Pseudarthrosis Post Cervical Surgery

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Patient factors
Surgeon factors
Efficacy of index procedure
Diagnosis: Radiographic vs. clinical
Revision options

It's much easier to stay out of trouble now than to get out of trouble later.

— Warren Buffett —

- Not all patients with pseudarthrosis are symptomatic
  - asymptomatic in approximately 30% of cases
  - leading cause of pain postoperatively (45%-50% of revisions)

<table>
<thead>
<tr>
<th>Table 1. Risk factors for pseudarthrosis</th>
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<tr>
<td>Smoking</td>
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<td>Metabolic syndrome</td>
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<td>Diabetes</td>
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<td>Obesity</td>
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<td>Younger age</td>
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<td>Chronic steroid use</td>
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<td>Malnutrition</td>
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- 190 patients for at least two years
  - 59 ACCF, 131 ACDF
  - 55 smokers; 15 ACCF, 40 ACDF
  - No internal fixation, autogenous iliac crest or fibular strut grafts
- 20/40 ACDF smokers fused vs 69/91 nonsmokers (p<0.02)
- 14/15 ACCF smokers and 41/44 nonsmokers fused (93%) (p<0.02)
- ↓ clinical outcome for smokers
- Subtotal corpectomy with autogenous strut-grafting for multilevel for smokers


- 8 Non-RCT reviews
- 21/245 (8.57 %) reoperation in anterior surgery, 1/285 (0.3 %) in posterior surgery.
  - 13 (5.3 %) for pseudarthrosis/non-union of the graft
- ACCF: ↑ EBL and ↑ OR time vs. LM or LP
  - ACCF vs LM or LP?
- Anterior: ↑ postop neural function without difference in RR

- Tricortical allograft vs tricortical AICBG in 2- and 3-level ACDF
  - 78/80 (97.5%) fused; 2 nonunions in allograft pts (not sig)
  - Similar clinical outcomes ~ 88% excellent and good
- Samartzis et al.: One level ACDF + plate with allograft and autograft
  - 35 allograft (100%), 31 autograft (90.3%), (p>0.05)
  - Contrary to allograft having higher pseudarthrosis


- Primary 1- to 3-level ACDF with ICBG (36) or BMP allograft (30; 0.9 mg BMP per level)
- Comparable preop disability
- VAS pain, pain drawing, Oswestry index, pain medication use, opinion of treatment success, and neurological recovery
- 2 pseudo in ICBG, 1 pseudo in BMP
- 50% neck swelling in BMP vs 14% in ICBG
- BMP: ↑ implant and hospitalization, ↓ OR time
- Not FDA approved

Diagnosis

- Difficult prior to a surgical exploration
- High rates of asymptomatic patients and diagnostic tests lacking high sensitivity and specificity
- History and physical examination
  - mechanical neck pain worsened by motion
  - Disease progression, infection, implant failure, ASD, and postoperative pain syndromes
- High percentage of asymptomatic pseudo (20-30%)
- Surgical exploration
Imaging Studies

- X-rays
  - Absence of bridging trabeculae between the host bone and graft,
  - Motion > 1 mm or 2 mm between spinous processes on F/E
  - Cannada et al.; specificity of 89% and sensitivity of 91%
  - Changes in the Cobb angles
    - >2 degrees, specificity of 39% and a sensitivity of 82%.
    - >4 degrees, a positive predictive value of 100%.
- CT; nonconclusive on x-rays
  - Fine-cut CT > flexion-extension x-rays (despite artifact)
  - Highest concordance with operative findings
- MRI; fair interobserver reliability, moderate agreement with intraoperative findings (Buchowski et al.)


- > 12º segmental motion, >T1 sagittal slope, and C6-7 level

Surgeon Factors

- Retrospective, 251 pts with 1- or 2-level plate vs 289 without

<table>
<thead>
<tr>
<th>TABLE 3. Fusion Rates with and without Plates</th>
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<td>Levels Fused</td>
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<tr>
<td>---------------</td>
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<tr>
<td>No Plate</td>
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<tr>
<td>One level</td>
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<tr>
<td>Two levels</td>
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<tr>
<td>Total</td>
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- 2 level ACDF
  - Static plate + AICBG (21), 87.8% per level @ 10 months, (76.2%).
  - Dynamic plate + fibular allograft (22), 89.7% per level @ 9.5 months (81.8%) (P = 0.469)

- Fusion rate increased over time; 84.7% vs. 90% @ 10-13 months, respectively
- Digitized angular measurement > 2°
- Dynamic plate performed at least as well as the static plate, despite the use of allograft


