni gibljive prsno-ledvene hrbtenice, za stabilnost sistema pa je potreben nasprotni navor, ki je zaradi kratke ročice odvisen predvsem od pričvrstitvene moči vsadka na kostne elemente medeničnega obroča. Sistemi SI-fiksiranja preprečujejo nastanek psevdoartroze kostne fuzije ledveno-križničnega prehoda, njen pojav pa je ob odsotnosti bioloških vzrokov (npr. okužba) odvisen izključno od trdnosti instrumentacijskega sistema (lomljivost materiala) in kakovosti fiksiranja instrumentarija na medenični obroč (omajanje na stiku med vsadkom in kostjo).

Indikacije za SI-fiksiranje so ledveno-križnična kostna fuzija (zatrditev) več kot treh ledvenih vretenc, razširjene korektivne osteotomije ledvenih vretenc, zlomi križnice s spinopelvično (SP) disociacijo, delna ali popolna sakrektomija, ledveno-križnična kostna fuzija pri osteoporotični kosti, spondilolisteza, ki je večja od II. stopnje po Meyerdingovi klasifikaciji, korekcija kifotične ali skoliotične deformacije ledvene hrbtenice in nagib medenice v čelni ravnini pri živčnomišičnih deformacijah ledvene hrbtenice.

Pregledni članek opisuje biomehaniko SP prehoda, predstavi zgodovino razvoja vsadkov ter kirurških tehnik in prikaže sodobne metode SI-fiksiranja.

1 Introduction

Surgical treatment of complex pathology of the thoracolumbar spine is based on the internal fixation of the bone structures involved in the disease process with the aim of preventing progression, and at the same time, stabilizing the corrected position of the deformed spinal column. Such an “internal fixator” is actually a multi-level instrumentation construct consisting of pedicle screws, fixated bilaterally to the vertebrae, and rods connecting the heads of the pedicle screws to one another. The instrumentation construct thereby turns the mobile segments of the thoracolumbar spine into an immobile structure of interconnected vertebrae, which is a prerequisite for early mobilization of the patient after surgery. By stabilizing the vertebrae, the instrumentation construct allows the bone graft placed on the decorticated bone structures to connect over time into a static bone fusion mass, which permanently fuses the mobile segments included in the construct. Biomechanically, the lumbosacral region is a junction between the mobile lumbar spine and the static pelvic ring. The axis of rotation between these two structures in the lateral plane passes through the posterior longitudinal ligament at the height of the intervertebral disc of the L5-S1 moving segment. This anatomical region is therefore the area where both static and dynamic load forces are concentrated. When the sacrum and multiple lumbar vertebrae are included in the instrumentation construct, biomechanical conditions are iatrogenically created that require balancing torques proximal and distal to the axis of rotation in the lumbosacral junction. The magnitude of the flexion torque proximal to the axis of rotation depends on the number of thoracolumbar vertebrae included in the instrumentation construct. The torque distal to the axis of rotation depends on the length of the distal lever arm and on the implant’s attachment strength to the bony elements of the pelvic ring. The prerequisite for flexion-extension stability is that the implants, which are fixed to the elements of the pelvic ring, run anterior to the axis of rotation. The term SP fixation broadly covers all instrumentation systems and surgical techniques for fixation of the lumbar spine to the sacrum, the latter being the biomechanical part of the pelvic ring. Sacroiliac (SI) fixation encompasses all instrumentation systems and surgical techniques for fixation of the lumbosacral spine to the ilium. Preventing the formation of pseudarthrosis of bone fusion mass of the lumbosacral junction and thus the failure of the instrumentation construct is one of the main challenges of surgical treatment of lumbar spine deformities today (1,2).

Indications for SIJ fixation are lumbosacral fusion above the third lumbar vertebrae, extensive corrective osteotomies of the lower thoracic and lumbar vertebrae, fractures of the sacrum with spinopelvic dissociation, partial or complete sacrectomy, lumbosacral fusion in the face of osteoporotic bone, spondylolisthesis grades III, IV, and V, kyphotic or scoliotic deformity of the lumbar spine, and unstable sitting position due to pelvic obliquity in the frontal plane in neuromuscular deformities of the lumbar spine (3).

