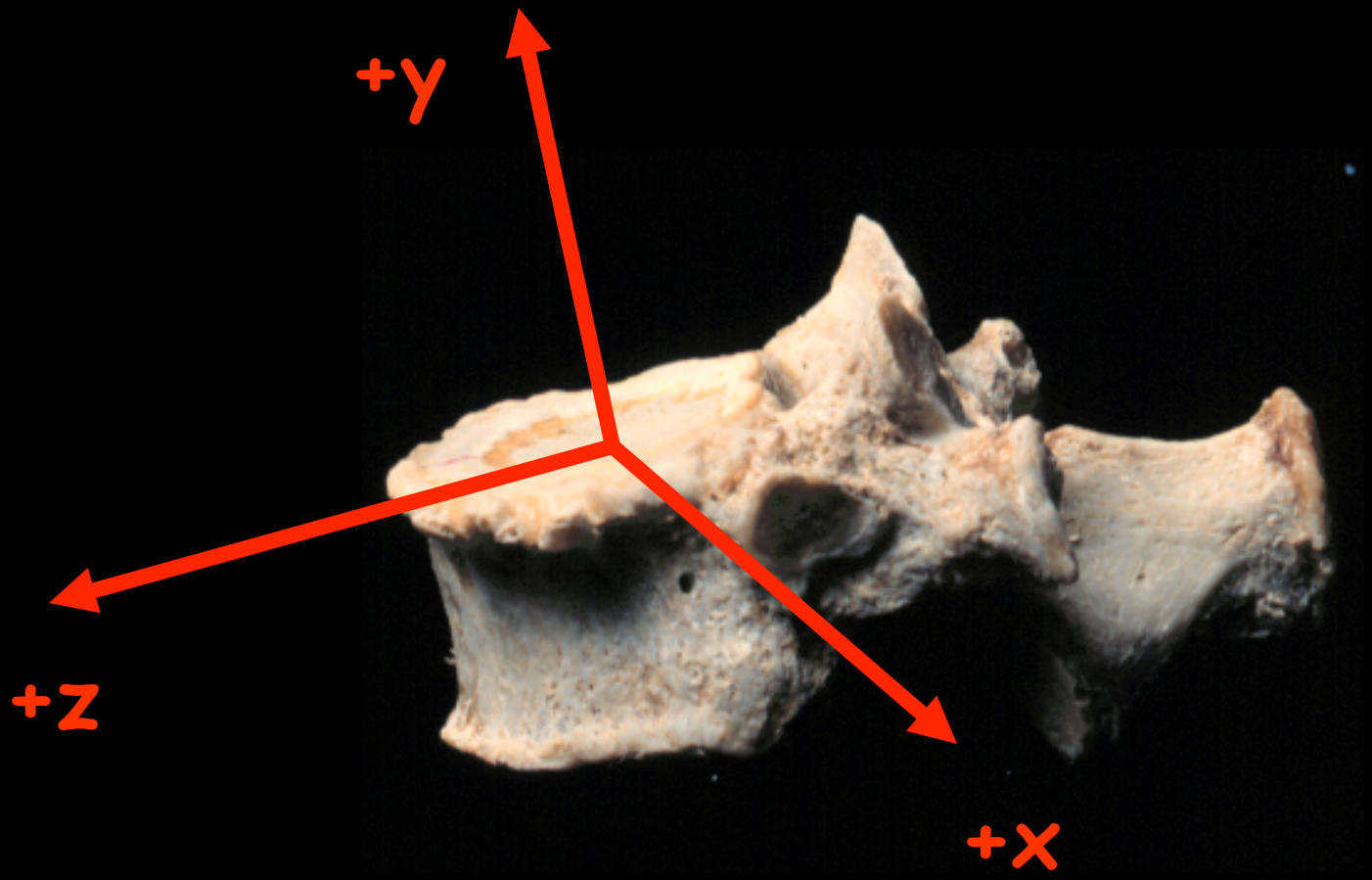
KLİNİK AÇIDAN SERVİKAL OMURGA BİYOMEKANİĞİ

Dr.Hakan BOZKUŞ

VKV Amerikan Hastanesi, Nöroşirurji Bölümü

İTÜ, Fen Bilimleri Enstitüsü

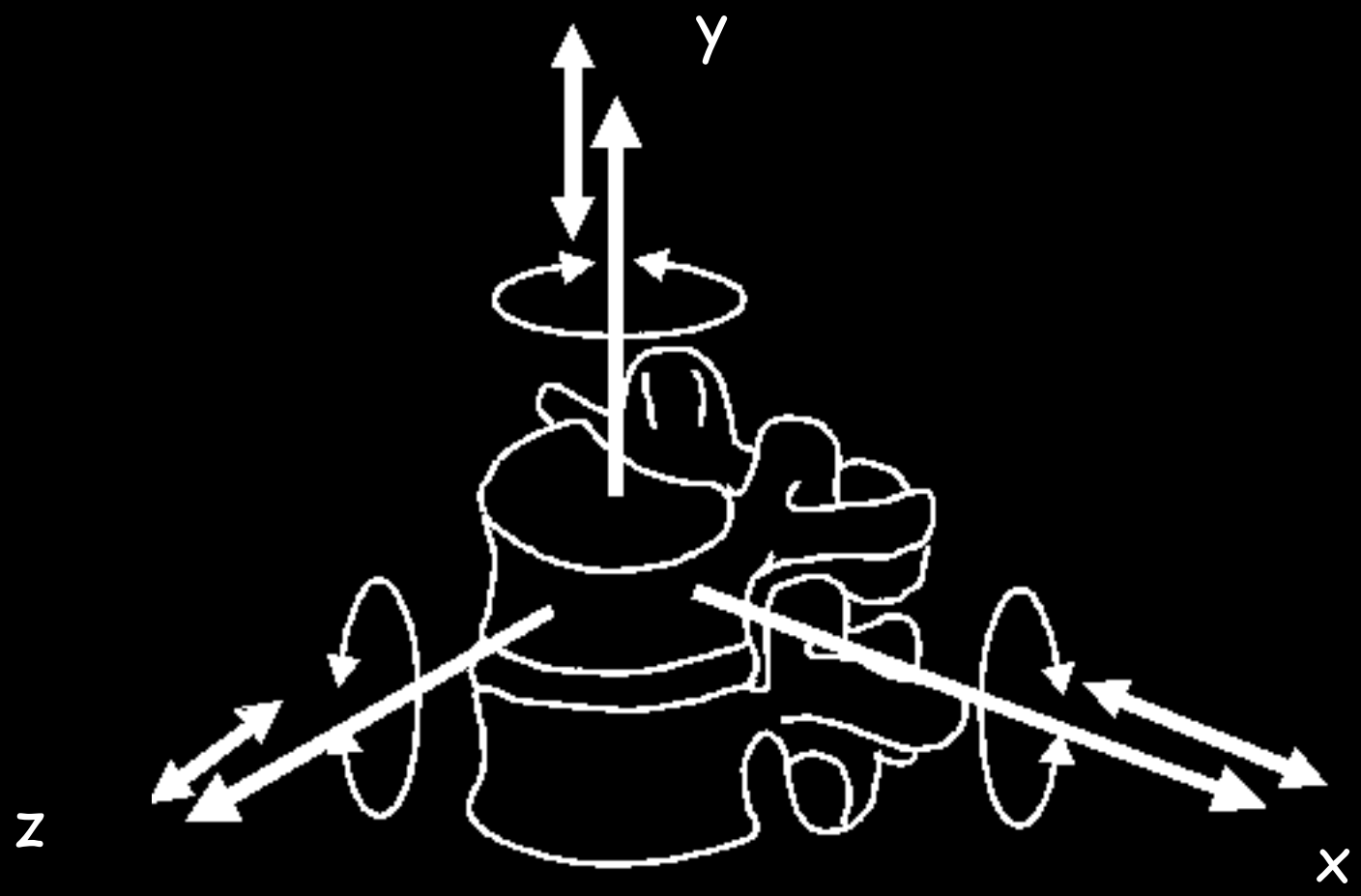
Pozitif Eksen Takımı



Panjabi, 1978

Hareket Serbestliği

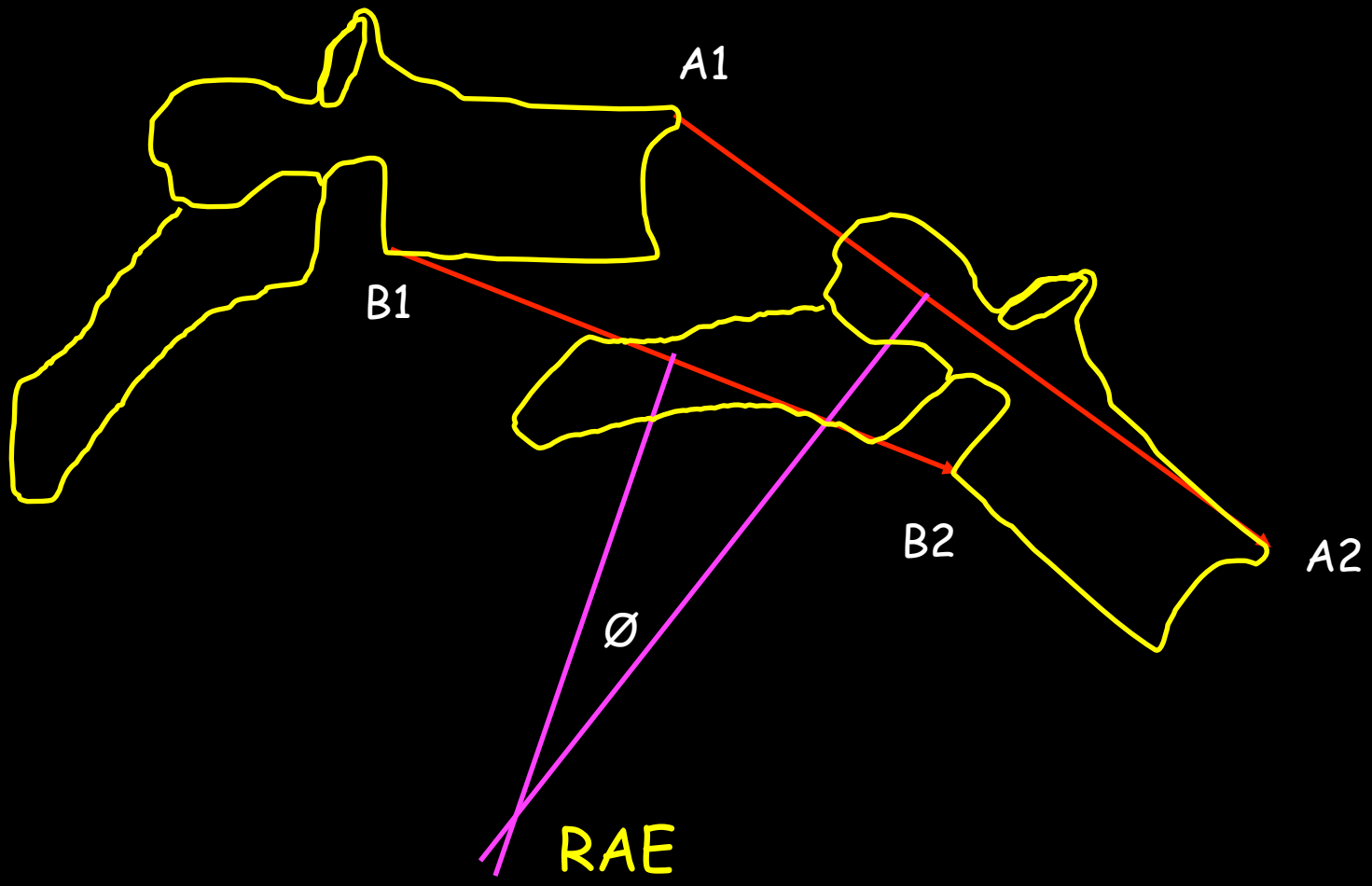
6 yönde hareket serbestliği



Rotasyonun Anlık Ekseni ?

Tek Planda RAE ?

2 translasyon vektörü, 1 rotasyon açısı



Tek Planda RAE Doğruluğu ?

GERÇEK KATI CİSİM HAREKETİNİ GÖSTERMİYOR !

- A1A2 ve B1B2 noktalarının translasyonu tek bir doğrultuda olmayabilir.

- İstatistiksel olarak aynı translasyon vektörlerinin kullanılması gerçekçi değil.

YAKINSAMA OLABİLİR !

Woltring ve ark., J Biomech 1985

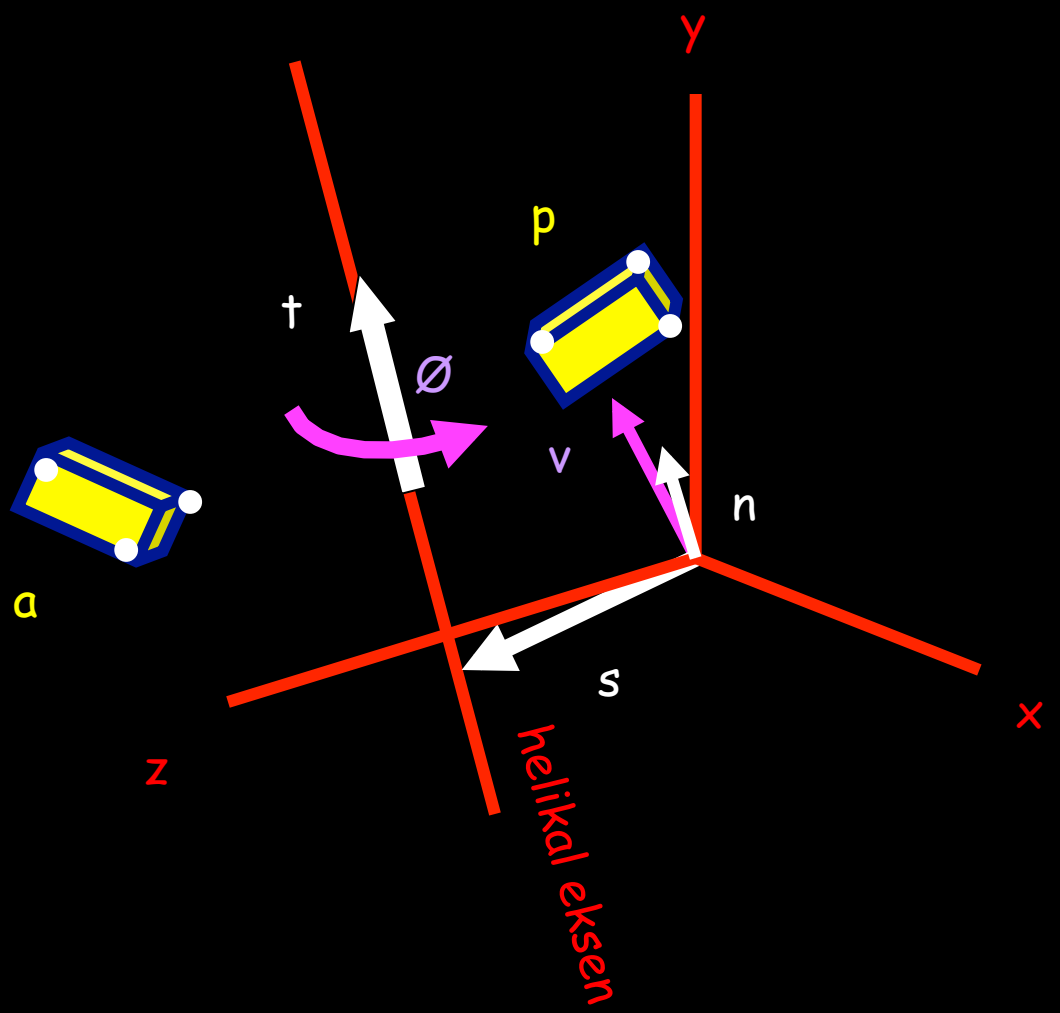
Gerçekçi RAE Çözümü ?

- En az 3 noktanın,
- Translasyon vektörü ve rotasyon matriksinin bilinmesi

(röntgen sterofotogrametri)

ÜÇ BOYUTLU RAE !

Helikal Rotasyon Ekseni



t; translasyon

Ø; rotasyon açısı

n; birim vektör

v; koordinat sisteminin hareket yönü

s; helikal eksene koordinat ekseninden en yakın dik vektör

Spoor ve Veldpaus, J Biomech 1980

Servikal Helikal Rotasyon Ekseni

- C2-3 segmenti
- 2 Nm aksiyal rotasyon
- 9.6° sağ aksiyal rotasyon, 8.6° sağ lateral bending ile birlikte birleşik hareket yapıyor.
- Helikal Rotasyon Ekseni yatayla 45° açı yapıyor.

