Nomenclature of Surgical Spinal Fusion in the Lumbar and Sacral Spine

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Objectives

- Correctly identify spinal fusion hardware in the lumbar and sacral spine.
- Develop the ability to draw conclusions about spinal fusion surgical procedures based on hardware seen in radiographic images.
- Gain a basic understanding of complications that are common with different types of surgical spinal fusion hardware.

Why is this important?

- There are various devices used in spinal fusion of the lumbar and sacral spine. These devices are constantly changing and evolving as attempts are made to improve surgical outcomes and to meet the needs of changing surgical approaches. It is important for radiologists to have an understanding of the devices used in spinal fusion because they each come with their own sets of problems and complications. As such, **using specific and descriptive terminology in radiology reports can help the physicians caring for spinal fusion patients to have a more focused approach to finding and addressing the underlying causes of postsurgical complications**.

Interbody Devices

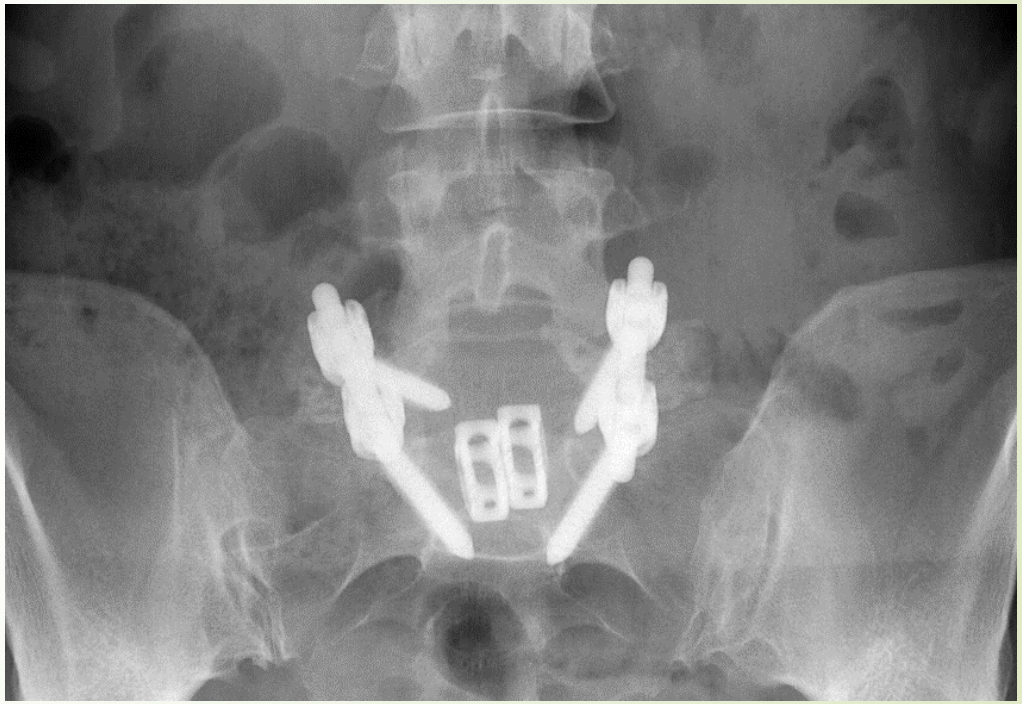
Cages

- These are **hollow**, which allows them to be **filled with bone graft material**.
- The shape of interbody cages can help us differentiate the surgical approach used.

Interbody Devices

Cages

- The use of **two rectangular cages**, as seen here, suggests a **posterior lumbar interbody fusion (PLIF)**.
- This approach requires **bilateral partial laminectomies and discectomy**.
- Posterior instrumentation, such as plates and screws, is used to provide rigid support until interbody fusion occurs.



Interbody Devices

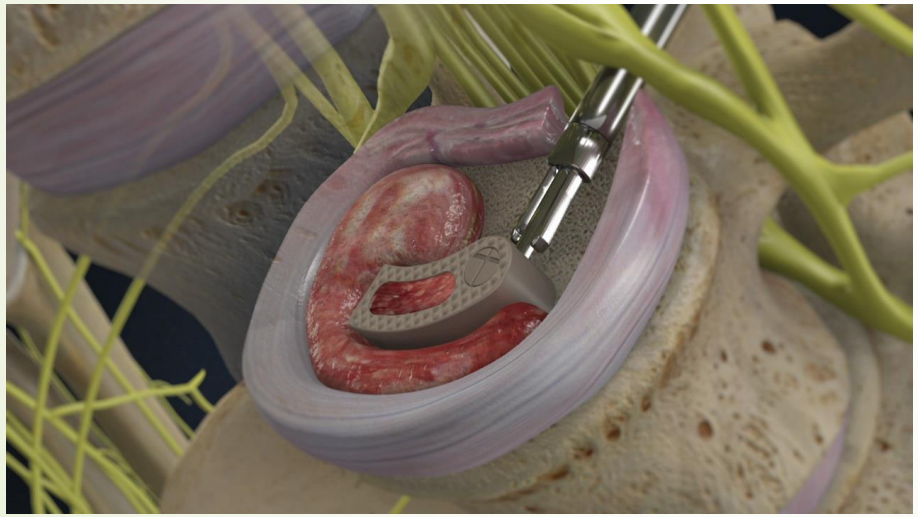
Cages

- A **curved design** is indicative of a **transforaminal lumbar interbody fusion (TLIF)**.
- The transforaminal approach generally requires a **unilateral total facetectomy**.

