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AOSpine Europe

Pedicle subtraction osteotomy

AOSpine Advanced Symposium— Managing the complex cervical spine

Barcelona
3-4 April 2017

Guillem Saló Bru, MD, PhD

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Associated Professor UAB



BJ Palmer (1882-1961)

Introduction

- Fixed sagittal deformity at the cervicothoracic junction results in high disability.
- Osteotomies can correct this disability
- Smith-Petersen osteotomy, Vertebral column resections (VCR) and pedicle subtraction osteotomies (PSO) are commonly performed at or below the mid thoracic to lower lumbar spine for sagittal imbalance
- Initially described by Simonds for ankylosing spondylitis.
- In comparison with the Smith-Petersen procedure, PSO is theoretically more stable
 - Shortens the spine
 - Bony contact at the osteotomy site



Simmons EH. The surgical correction of flexion deformity of the cervical spine in ankylosing spondylitis. Clin Orthop Relat Res. 1972; 86:132-143.

Etiology of cervical kyphosis.

- Most common cause is iatrogenic (i.e., postsurgical, laminectomy).
- Advanced degenerative disease.
- Drop Head Syndrome.
- Posttraumatic.
- Radiotherapy in the neck.
- Neoplastic disease.
- Infection (Sequels of Pot's disease..).
- Systemic arthritis.
 - Ankylosing spondylitis.
 - Rheumatoid arthritis.
- Others (syndromic, congenital).



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■ Post-traumatic Spinal Deformity

Alexander R. Vaccaro, MD,* and Jeff S. Silber, MD†

Spine

SRS FOCUS ISSUE

SPINE Volume 37, Number 5, pp E342-E348
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Pedicle Subtraction Osteotomy in the Cervical Spine

Adam L. Wollowick, MD,* Michael P. Kelly, MD,† and K. Daniel Riew, MD†

Clinical presentation.

- Unable to maintain horizontal gaze
- Ventral compression
- Swallowing difficulties
- Respiratory compromise
- Neurological deficits.
 - Radiculopathy
 - Myelopathy
- Mechanical neck pain: Worst with activity.

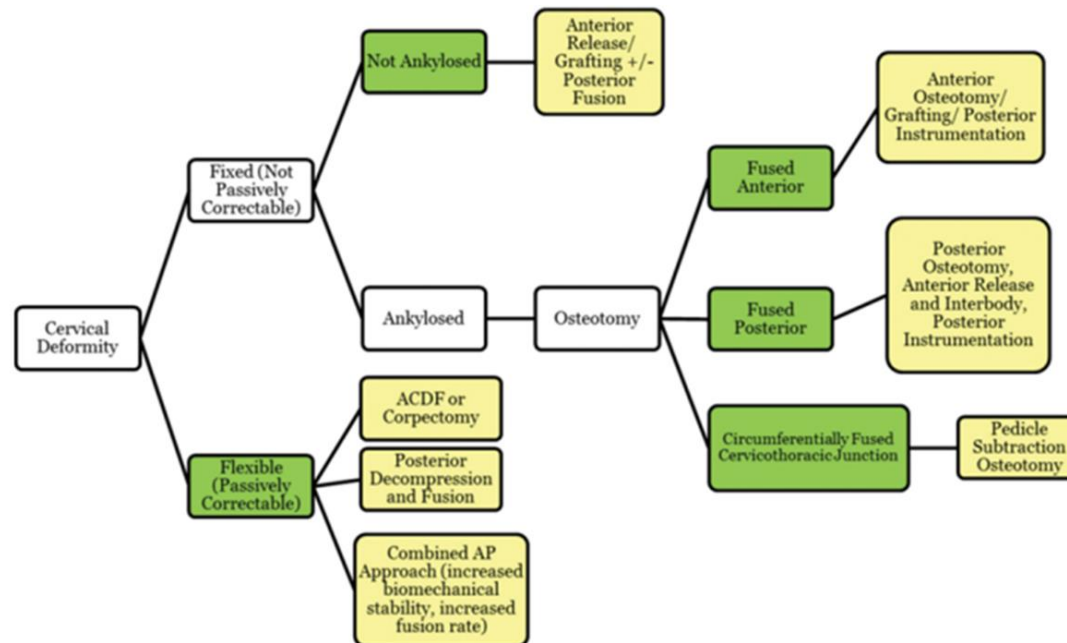


An algorithmic strategy for selecting a surgical approach in cervical deformity correction

SHANNON HANN, M.D.,¹ NOHRA CHALOUHI, M.D.,¹ RAVICHANDRA MADINENI, M.D.,¹
ALEXANDER R. VACCARO, M.D.,² TODD J. ALBERT, M.D.,² JAMES HARROP, M.D.,¹
AND JOSHUA E. HELLER, M.D.¹

Departments of ¹Neurosurgery and ²Orthopedic Surgery, Thomas Jefferson University, Philadelphia, Pennsylvania

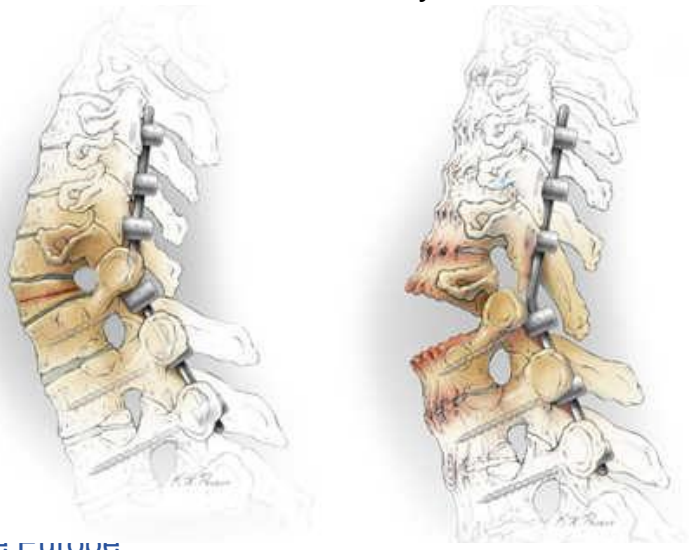
Indications of PSO.



- Patients with a **fixed** cervical kyphotic deformity >30°.
- Chin-on chest deformity.
- Progressive kyphosis.

Indications.

- **Semi-rigid kyphosis w our w/o neurologic symptoms:** Multilevel Smith-Petersen Osteotomy with Posterior Stabilization
- **Rigid subaxial kyphosis w neurologic symptoms:** Circumferential Osteotomy with a double approach, or anterior only in cases without posterior ankylosis of the facet joints
- **Rigid subaxial or cervicothoracic kyphosis w/o neurologic symptoms:** Open wedge osteotomy or Pedicle subtraction osteotomy.



