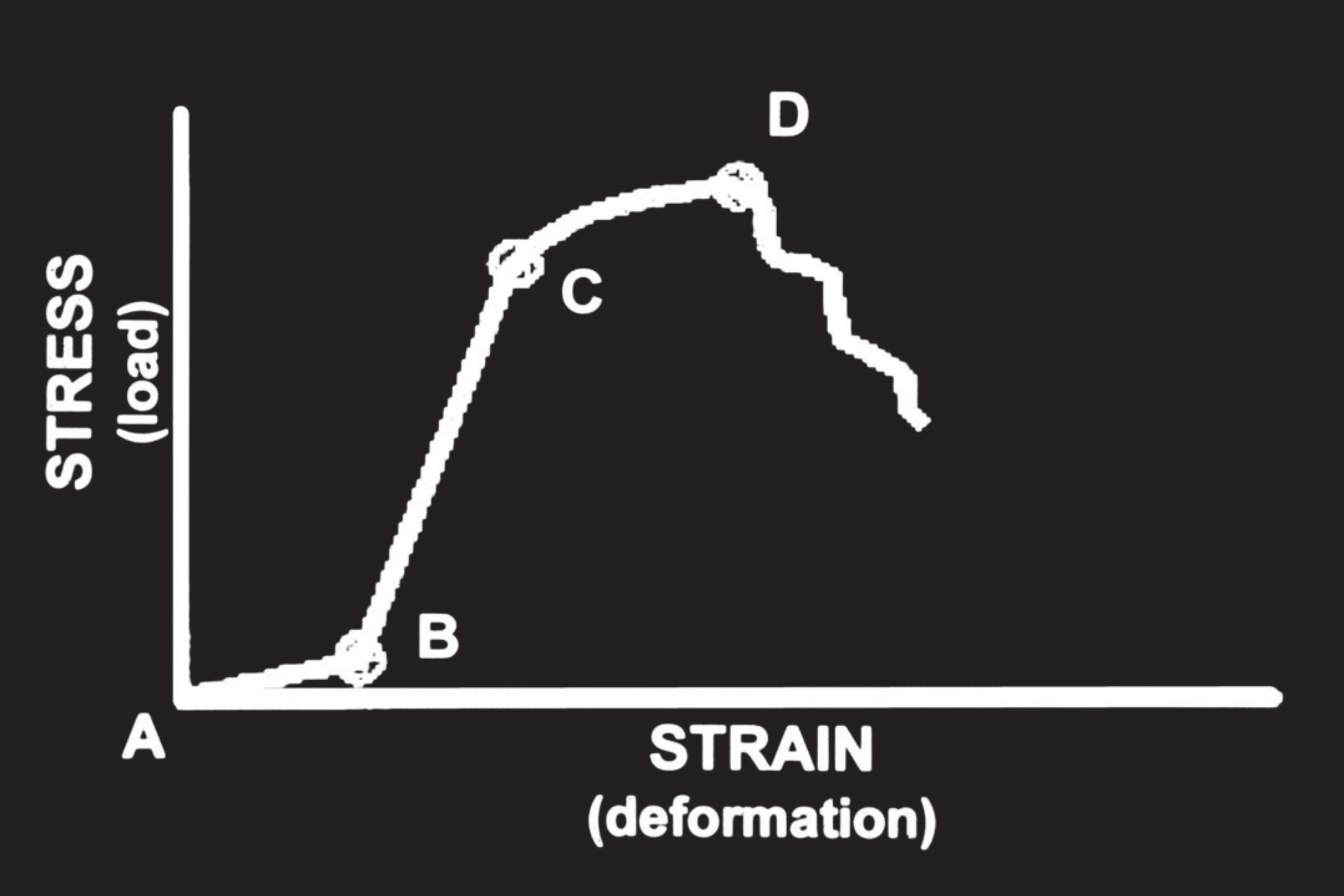
Cervical Deformity