SP fixation techniques are divided according to the area of fixation in the sacropelvic region, which is defined by O'Brien's anatomic zones (Figure 1). The attachment strength of the distal part of the instrumentation construct increases depending on the number of zones included in the construct (4-6). O'Brien zone I consists of the S1 vertebral body and the cranial sacral alae, and SP fixation techniques in this anatomical area are the S1 pedicle screw, L5-S1 transfacet screw, and the Dunn-McCarthy technique. In the latter, the S-shaped rods are posteriorly fixated to the sacral ala. It is suitable for non-ambulatory children with neuromuscular scoliosis, in whom the pelvis is too small and the iliac cortices are too thin for classic iliac fixation (7). O'Brien zone II consists of the S2 vertebral body, caudal sacrum, and coccyx. SP fixation techniques in this anatomical area are the S2 pedicle screw, sacro-alar iliac screw, sacral neural foramina hooks in the form of a jaw construct, and the Jackson technique with intrasacral rods (8). O'Brien zone III constitutes the ilia and the SP fixation techniques in this anatomical area are the Galveston technique, the iliac screw, and the Kostuik transilial bar technique. In order to achieve the greatest possible fixation strength on the pelvic ring, these techniques are combined or implants are used that allow fixation through two O'Brien zones at the same time. These are the Chopin block, the Tacoma plate, the Colorado 2 iliosacral plate, the Warner and Fackler technique, the iliosacral screw, and the S2-alar-iliac screw (S2AI) (9).

Biomechanical stress on the fixation construct is significantly reduced with additional stabilization by inserting an intervertebral cage between the L4, L5, and S1 vertebral bodies (L4-L5 and L5-S1 mobile segments of the lumbosacral junction). This reduces micromovements anterior to the axis of rotation in the lumbosacral junction, the axis of rotation moves proximally, and the intervertebral cage thus provides support to the construct and "protects" it against failure (breakage or loosening of the implants) (10). Biomechanical research has proven that SIJ fixation with iliac screws

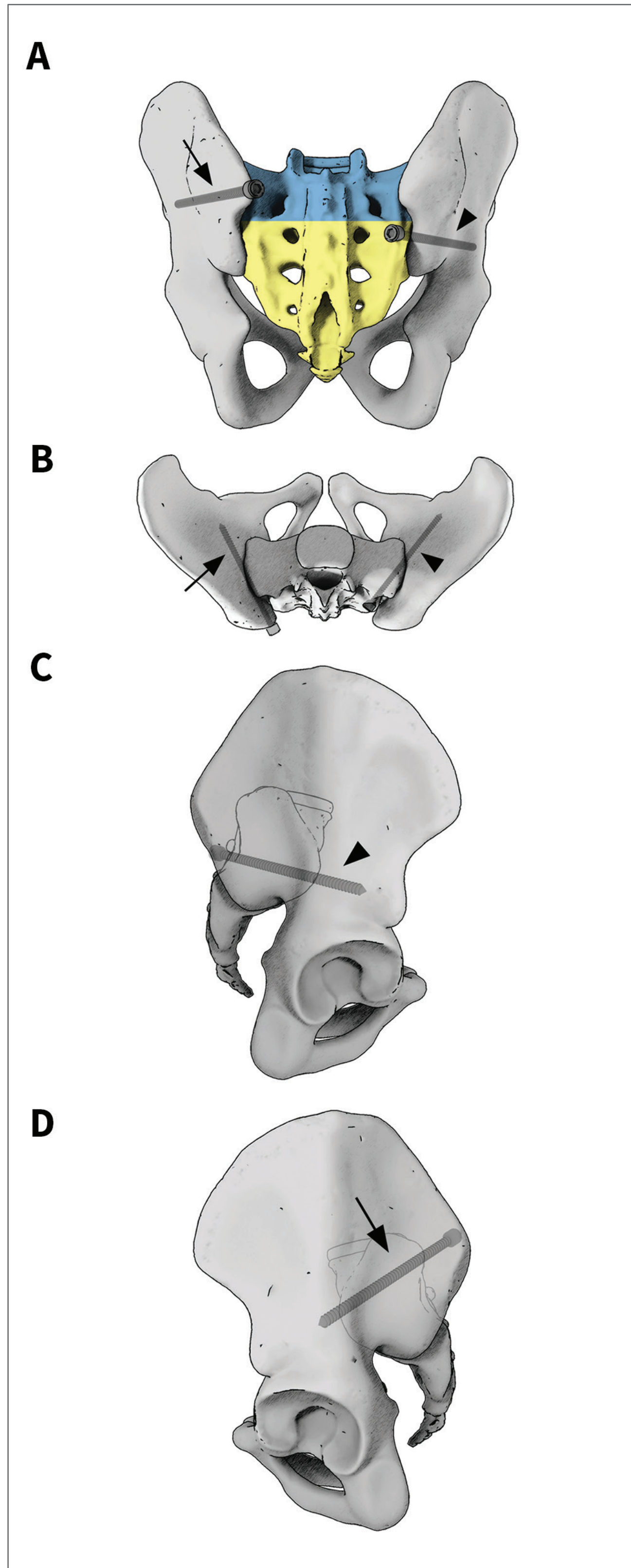

Figure 1: Posterior (A), superior (B), and lateral (C and D) views of the anatomical diagram of the pelvic ring with O'Brien zones marked (zone I = blue, zone II = yellow, zone III = grey) and with the iliac (arrow) and S2AI screws (arrow head) inserted.