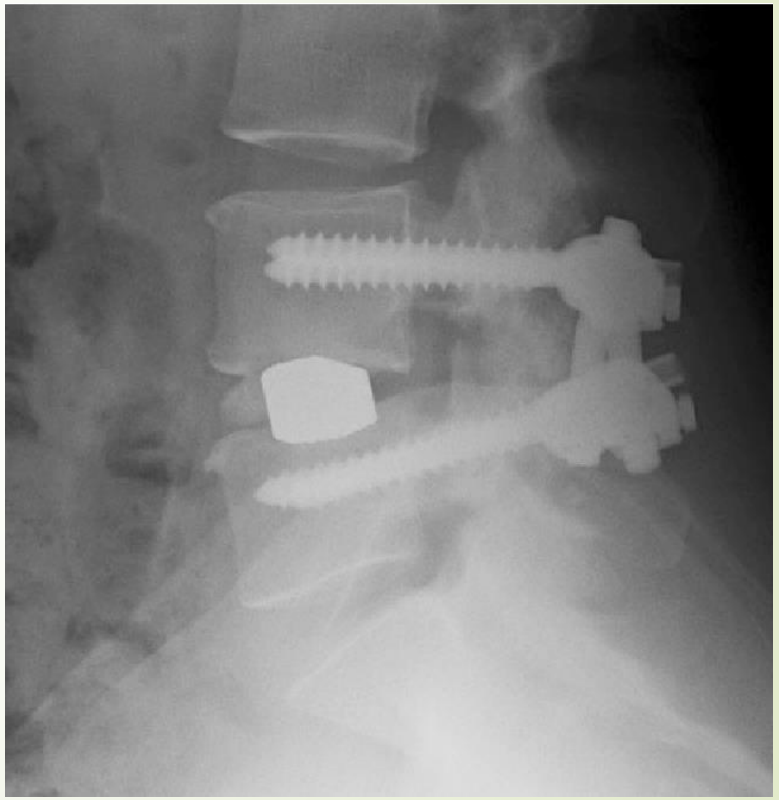
Interbody Devices

Cages

Transforaminal Lumbar Interbody Fusion



Device placement



Postsurgical radiograph

Interbody Devices

Cages

- Anterior approaches to interbody fusion allow for placement of devices with **bigger diameters and heights**, because they do not need to bypass the posterior column of the vertebrae.
- An anterior approach requires **retraction of the abdominal muscles, peritoneum, aorta, and vena cava**, which certainly presents ample risk of complications unique to this approach.

