Fusion Techniques in Degenerative Disc Disease

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Disclosure information

I have no financial relationships with commercial entities that produce health-care related products.

Cervical Disc Disease. Introduction.

- ✓ Degenerative process.
- ✓ Natural part of aging process.
- ✓ Spectrum of clinical sd. associated with:
  - ✓ Neck pain.
  - ✓ Neurologic dysfunction.
- ✓ Incidence unknown.
- ✓ Radiographic degeneration:
  - ✓ 90% in patients older than 65 years[1].
  - ✓ 76% in patients older than 56 years[2].
- ✓ Symptomatic degeneration:
  - ✓ 9.5% of men and 12.5% of women complained with chronic pain[3].
  - ✓ 24% overall frequency of neck pain[4].

1. Laurence JC. Disc degeneration. Its frequency in relationship to symptoms. *Ann Rheum Dis* 1969;28:121-37.
2. Hortwitz T. Degenerative lesions in the cervical portion of the spine. *Ann Intern Med* 1940: 55;1178.
3. Makela M et al. Prevalence, determinants and consequences of chronic neck pain in Finland. J *Epidemiol* 1991;134:1356-67.
4. Bovim et al. Neck pain in general population. *Spine* 1994; 19: 1307-9.

Cervical Disc Disease

Cervical degenerative disorders:

1. Spondylotic degeneration with axial pain (neck pain).
2. Disc displacement with radiculopathy (soft disk).
3. Spondylotic radiculopathy (hard disk).
4. Spondylotic myelopathy.

Cervical Disc Disease

1. Spondylotic degeneration with neck pain.

Desiccation of nucleus pulpous

↓

Loss of mechanical conditions

↓

Increased strain on the annulus

↓

Tears and protrusion

↓

Excess of motion in zygapophyseal joints

↓

Increased strain in the supporting ligaments

Cervical Disc Disease

1. Spondylotic degeneration with neck pain.

- C5-C6 most commonly involved.
- Primary Pain generator: Intervertebral disc.
- Facet joints can become painful.
- Axial neck pain.
- Loss of motion.
- Interscapular and upper brachial sclerotomal pain radiation.
- Pain is mechanical in nature, worst in flexion and extension.

Cervical Disc Disease

2. Cervical disc displacement / prolapse.

Disc material prolapsed through tears in annulus

↓

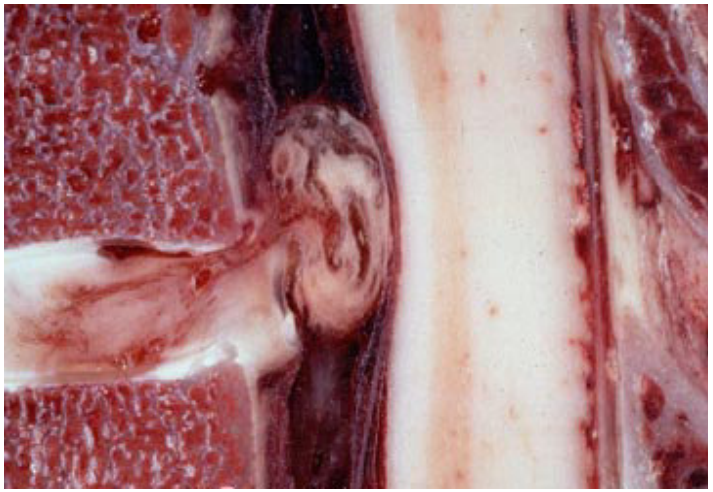
Root impingement / cord impingement.

↓

Nerve dysfunction
(directly and through vascular compromise)

↓

Sensory or motor dysfunction



Cervical Disc Disease

2. Cervical disc displacement / prolapse.

- Younger patients.
- Exiting root most commonly involved (C6).
- C5 and C7 are also common.
- Radiating lacerating pain located on the dermatotoma.
- Pain may be intensified with maneuvers (Valsalva, rotation and flexion, axial compression).

Cervical Disc Disease

3. Spondylotic radiculopathy (hard disc).

Mechanical incompetence of the motion segment

↓

Degeneration of the facets

↓

Disc colapse

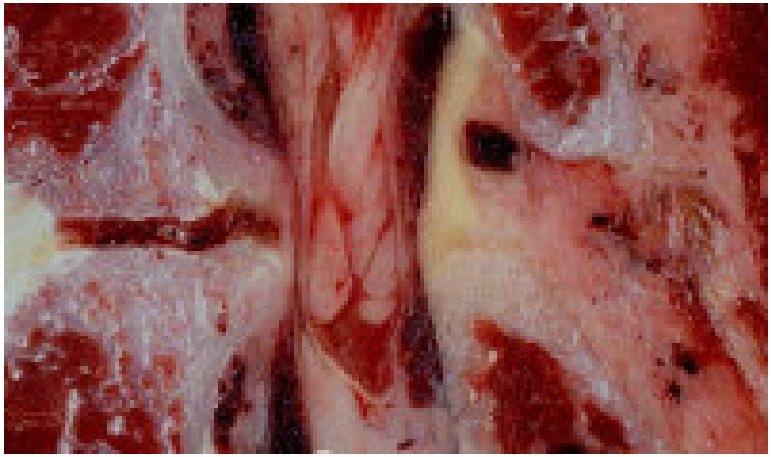
↓

osteophytes on the annulus

osteophytes on the facet joints

↓

Compression the nerve root



Cervical Disc Disease

3. Spondylotic radiculopathy.

- Older patients.
- Symptoms develop more gradually.
- More likely to complain multilevel or bilateral radicular symptoms
- Radiating lacerating pain located on the dermatotoma.
- Pain may be intensified with maneuvers (Valsalva, rotation and flexion, axial compression).

Cervical Disc Disease

4. Spondylotic myelopathy.

Osteophytes compress de central spinal canal

↓

Vascular insufficiency

↓

Spinal cord dysfunction

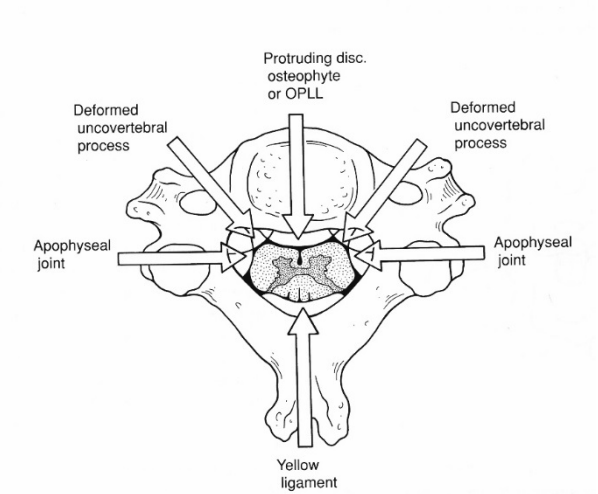
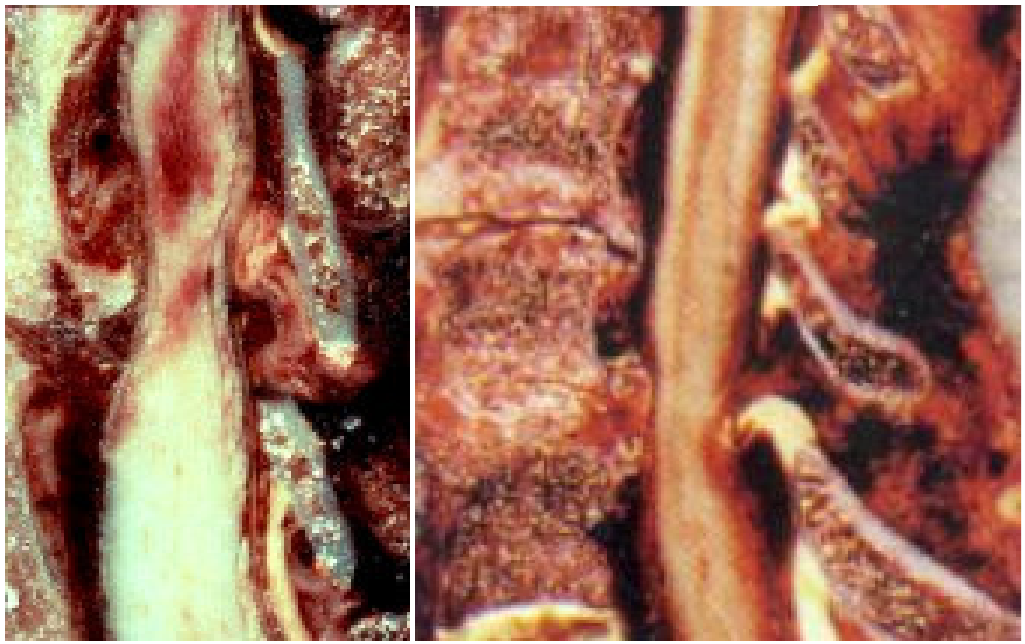
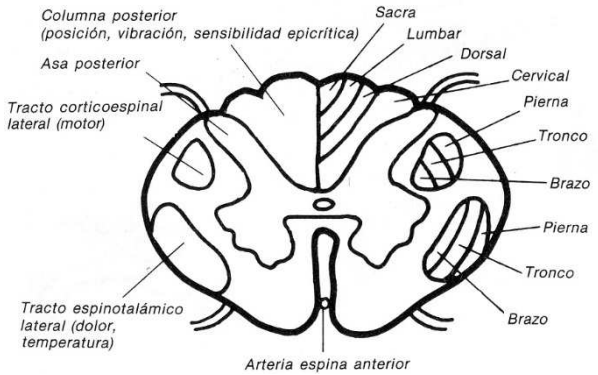


