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REVIEW
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Sacropelvic fixation

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Abstract

The sacropelvis is not only an anatomically complex region but also a biomechanically unique zone transferring axial weights via the transitional lumbosacral junction and the pelvic girdle to the lower appendicular skeleton. When the sacral instrumentation alone is insufficient to achieve stability and solid arthrodesis across the lumbosacral junction, as in long-segment fusions, high-grade spondylolisthesis, deformity corrections, complex sacral/lumbosacral injuries, and neoplasms, sacropelvic fixation is indicated. Many modern sacropelvic fixation modalities outperform historical modalities, especially the conventionally open and percutaneous iliac and S2-alar-iliac screw (S2AI) fixation techniques. Novel screw insertion technologies such as navigation and robotics and modern screw designs aim to maximize the accuracy of screw placement and minimize complications. This review addresses the anatomy and biomechanics of the sacropelvic region as well as the indications, evolution, advantages, and disadvantages of various past and contemporary techniques of lumbosacral and sacropelvic fixation.

Keywords: Sacropelvic, Fixation, Iliac, S2AI, Sacroiliac, Lumbosacral

Introduction and overview

Pseudarthrosis and instrumentation failure at the lumbosacral junction continue to be a challenge for spine surgeons worldwide. These could be attributed to the unique anatomical, structural and biomechanical properties of the sacrum, the lumbosacral junction as well as the sacropelvis. Significant efforts have been made and continue to be exerted to overcome these complications to improve the clinical and radiological outcomes of lumbosacral and sacropelvic fixation techniques [1].

This review addresses the anatomy and biomechanics of this region as well as the indications, evolution, advantages, and drawbacks of various past and contemporary techniques of lumbosacral and sacropelvic fixation.

Anatomy and biomechanics

The lumbosacral junction is a critical motion segment that includes the fifth lumbar vertebra, the sacrum, and the intervening articulations, including the L5–S1 disc anteriorly and the facet joints posteriorly as well as the supporting ligaments and muscles. It is a transitional zone transferring weights from the axial to the appendicular skeleton through the pelvic girdle, being the focus of significant biomechanical stresses that may reach up to 100 N with some activities [2]. When fusions are extended to it, a strong lever arm is formed, transmitting flexion, extension, as well as torsional forces from the superjacent spine, thus increasing the risk of pseudarthrosis and instrumentation failure. The obliquity of the L5–S1 disc, the suboptimal fixation due to the paucity of cortical bone in the sacrum, and the relatively weak purchase of S1 pedicle screws all contribute to these risks.

Long-segment fixations (i.e., ≥ 4 levels) with sacral inclusion, especially when crossing the thoracolumbar junction, are more prone to failure than short-segment ones due to longer lever arm exertion by the proximal column on the distal sacral instrumentation. [1, 3, 4] (Fig. 1).

The 80–20 rule of Professor Harms

The anterior spinal column transmits approximately 80% of the axial load, while the posterior column transmits only 20%. Fusions and instrumentations across the lumbosacral junction should biomechanically restore the

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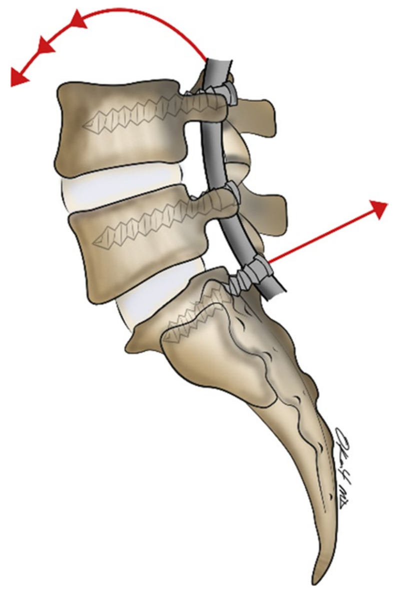

Fig. 1 Long-segment fixations, including the lumbosacral junction, resulting in a strong cantilever effect making the construct more prone to failure [5]

anterior column load-sharing property; otherwise, failure will supervise [3].

The concept of the lumbosacral pivot point

McCord et al. [6] first defined this concept as the midpoint of the osteoligamentous column at the L5/S1 junction. As the fixation progresses anteriorly, the stability of the sacropelvic instrumentation increases [6].

Consequently, when stability is a concern, iliac or S2AI screws are considered the best sacropelvic fixation modality [3, 4] (Fig. 2).

Pelvic parameters

The relationship of the spine to the pelvis is the key determinant of the sagittal spinal alignment and is analyzed by the following parameters: the pelvic tilt (PT), the pelvic incidence (PI), and the sacral slope (SS) [8]. The relationship between the above-mentioned parameters is determined by the following equation [9]: $PI = PT + SS$. In the context of sacral/sacropelvic fixation, these parameters must be assessed preoperatively in order to achieve/restore spinopelvic harmony both clinically and radiologically [5, 10] (Fig. 3).

The zone concept of O'Brien [11]and options for arthrodesis

Based on this concept, there are three zones of the sacropelvic unit available for sacral/sacropelvic fixation: [1, 3, 4] (Fig. 4).

- *Zone 1:* S1 body and upper part of the sacral alae.
- *Zone 2:* lower part of the sacral alae, the middle and lower sacrum, and the coccyx.
- *Zone 3:* Bilateral ilia.

Stability increases when fixation goes caudally utilizing more anchor points, and the best is through zone 3, with fixation extending beyond the pivot point.

There are plenty of options available for sacral/sacropelvic fixation, with sacral pedicle, iliac and S2AI screw fixation techniques being the most commonly used nowadays.

Below is a detailed list of these options, including methods of historical value only.

Zone I options

- S1 pedicle screws.
- S1 tricortical pedicle screws.