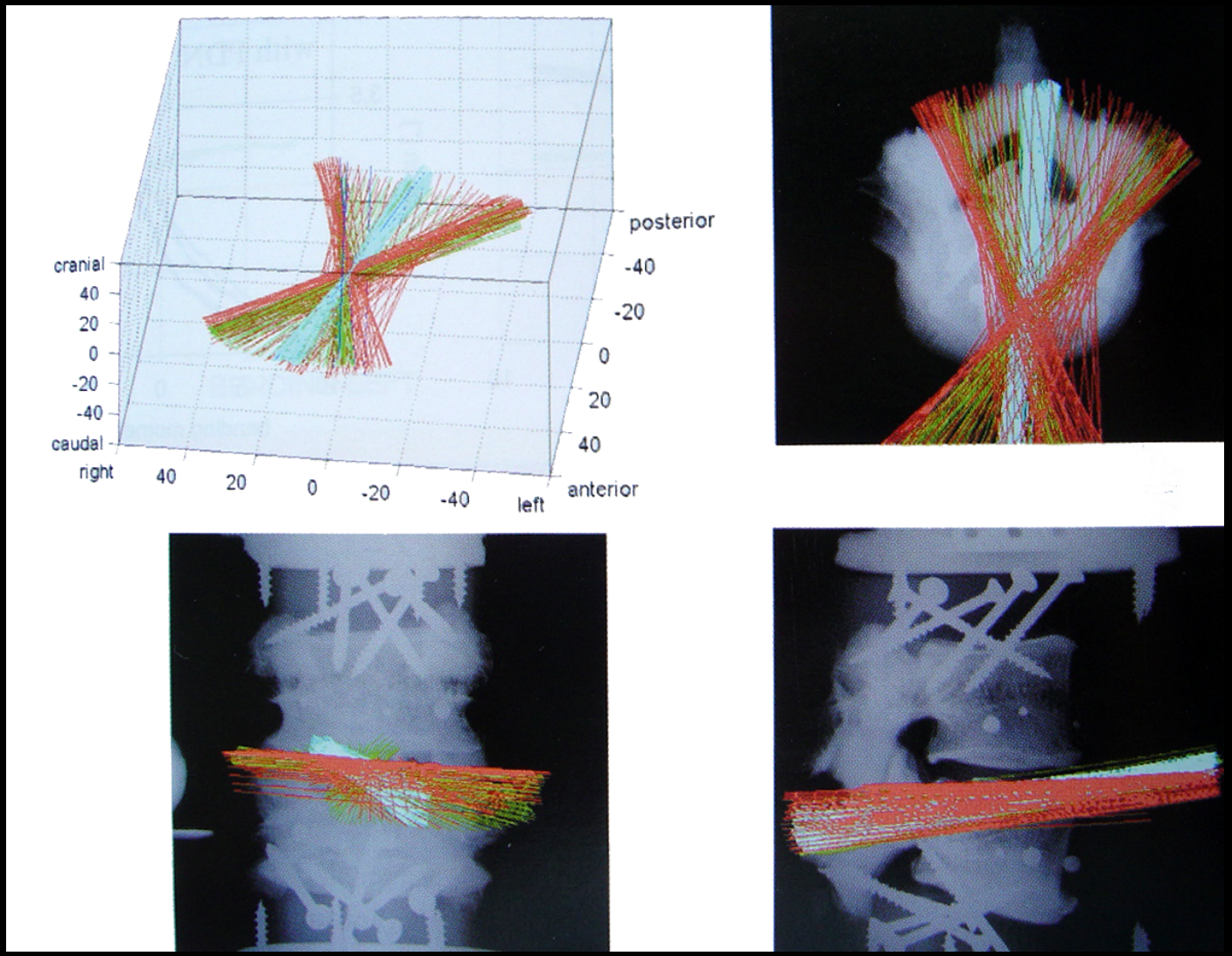
Cripton ve ark., J Biomech 2001

Servikal Helikal Rotasyon Ekseni



Cripton ve ark., J Biomech 2001

Helikal eksen hareketi (HAM)

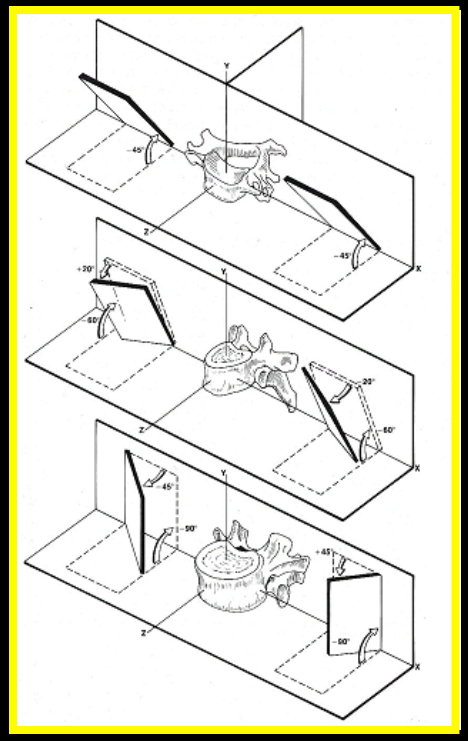


Roundtables in Spine Surgery, 1; 1, 2005

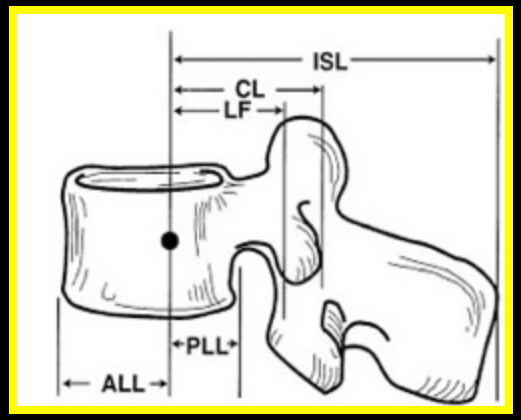
Hareket Aralığı ?



Hareketi Sağlayan Yapılar



Fasetler



Ligamanlar



Adaleler



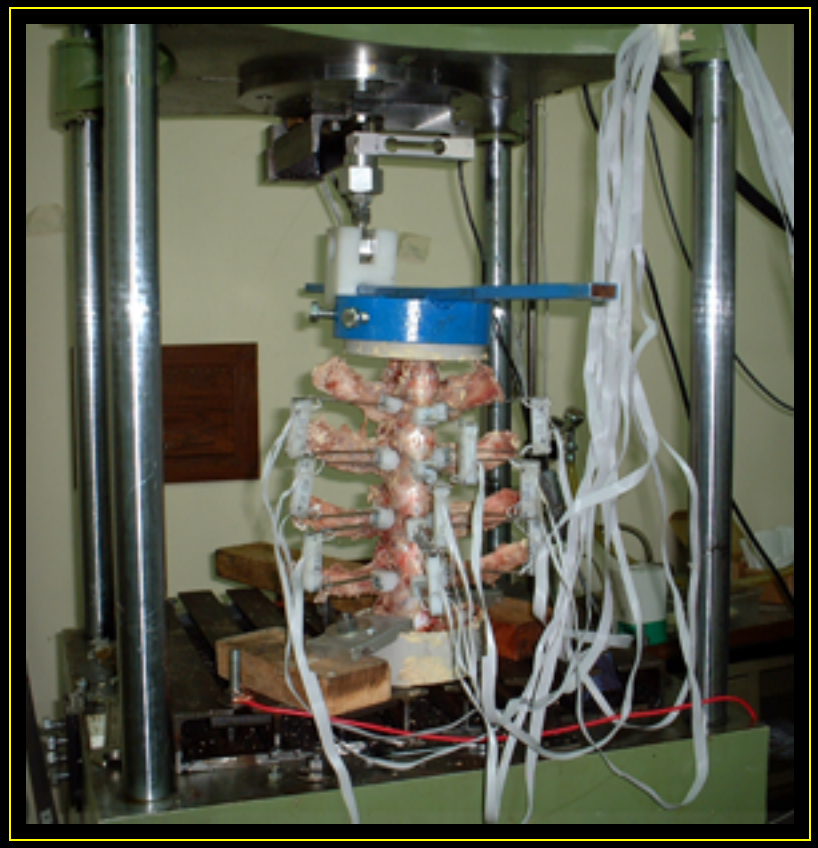
İntervertebral disk

Faset yapısı



koronal

Hareket Aralığı Ölçümü

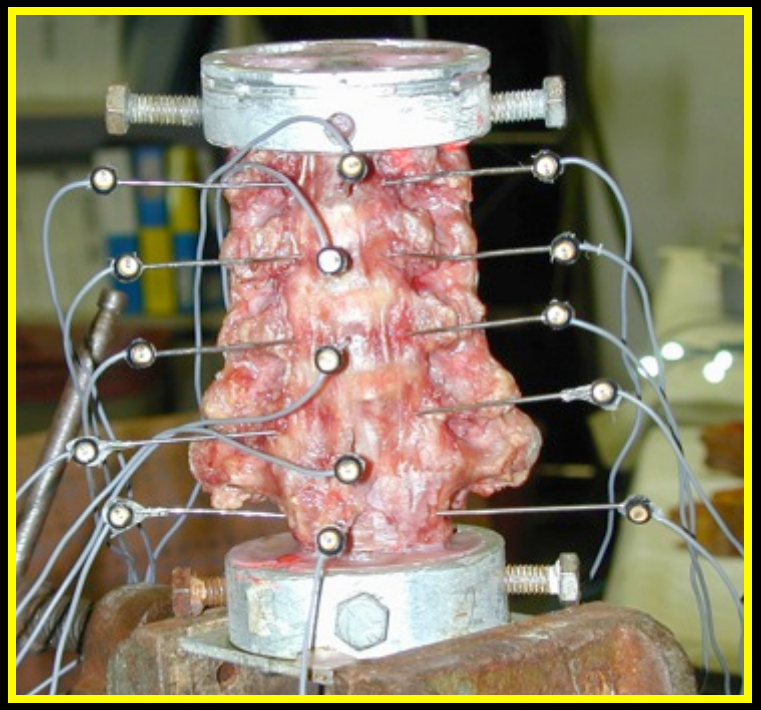




Ekstansometre

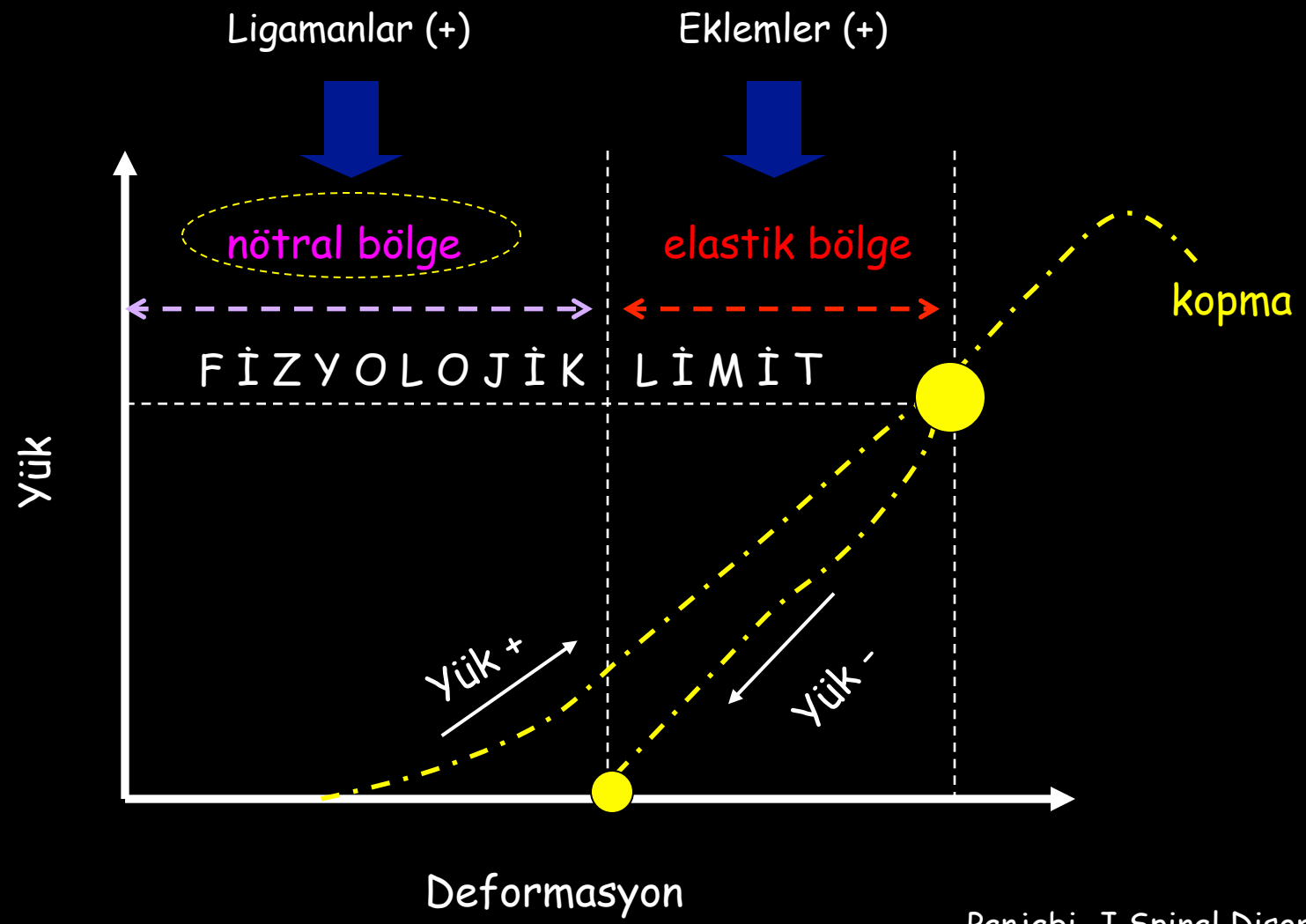
Hareket Aralığı Ölçümü





Sterofotogrametri

Hareket Aralığı (ROM)



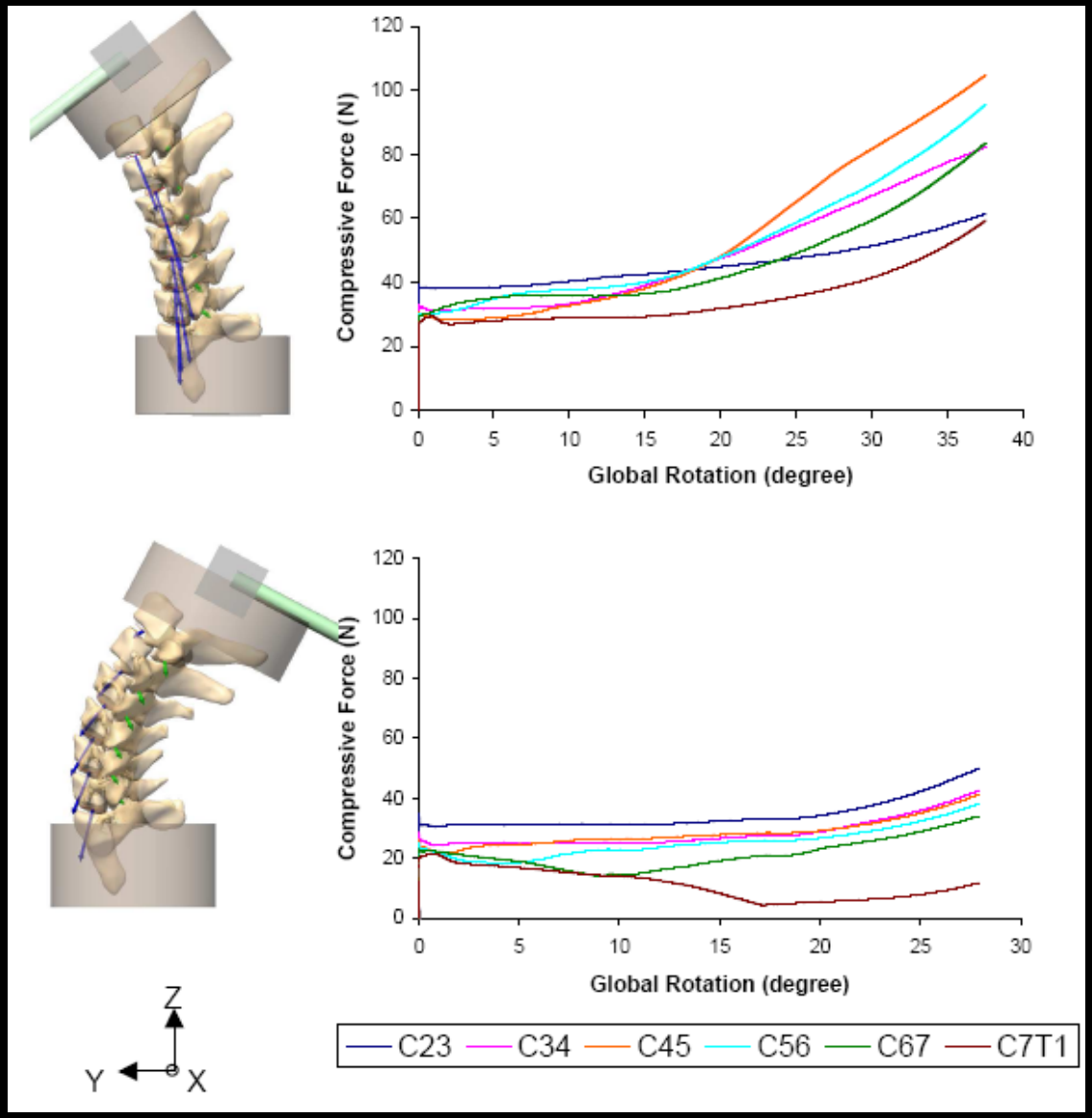
Panjabi, J Spinal Disord 1992

Servikal Hareket Aralığı (°)

	C0-C1	C1-C2	C2-C3	C3-C4	C4-C5	C5-C6	C6-C7
Fleksiyon	7.2±2.5	12.3±2.0	3.5±1.3	4.3±2.9	5.3±3.0	5.5±2.6	3.7±2.1
Ekstansiyon	20.2±4.6	12.1±6.5	2.7±1.0	3.4±2.1	4.8±1.9	4.4±2.8	3.4±1.9
Aksiyal Rotasyon	9.9±3.0	56.7±4.8	3.3±0.8	5.1±1.2	6.8±1.3	5.0±1.0	2.9±0.8
Lateral Bending	9.1±1.5	6.5±2.3	9.6±1.8	9.0±1.9	9.3±1.7	6.5±1.5	5.4±1.5

Panjabi ve ark., Spine 2001

Servikal Hareket Aralığı (°)