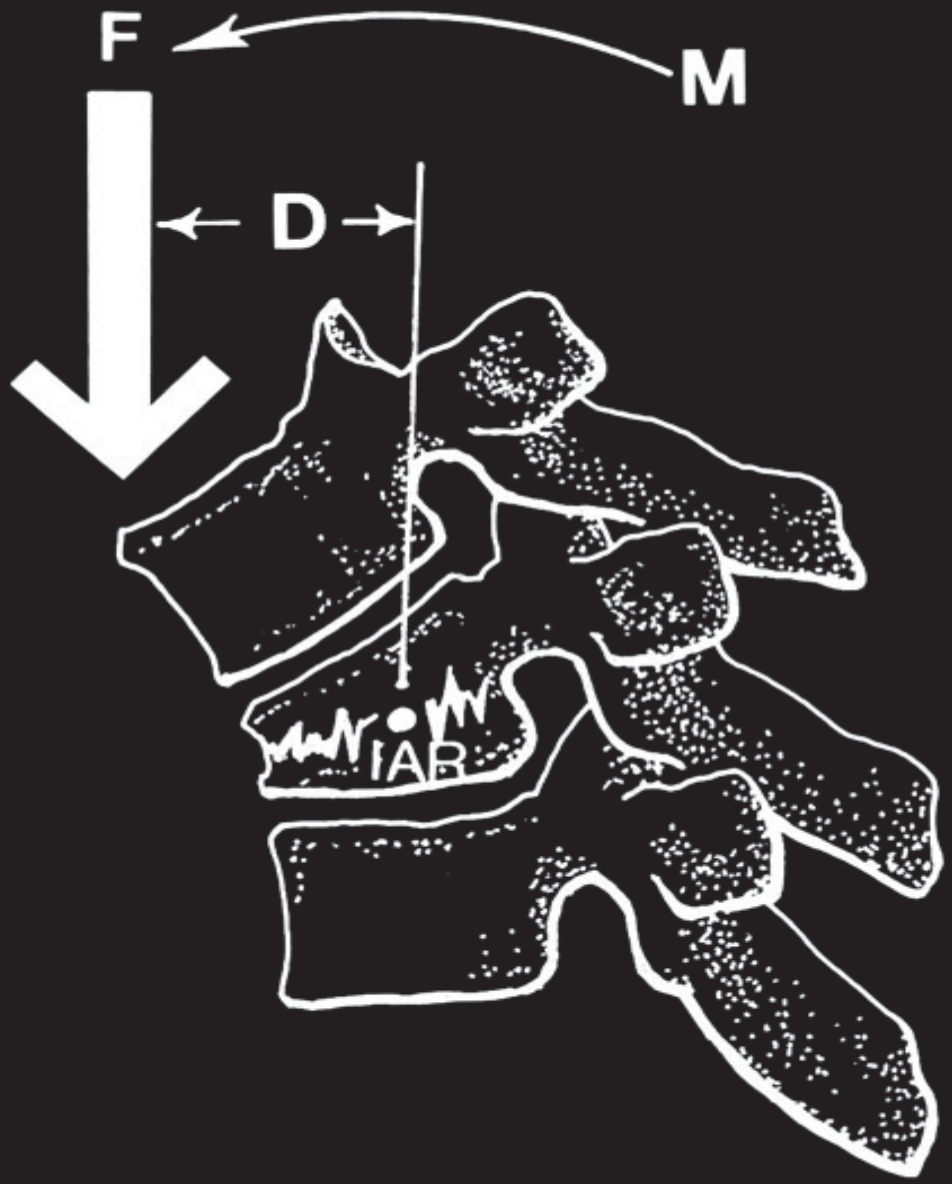
Ed Benzel

DePuy
OrthoMEMS
AxioMed

