# OSSTF-Target 2

## Surgical planning and technique

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# Objectives

1. Screw hole preparation and fill
2. Screw purchase
3. Anchor points-screw trajectory
4. Augmentation
5. SI-ilium fixation
6. Fusion bed preparation

# Goals after collecting relevant literature and organizing it in group access dropbox files

- Can we draw (preliminary) conclusions from literature?
- Any next steps based on these conclusions?
- Recommendations?

# 1. Screw hole preparation and additional techniques

| |
|---|
| The probe or 3.2 mm drill pilot hole preparation no clear difference in human anatomical specimen of osteoporotic Th vertebra model (fatigue test). Comparable for lumbar pedicles |
| Critical pilot hole size 71.5% of pedicle diameter |
| Small diameter hole + tap versus non-tapping: no clear yes or no |
| Fill entire trajectory pilot hole (allograft [1//2 mm], hydroxyapatite (HA) granules or sticks): all studies use torque measurement for initial screw grip and fatigue (toggle) as well as pull-out for failure test. Mix of synthetic and human anatomical models |

8 references

# Screw hole preparation and additional techniques: conclusions

- Smaller pilot hole – makes sense
- Under tapping – makes sense
- Cross-link – triangulation
- Sublaminar wires
- Laminar hooks
- Pedicle hooks
- Other advancements in pedicle fixation

**Summary** – lots of options, variable data, no clear consensus or conclusions

# Next steps and recommendations: pilot hole preparation

1. Probe or drill not so relevant (surgeon preference and training)
2. Undersizing hole and (not) tapping are more relevant: needs evaluation in design testing
3. Pilot hole grafting in any manner can be considered in index surgery
4. Torque measurement makes sense in clinical practice

   Torque measurement tool design
5. Mechanical testing must include toggle fatigue and pull-out as standard

# 2. Screw purchase: conclusions

| |
|---|
| Cement augmentation is most important factor contributing to pull-out strength |
| Larger diameter screws increase pull-out by 35% per mm |
| Expandable screws (anterior to pedicle lock) increase critical pull-out load |
| Expandable screw design not clear (where, how many %, mechanism, material, reversible option) |
| Less rigid connection of screw to tulip/rod may prevent screw purchase loss |
| 8 references |