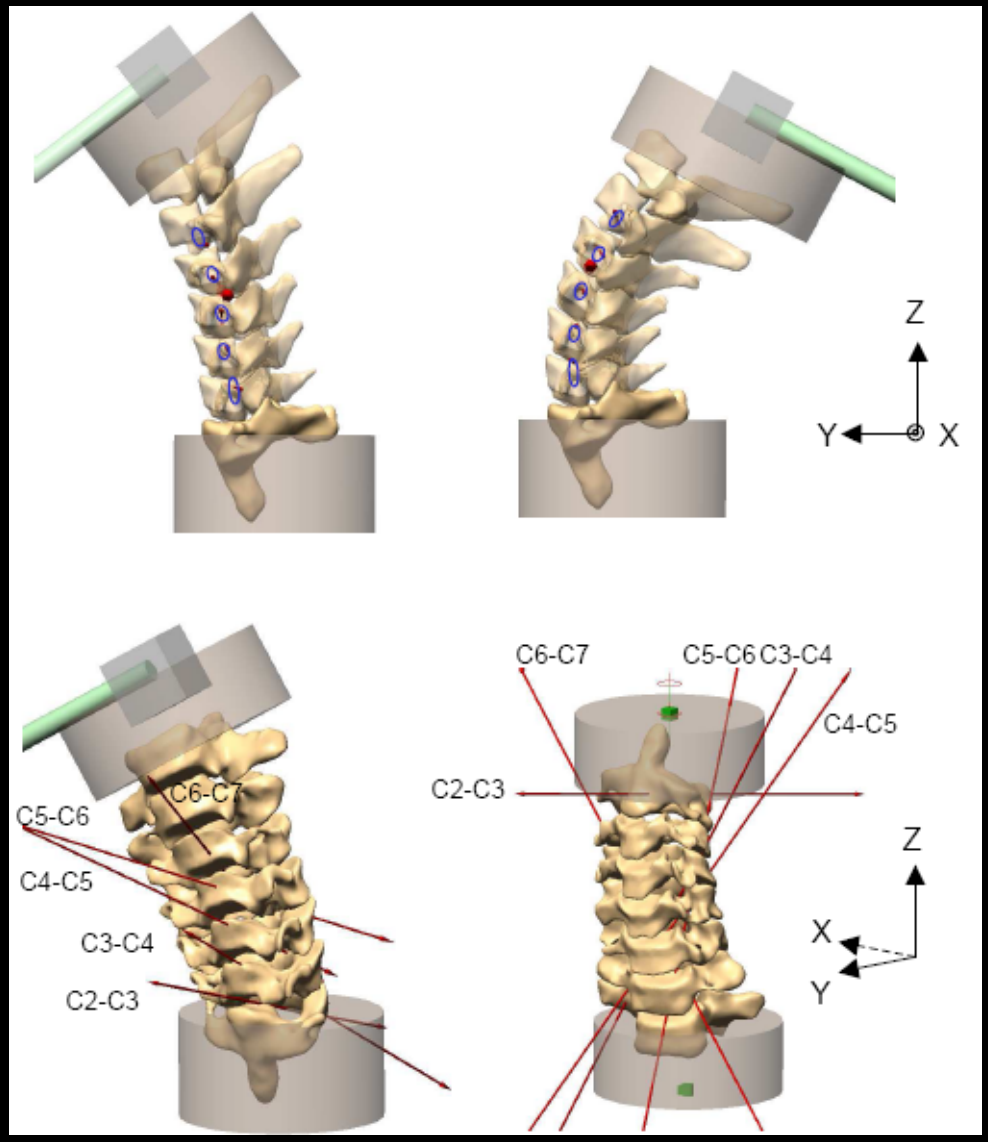
Ahn HS,
Univ. Memphis,
PhD 2005

Servikal RAE

Sagittal plan



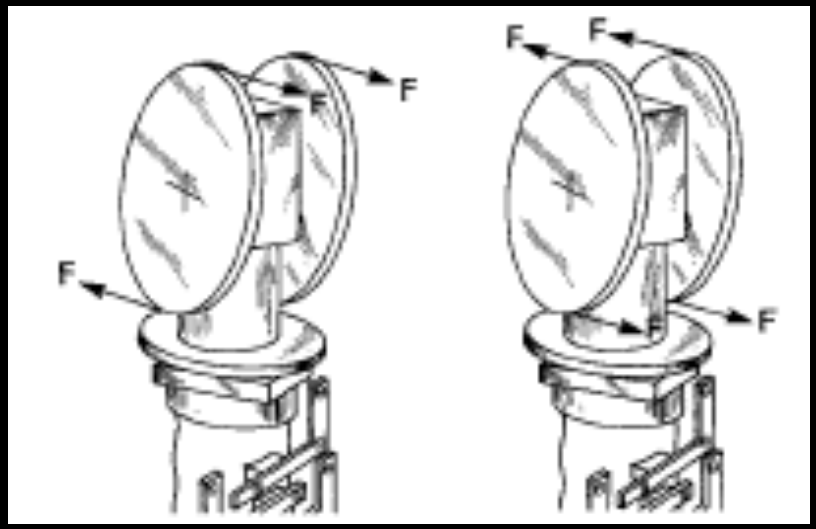
RAE ve HAM

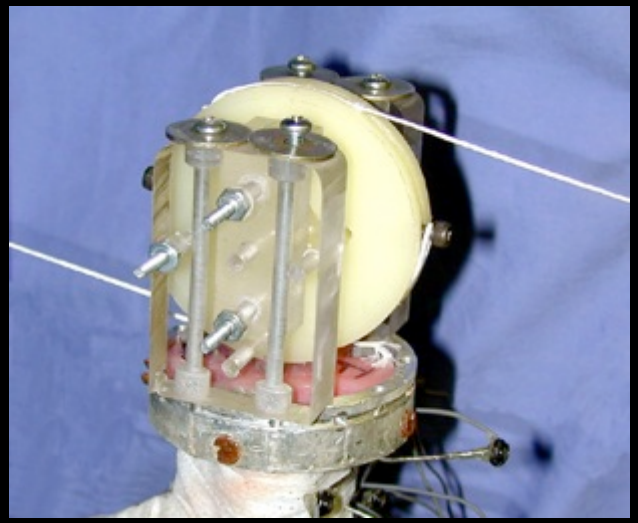


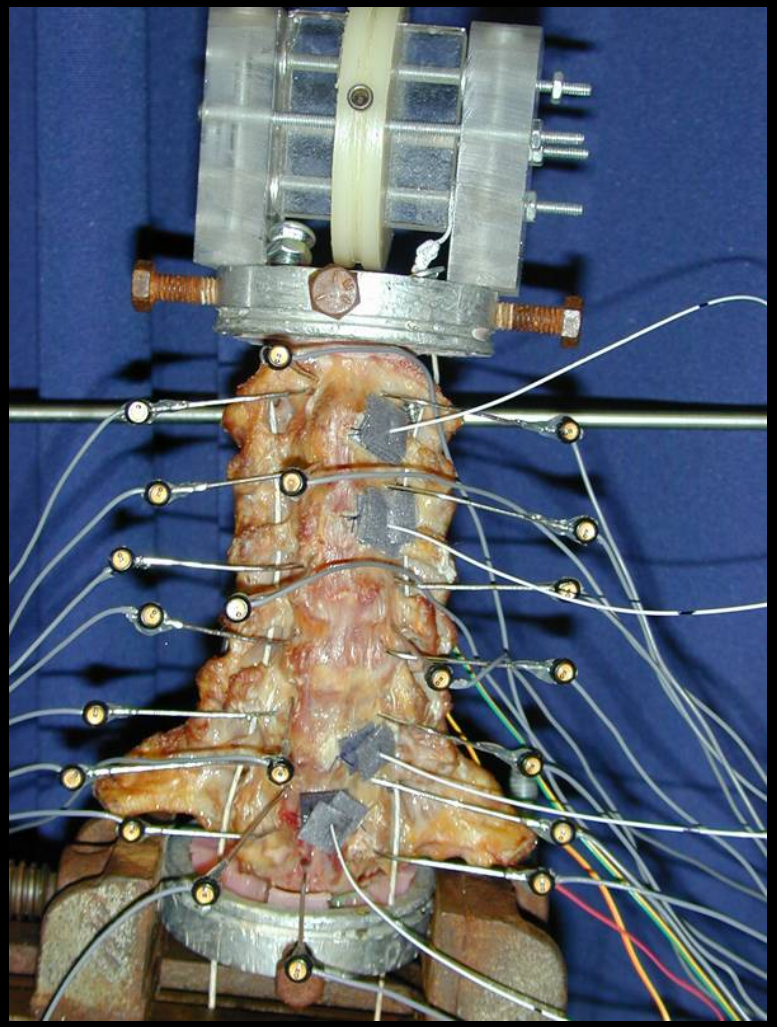
Ahn HS,
Univ. Memphis,
PhD 2005

Yükleme protokolü ?

