

Omurga Kinematiđi ve Biyomekanik Kavramlar

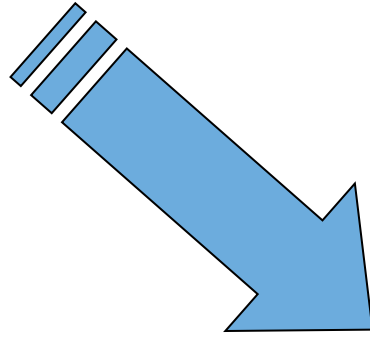
Dr.Hakan BOZKUŞ

Omurga Sorunları Çözümü ?

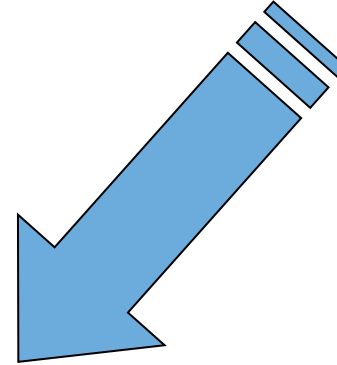
1. Deneysel uygulama sonuçları
2. Klinik uygulama sonuçları

Deneysel Çözüm

MÜHENDİSLİK



TIP



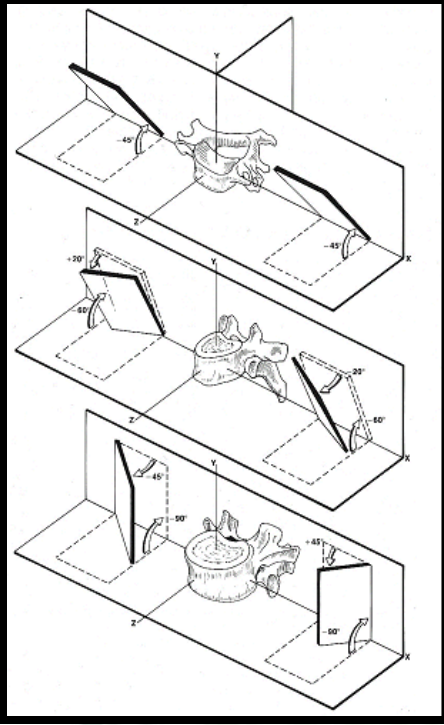
BİYOMEKANİK

Omurga Biyomekanik Davranışı

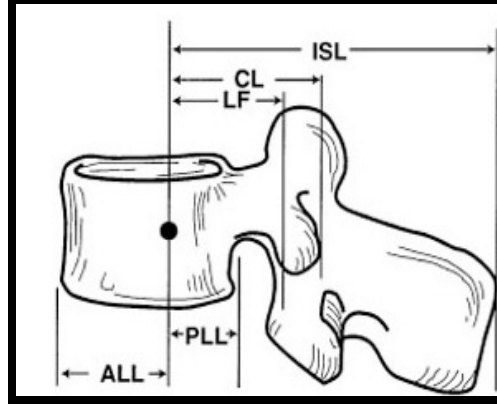


- Hareket aralığı (ROM)
- Rotasyonun anlık eksenini (IAR)
- Yük/Deformasyon Eğrisi
- Stabilite
 - Cerrahi
 - Fiksasyon

Hareketi Sağlayan Yapılar



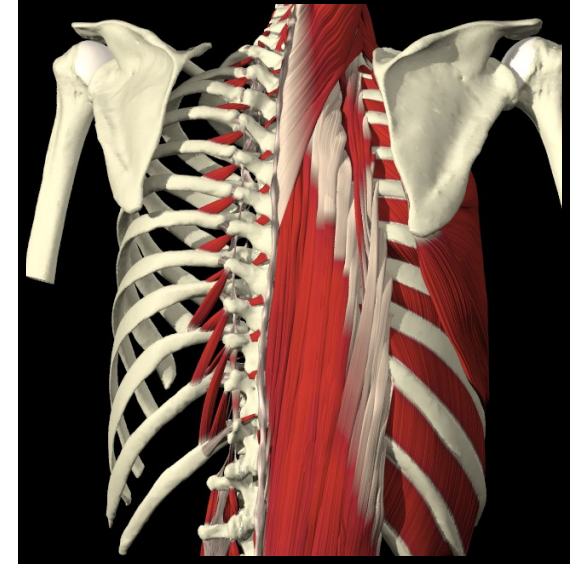
Fasetler



Ligamanlar

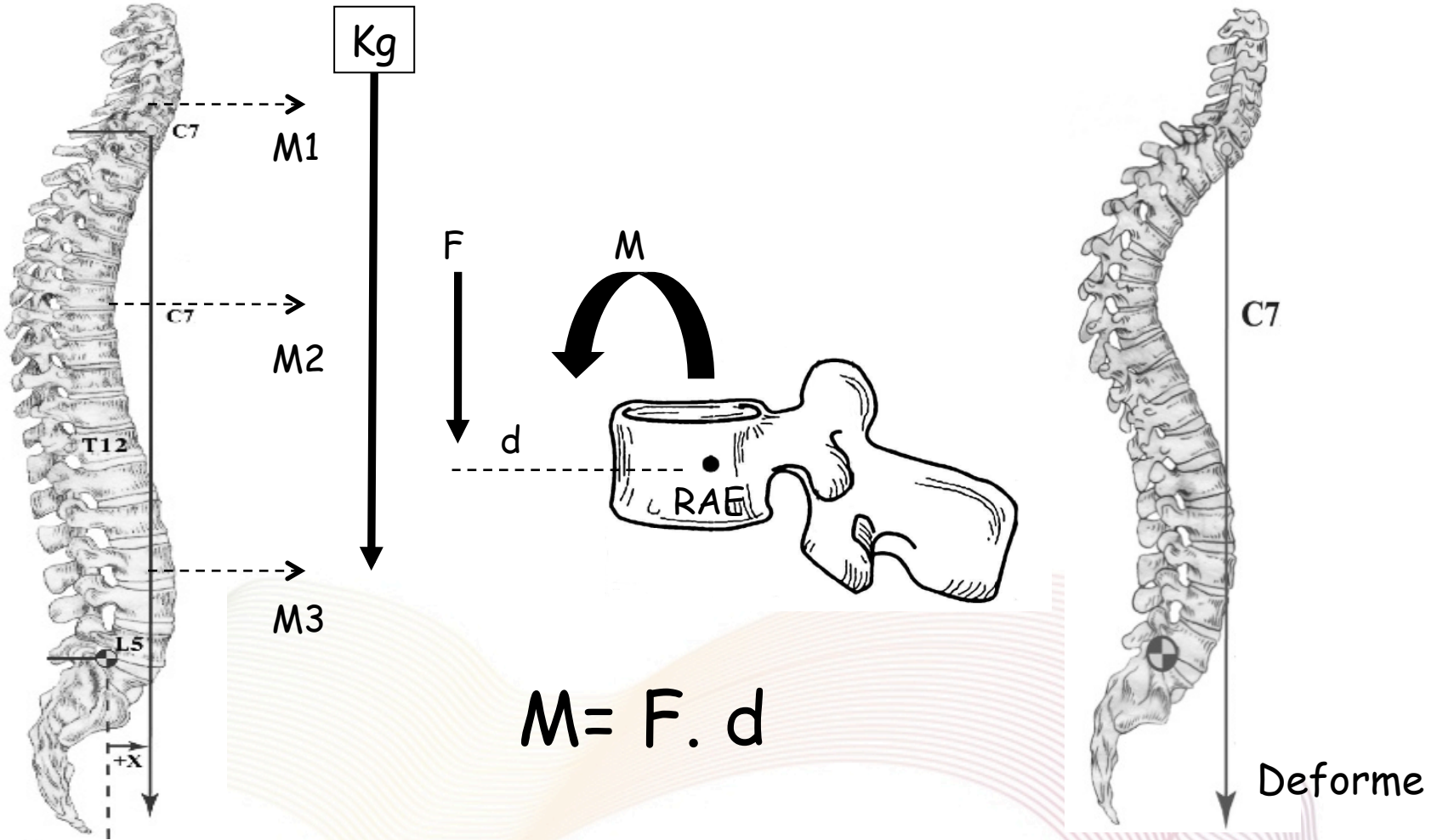


İntervertebral disk

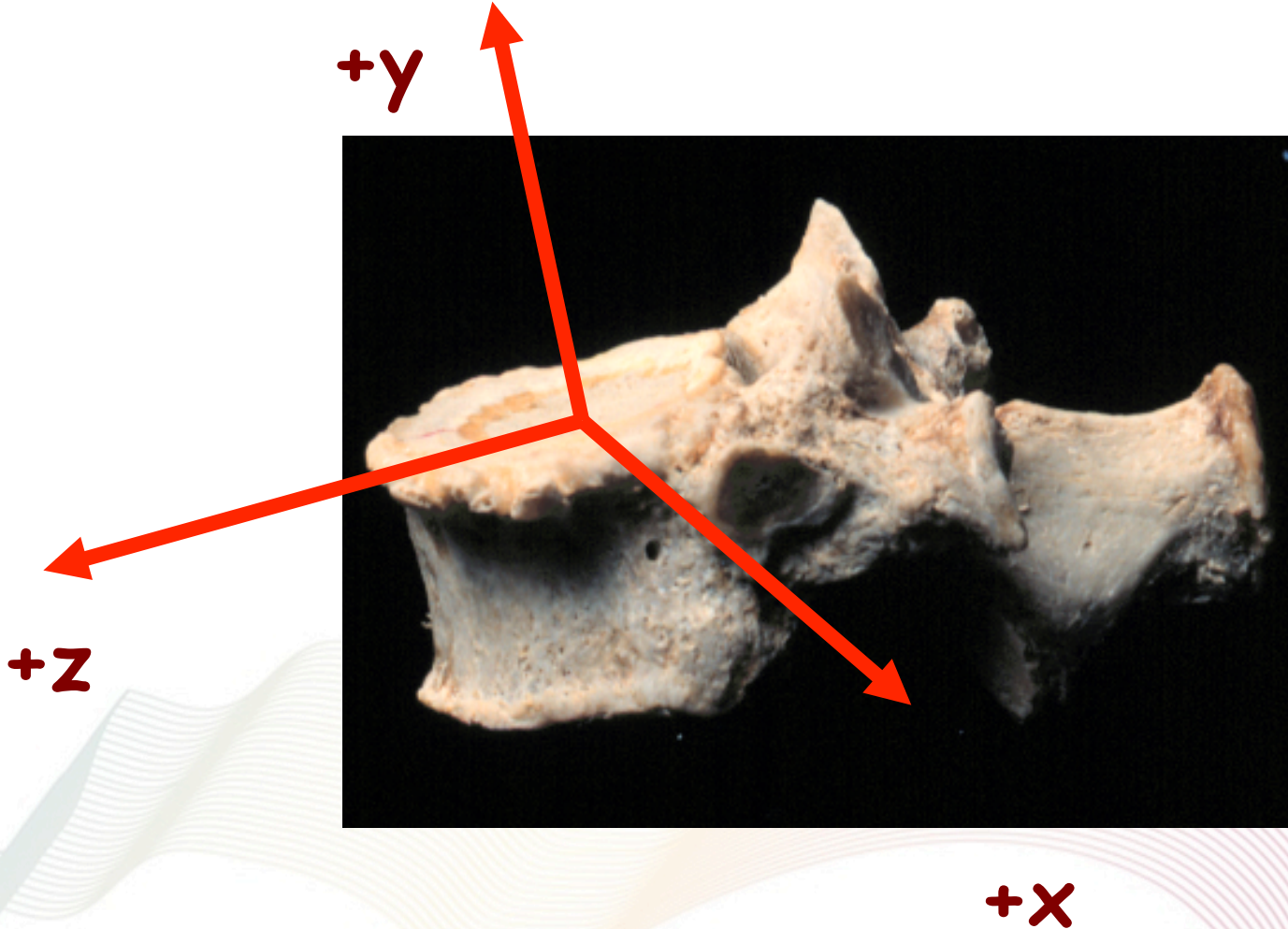


Adaleler

Moment



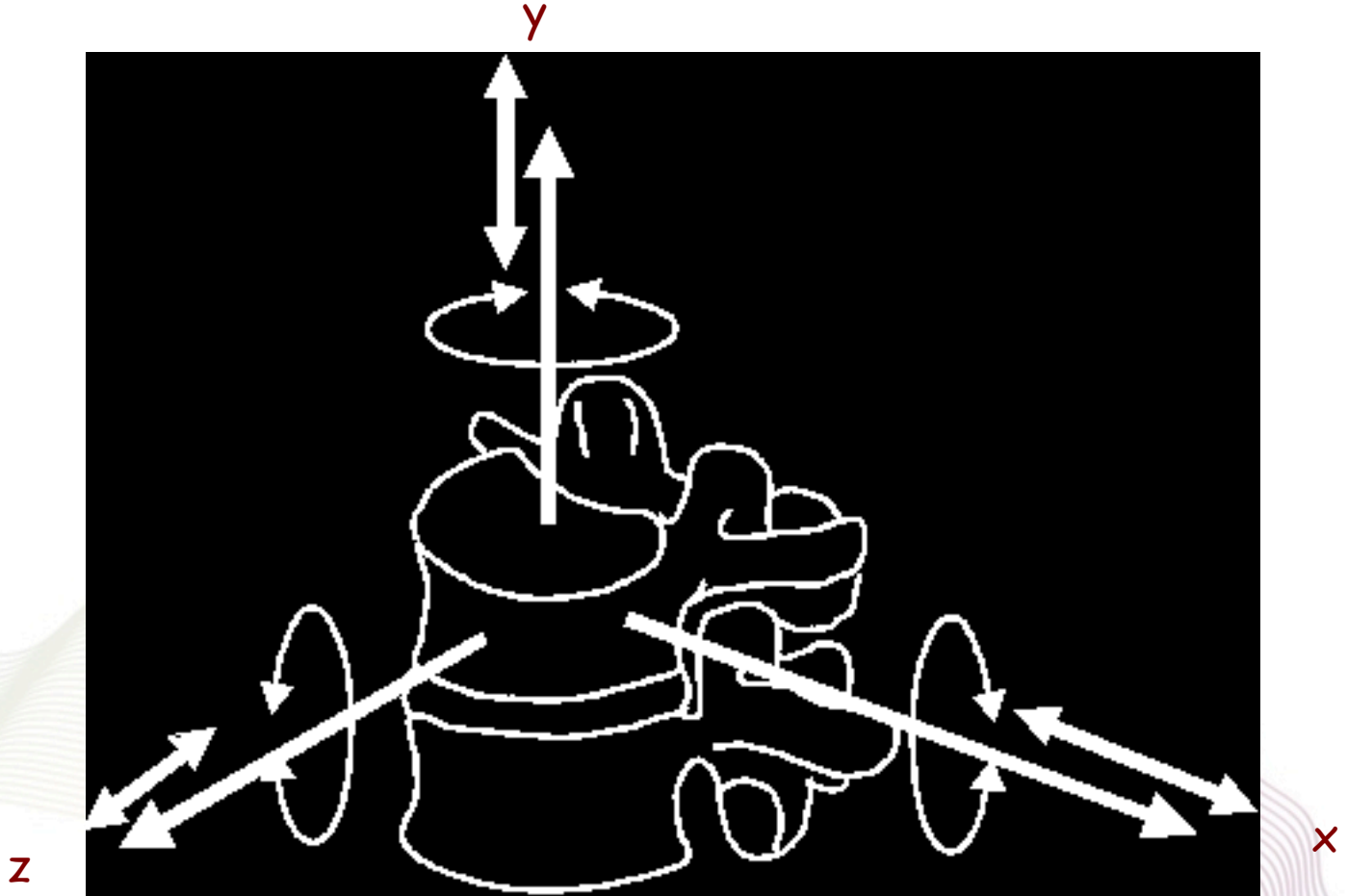
Pozitif Eksen Takımı



Panjabi, 1978

Hareket Serbestliđi

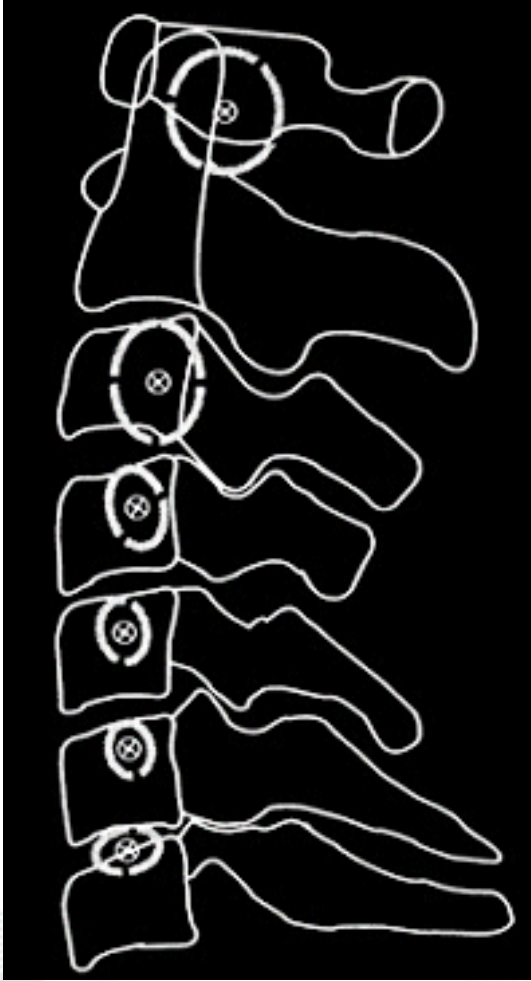
6 yönde hareket serbestliđi



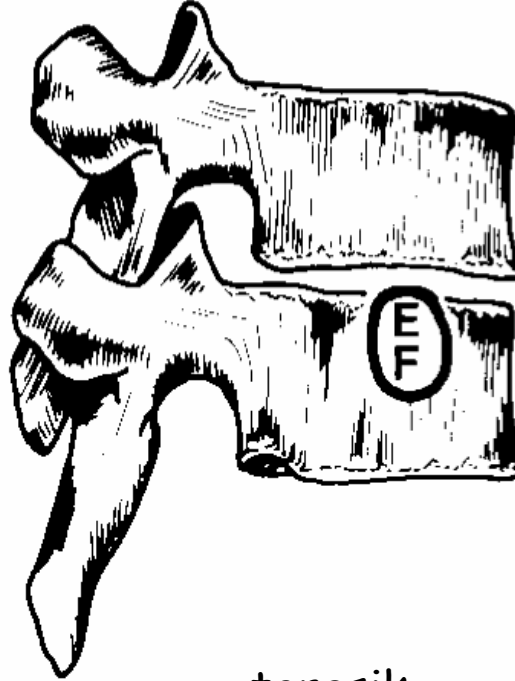


Rotasyonun Anlık Ekseni (RAE)

