C1-C2 Fusion Techniques
Current Concepts

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Disclosure

• Grant Support/ Royalties/Stock options/Consulting/Editorial Board:

• Board Member: CSRS

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INTRODUCTION

• Multiple Options
  • Wiring
  • Hooks
  • Magerl Transarticular Screws
  • Harms C1 lateral mass -C2 pars/pedicle screw Technique
  • Translaminar
Posterior Gallie Wiring
Posterior Brooks Fusion
Posterior C2/C1 Magerl Transarticular Screws
C1-2 Transarticular Screws

- Vertebral artery perforation: 4%
  - Neurologic deficit: 0.2%
    - Wright, J Neurosurg, 1998

- Pre-operative CT with reconstructions
  - 18-23% may not be candidates
    - Sonntag, J Neurosurg, 1996
C1-2 Transarticular Screws

• Starting point
  – 3mm cranial and 2mm lateral to the inferior edge of the inferior articular C2 process
• Average screw length 40-45 mm
• If vertebral artery injury do not attempt other side
Very steep angle needed:
Hooks
Anterior C2/C1 Screw Fixation
Anterior C2/C1 Screw Fixation
Anterior C1/C2 Screw Fixation
C1/C2 Lateral Approach
C1/C2 Lateral Approach
Anterior Transoral Plating
C1-2 Anterior Plating
C1 Lateral Mass/C2 Pedicle/Pars Screw

Harms Technique:

• 1st described by Atul Goel with plates in 1994

• Popularized by Harms with Polyaxial screws & rods in 2001
Two Options:
1. Thru Pedicle Analog
2. Below Confluence of post Ring
**C₁ Lateral Mass Screw**

Two Options:
1. Thru Pedicle Analog
2. Below Confluence of post Ring
For 3.5 mm screw:
ARCH 14% feasible
NOTCH 85%
15% VA at risk even with Notch technique!!!
Below Confluence

• Palpate Midpoint of LM with Penfield 4
• Burr 2mm drill seating

Hong X, et al. Spine. 2004
Cranio-Caudal Angulation

- Easy to violate Oc-C₁ Joint
- Avoid > 25° Medialization
- Aim for cephalad 20-40% of C₁ Ant Tubercle

Yeom, Spine J, 2009
Medial Angulation

- Initially, straight ahead, now 10-15° medial
  - To avoid ICA
  - Avoid > 25° Medialization
Bicortical C1 LM screws provide significantly better pullout strength

Eck, JSDT, 2007
C1 ring- Internal carotid artery relationship

Currier, Spine, 2008

• Highly variable location. Near the lateral edge of LM. Avg shortest distance from C1 anterior arch ~ 3mm.
• Vulnerable with bicortical screws
Hypoglossal nerve also at risk

Ebraheim, Surg Neurol, 2000

Located on the lateral border of lateral mass
Just medial to the C1 transverse process C
Postoperative occipital neuralgia with and without C2 nerve root transection during atlantoaxial screw fixation

Yeom, Spine J, 2013

PROSPECTIVE STUDY

N= 24 consecutive Transections

N= 41 consecutive Preservations

~20-30% worse neuralgia at every timepoint up to 2 yrs postop (significant at each timepoint except 1 month)
C2 root transection-*necessary* for joint distraction technique (Goel):

17 yo congenital anomalies and basilar invagination

Goel, *Neurol India*, 2008
C2 Anatomy
C2 Posterior Screw Fixation Techniques

- C2 Pedicle Screw
- C2 Isthmus Screw
- C2 Angled Isthmus Screw
Posterior C2 screw Fixation Techniques

- C2 pars
- C2 pedicle
Vertebral Artery Anomalies

- Ectasia: 20% at least 1 ectatic artery
- Prevents safe placement past isthmus
- RA: high-riding VA more likely
Preoperative Assessment

- Reformatted CT:
- Adequate width of C2 pars interarticularis and pedicle
To determine feasibility of C2 pars screws:

Evaluate the sagittal CT recon
To determine feasibility of C2 pedicle screws:

Scrutinize axial CT scans
C₂ Pedicle Screw

- Start: lat on C₂ lateral mass

- Palpate Isthmus

- 15-45° Medial
  - 28-35 mm screw
  - Longer when entering C₂ body

- 30° Cephalad
C₂ Pars Screw

- Pars screw less likely to injure VA
  - 0% vs. 0.3% with pedicle screws
C2 Translaminar screws:

- Unilateral or bilateral
- Technically very easy to do
- No fluoroscopy needed
Translaminar Screw Technique

- Plan for 2 crossing screws
  - One very high, other low
- Modifications
  - 2 ipsilateral, parallel screws
Biomechanics of C2 Translaminar screws:
Claybrooks, TSJ, 2007

N=8 INSTRON testing

<table>
<thead>
<tr>
<th>Mode</th>
<th>C2 Pedicle</th>
<th>C2 Translaminar</th>
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<tr>
<td>F/E</td>
<td>=</td>
<td>=</td>
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<tr>
<td>Transl</td>
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<td>=</td>
</tr>
<tr>
<td>Bend</td>
<td>+</td>
<td></td>
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<tr>
<td>Rotation</td>
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C2 Translaminar screws:

**Best indications:**

Insufficient Pedicle or Pars due to medial VA aberrancy

Salvage of failed Pedicle or Pars screws
C2 Translaminar screws:

**Downsides:**

Harder to hook up to longitudinal rod fixation (usually need offset connectors)

May not have enough room for two screws in one lamina
Summary: Types of C2 fixation

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<th></th>
<th>Pars</th>
<th>Pedicle</th>
<th>Translaminar</th>
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<tr>
<td>Biomechanics</td>
<td>++</td>
<td>++</td>
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<tr>
<td>VA risk</td>
<td>higher</td>
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<td>none</td>
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<tr>
<td>SCI risk</td>
<td>low</td>
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<tr>
<td>Anatomically feasible</td>
<td>most pts</td>
<td>most pts</td>
<td>almost always</td>
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<tr>
<td>Ease of rod hookup</td>
<td>easy</td>
<td>harder</td>
<td>hardest</td>
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Thank You