Moment yüklemesi

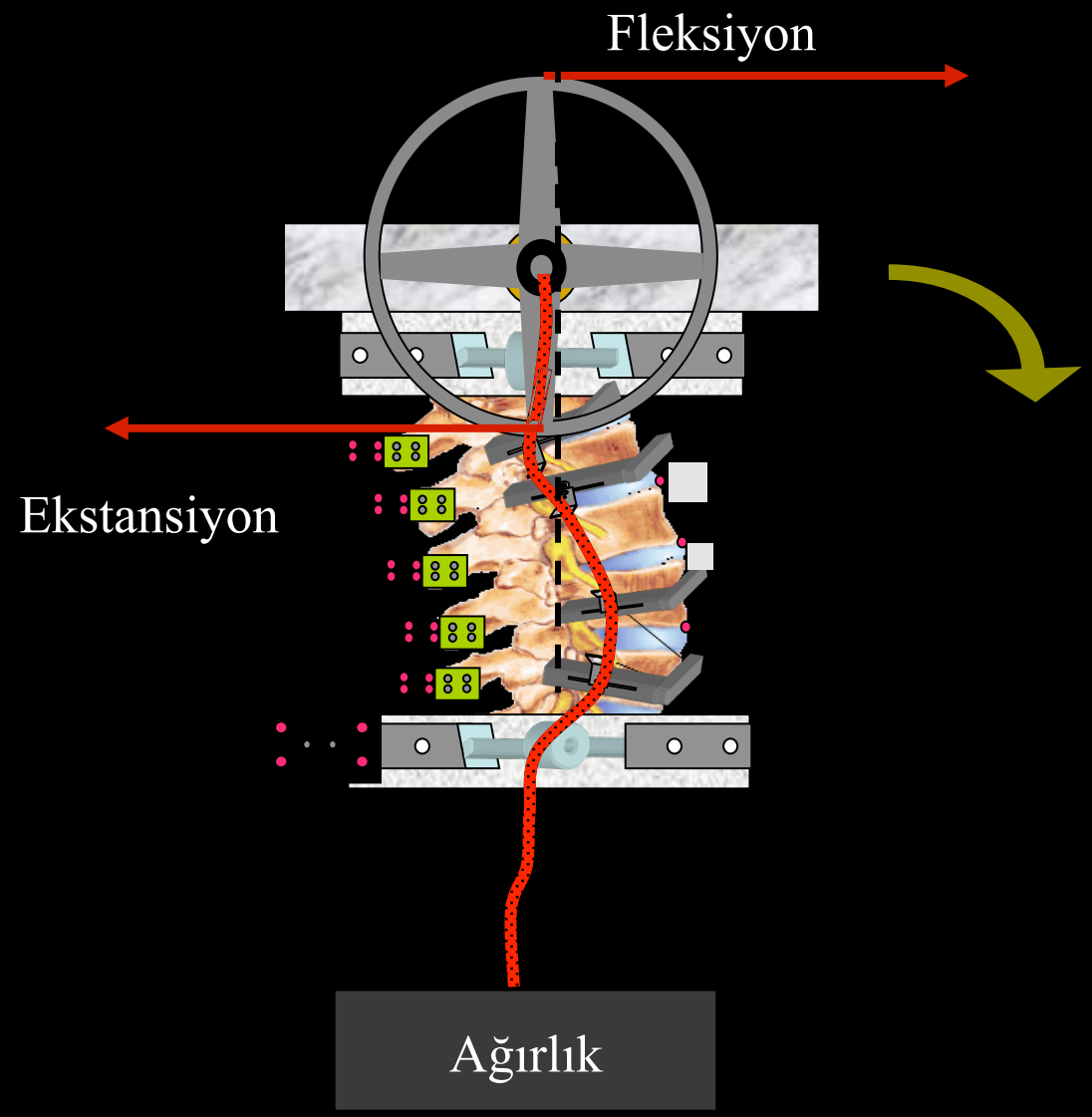


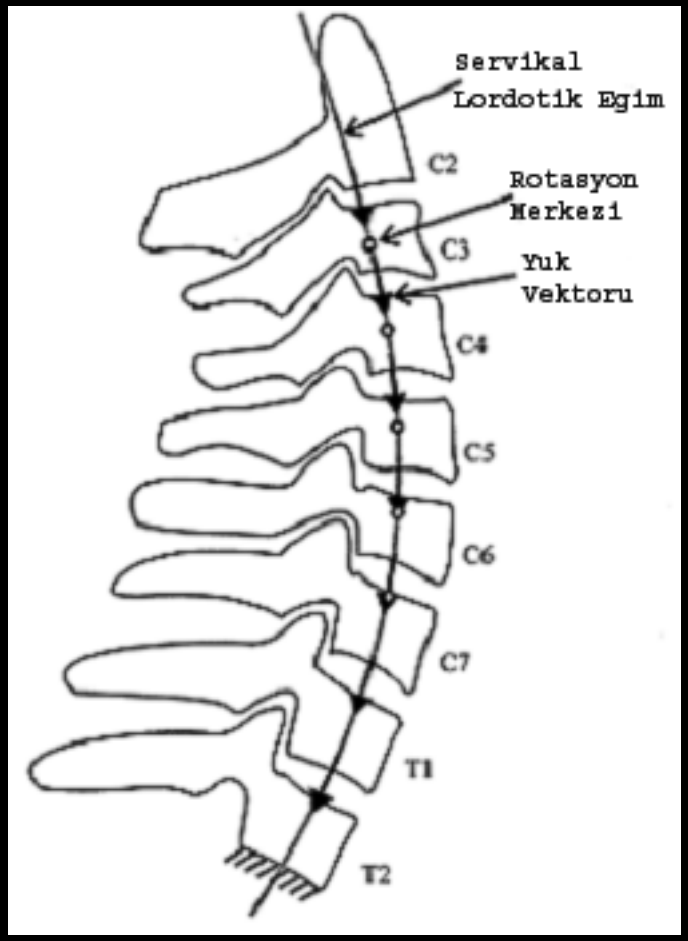




Panjabi ve ark. Spine, 2001

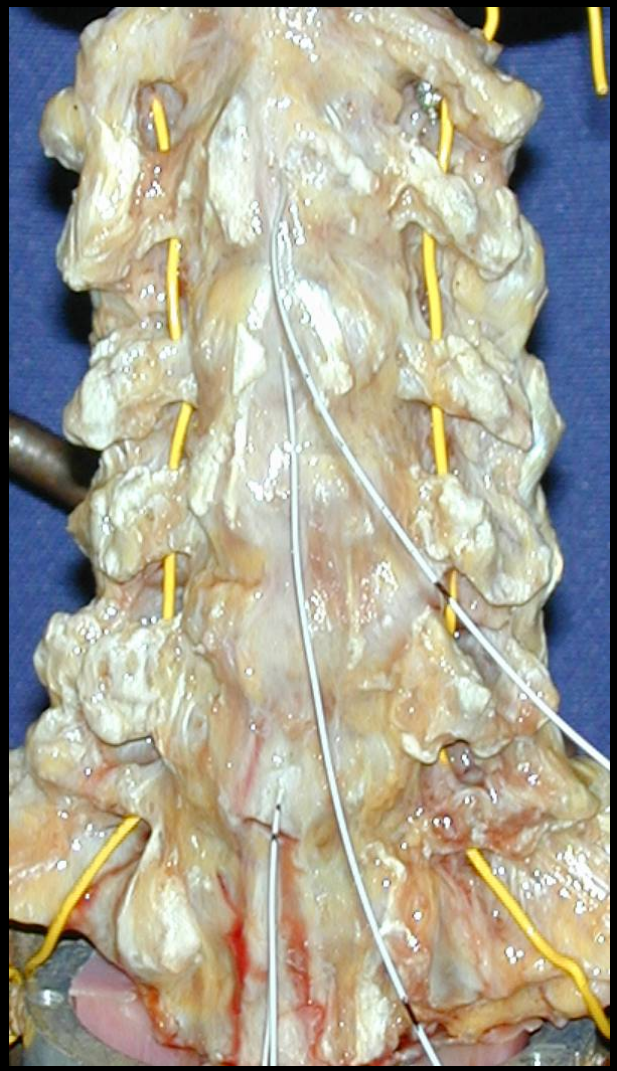
Tanjansiyel aksiyal yükleme

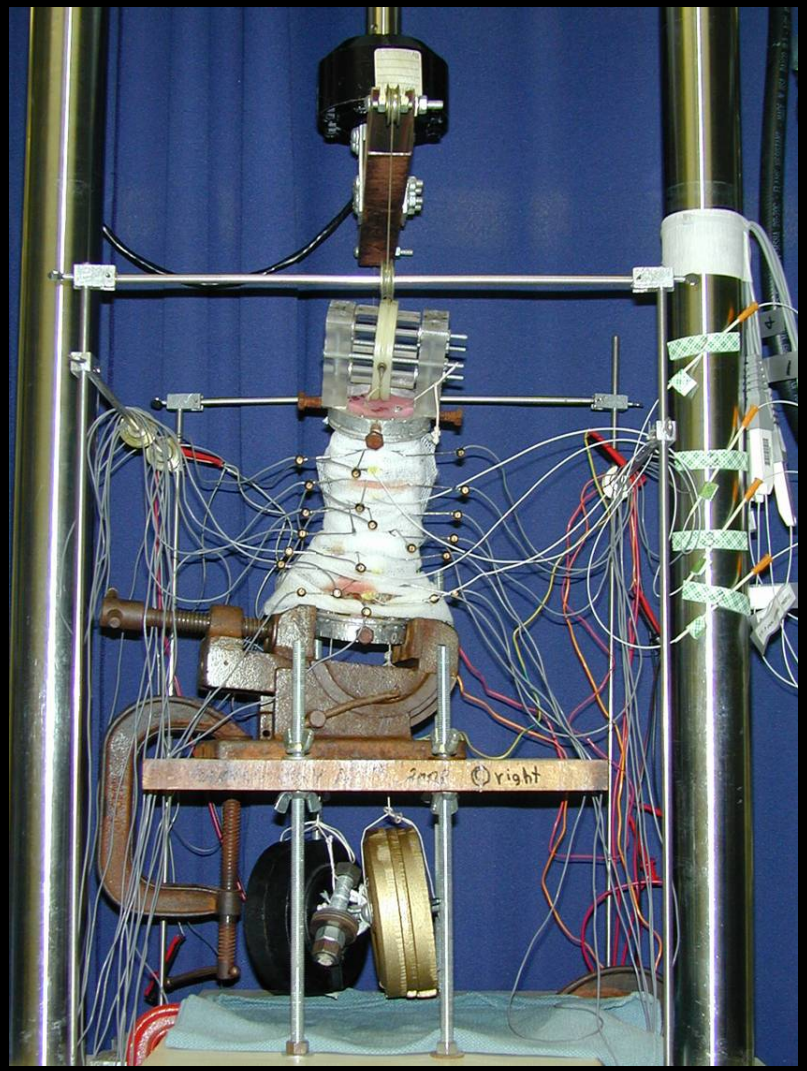




Patwardhan ve ark. Spine, 2000

Tanjansiyel aksiyal yükleme





Bozkuş ve ark. BNI, 2002

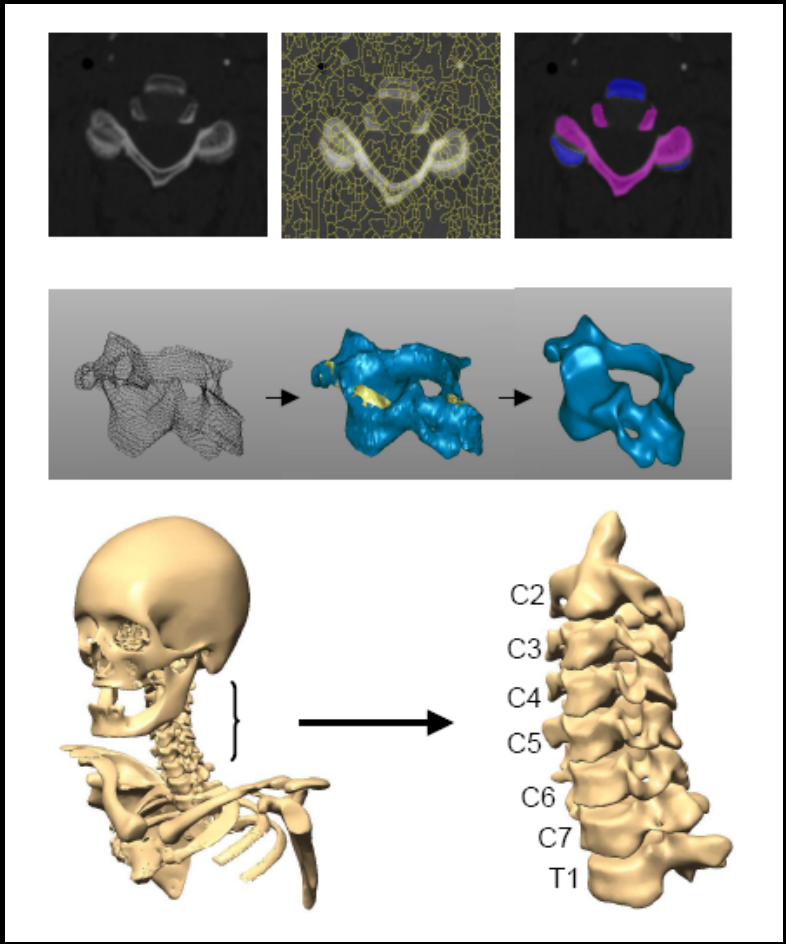
Sürekli moment yüklemesi

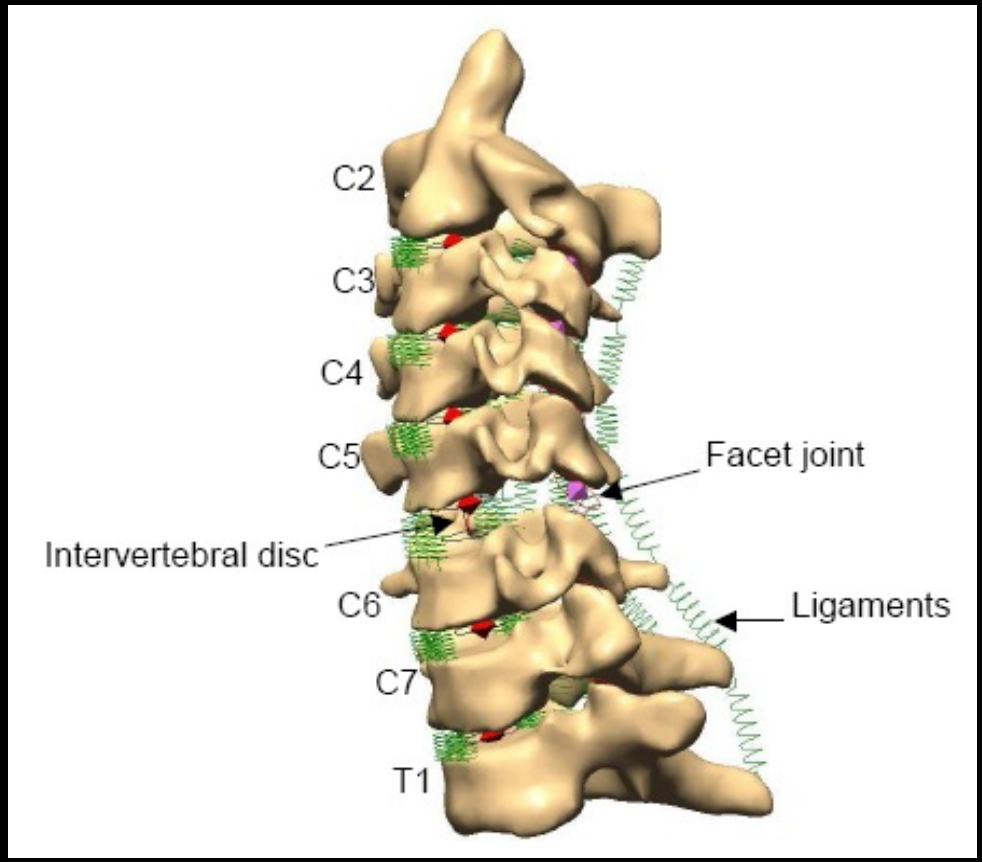


FULL SPINE
SIMULATOR

EnduraTEC
Life Enhancing Test Solutions

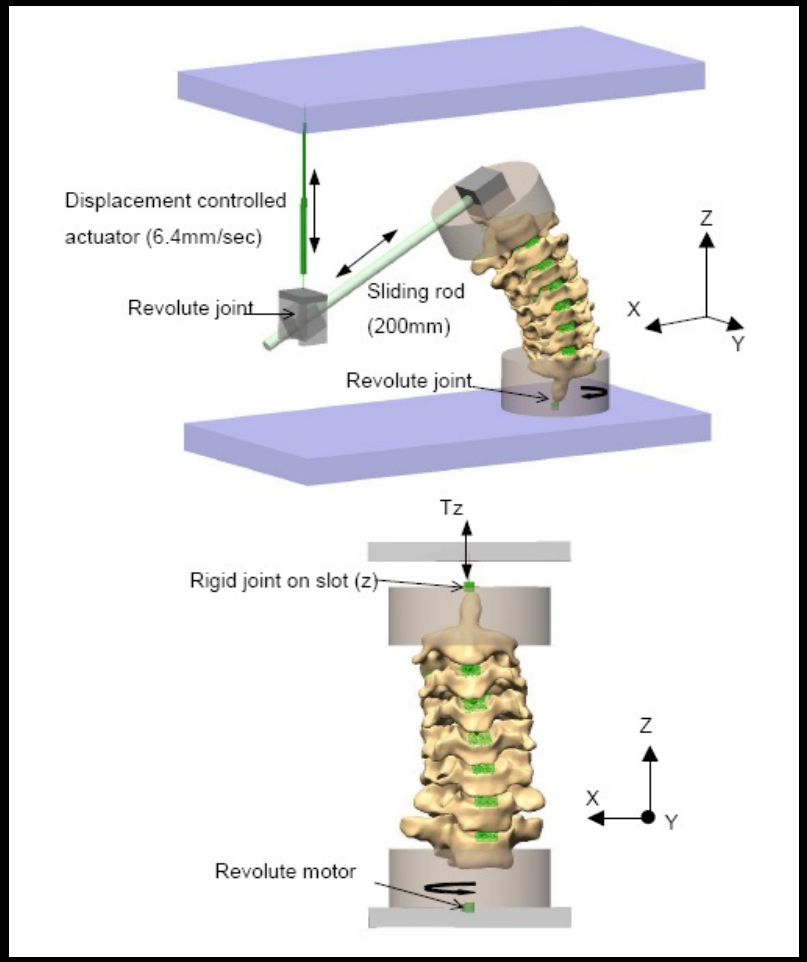
Sonlu eleman yöntemi (FEM)

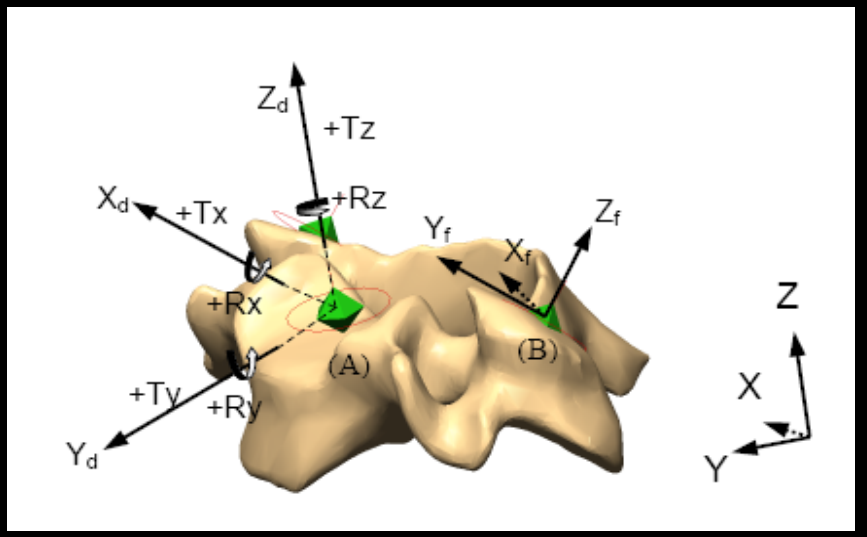




Ahn HS,
Univ. Memphis,
PhD 2005

Sonlu eleman yöntemi (FEM)





Ahn HS,
Univ. Memphis,
PhD 2005

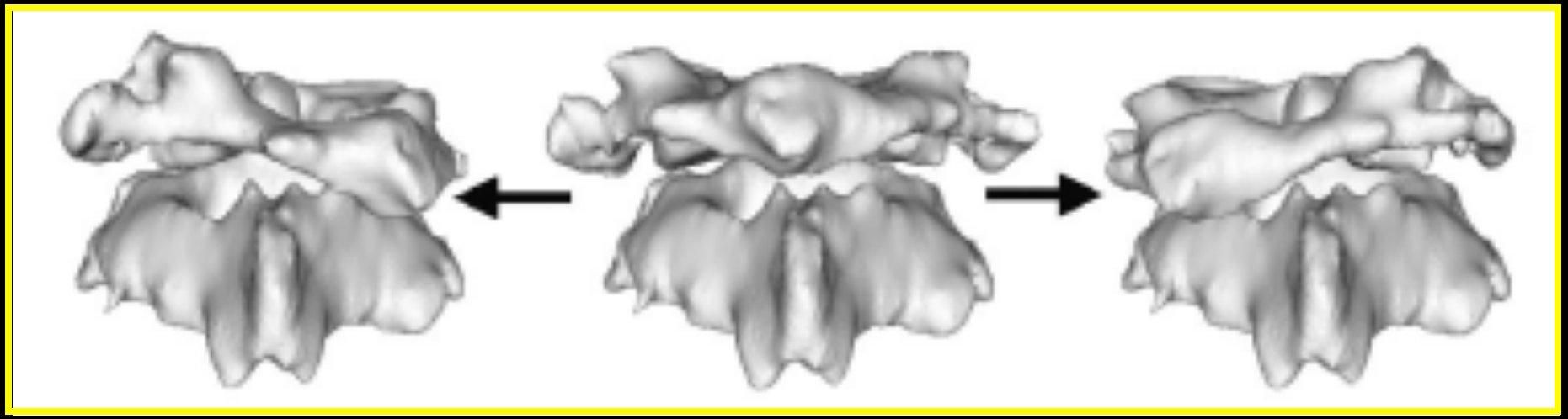
Birleşik Hareket

Üst servikal bölge

Sol aksiyal rotasyon

Normal pozisyon

Sağ aksiyal rotasyon



Rotasyonun karşı yönünde lateral bending ve ekstansiyon

Mekanik olarak stabilizasyon bozulması ?



Üst servikal bölge stabilizasyon bozulması kriterleri

- Atlanto-oksipital dislokasyon
- Oksipital kondil kırıkları
- Atlas kırıkları (Landell sınıflandırması)
- Aksis kırıkları
  - Odontoid kırıklar (Anderson ve D' Alanzo sınıflandırması)
  - Asılmış adam kıkları (Effendi ve Francis sınıflandırması)

Alt servikal bölge stabilizasyon bozulması kriterleri

YAPILAR	PUAN
Ön eleman hasarı	2
Arka eleman hasarı	2
Dinamik grafide;	
Sagittal ötelenme 3.5mm> veya %20	2
Sagittal plan açılanma 20°>	2
Statik grafide;	
Sagittal ötelenme 3.5mm> veya %20	2
Sagittal plan açılanma 11°>	2
Pozitif gerilme testi 1.7mm >	2
Sagital kanal çapı <13 mm	1
Omurilik hasarı	2
Sinir kökü hasarı	1
Disk mesafesinde daralma	1
Aşırı yüklenme şüphesi	1

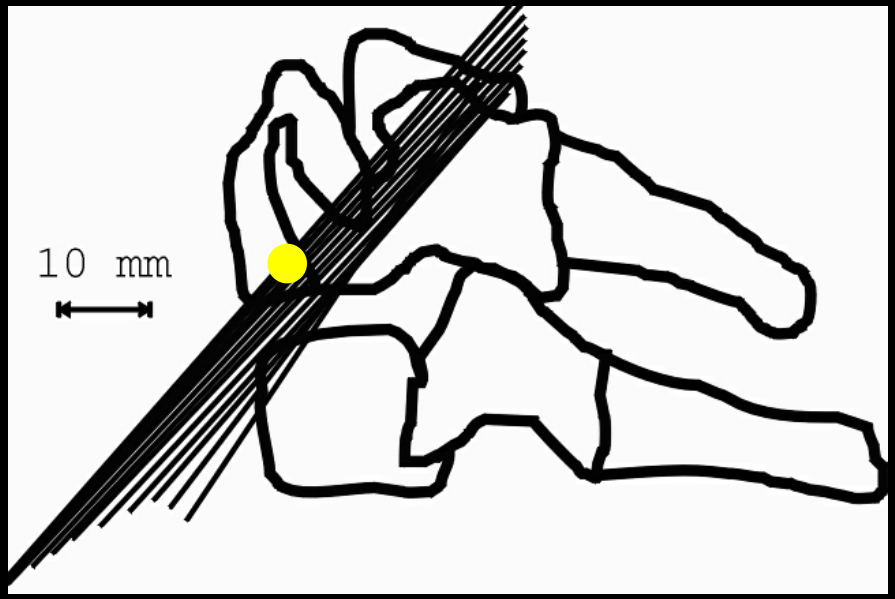
Beş veya daha fazla puan stabilizasyon bozulması

White III AA, Panjabi MM, 1990

Destabilizasyon Durumunda RAE

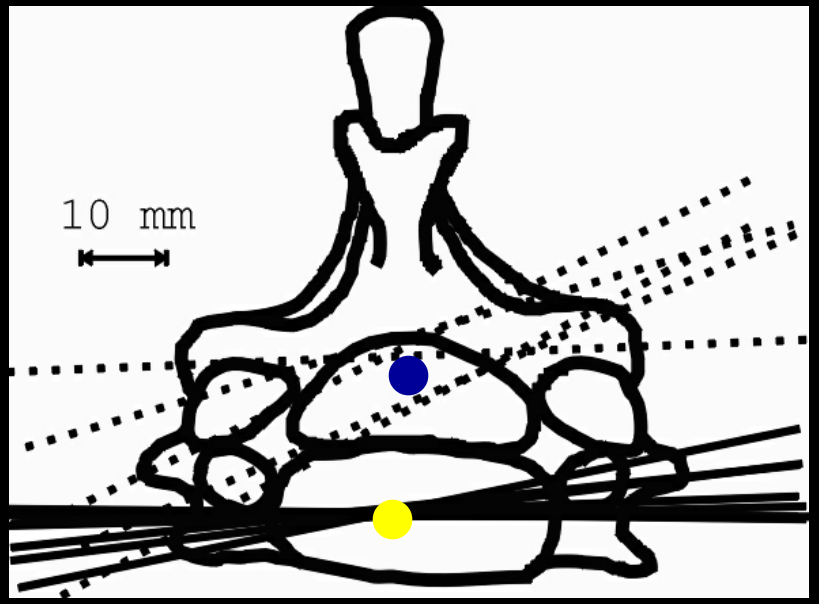
C5-C6 FSU

aksiyal rotasyon,
lateral bending ile birleşik hareket



NORMAL

ekstansiyon RAE' si
yer değiştiriyor



ALL REZEKSİYONU SONRASI

Crawford ve ark., ASB, 1997

Stabilizasyon Teknikleri ?

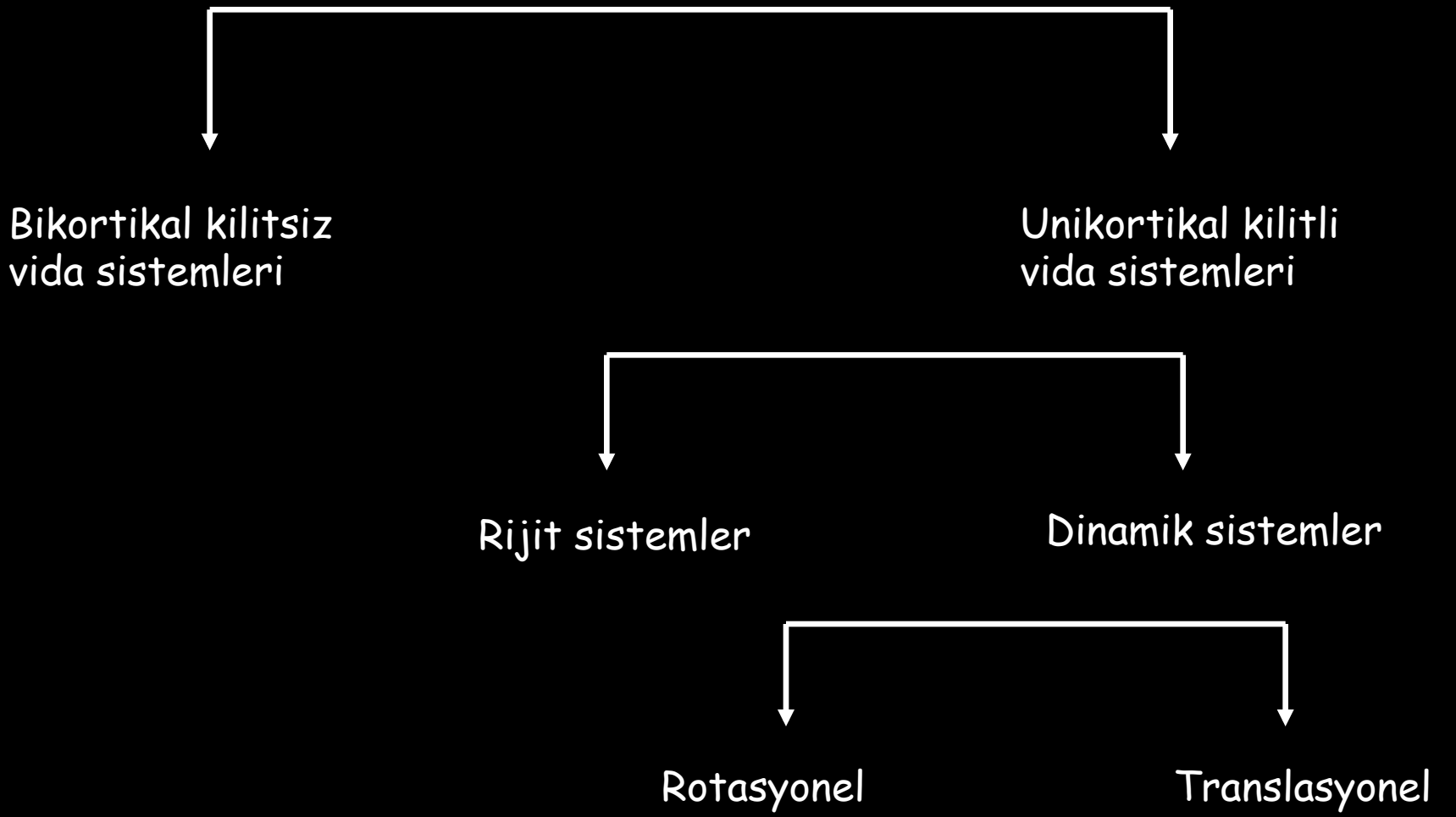
AMAÇ

Bozulan RAE' ini eski haline getirebilmek !

Normal hareket aralığını sağlayabilmek !