reduces the strain on the instrumentation construct more than the intervertebral cage alone (10,11). Intervertebral cage implantation between the vertebral bodies of the lumbosacral junction is therefore a prerequisite for all instrumented lumbosacral fusions. In the case of long thoracolumbar-sacral instrumentation constructs, the insertion of the intervertebral cage must always be combined with SIJ fixation.

2 Development of implants for Fixation in O'Brien zone III

The first example of an implant in O'Brien zone III was a transiliac rod connecting the iliac alae to which a lumbar instrumentation was attached. This concept was first described as early as 1962 in the form of the Harrington rod, a modification of which was later upgraded by Kostuik with his own implant suitable for more modern and more rigid instrumentation systems (12,13).

In the 1970s, when fixing his multisegmental system of rods and sublaminar wires to the pelvis, Luque curved the distal ends laterally and led them through the posterior alae of ilium. As the Luque L-rod is considered a weak SIJ fixation, it was not able to withstand physiological flexion and torsion forces (14,15).

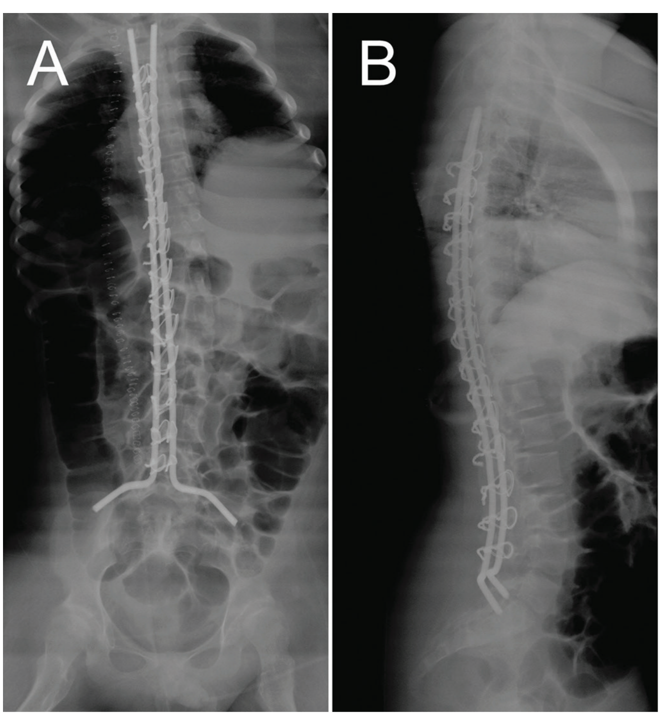

Figure 2: SP fixation with the Luque-Galveston technique in a 13-year-old boy with scoliosis as part of spinal muscular atrophy; anteroposterior (A) and lateral (B) projection (source: Archives of the Department of Orthopaedic Surgery of the University Clinical Centre Ljubljana).

In 1982, Allen and Ferguson of the University of Texas Medical Branch at Galveston described a technique for pelvic fixation with Luque's segmental instrumentation by inserting extended left and right L-shaped rods into the ilia (16). The Luque-Galveston technique of intrailiac rod stabilization (Figure 2) became the first biomechanically and clinically successful form of fixation of long instrumentation constructs in O'Brien's zone III. The technique involves the introduction of rod instrumentation with an entry point at the posterior superior iliac spine, the rod passing between the two cortices of the ilium. The degree of lumbosacral spinal fusion rate using this technique is described to be 88-90% (17,18). Biomechanically, the Luque-Galveston technique does not provide enough resistance to axial traction, which represents the force component during lumbar flexion, so micromovements in the sacroiliac joint can lead to erosive changes in the contact between the rod and the bone (windshield-wiper effect), which results in the loss of the fixation function of the implant. Erosive changes do not always lead to clinically expressed pseudoarthrosis, although it is more common in the presence of the "windshield-wiper effect" (18). The described rate of pseudoarthrosis of the lumbosacral junction when using the Luque-Galveston technique in adult spinal deformities varies between 36% and 41% (19,20). An additional weakness of the technique is the demanding, anatomy-adapted bending of the rods that are inserted into the ilium. The Luque-Galveston technique is still a relative indication in non-ambulatory patients with neuromuscular scoliosis, due to the low profile of the implant and the price of the commercially proximally pre-bent U-shaped rod (unit rod). The Luque-Galveston intrailiac rod concept later led to the development of SIJ fixation with iliac screws (21).