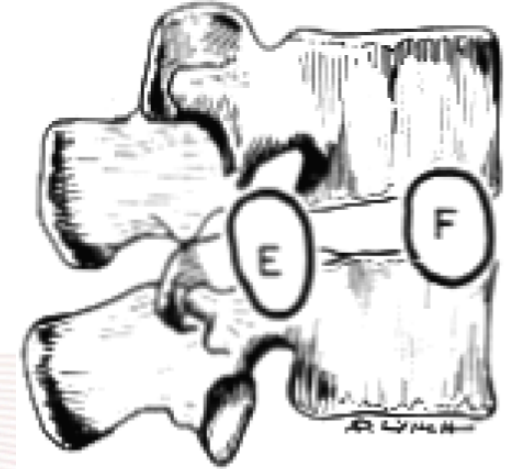
Sagittal plan



servikal

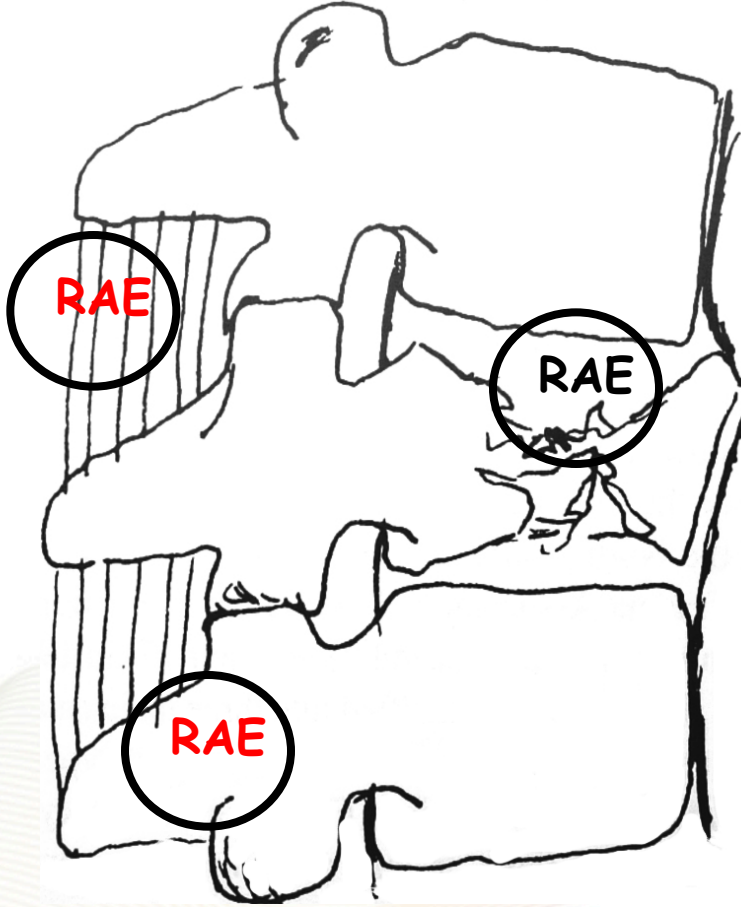


torasik



lomber

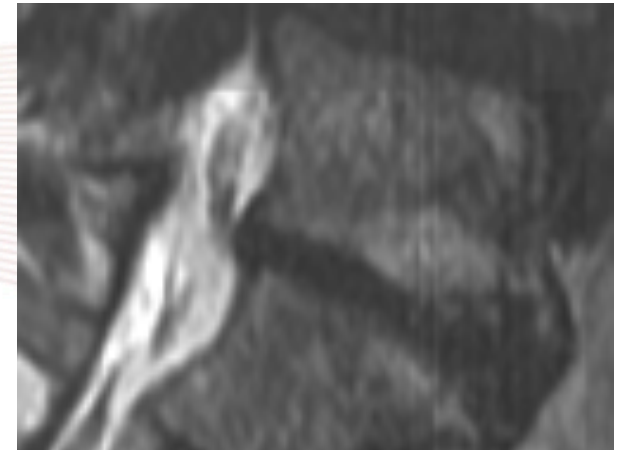
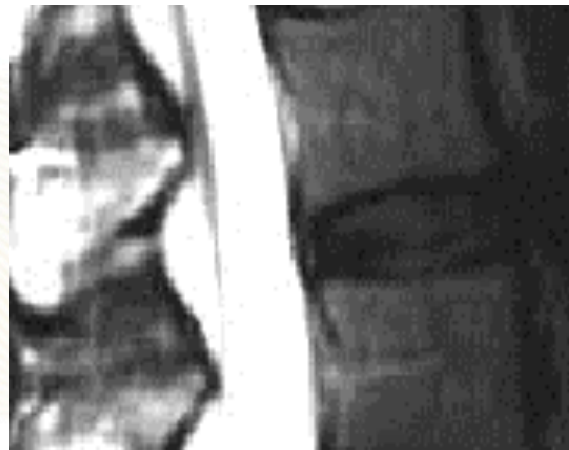
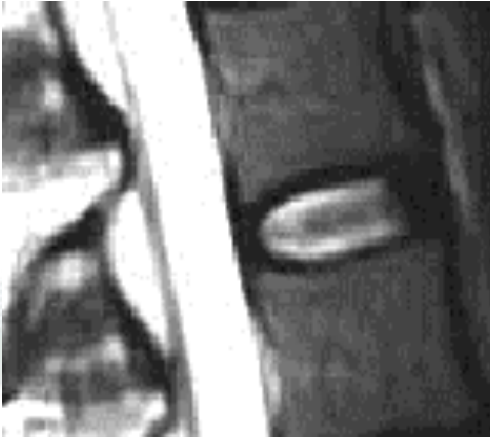
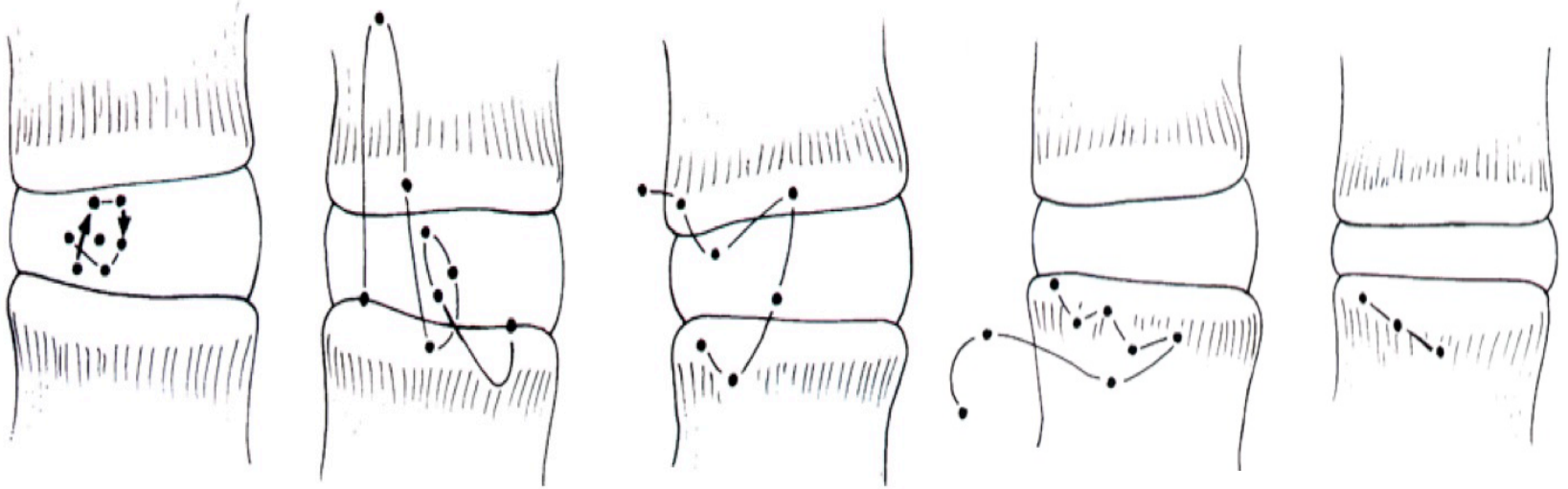
RAE yer deęiřtirir mi ?



Stabilizasyon bozulması

RAE yer deęiřtirir mi ?

Lomber sagittal plan



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.

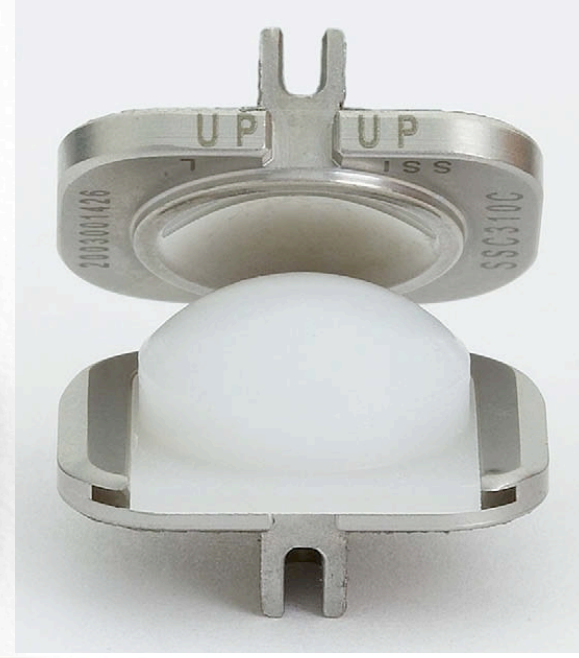
YAKINSAMA OLABİLİR !

Gerçekçi RAE Çözümü ?

- En az 3 noktanın,
- Translasyon vektörü ve rotasyon matriksinin bilinmesi (röntgen sterofotogrametri)

ÜÇ BOYUTLU RAE !

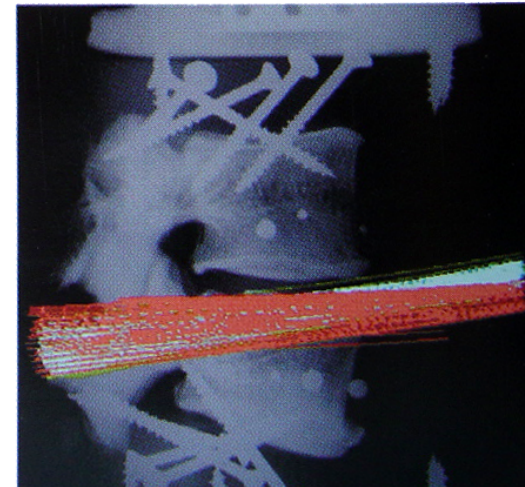
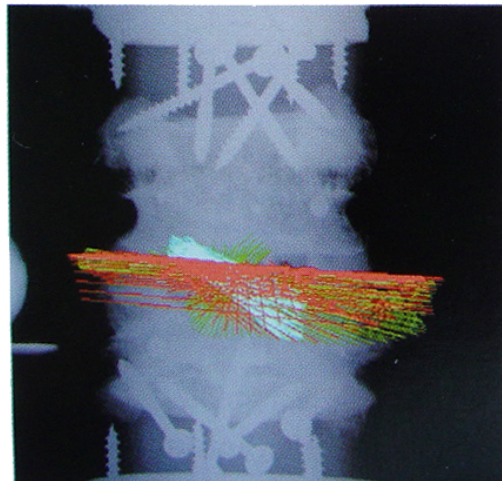
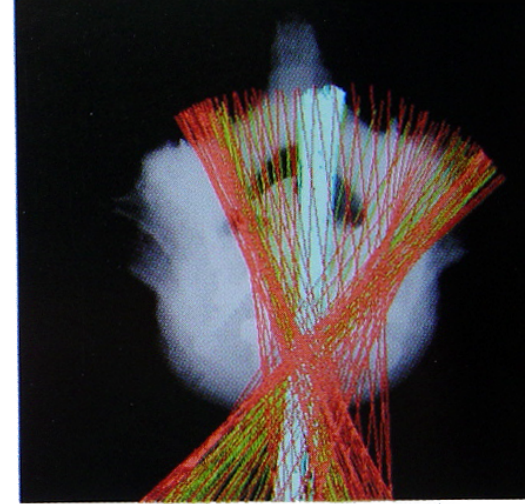
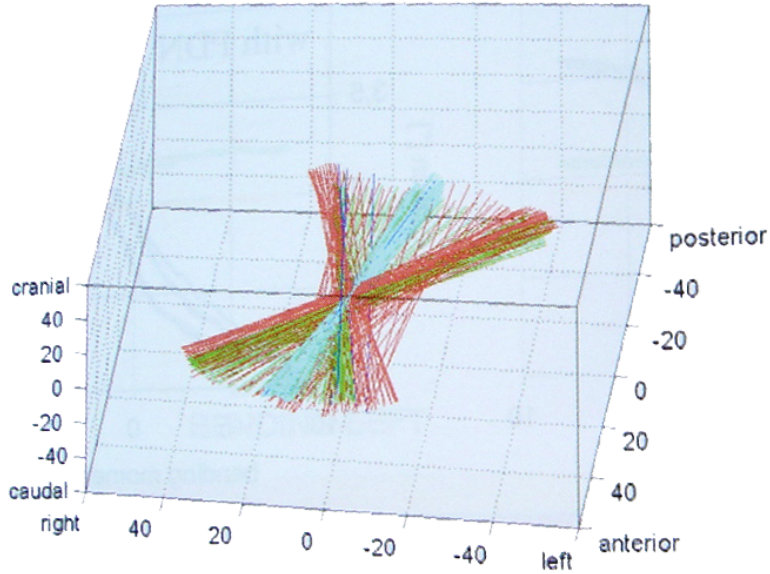
Helikal Rotasyon Ekseni