Osteotomies in the Cervical Spine

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Eur Spine J (2011) 20:523–536
DOI 10.1007/s00586-010-1602-8

REVIEW ARTICLE

Surgical treatment of cervical kyphosis

Ke Han · Chang Lu · Jing Li · Guang-Zhong Xiong ·
Bing Wang · Guo-Hua Lv · You-Wen Deng

Eur Spine J (2015) 24 (Suppl 1):S31–S37
DOI 10.1007/s00586-014-3654-7

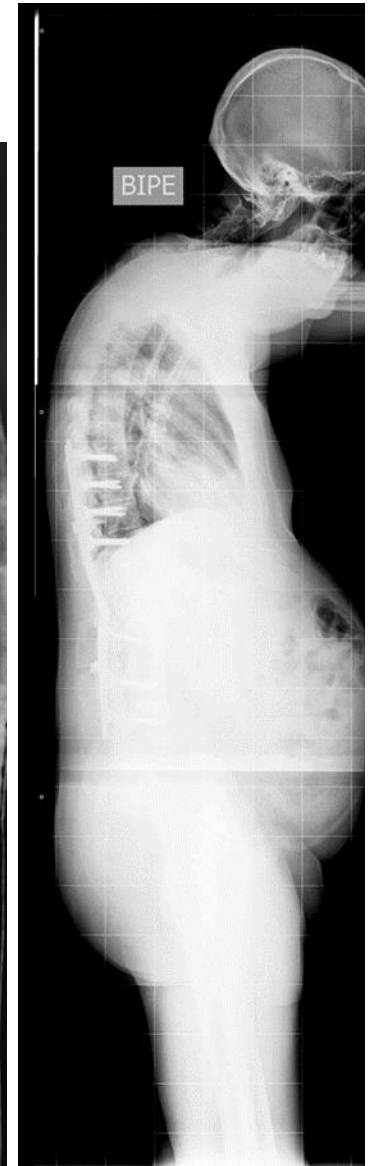
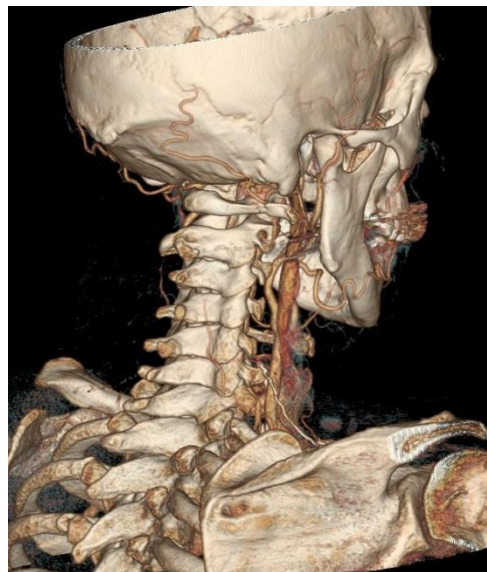
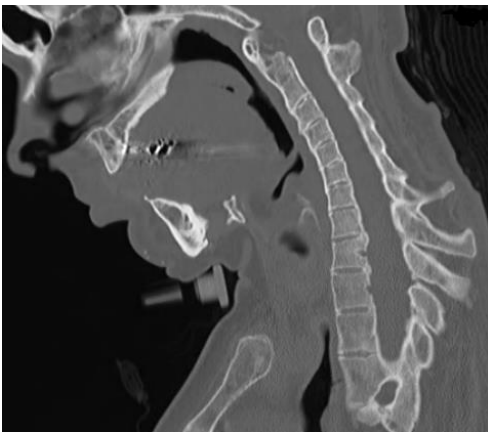
ORIGINAL ARTICLE

Osteotomies in proximal junctional kyphosis in the cervicothoracic area

R. Cecchinato · P. Berjano · R. Bassani ·
C. Lamartina

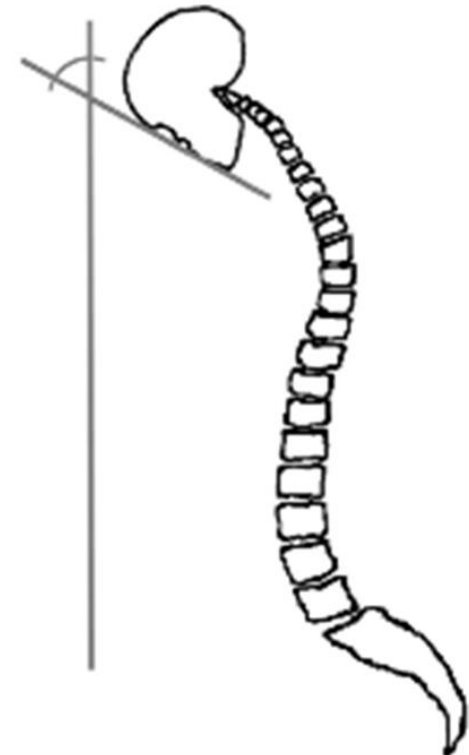
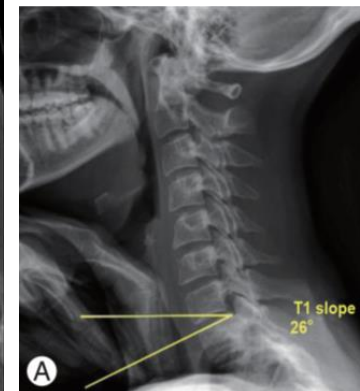
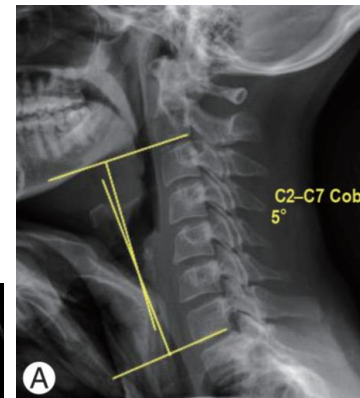
Preoperative evaluation.

