Pedicle Screw Fixation for Cervical Spinal Disorders

Morio Matsumoto  
*Associate Professor*  
*Director of Spine Section*  
*Dept. Of Orthopaedic Surgery, Keio University, Japan*

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Cervical Pedicle Screws

First used for C2 Fx  
Le conte P  
Borne GM  
1964  
1984

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Disclosure

Morio Matsumoto received honorarium for lecture from Medtronic Sofamor Danek Japan.

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Transpedicular Screw Fixation for Traumatic Lesions of the Middle and Lower Cervical Spine. Description of the Techniques and Preliminary Report

Kumiyoshi Awata, Hajime Ishi, Hiroshi Tanaka, and Kiyoshi Kusunoki

Report of 13 cases with middle and lower cervical spinal trauma treated with PS

Borne GM

Transpedicular Screw Fixation of Articular Mass Fracture—Separation: Results of an Anatomical Study and Operative Technique

B. Jeanrot, J.S. Gobert, and F. Magne

Anatomical study and report of 3 patients with articular mass fracture

J Spinal Disord 1994
Cervical Pedicle Screws

- C2 and 7
  Widely used because of anatomical feasibility if VA anomaly is absent
- C3-6
  Rarely used because of anatomical limitation due to the existence of VA

Advantages of PS Constructs

- Good stabilization and bone union
- Excellent correction of deformities and its maintenance
- Short fusion
- Eliminating need of anterior procedures, postop. external fixation

Biomechanical Superiority

- PS > LMS in pull-out strength
  *Ladd JE et al. Spine 1997*
- PS-rod : greater reduction in axial load transfer in anterior column than LMS-rod
  *Dunlap BJ et al. ESJ 2010*
- PS>LMS Pull-out strengths and bone-screw interface after cyclic loading
  *Johnston TL et al. Spine J 2006*

Indication

- Unstable spine caused by trauma, tumors, RA, DSA after hemodialysis, CP
- Lack in intact laminae or lateral masses by previous surgery, trauma, tumors, severe bone fragility, etc.
- Fixed cervical deformities (kyphosis, O-C subluxation, etc.)
Contra-indication of PS placement

- An absent or extremely small pedicle (outer diameter < 4mm)
- A pedicle destroyed by tumors etc.
- Anomalies of the vertebral artery
- Infection in the posterior elements

Pedicle Morphology - Axial Plane

Pedicle Morphology - Sagittal Plane

Internal Morphology of Human Cervical Pedicles

- Medial cortical shell (1.2–2.0 mm);
- 1.4 to 3.6 times as thick as lateral cortical shell (0.4–1.1 mm)
- PS more likely to penetrate lateral cortex
Preoperative Imaging

*Individual variations++*

- Morphology of Pedicles
- Anatomy of Vertebral Artery

- Fine cut CT
- CT / MR angiography

Dominancy of VA
Lt side dominant 70%
*(Tomashino, JNS 2010)*

Tortuous pathway of VA in severe OA and RA

VA and Transeverse foramen
*(Tomashino A, et al JNS 2010)*

- The VA entry was found at C7 in 2.4 and 5.5% of the patients' right and left sides.

- Transverse foramen occupied by VA was the greatest in C-4 and C-7 (37.1 and 74.2%, respectively).

- C-4 and C-7 can be considered critical levels for CPS placement.

Wide Exposure to the outer border of LM for PS placement

- Important for identification of anatomical landmarks
- for prevention of pushback from PVM
Starting Points proposed by Abumi (J Spinal Disord, 1994)

Drilling of the posterior cortex of LM allows for more flexible screw trajectory

Starting Points

Lee DH
Eur Spine J 2011

C3: 2mm
C4: 2mm
C5: 2mm
C6: 2mm
C7: 2mm lateral
2mm superior of midpoint of LM

Karaikovic EE.
J Spinal Disord 2000

C2: $2.3 \pm 1.4$
C3: $0.8 \pm 1.0$
C4: $0.8 \pm 0.9$
C5: $1.9 \pm 1.3$
C6: $3.3 \pm 1.5$
C7: $4.2 \pm 1.3$

PS Placement under fluoroscopic guidance (lateral view)

Pedicle probe
tapping

Pedicle sounder
screw insertion

Courtesy of Prof. Abumi
Steep Learning Curve

Yoshimoto H et al. ESJ 2009

% of misplacement
Early phase 12.0%
Middle phase 7.0%
Late phase 1.1%

(90-100 PS/ phase)

Methods to Enhance Accuracy of PS Placement

- Laminoforaminotomy Miller RM Spine 1996
- Pedicle axis view technique Yukawa Y, JNS 2006
- Navigation systems Kotani Y, JNS 2003
  Rath SA. JNS 2008
  Ito Y, et al. JNS 2008
  Ishikawa Y JNS 2011
- O-arm based navigation Ishikawa Y (JNS 2011)
- Key slot technique Lee SH (Jspinal Disord 2012)

Pedicle axis view technique

Yukawa, JNS Spine 2006

Navigated PS Placement

Enhance accuracy but
not eliminate misplacement (major perforation 1.2-2.8%) Kotani Y, JNS 2003
Rath SA. JNS 2008
Ito Y, et al. JNS 2008
Ishikawa Y JNS 2011

Courtesy of Dr. Yukawa.
Percutaneous Transmuscular Insertion for patients with thick nuchal muscles

Useful to prevent lateral perforation caused by pressures from nuchal muscles

Indication

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- Lack in intact laminae or lateral masses by previous surgery, trauma, tumors, severe bone fragility, etc.
- Correction of fixed cervical deformities (kyphosis, O-C subluxation, etc.)