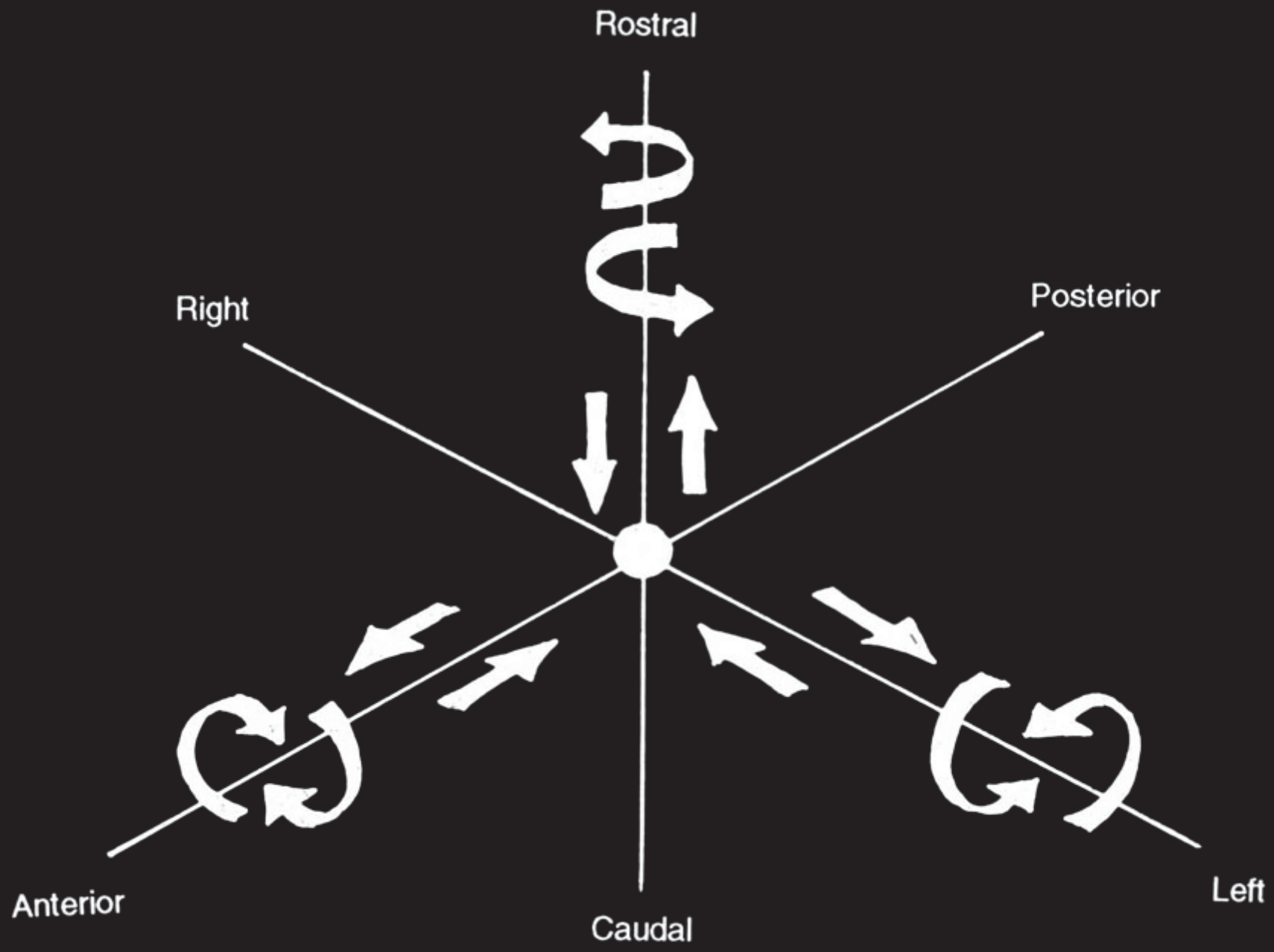

D
C
B
A
STRESS
(load)
STRAIN
(deformation)