# Expandable screw designs: examples


# Next steps and recommendations: screw purchase

Expandable screws designs need more work

Screw – polyaxial head connection needs more work

Improved load sharing: mechanical versus cement augmentation

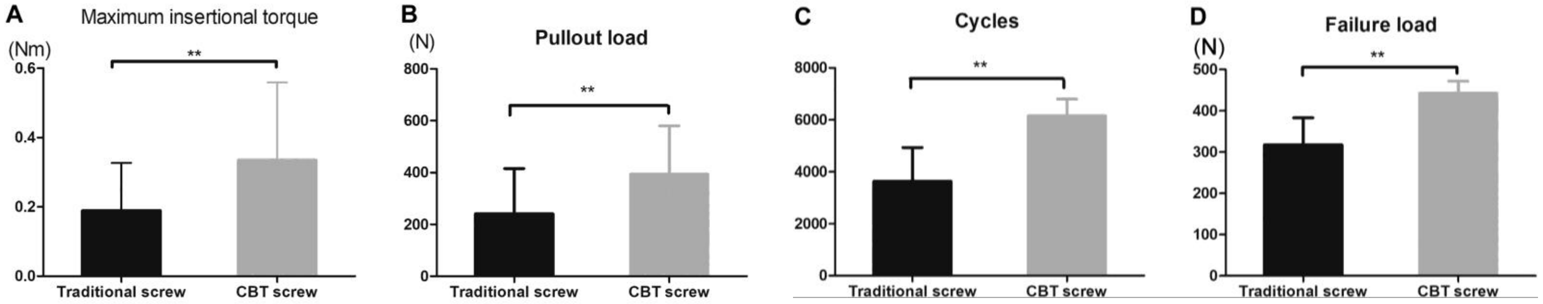
# 3. Anchor points—screw trajectory

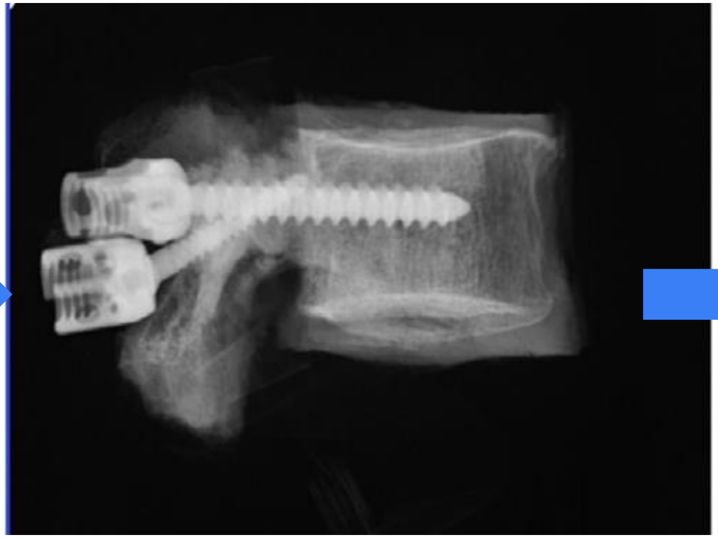
- Bicortical caudal direction
- Bicortical ± cement augmentation
- Traditional trajectory (TT) and cortical bone trajectory (CBT) combined (crossed trajectory)
- CBTs increase purchase and load of failure in osteoporotic spine versus TT
- Midline Cortical (MC) Trajectory: superior load of cyclic load failure over CBT
- Revision of TT-CBT or CBT-TT screws is a challenge
- 14 references

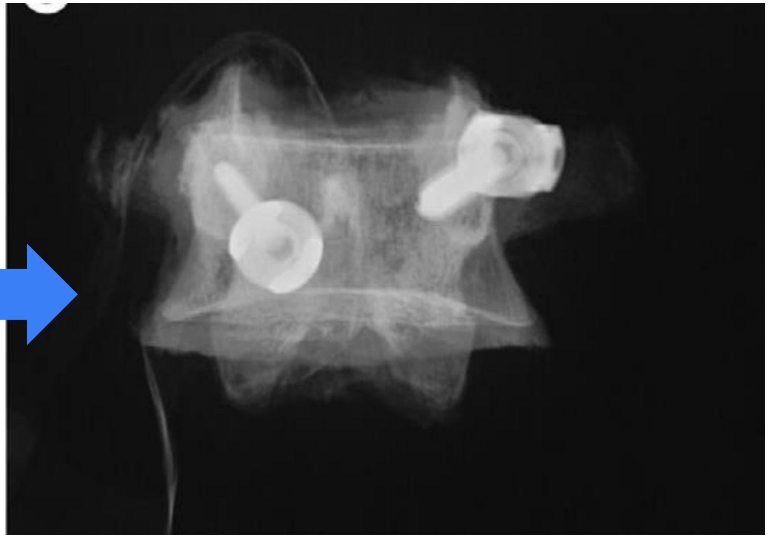
# Screw trajectory 1

Traditional trajectory screw

Cortex screw (Yu)