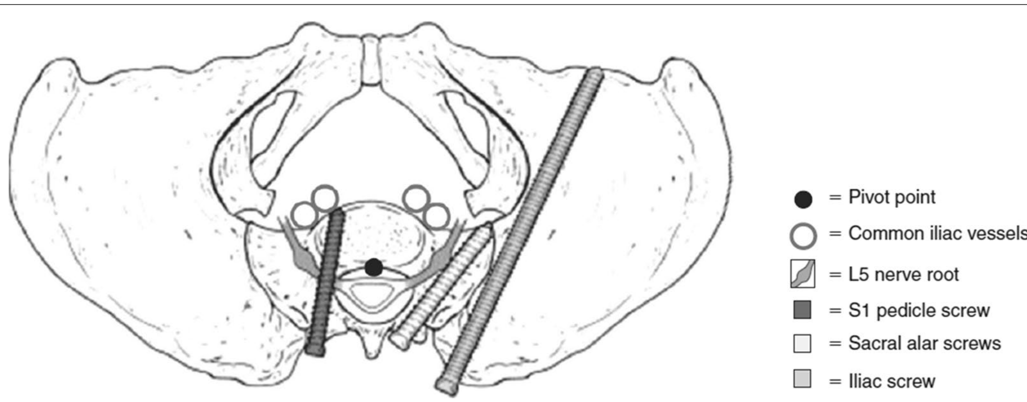

Fig. 2 Different options for sacropelvic fixation in relation to the pivot point and adjacent neurovascular structures [7]

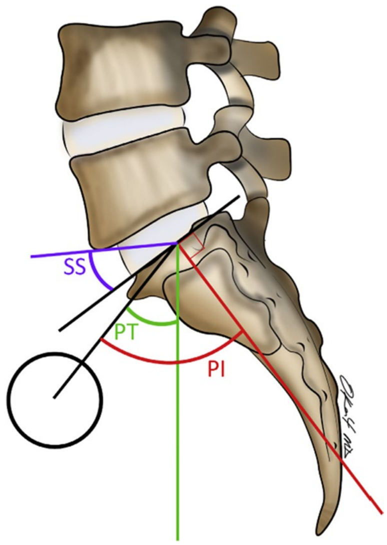

Fig. 3 PT (green line) is defined as the angle between the vertical reference line and the line connecting the femoral head to the midpoint of the sacral plate. PI (red line) is defined by the angle between the line perpendicular to the sacral plate midpoint and another line connecting the sacral plate midpoint to the femoral head. SS (purple line) is the angle formed between the sacral endplate and the horizontal reference line [5]

- L5–S1 transfacet pedicle screws (TFPS).
- Transdiscal fixation.
- Transsacral fixation.
- Sacral sublaminar wires, hooks, and cables.
- Dunn-McCarthy S-rod fixation.

Zone II options

- Sacral alar screws.
- Intrasacral Jackson rod fixation.

Zone III options

- Iliac screw fixation.
- Maximum width (MW) spinopelvic construct.
- The T-construct.
- S2AI screw fixation.
- S1-ALAR-ILIAC screws (S1AI).
- Combined S1AI and S2AI screws.
- S3-ALAR-ILIAC screws (S3AI)
- Iliosacral screw (ISS) fixation.
- Transiliac (sacral) bar and spinopelvic transiliac fixation (STIF).
- Galveston L-rod fixation.

Indications of sacropelvic fixation

When sacral pedicle screws are not sufficient to achieve stability and solid arthrodesis across the lumbosacral junction, sacropelvic fixation is indicated as in:

- Long-segment fixation (i.e., ≥ 4 levels) with sacral inclusion especially when crossing the thoracolumbar junction and also when pelvic obliquity should be corrected as during deformity corrections.
- High-grade spondylolisthesis stabilization with or without reduction.
- Lower lumbar spine osteotomies and revisions entailing potential destabilizations.

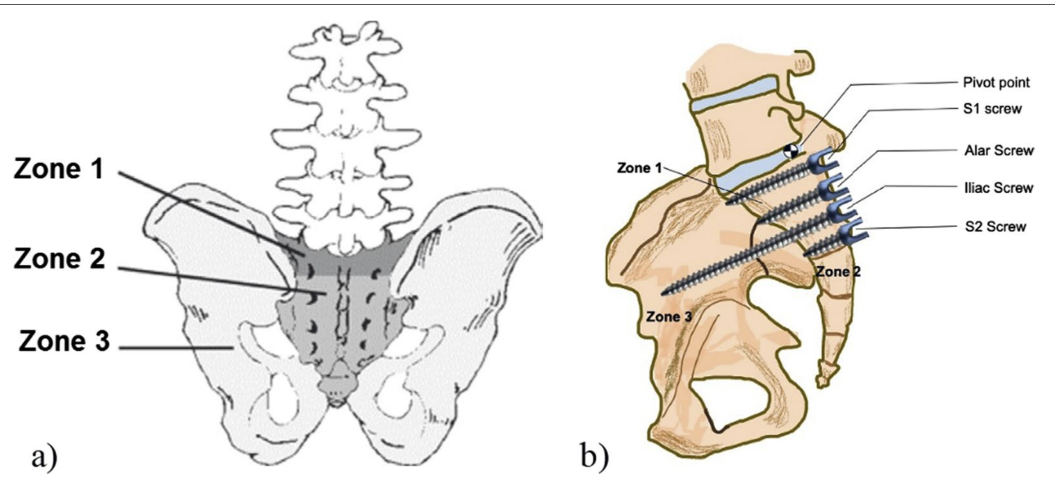

Fig. 4 **a** The sacropelvic zones of O'Brien [11]. **b** Sacropelvic fixation options in relation to McCord's pivot point and zones of O'Brien [4]

- Spinopelvic dissociation, sacral fractures, and reconstruction of the sacropelvic unit after sacrectomy as in sacral tumors.
- Osteopenic and osteoporotic patients to provide more anchoring points for solid arthrodesis.
- Multimodal plans in the management of extensive neoplastic and inflammatory lesions of the lower lumbar spine, the sacrum, and the pelvis [1, 3, 4].

Sacral pedicle screws

After entry point preparation at the base of the S1 cranial facet, a pedicle probe is introduced perpendicularly with medial angulation and aimed toward the sacral promontory. In order to avoid loosening of *unicortical* screws, controlled *bicortical* (penetration of the anterior cortex) and even *tricortical* (with S1 endplate penetration at the promontory) screw purchase could be utilized. Even though tricortical screws have twice the insertional torque of bicortical screws, [12] the failure rate with long fusions is 44% [13, 14]. Being posterior to the pivot point with narrow safety zones of insertion, S2 pedicle screws have no statistically significant effect on construct strength [1, 3, 6, 15] (Fig. 5a).

Laterally directed sacral screws (alar screws)

The S1 alar screw entry is just distal to the S1 cranial facet parallel with the dorsal S1 foramen, whereas that of S2 is between the dorsal S1 and S2 foramina. The trajectory is ideally 35° laterally and parallels with the S1 endplate. The controlled bicortical purchase is desired. Aside from the narrow safety zones of insertion, pseudarthrosis and poor clinical outcomes are common [1, 3, 6, 14, 15] (Fig. 5b).