BIOMECHANICS OF SPINAL COLUMN FAILURE


M = F x D

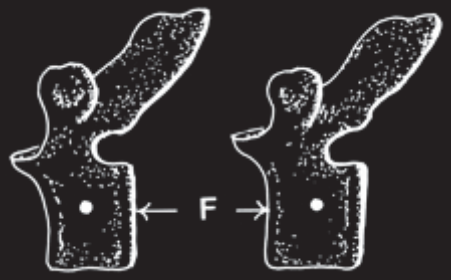

F
M
D
IAR

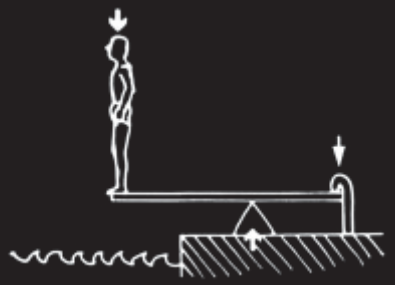
BIOMECHANICS OF SPINE INSTRUMENTATION


Rostral
Right
Posterior
Anterior
Caudal
Left


M = F X D

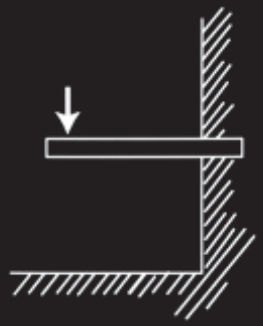

M
F
D
IAR

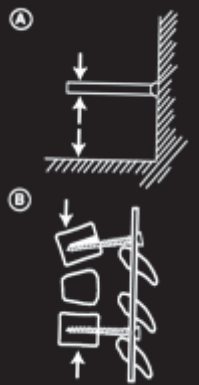


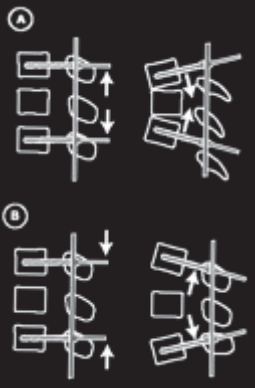


SIX DEFORMATION RESISTANCE MECHANISMS

Distraction
Three-Point Bending
Tension-Band Fixation
Fixed Moment Arm Cantilever Beam Fixation
Non-Fixed Moment Arm Cantilever Beam Fixation
Applied Moment Arm Cantilever Beam Fixation



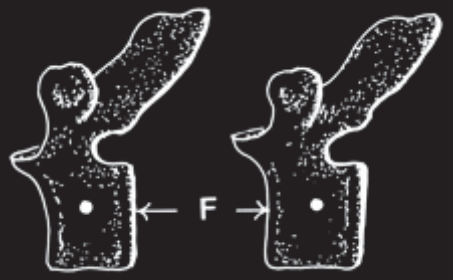


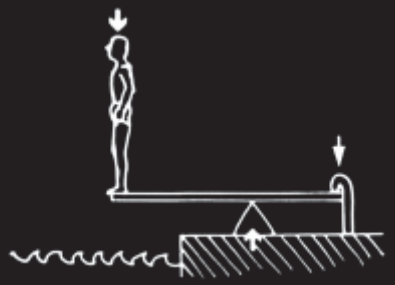


PRINCIPLES

Use as Many Mechanisms as Possible to Resist Deformation

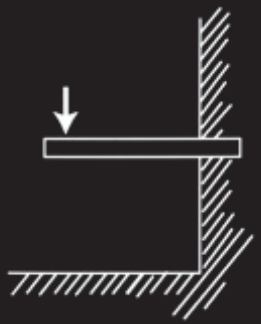
Implants Function Uniquely Under Different Loading Conditions