Anterior Servikal Stabilizasyon

Servikal Anterior Plaklar



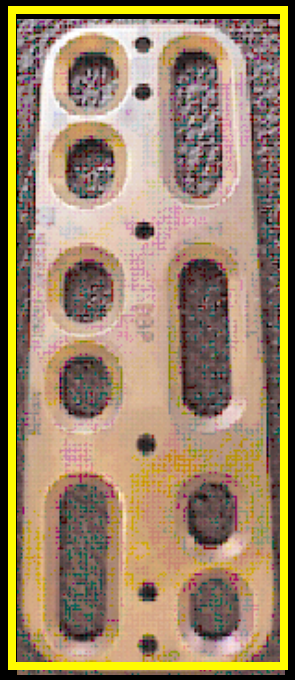
Bikortikal kilitsiz vida sistemleri

Vida açılanabilir
Sabit moment kolu yok
Vida-plak fiksasyonu kısıtlı
Rijit sistem değiller

ASIF (Synthes)



Caspar (Aesculap)



1970

1980

Unikortikal kilitli vida sistemleri

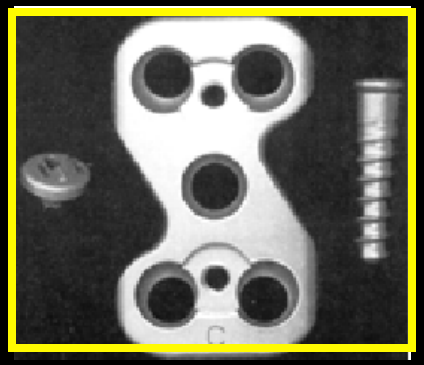
Vida açısı sabit
Vida-plak fiksasyonu sabit
Vidanın geri çıkması yok

CSLP (Synthes)



Vida açısı sabit
Plak lordozu mevcut
Vida ucuna doğru inceliyor
(tapered)

Orion (Medtronic
Sofamor Danek)



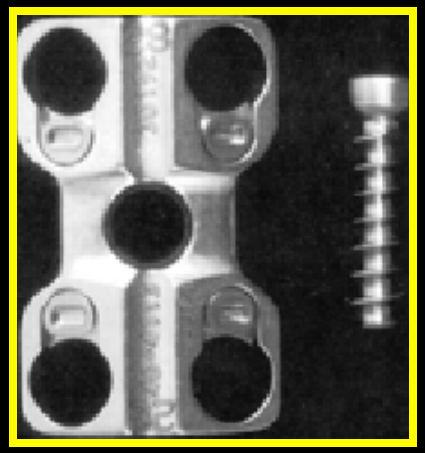
1984-1986

Unikortikal kilitli vida sistemleri

Rotasyonel Dinamik Sistemler

Vida açıları değişebilir

Codman (Codman)



Zephir (Medtronic Sofamor Danek)



Atlantis (Medtronic Sofamor Danek)



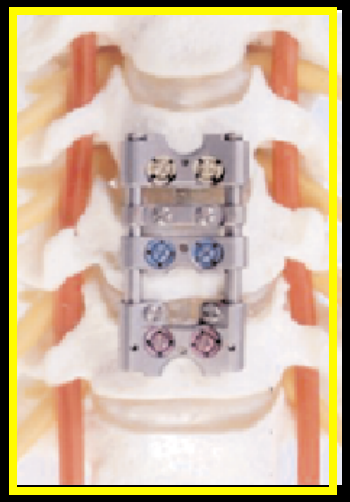
2000 ve sonrası

Unikortikal kilitli vida sistemleri

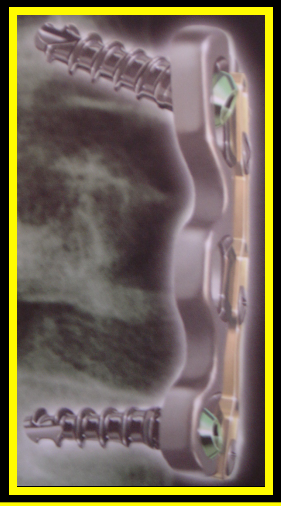
Translasyonel Dinamik Sistemler

Rodlar üst vidalarda translasyon yapar
Arabağlantı *kontrollü dinamizm* sağlıyor

DOC (Depuy Acromed)



Premier (Medtronic Sofamor Danek)

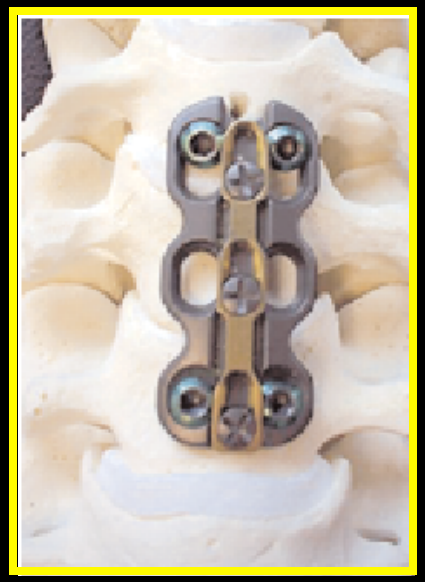


2000 ve sonrası

Unikortikal kilitli vida sistemleri

Translasyonel ve Rotasyonel Dinamik Sistemler

ABC (Aesculap)





2000 ve sonrası

Tek seviye servikal diskektomi

Eur Spine J (2006) 15: 1339–1345
DOI 10.1007/s00586-005-0047-y

ORIGINAL ARTICLE

Stephen I. Ryu
Jesse T. Lim
Sung-Min Kim
Josemaria Paterno
Daniel H. Kim

Comparison of the biomechanical stability of dense cancellous allograft with tricortical iliac autograft and fibular allograft for cervical interbody fusion

- Tüm greft tipleri aynı stabilizasyonu sağlıyor
- Plak fiksasyonu özellikle dışyana harekette stabilizasyonu artırıyor



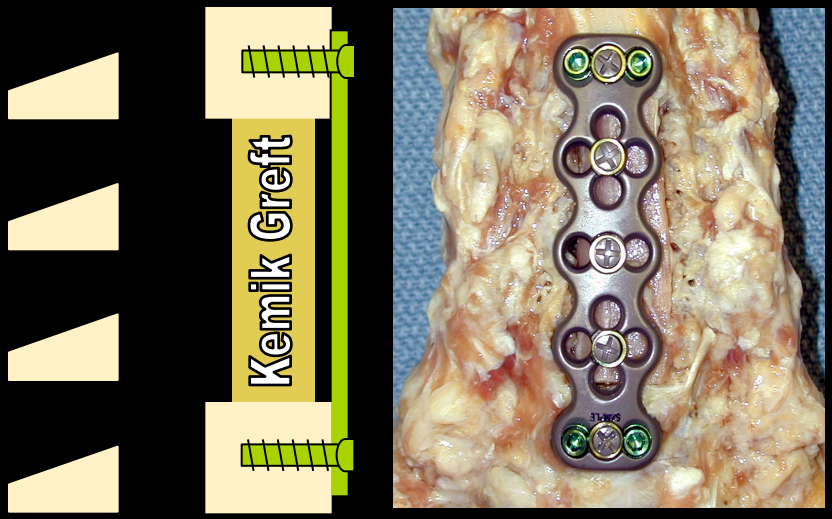
Fibular otogreft

Spongioz allogreft

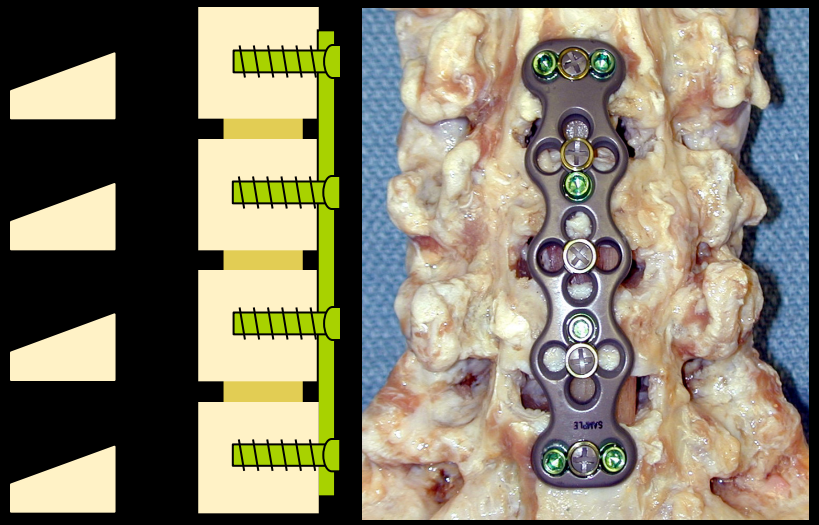
İliak otogreft

Servikal Korpektomi ? Diskektomi ?

2 seviye korpektomi



3 seviye diskektomi



Her iki gruptada anterior plak ile yeterli stabilizasyon sağlanıyor

Galler ve ark., BNI 2003

Tek seviye korpektomi (anterior ?/ posterior?)

Eur Spine J (2005) 14: 372–380
DOI 10.1007/s00586-004-0763-8

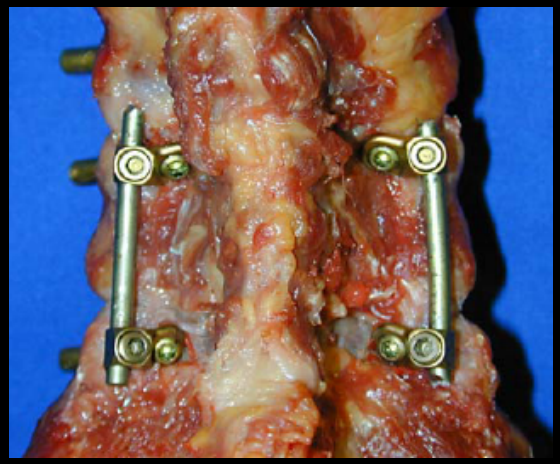
ORIGINAL ARTICLE

René Schmidt
Hans-Joachim Wilke
Lutz Claes
Wolfhart Puhl
Marcus Richter

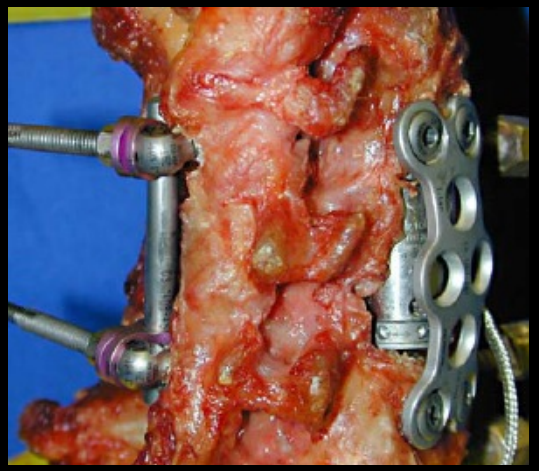
Effect of constrained posterior screw and rod systems for primary stability: Biomechanical in vitro comparison of various instrumentations in a single-level corpectomy model



rijit



Yarı-rijit



kombine

- Rijit sistemler daha iyi stabilizasyon sağlıyor
- Kombine fiksasyon hepsinden üstün stabilizasyon sağlıyor

Birden fazla korpektomi

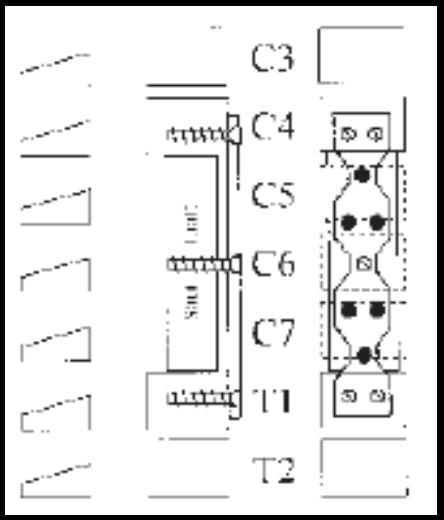
J Neurosurg (Spine 1) 99:98–103, 2003

Biomechanical analysis of multilevel cervical corpectomy and plate constructs

RANDALL W. PORTER, M.D., NEIL R. CRAWFORD, PH.D., ROBERT H. CHAMBERLAIN, B.S.E., SUNG CHAN PARK, M.D., PAUL W. DETWILER, M.S., M.D., PAUL J. APOSTOLIDES, M.D., AND VOLKER K. H. SONNTAG, M.D.

Division of Neurological Surgery and Spinal Biomechanics Research Laboratory, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona; Tyler Neurosurgical Group, Tyler, Texas; and Orthopedic & Neurological Surgery, Greenwich, Connecticut

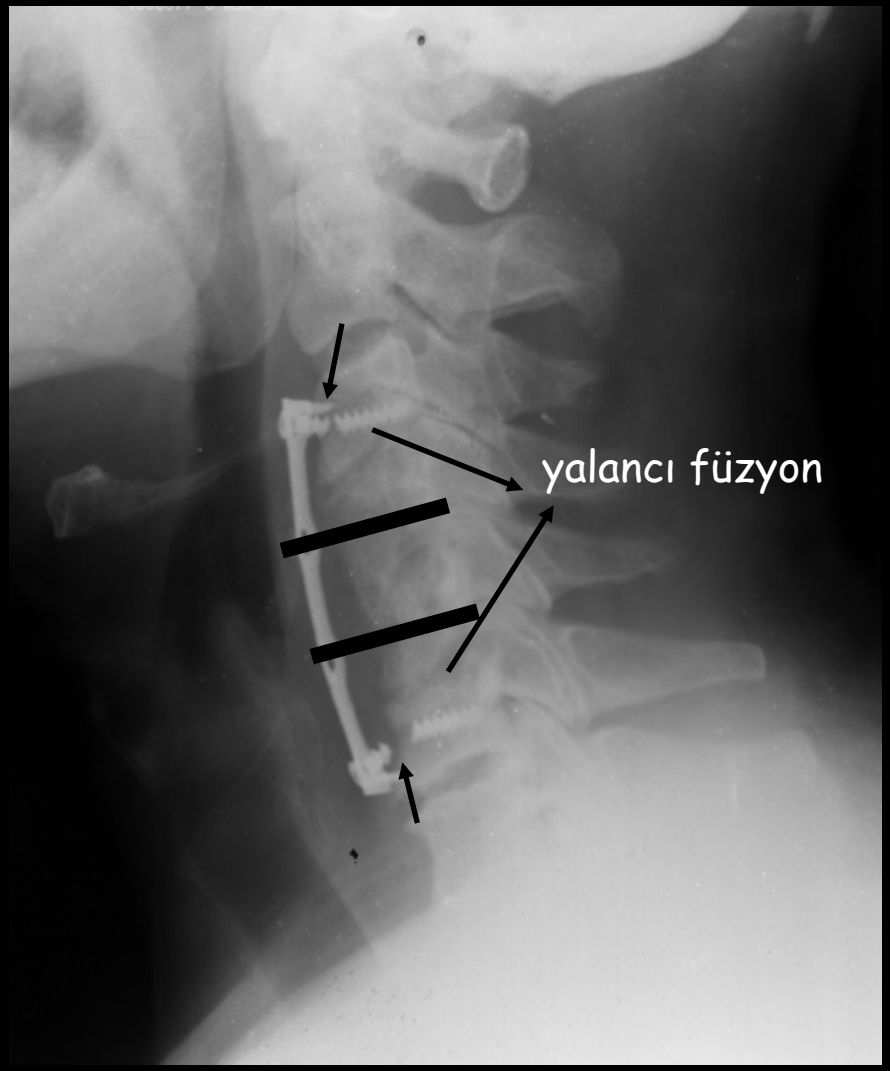
- Üç mesafe korpektomide greftin vida ile fiksasyonu özellikle fleksiyon ve dışyana hareketi kısıtlıyor



Uzun plakta yetersiz fiksasyon



Erken postop.



Geç postop.

3 kolon hasarı

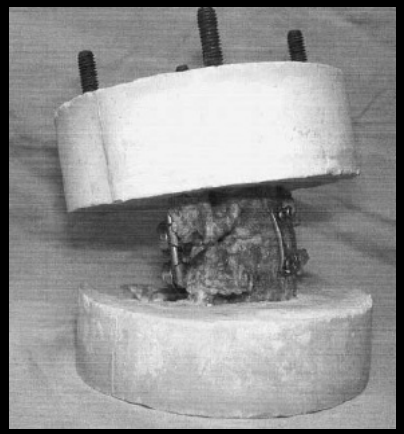
J Neurosurg (Spine 1) 99:84–90, 2003

Anterior cervical plate fixation: biomechanical effectiveness as a function of posterior element injury

TOBIAS PITZEN, M.D., CHRIS LANE, M.ENG., DARRELL GOERTZEN, M.SC., MARCEL DVORAK, M.D., CHARLES FISHER, M.D., DRAGOS BARBIER, M.D., WOLF-INGO STEUDEL, M.D., PH.D., AND THOMAS OXLAND, PH.D.

Department of Neurosurgery, University of Saarland, Homburg, Germany; Division of Orthopaedic Engineering Research, Departments of Orthopaedics and Mechanical Engineering, University of British Columbia; and Division of Spinal Surgery, Department of Orthopaedics, Vancouver General Hospital, Vancouver, Canada

- Üç kolon hasarında yalnızca anterior servikal plak yeterli stabilizasyon sağlamıyor