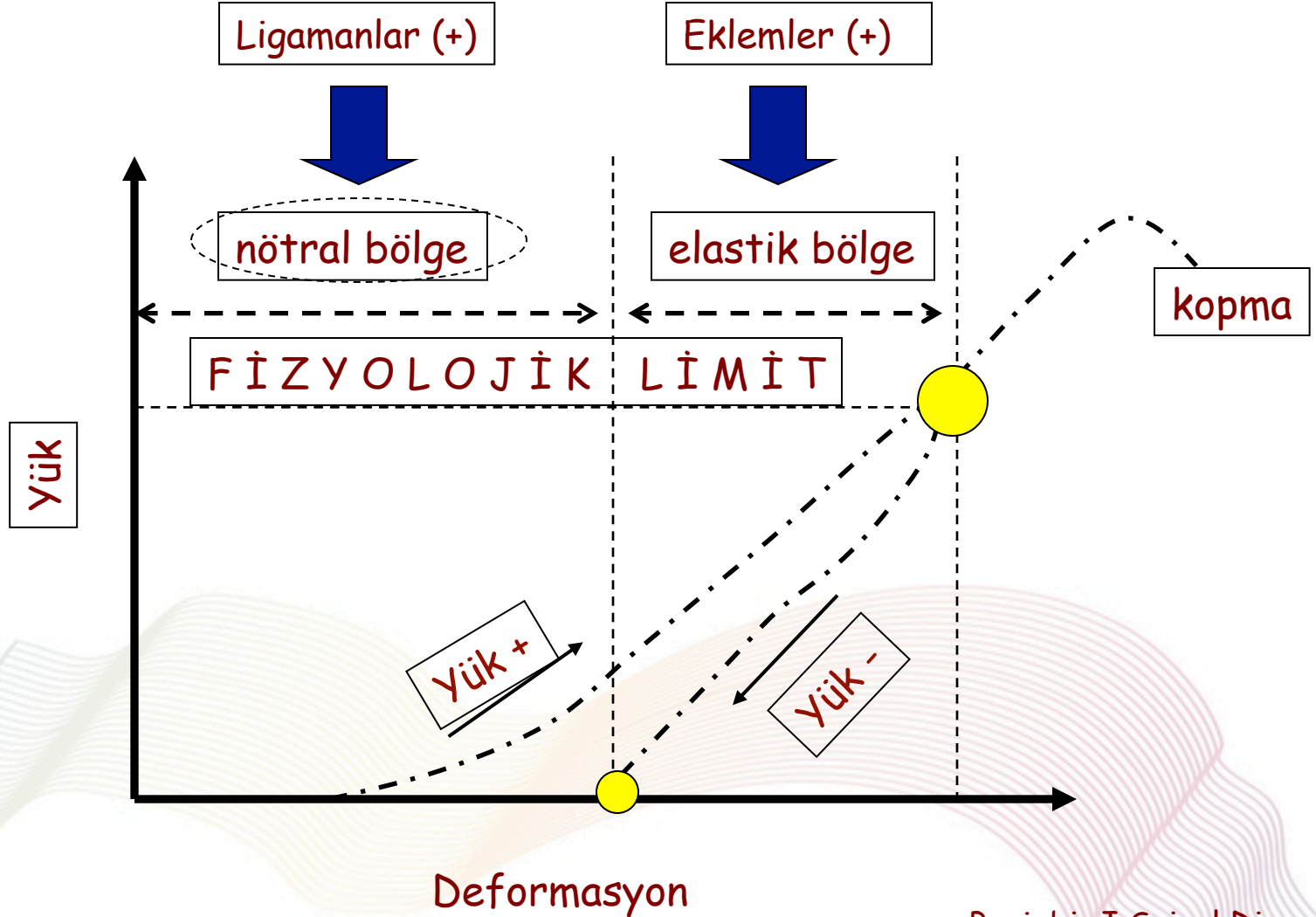
Helikal eksen

Spoor ve Veldpaus, J Biomech 1980

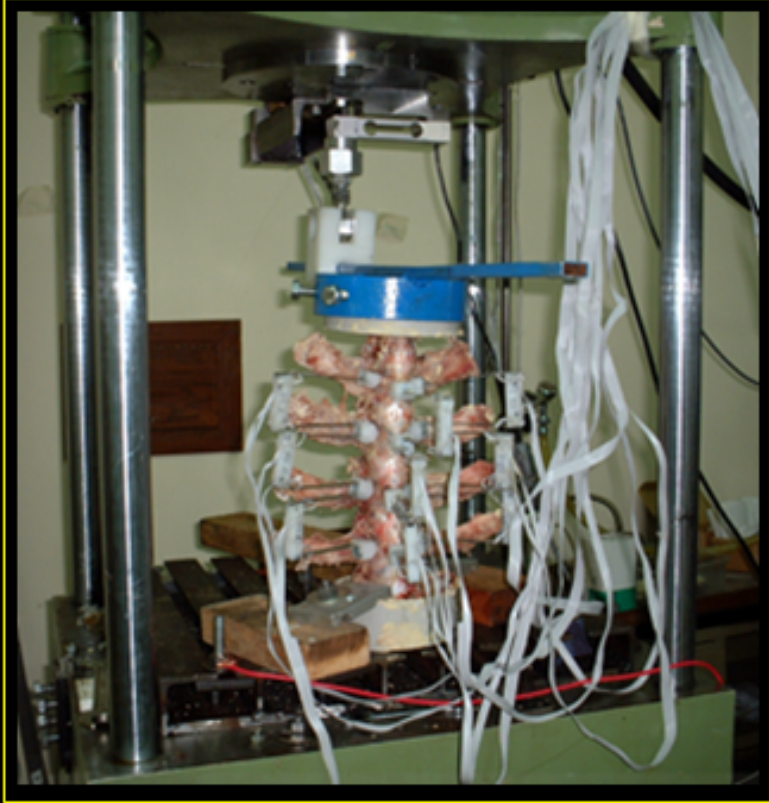
Helikal eksen hareketi (HAM)



Hareket Aralığı (ROM)



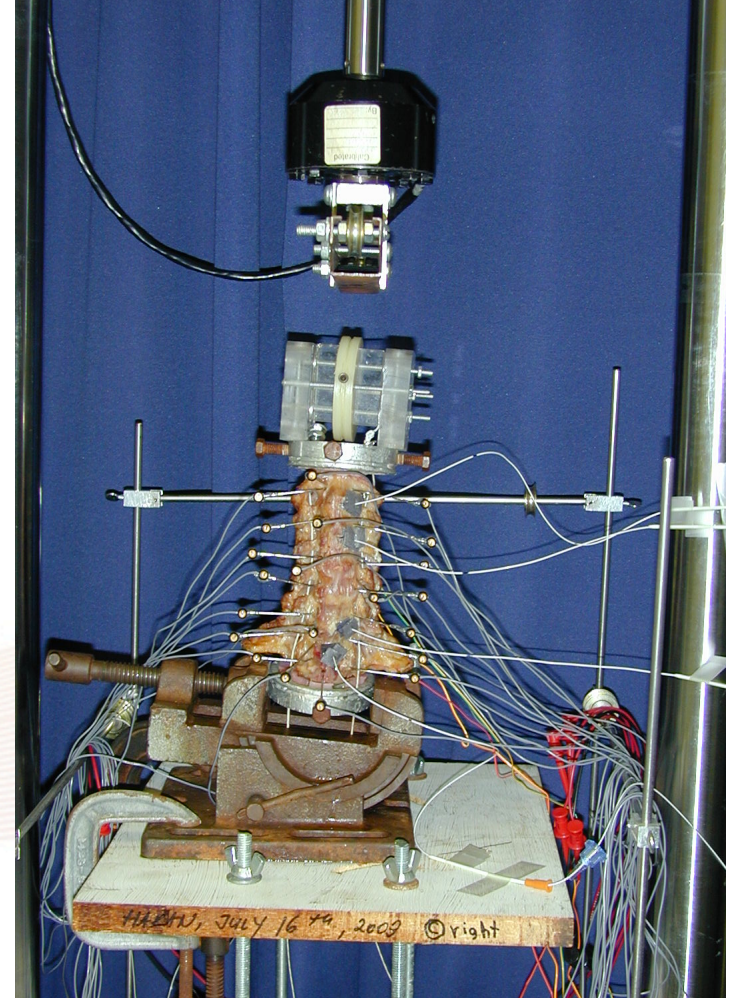
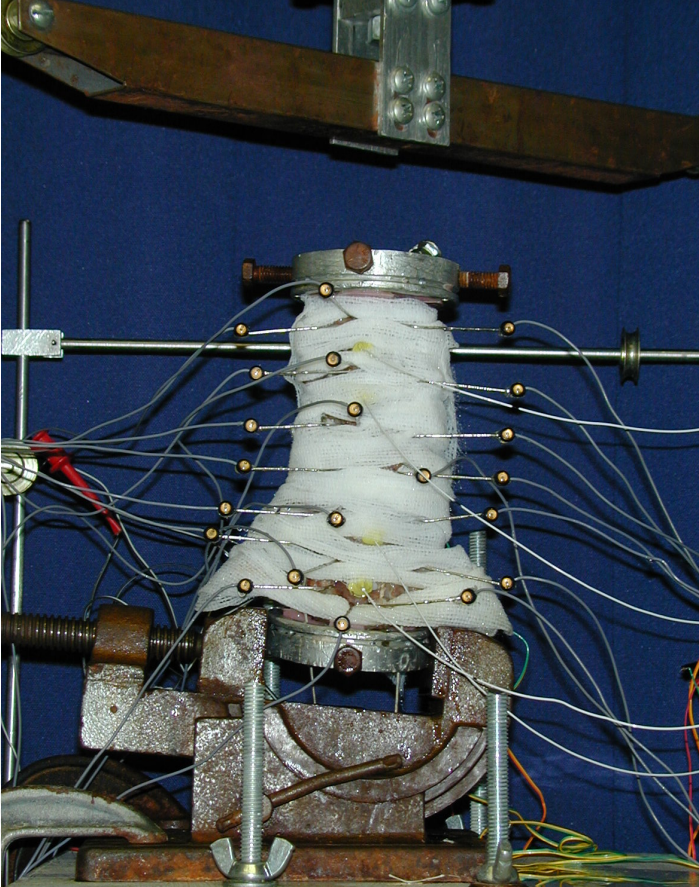
Hareket Aralığı Ölçümü



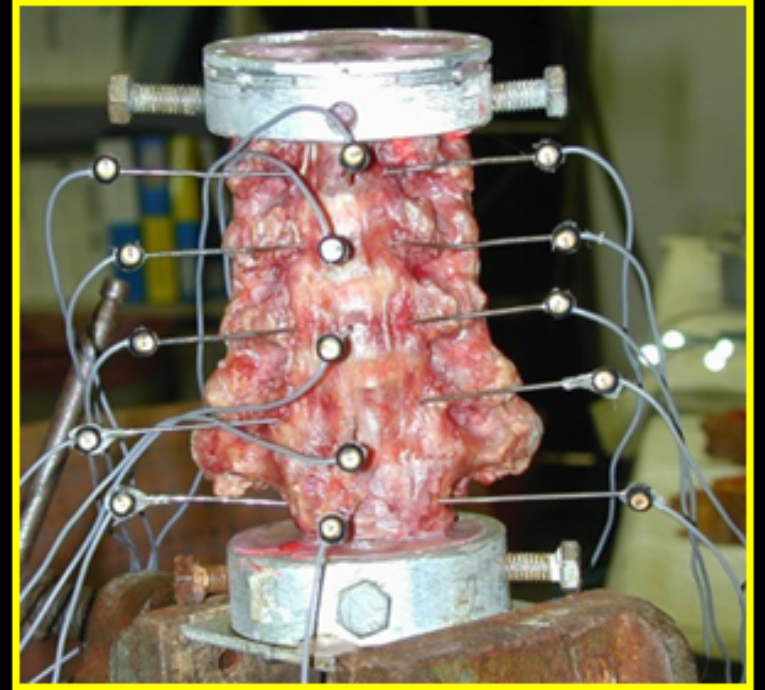
Ekstansometre

Deney düzeneği

İnfrared işaretlerin yerleştirilmesi

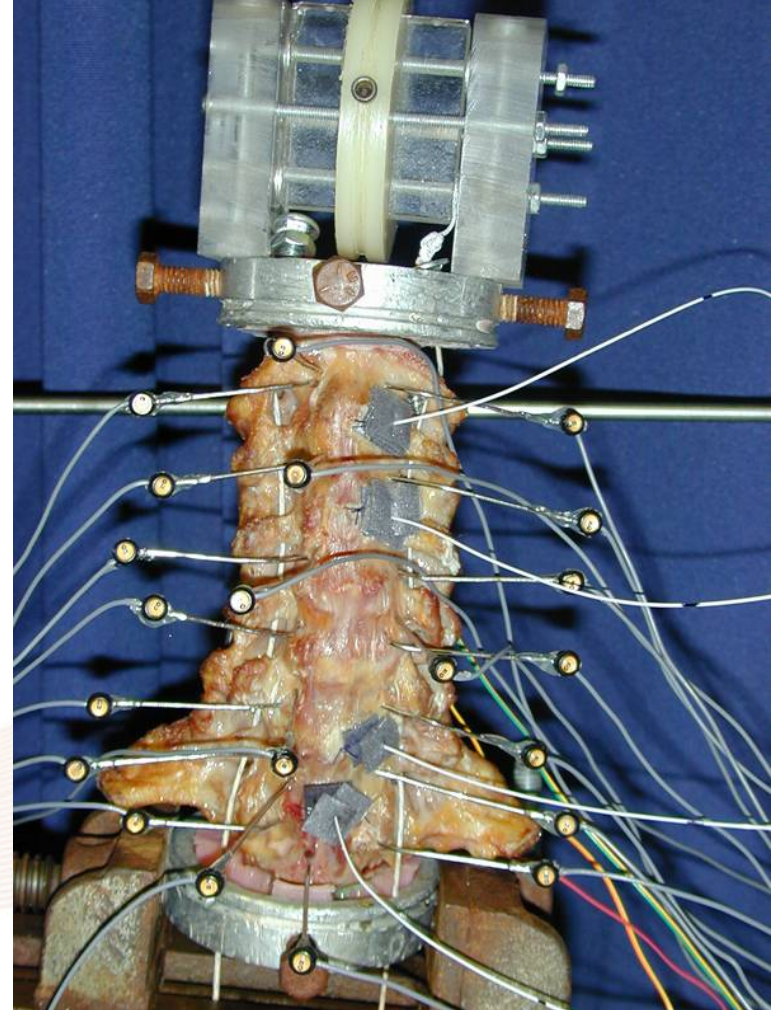
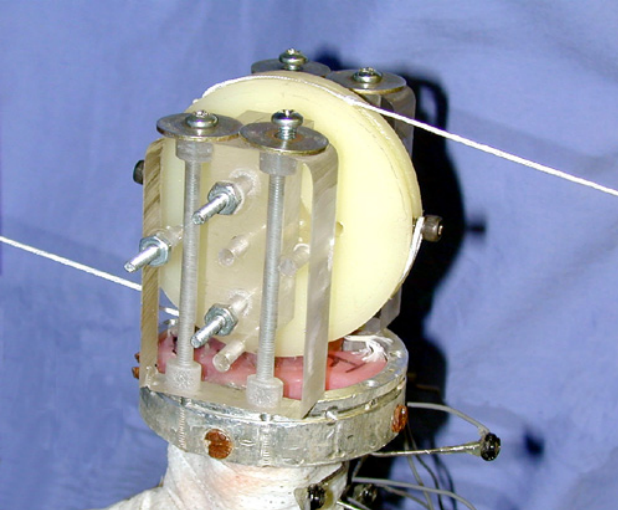
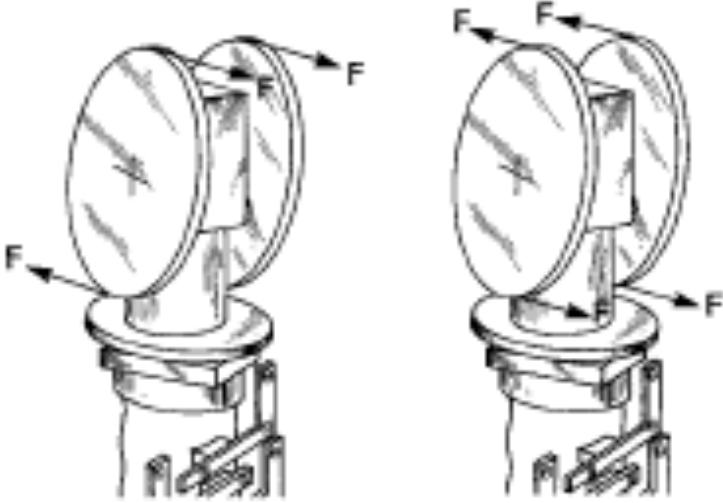