Fracture dislocation at C5-6
50 y/o Male after fall
Frankel C paralysis

Slight distraction to prevent spinal cord compression due to traumatic disc herniation (Abumi, J Neurosurg 2000)

80y/o male with ASH and OPLL
Quadripareisis after fall
C7 Extension Fracture

Hybrid Construct
Dominant Side: Lateral Mass
Non-dominant Side: Pedicle

72 Female RA
Severe Neck pain
Progressive myelopathy
52y/o male with severe neck & arm pain
Metastasis of Follicular Thyroid Carcinoma

Immediately after surgery
Relief of neck pain
Palliative Spinal Reconstruction Using Cervical Pedicle Screws for Metastatic Lesions of the Spine
A Retrospective Analysis of 32 Cases
Itaru Ueda, MD,* Kaniiyoshi Aizumi, MD,* Manabu Ito, MD,* Yoshitsugu Kotani, MD,* Takashi Oya, MD,* Kyoichi Hasegawa, MD,* and Akio Minami, MD*

- 32 patients with metastatic cervical spinal tumors undergoing reconstructive surgery using PS.
- 4 upper cervical lesions, 28 subaxial lesions.
- Posterior alone in 25
- Combined AP in 7
- Neck pain improved in all cases.
- 83% presented neurologic improvement
- Anterior column reconstruction could be avoided in 78%

Chordoma 65 y/o M
Recurrence after partial resection twice & Ion-beam radiation
Intractable neck pain and quadriparesis

Preoperative Embolization of Lt VA
24y/o female with GCT at C2
Neck pain and quadriparesis

X ray and CT-scan after surgery
11/8/2013

1st stage Operation (posterior)
Curretage and Fusion with PS

2nd stage Operation (Anterior)
Mandible splitting approach

Dislodgement and retrieval of Iliac crest graft (1 month p.o.) followed by additional posterior bone graft

No recurrence at 5 years after surgery
Neurofibromatosis 1 with dystrophic changes
Neck Pain & Mild myelopathy (23y/o Female)

O-T4 fusion followed by ASF C2-C5 with fibula strut
Cervical myelopathy due to Athetoid CP (58 y/o Male)

Posterior decompression & PS fusion
No recurrence of myelopathy 7 years po

Laminoplasty and Pedicle Screw Fixation for Cervical Myelopathy Associated With Athetoid Cerebral Palsy

- 17 patients who underwent midline laminoplasty and posterior spinal fusion using PS.
- Kyphosis 11.0° improved to 1.5° p.o.
- Solid bony fusion achieved in all cases
- 13% PS misplacement with no sequel
- Laminoplasty and PS provided strong internal fixation and improved neurological function

Cervical Myelopathy Due to Congenital Anomalies at the upper cervical spine (17 y/o Male)
Neurologically improved w/o neck pain 4 years after O-C2 fusion

70 y/o Female with Pseudotumors
- Myelopathy worsened after C1 laminectomy
- O-C fusion was conducted with improvement of myelopathy
- Regression of pseudotumor and reduction of clivoaxial angle was observed

Indirect Decompression using PS System
- Reduction in clivoaxial angle and cervicomedullary angle
- Reduction of vertical subluxation

Complications
- Screw misplacement (w/wo sequel) 2-30%
- Vertebral artery injury 0.15-0.9% controlled by bone wax etc.
- Nerve root injury 0.3-1.5%
  - screw misplacement
  - screw removal if necessary
  - iatrogenic foraminal stenosis (C5)
  - addition of foraminal decompression
- Implant failure rare<5%

Abumi K et al, Spine 1999
Ding X et al, Eur Spine J 2011
Abumi K et al Spine 2012
Yoshihara H et al JNS 2013
Screw Misplacement

• Transient radiculopathy

• Sporadic reports of VA injury resulting in cerebral infarction (Onishi E, Spine 2010)

Perforation Rates of Cervical Pedicle Screw Insertion by Disease and Vertebral Level


Major perforation rate in 53 patients treated using PS under navigation

Per Disease

- CSM (15.0%)
- CP (10.0%)
- DSA (4.6%)
- RA (3.4%)
- Spine tumor (0.0%)

Per Level

C2(6.7%), C3(8.2%), C4(14.0%), C5(3.1%), C6(2.4%), C7(2.2%)

Opinions against PS Use for Relatively Common Diseases

Kast et al, ESJ 2006

Reserve this technique for use in highly selected patients with clear indications and for highly experienced spine surgeons

Hasegawa K et al, Spine 2008

No indication in cases of typical CSM and OPLL if a potential risk of vertebral artery or nerve injury is taken into account.

Balance between Needs and Potential Risks

Needs

Severe fixed deformity
Destructive disease
Tumor
Trauma

Risks

Complications
VA injury
Nerve root injury

Skills
Summary

- PS is useful for treatment of trauma, severely destructive diseases, tumors, and deformities.
- Preoperative precise evaluation of bony and neurovascular anatomy is mandatory.
- PS is associated with potentially catastrophic complications
- PS use for degenerative diseases is debatable.