The technique of fixing the lumbar instrumentation to the iliosacral screw was first described in 1973, but later developed in its improved form in the 1980s into the possibility of SIJ fixation with the first generation of hybrid segmental instrumentation with the Cotrel-Dubousset system (22,23). In this technique, a screw is inserted from the outer side of the ilium towards the body of the S1 vertebra. The screw provides strong tricortical bone graft (inner and outer cortices of the ilium and posterior cortex of the sacrum). The iliosacral screw as a stand-alone implant in SIJ fixation is connected to the rods of the lumbar instrumentation construct via a connecting element. In this technique, the S1 pedicle screws are not used due to possible contact with the iliosacral screws within the S1 vertebral body. The technique itself, however, allows considerable modularity in relation to anatomical conditions. Due to the extensive dissection along the iliac edge and the possibility of damaging the posterior iliosacral ligament, which triggers sacroiliac joint instability and a high incidence of neurological injuries due to incorrect position of the screw, the use of this technique is currently limited mainly to revision cases (15,23).

3 Modern techniques of SIJ fixation

3.1 Iliac screw

Certain shortcomings of the Luque-Galveston technique were overcome by the technique of connecting iliac screws to the rod of the instrumentation construct with modular connectors (24). On the cadaver model, a three times stronger fixation of the iliac screws into the ilium is made possible compared to the Galveston intrailiac rod by the presence of threads and the greater thickness of the implant (25). The entry point of the iliac screw is at the level of the posterior superior iliac spine or just below it, and the direction (trajectory) of insertion is either towards the superior portion of the acetabula or towards the anterior inferior iliac spine. The latter direction allows the insertion of longer implants, is safer regarding the possibility of piercing the acetabular floor and the fixation can be made stronger, since the screw is inserted through a greater narrowing between the cortices of the ilium in its course above the sciatic notch (26). Due to the longer iliac screw, there is a greater possibility for it to go outside the safety trajectory and thus for more complications, however, the longer screw enables a stronger fixation to the ilium. Longer iliac screws have been proven to have a greater pull-out force, and under physiologic torsion, and compressive loading conditions there should be no statistically significant differences in the mechanical stability of SIJ fixation between shorter and longer iliac screws, but on the condition that the shorter screw also runs anterolaterally of the sciatic notch (27). The gold standard for iliac screw insertion is therefore the thickest and longest possible implant, which runs in the direction of the anterior inferior iliac spine, namely anterolaterally of the sciatic notch.

The SIJ fixation construct with iliac screws fails in two ways: either by loosening which causes pseudarthrosis, or by the implant breaking. Loosening of the iliac screw occurs during cyclic micromovements at the bone-implant interface. The phenomenon is common, but in most cases, it is clinically silent, except when the loosening leads to pseudarthrosis (2,28,29). Revision of loose iliac screws is necessary if pseudarthrosis develops, namely by inserting longer and thicker implants, reinforcing the contact between the implant and the bone with bone cement, or by stabilization using dual iliac screws (30-33). The latter technique, i.e. DIS (Dual Iliac Screw), is primarily suitable for resections and osteotomies of the sacrum and certain forms of sacrum fractures with dislocation of fragments (34).

Screw fracture is a rarer form of fixation failure with a reported rate of 5.3%, which more often affects the younger population with good bone quality and insufficient screw diameter (28). The indication and options for revision surgery are otherwise the same as in the case of loosening.

The SIJ instrumentation construct in the form of combined S1 pedicle screw and iliac screw has certain disadvantages:

- Insertion of the iliac screw requires an extensive lateral soft tissue dissection along the iliac crest, thereby creating a surgical "dead space" (a prerequisite for local infection).
- The iliac screw is connected to the rod of the construct via a connector, which further reduces the stiffness of the construct and thus represents an additional *locus minoris resistentiae* for its failure, while there are no biomechanical differences if the connector is fixed to the rod above or below the S1 pedicle screw (35). The described rate of pseudarthrosis in the lumbosacral junction when using instrumentation with iliac screws in adult spinal deformities varies between 6.4% and 14% (19,36).
- The head of the iliac screw and the connector represent a significant implant prominence, which is a relatively common cause of local pain and revisions (incidence between 6% and 22%) (2,19,37). The results of recently published research show a significantly lower rate of this type of complication if the entry point of the iliac screw is below the posterior superior iliac spine, or if the screw head is "sunk" deep into the iliac bone (38-40). Under favourable anatomical conditions, the "anatomical" or "subcrestal" entry point of the iliac screw, it is possible to fix the rod on the screw head without using connectors (41).