FIG. 52-5. Narrowing of the spinal canal. (Modified from Bernhardt et al., ref 1



Cervical Disc Disease

4. Spondylotic myelopathy.



- Older patients.
- Most common cause of spinal cord dysfunction in patients older than 55 years.
- Most common at C5-C6 level.
- Complete symptomatic reversal after treatment is rare.
- Five categories according neurologic findings:
  1. Transverse lesion sd. (corticospinal and spino-thalamic)
  2. Motor sd. (corticospinal or anterior horn cells).
  3. Central cord sd. (central grey mater of cord).
  4. Brown-Séquard sd. (unilateral cord lesion).
  5. Brachialgia cord sd. (myeloradiculopathy)

Options of surgical treatement.

Options for this 4 types of patients:

- The type of surgical procedure advocated for cervical disc disease is dictated by the location and extent of the pathology.
- There are also situations in which similar pathology can be addressed in several ways, with roughly similar results.

Options of surgical treatement.

Decompression

- Corporectomy,
- Laminoforaminotomy.
- Laminectomy
- Laminoplasty

+/-

Fusion techniques

- Anterior fusion.
- Posterior fusion.
- Combined fusion

Total disc replacement.

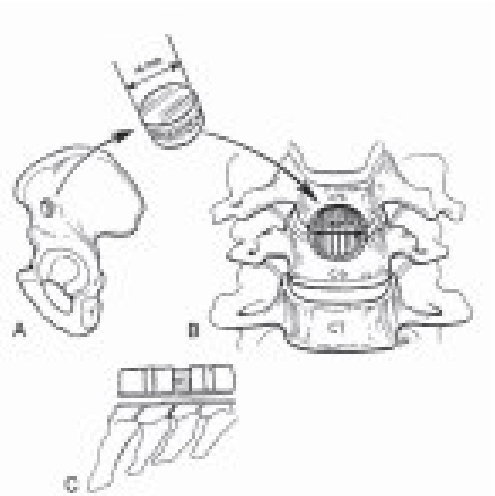
Anterior Fusion

Anterior Fusion

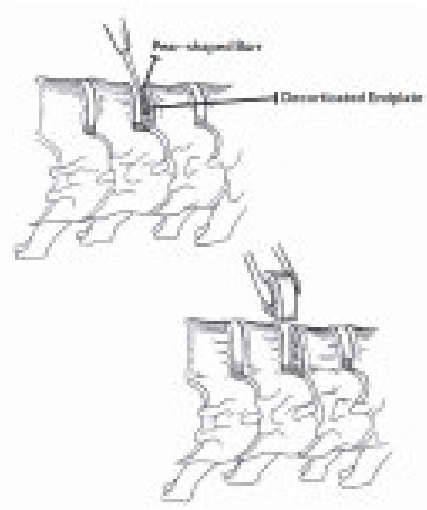
- The gold standard for the surgical treatment of cervical radiculopathy. Indications.
  - Radiculopathy responds well to the surgical treatment (success rates of surgical treatment greater than 90%).
  - Myelopathy is generally a clear indication for surgical intervention, specially if the patient develop signs or symptoms of neurological damage. 90% good to excellent results
  - Axial neck pain from degenerative disk disease is a rare indication (success rates of surgical fusion only 60%).
- Most patients will have immediate relief of arm symptoms
- Recovery time: 4-6 weeks for office work, 8-12 weeks for heavy physical work
- Continued neck pain may be troublesome

Anterior Fusion. Historical aspects.

- 1952: Anterior cervical approach: Leroy Abbot, Bailey & Badgley[1]
- 1958-61: Anterior discectomy & interbody fusion: Smith & Robinson[2] (horseshoe graft), Cloward[3](dowel graft).
- 1970: Anterior cervical Plate. Orozco y Llobet[4]
- 1989: Improve of surgical supplies & trapezoidal plate. Caspar[5]
- 1986-90: Unicortical anchoring plates. Morscher[6]
- 2000: Anterior dynamic plates (load-sharing)[7]
- 2000-2014: New plates design and materials. Development of cages[8]



Cloward Technique[3]



Smith Robinson Technique[2]

1. Bailey R, Badgley C. Stabilization of the cervical spine by anterior fusion. J Bone Joint Surg Am 1960; 42: 565-94.
2. Smith G, Robinson R The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. J Bone Joint Surg Am 1958; 40:607-24.
3. Cloward R Treatment of acute fractures and fracture-dislocations of the cervical spine by vertebral body fusion. J Neurosurg 1961;18:201-9
4. Orozco R, Llobet J Osteosintesis en las fracturas del raquis cervical. Rev Ortop Traumatol 1970;14:285-8
5. Caspar W, Barbier D, Klara P. Anterior cervical fusion andC aspar plate stabilization for cervical trauma. Neurosurgery 1989;25:491-502.
6. Morscher E, Sutter F, Jenny H, Olerud S Anterior plating of the cervical spine with the hollow screw-plate system of titanium. Chirurg 1986;57(11):702-7.
7. Epstein NE. Anterior dynamic plates in complex cervical reconstructive surgeries. J Spinal Disord Tech 2002; 15: 221-8.
8. Garcia CM. Stabilization and replacement devices currently used in arthrodesis and arthroplasties of the cervical spine. Rev Chil Radiol 2008; 14:181-99.

Anterior fusion: Preoperative evaluation.