- Medical evaluation prior to surgery
- Complete history of prior spine surgeries
- Full-length radiographs
- Flexion-extension and lateral bending views
- High-resolution CT scan
- Magnetic resonance imaging
- Preop angio CT

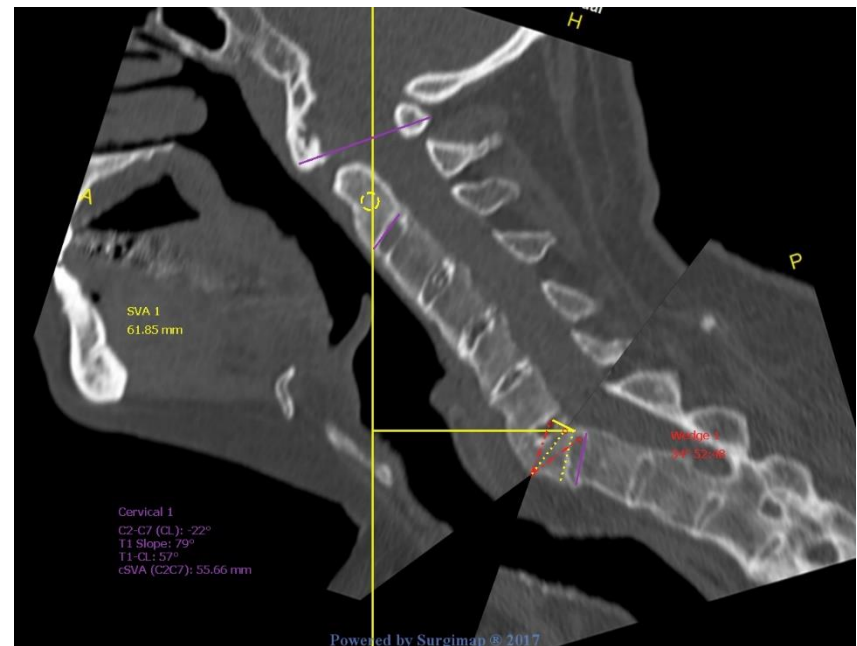
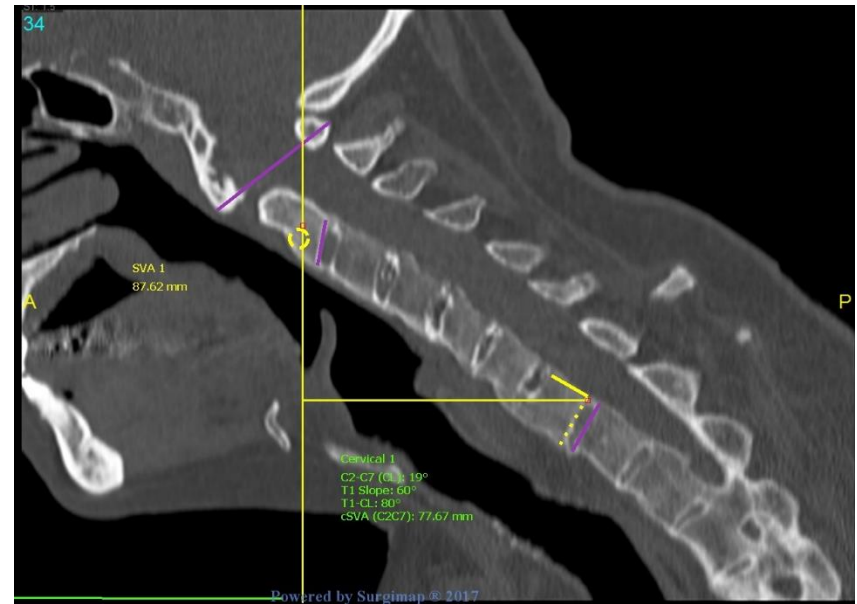
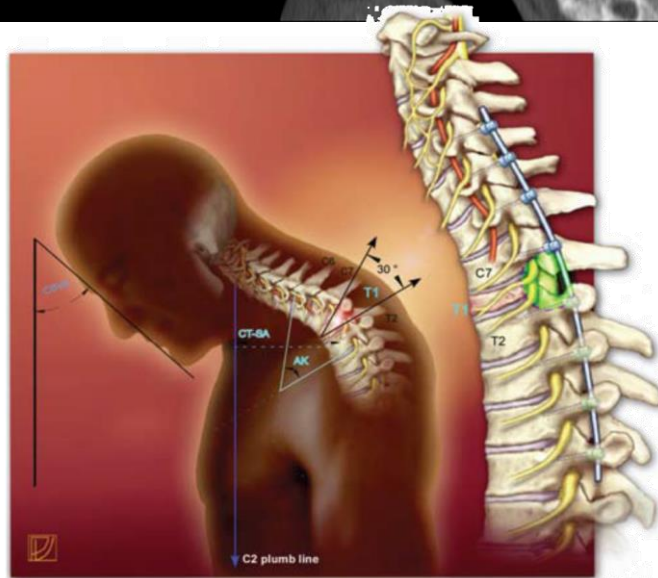


Osteotomy Planning

- The chin-brow angle (correction to a slightly flexed position, usually 15 to 20°)
- To calculate the amount of correction needed we prefer to use the preoperative CT scan:
 - Local sagittal angle
 - Cervical lordosis: C2-C7 Angle
 - Cervical plumbline
 - C2-C7 CSVA
 - T1 Slope

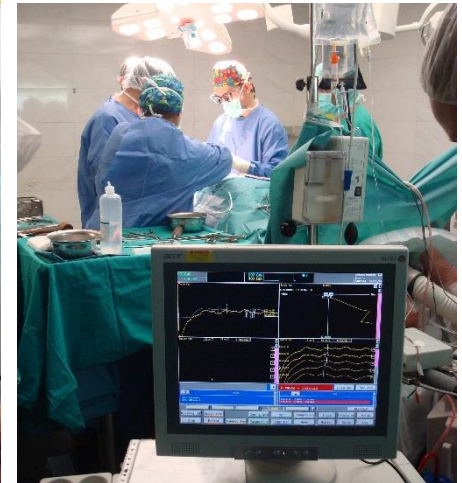
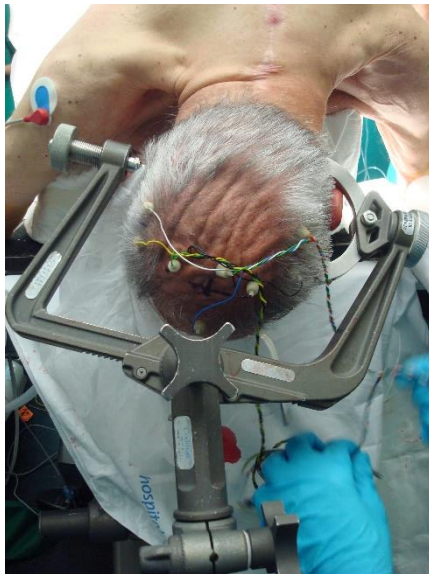


Osteotomy Planning



Surgical technique: anesthesia and patient positioning

- General anesthesia. Complex intubation.
- Neurological monitoring, including both somatosensory evoked potential (SSEP) and motor evoked potential (MEP) techniques
- Mayfield head clamp.
- Maximum amount of reverse Trendelenburg