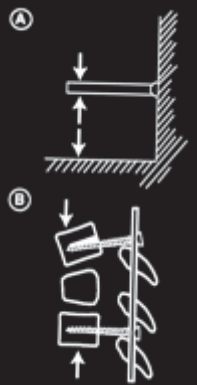


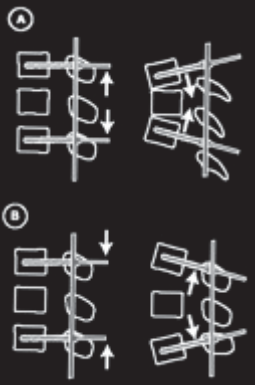


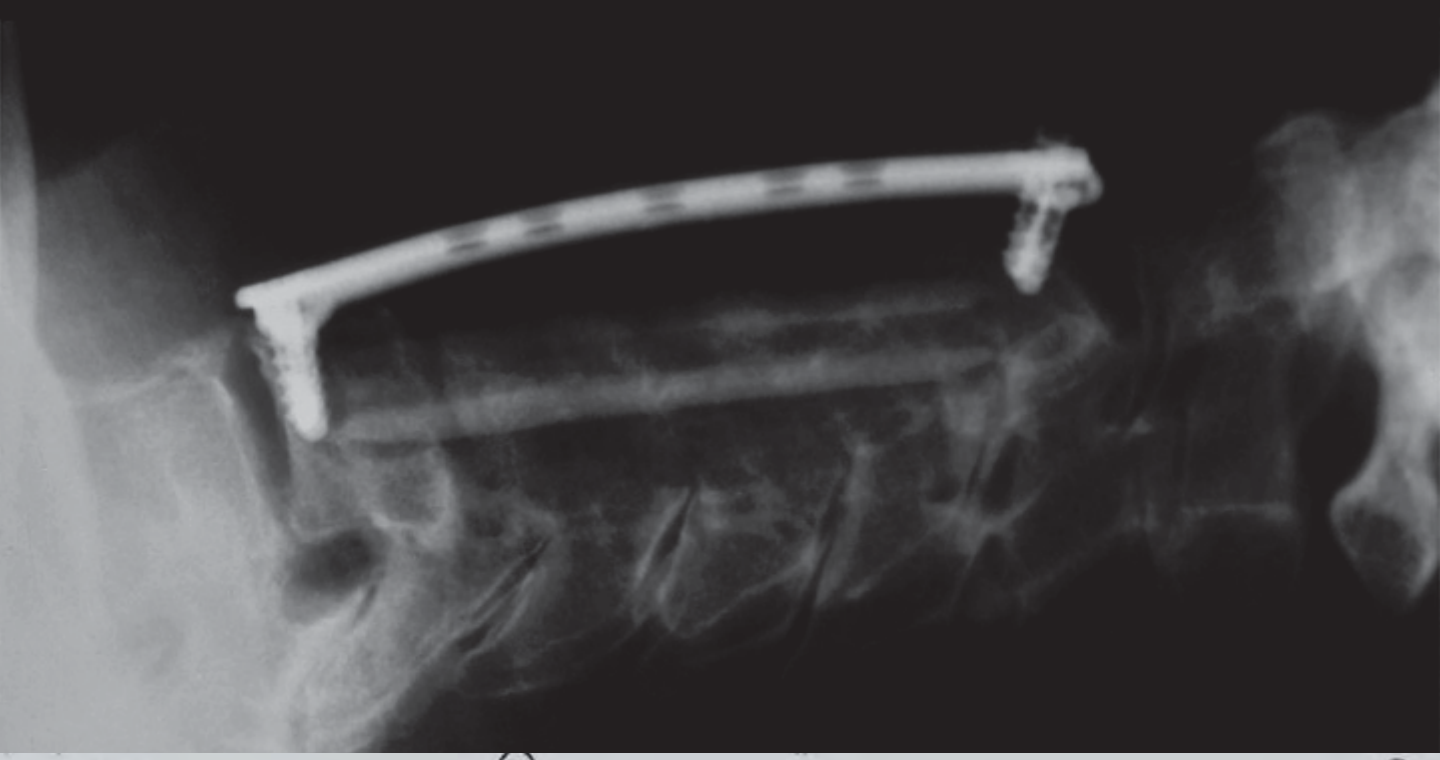