- Complaint and Physical Exam
  - Neck Pain
  - Arm Pain/Numbness/Tingling
  - (radiculopathy)
  - Myelopathy (cord abnormalities)
    - Balance.
    - Unusual sensations.
    - Slow wide based gait

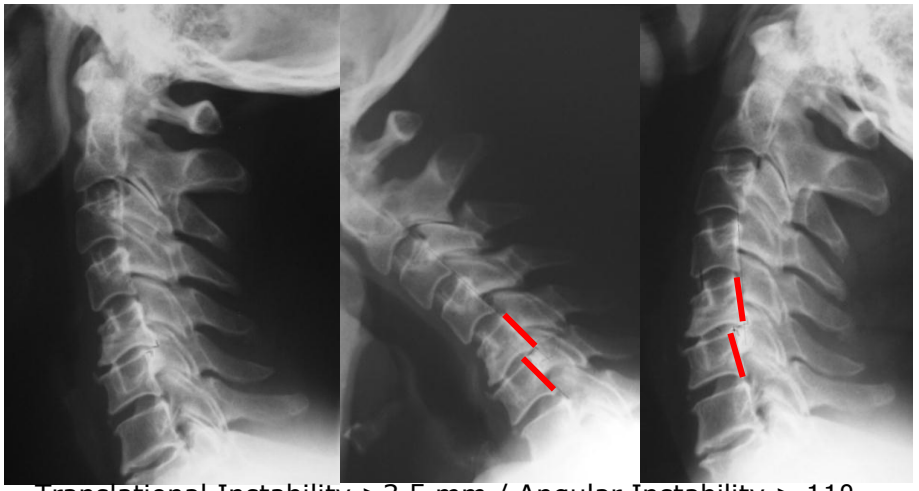
Anterior fusion. Preoperative evaluation

XRAYS

- Bone structure and quality
- Alignment
- Lordosis
- Instability
- Other diagnosis of neck pain (Cancer/Infection/Fracture)

MRI/CT Scan

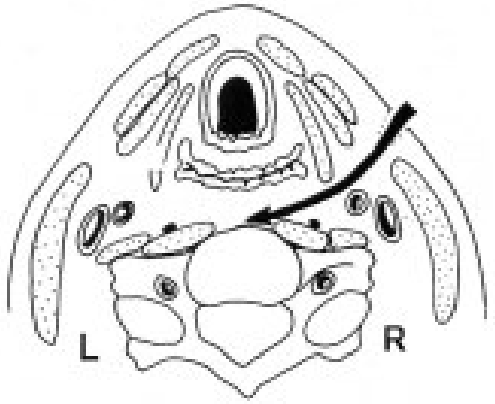
- Condition of discs
- Spinal stenosis/Disc herniation
- Root impingement
- Myelomalacia
- Other diagnosis of neck pain (Cancer/Infection/Fracture).



Translational Instability >3.5 mm / Angular Instability > 11º

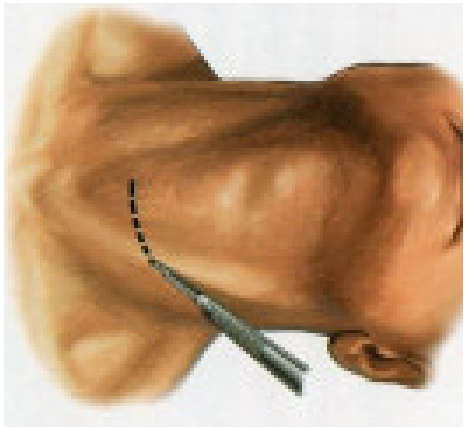
Anterior approach (Smith and Robinson[1]):

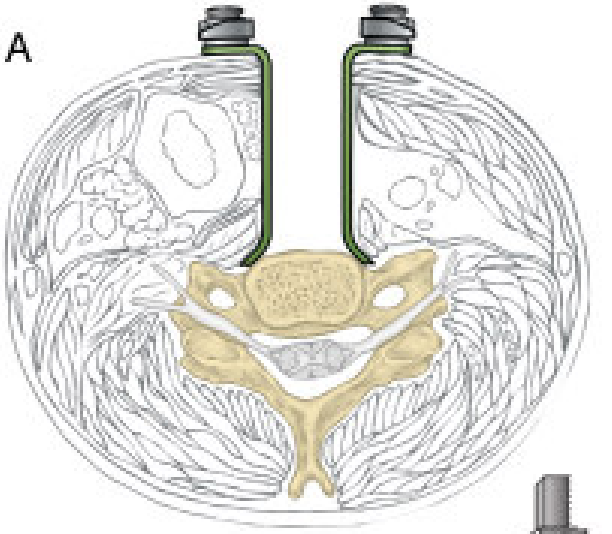
- Patient position :neck in slight extension.
- Arms tucked and placed under light traction.
- Surgical landmarks: carotid tubercle (C6), cricoid cartilage (C5-C6), thyroid cartilage(C4-C5).
- Identify the level by fluoroscopy.
- Transverse skin incision: one or two levels.
- Oblique skin incisions: longer exposure.
- Section of *"platisma colli"* and blunt dissection.
- Right side: better for a right-handed surgeon.
- Left side: theoretically decrease injury rate of laryngeal recurrent nerve[2].
- Safe approach to anterior cervical spine.

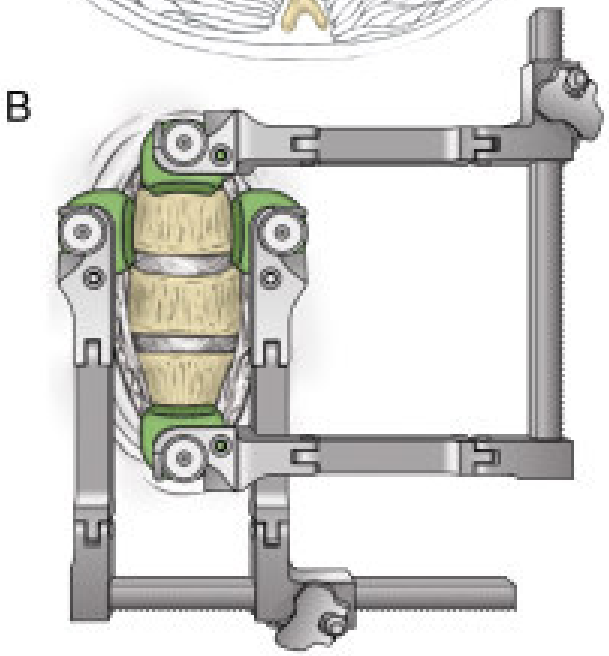


1. Smith G, Robinson R The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. J Bone Joint Surg Am 1958; 40:607-24.
2. Jung A, Schramm J. How to reduce recurrent laryngeal nerve palsy in anterior cervical spine surgery: a prospective observational study. Neurosurgery. 2010; 67(1):10-5.

Cervical Anterior fusion tecnique

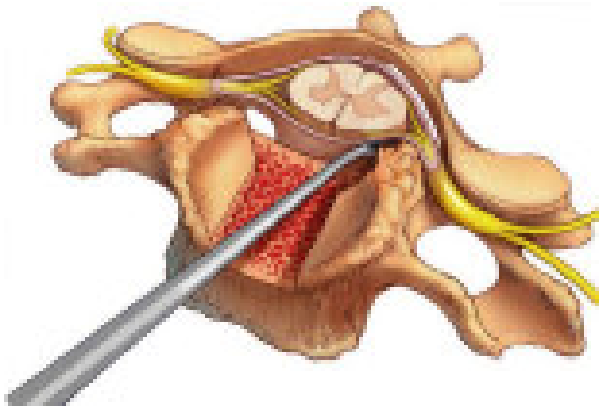


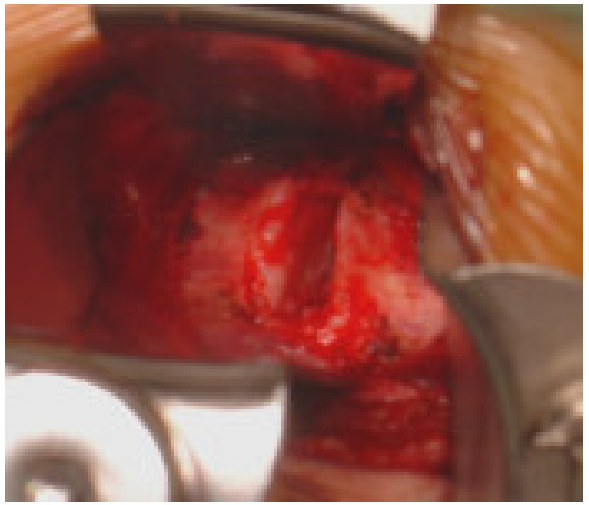




Cervical Anterior fusion tecnique

- Complete removal of disc.
- Curettage of vertebral endplates
- Posterior osteophytes must be taken down:
    - More immediate and complete relief of neural symptoms.
    - Increases the foramina decompression.
    - Better identification of extruded disk fragments.
- The posterior ligament can be removed or not[1].
- It's important to restore the disc height: The graft or cage should be 2 mm oversized[2].

