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

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<td>makes sense</td>
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<td>Under tapping</td>
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<td>Cross-link</td>
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<td>Other advancements in pedicle fixation</td>
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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

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<td>Traditional trajectory (TT) and cortical bone trajectory (CBT) combined (crossed trajectory)</td>
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<td>CBTs increase purchase and load of failure in osteoporotic spine versus TT</td>
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<td>Midline Cortical (MC) Trajectory: superior load of cyclic load failure over CBT</td>
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<td>Revision of TT-CBT or CBT-TT screws is a challenge</td>
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<td>14 references</td>
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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

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.

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

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.

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

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