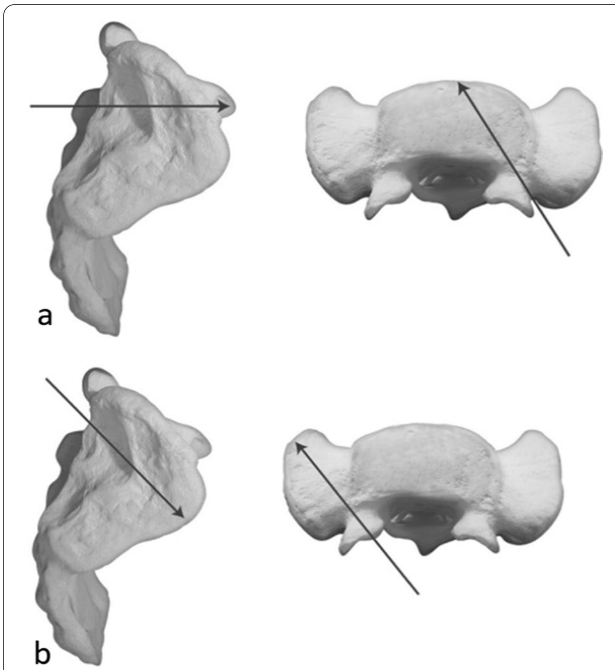

Fig. 5 S1 screw options. **a** S1 pedicle screw and **b** S1 alar screw [16]

Structures endangered with screw placement through the anterior cortex of the sacrum

Except for the middle sacral vessels, no neurovascular structures are jeopardized by medial angulation of S1 pedicle screws and strict direction toward the promontory. Straightforward trajectories put the L5 nerve root at risk where it crosses the anterior sacrum. Lateral S1 screws endanger the lumbosacral plexus, the internal iliac vessels, and the sacroiliac (SI) joint. Lateral S2 screws may endanger the nearby colon [3].

L5–S1 transfacet pedicle screws (TFPS)

This technique of lumbosacral stabilization and fixation entails passing the pedicle screw through the L5–S1 facet into the S1 pedicle providing multiple anchoring points to obtain short segments and more solid constructs than classic pedicle screw rod fixation. In an in vitro study conducted by Chin et al. [17], TFPS achieved better immediate postoperative stability than standard pedicle screws at L5–S1 level. They recommended further validation of these results via biomechanical and clinical studies [17] (Fig. 6).

Transdiscal fixation

This type of fixation introduced in 1994 by Abdu et al. [18] is sometimes utilized in high-grade spondylolisthesis. Screws passing from the sacral pedicles via the L5–S1 disc space and into L5, improve construct stability and fusion rates with a good clinical outcome. The triangular configuration of the construct (i.e., created by the transdiscal screw, the L5 screw, and the rod) is sometimes referred to as "delta" fixation resembling the Greek letter Δ [18] (Fig. 7).

Transsacral fixation

In order to stabilize the posterior pelvic ring, this method is most commonly utilized for longitudinal sacral fractures including type B and minimally displaced type C fractures. Under fluoroscopic guidance, one or more screws are advanced and anchored in the sacral bodies or the contralateral ilium (i.e., transsacral-transiliac screws). When the sacral ala is not comminuted, lag screws of sufficient length can be utilized; otherwise, two or more static screws in the uninvolved sacral side are preferred. These screws can be combined with other modalities of spinopelvic fixation. The main limitations of these techniques are closed reduction for severely displaced fractures and limited stability [3].

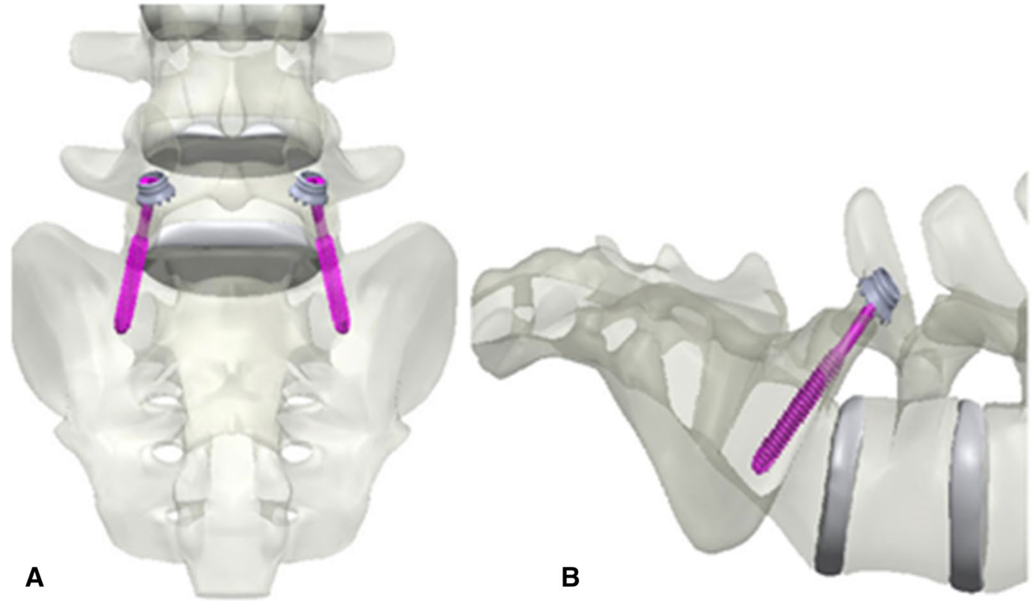

Fig. 6 Bilateral TFPS at L5–S1. **A** Anterior–posterior view, **B** Lateral view [17]

Fig. 7 Transdiscal or "delta" fixation [19]

Sacral sublaminar wires, hooks, and cables

These methods lack anchoring strength and rigidity and may be reverted to in combination with pelvic screws when anatomy is disturbed as in revision cases, keeping in mind the poor pullout strength and high failure rate [1, 6, 11, 20].

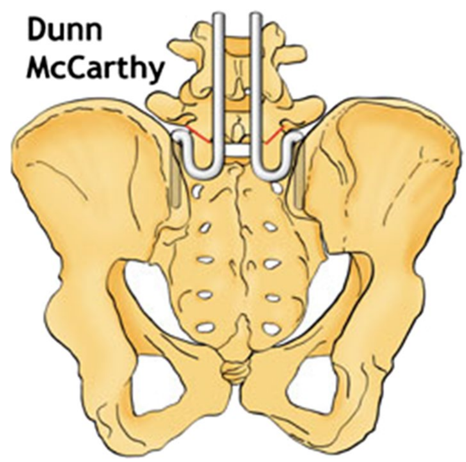

Fig. 8 Dunn and McCarthy S-rods fixation [24]

Dunn-McCarthy S-rod fixation

In 1989, this technique was developed mainly for myelodysplastic pediatric patients and entails an S-shaped rod passing over the ala of the sacrum after releasing the iliolumbar ligament [21–23]. It provides a sufficient lever arm action against flexion forces being the most useful in non-ambulatory patients with neuromuscular deformities. On the contrary, it provides less resistance to distraction, rotation, and lateral bending forces being less suitable in ambulatory patients [11]. In a retrospective review of 67 patients with neuromuscular deformity, it demonstrated a 53% correction of pelvic obliquity with no significant demise at 6 years [22, 24] (Fig. 8).