- Cochrane Library, EMBASE, PubMed, and CBM
- Five studies, 172 pts dynamic and 143 static
  - 4 studies: Radiographic and clinical outcome in 1- and 2-levels
  - 1 with multilevels
  - 2 with AICBG, 3 with allografts
  - 2 studies with similar clinical outcome
  - Dynamic plate: Better for multiple-level
  - Similar clinical outcome was found in the one-level
- The two RCT studies: 4 static pts with HW complications
  - None in dynamic

- Not for kyphosis. ↑ Pain, ↓ cosmesis, unable to access anterior pathology (Rhee, et al)
- Lower pseudarthrosis than anterior procedures
- NV injury, screw malposition, iatrogenic NFS >>> pseudarthrosis
- 3.0 x ↑ ASD vs anterior
- Posterolateral bone-grafting and wiring fusion rates of 96% (50/52). Callahan et al.
- Clinically similar outcome


- Complications: Anterior; a bone graft donor site infection.
- Posterior; 4 patients wound infections, 3 bone graft site infection
- Posterior: ↑ fusion rate, ↓ incidence of repeat revision

- The National Library of Medicine and Cochrane Database
- Variable incidence of symptomatic and asymptomatic pseudarthroses
- Revision may be considered to improve clinical outcome
- Both posterior and anterior approaches have proven successful
- Posterior approaches with higher fusion rates
- All class III level of evidence


- Pain is the most common presenting symptom for pseudarthrosis
  - After laminectomy and fusion, the pseudarthrosis rate was found to range from 1% to 38%.
  - In multilevel anterior cervical fusion, commonly occurs at the lowest fusion level, the rate is approximately 10%.
- 4° of intervertebral body motion on flexion/extension radiographs
- Infection, medical comorbidities, malnutrition, and smoking status
- If patients are asymptomatic, treatment of pseudarthrosis may be nonoperative
- Anterior revision: Vocal cord status


- Sixteen studies (out of 281) with reported fusion outcomes
  - 10 anterior, 10 posterior, 3 with A/P combined
  - All the studies were level IV evidence.
- Fusion rate: 86.4%\(^{\text{HT}}\) in anterior and 97.1%\(^{\text{HM}}\) in posterior (p . 0.028)
- Clinical success rate: 77.0%\(^{\text{HT}}\) for anterior and 71.7%\(^{\text{HT}}\) for posterior
- Limitations:
  - Variety of surgical techniques
    - Anterior: plate vs no plate, type of grafts
    - Posterior: wires, screw + plates, screw + rods
  - Number of Levels treated, number of levels of nonunion

- Anterior Alone vs. Combined Anterior and Posterior Fusion
- ↓ alignment correction and maintenance
- ↑ Pseudarthrosis (20% vs. 0%, *p*=0.034)
- ↑ Cage subsidence (40% vs. 6.7%, *p*=0.025)
- ↑ Hardware-related complications (26.7% vs. 0%, *p*=0.013)
- ↓ Clinical outcomes (*p*=0.046)
- ↓ Operative time (86 minutes versus 266 minutes, *p*<0.05)
- ↓ EBL (188 mL vs. 329 mL, *p*=0.05)


- Posterior: Significantly higher fusion rates, ~100%
- Carreon et al., 27 anterior and 93 posterior ACDF revisions.
  - 44% of anterior revision group (plate with ICBG) and 2.1% of posterior revision group (24 wires, 32 plates, and 27 rods) required a second revision for persistent nonunion
- 217 patients anteriorly and 280 patients posteriorly.
  - 96.0% [confidence interval (CI), 89.1%–98.6%] in the posterior group and 64.2% (CI, 47.3%–78.1%) in the anterior group (*P*=0.028).
- Large fusion bed, more vascular, presence of bone stock, avoid repeat approach morbidity


- Tribus et al.: 16 patients with revision anterior surgery using anterior plating, 81% fusion rate.
- Coric et al.: 19 consecutive patients with anterior revision using allograft and plating.
  - 100% Solid osseous fusion, 83% good or excellent clinical results
- Zdeblick et al.: 23 patients with a repeat ACDF
  - All with a solid osseous fusion. Twenty patients had an excellent result and 3 patients had a fair result
- Surgeon and patient-specific factor driven for anterior revision
- Advantages: Direct visualization and removal, decompression, sagittal restoration, decrease axial pain, decrease infection, shorter hospital stay
Factors To be Considered in Treatment of Pseudarthrosis

- Pseudarthrosis alone is not an indication for revision.
- Nutritional counseling, smoking cessation, and the stabilization of medical comorbidities

Factors To be Considered in Treatment of Pseudarthrosis

- Biology
  - Smoking cessation, optimize health status
  - Autograft, allograft, BMP(?)
- Instrumentation
  - Static vs. Dynamic for anterior
- Salvage
  - Redo anterior
  - Posterior fusion
  - Combined anterior and posterior
  - Biological agents
  - “Benign neglect”
- “Don’t hate the player, hate the game”