Hareket Aralığı Ölçümü

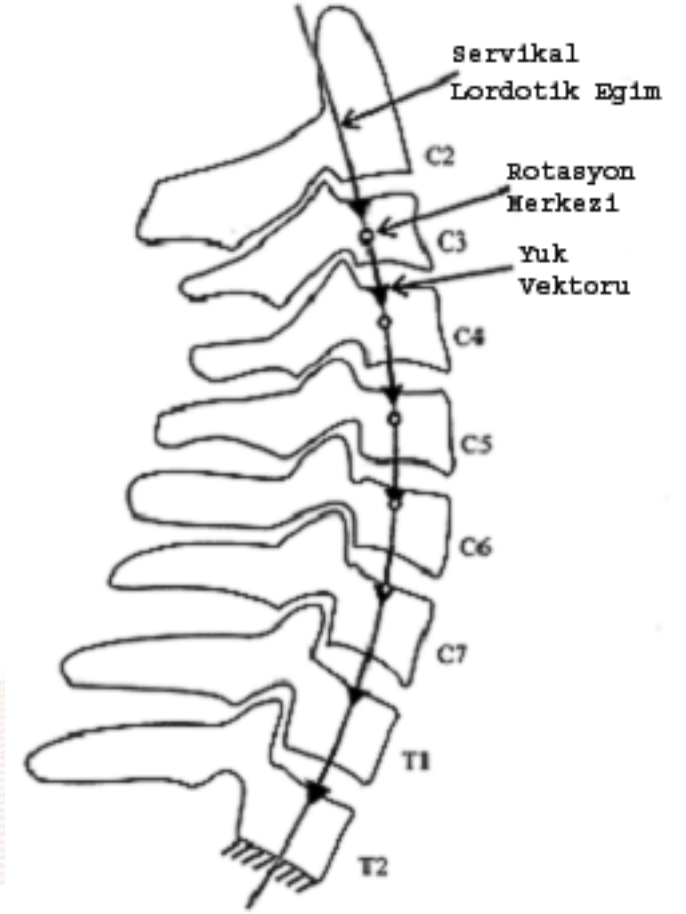
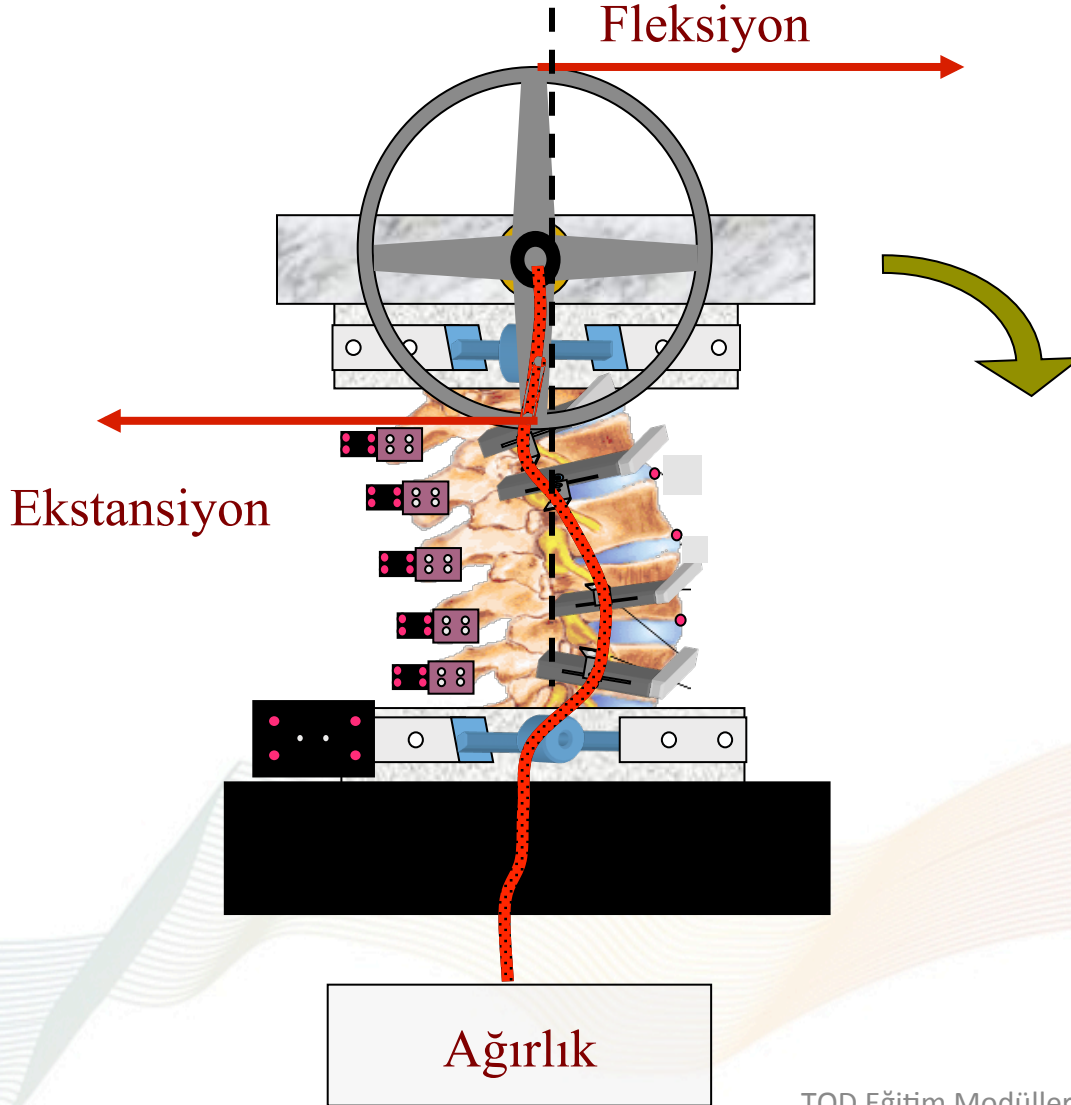


Sterofotogrametri

Moment yüklemesi

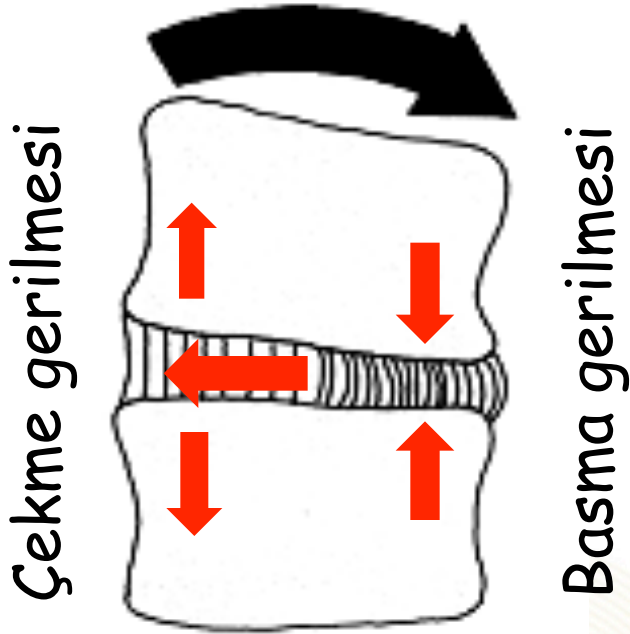


Tanjansiyel aksiyal yüklenme



Disk Dokusu Davranışı

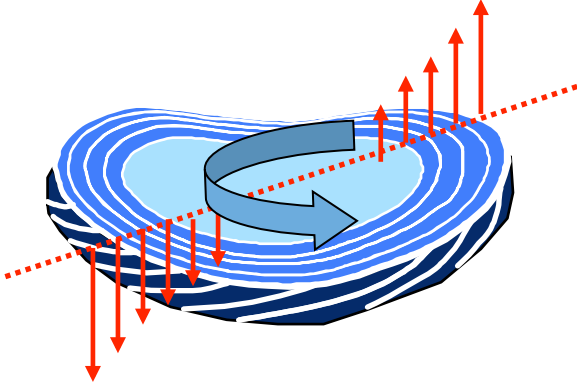
Flexion/ Extention/ Lateral Bending



- Annulus lifleri basma olan tarafta basma gerilmesi altında
- Annulus lifleri çekme olan tarafta çekme gerilmesi altında
- Nukleus çekme gerilmesi olan tarafa yer değiştirir

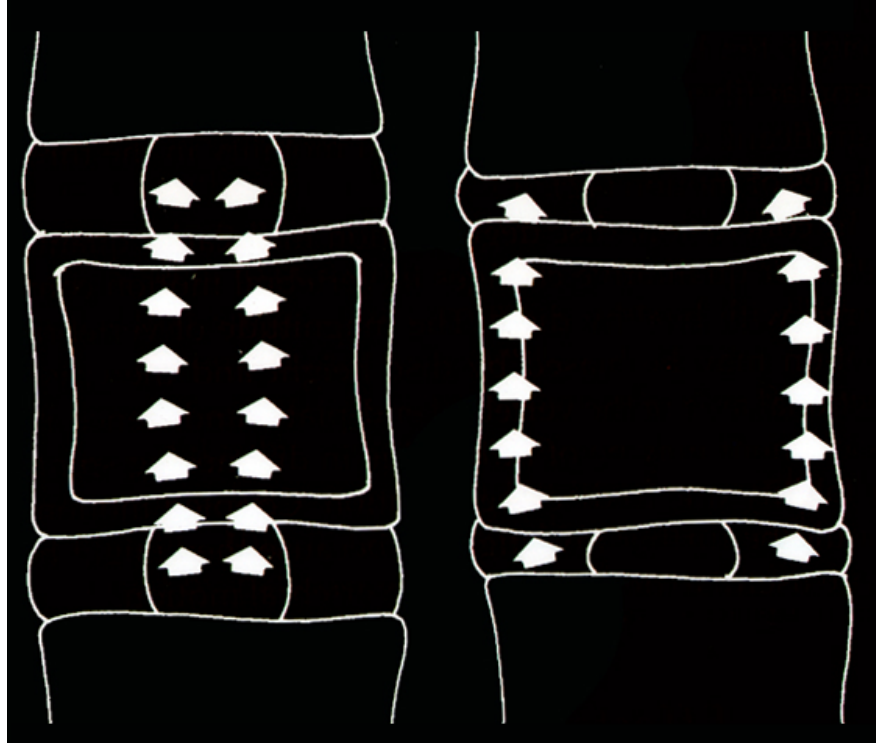
Disk Dokusu Davranışı

Axial Rotasyon



- Kayma gerilmesi en fazla posterolateral annulus liflerinde olur
- Bu bölge yırtılmaya ve disk herniasyonuna duyarlı

Disk Dejenerasyonu

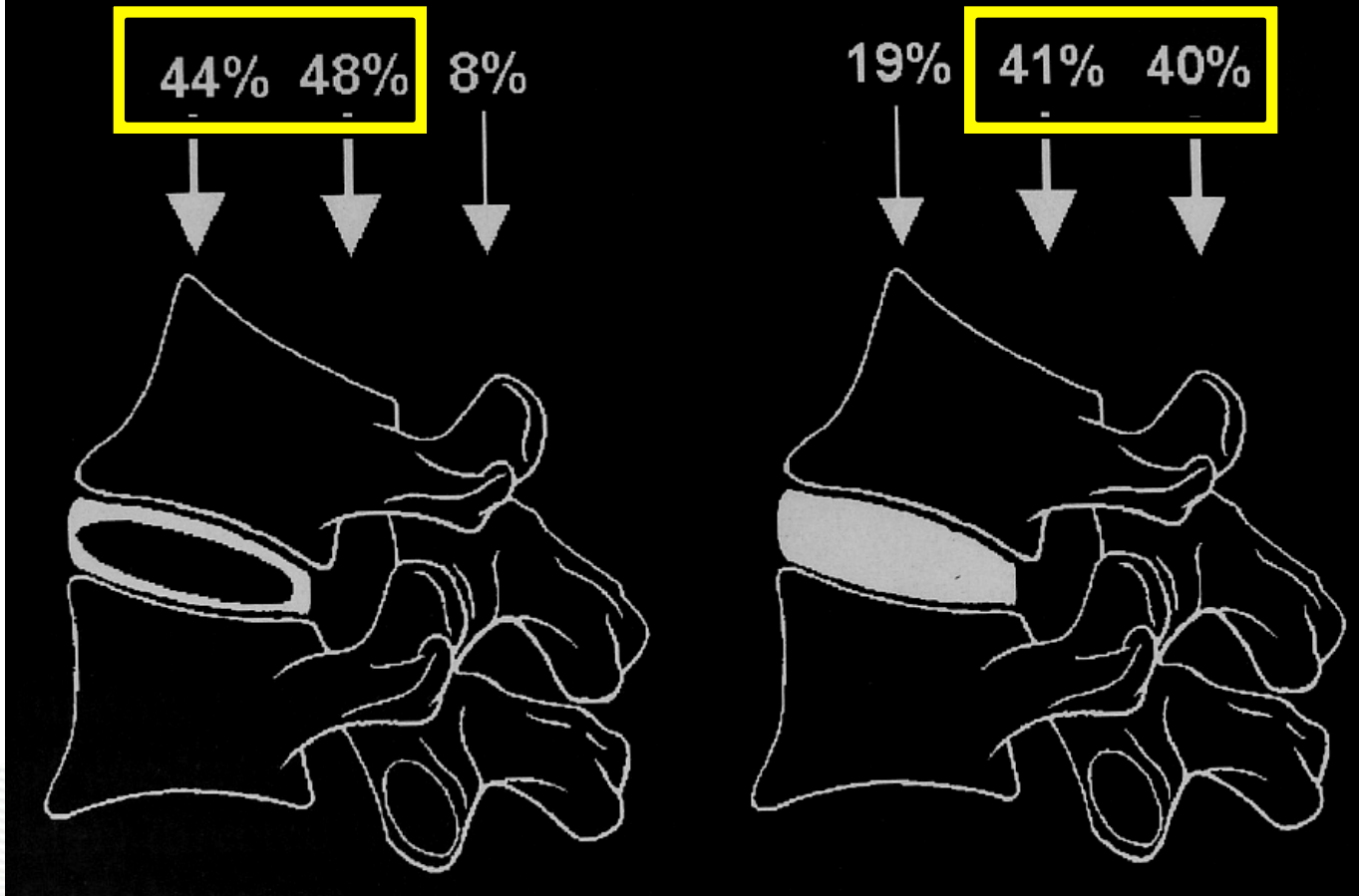


Normal

Dejenere

- Annulus nukleusdan daha fazla yük taşır

Yük Dağılımı



Normal

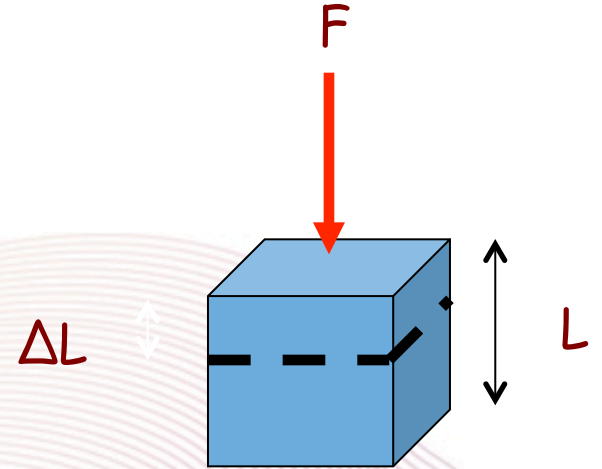
Dejenere

Birim Şekil Değişirme (strain, ϵ)

- Geometride oluşan şekil değiştirmenin (uzama, kısalma, kayma) ilk duruma oranı (BİRİMSİZDİR!)