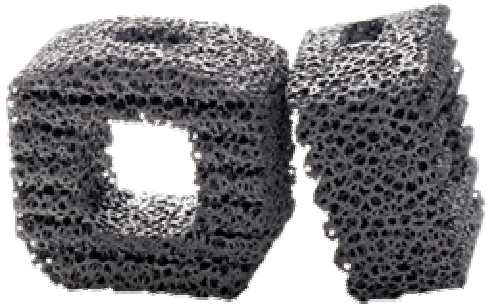




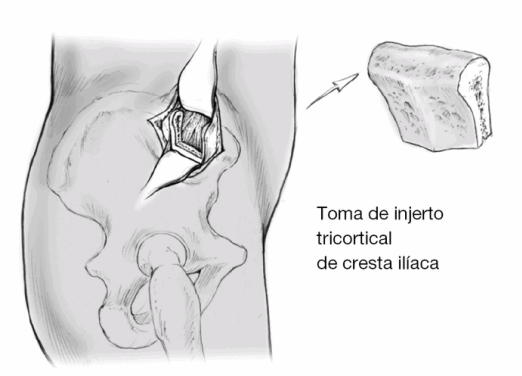
1. Schulte K, Clark CR, Goel VK. Kinematics of the cervical spine following discectomy and stabilization. Spine 1989; 14: 1116-21.
2. An HS, Evanich CJ, Nowicki BH, Haughton VM. Ideal thickness of Smith-Robinson graft for anterior cervical fusion. A cadaver study with computed tomographic correlation. Spine 1993; 18:2043-7.

Cervical Anterior fusion tecnique

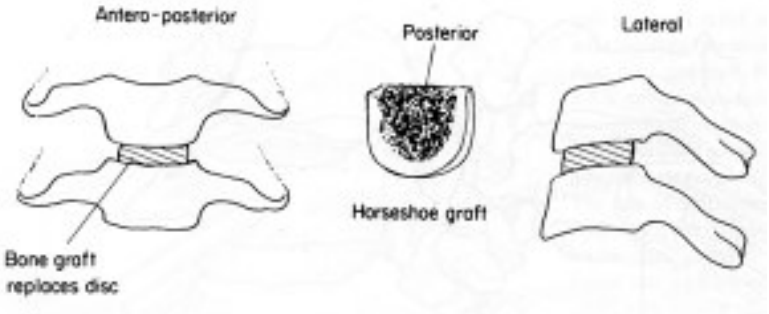
- Interbody spacer / fusion device
  - Autograft (Iliac crest, peroneus)
  - Allograft
  - Cage filled with cancellous bone
    - Titanium.
    - PEEK
    - Tantalium
    - Bone
- Anterior plate fixation.
  - Non-locked
  - Locked
  - Dynamic
- Cervical collar Post-op (soft or hard)

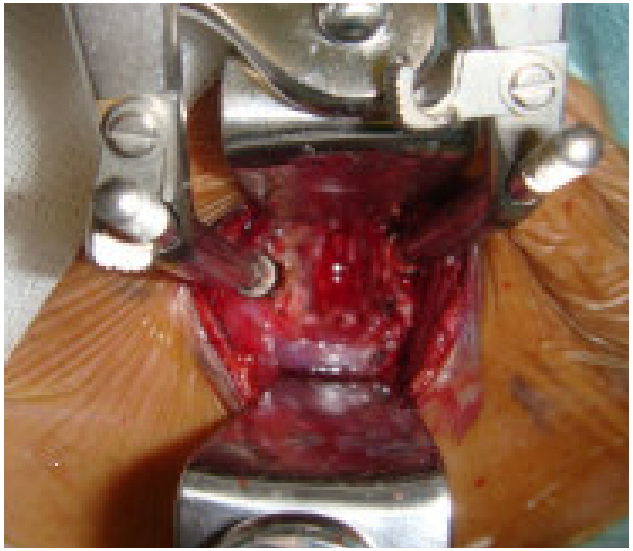


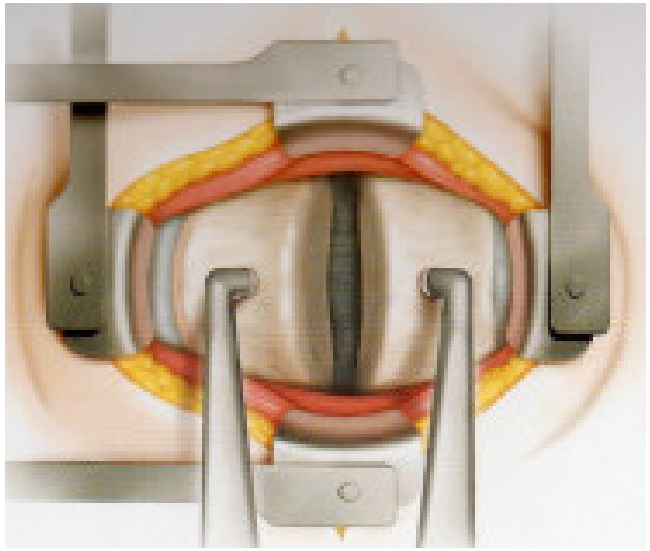
Cervical Anterior fusion tecnique

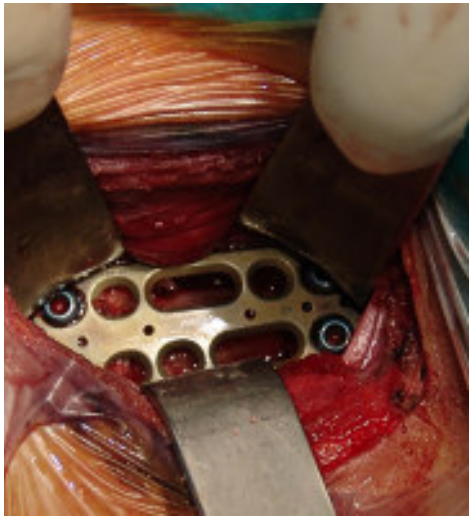


Toma de injerto
tricortical
de cresta ilíaca

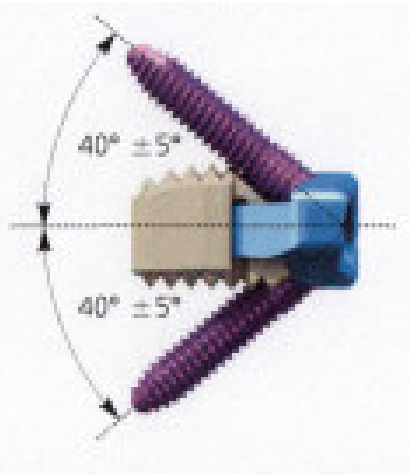








Anterior fusion. New implants.



Scholz M, Reyes PM, Schleicher P, Sawa AG, Baek S, Kandziora F, Marciano FF, Crawford NR. A new stand-alone cervical interbody fusion device: biomechanical comparison with established anterior cervical fixation devices. Spine. 2009; 34(2): 156-60.

Anterior fusion. Role of anterior platting.

- Widely used after 70‘s
- Increases chance of fusion.
- Recommended specially for more than one level of fusion[1]
- The plate protects the graft against an excessive axial load[2].
- In a one-level fusion, the anterior plate is a mechanic device for distribution of loads. This increases the vertebral fusion rate[2].
- Not demonstrated an increased risk of adjacent disc degeneration
- Good clinical and radiological results

1. Daffner SD, Wang JC. Anterior cervical fusion: the role of anterior plating Instr Course Lect. 2009;58:689-98.
2. Rapoff AJ, O’Brien TJ, Ghanayem AJ, Heisey DM, Zdeblick TA. Anterior cervical graft and plate load sharing. J Spinal Disord. 1999;12(1):45-9.

Anterior fusion. Role of anterior platting.

Wright IP, Eisenstein SM. Anterior cervical discectomy and fusion without Instrumentation .Spine. 2007;32(7):772-4.