Interbody Devices

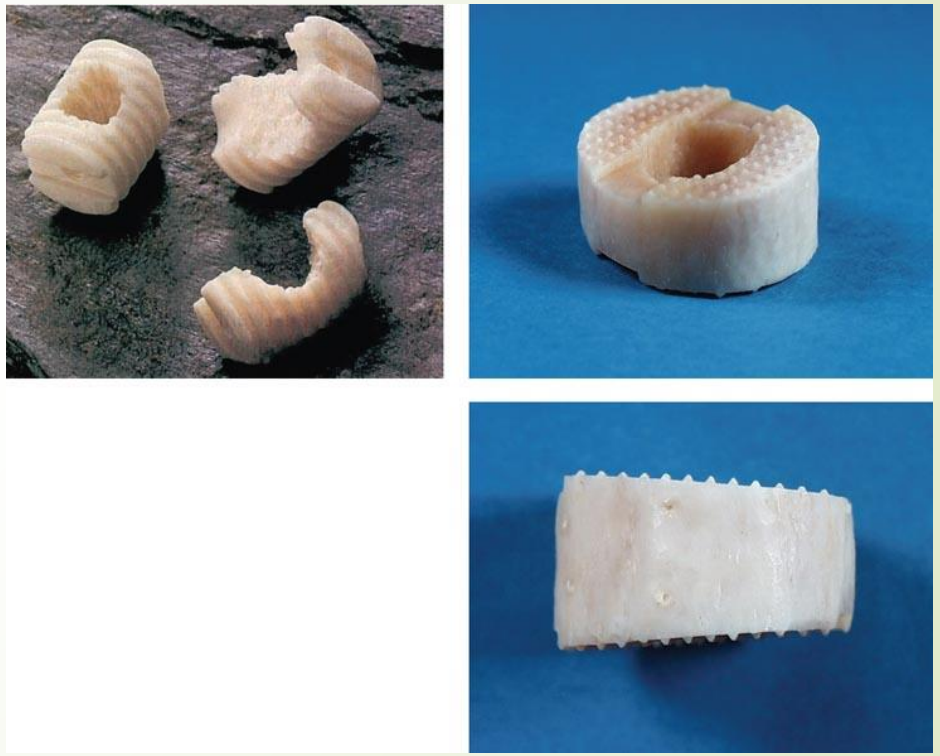
Ramps

- **Solid construction** (holes in side are only to facilitate device placement, not to be filled with bone graft material), as opposed to hollow design of interbody cages.
- Most commonly seen with an **anterior approach**.
- The solid construction increases the risk of **subsidence and slippage**.

Interbody Devices

Bone Dowels/Allograft Implants

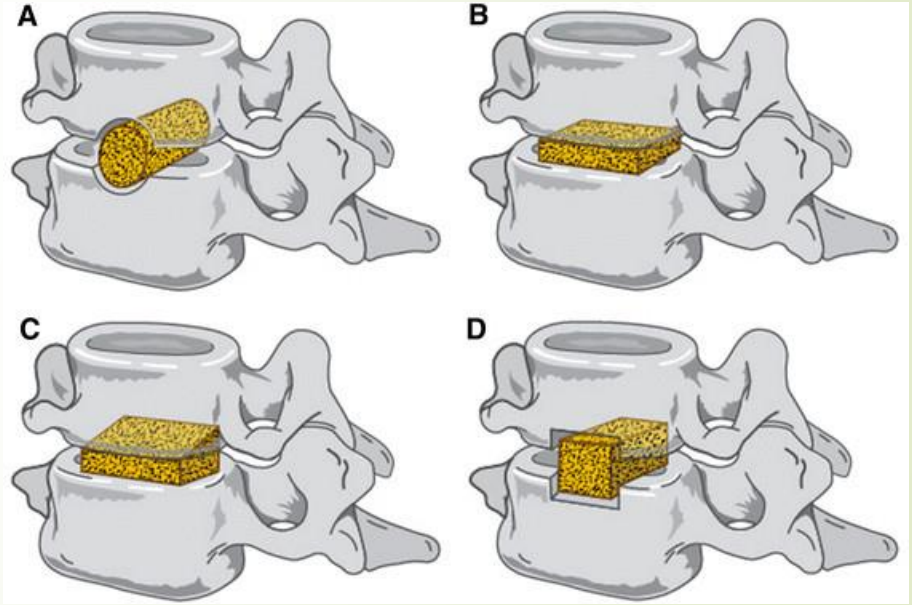
- These are **made from cadaveric bone** that has been stripped of live, bone-forming cells. It provides a framework for new bone growth to occur. **Bone-forming cells will eventually remodel and replace the allograft.**



Interbody Devices

Bone Dowels/Allograft Implants

- While minimal, there is **some risk of infection** from the allograft material.
- **Fusion will be slow**, as the allograft must be replaced by bone-forming cells.
- These devices have **limited strength**, due to the removal of the bone-forming cells.



