Recent Advances in Pelvi-acetabular Fracture Fixation

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3-in-1 Exsanguinating Pelvic Fracture Protocol
Unstable Pelvic Fractures

Trauma Activation in 5 Trauma Centers in HK
• Pelvic course with simulation
• Mandatory to all Orthopaedics Trainees Since 2017
Challenges after Increased Survival

More complex /displaced pelvic fractures to be fixed
Pelvic Fracture
Abdominal Injuries
Thoracic Injuries
Spinal Injuries
Vascular Injuries
Medical Complications
Surgical Complications
Associated Limb Fracture/Injuries
Prolonged ICU Stay and Hospitalization

Streamline Management
Burden
Definitive treatment

Open reduction internal fixation (ORIF) (Gold standard)

- Extensive Dissection
- Intra-op Blood Loss
- Surgical morbidities
- Post-op wound pain

Prolonged External Fixation

- Pin tract complications
- Delayed mobilization
X-ray Guided MIS (percutaneous screw fixation)

- Small incision
- Minimal surgical dissection
- Technically demanding
- Narrow pelvic corridor
- Difficult intra-op x-ray assessment
- Excessive radiation

Limited to
- non-displaced fracture
- minimally displaced fracture
- reducible fracture


Limited to
- non-displaced fracture
- minimally displaced fracture
- reducible fracture
3D-Navigation guided MIS

- Started in QEH since Oct 2015
- **Real-time** 3D-guidance
- Safety margin of MIS - much improved

***Allowed Pre-op planning***

→ Maximize MIS utility and its benefits

*Daniel Behrendt · Maria Mütze · Hanno Steinke · Martin Koestler · Christoph Josten · Jörg Böhme (2012). Evaluation of 2D and 3D navigation for iliosacral screw fixation. Int J CARS 7:249–255
3D Navigation MIS – Requirement

**Hardware**
- Radiolucent table
- Navigation system
- Intra-op 3D C-arm (w/ calibrate cage)

**Manpower**
- 2 Orthopaedic Surgeons
- 1 Scrubbed Nurse
- 1 Technical support outside sterile field
- 1 Radiographer
34/M
Fell from height
Transient responder
3-in-1 Damage control procedures for pelvic hemostasis
Stabilized -> Whole body CT
Traditional
Fracture minimally displaced -> Navigation MIS feasible
Fracture alignment maintained by pelvic Ext Fix (already applied in 3-in-1)
DICOM → Navigation Computer → Feasible
OT Setting

- +/- Pre-op bowel prep
- Supine on OSI table
- +/- sacral support
- Pubic shaving
• Modify pelvic Ext Fix configuration
• Maintaining same fracture alignment
• Install patient reference tracker, **rigidly and stably**
Intra-op 3D fluoroscopy

All OT staff outside OT suite
Intra-op 3D image and Pre-op CT Fusion

- Geometric/spacial registration of pelvis
- Make sure ≠ not displacement

- Avoid merging mobile structure
Real-time 3D-Navigation According to pre-op planning

Navigate on **rigid drill sleeve** for insertion of **long flexible** 3.2mm drill tip guide pin

*Perfect Green Cone = Perfect Execution*
Intra-op X-ray

• Few essential views for each guide pin for verification
• Insert all guide pins before lag screws
OT time: 2.5 hours
Blood loss: 200ml
Limited dissection
Limited radiation to OT staff
63/M; Fell from height; ISS 48
Tile C2 + Both column

Traditional:
• Anterior ORIF
• Posterior ORIF
• Bilateral SI screws +/- ORIF
• Lengthy surgery
• Extensive dissection
• Anticipate large blood loss
With the aid of 3D-navigation technology...

• We try our best to explore possibility of MIS
Day 2 Removal of Pelvic Packing

**Window of opportunity:** Close reduction + adjust ext fix

Reduction hold by pelvic external fixator
Repeat CT pelvis

MIS seems Feasible after reduction
MIS Made Feasible even in grossly displaced complex pelvi-acetabular fracture

OT time: 3h 26mins  
Blood loss: 250ml

# healed at 4 months; Congruent left hip joint walk unaided; squatting ok; VAS 1/10
Intra-op reduction + Intra-op planning → One stage surgery

• For displaced reducible less complex fracture pattern

OT Time: 148 mins
Blood loss: 240ml
Pelvi-acetabular Fracture Operation indicated?

Yes → CT Planning

Navigation MIS Feasible?

Yes → Repeat CT for planning/Intra-op 3D Planning

Fracture Reducible?

Yes → 3D-Navigation MIS

No (due to fracture displacement)

No → No (due to fracture pattern such as pubic symphysis diastasis or posterior acetabular wall fracture)

Traditional ORIF / External Fixation

Adjunct screw fixation If indicated

Conservative
Pelvi-acetabular Fracture Operation indicated?