DEFORMATION RESISTANCE MECHANISMS

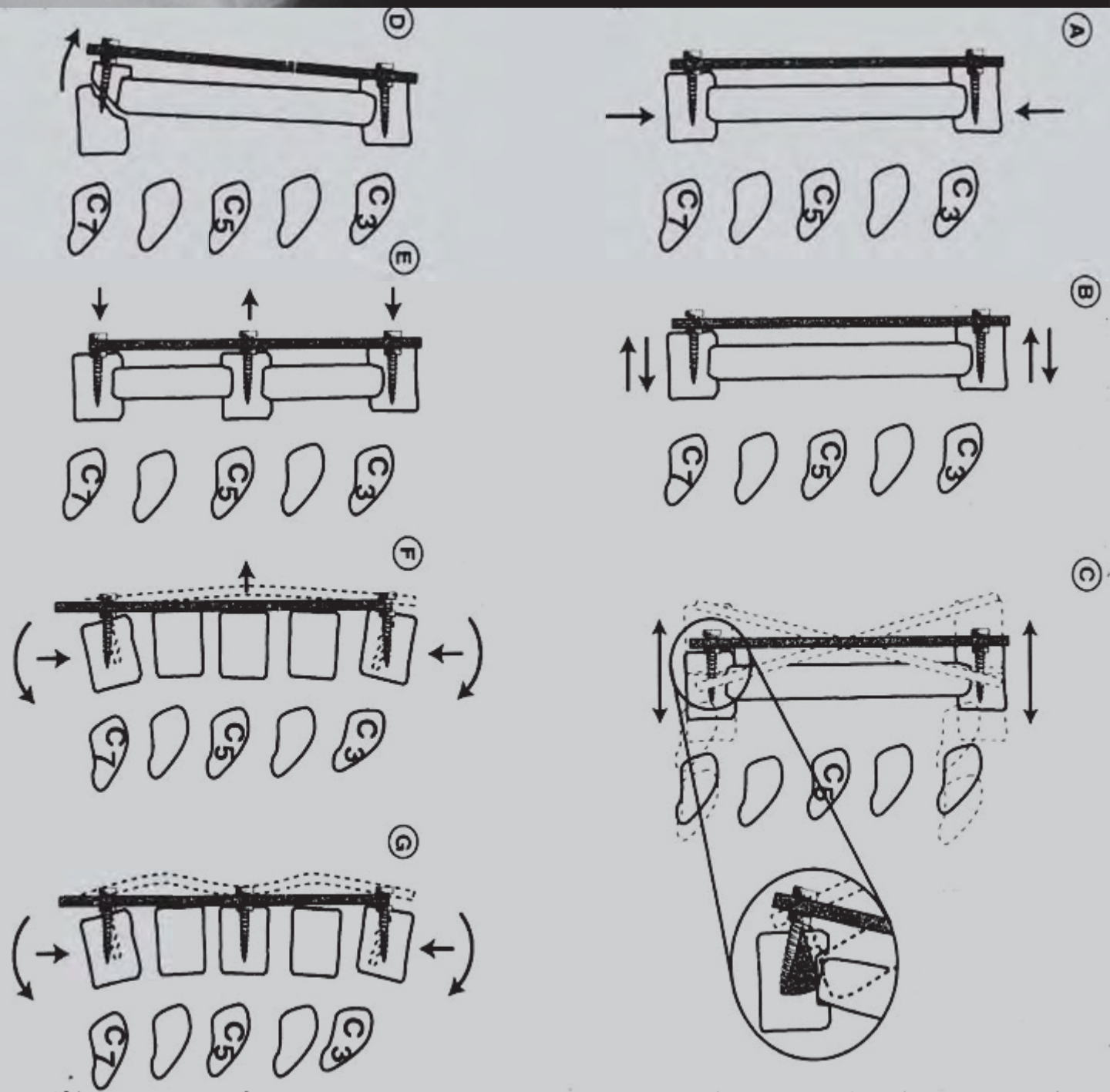
Distraction
Tension-Band Fixation
Three-Point Bending
Cantilevers