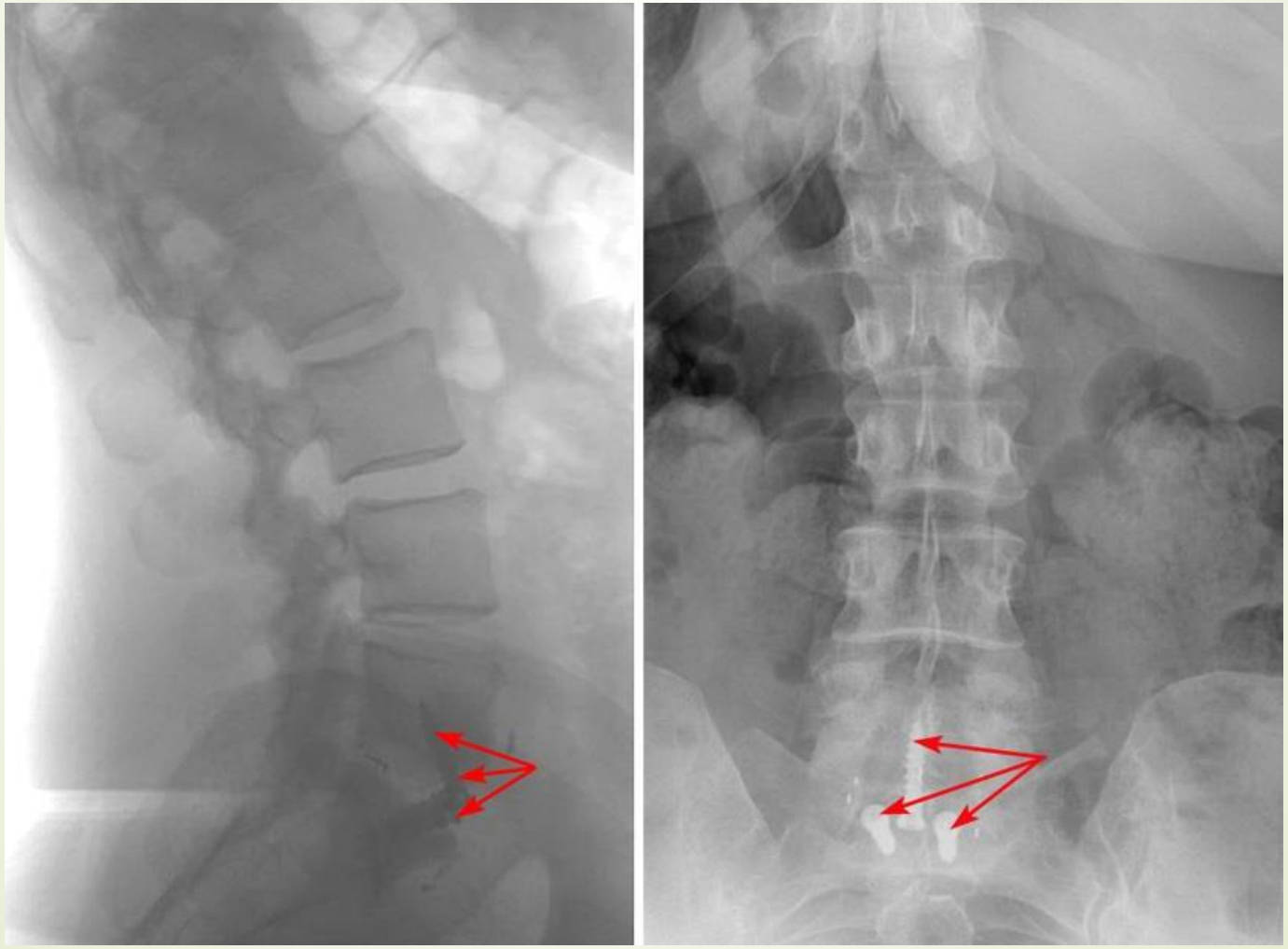
Interbody Devices

Stand-alone Interbody Cage

- Similar to the previously discussed fusion methods, but the cage is **fixed to the adjacent vertebral bodies** to obviate further posterior instrumentation.
- Placed using an anterior approach, which requires **retraction of the abdominal muscles, peritoneum, aorta, and vena cava.**
- **Screws will be visible** on radiographs.