Birim şekil değişirme = $(\Delta L / L)$

- Basma (compressive)
- Çekme (tensile)
- Kayma (shear)

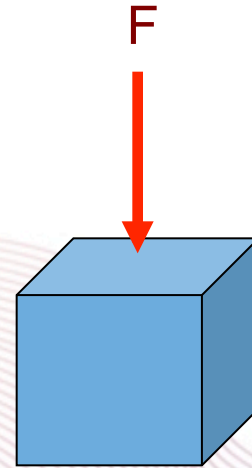


Gerilme (Stress, σ)

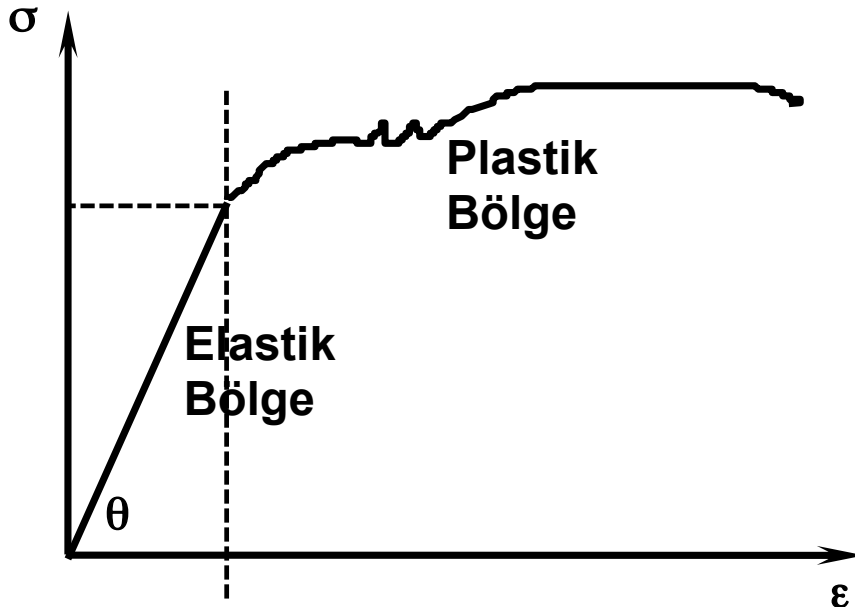
- Birim alana gelen kuvvet ($\text{Pa} = \text{N}/\text{m}^2$)

Gerilme = Kuvvet / Alan

- Basma (compressive)
- Çekme (tensile)
- Kayma (shear)



Elastik bölge, Hooke kanunu



$$\epsilon = \frac{\Delta l}{l}$$

$$\sigma = E \cdot \epsilon$$

Elastisite modülü (Young Modülü) = (σ / ϵ)

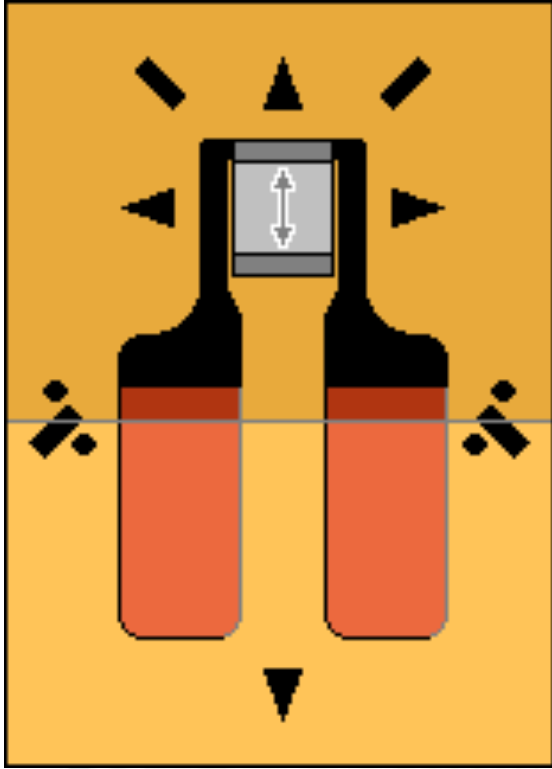
Mühendislik Teknolojilerinin Kullanımı

1. Kolonlar arasındaki yük dağılımı analizi
Arka kolon ----- strain gage
Ön ve orta kolon ----- load cell
2. Komşu disk mesafesindeki basınç değişimi
Basınç transduserler
3. Omur segmentleri arasındaki hareket
Sterofotogrametri

Strain (birim şekil deęiřtirme) ölçüm teknikleri

- Gevrek kaplama
- Fotoelastisite
- Termografi
- Elektrik rezistans strain gage teknięi
- Sonlu eleman yöntemi

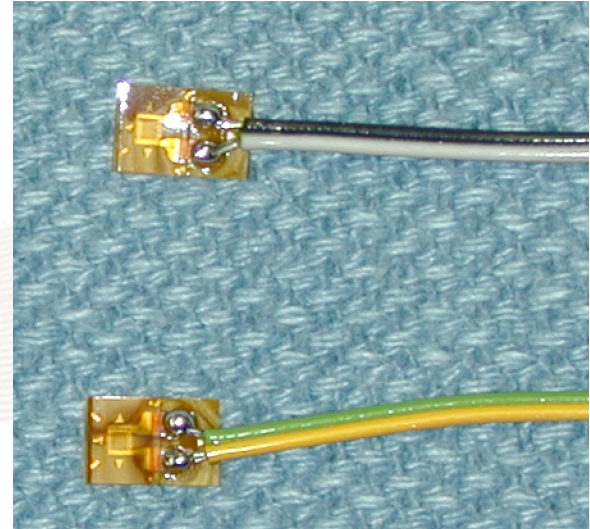
Strain gage



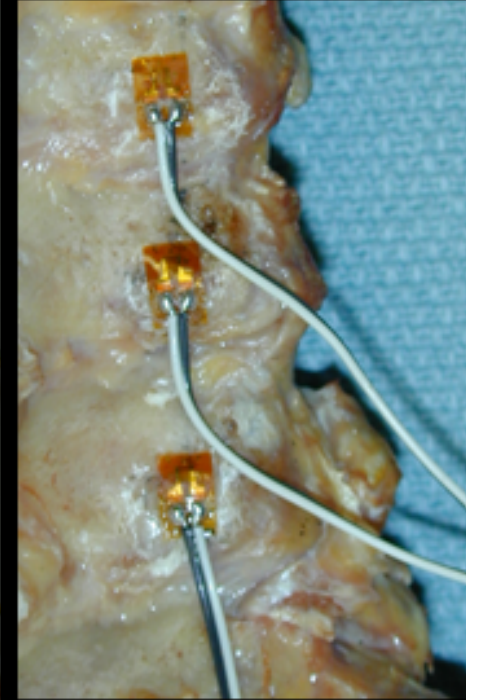
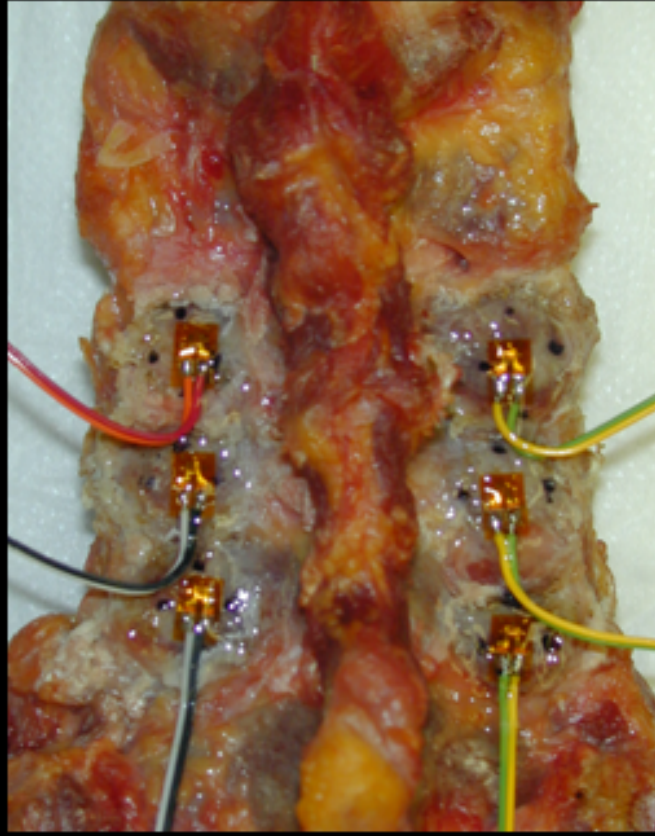
6.9 mm

4.8 mm

- Tek eksenli strain gage
- Statik ve dinamik gerilme analizi.



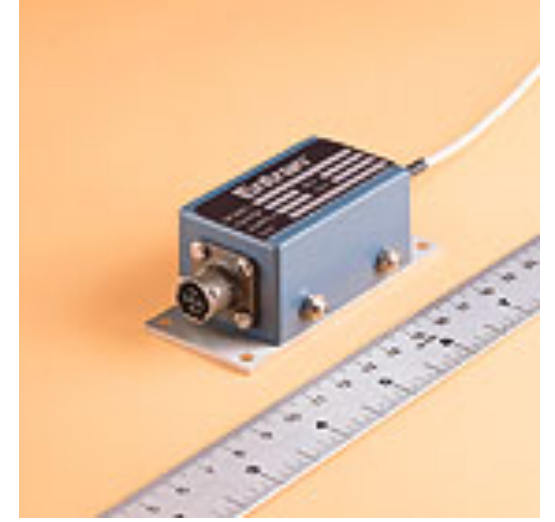
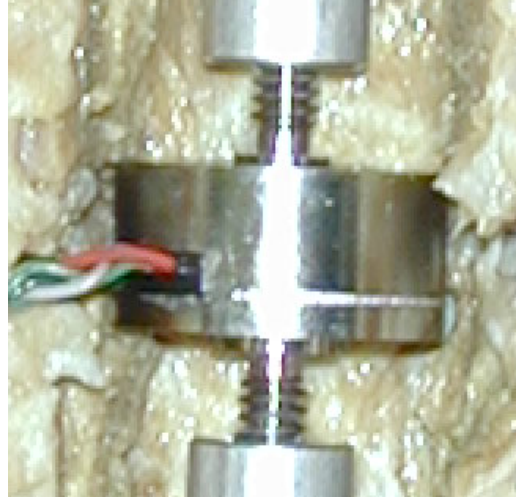
Lateral mass' lara strain gage yapıştırılması



Load cell



17.35 mm

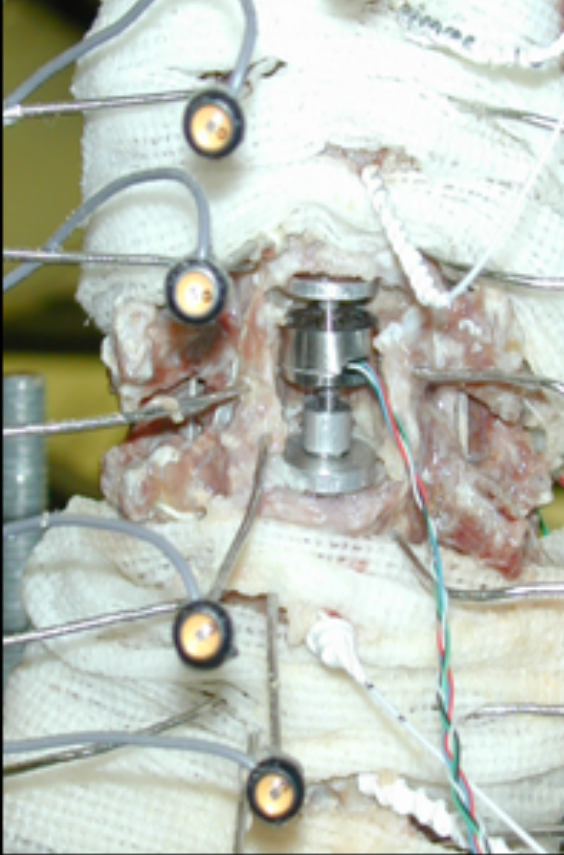


12.7 mm

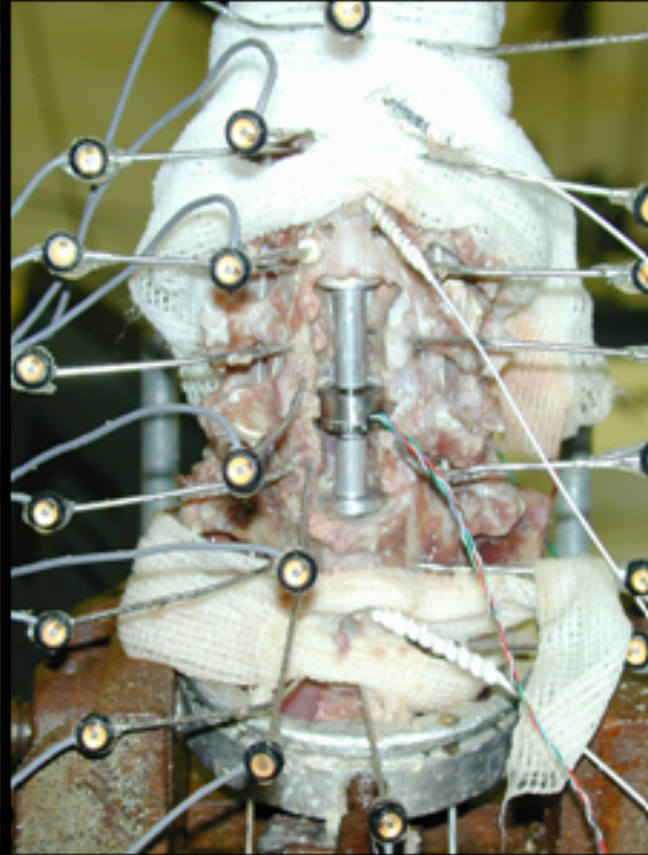
Yükseltici

- Load cell boyutu; 17.35 x 12.7 mm,
- Tek mesafe korpektomi için yeterli.