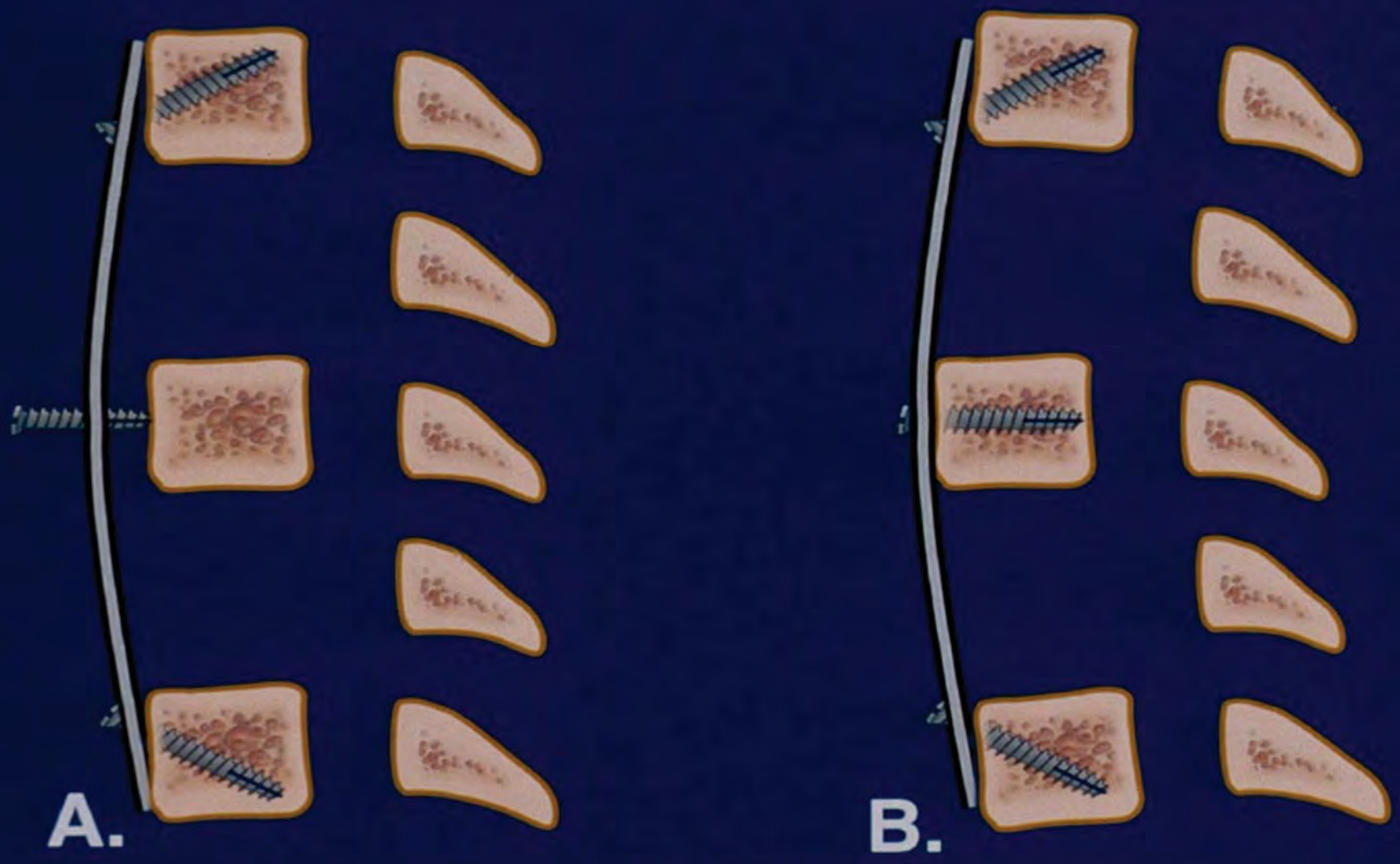