Interbody Devices

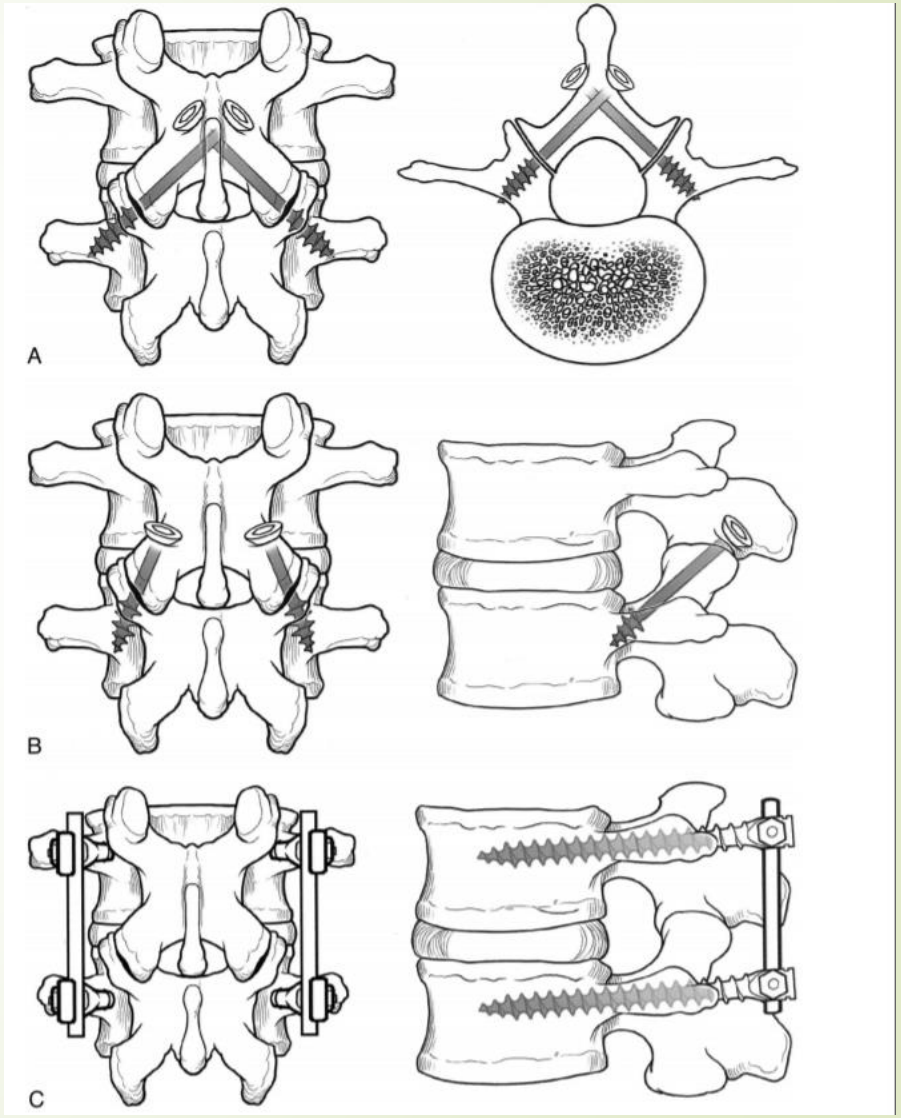
Stand-alone Interbody Fusion



Posterior Fixation

Screws

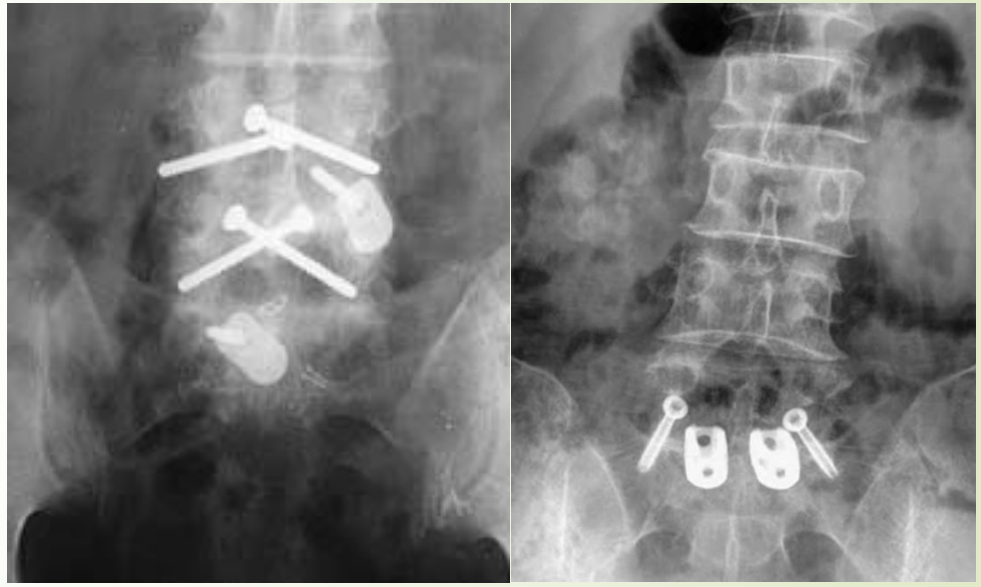
- There are three main types of screws, which are **named based on their trajectory**:
  - Translaminar screws (A), which are inserted on the contralateral side of the spinous process, then **into the opposite lamina of the vertebra below**.
  - Transfacet screws (B), which are inserted into the posterior surface of the inferior articular process, then **across the facet joint** and into the superior articular process of the vertebra below.
  - Pedicle screws (C), which are inserted at the junction of the superior articular process and the transverse process and have a superior-to-inferior and medial-to-lateral trajectory **into the vertebral body**.



Posterior Fixation

Screws

- Pedicle screw fixation provides **3-column support of the vertebra**, giving greater biomechanical strength than is expected with translaminar or transfacet screws.
- When posterior rods or plates are seen or the fusion involves three or more vertebrae, it is more likely you'll see pedicle screws.
- Translaminar and transfacet screws can be placed with **less anatomic disruption** but are more appropriate in the setting of a **short-segment fusion or as supplementation** to interbody devices.



Translaminar Screws

Transfacet Screws

Posterior Fixation

Interspinous Fusion Devices (IFDs)

- These are newer devices and their efficacy is **still more debatable** than other, more proven, fusion methods.
- IFDs are placed **between adjacent spinous processes**.
- They are intended to widen the intervertebral foramen, **relieving nerve root compression** and, arguably, unload the intervertebral disc.

Interspinous Fusion Devices (IFDs)

- Placement of IFDs **does not require removing bone or cutting muscle**. This makes it an appealing option **for patients who may not tolerate more extensive surgeries**.
- It is hypothesized that these devices decrease risk of adjacent segment degeneration.
- There is, however, **risk of spinous process fracture** when these devices are placed.