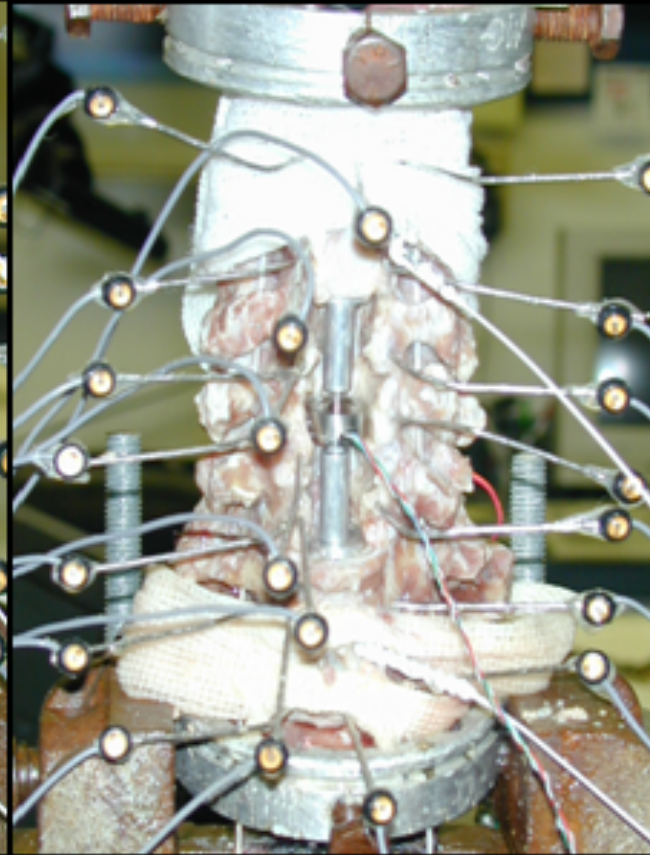
Load cell'lerin yerleştirilmesi



C5 load cell



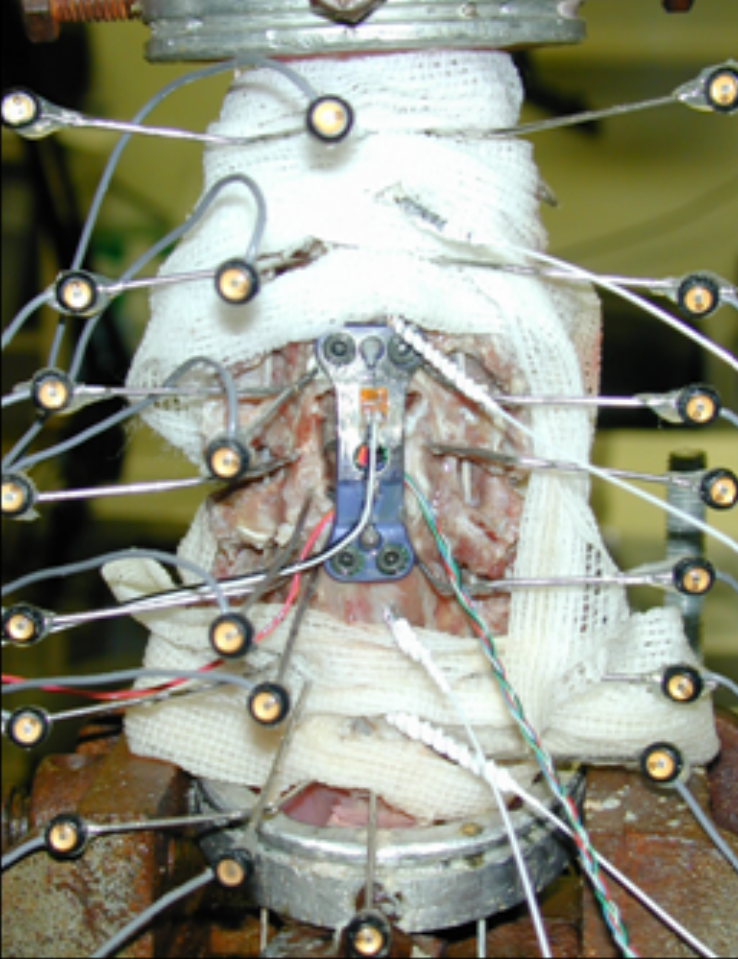
C5-6 load cell



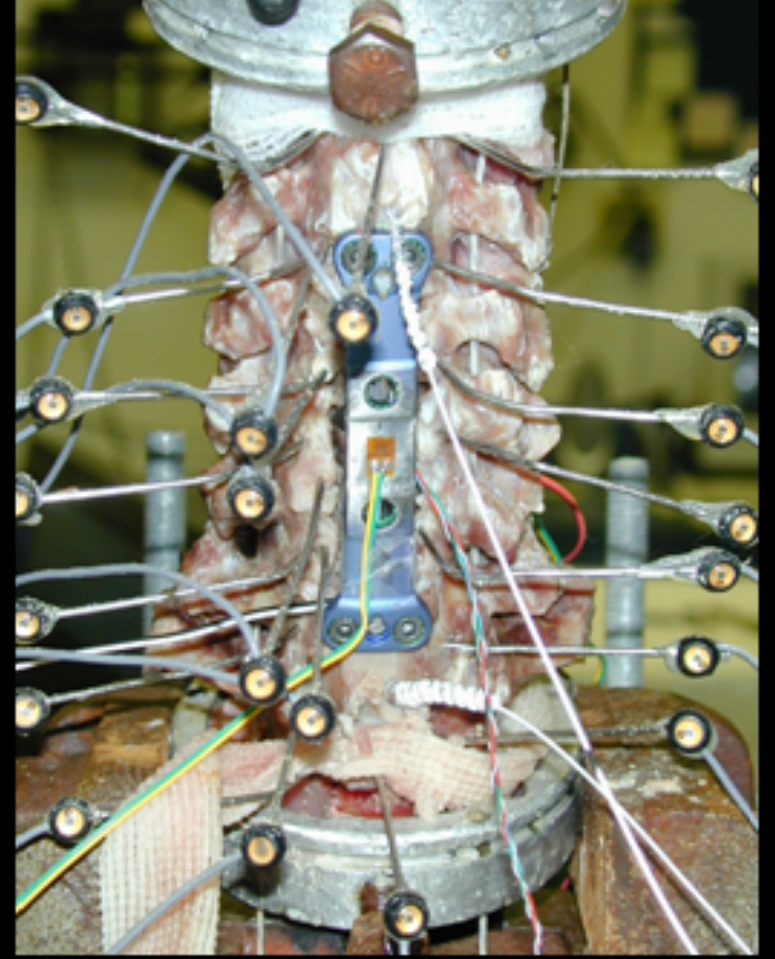
C4-5-6 load cell

Load cell ve plak yerleřtirilmesi

türkomurğa



C5 anterior plak



C4-5-6 anterior plak

Ultra-minyatür tek alıcılı mikro basınç transduseri



SPR-524

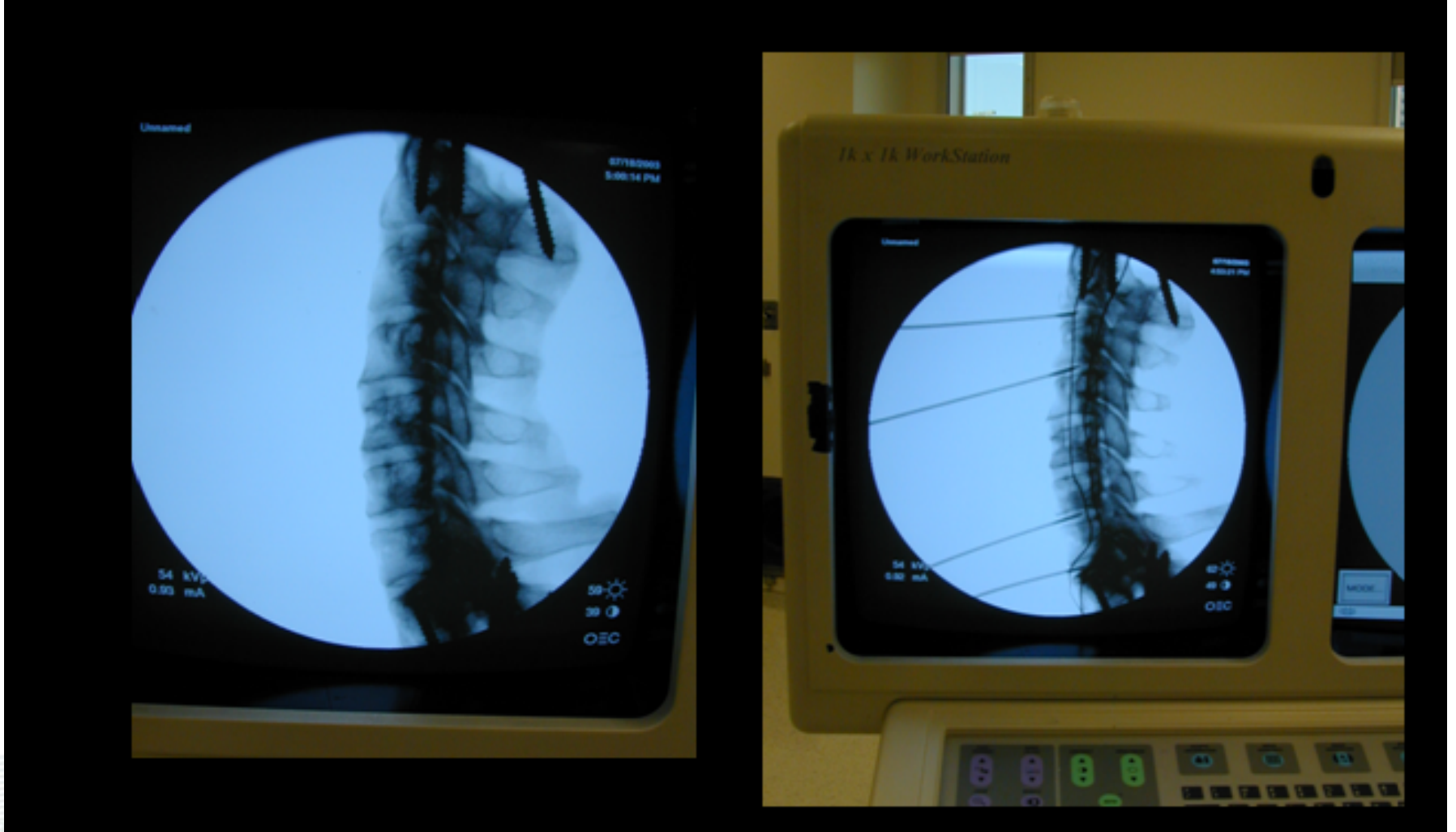
3.5 French (alıcı)

(3 French ~1 mm)

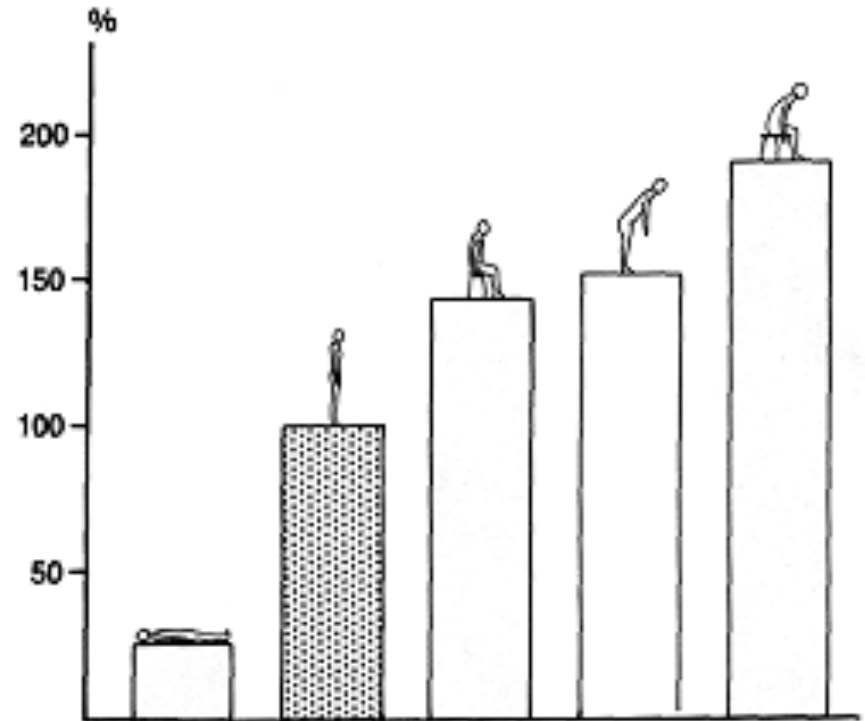


Basınç kontrol ünitesi

Basınç transduserlerinin yerleştirilmesi

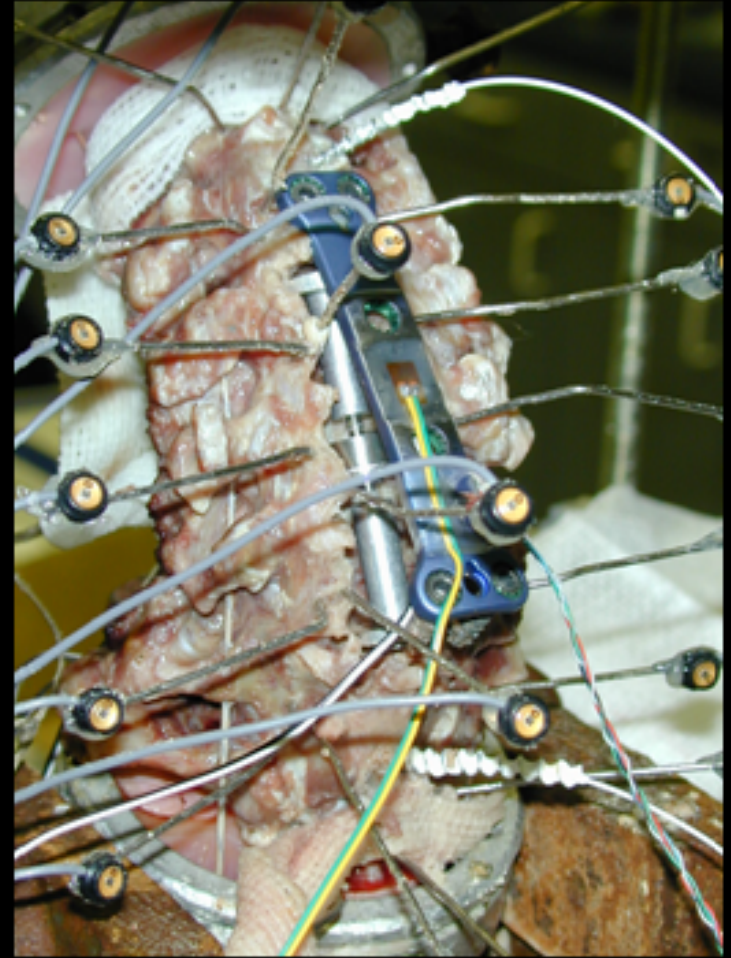
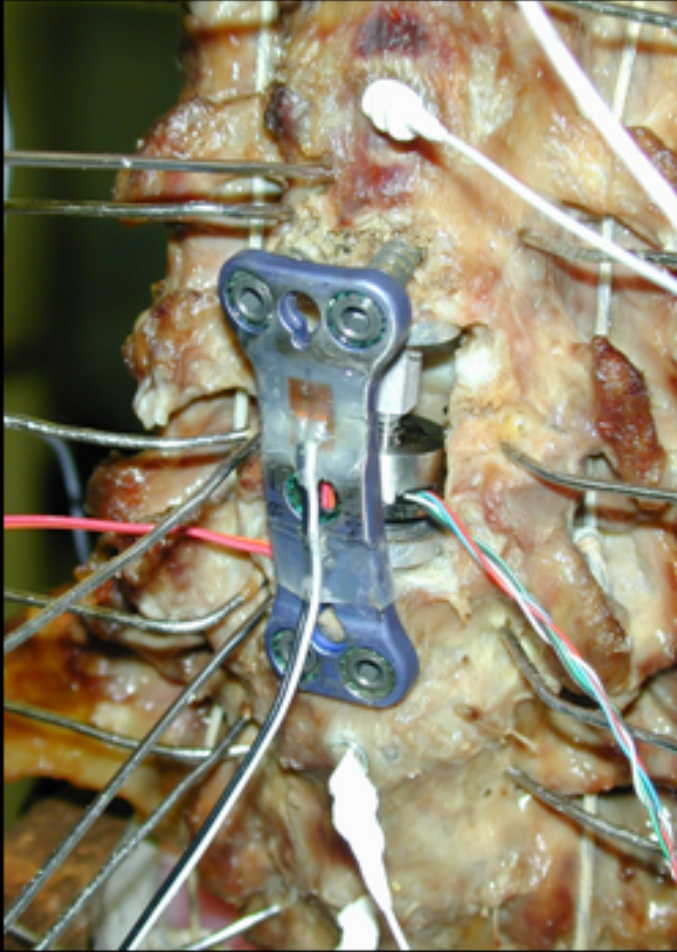


Disk içi basınç



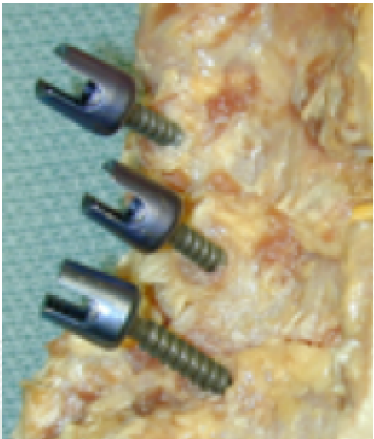
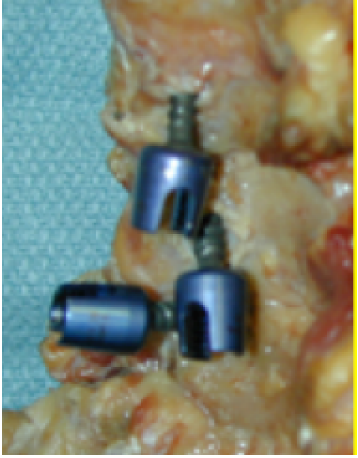
Nachemson., 1966

Başarısız sonuçlar



Biomechanical Analysis of Rigid Stabilization Techniques for Three-Column Injury in the Lower Cervical Spine

Hakan Bozkus, MD,* Christopher P. Ames, MD,† Robert H. Chamberlain, MS,‡
Eric W. Nottmeier, MD,§ Volker K. H. Sonntag, MD,‡ Stephen M. Papadopoulos, MD,‡ and
Neil R. Crawford, PhD‡

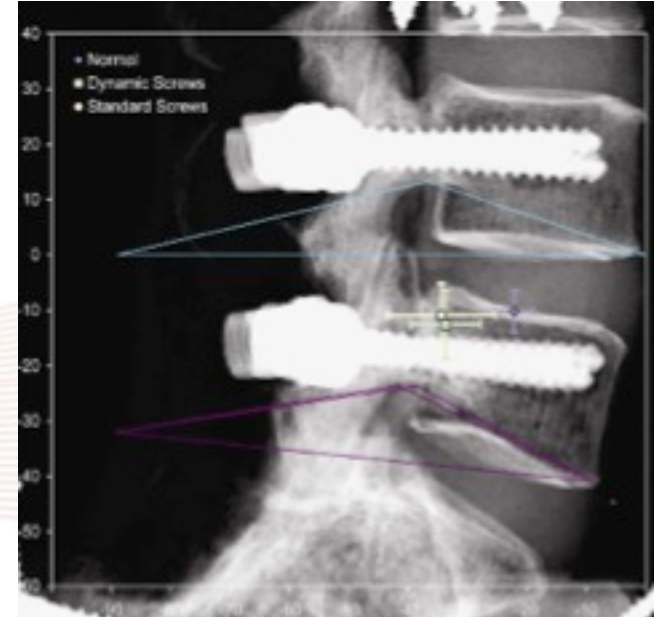
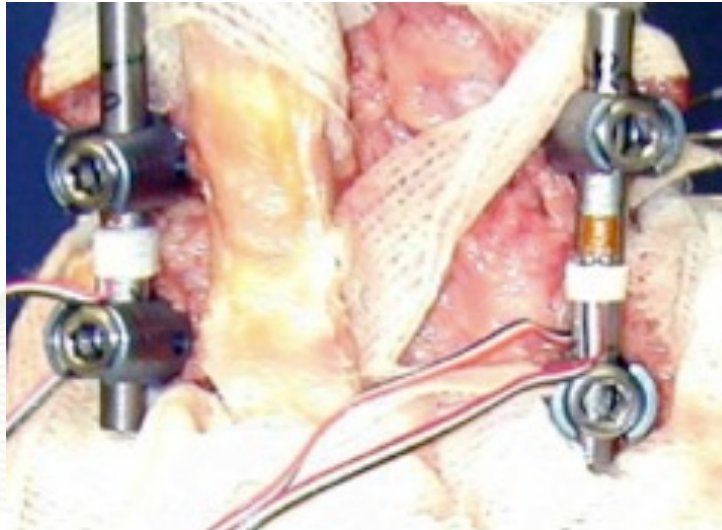
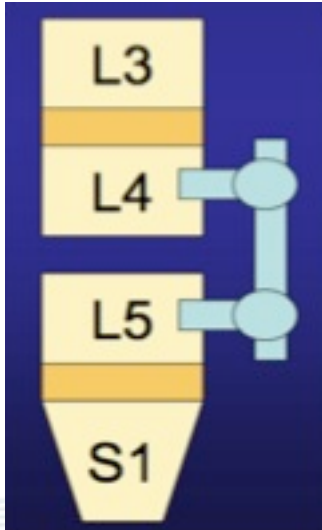