The Jackson intrasacral rods

Rods—not crossing the SI joint—are vertically inserted into sufficient alae of the sacrum from S1 to S2 and then, connected to the S1 pedicle screws and above. Bilateral pelvic fixation with S1 pedicle screws appears biomechanically stronger [1, 25] (Fig. 9).

The Galveston technique

This technique entails submuscular iliac rod insertion at the posterior superior iliac crest crossing the SI joint [6, 27]. The trajectory is 30–35° caudally and 20–25° laterally. The micromovement-induced windshield-wiper effect may supervene, necessitating implant removal. [1, 28, 29] (Fig. 10).

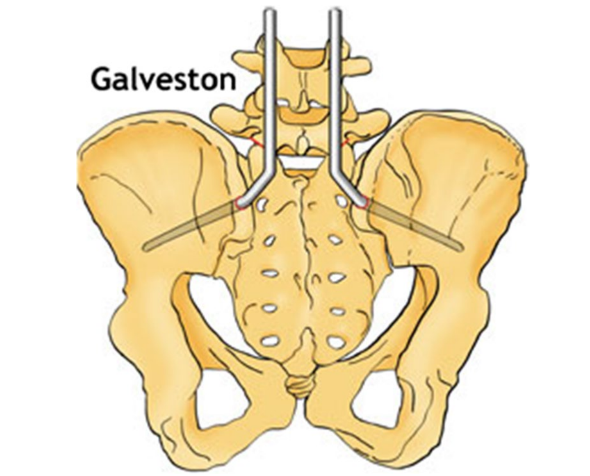

Fig. 10 Galveston L-rod fixation [24]

Transiliac (sacral) bar and spinopelvic transiliac fixation (STIF)

Sacral bar fixation entails rod(s) spanning the sacrum that passes horizontally from ilium to ilium. It is rarely used nowadays in the context of sacral fractures and complex lumbosacral/sacropelvic reconstructions. STIF technique was introduced by King et al. [30] consisting of L-shaped rods with threaded ends, washers, and locking nuts. The rod threads are inserted through the posterior ilium at the level of S2. The rods are then linked just proximal to the right angle of the bend followed by tightening the nuts over the washer and the ilium compressing the SI joints on each side. At long-term follow-up, STIF provides 67% correction of the pelvic obliquity, with only a 7.4% pseudarthrosis rate [3, 24, 31] (Fig. 11).

Iliosacral screws (ISS)

These are directed from the ilium's outer cortex, across the inner table, and then include the S1 pedicle dorsal to the SI joint [32]. Then, special connectors are utilized to accommodate the longitudinal rods to complete the construct. Extensive soft tissue dissection and dorsal iliosacral ligament resection are usually required. Some studies had yielded good fusion rates [33, 34], but others had a failure rate of 28% [1, 13] (Fig. 12).

Iliac screws (iliac bolts)

This relatively new method of fixation entails the independent placement of screws in the ilium, and special connectors are then used to connect them to the

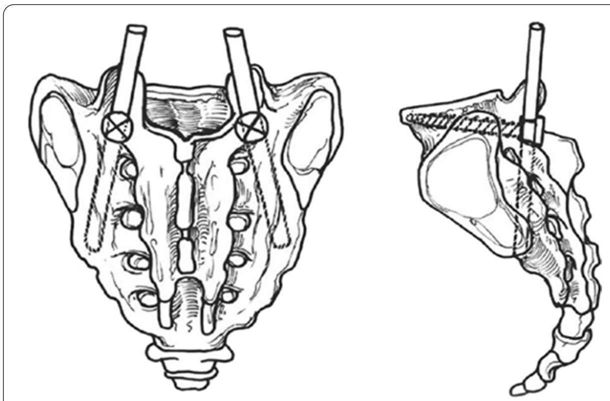

Fig. 9 Jackson intrasacral rods [26]

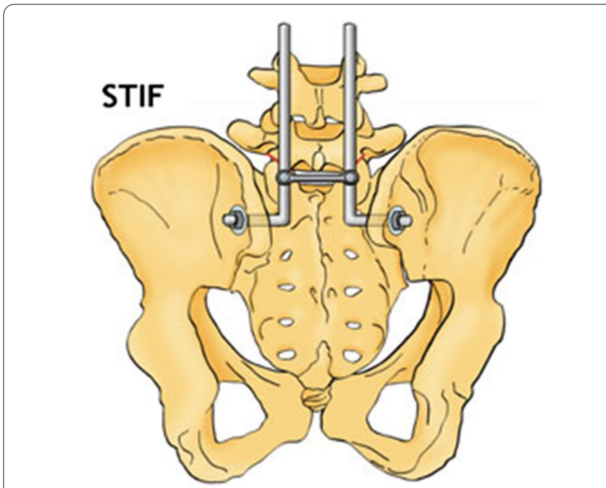

Fig. 11 STIF system [24]

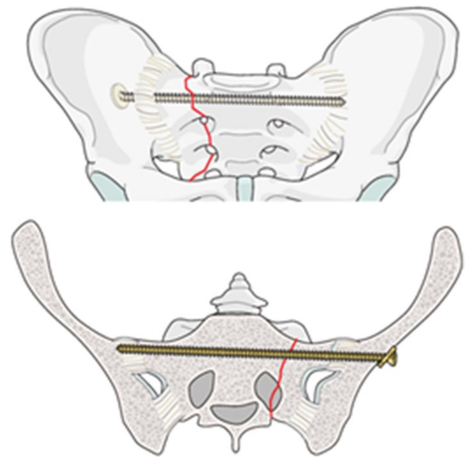

Fig. 12 ISS fixation [35]

longitudinal rods. Iliac screws have superior pullout strength and fusion rates when compared with the previously mentioned modalities, especially the Galveston rods [1, 28, 36–40].