Sacroiliac Joint Fusion

Triangular Titanium Implants (iFuse)

- These implants are placed via a **minimally-invasive procedure** and a **lateral approach**, through a 2-3 cm incision on the buttock.
- These implants provide immediate stabilization and **do not require bone graft material.**
- The porous surface promotes **bony ongrowth and ingrowth.**

Sacroiliac Joint Fusion

Triangular Titanium Implants (iFuse)

- The placement of these devices is **minimally-invasive**.
- Direct arthrodesis between the sacrum and ilium is not a goal of the surgery, so failed arthrodesis of the SI joint is not a concern (although bone resorption around the implant is still possible).
- Surgery utilizes a lateral approach, which involves **risk of neurovascular injury.**

Sacroiliac Joint Fusion

Screws

- There are various implant systems involving screw fixation, but there are common trends among them.
- Screws are most commonly **hollow-bodied with multiple fenestrations**. They are filled with bone graft material during the surgery, to promote arthrodesis

Diana Implant

Sacroiliac Joint Fusion

Screws

- Screw fixation methods often involve some form **of decortication and placement of bone graft material**, to facilitate true bony fusion across the SI joint. The decortication is particularly **crucial with fusion systems that involve a solidly-constructed screw**, as opposed to a hollow, fenestrated screw.
- Solid screws are placed to hold the pelvis in place while fusion occurs, whereas hollow, fenestrated screws, when filled with bone graft material, will facilitate the fusion.

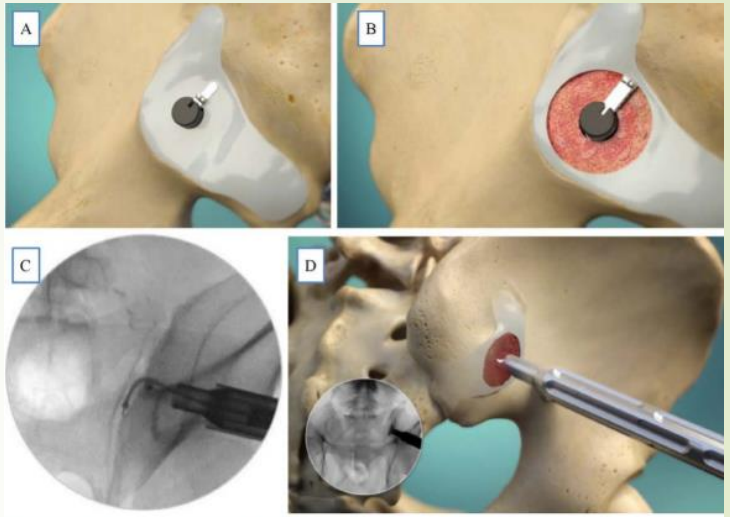


Figure 4. Cartilage removal and decortication with simmetry Decorticator. (A flexible cutting element advanced into joint space; (B) cartilage removed an surface of ilium decorticated; (C) radiographic view of decorticator with cut ting element extended into joint space; (D) oblique lateral view of decorti cated joint (inset: radiographic view).