Dynamic lumbar pedicle screw-rod stabilization: in vitro biomechanical comparison with standard rigid pedicle screw-rod stabilization

Laboratory investigation

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ANNA G. U. SAWA, M.S.,² ALI FAHİR ÖZER, M.D.,¹ VOLKER K. H. SONNTAG, M.D.,²
AND NEIL R. CRAWFORD, PH.D.²**

¹Department of Neurosurgery, VKV Amerikan Hastanesi, Istanbul, Turkey; and ²Barrow Neurological Institute, Spinal Biomechanics Research Laboratory, Phoenix, Arizona



Standartlar

ASTM F1717 - 13

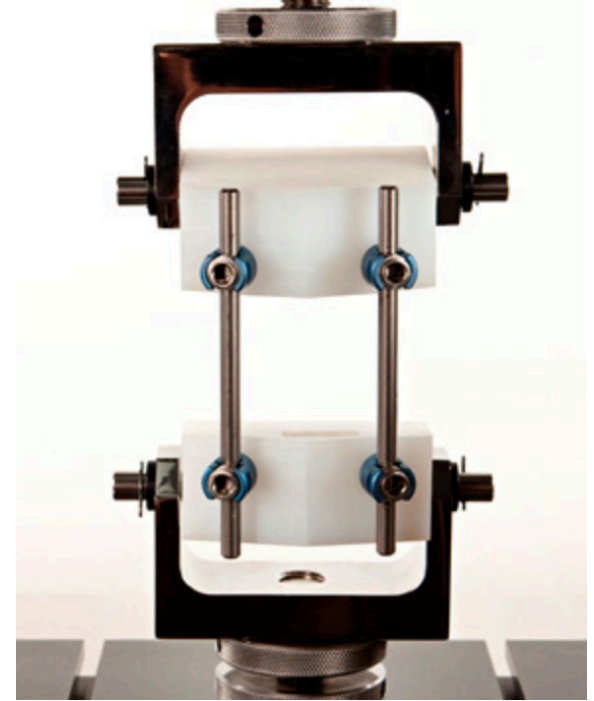
Standard Test Methods for Spinal Implant Constructs in a Vertebrectomy Model

Active Standard **ASTM F1717** | Developed by Subcommittee: [F04.25](#)

Book of Standards Volume: [13.01](#)

ISO 12189:2008

Implants for surgery -- Mechanical testing of implantable spinal devices -- Fatigue test method for spinal implant assemblies using an anterior support



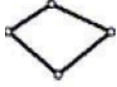






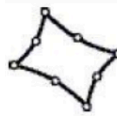



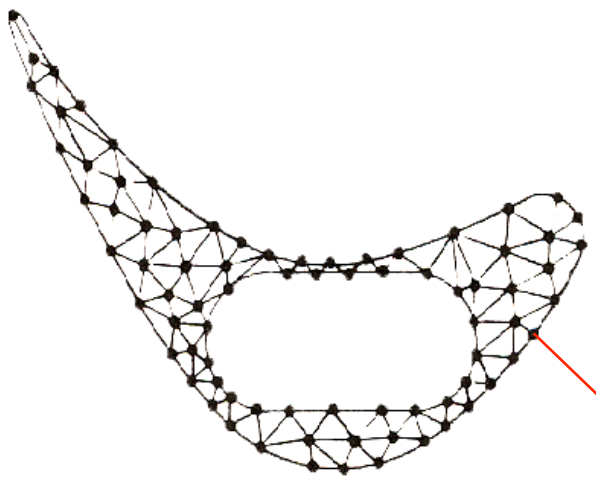
Sonlu Eleman Yöntemi

- Bir bütünün parçalara ayrılarak incelenmesi
- Uygun geometri (model)
- Mesh yapılması
- Materyel özellikleri
- Sınır şartlarının belirlenmesi
- Yükleme
- Sonuçların deneysel modeller ile kanıtlanması

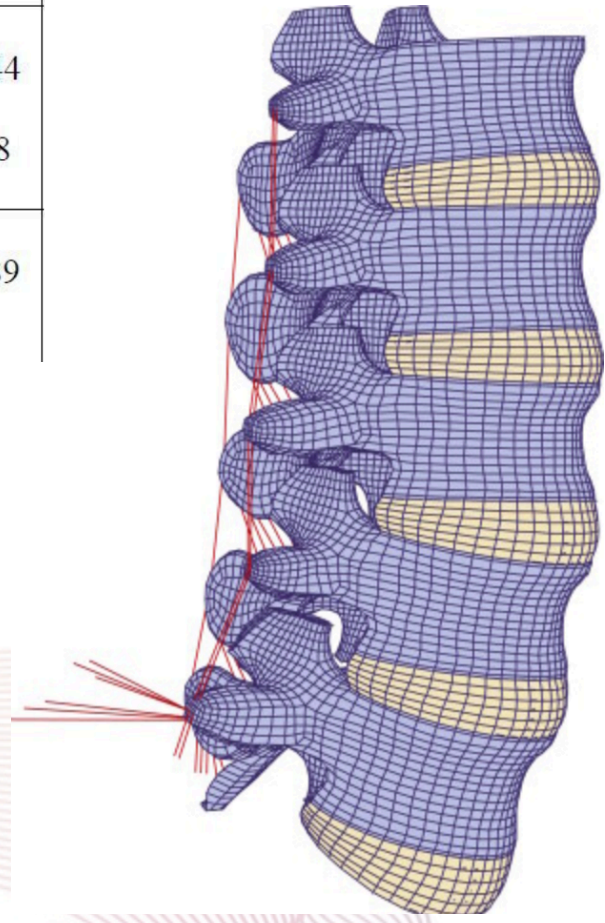


Model ve Mesh

2D Solid	3D Solid	3D Shell	Line Elements
 PLANE42 PLANE182	 SOLID45 SOLID185	 SHELL63 SHELL181	 BEAM3/44  BEAM188
 PLANE82/183  PLANE2	 SOLID95/186  SOLID92/187	 SHELL93	 BEAM189



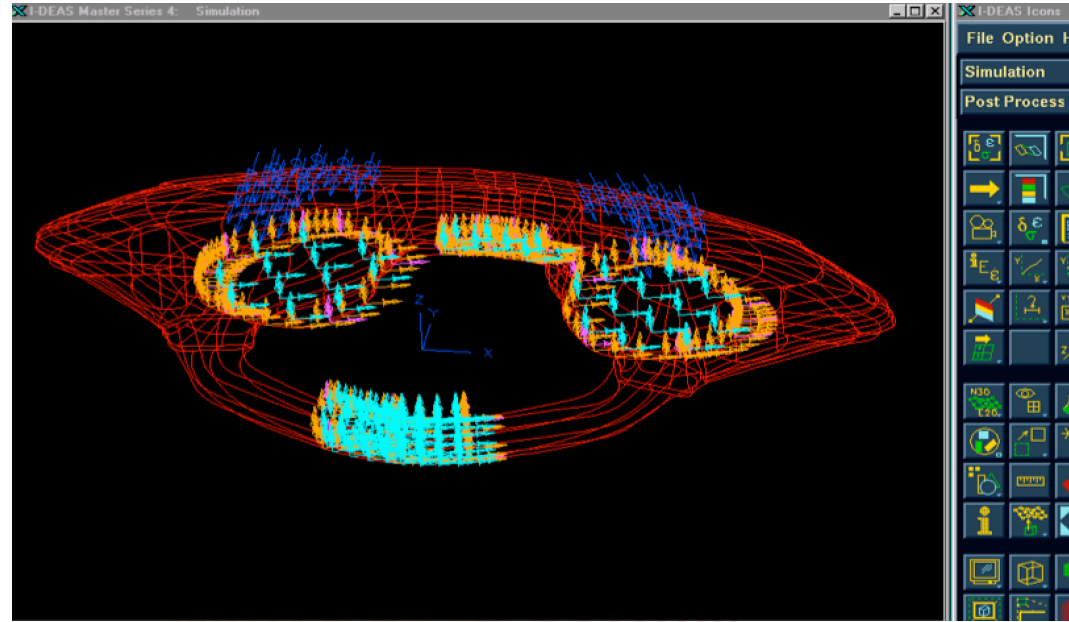
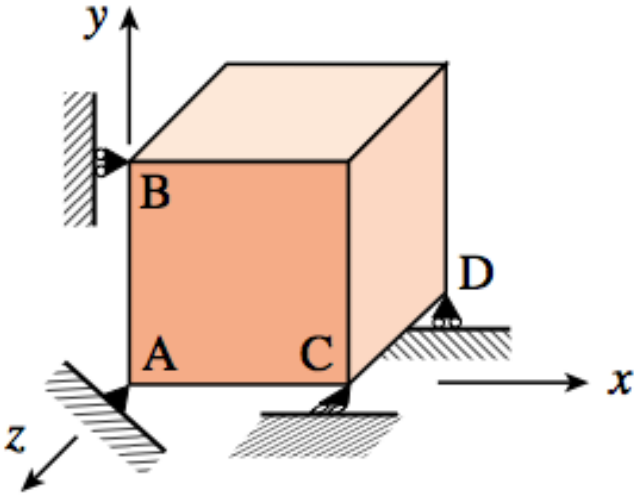
nod



Materyel Özellikleri

Anatomik bölge	Young's modülü (Mpa)	Poisson's oranı
Kortikal kemik	10000	0.29
Trabeküler kemik	100	0.29
Endplate	500	0.40
Lamina, spinoz proses	3500	0.29
Disk annulusu	3.4	0.40
Disk nukleusu	3.4	0.49
Anterior longitudinal ligaman	11.9	0.39
Posterior longitudinal ligaman	12.5	0.39
İnterspinoz ligaman	3.4	0.39
Ligamentum flavum	2.4	0.39
Kapsular ligaman	7.7	0.39

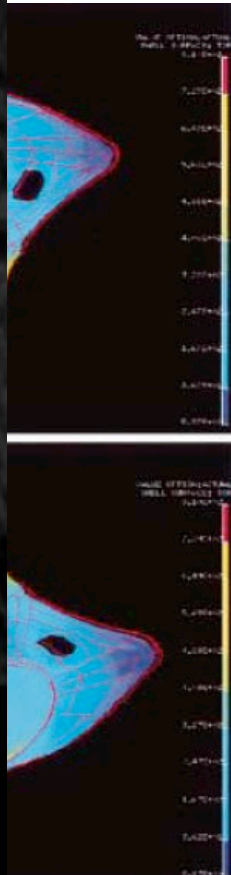
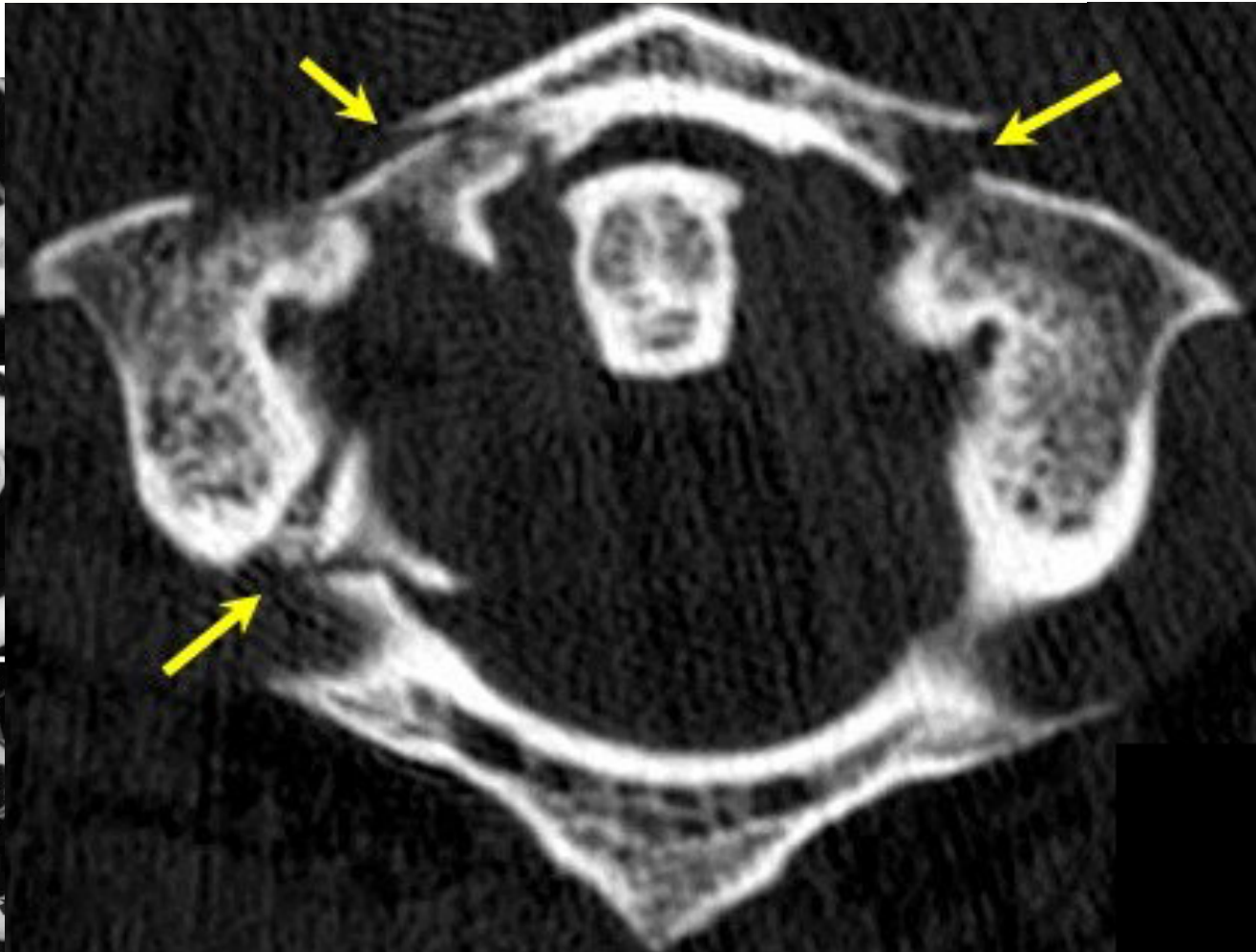
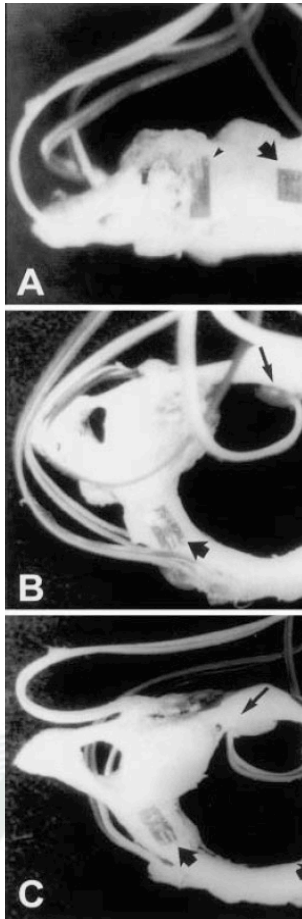
Sınır Şartları ve Yükleme



DeneySEL Model ile Geçerlilik ?