97 patients. Discectomy plus Anterior fusion only with tricortical graft:

- 11% non-fusion rate in one level
- 28% non-fusion rate in two levels

The authors recommended to add a plate.

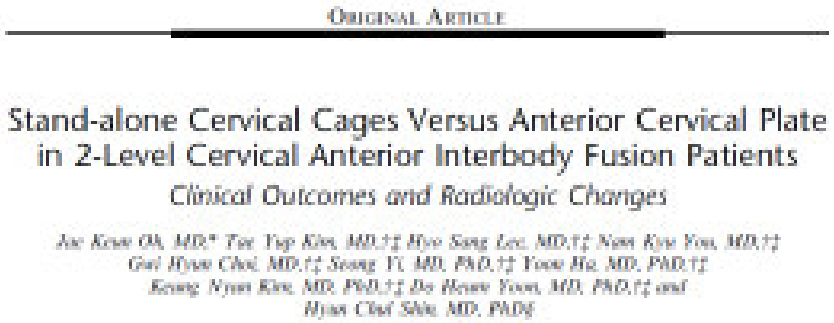
Song KJ, Taghavi CE, Lee KB, Song JH, Eun JP. The efficacy of plate construct augmentation versus cage alone in anterior cervical fusion. Spine. 2009;34(26):2886-92.

78 patients. Discectomy and fusion

- 38 only with a interbody cage (79% of fusion, 32,3% of subsidence, 10,5% of revision surgery)
- 40 with a interbody cage and plate.(97,5% of fusion, 9,7% of subsidence, 0% of revision surgery)

Similar clinical results.

Anterior fusion. Role of anterior platting.



ORIGINAL ARTICLE

Stand-alone Cervical Cages Versus Anterior Cervical Plate in 2-Level Cervical Anterior Interbody Fusion Patients

Clinical Outcomes and Radiologic Changes

Jae Keun Oh, MD, Tae Yup Kim, MD,†‡ Hyo Sang Lee, MD,†‡ Nam Kyu You, MD,†‡ Gui Hyun Choi, MD,†‡ Seung Yi, MD, PhD,†‡ Yoon Ha, MD, PhD,†‡ Keung Nyun Kim, MD, PhD,†‡ Do Heum Yoon, MD, PhD,†‡ and Hyun Chul Shin, MD, PhD‖*

J Spinal Disord Tech Volume 26, Number 8, December 2013

- 28 cage alone / 26 cage + plate
- No differences in fusion (96%) or segmental kyphosis.
- Differences in subsidence: 35.71% vs 11.54% ($P<0.05$).
- Clinical outcomes were similar in the 2 treatment groups.
- Conclusions: The use of cage and plate construct in 2-level ACDF results in a shorter fusion duration and a lower subsidence rate than that of cage alone; however, there is no significant difference in the postoperative global and segmental alignment and clinical outcomes between groups

Anterior fusion. Role of anterior platting.

Dynamic Plates

Rhee JM, Riew KD. Dynamic anterior cervical plates. J Am Acad Orthop Surg. 2007; 15(11):640-6.

- The dynamic plates improved the loads distribution and provides a good resistance against movement.
- It can lead to a segmental kyphosis due the movement between plate and screws.
- It could have a less fusion rate due excessive movement between plate and screws

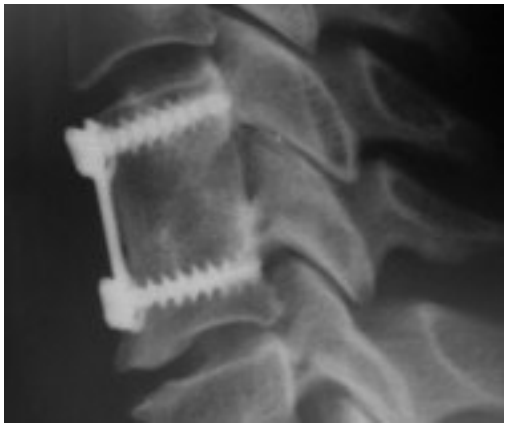
Goldberg, G., Albert, T., et al Short Term Comparison of Cervical Fusion with Static and Dynamic Plating Using Computerized Motion Analysis., SPINE 32:E371-375, 2007

- 2 level ACDF.
- ACDF/Static Plate/autograft: 87.8% per level
- ACDF/Dynamic Plate/allograft: 89.8% per level
- All pseudarthrosis patients were asymptomatic (10-13 months)

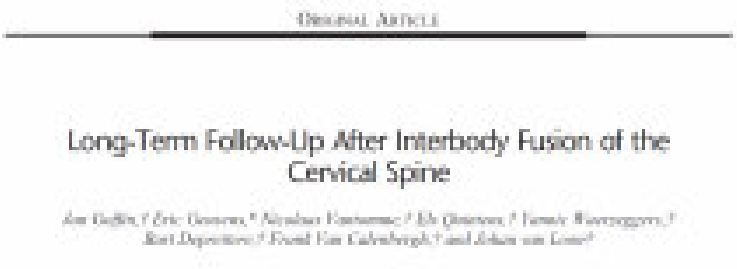
DuBois CM, Bolt PM, Todd AG, Gupta P, Wetzel FT, Phillips FM. Static versus dynamic plating for multilevel anterior cervical discectomy and fusion. Spine J. 2007; 7(2):188-93

- Retrospective. 52 patients.
- No clinical differences (84% good/excellent results).
- Non-union rate 16 % with dynamic / 5 % with static plate
- Conclusion: dynamic plate not offers advantages compared with static plates

Anterior fusion. Results.



- Moderate success in reducing neck pain by >50%
- Excellent success in reducing arm symptoms by >80%.
- Global results good-excellent between 85-95%.
- Fusion rate 95%
- Complications rate less than 5%.
- Gold standard.



ORIGINAL ARTICLE

Long-Term Follow-Up After Interbody Fusion of the Cervical Spine

1. DePalma AF, Rothman R, Lewinnek G, Canale ST. Anterior interbody fusion for severe cervical disc degeneration. Surg Ginecol Obstet. 1972;134:755-61.
2. Radhakrishnan K, Litchy WJ, O'Fallon WM, Kurland LT. Epidemiology of cervical radiculopaty. A population-based study from Rochester, Minnesota, 1976 through 1990. Brain. 1994;117:325-35.
3. Rhee JM, Yoon T, Riew KD. Cervical radiculopathy. J Am Acad Orthop Surg 2007;15:486-94.

Lied B, Roenning PA, Sundseth J, Helseth E. Anterior cervical discectomy with fusion in patients with cervical disc degeneration: a prospective outcome study of 258 patients. BMC Surg 2010; 21:10.

Anterior fusion. Results. Cage vs graft


Spine

COCHRANE COLLABORATION

Systematic Review of Anterior Interbody Fusion Techniques for Single- and Double-Level Cervical Degenerative Disc Disease

Low-quality evidence was found that iliac crest autograft results in better fusion than a cage (RR: 1.87; 95% CI: 1.10–3.17); but more complications (RR: 0.33; 95% CI: 0.12–0.92). When fusion of the motion segment is considered to be the working mechanism for pain relief and functional improvement, iliac crest autograft appears to be the golden standard. When ignoring fusion rates and looking at complication rates, a cage as a golden standard has a weak evidence base over iliac crest autograft, but not over discectomy.


Spine

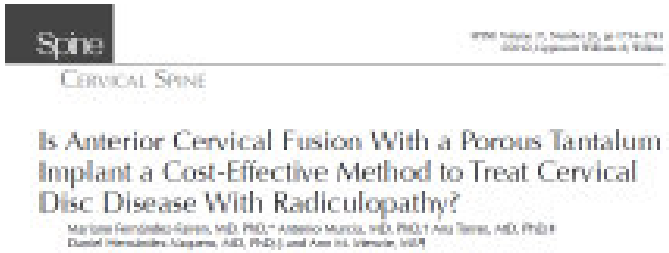
CERVICAL SPINE

Safety and Effectiveness of Bone Allografts in Anterior Cervical Discectomy and Fusion Surgery

Fusion rates were 91% for allograft and autograft and 97% for cage. Adverse events were uncommon in all groups. ACDF with allograft, ACDF with autograft, ACDF with cage, and cervical disc arthroplasty show similar improvements in pain, function, and quality of life with correspondingly low adverse event rates. All ACDF procedures result in high fusion rates.