The conventional open iliac screws insertion technique

The overlying cortex is breached at the level of S2–S3, about 1 cm from the distal ilium, after the posterior superior iliac spine (PSIS) is palpated and exposed with Bovie cautery and Cobb retractors, taking into consideration the later on prominence of the implant. A pedicle probe is then introduced at 25° lateral to the sagittal plane and 30–35° caudal to the transverse plane aimed toward the anterior inferior iliac spine (AIIS). A fluoroscopic check or finger palpation of the sciatic notch may guide the screw path. The medial or lateral cortical breach is checked via a blunt probe with determination of the screw length which is commonly 8–10 mm in diameter and 80–100 mm in length. Finally, the iliac screw is inserted and then secured to the longitudinal rod of the main construct via a modular connector. There are modified techniques for medially placing the screw head to help decrease the prominence of the implant and avoid the use of connectors. There is also the minimally invasive percutaneous iliac screw insertion technique utilizing fluoroscopy to visualize the iliac teardrop as a guide for screw placement [3, 41] (Fig. 13).

Maximum width (MW) spinopelvic construct

This technique was developed by Arlet et al. [44] in 1999 for the correction of pelvic obliquity in patients with neuromuscular deformity. It entailed combining iliosacral and iliac screws, in an MW construct, to increase the

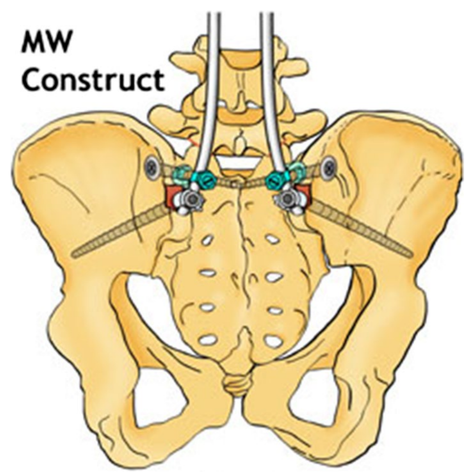

Fig. 14 MW spinopelvic construct [24]

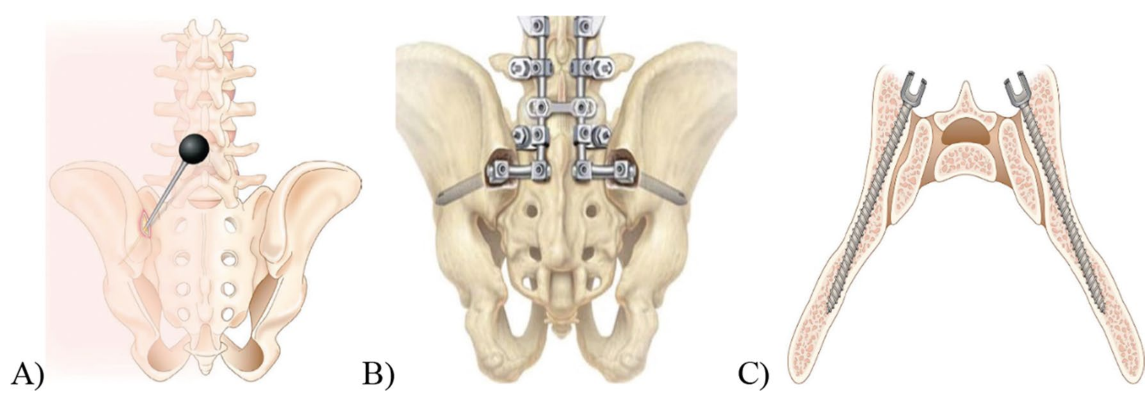

Fig. 13 Open iliac screw insertion technique **A** Entry point preparation and trajectory. **B** conventional iliac screws are connected to the rods via modular connectors. **C** A modified technique minimizes screw prominence by medializing the screw head obviating the need for modular connectors [42, 43]

stabilization at the lumbosacral junction. [45] The construct constituted an "M" and a "W" on posteroanterior radiograph and axial reconstruction images, respectively. Carroll et al. [46] reported an approximate reduction of 61% in pelvic obliquity at 3 months of follow-up [24] (Fig. 14).

The T-construct

This method has been used successfully for deformity correction in patients with neuromuscular scoliosis. A transverse rod is fixed to S1 and iliac screws resulting in a more stable T-shaped configuration of the construct [47–49] (Fig. 15).

S2-alar-iliac (S2AI) screws

This is a contemporary technique of SI arthrodesis that crosses the SI joint. The screw entry is 2–4 mm lateral and 4–8 mm distal to the S1 dorsal foramen [51]. After entry point preparation, a 2.5 mm drill is advanced with a lateral trajectory of about 40° to the horizontal plane and a caudal trajectory of 20–30° depending on the PT. Fluoroscopic guidance is beneficial, and the trajectory should aim toward the AIIS being always above the greater sciatic notch. To avoid breaking the drill after crossing the SI joint, it is changed to a 3.2 mm drill. A teardrop fluoroscopic view ensures being within the confines of the iliac cortex. An 80–90 mm in length and 8–10 mm in diameter polyaxial screw is introduced. Unlike iliac screws, this technique avoids the implant prominence and obviates the need for connectors [51, 52]. This technique has the lowest overall complication rate among other techniques, but long-term follow-up is required, particularly to evaluate its adverse effects on the SI joint [1, 53, 54] (Fig. 16).

The minimally invasive percutaneous S2AI screw insertion technique

S2AI screws could be placed percutaneously and combined with percutaneous fixation of the lumbar spine when indicated. The approach entails a 3 cm skin incision and the entry point aligned with the lateral margin of the S1 foramen and midway between the S1 and S2 foramina. The trajectory is identical to that of the open procedure. The Jamshidi needle is introduced and angled toward the AIIS above the sciatic notch. Standard anteroposterior (AP), pelvic inlet, and teardrop fluoroscopic views are utilized. The needle is advanced within the confines of the teardrop and across the SI joint into the ilium, followed by guidewire placement, tapping, and screw insertion [3] (Figs. 17 and 18).

Risks associated with iliac and S2AI screw fixation

Due to their superficial location and use of connectors, iliac screws are more commonly associated with implant prominence than S2AI screws. Screw misplacement may injure the superior gluteal artery, the internal iliac vessels, the sciatic nerve, the obturator nerve, the lumbosacral plexus, or the cluneal nerves. Hip joint violation and chondral injury are feasible by misplaced or long screws.