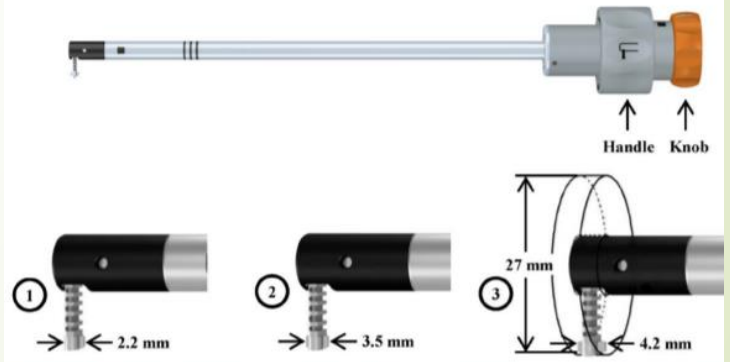
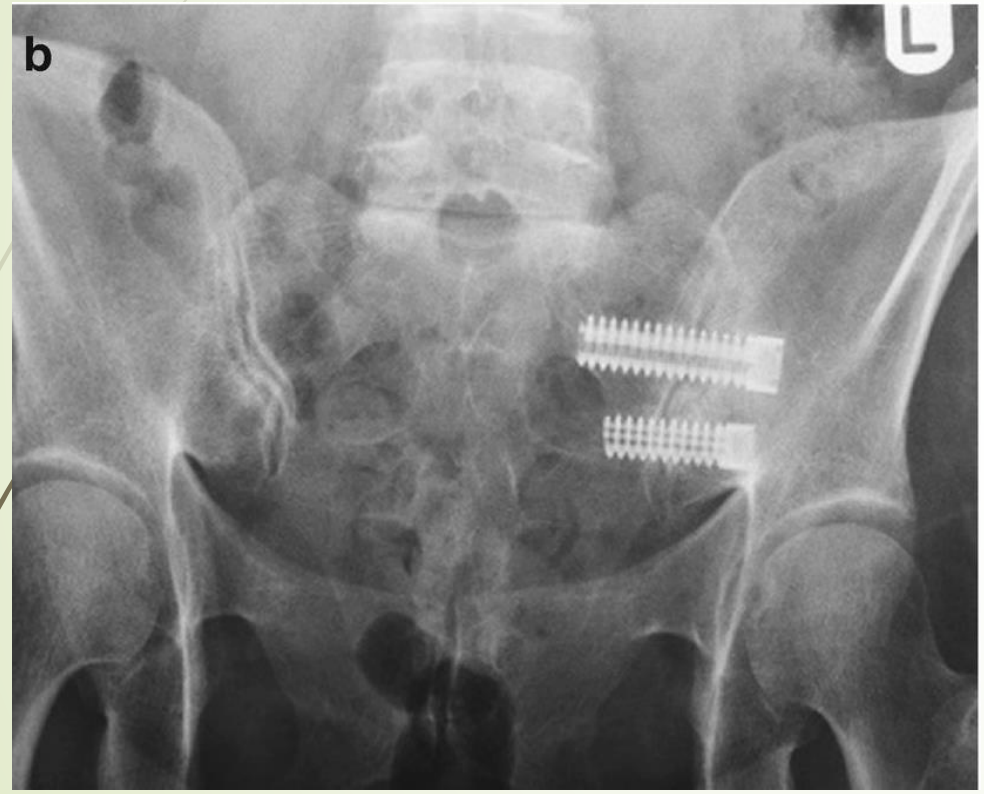


Figure 5. SImmetry decorticator. Complete instrument (top); detailed view of flexible cutting elements of decorticators 1, 2 and 3 (bottom).

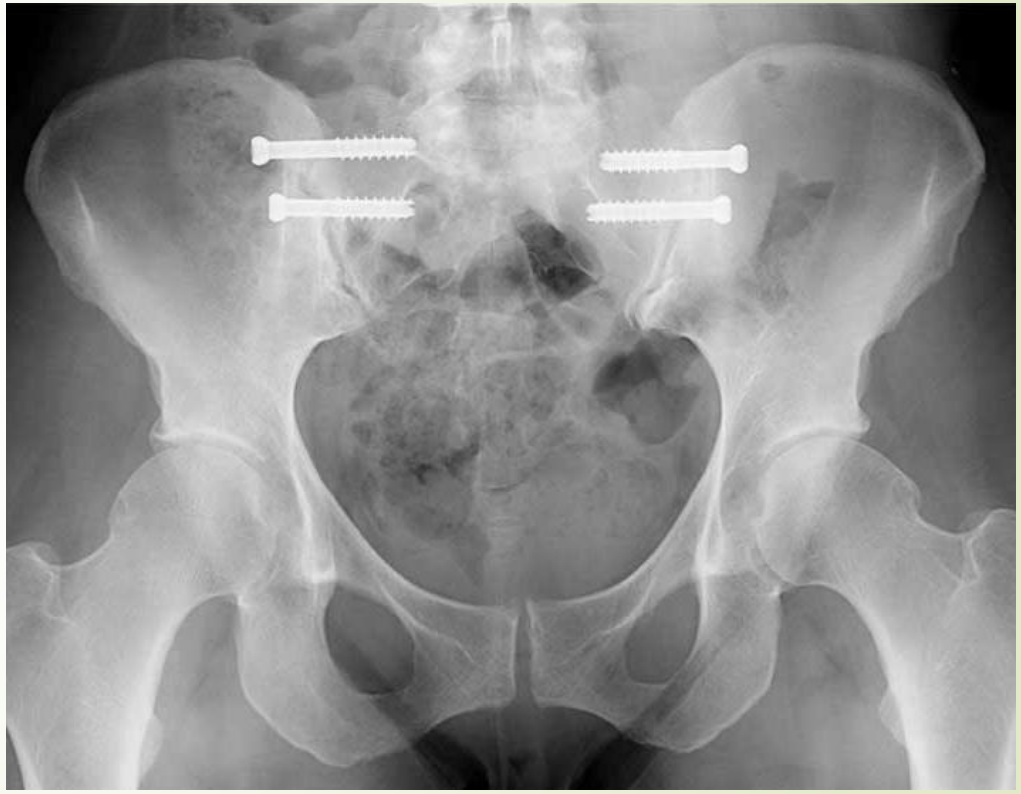
SImmetry fusion system

Sacroiliac Joint Fusion

Screws



Hollow screw fixation—screws were likely **filled with bone graft material**



Solid screw fixation—more likely that **decortication was used** with this fusion