Hakan Bozkus
Askin Karakas
Murat Hanci
Mustafa Uzan
Ergun Bozdog
Ali Cetin Sarioglu

Finite element model of the Jefferson fracture: comparison with a cadaver model



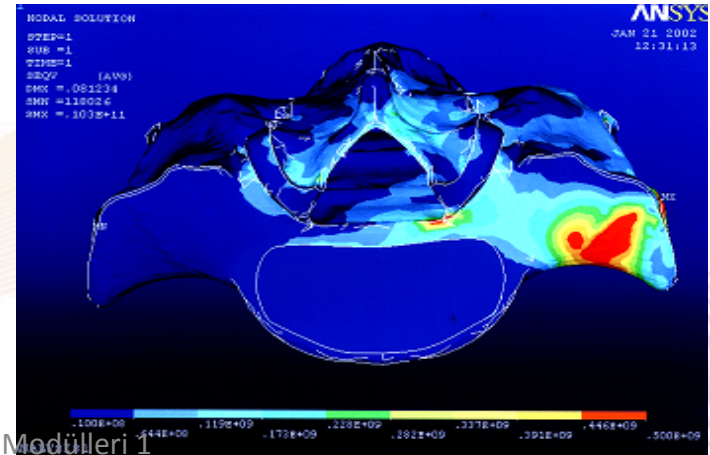
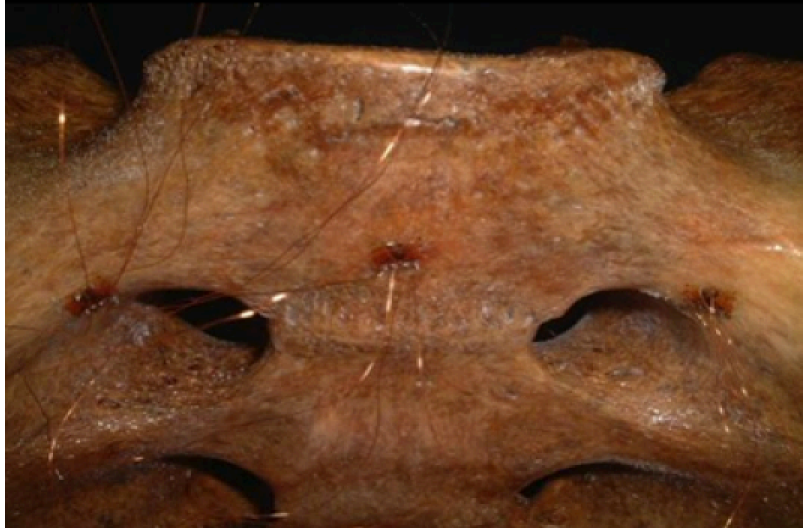
Finite element method based stress analysis of zone I and zone II sacral fractures

Birinci ve ikinci bölge sakrum kırıklarının sonlu eleman
metoduna dayalı gerilme analizi

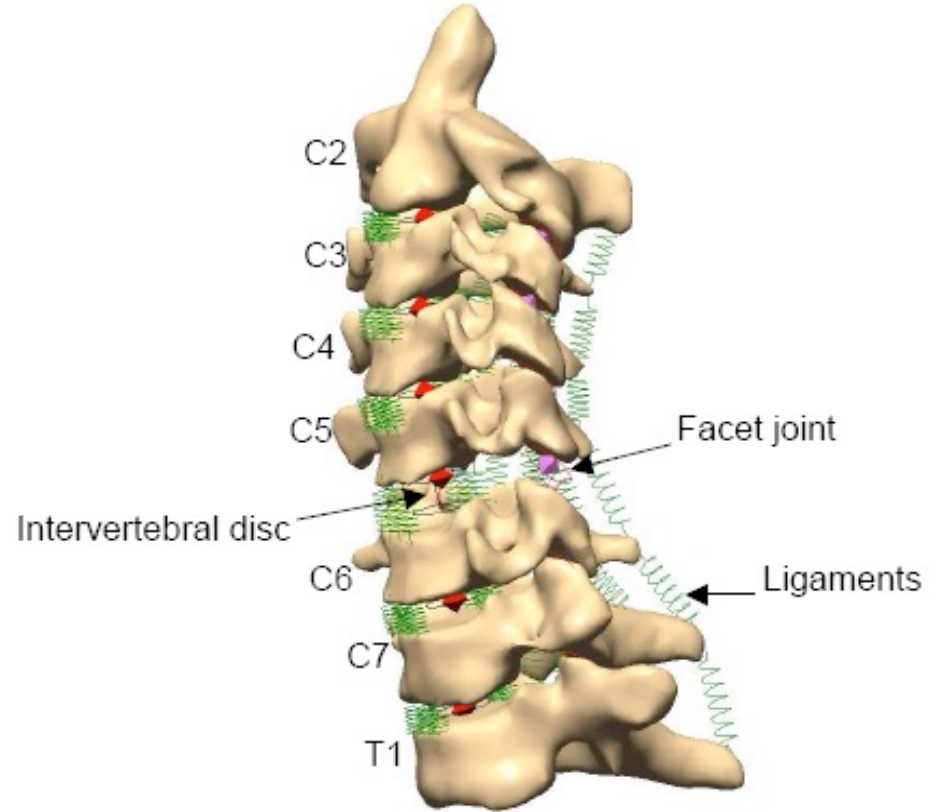
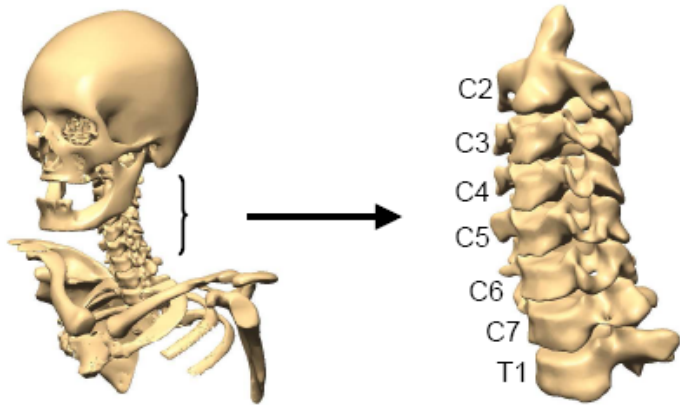
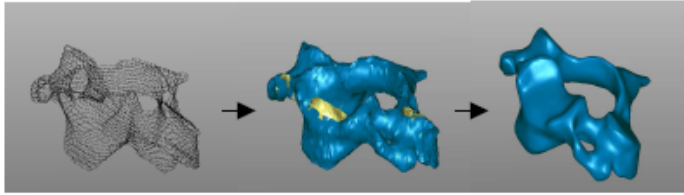
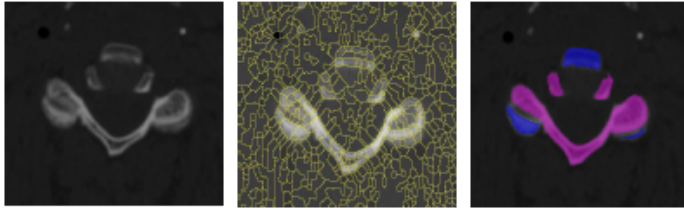
Hakan BOZKUŞU^{1,5}, Murat HANCI², M.Emin SÜNBUĞLU³, M.Ali TUNALI²,
S.Ergun BOZDAĞ³, Önder AYDINGÖZ⁴, Alaattin ARPACI³

Turkish Journal of Trauma & Emergency Surgery

Ulus Travma Derg 2005

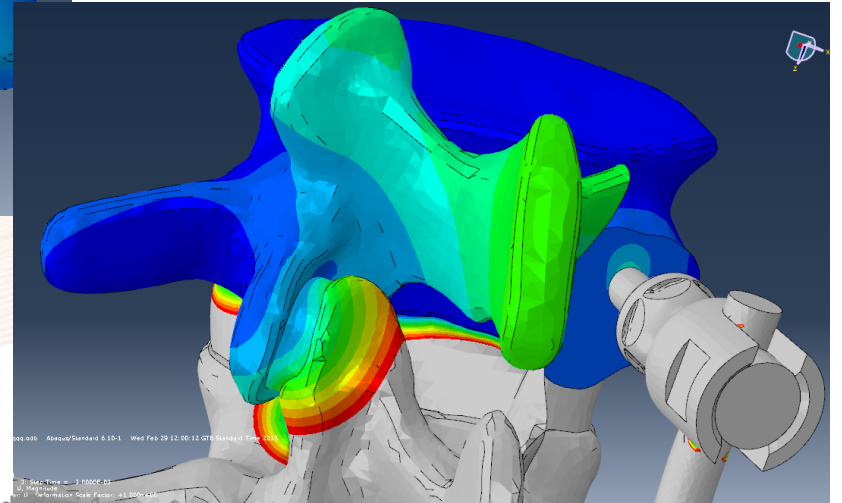
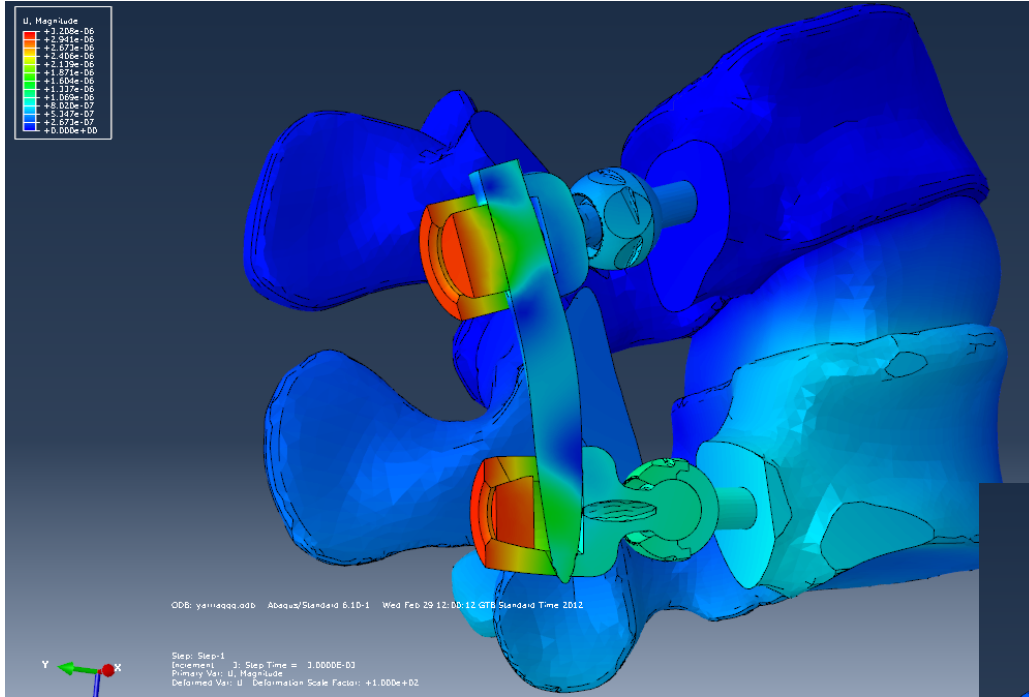


Sonlu eleman yöntemi (FEM)



FEM Kesitsel Von Mises Stress

Dinamik Pedikül Vida+ Rijit Rod



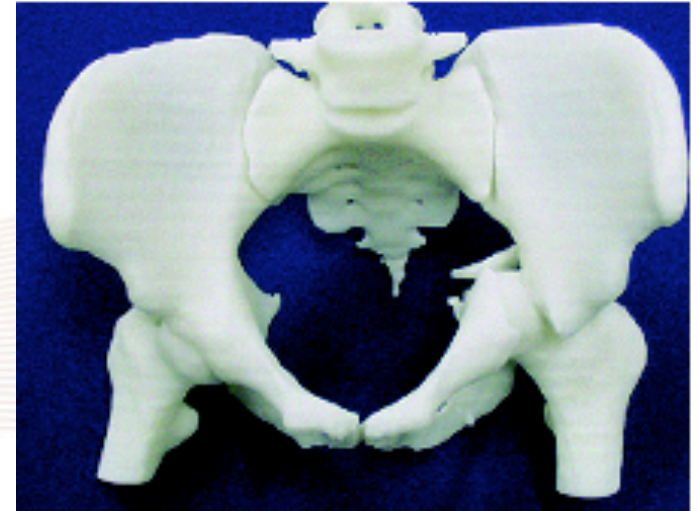
Stereolithography Model

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RAPID PROTOTYPING: THE FUTURE OF TRAUMA SURGERY?

BY GEORGE A. BROWN, MS, MD, KEIKHOSROW FIROOZBAKHSH, PHD,
THOMAS A. DECOSTER, MD, JOSÉ R. REYNA JR., MD, AND MOHEB MONEIM, MD



Biyomodelleme (Stereolithography)

türkomurga

Arq Neuropsikiyat 2007;65(2-B):443-445

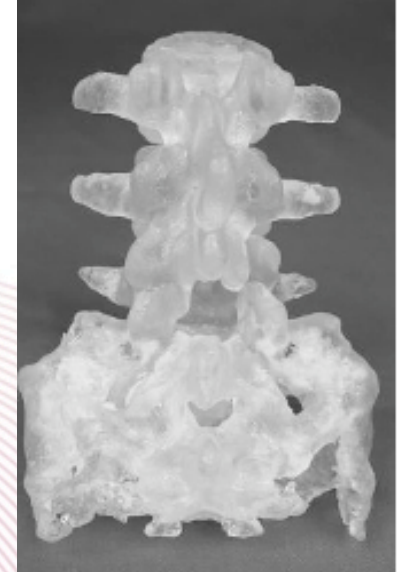
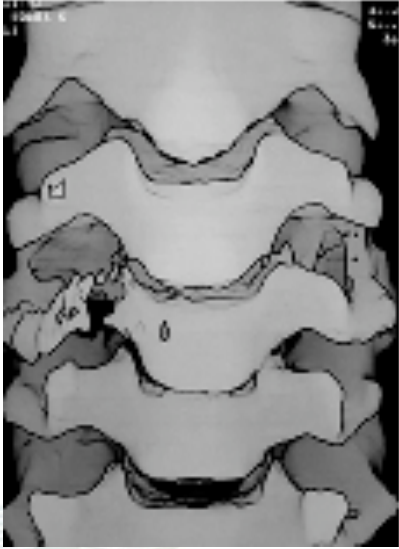
SPINE Volume 30, Number 24, pp 2841-2845
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APPLICATION OF THE STEREO LITHOGRAPHY TECHNIQUE IN COMPLEX SPINE SURGERY

*Wellington Silva Paiva¹, Robson Amorim¹,
Douglas Alexandre França Bezerra¹, Marcos Masini²*

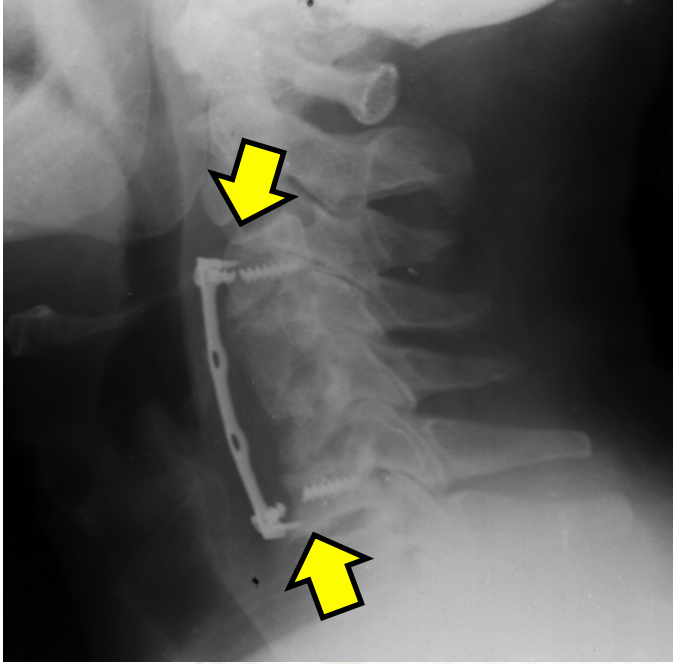
Biomodeling as an Aid to Spinal Instrumentation

Paul S. D'Urso, MBBS, PhD, FRACS,* Owen D. Williamson, MB, BS, FRACS,†
and Robert G. Thompson, BInfoTech‡

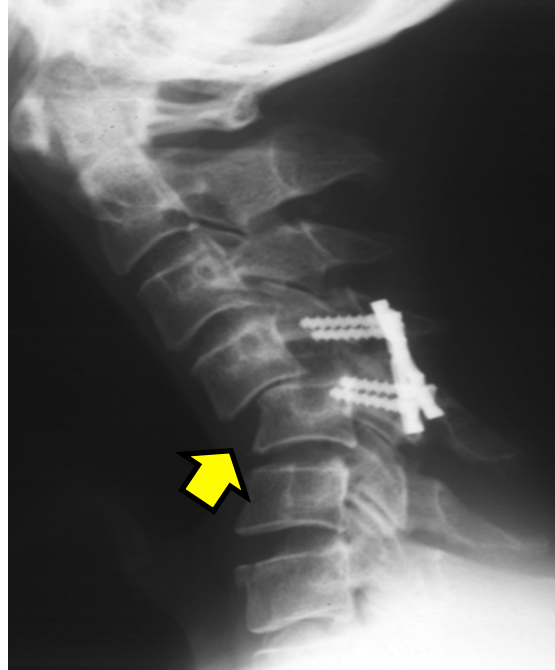




Ben cerrahım mühendis değilim !



Vida kırılması



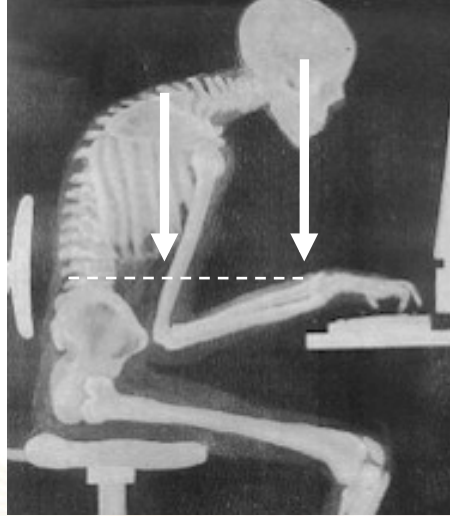
Yetersiz stabilizasyon



Komşu segment hastalığı

Konuřmanın Slaytları

sunumlar@
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Teřekkür Ederim