3.2 S2AI screw

The instrumentation construct with the S2AI screw is the latest SIJ fixation technique, which enables stability without the necessary use of connectors, with a less prominent screw head, and with less extensive lateral soft tissue dissection (42-44). In this technique, a polyaxial screw is inserted through a starting point on the sacrum that is 2–4 mm lateral and 4–8 mm distal to the S1 dorsal foramen (lateral to the midline connecting the S1 and S2 foramen), and the trajectory passes through the sacrum, sacroiliac joint and into the ilium in the direction towards the anterior inferior iliac spine (1,21,44). S2AI screw enables a tricortical fixation (posterior cortex of the sacrum and both cortices of the sacroiliac joint) and is suitable for both children and adults (45-48). Insertion of the S2AI screw through the cartilaginous tissue of the sacroiliac joint may increase local postoperative pain and accelerate degenerative changes in the joint (49,50). Additional potential complications are screw misalignment and, rarely, screw head prominence in lean subjects with pain over the sacral area. Incorrect position of the S2AI screw with posterior iliac wall perforation leads to its reduced fixation strength and thus to reduced stability of the construct, while anterior or inferior prominence of the ilium endangers vital structures in the pelvis and sciatic notch (superior gluteal artery and sciatic nerve) (3,44).

3.3 Comparison between the iliac screw and the S2AI screw

Research on biomechanical studies between the iliac screw and the S2AI screw showed statistical comparability in the strength of the two constructs under different types of strain on cadaver models (51-53). Meta-analyses of clinical comparisons between the iliac screw and the S2AI screw published so far have demonstrated a statistically significant reduction in the risk of revision

Table 1: Patient cohort characteristics.

Patient number	Gender	Age (years)	Indication for surgery	Levels of instrumentation placement	Follow-up time after surgery (months)
1	female	72	iatrogenic deformation	T11-ilium	66
2	male	62	iatrogenic deformation	T11-ilium	59
3	female	43	adult idiopathic scoliosis	T8-ilium	49
4	male	54	iatrogenic deformation	T12-ilium	45
5	female	60	sagittal imbalance	L2-ilium	44
6	female	48	iatrogenic deformation	L3-ilium	44
7	male	64	sagittal imbalance	T11-ilium	44
8	female	58	adult idiopathic scoliosis	T10-ilium	42
9	female	64	adult idiopathic scoliosis	T3-ilium	39
10	female	57	adult idiopathic scoliosis	T10-ilium	38
11	female	52	adult idiopathic scoliosis	T11-ilium	38
12	male	61	degenerative scoliosis	T11-ilium	34
13	female	49	sagittal imbalance	L2-ilium	26
14	female	39	congenital deformity	L3-ilium	25
15	female	46	syndromic scoliosis	T6-ilium	24
16	female	58	adult idiopathic scoliosis	T2-ilium	21
17	female	69	degenerative scoliosis	T11-ilium	16
18	male	63	degenerative scoliosis	T12-ilium	16
19	male	72	iatrogenic deformation	T11-ilium	11
20	female	50	adult idiopathic scoliosis	T9-ilium	7

Table 2: Descriptive cohort statistics.

Sample characteristics	Number
Number of patients	20
Gender	6 men / 14 women
Age (years)	57 ± 9 (39–72)
Number of levels of instrumentation placement	9 (5–18)
Follow-up time (months)	34 ± 16 (7–66)

surgery, wound infection, or implant prominence with local pain after surgery when using the S2AI screw in both adults and children, while the use of an iliac screw increased the risk of the fixation construct loosening or breaking threefold (54-56). Despite the more challenging technique of inserting the S2AI screw through the sacrum and pelvis, and despite concerns about the long-term effect on sacroiliac joint degeneration, for which there is no clinical evidence yet, there is now sufficient evidence that SIJ fixation with the S2AI screw is superior to SIJ fixation with an iliac screw (57-65).