Anterior fusion. Tantalum cage.

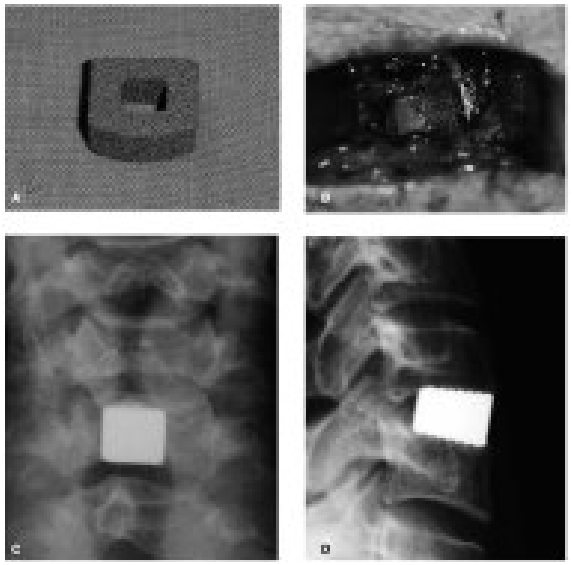
Fernandez-Fairen M, Sala P, Dufoo M Jr, Ballester J, Murcia A, Merzthal L. Anterior cervical fusion with tantalum implant: a prospective randomized controlled study. Spine. 2008;33:465-72.

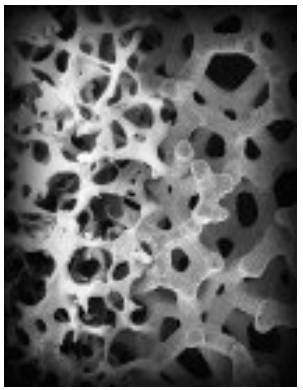

Spine

CERVICAL SPINE

Is Anterior Cervical Fusion With a Porous Tantalum Implant a Cost-Effective Method to Treat Cervical Disc Disease With Radiculopathy?

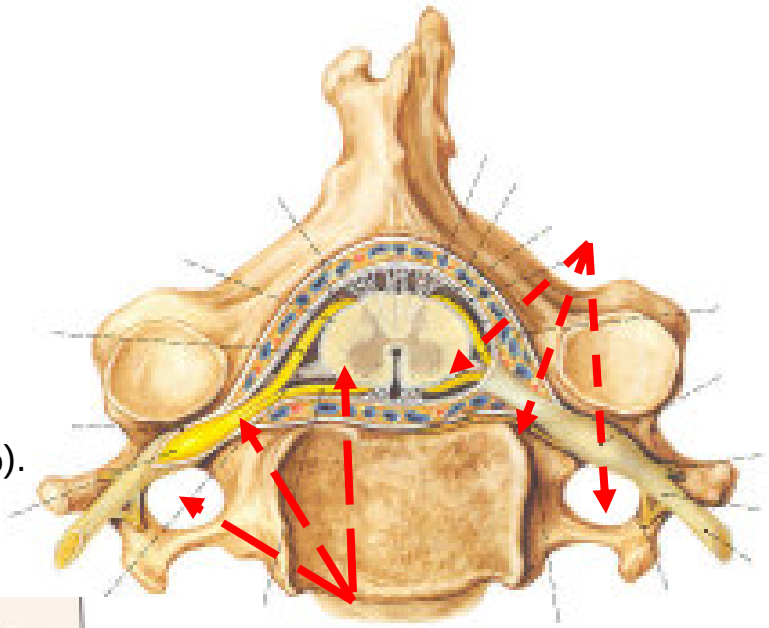
- Prospective. Randomized. 28 tantalum cage vs 33 iliac crest + plate in one level.
- At 24 months, equal results for both groups.
- The data reported suggest that using porous tantalum as a stand-alone device is less costly and more effective than autograft and plate in ACDF procedures.

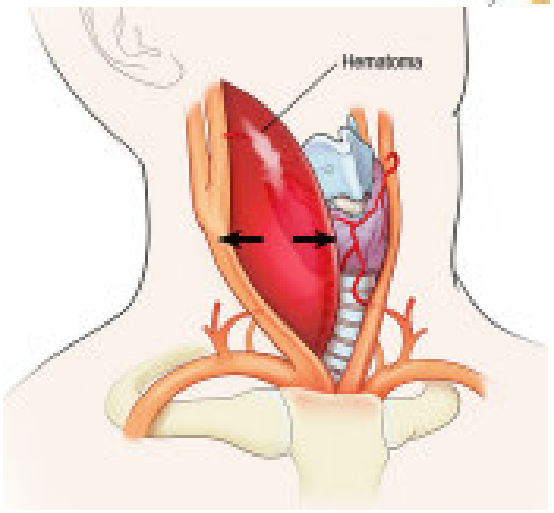


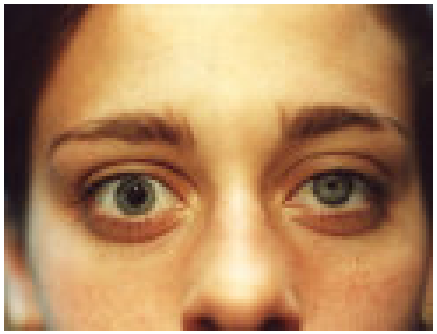


Anterior fusion: Early Complications.

1. Complications related to approach
   - Vascular injury
   - Root injury
   - Cord injury / Dural penetration (0.5%)
   - Recurrent laryngeal nerve palsy (bimodal voice). 3.1%
   - Stellated ganglion injury (Horner's syndrome) 0.1%,
   - Visceral injury (esophageal perforation 0.3%),
   - Cervical Haematoma 5.6%, (surgical intervention only 2.4%).
   - Airway occlusion







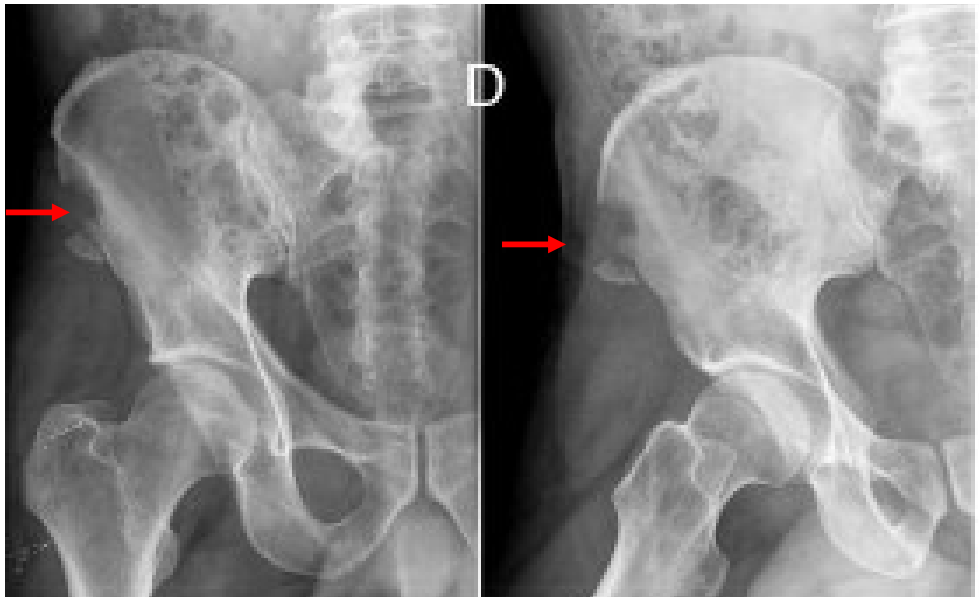
Lied B, Sundseth J, Helseth E. Immediate (0-6 h), early (6-72 h) and late (>72 h) complications after anterior cervical discectomy with fusion for cervical disc degeneration; discharge six hours after operation is feasible.. Acta Neurichir (Wien). 2008; 150(2):111-8.