- Yes
  - CT Planning

- No
  - Conservative

Navigation MIS Feasible?

- Yes
  - Fracture Reducible?
    - Yes
      - Repeat CT for planning/Intra-op 3D Planning
    - No
      - Traditional ORIF / External Fixation

- No
  - No (due to fracture displacement)

Fracture Reducible?

- Yes
  - Repeat CT for planning/Intra-op 3D Planning

- No
  - No (due to fracture pattern such as pubic symphysis diastasis or posterior acetabular wall fracture)

Always prepare for ORIF in every case (Informed Consent, Instruments, Expertise)
1 year result – 38 cases; 143 screws inserted under 3D-navigation

- 22 cases (58%) required fracture reduction
- Average operative time – 2h 21 mins
- Average blood loss ~ 180ml
- No immediate and early post-op complication
- Mean deviation of planned and executed screw entry and tip 1.91mm and 1.94mm

<table>
<thead>
<tr>
<th>Category Name</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Sacroiliac</td>
<td>59</td>
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<tr>
<td>Anterior column</td>
<td>45</td>
</tr>
<tr>
<td>Supra-acetabular</td>
<td>34</td>
</tr>
<tr>
<td>Posterior column</td>
<td>3</td>
</tr>
<tr>
<td>Sub-cristal</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>143</strong></td>
</tr>
</tbody>
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Walking status at latest Fu

- Fracture union
  - Healed in Avg 4-5M
  - 5 Delayed Union at 7M
  - 1 Case Delayed Union

Fracture union

- VAS 2.69
MIS Fixation Stability

- Comparable to ORIF*
- Accelerate rehabilitation
- Early FWB walking

- Gras et al. found that for high anterior column fracture, screw fixation showed equivalent fixation strength compared with ORIF in Synbone (No. 4060; Synbone, Malans, Switzerland)
- Kraemer et al. found that fixation stiffness of lag screws was greater than that of plate fixation for transverse acetabular fractures
Navigation MIS – standardized fixation strategy

- Anterior column screw
- Posterior column screw
- SI screw
- Dome screw
- Subcristal screw

With appropriate fracture reduction (if necessary), 3D-Navigation MIS fixation technique can tackle most pelvi-acetabular fracture
Navigation MIS cannot replace ORIF

- Too small pelvis
- Severely comminuted fracture pattern (fixation stability)
- Non-reducible fractures
- Pubic symphysis diastasis
- Posterior wall fracture
- Fracture acetabulum with hip instability

3D-Navigation + Pre-op planning allow special screws insertion

- Posterior wall screw
- S2 SI screws
- Transpubic screws
Combined Navigation MIS + ORIF

• Not mutually exclusive
• **Comprehensive and supplementary**
• Provide more versatile fixation options to
  - different patients with
  - different fracture patterns in
  - different clinical situation
3D-Navigation MIS for Pelvi-acetabular Fracture
2-year review (Oct 2015 - Sept 2017)

• 83 cases
• Total 305 screws
• Average age 57.8 (17-101)
### 3D-Navigation MIS (2-year) vs ORIF (2007-2016) In QEH

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<tr>
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<tbody>
<tr>
<td>ISS</td>
<td>23.2</td>
<td>33.3</td>
</tr>
<tr>
<td>Pelvic AIS</td>
<td>3.3</td>
<td>3.89</td>
</tr>
<tr>
<td>Trauma Activation</td>
<td>72%</td>
<td>77.6%</td>
</tr>
<tr>
<td>3-in-1 Pelvic Protocol</td>
<td>37.8%</td>
<td>59.2%</td>
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<tr>
<td>Injury to Operation Duration</td>
<td>5.2 days</td>
<td>6.8 days</td>
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<tr>
<td></td>
<td>4.2 days if excluding non-trauma cases</td>
<td></td>
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<tr>
<td>Operative Time</td>
<td>119.5 mins <em>(1 hour less)</em></td>
<td>179 mins</td>
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<tr>
<td>Intra-operative Blood Loss</td>
<td>139ml <em>(7x less)</em></td>
<td>970ml</td>
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<tr>
<td>Acute LOS</td>
<td>29.9 days <em>(~2 weeks less)</em></td>
<td>42.3 days</td>
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<td>Early Complication</td>
<td>2 superficial and 1 deep infection</td>
<td>5 Major Complications</td>
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<tr>
<td></td>
<td>1 broken drill bit intra-op</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 SI screw cortical perforation</td>
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Further Development?

- Incorporate robotic control
- Augmented Reality
Thank You