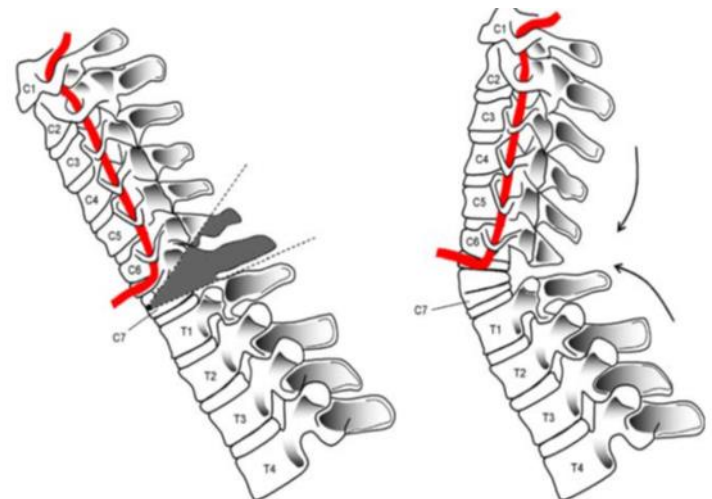
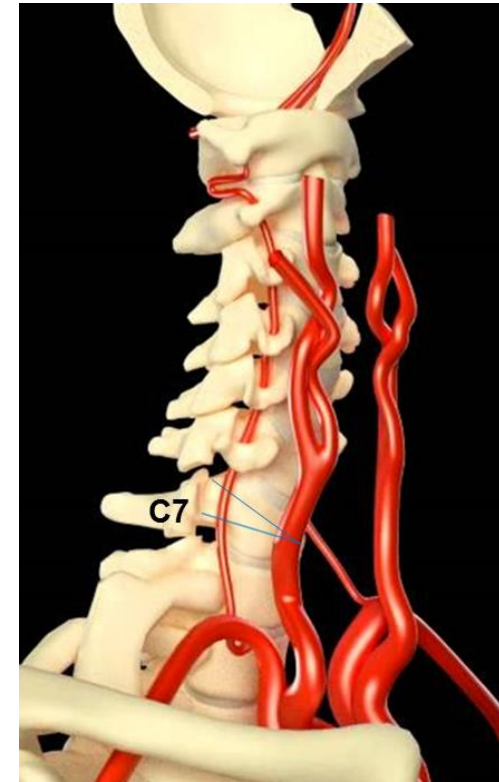
Surgical technique

Level : C7

- Fairly safe position of the vertebral artery
- Size of the spinal canal
- Mobility of the spinal cord
- Preservation of reasonable hand function in the event of C8 nerve root injury

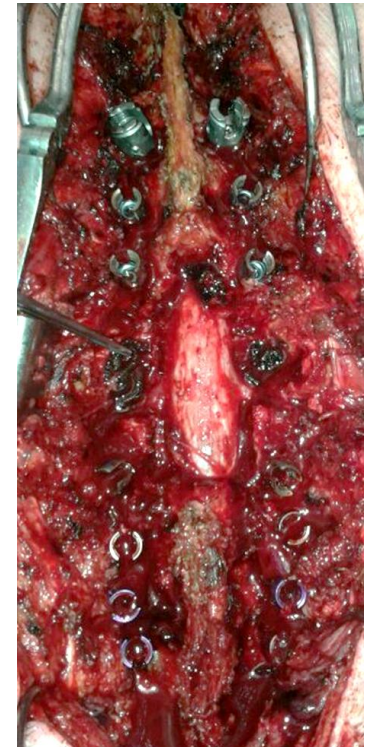
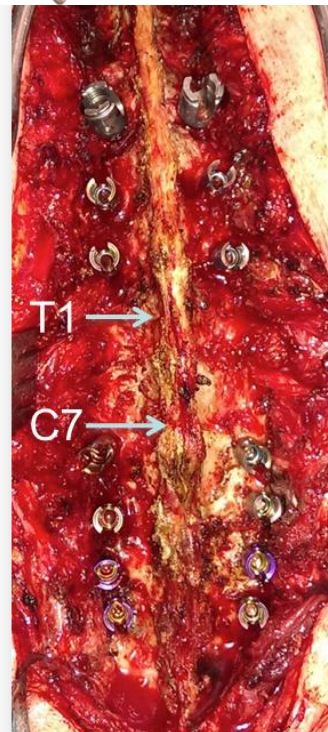
Extension of instrumentation:

- Minimum six points of fixation above and below osteotomy
- Preserve mobile occipitocervical and atlantoaxial joints whenever possible