Anterior fusion: Early Complications.

2. Donor site complications
   - Pain.
   - Infection
   - Bleeding.
   - Iatrogenic fracture.
3. Other complications
   - Wound infection 0.1%
   - Skin problems (rare)
   - Postoperative dysphagia 9.5%

Mortality rate 0.1%

Overall morbidity rate was 19.3%



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Anterior Cervical Discectomy and Fusion Associated Complications

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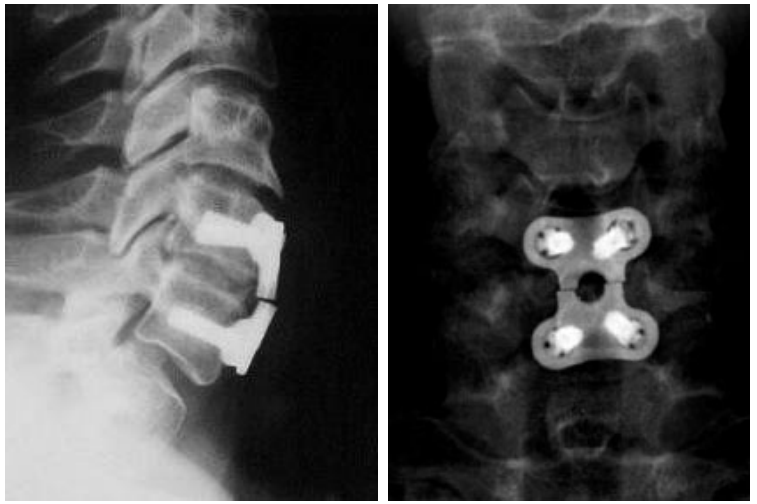
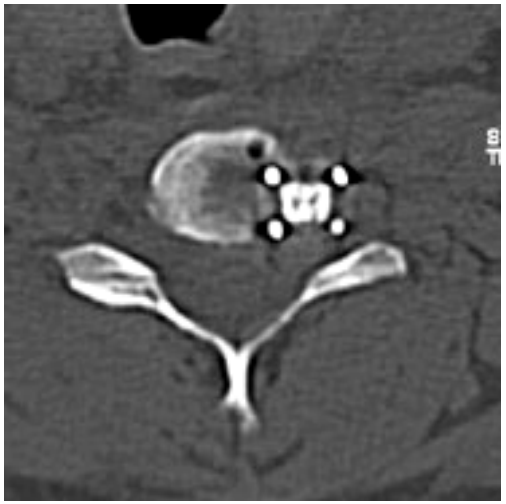
Anterior fusion: Late Complications.

1. Hardware complications (1%).
2. Pseudoartroses.
3. Subsidence of the graft / cage.



Anterior fusion: Late Complications.

4. Extrusion of the bone graft or cage: 2%.
5. Kiphotic deformity.

Anterior fusion: Late Complications.

6. Adjacent disk degeneration.

Spine

CERVICAL SPINE

Rate of Adjacent Segment Disease in Cervical Disc Arthroplasty Versus Single-Level Fusion

A Meta-Analysis of Prospective Studies

REVIEW ARTICLE

Mid- to long-term outcomes after cervical disc arthroplasty compared with anterior discectomy and fusion: a systematic review and meta-analysis of randomized controlled trials

Clinical Orthopaedics and Related Research

SURVEY

Is Cervical Disc Arthroplasty Superior to Fusion for Treatment of Symptomatic Cervical Disc Disease? A Meta-Analysis

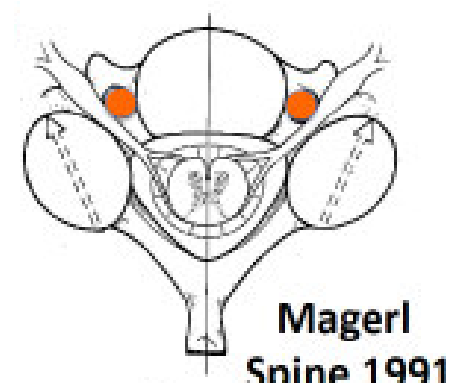
From a meta-analysis of prospective studies, there is no difference in the rate of ASD for ACDF *versus* TDA. We also report an overall lower rate of follow-up for patients with ACDF than for those with TDR. Future prospective studies should continue to focus on excellent patient follow-up and accurate assessment of patient symptoms that are attributable to an adjacent level as this has been an under-reported finding in prospective studies..

Conclusions CDA may result in better mid- to long-term functional recovery and a lower rate of subsequent surgical procedures than ACDF would. A review of the literature showed that only an insufficient number of studies had investigated adjacent segment disease; therefore, it is mandatory that adequate future research should focus in this direction.

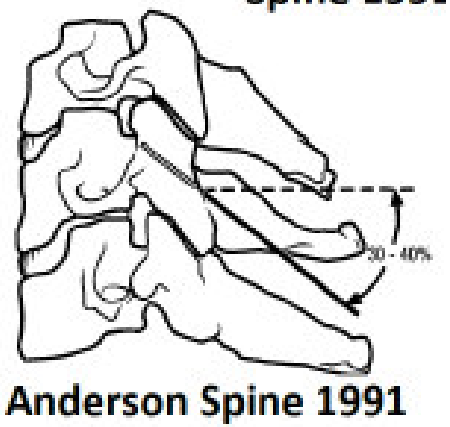
For treating symptomatic cervical disc disease, cervical disc arthroplasty appe ars to provide better function, a lower incidence of reoperation related to index surgery at 1 to 5 years, and lower major complication rates compared with fusion. However, cervical disc arthroplasty did not reduce the reoperation rate attributable to adjacent segment degeneration than fusion. Further, it is unclear whether these differences in subsequent surgery including arthroplasty revisions will persist beyond 5 years