4 Case series analysis of sacroiliac screw fixation

Between July 2015 and June 2020, 20 bilateral SIJ fixations with an iliac screw were performed at the Valdoltra Orthopaedic Hospital, representing the author's initial series of consecutive cases using this technique (Table 1 and 2). All iliac screws were inserted using the free-hand technique and their position was checked with an X-ray image intensifier during the operation. Due to the expected complexity, three procedures (patients 9, 15 and 16) were performed in two stages during the same hospitalization (in the first stage, the placement of the implants, and in the second stage, deformity correction). In 15 cases it was a primary operation with a predominant idiopathic aetiology, and in five cases it was a revision procedure as part of an iatrogenic deformity, either kyphosis or kyphoscoliosis. In two patients (number 3 and 16), three revision procedures were performed due to the indication in the area of SIJ fixation (fracture of the iliac screw, local infection, and iliac screw prominence). The retrospective analysis of the case series was approved by the Ethics Committee of the Valdoltra Orthopaedic Hospital,

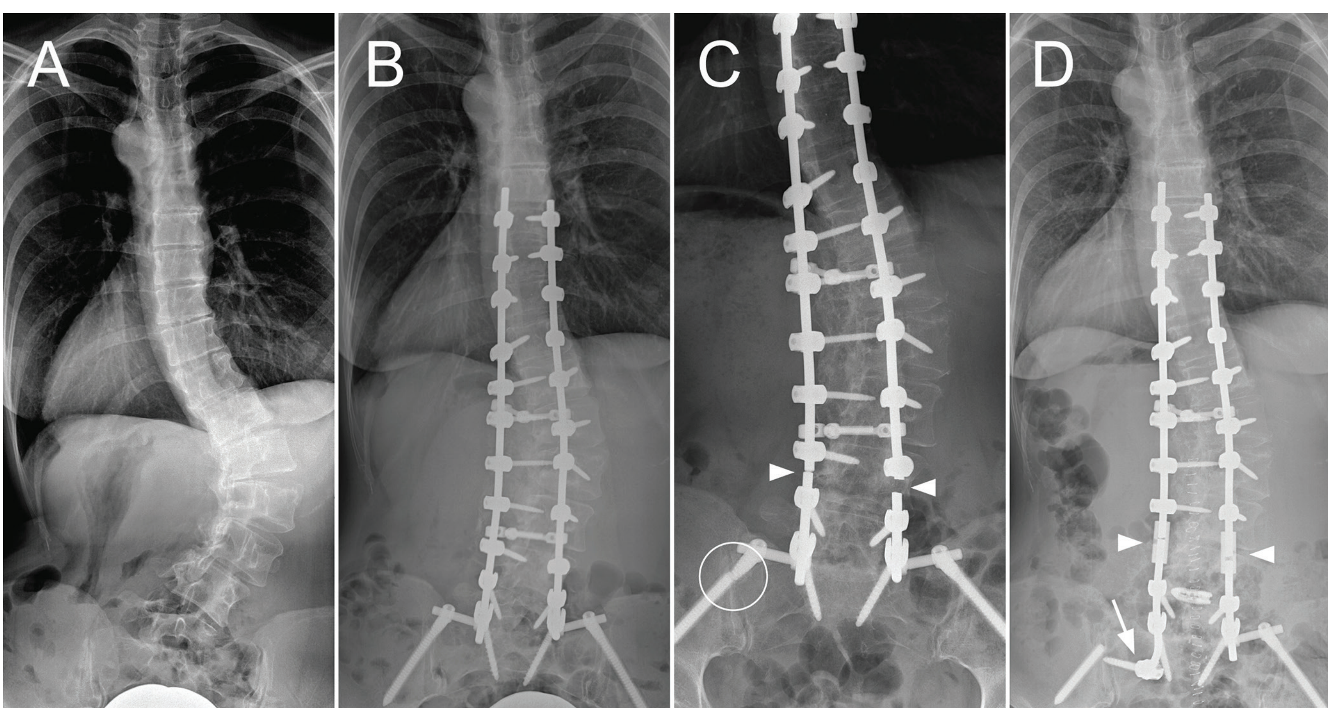

Figure 3: Revision Case No. 1: Anteroposterior radiographs of the patient's spine before (A) and after surgery (B). C – the condition after the breakage of the left and right fixation rods (arrowheads) and the breakage of the left iliac screw (circled). D – connection of the broken rods with a connecting link (arrowheads), removal of the proximal part of the iliac screw and fixation of the distal part of the left rod into the sacrum with a sacral-alar screw (arrow).