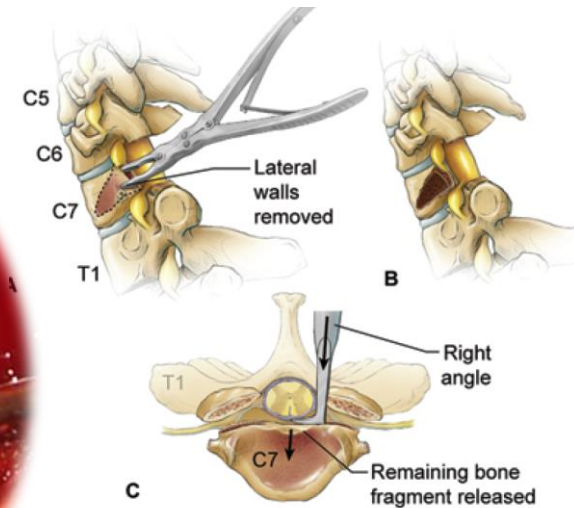
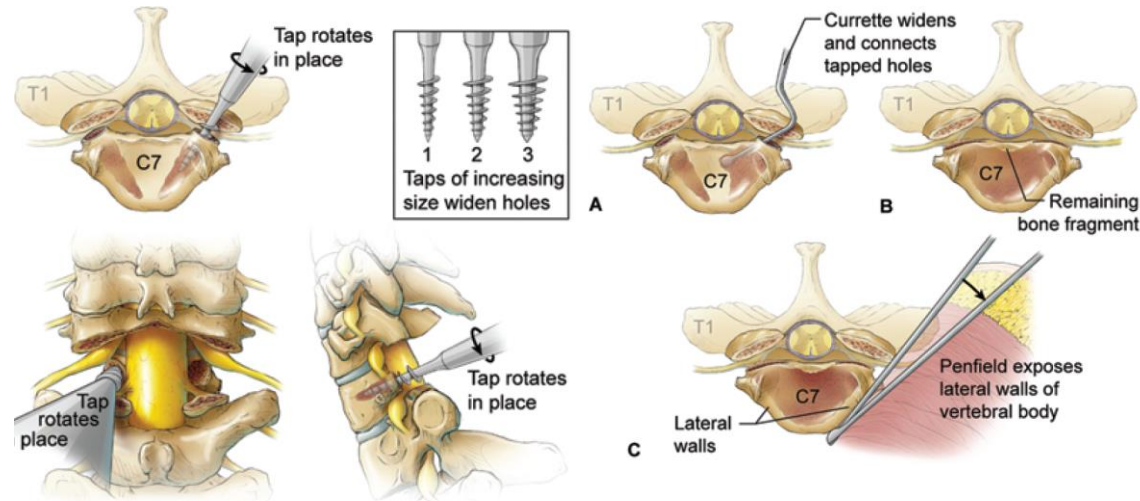
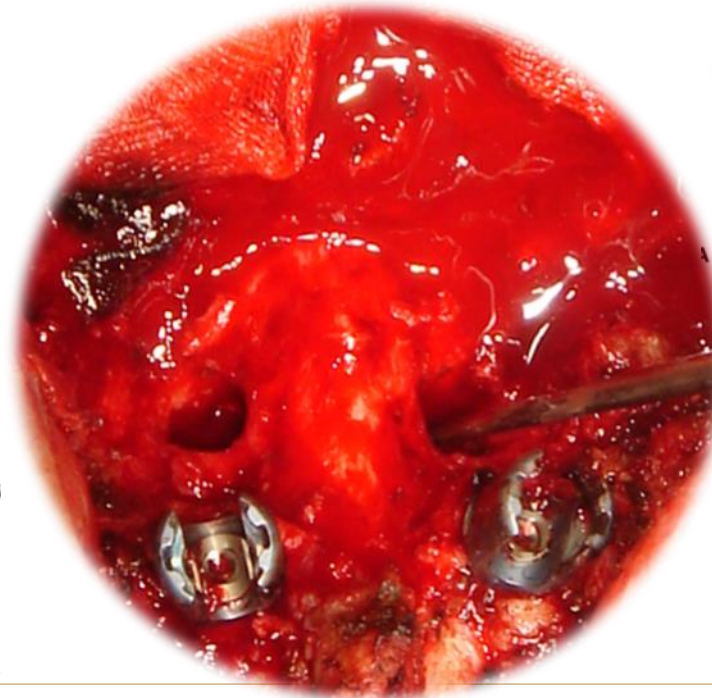
Surgical technique

- The lateral masses are exposed in their entirety.
- Lateral mass screws and pedicle screws.
- Place the screws in a straight line.
- Laminectomy at C7, and the half of C6 and T1.
- The facets must be completely excised, including the caudal aspect of the inferior facet of C6 and the cranial aspect of the superior facet of T1.



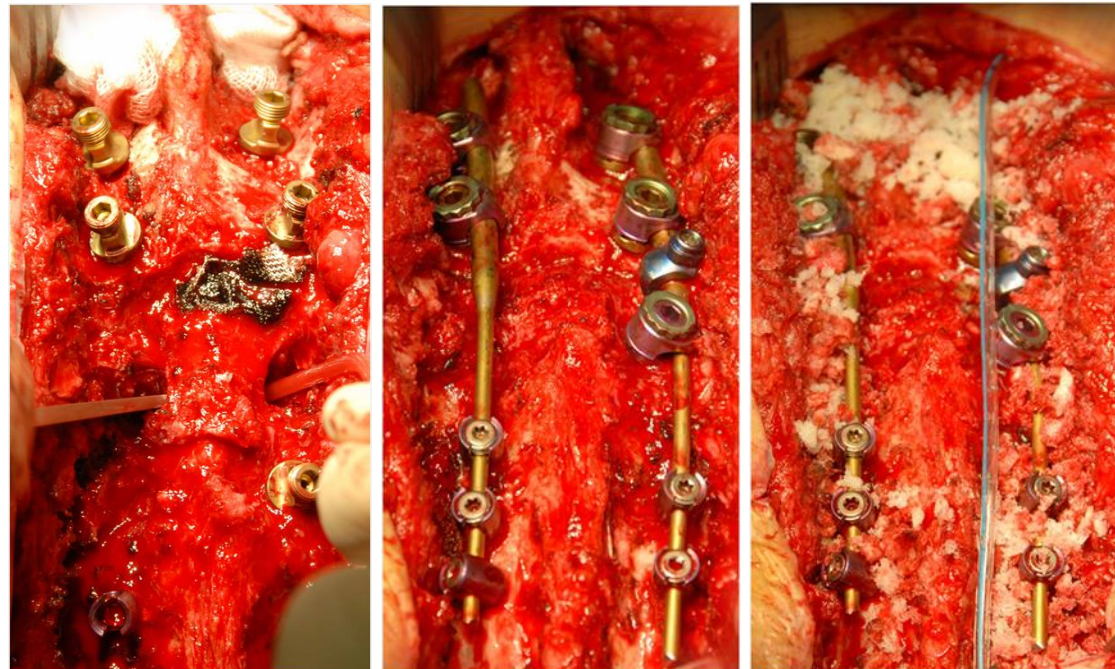
Surgical technique

- Expose de C7 and C8 roots
- Decancellation of vertebral body through the C7 pedicles (Tap / Curette)
- Remove bony wall of pedicles
- Remove the lateral wall of vertebral body.
- Impact the dorsal cortex of vertebral body.