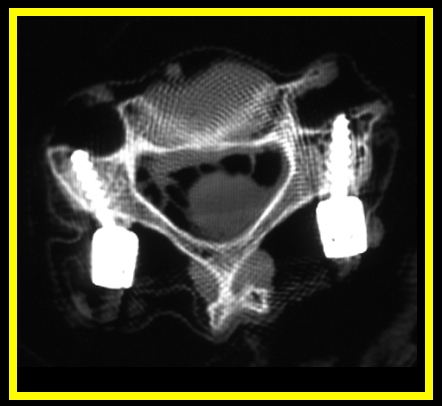


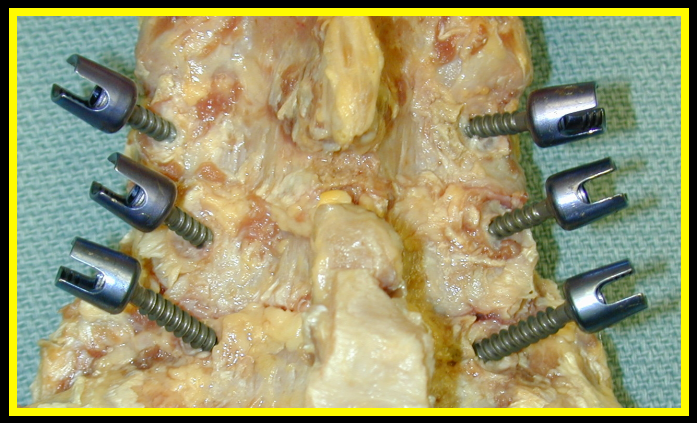
Posterior Servikal Stabilizasyon

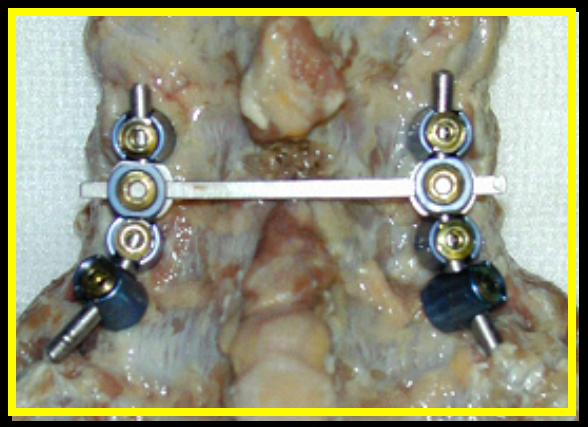
Posterior Servikal Fiksasyon

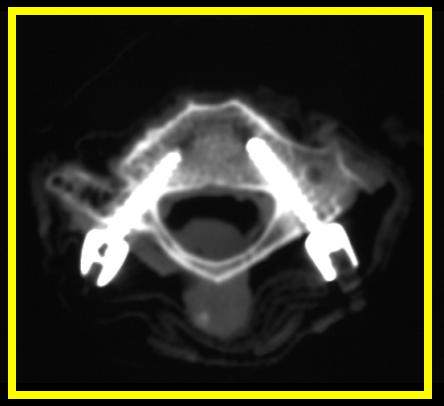








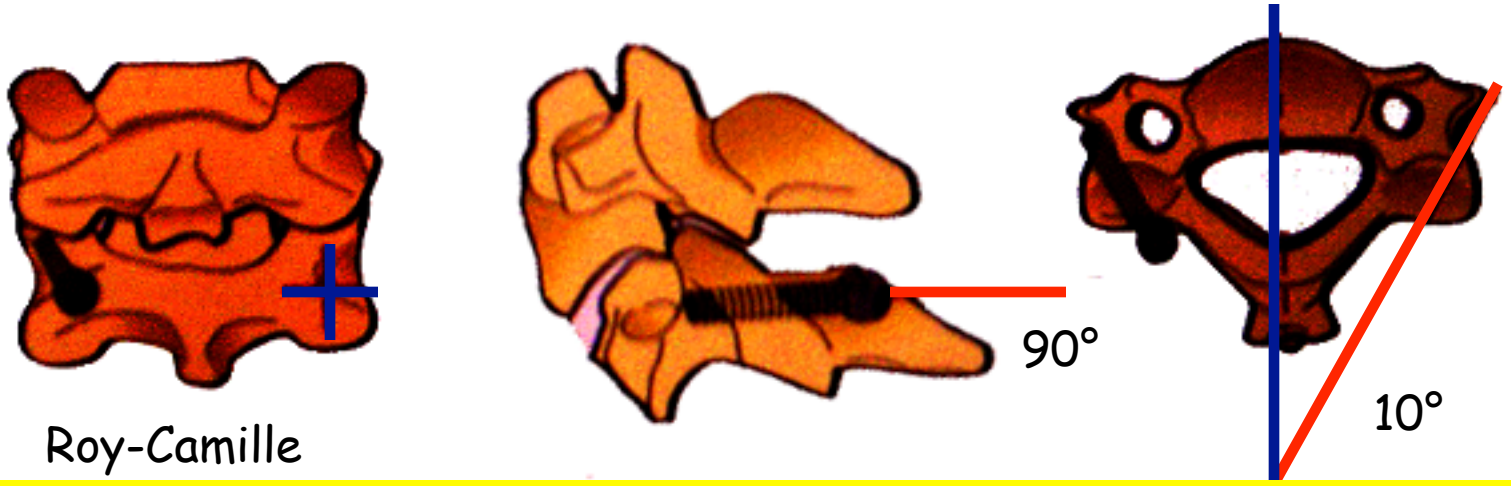




Vertex, Medtronic Sofamor Danek

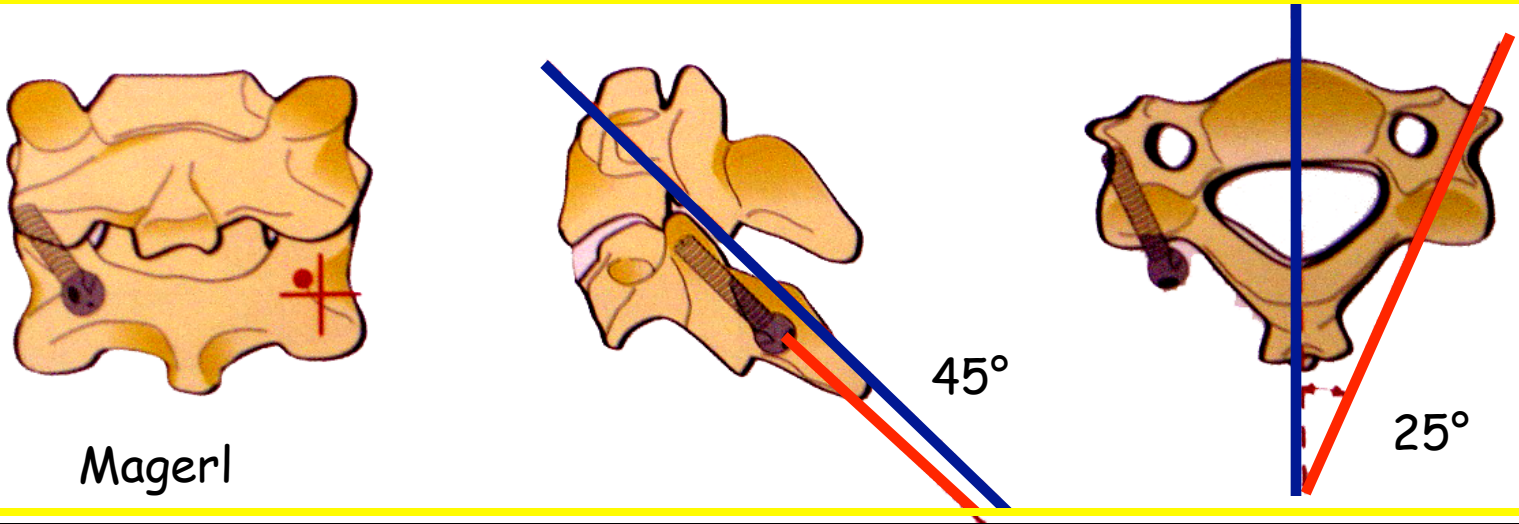
Lateral Mass Vida Uygulaması

1972



Roy-Camille

1991



Magerl

Lateral Mass Vida Pullout Dayanımı

En büyük pullout direnç	Uygulama şekli	Dayanım
3.5 mm kortikal vida	Bikortikal	448±253 N
Orta derece pullout direnç		
2.7 mm kortikal vida	Bikortikal	321±223 N
3.5 mm kortikal vida	Unikortikal	289±231 N
3.5 mm spongioz vida	Unikortikal	277±126 N
En düşük pullout direnç		
3.5 mm self-tapping vida	Bikortikal	236±124 N
3.5 mm self-tapping vida	Unikortikal	216±166 N

Heller ve ark., JBJS 1996

Lateral Mass Vida Uygulamaları

Roy-Camille	vida pullout	152 N
Magerl	vida pullout	585 N

Roy-Camille	vida pullout	471 N
Magerl	vida pullout	607 N

Magerl Tekniği > Roy-Camille Tekniği

Montesano ve ark., Spine 1991
Errico ve ark., J Spinal Disord 1992

Lateral Mass Vida Uygulaması

Roy-Camille (266±124 N) ve Magerl (231±94 N) uygulamaları arasında vida pullout yönünden çok büyük farklılık bulunmamaktadır.

- Roy-Camille C3-4' de %23 daha dayanıklı.
- C5-6' da Roy-Camille ve Magerl aynı dayanımda.

Magerl Tekniği = Roy-Camille Tekniği

Barrey ve ark., J Neurosurg 2004

Lateral mass vida dayanımı ?

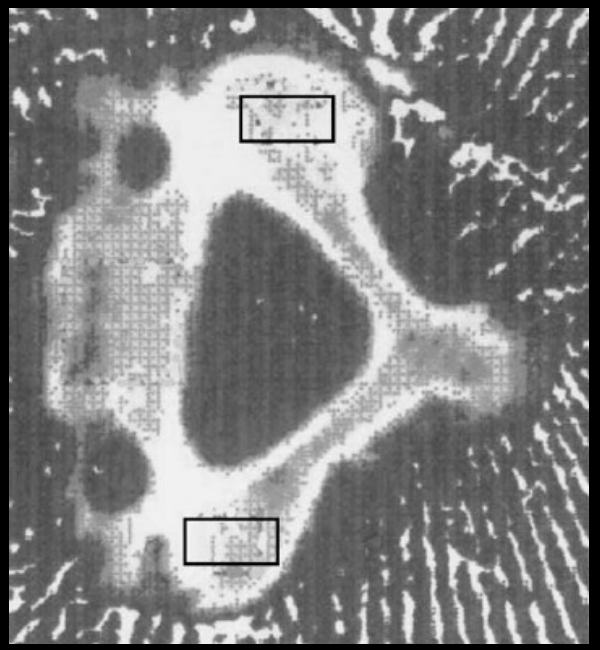
Eur Spine J (2004) 13 : 524–529
DOI 10.1007/s00586-004-0685-5

ORIGINAL ARTICLE

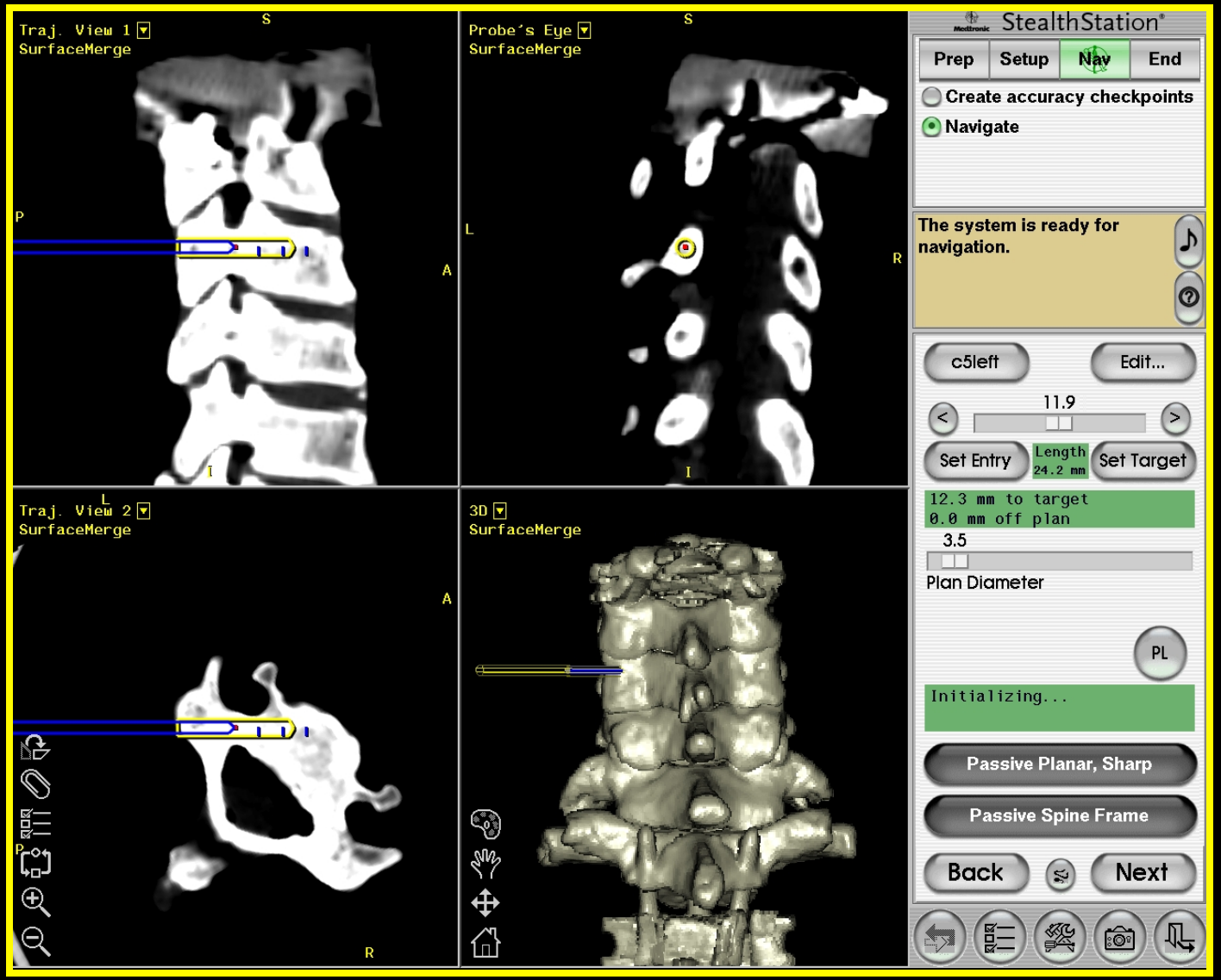
T. R. Pitzen
S. Zenner
D. Barbier
T. Georg
W. I. Steudel

Factors affecting the interface of cervical spine facet screws placed in the technique by Roy-Camille et al.

- Kemik mineral dansitesi dayanımı artırıyor
- PMMA uygulaması dayanımı artırıyor
- Kemikte açılan yolun uzunluğunun önemi yok



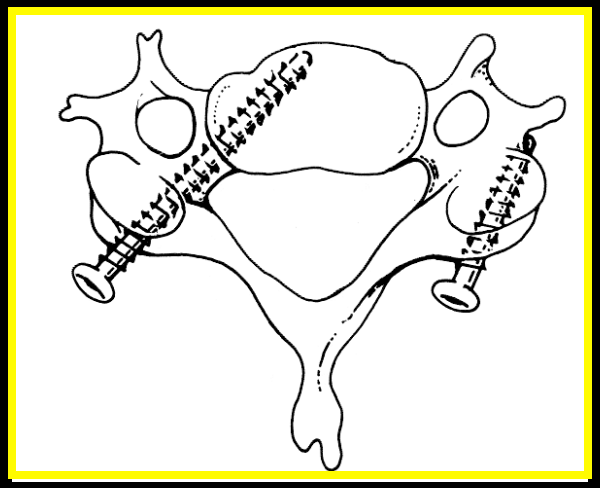
Servikal Pedikül Vida Uygulaması

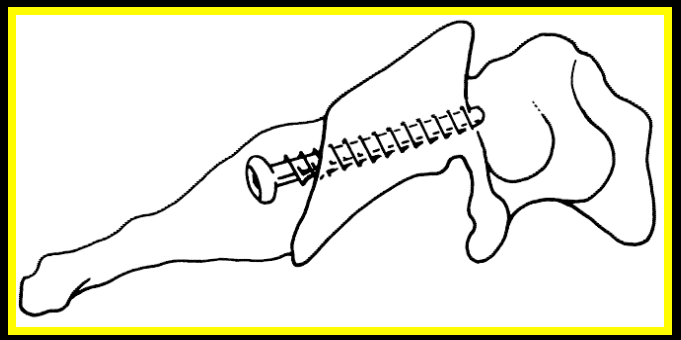


Lateral mass ? Pedikül vidası ?

- Lateral mass vida pullout 355 N
  - 3.5 mm bikortikal (Ann tekniği)

- Pedikül vida pullout 677 N
  - 3.5 mm unikortikal





Jones ve ark, Spine 1997

Servikal Pedikül Vida Uygulaması





C5-6-7 mesafesi- üç kolon hasarı olan durumlarda pedikül vida/rod sisteminin stabilizasyon yönünden pedikül vidası- lateral mass vidası/rod kombine sistemine belirgin bir üstünlüğü bulunmamaktadır.

Bozkuş ve ark, Spine 2005

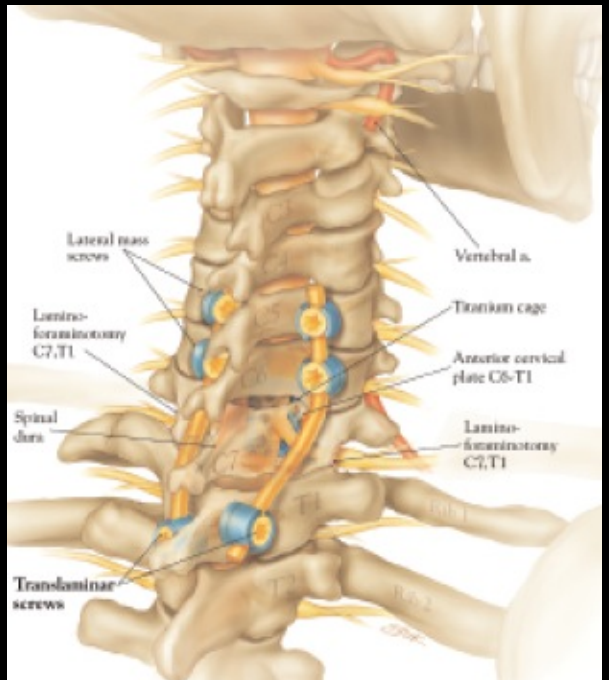
Translaminar fiksasyon

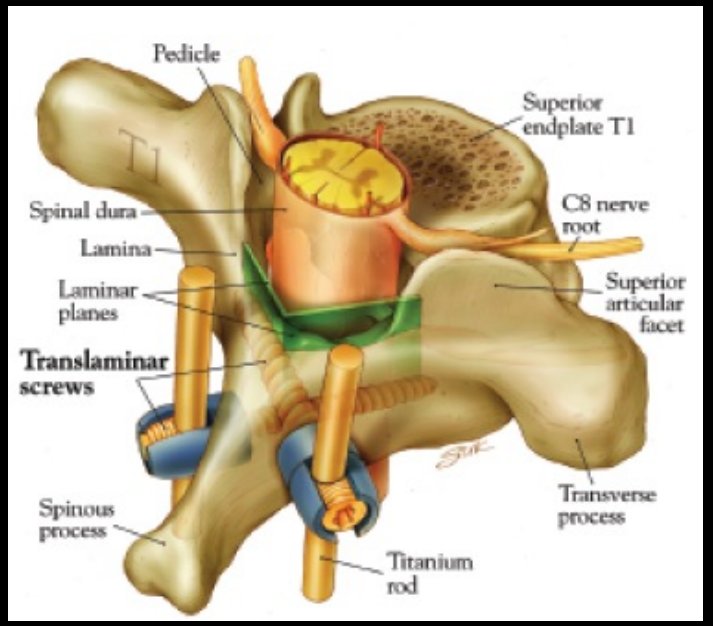
J Neurosurg Spine 5:527–533, 2006

Translaminar screw fixation in the upper thoracic spine

RYAN M. KRETZER, M.D., DANIEL M. SCIUBBA, M.D., CARLOS A. BAGLEY, M.D., JEAN-PAUL WOLINSKY, M.D., ZIYA L. GOKASLAN, M.D., AND IRA M. GARONZIK, M.D.