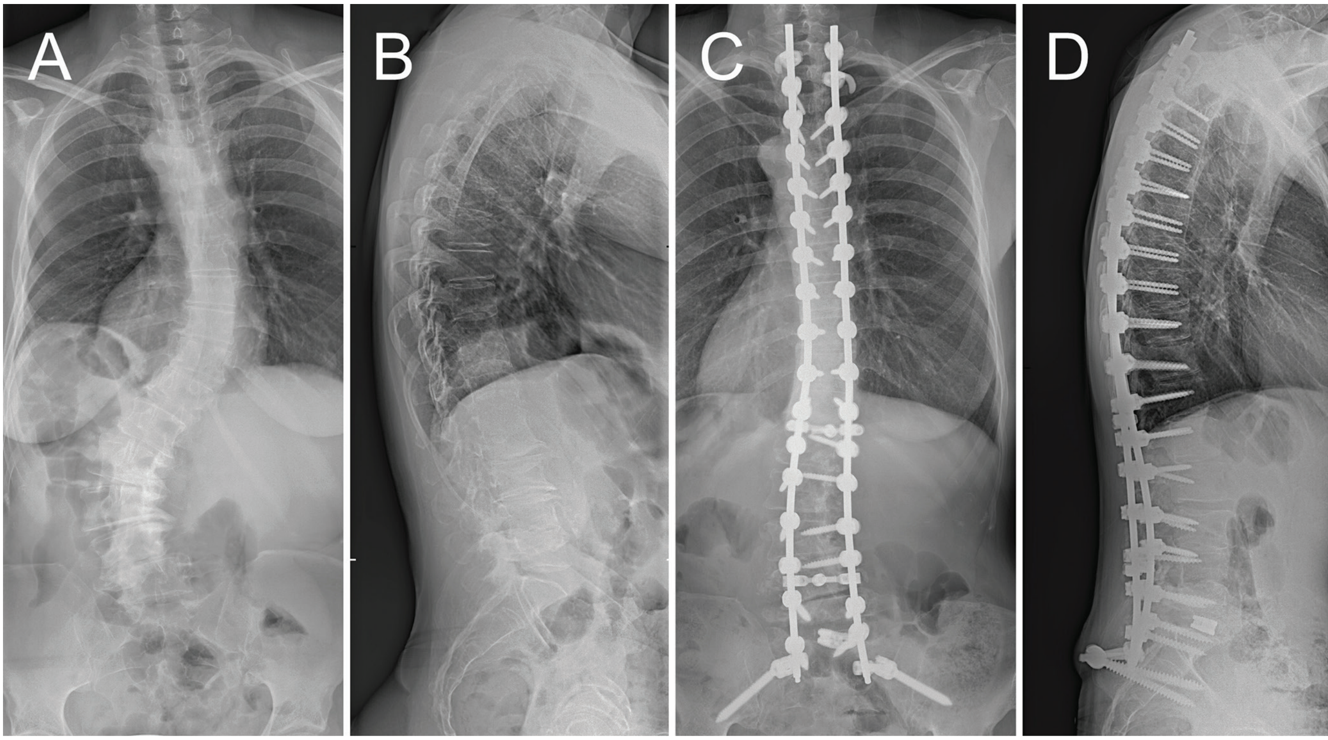

Figure 4: Revision Case No. 2: X-ray image of the patient's spine, anteroposterior (A) and lateral (B) before the surgery and anteroposterior (C) and lateral (D) after the surgery.

No. 1/2021, on January 20, 2021. The author confirms that he received written consent from both patients for the anonymized medical data and image material publication.

4.1 Revision case No. 1

A 43-year-old patient (No. 3, Table 1) with a rigid, right-sided idiopathic scoliotic curvature of the lumbar spine between the T12 and L4 vertebrae and the apex of the L2 vertebra underwent a one-stage correction, a posterior instrumented bone fusion between the T8 vertebra and the sacrum, and SIJ fixation (Figures 3A in 3B). Four months after the operation, she was involved in a traffic accident when another vehicle hit hers from behind. On the basis of imaging tests, skeletal damage or a change in the position of the implants were ruled out, but chronic pain appeared in the lumbosacral region. Three years after the operation, she sensed a crack in the lumbosacral junction and felt a severe localized pain. Imaging tests showed the failure of the instrumentation construct with fixation rod breakage between the L4 and L5 vertebrae and the left iliac screw breakage (Figure 3C). During the revision procedure, the distal part of the instrumentation was repaired and an intervertebral cage was inserted through the foramen to allow additional intracorporeal bone fusion (Figure 3D). The explanation for the instrumentation construct failure is the cyclic loading on the material and its stress fracture, the cause of which is pseudoarthrosis of the posterior bone fusion between the fourth and fifth lumbar vertebrae (discovered during surgery). The occurrence of pseudoarthrosis was most likely caused by insufficient stabilization of the lumbosacral junction during the first operation, since the intervertebral cage was not inserted at the L5-S1 segment.