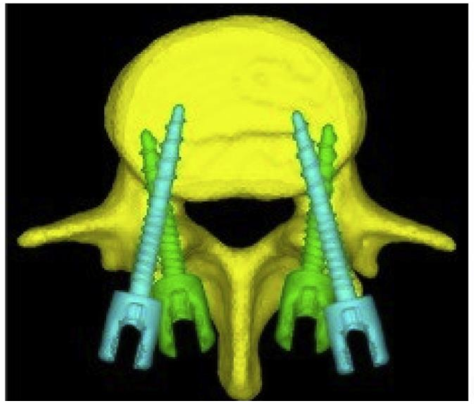


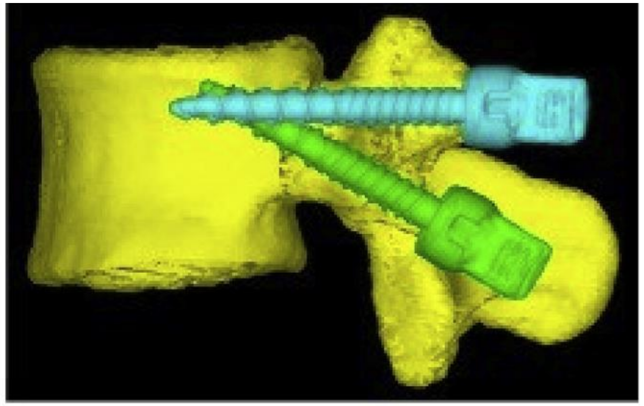





# Screw trajectory 2

Double screw (Jiang)