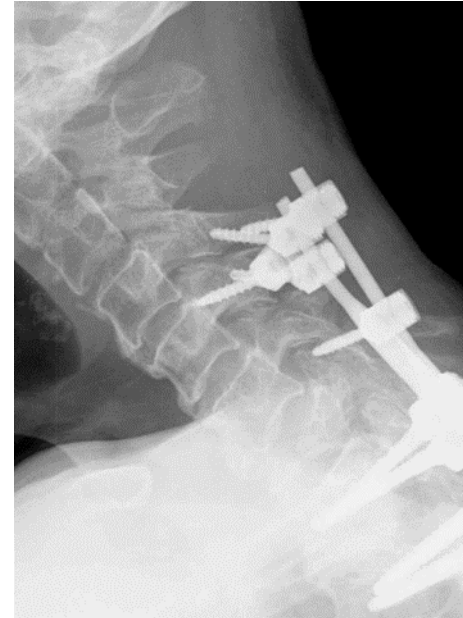
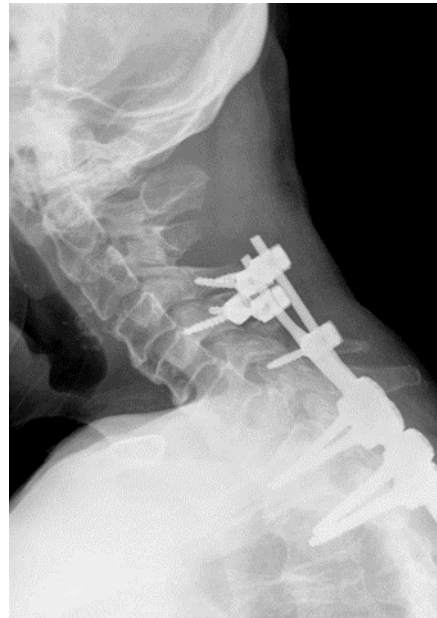
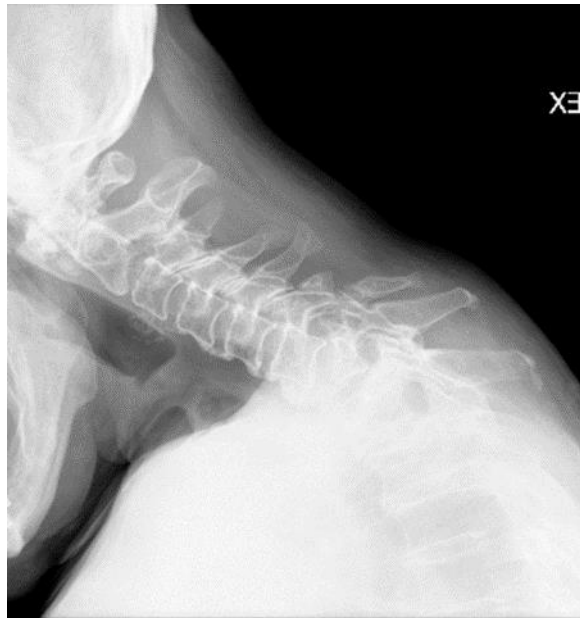
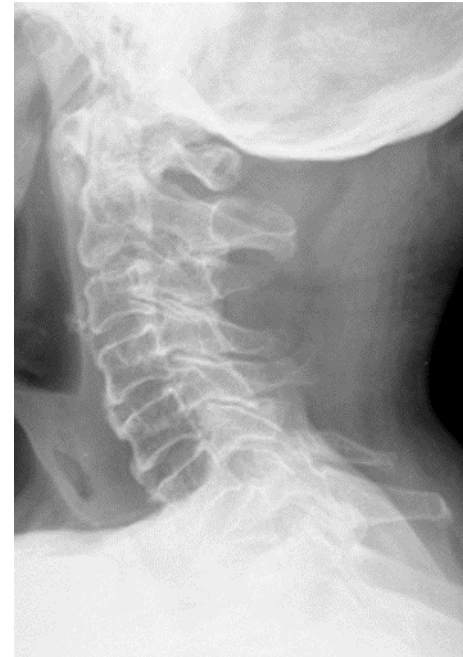
Surgical technique

- Fix the prebended road to cervical screws.
- Extend the neck to close the osteotomy. Mayfield/Halo Manipulation
- Check the roots.
- Close the instrumentation.
- Check the neuromonitoring signals.
- Lateral X-ray
- Autografts.
- Wound closure
- Hard cervical collar.



Case 1

- 70 year-old male.
- Neoplasm of larynx 10 years ago. Treated with laryngectomy, chemotherapy and radiotherapy.
- Fracture of C7 treated initially conservatively, and after with posterior arthrodesis C4-T2.
- After 3 months, Pull-out of the cervical screws



Case 1

- Chin-brow axis 45°. Postraumatic rigid Cervical kyphoses 38°.



Case 1

- Pedicle subtraction osteotomy at C7.
- Postoperative global lordosis 15°



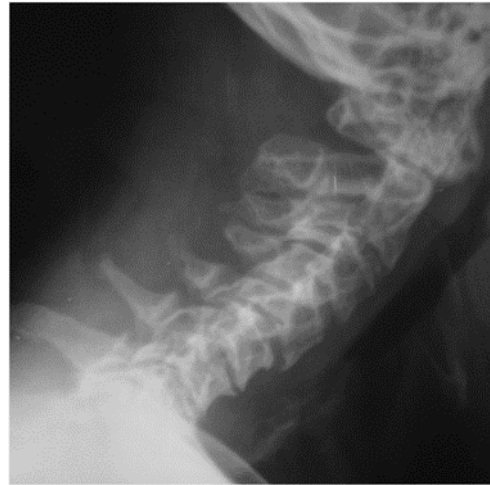
Case 1

- Chin-brow axis -5°



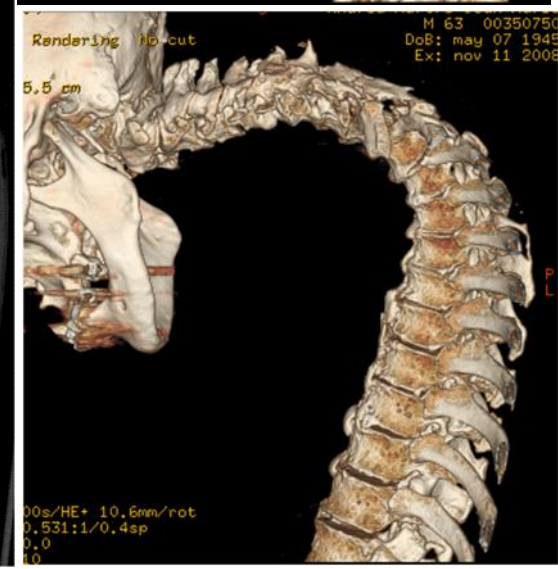
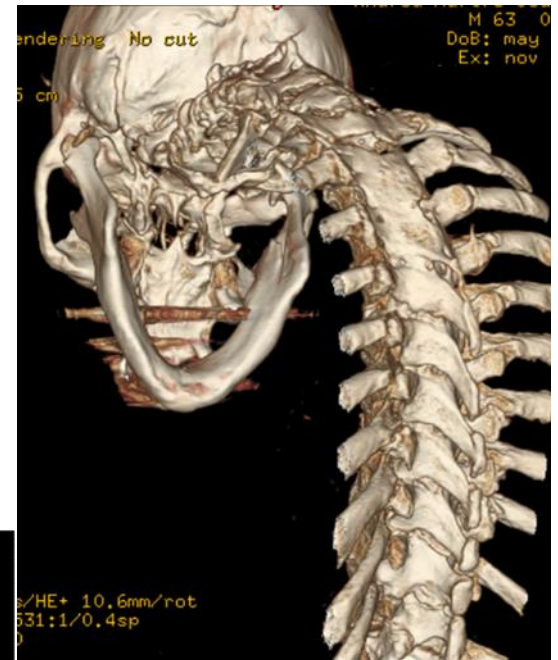
Case 2

- 64 year-old male.
- Car accident . Fractures of T1-T2 and both clavicles
- Posterior Fusion C4-T4.
- Failure of cervical fixation.
- Postraumatic kyphoses.