Sacroiliac Joint Fusion

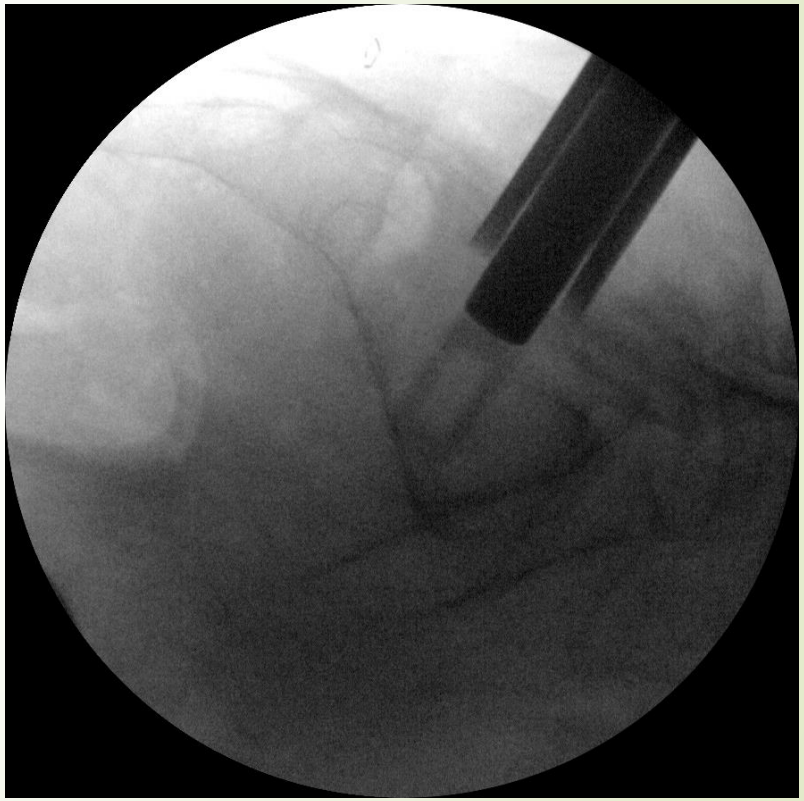
Allograft Implants

- Small implant **made from cadaveric bone** is implanted in a "mortise and tenon" fashion.
- The allograft will slowly be replaced by new bone. Fusion will be a **slow process**.
- There is only one implant and **no screws or rods** are needed.

Sacroiliac Joint Fusion

Allograft Implants

- This technique utilizes a posterior approach, which **reduces the chances of neurovascular complications**.
- There is **minimal disruption of the anatomy**.



Summary

Device Type	Device	Region	Benefit	Drawback
Interbody	Cages	Lumbar	1. Hollow design means these can be filled with bone graft material 2. The shape of the cage can help us draw conclusions about the surgical approach used	1. Placement requires invasive surgery
Interbody	Ramps	Lumbar		1. Risk of subsidence and slippage
Interbody	Allograft Implants	Lumbar	1. Promotes replacement of the allograft by the body's own bone-forming cells	1. Slow healing process 2. Small risk of infection 3. Lack of bone-forming cells in the allograft leads to little initial strength
Interbody	Stand-alone Interbody Cage	Lumbar	1. Eliminates the need for posterior instrumentation	1. Anterior approach requires retraction of the abdominal muscles, peritoneum, aorta, and vena cava, providing ample opportunity for complications
Posterior Fixation	Screws - Translaminar - Transfacet - Pedicle	Lumbar	1. Translaminar and Transfacet screws can be placed with less anatomic disruption 2. pedicle screws provide three-column support, which increases biomechanical strength	1. Translaminar and transfacet screws are mainly limited to short-segment fusions and as supplementation to interbody devices
Posterior Fixation	Interspinous Fusion Devices (IFDs)	Lumbar	1. Does not require removing bone or cutting muscle 2. good option for patients who may not tolerate more extensive surgeries	1. Risk of spinous process fracture 2. efficacy is still debatable.
Sacroiliac Joint Fusion	Triangular Titanium Implants (iFuse)	Sacroiliac	1. Minimally invasive 2. Does not require true fusion across the SI joint	1. Risk of neurovascular injury due to lateral surgical approach
Sacroiliac Joint Fusion	Screw Fixation - Hollow screws - Solid screws	Sacroiliac	1. Minimally invasive	1. Requires true bony fusion across the SI joint
Sacroiliac Joint Fusion	Allograft Implants	Sacroiliac	1. Posterior approach reduces the changes of neurovascular complications 2. Minimal disruption of the anatomy	1. Slow healing process 2. Small risk of infection 3. Lack of bone-forming cells in the allograft leads to little initial strength

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