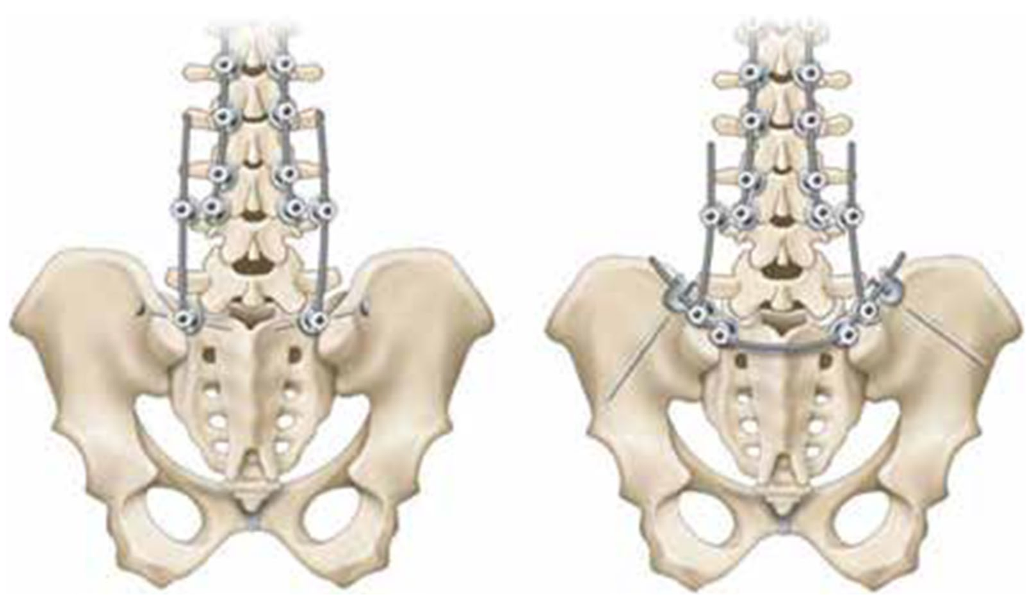

Fig. 15 The T-Construct [49, 50]

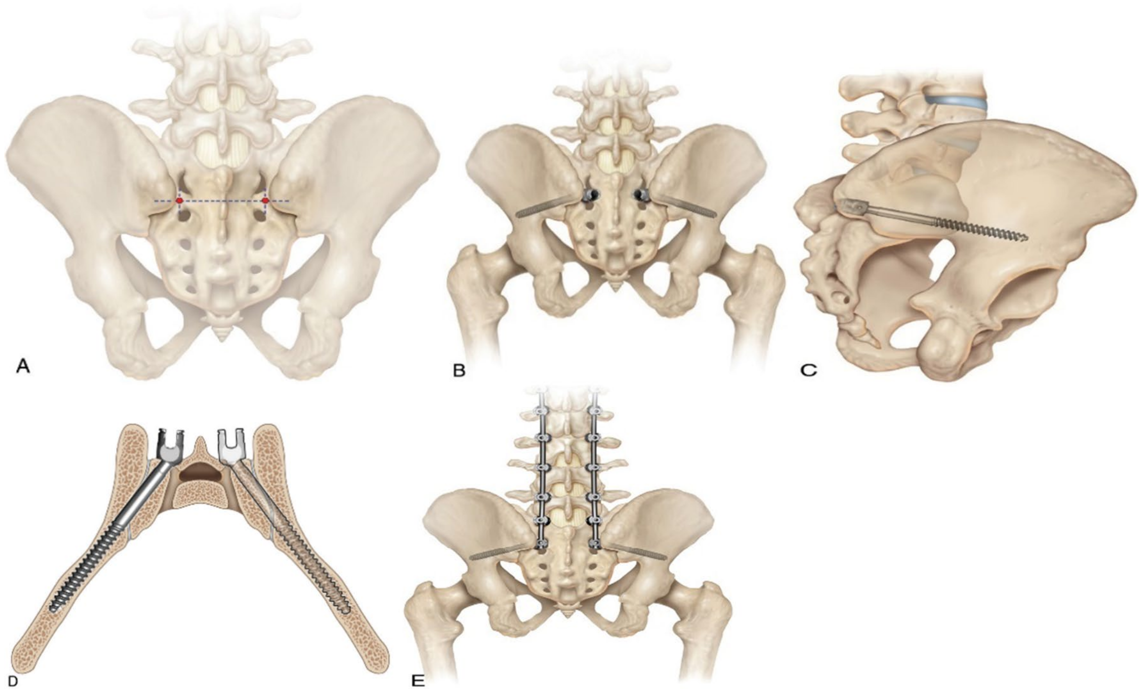

Fig. 16 Open S2AI screw insertion technique. **A** The entry point. **B**–**D** Coronal, sagittal, and axial views, respectively, of the final trajectory. **E** The connection of the S2AI screws to the longitudinal rods completes the construct [3]

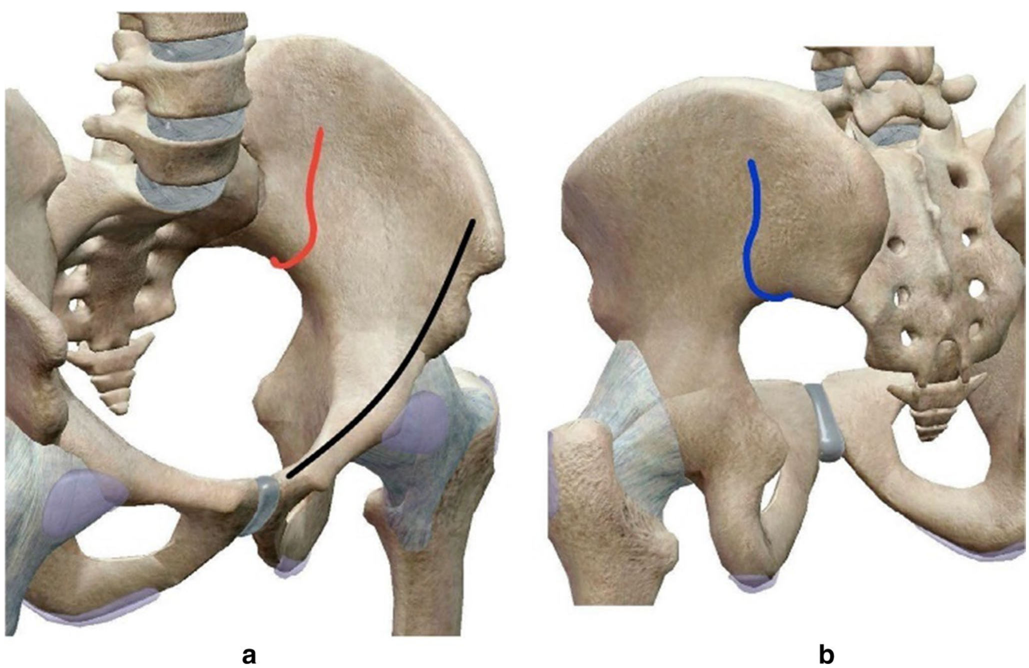

Fig. 17 The creation of the "teardrop" view. **a** The red line represents the contour of the inner table and sciatic notch creating the medial half of the "teardrop". The black line represents the contour of the anterior ilium that creates a portion of the teardrop. **b** The blue line represents the contour of the opposite lateral half of the "teardrop". The ideal "teardrop" view results from an overlap of the blue, red, and black lines [41]