Posterior Fusion

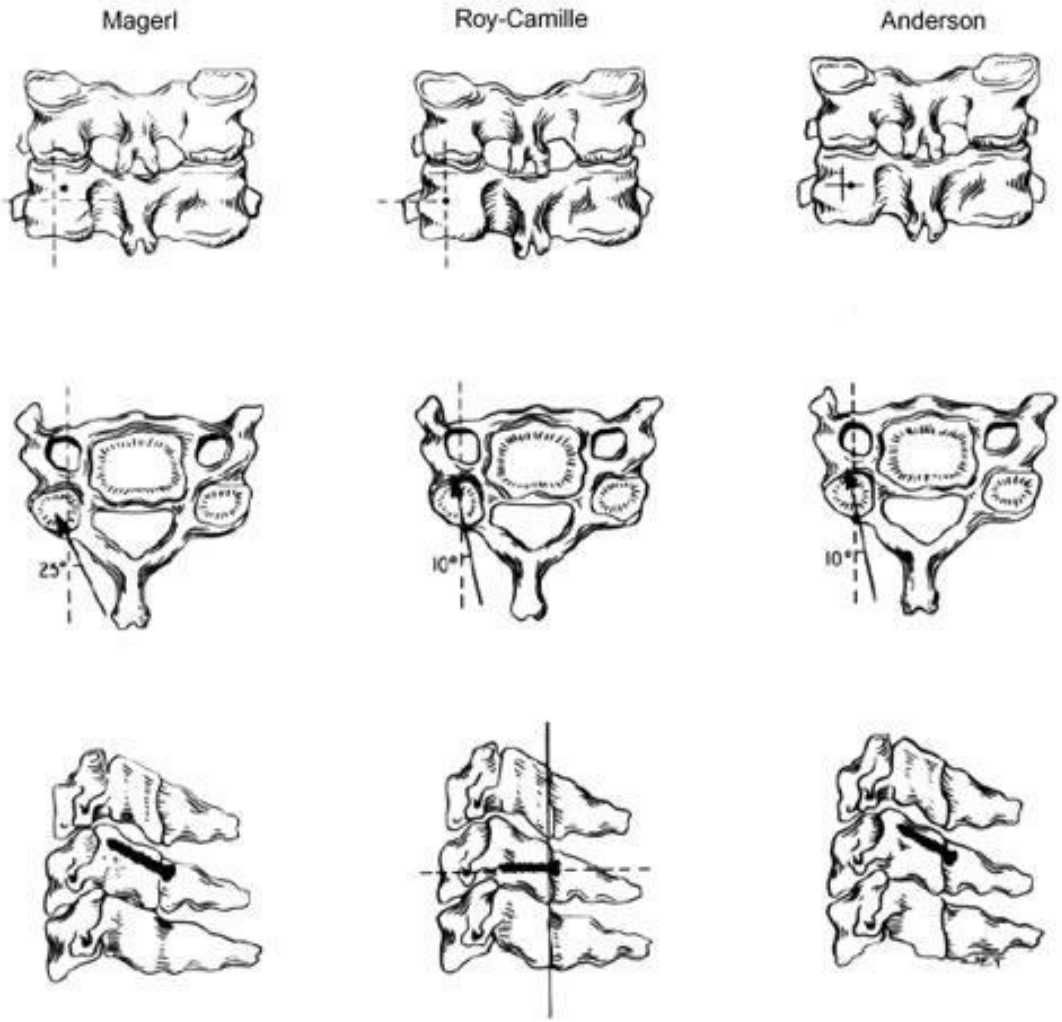
Cervical posterior fusion tecnique



Magerl
Spine 1991

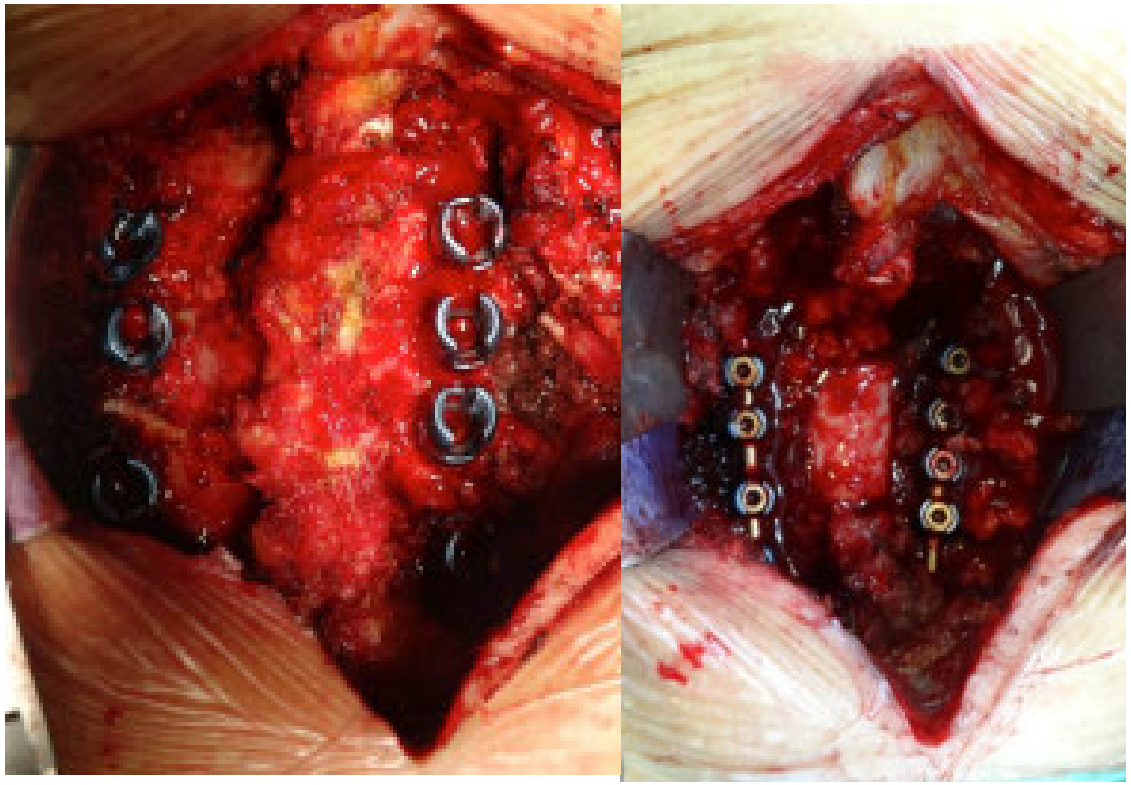


Anderson Spine 1991



Posterior approach

Cervical posterior fusion tecnique



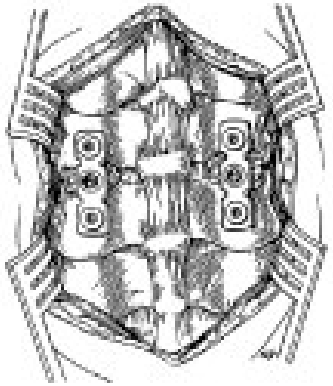
Posterior Fusion (C3-C7 Lateral Masses)

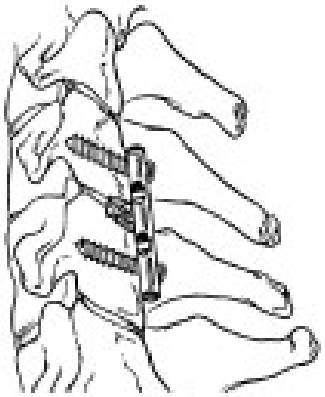
	Journal	Year	Patients	Follow-up (mo)	Root Injury	Vertebral Artery Injury	Fusion (%)	Construct Failures
Ebraheim	J OrthoTrauma	1989	13	13.1	0	0	100	0
Anderson	Spine	1991	30	17.8	0	0	100	3 Inc kyphosis
Jeanneret	Spine	1991	51	12-54	0*	0	100	0
Nazarian	Spine	1991	23	12-24	0	0	100	-
Levine	Spine	1992	221	?	?	?	100	6 Inc kyphosis
Roy-Camille	Spine	1992	24	19	6 (25%)	0	?	15 (6.7%) Inc kyphosis
Fehlings	JNS	1994	44	46	0	0	93	3 Failures
Ebraheim	JSpOs	1995	36	17	0*	0	100	1
Heller	Spine	1995	78	24	7 (9%)	0	98	6 hardware,Inc kyphosis
Wellman	Spine	1998	43	25	0	0	97%	1 Hardware failure
Horgan	JNS Focus	2002	9	9	0	0	100	0
Deen	Spine Journal	2003	225	18	5 (2.2%)	0	-	0
Sekhon	JSpOs	2005	21	12	3 (14.3%)	0	-	3
Wu	Surg Neuro	2008	115	-	1 (0.7%)*	0	-	1 Inc kyphosis
Katonis	JSpOs	2011	115	-	0	0	97.5	3 Screw pullout
Liu	JSpOs	2012	37	28	0	0	100	0

Efficacy: High fusion success Mostly plates, few rod-screw 0-10% Increased kyphosis,
Safety: Rare hardware failure, Root at small risk (1.2%), very low risk for vertebral artery

Posterior fusion.

- High efficacy >97% healing
- Poor study design
- Maintenance of stability good >95% of cases.
- Complications:
  - Vertebral artery injury rare
  - Root injury 0-5%
  - Hardware failure rare except screw back out in plates





Liu H, Ploumis A, Schwender JD, Garvey TA. Posterior cervical lateral mass screw fixation and fusion to treat pseudarthrosis of anterior cervical fusion. Journal of spinal disorders & techniques 2012;25:138-41.

Conclusions. Take at Home messages.

- Despite of the interest in cervical motion preservation, fusion still is the gold standad of treatement for disc degeneration disease.
- Fusion rate of bone allograft and plate is over 95%.
- There is no diferences in fusion rate between cages and graft.
- In more than one-level fusion is recommended to add a plate.
- Posterior fusion has similar results than anterior fusion in terms of safety and Efficacy.
- The long term results of new implants and matherials (bone cages, tantalum cages, screwed cages) is not known.

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