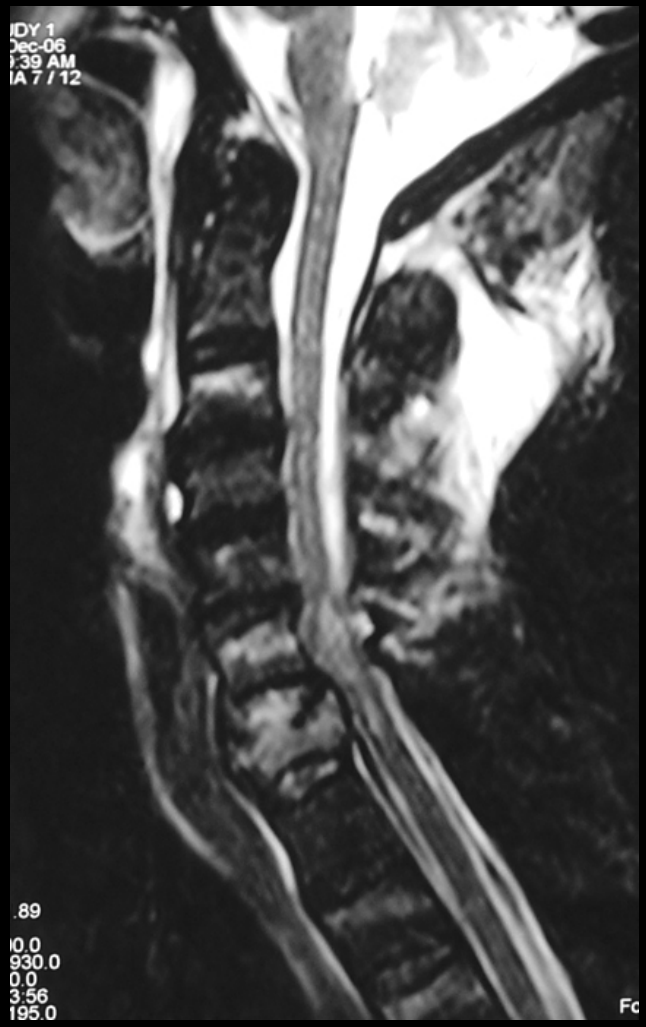
Department of Neurosurgery, The Johns Hopkins University School of Medicine, Baltimore, Maryland





Servikotorakal bileşke travmaları





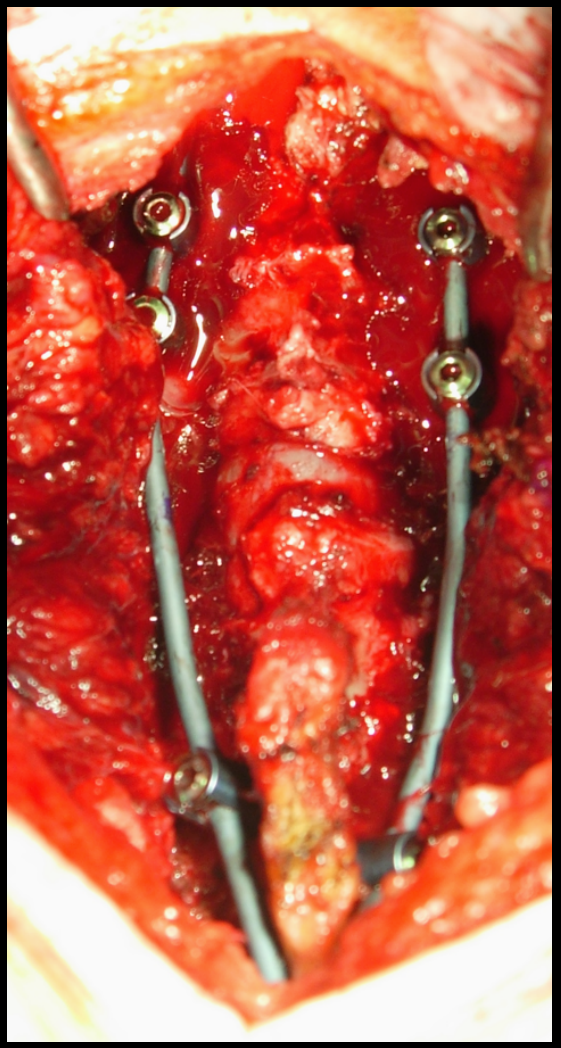
Stabilizasyon ?

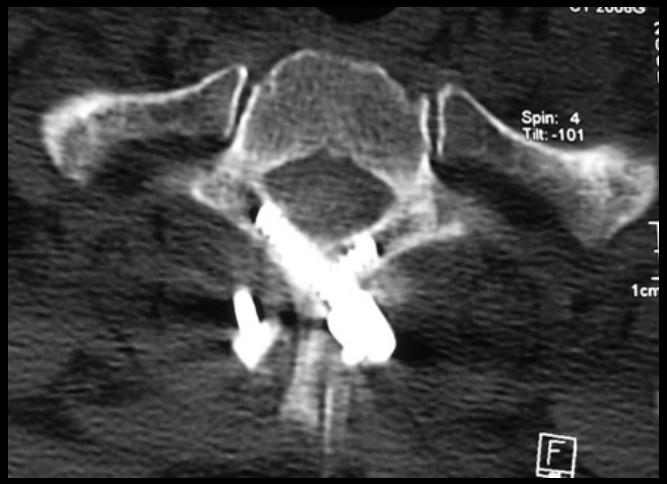


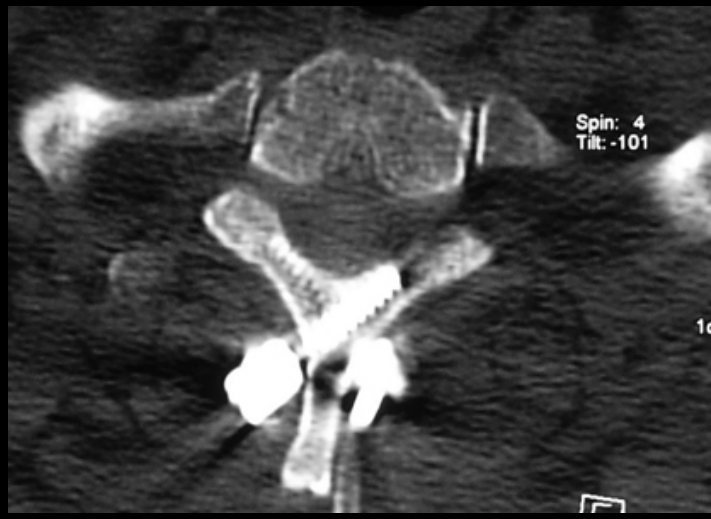


Translaminar vida

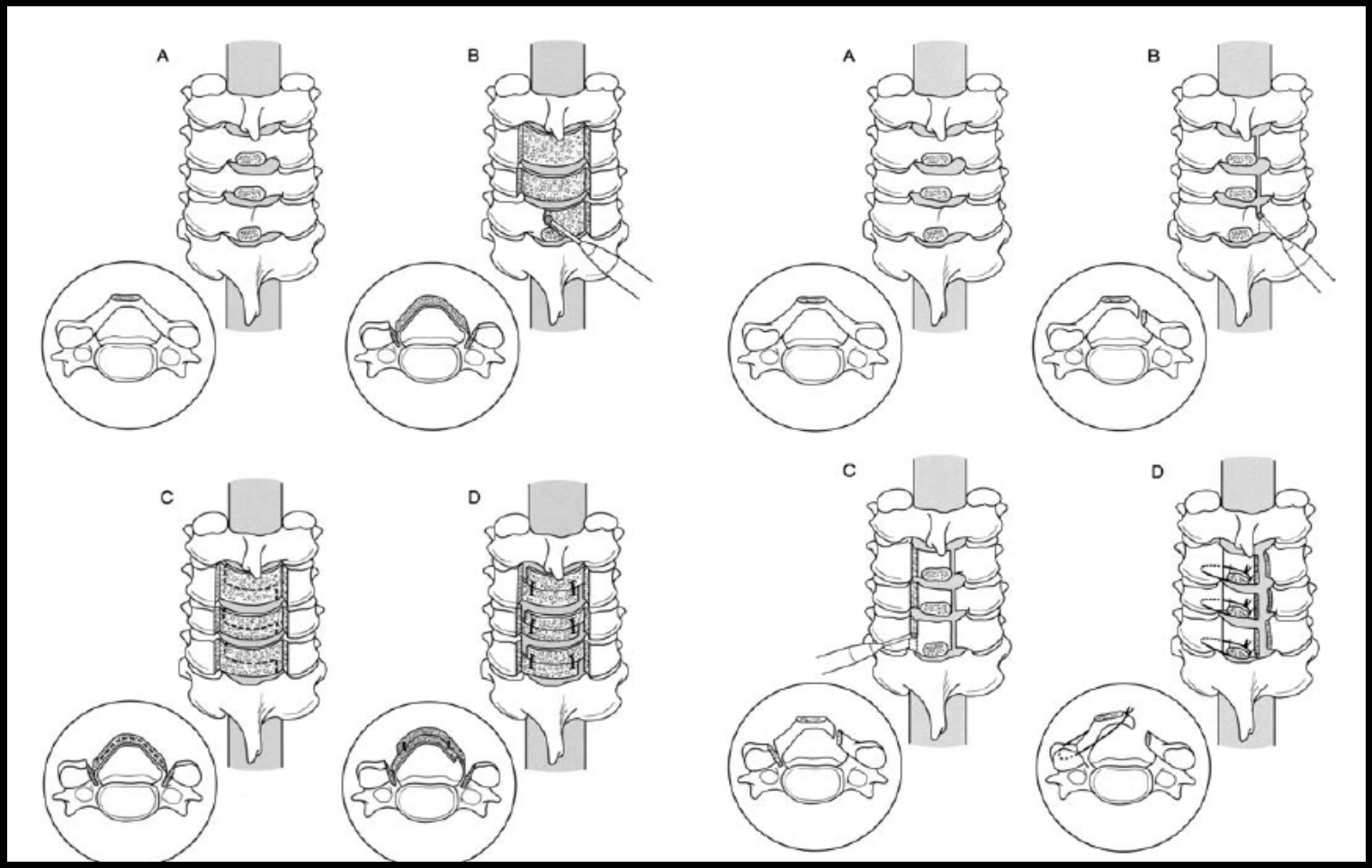








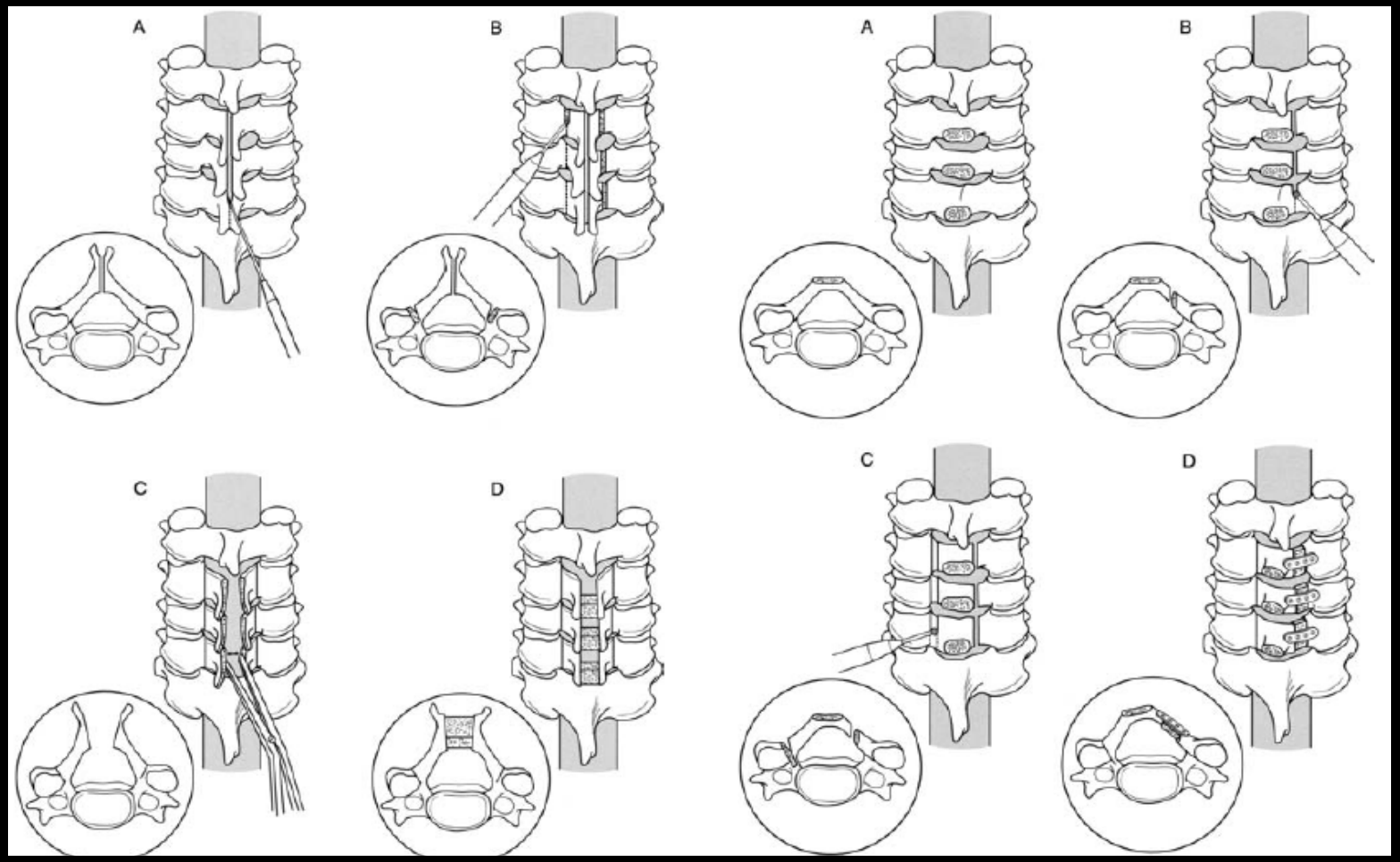
Laminoplasti



Orjinal laminoplasti

Hirabayashi laminoplasti

Laminoplasti



Kurokawa laminoplasti
Tomita-Morimoto laminoplasti

Shaffrey laminoplasti

Laminoplasti

J Neurosurg (Spine 3) 98:230–238, 2003

Cervical laminoplasty: a critical review

JOHN K. RATLIFF, M.D., AND PAUL R. COOPER, M.D.

Department of Neurosurgery, Rush-Presbyterian-St. Luke's Medical Center and Chicago Institute of Neurosurgery and Neuroresearch, Chicago, Illinois; and Department of Neurosurgery, New York University School of Medicine, New York, New York

- Laminoplastinin laminektomiye klinik ve biyomekanik bir üstünlüğü yok

Servikal laminoplasti ?

J Neurosurg Spine 6:386–390, 2007

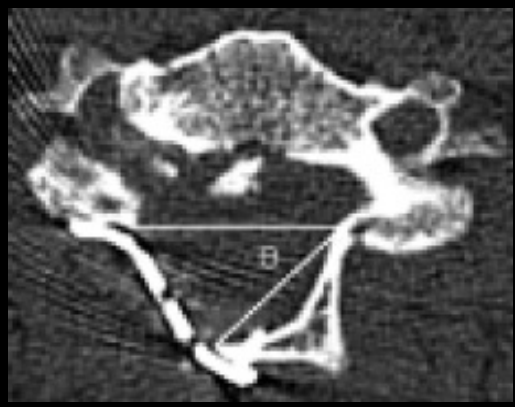
Postlaminoplasty cervical range of motion: early results

SUK-HYUNG KANG, M.D., SEUNG-CHUL RHIM, M.D., SUNG-WOO ROH, M.D.,
SANG-RYONG JEON, M.D., AND HYUN-CHUL BAEK, M.D.

Department of Neurological Surgery, University of Ulsan College of Medicine, Asan Medical Center, Seoul, Korea

- Hirabayashi tipi tek teraflı laminoplasti hareket aralığını klinik olarak azaltıyor



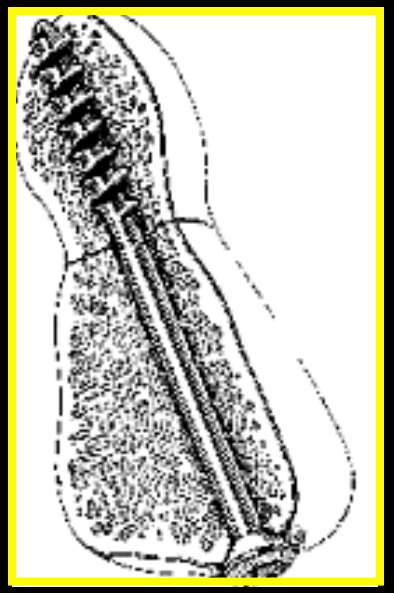


Özellikli Servikal Stabilizasyon

Odontoid Vida Fiksasyonu

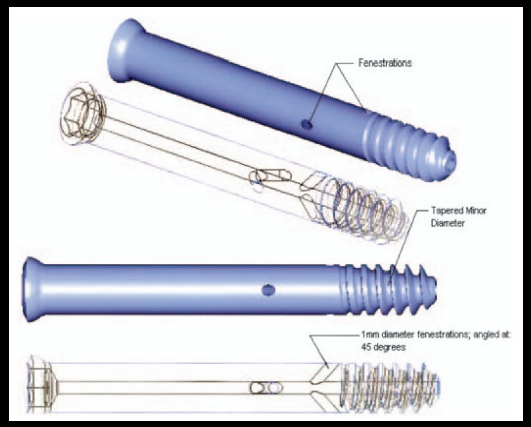
- İki vidanın bir vidaya göre klinik ve biyomekanik üstünlüğü yok.