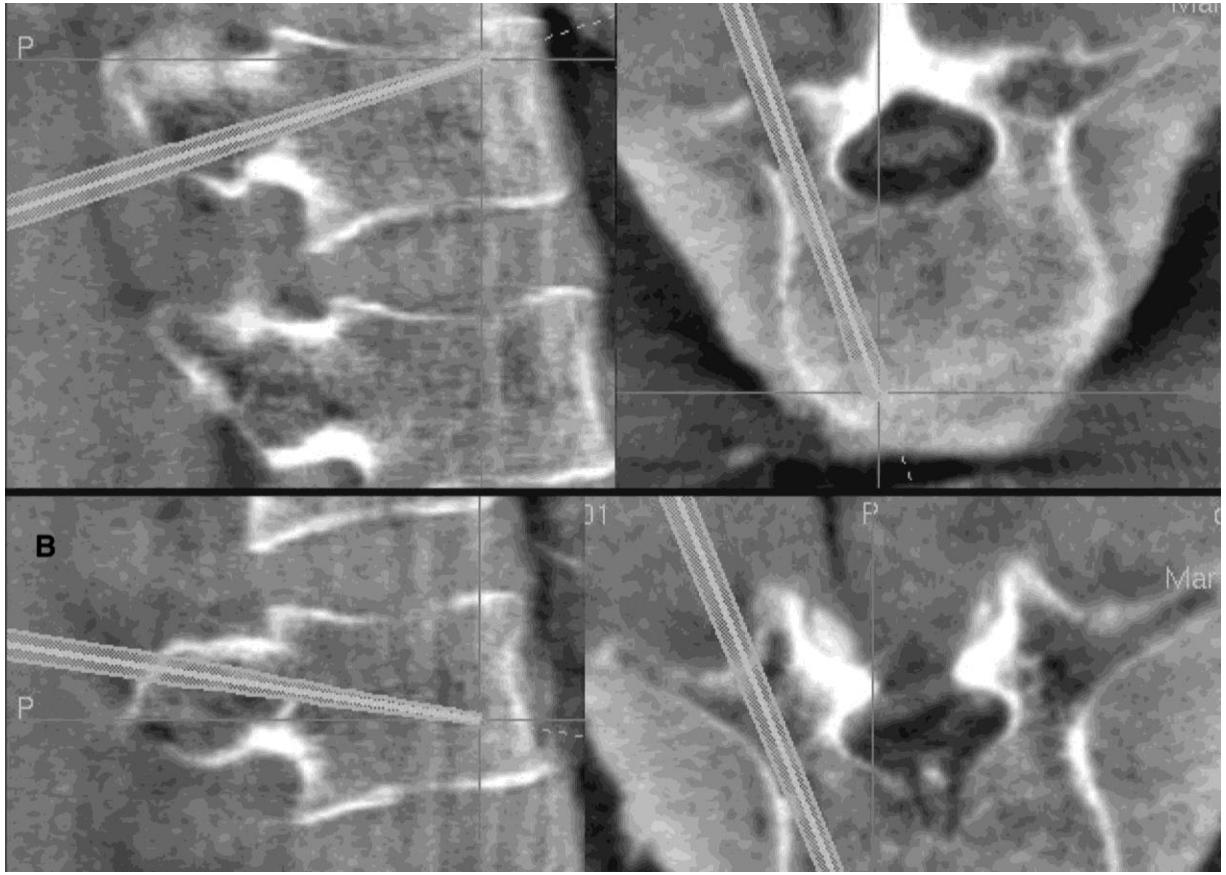


Cross trajectory (Matsukawa)

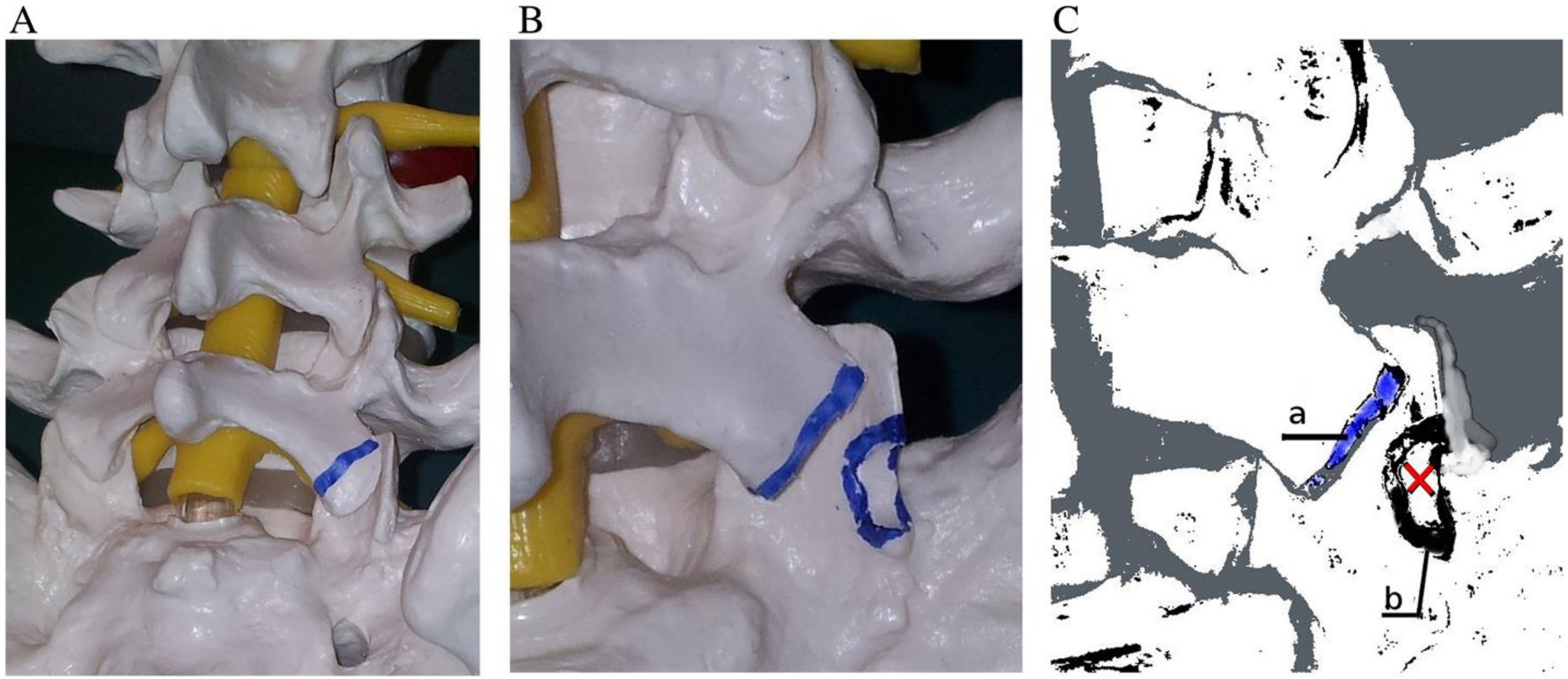
# Screw trajectory 3

Cortical superior fixation to pedicle (Matsukawa)