4.2 Revision case No. 2

In a 58-year-old patient (no. 16, Table 1) with double adult idiopathic scoliotic curvature, a two-stage correction, an instrumented bone fusion between the T2 vertebra and the sacrum, and SIJ fixation were performed due to the progression of the deformity and persistent pain despite conservative measures (Figure 4). After the surgery, the patient lost some weight, but due to the reduction of subcutaneous fat over the posterior superior iliac spine area, the heads of the iliac screws and both connectors protruded, which irritated the patient locally. Five months after the procedure, there was a perforation of the skin envelope and a fistula with pus discharge above the right illiac screw prominence with systemic and laboratory signs of inflammation. The patient underwent emergency surgery with excision of the fistula, explantation of the right iliac screw and the distal part of the rod with a connector, necrectomy, lavage and drainage, and primary wound closure. *Staphylococcus Aureus Spp* were isolated from specimens, and the inflammation was cured after several weeks of antibiotic treatment. Nine months after the primary procedure, the left iliac screw was also electively removed due to pronounced localized pain with the patient signing that she is aware of possible later complications related to the loss of strength of the lumbosacral instrumentation construct (Figure 5).

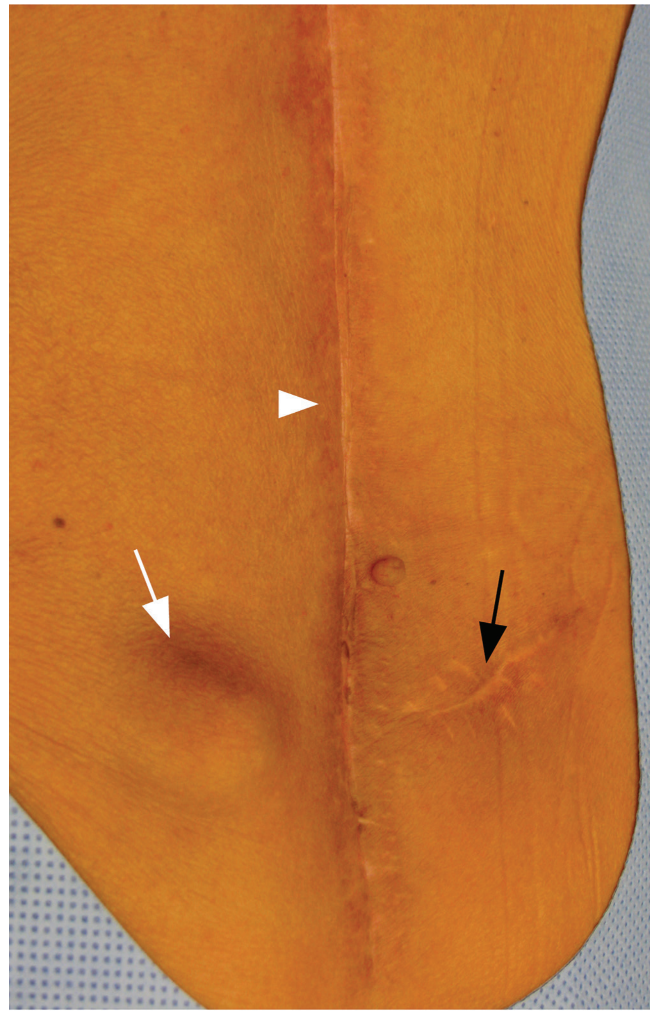

Figure 5: Revision Case No. 3: image of the patient before the removal of the second iliac screw. The scar after the posterior approach to the spine (arrowhead), the scar after excision of the purulent fistula and removal of the right iliac screw (black arrow) and the prominence of the head of the left iliac screw (white arrow) are visible.

5 Conclusion

Modern SIJ fixation techniques, such as internal fixation with the iliac and S2AI screws, improve the bone fusion rate after transplantation of a free bone graft into the lumbosacral region. This creates the prerequisites for sustainable clinical and health-economic justification of corrective interventions for thoracolumbar spine deformities in adult patients. Due to the aging of the population, the demands for a better quality of life, and the ever-increasing physical activity of the elderly population, the number of such operations is increasing in the developed world.

Conflict of interest

None declared.

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