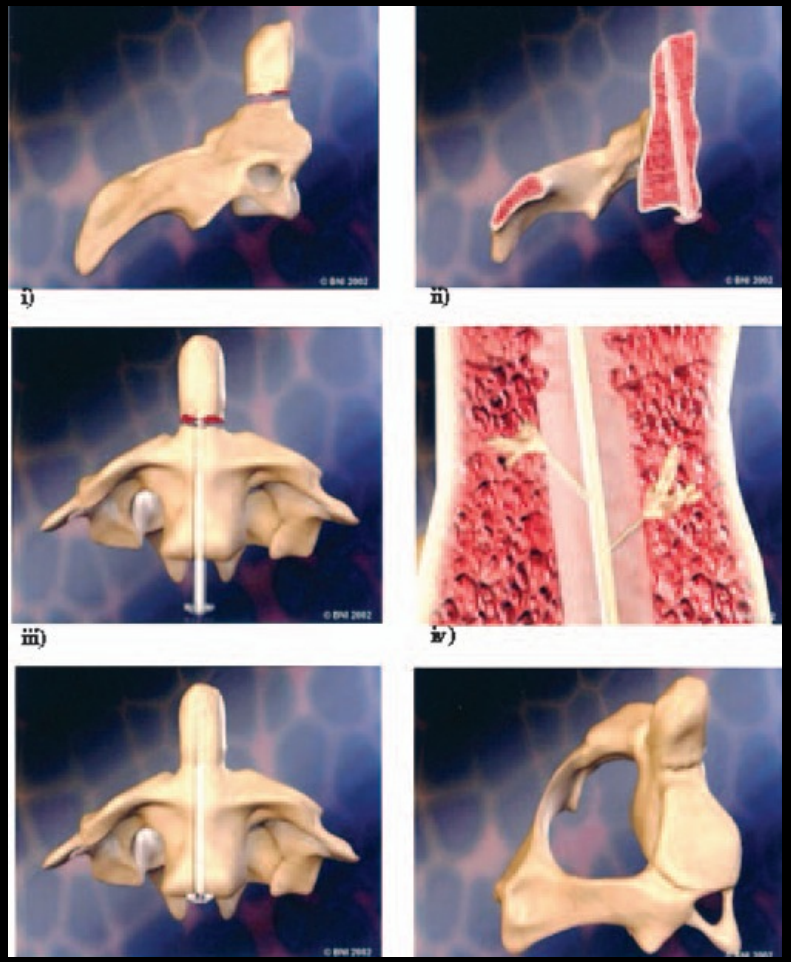


Jenkins ve ark., J Neurosurg 1998
McBride ve ar., Spine 1995
Sasso ve ark., Spine 1993
Özer ve ark., The Journal of Turkish Spine Surg 1998

Absorbe olabilen odontoid vida



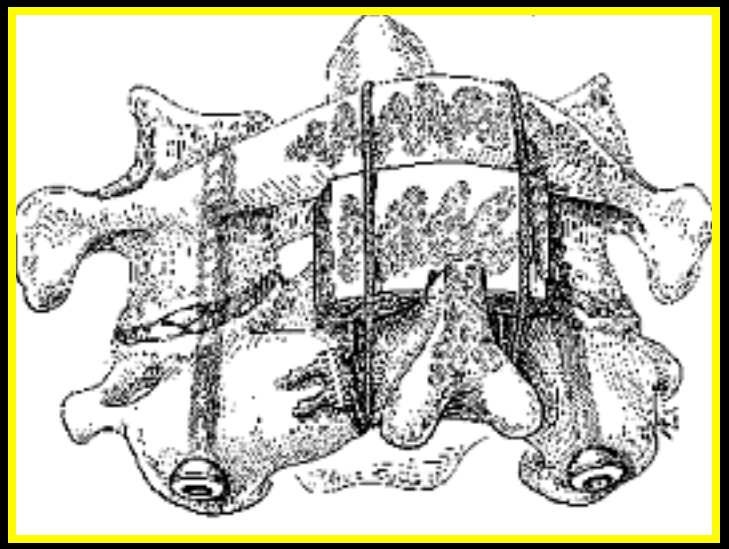
- Titanyum ve absorbe olabilen vida odontoid vidalarında benzer stabilizasyon sağlıyor
- Absorbe olabilen vida dayanımı azalınca kırılma yerine eğilme şeklinde cevap veriyor



Ames CP, J Neurosurg Spine, 2005

Posterior C1-2 Fiksasyon

- C1-2 kemik greft-tel fiksasyonuna transartikuler vida eklenmesi ile aksiyal rotasyon ve lateral bending daha çok önlenmiş olmaktadır.



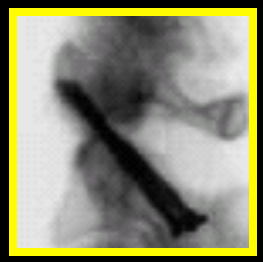
Marcotte ve ar., J Neurosurg 1993
Naderi ve ark., Spine 1998

Anterior- Posterior C1-2 Fiksasyonu

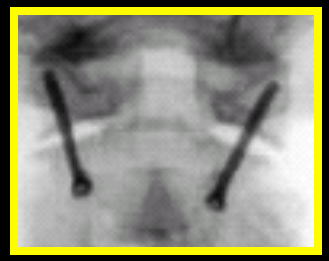
- Posterior C1 LM, C2 pedikül vida fiksasyonu



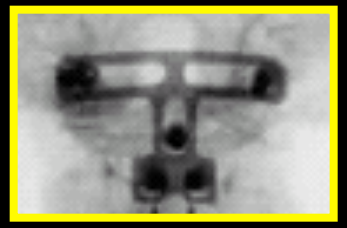
- Posterior C1-2 transartikuler fiksasyon



- Anterior C1-2 transartikuler vida fiksasyonu



- Anterior C1-2 plak fiksasyonu



Kim ve ark., J Neurosurg (Spine) 2004

C1-2 fiksasyon

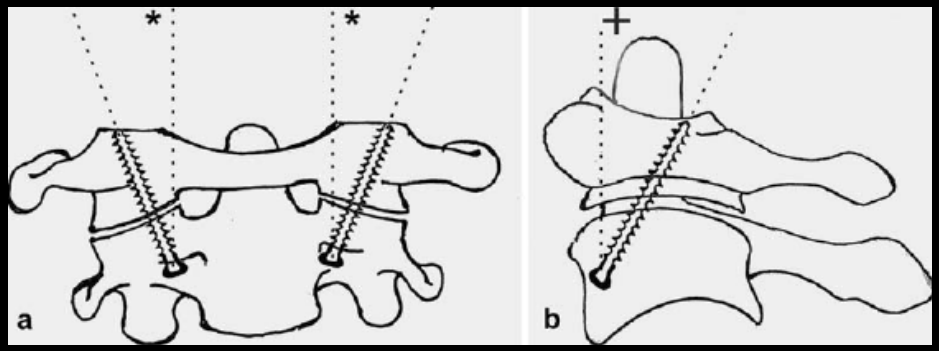
Eur Spine J (2005) 14: 512–518
DOI 10.1007/s00586-004-0823-0

TECHNICAL INNOVATION

Milan K. Sen
Thomas Steffen
Lorne Beckman
Anthony Tsantrizos
Rudolph Reindl
Max Aebi

Atlantoaxial fusion using anterior transarticular screw fixation of C1–C2: technical innovation and biomechanical study

- Posterior transartikular vida gibi stabilizasyon sağlıyor
- Posterior vida + interlaminar telleme özellikle fleksiyon/ ekstansiyonda daha stabil



Absorbe olabilen servikal plak

J Neurosurg Spine 3:465–470, 2005

Biomechanical analysis of a newly designed bioabsorbable anterior cervical plate

Invited submission from the Joint Section Meeting on Disorders of the Spine and Peripheral Nerves, March 2005

CHRISTOPHER P. AMES, M.D., FRANK L. ACOSTA JR., M.D., ROBERT H. CHAMBERLAIN, M.S., ADOLFO ESPINOZA LARIOS, M.D., AND NEIL R. CRAWFORD, PH.D.

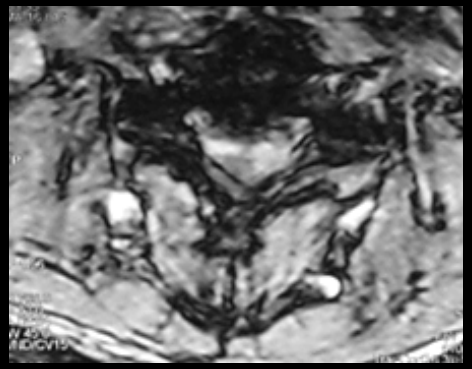
Department of Neurological Surgery, University of California, San Francisco, California; and Spinal Biomechanics Research Laboratory, Barrow Neurological Institute, Phoenix, Arizona

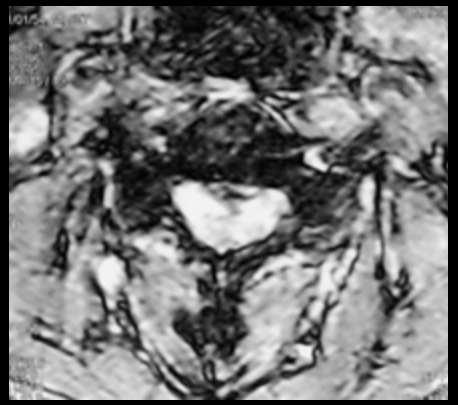
- Tek mesafe diskektomide yeterli stabilizasyon sağlıyor



Yeniliklere açık olmalıyız ?

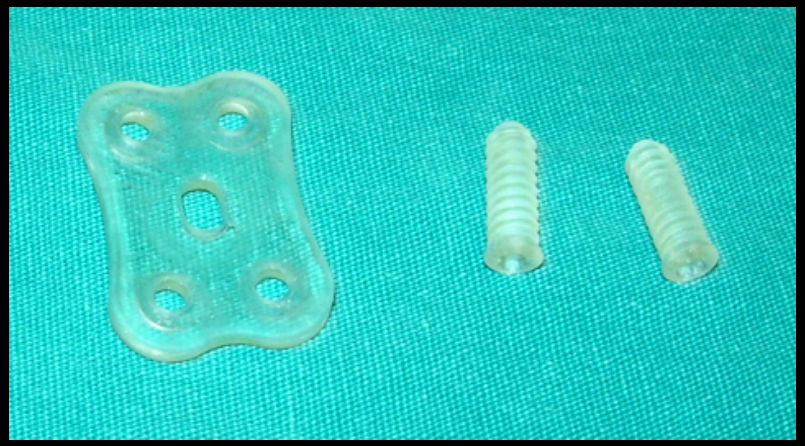


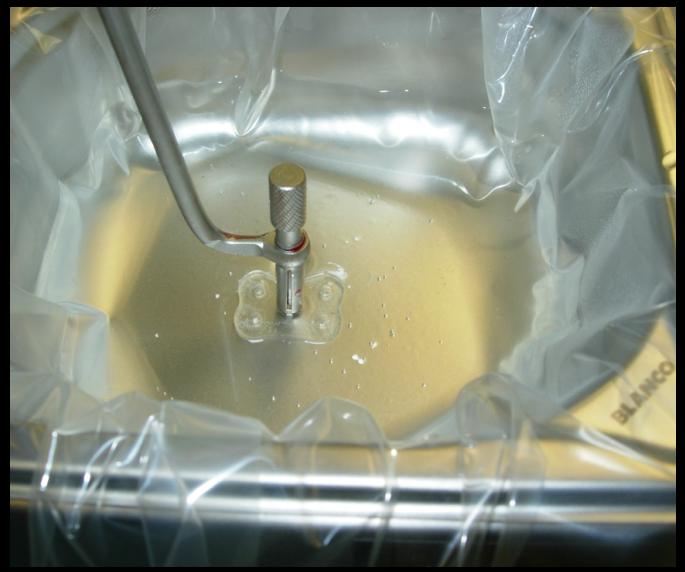


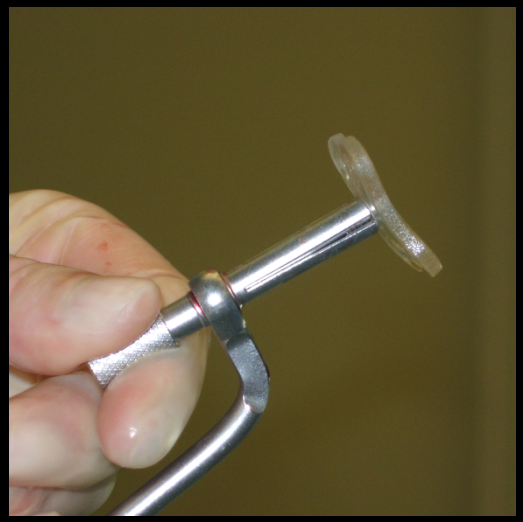


C3-4

Absorbe olabilen servikal plak







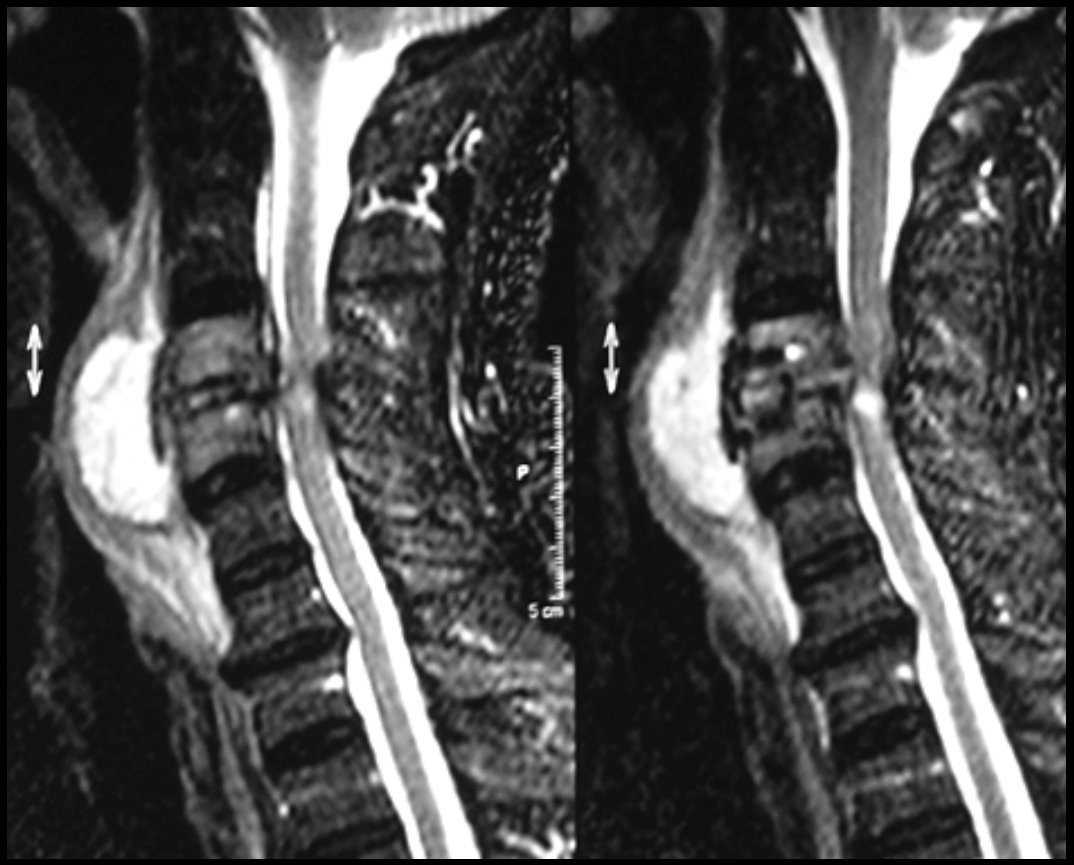
Perop. ve Postop 1.gün

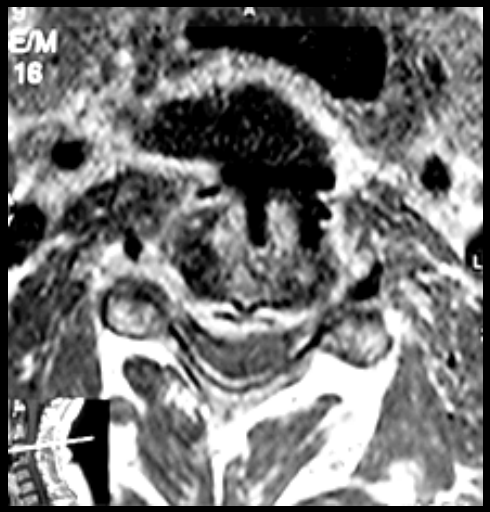




Postop 1.hafta

KÜLTÜR NEGATİF, AŞIRI İMMUN REAKSİYON ?

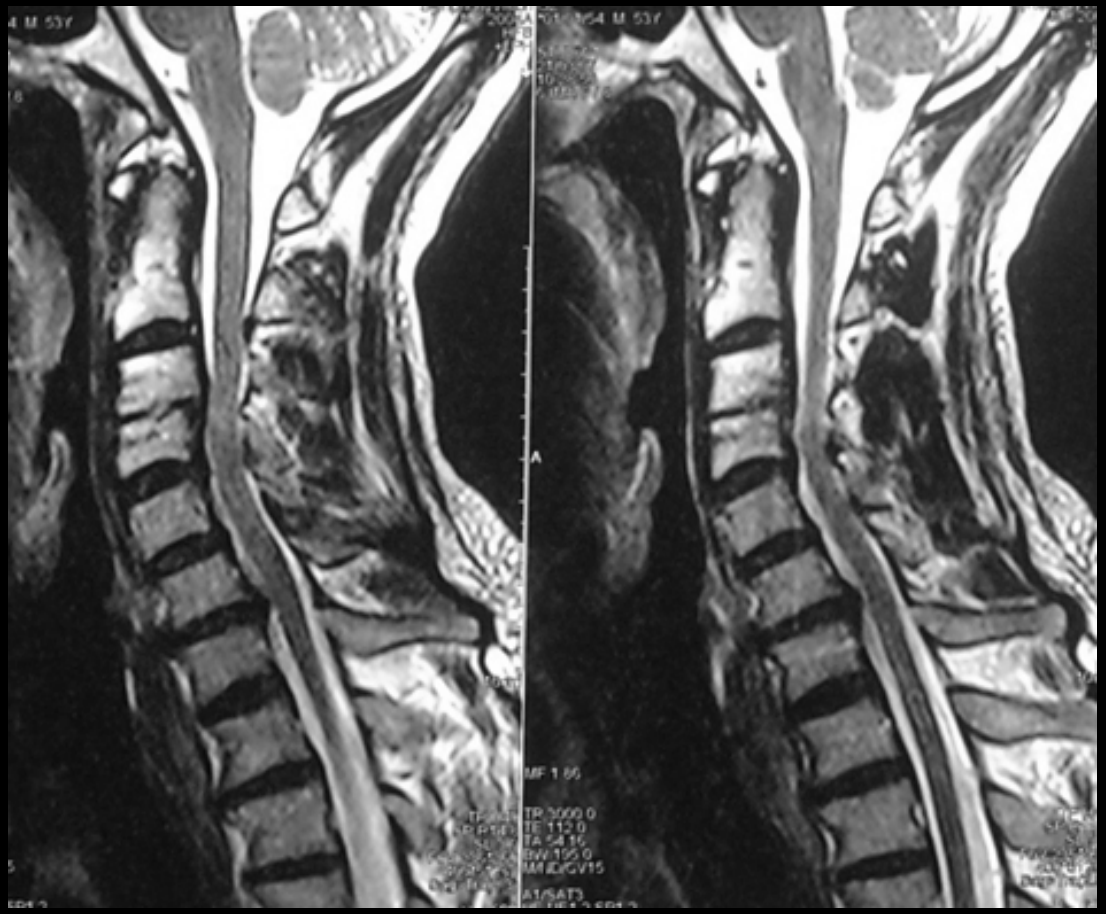


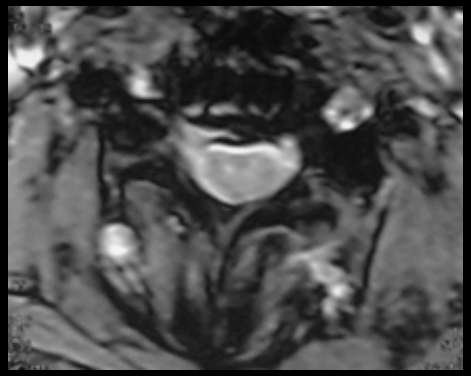


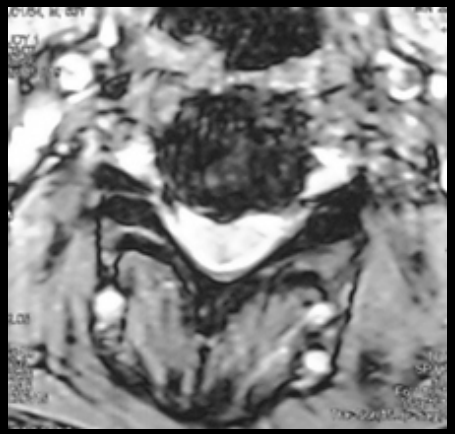


Tetraparezi ve disfaji

2.Postop 3.ay









Teşekkür ederim