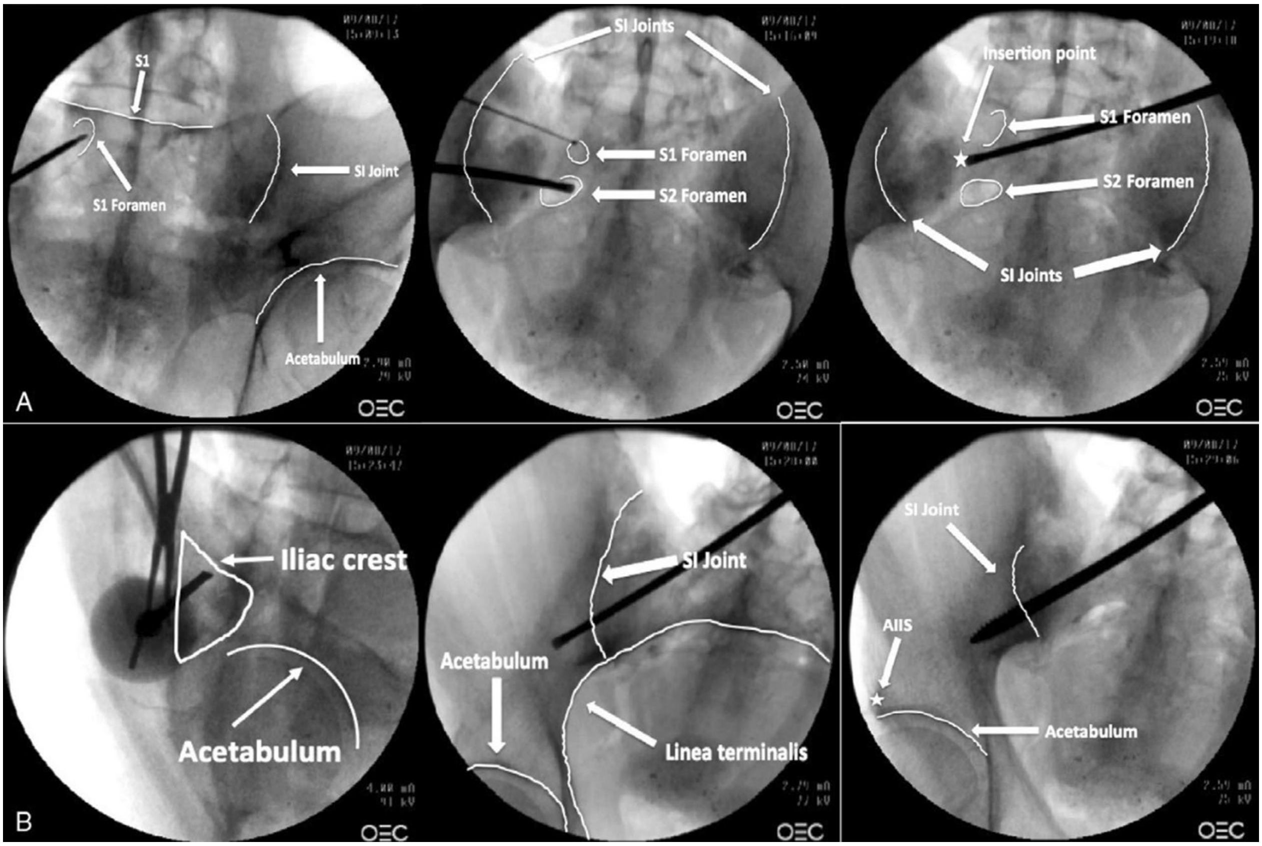

Fig. 18 The percutaneous S2AI screw insertion technique. **A** Entry point determination. *Left:* Localization of the S1 foramen using a standard probe. The *white arrows* refer to the S1 upper endplate, the SI joint, and the acetabulum. *Middle:* Localization of the S2 foramen. *Right:* The entry point *(white star)* is 10 mm lateral to the midpoint between S1 and S2 foramina. **B** Trajectory verification. *Left:* The probe is advanced keeping its tip in the center of the (teardrop) identified on the oblique obturator view. *Middle:* In the anteroposterior view, the probe is directed laterally in the transverse plane and caudally in the sagittal plane. *Right:* The screw is advanced in the direction of the AIIS *(white star)* (From Yilmaz E, Abdul-Jabbar A, Tawfik T, et al. S2 alar-iliac screw insertion: Technical note with pictorial guide. World Neurosurg 2018;113:296–301, Fig. 2, p. 297; Fig. 4, p. 298.) [55]

SI joint pain and dysfunction are commonly encountered but not properly estimated [3].

S2AI screws versus iliac screws

S2AI screws outperform iliac screws as reported in many studies in the literature, especially concerning revision and failure rates, wound problems as well as pain, and return to work activities [56, 57]. Ilyas et al. [58] conducted a clinical and radiological comparison between iliac and S2AI screws and reported that using S2AI screws had statistically better outcomes with respect to implant loosening, and revision surgery because of implant loosening, acute infections, delayed wound complications, and late pain. Keorochana et al. [59] came to the conclusion that both techniques have the same outcomes in the pediatric and adult populations and when pain scores are considered, but with superior complication and revision rates associated with iliac screws. Sponseller et al. [60] concluded that S2AI screws are better at correcting pelvic obliquity than iliac screws.

Better biomechanical outcomes and complication rates were observed with S2AI screws in a meta-analysis conducted by De la Garza Ramos et al. [61]. Hasan et al. [62] conducted another meta-analysis focusing mainly on the post-operative complications and concluded that lower profile S2AI screws outperformed iliac screws but with more concerns regarding SI joint violation resulting in pain and dysfunction.

Mazur et al. [63] suggested that S2AI screws have greater purchase and obviate the need for cumbersome connectors. Perrault et al. [64] illustrated that the use of connectors augments the loads and stresses on iliac screws and that the toggle movement on screws is decreased by 17% if a sacral screw entry is applied instead of the standard iliac crests. Lee et al. [65] revealed that S2AI screws have low implant failure rates and that cross-linkage with iliac screws reinforces the construct decreasing implant failure.