Case 2

- Progressive postraumatic kyphosis 95°



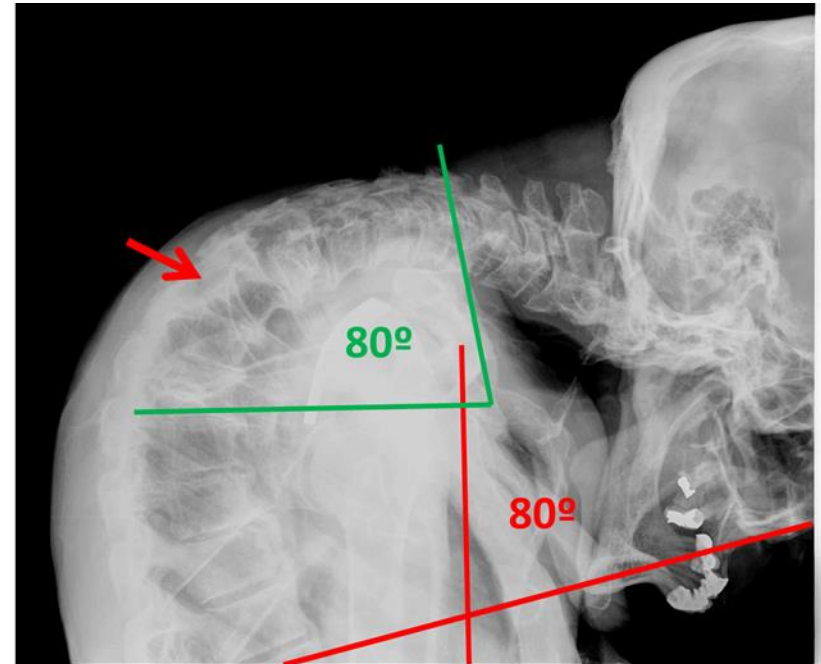
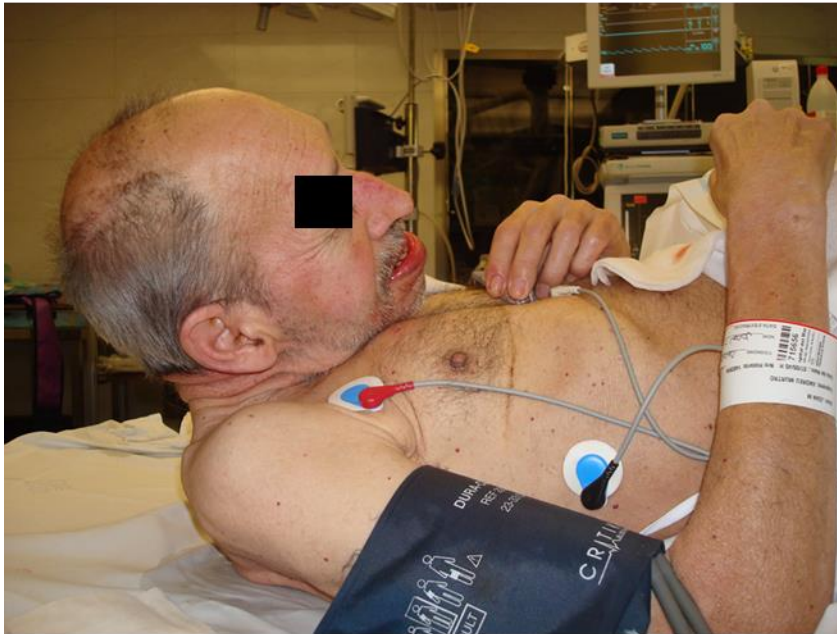
Case 2

- Chin–brow axis of 80 degrees.



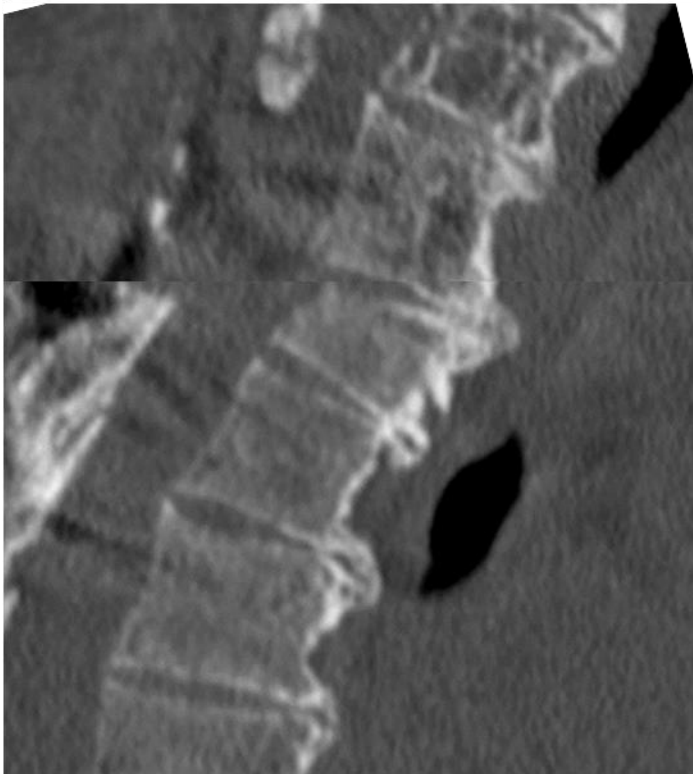
Case 2

- C7 pedicle subtraction osteotomy



Case 2

- Radiological outcome:
Kyphoses 32°



Case 2

- Clinical outcome: Chin-brow axis 10 degrees.



Results

SPINE Volume 33, Number 16, pp E559–E564
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■ Surgical Management of Symptomatic Cervical or Cervicothoracic Kyphosis Due to Ankylosing Spondylitis

Arnold B. Etame, MD, Khoi D. Than, MD, Anthony C. Wang, MD, Frank La Marca, MD,
and Paul Park, MD

Literature review on severe chin-on-chest deformities due to ankylosing spondylitis

- Six retrospective clinical studies
- Indication for surgery was primarily loss of horizontal gaze.
- The most common surgical technique was based on the original Simmons osteotomy at C7–T1.
- The complication rate was high, 26.9% to 87.5%,
- Mortality rate of 2.6%
- Permanent neurologic complication rate was 4.3%.
- All patients had improvement in horizontal gaze and chin-brow to vertical angles
- Patient satisfaction after surgery appeared high.