Caudal screw trajectory (Battula)



# Screw trajectory 4




S1: upward and medial (**a**) versus below and lateral (**b**)

**Summary**

Lots of options, variable data, limited data in live patients, no clear consensus, or conclusions. Probably more clinical studies necessary.

# Screw trajectory
# Pull-out data

Conventional pedicle screw pull-out → 491.72 ± 187.2 N

Cortex inferosuperior screw pull-out → 822.16 ± 295.73 N

Cortex superoinferior screw pull-out → 644.14 ± 201.97 N

Cortical inferosuperior and cortical superoinferior trajectories attained **67%** and **30%** higher pull-out

- **Singkat DA et al.** *Int J Spine Surg.* 2020 Jul 27.

# Next steps and recommendations: anchor points and trajectory

Interesting trajectory concepts need more clinical work even though there is a lot of ‘mechanical’ literature already

Can we produce alternative screw trajectory options not mentioned in literature?

# 4. Augmentation

What do we mean by "augmentation"

1. Expandable screws (discussed in part 1)
2. "Cement"—what cement?
3. Calcium phosphate
4. Calcium apatite
5. Hydroxyapatite

**Differing understandings**

Fenestrated screws?
Cement then screw?
Volume of cement?
Type of cement?
Level above only?
Vertebroplasty?
Kyphoplasty?

# Augmentation

- The worse the osteoporosis, the better the improvement with augmentation.
- The cement-augmented fenestrated pedicle screw was superior biomechanically to the alternative "solid-fill" technique.
- Cement extravasation in as high as 79%.
- The use of cement-augmented fenestrated pedicles decreased screw pull-out and improved fusion rates; however, the clinical outcomes were similar to those with traditional pedicle screw placement.

**Yamaan SS et al.** *World Neurosurg.* 2020 Nov;143:351−361.

# Augmentation

- Screw augmentation increased the pull-out strength by 47%, cycles to failure by 31%, and failure loads by 21% compared with the screw in the original pedicle ($P$ <.05).
- Higher rates or loosening at cranial and caudal ends

**Chongyu J et al.** *Spine J.* 2019 Aug;19(8):1443−1452.

# Augmentation

**01**

Various augmentation choices

**02**

Very little comparative data

**03**

Complications occur, revision strategies limited

**04**

How do we predict which patients will benefit and need it?

# 5. SI-Ilium

Additional ilium screws have the highest potential to protect the S1-anchorage. Additional L5/S1-translaminar-screws can increase stability of the lumbosacral junction without bridging the iliosacral joint, whereas lamina hooks showed no significant biomechanical benefit.

**Volkheimer D et al.** *Clin Biomech.* 2017 Mar;43:34−39.

# SI-Ilium fixation: iliac versus S2-iliac

**Summary**—This is something that we seem to have fairly well figured out.
No real difference in various “techniques”.
Proved to be beneficial with minimal downside.

# 6. Fusion bed preparation

Could find no literature discussing differences in fusion bed preparation in patients with osteoporosis versus those without osteoporosis.

Pseudarthrosis rates are higher, but no guidance exists how to improve bony fusion.

**Summary**—No consensus. Huge variability. Big opportunity.

# Opportunities target 2: surgical planning and technique

- Develop torque measurement tool and study clinical application
- Design screws for better purchase—expandable vs augmentation (bone, dowels, cement)
- Additional fixation options—hooks, “blades”, bands, wiring?
- Study pedicle screw bone trajectories versus osteoporotic bone tolerance
- Soft “tulips”/rod transitions (tapered rod)
- Best graft options in OS fusion? Location and graft type