In a cadaveric biomechanical study conducted by Hoernschemeyer et al. [66], less stiffness in iliac screws was reported, but with no statistical significance [4].

S1-alar-iliac (S1AI) screws

They are rarely reverted to as a salvage option in cases with a failed promontory screw. The entry is identical to that of the S1 pedicle. The entry point should not be too lateral or too medial. The trajectory is 35–45° caudally and 20° horizontally in the coronal plane targeting the ipsilateral greater trochanter [4, 67].

Combined S1AI and S2AI screws

This is a salvage technique first described by Mattei et al. in 2013 and was reverted to in cases of pseudarthrosis, complex deformities, and failed instrumentation to gain better fixation and union [68].

S3-alar-iliac (S3AI) screws

This emerging technique was first described by Mattei et al. in 2020 as a salvage procedure for complex deformities. The entry is located at the midpoint of S2 and S3 foramina, 2 mm medial to the lateral iliac crest. Due to its proximity to the sciatic notch, navigation systems were warranted over the freehand for such screws [69].

Advances in screw design

For better fixation in and around the SI region, emerging screw designs are available. *Dual outer diameter (DOD) screws*: Their distal diameter is designed to penetrate deeply into bone without cortical violation providing better purchase in the sacrum, ilium, and osteoporotic bones via dual-diameter and threading (Fig. 19a).

Closed head DOD screws: These polyaxial, monoaxial, or angled monoaxial screws, are primarily designed for iliac fixation having better purchase in cancellous bone. They taper distally for better navigation within the confines of the cortex with maintained core diameter. The closed heads provide better security, and their profile accepts round, faceted, and D-shaped offsets [4] (Fig. 19b).

Navigation and robotics

Navigation systems have emerged for accurate and safe screw placement including pedicle and S2AI screws. A stereotactic frame mounted on the spinous process of the lumbar vertebrae is utilized followed by determination of the screw entry on CT scan pre or intraoperatively. Screw trajectory and size are determined based on the CT scan. K wire and Jamshidi needle are then introduced followed by screw insertion. In a navigation-guided series of 36 S2AI screws conducted by Ray et al. [70], there was a single anterior breach that necessitated repositioning.

Robotics is recently applied, and it requires a thin cut (1 mm) CT scan uploaded to the planning software preoperatively. Individual segmentation of the vertebrae keeps the registration unaltered. The screw entry and trajectory are preplanned. Fluoroscopic images are then taken and synchronized with the preoperative CT scan. The robot is then positioned, and the predetermined

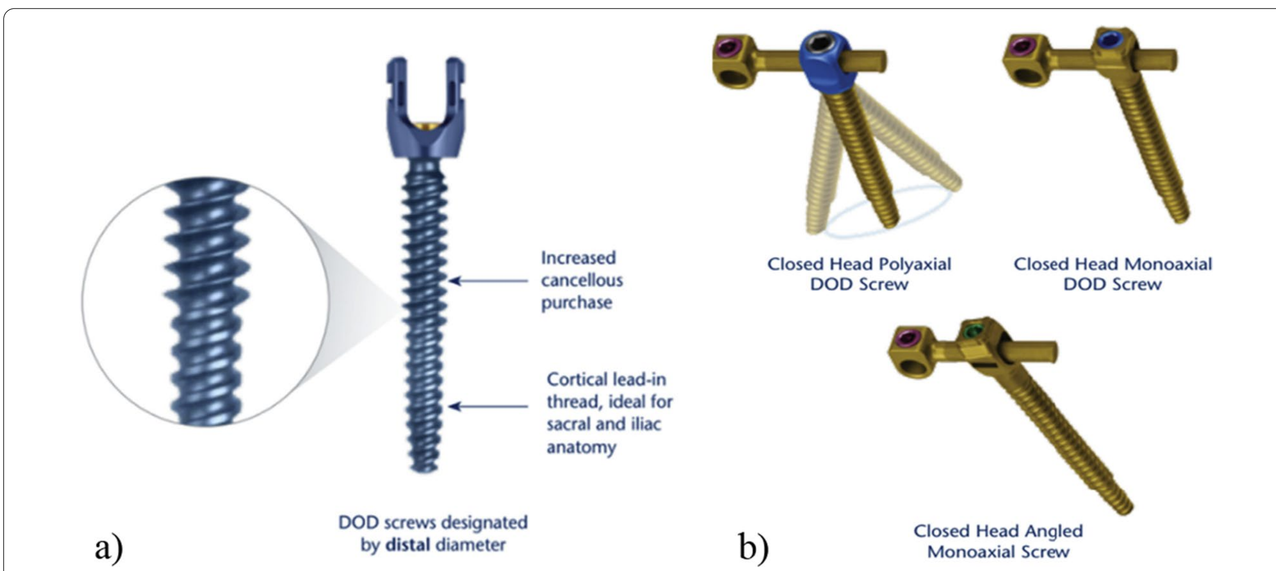

Fig. 19 **a** DOD screws. **b** Closed head polyaxial, monoaxial, and angled monoaxial DOD screws [4]

arms are fixed to it followed by drilling and screw placement [4].

Bederman et al. [71] inserted 31 robotically guided S2AI screws; 20 of them penetrated the distal ilium by <2 mm, 1 screw by 2–4 mm, and 10 screws by ≥4 mm. They encountered no violations proximally, to the sciatic notch or the pelvis. No neurovascular complications were detected. Shillingford et al. [72] reported no significant difference between the freehand and the robotic techniques in terms of accuracy and complications [4].

Conclusion

Although there are numerous techniques for sacropelvic fixation, some of them are only of historical interest. Iliac and S2AI screw fixation are considered the most commonly utilized modalities nowadays with better clinical and radiological outcomes in favor of the latter. Both could be placed percutaneously and combined with percutaneous fixation of the lumbar spine. Navigation and robotics are novel techniques that aim to maximize the accuracy of screw placement and minimize complications. Spine surgeons dealing with complex spine deformities and reconstructions should master the different modalities of sacropelvic fixation and be aware of the potential risks and complications associated with them. Surgical decision-making should be individualized for every patient, and the surgeon's experience should be considered.

Abbreviations

AIIS: Anterior inferior iliac spine; DOD: Dual outer diameter; ISS: Iliosacral screw; MW: Maximum width; PT: Pelvic tilt; PI: Pelvic incidence; PSIS: Posterior superior iliac spine; SS: Sacral slope; SI: Sacroiliac; S1AI: S1-alar-iliac screws; S2AI: S2-alar-iliac screws; S3AI: S3-alar-iliac screws; STIF: Spinopelvic transiliac fixation; TFPS: Transfacet pedicle screws.

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