Results

Eur Spine J (2007) 16:1471–1478
DOI 10.1007/s00586-006-0290-x

ORIGINAL ARTICLE

C7 decancellation closing wedge osteotomy for the correction of fixed cervico-thoracic kyphosis

Devi Prakash Tokala · Khai S. Lam ·
Brian J. C. Freeman · John K. Webb

J Neurosurg Spine 13:695–706, 2010

Cervicothoracic junction kyphosis: surgical reconstruction with pedicle subtraction osteotomy and Smith-Petersen osteotomy

Presented at the 2009 Joint Spine Section Meeting

Clinical article

SRINATH SAMUDRALA, M.D., SHOSHANNA VAYNMAN, PH.D., TY THIAYANANTHAN, M.D.,
SAMER GHOSTINE, M.D., DARREN L. BERGEY, M.D., NEEL ANAND, M.D.,
ROBERT S. PASHMAN, M.D., AND J. PATRICK JOHNSON, M.D.

Departments of Neurosurgery and Surgery-Orthopedics, Cedars-Sinai Institute for Spinal Disorders,
Los Angeles, California

J Neurosurg Spine 15:174–181, 2011

Technique of cervicothoracic junction pedicle subtraction osteotomy for cervical sagittal imbalance: report of 11 cases

Clinical article

VEDAT DEVIREN, M.D.,¹ JUSTIN K. SCHEER, B.S.,² AND CHRISTOPHER P. AMES, M.D.²

Departments of ¹Orthopaedic Surgery and ²Neurological Surgery, University of California, San Francisco, California

- PSO has produced gratifying results in this series of cervical osteotomy for fixed cervico-thoracic kyphosis patients.
- Pedicle subtraction osteotomy can provide excellent sagittal correction while simultaneously forming a stable construct and minimizing neural compression.

N	year	Restoration forward gaze	Mean lordosis correctio n	Sagittal balance	Inmervi ng CVA	complications
8	2007	8	57°	-----	35°	2 infection
8	2010	8	35,6°	2,74 cm	32°	2 radicular
11	2011	11	49°	4,5 cm	36,7°	1 Disphag 1 Rod fx

- Conclusions. The cervicothoracic junction PSO is a safe and effective procedure for the management of cervicothoracic kyphotic deformity. It results in excellent correction of cervical kyphosis and CBVA with a controlled closure and improvement in health-related quality-of-life measures even at early time points.

Results

Eur Spine J (2015) 24 (Suppl 1):S16–S22
 DOI 10.1007/s00586-014-3656-5

ORIGINAL ARTICLE

Cervical osteotomies for neurological deformities

Han Jo Kim · Venu M. Nemani · K. Daniel Riew

- 35 patients, 31 anterior vs. 4 PSO.
- Greater angular correction.
- Greater translational correction.
- Similar clinical outcomes.

Table 2 Radiographic and clinical outcomes from baseline to latest follow-up

Parameters/ groups	Anterior osteotomy group 1 (n = 31)	Pedicle subtraction osteotomy group 2 (n = 4)	p value
Radiographic parameters			
Pre-operative cervical lordosis (°)	24.8	4.3	0.73
Pre-operative basion PL (cm)	−1.5	4.6	<0.01
Post-operative cervical lordosis (°)	−5.0	−16.2	0.03
Post-operative basion PL (cm)	−1.6	2.4	0.02
Total angular correction (range)	27.7 (9.0–66.0)	48.8 (38.4–68.3)	0.03
Total translational correction (range)	1.8 (0.1–2.4)	2.8 (0.1–5.6)	0.56
Clinical outcome—Neck Disability Index (NDI)			
Pre-operative NDI	26.0	25.2	0.99
Post-operative NDI	21.5	20.5	0.99

Results

Comparison of Smith-Petersen Osteotomy *Versus* Pedicle Subtraction Osteotomy *Versus* Anterior-Posterior Osteotomy Types for the Correction of Cervical Spine Deformities

Han Jo Kim, MD,* Chaiwat Piyaskulkaew, MD,† and K. Daniel Riew, MD‡

TABLE 3. Radiographical Comparisons With Amount of Angular and Translational Corrections Between Osteotomy Types

Groups/Radiographical Parameters	Total Mean Angular Correction (°)	Angular Correction per Level (°)	Total Mean Translational Correction (cm)	Translational Correction per Level (cm)
SPO (n = 13)	19.4	10.1 (range, 1.0°–24.9°)	3.5	1.8 (range, 0.5–4.0 cm)
PSO (n = 10)	44.8	34.5 (range, 28.2°–80.0°)	2.8	2.5 (range, 0.2–5.6 cm)
ATO (n = 16)	22.4	17.1 (range, 3.5°–32.1°)	1.3	1.0 (range, 0.1–3.0 cm)
ATO + SPO (n = 22)	32.5	27.8 (range, 3.7°–66.7°)	3.6	3.1 (range, 0.2–7.0 cm)

SPO indicates Smith-Peterson Osteotomy; PSO, pedicle subtraction osteotomy; ATO, anterior osteotomy.

Conclusion. Posteriorly based osteotomies provided better translational correction than ATOs. The angular correction achieved by 1 PSO was similar to ATO + SPOs. ATO + SPOs provided equal or better corrections than isolated PSOs, with equal length of stay and less estimated blood loss.

Complications

- Technically challenging procedure and had a 4% of mortality rate.
- **Wound complications:** hematoma formation, necrosis, postoperative infection, wound dehiscence, and poor cosmesis.
- **Neurological complications:**
 - The overall rate of neurological injury is approximately 23%.
 - In most cases, neurological complications are transient, and C8 nerve root palsy seems to be the most commonly encountered problem.
- **Vascular complications:** There is also a risk of injury to the vertebral artery, but this is minimized by performing the procedure at C7 and appropriate intraoperative awareness of the local anatomy
- **Mechanical complications:** Hardware failure or pseudoarthrosis.
- **Dysphagia** has been reported by several authors after cervical extension osteotomy but appears to be a transient phenomenon

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Eur Spine J (2011) 20:523–536
DOI 10.1007/s00586-010-1602-8

REVIEW ARTICLE

Surgical treatment of cervical kyphosis

Ke Han · Chang Lu · Jing Li · Guang-Zhong Xiong ·
Bing Wang · Guo-Hua Lv · You-Wen Deng

Conclusions

- Complex reconstructive procedure.
- Right indication: fixed cervical kyphotic deformity
- Exhaustive preoperative planning
- Meticulous operative technique.
- Multiple complications associated.
- The safety has been enhanced by the use of modern methods of anesthesia, neurological monitoring, and spinal instrumentation.
- Cervicothoracic junction PSO being a safe, reproducible and effective procedure for the management of cervicothoracic kyphotic deformities.



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