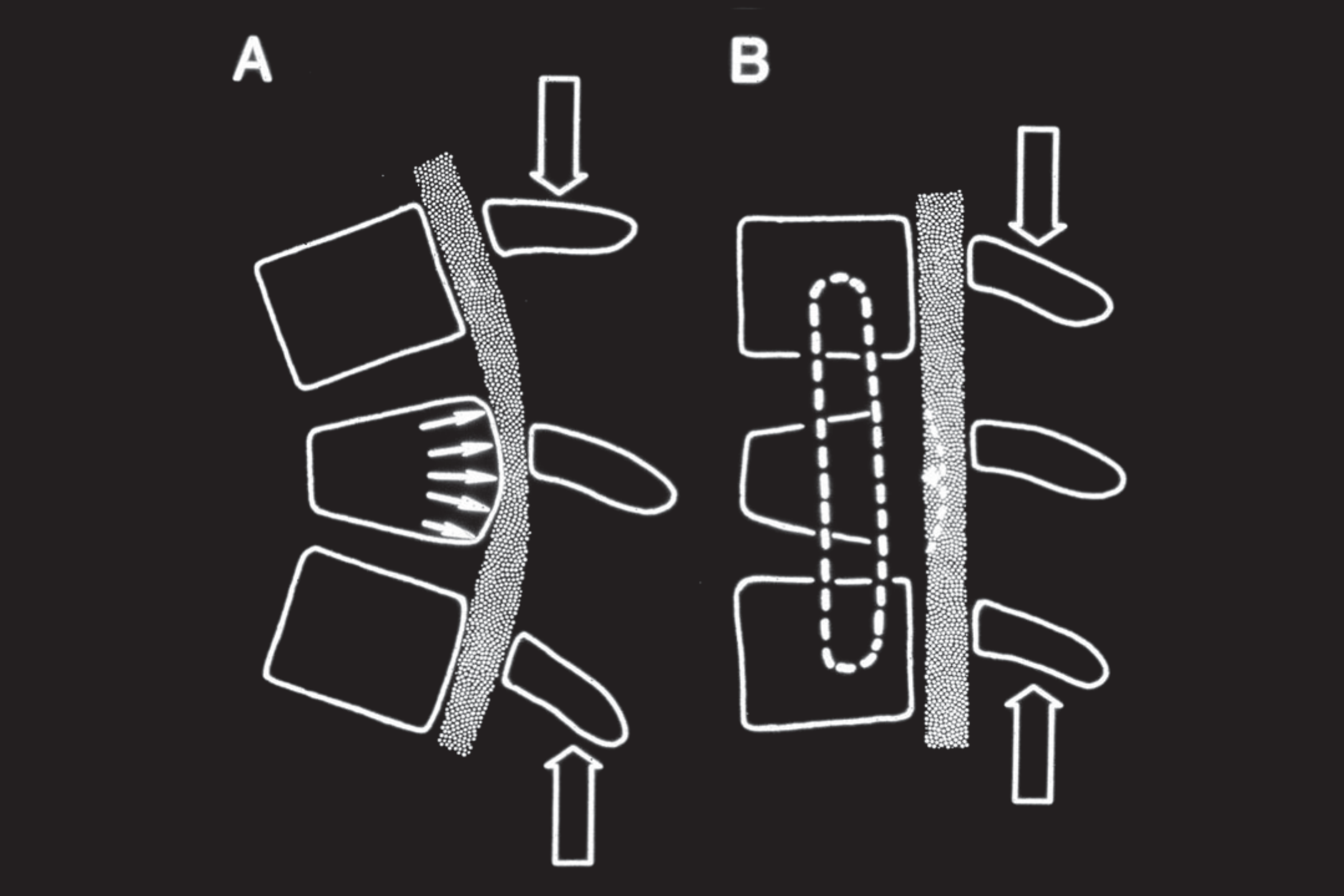


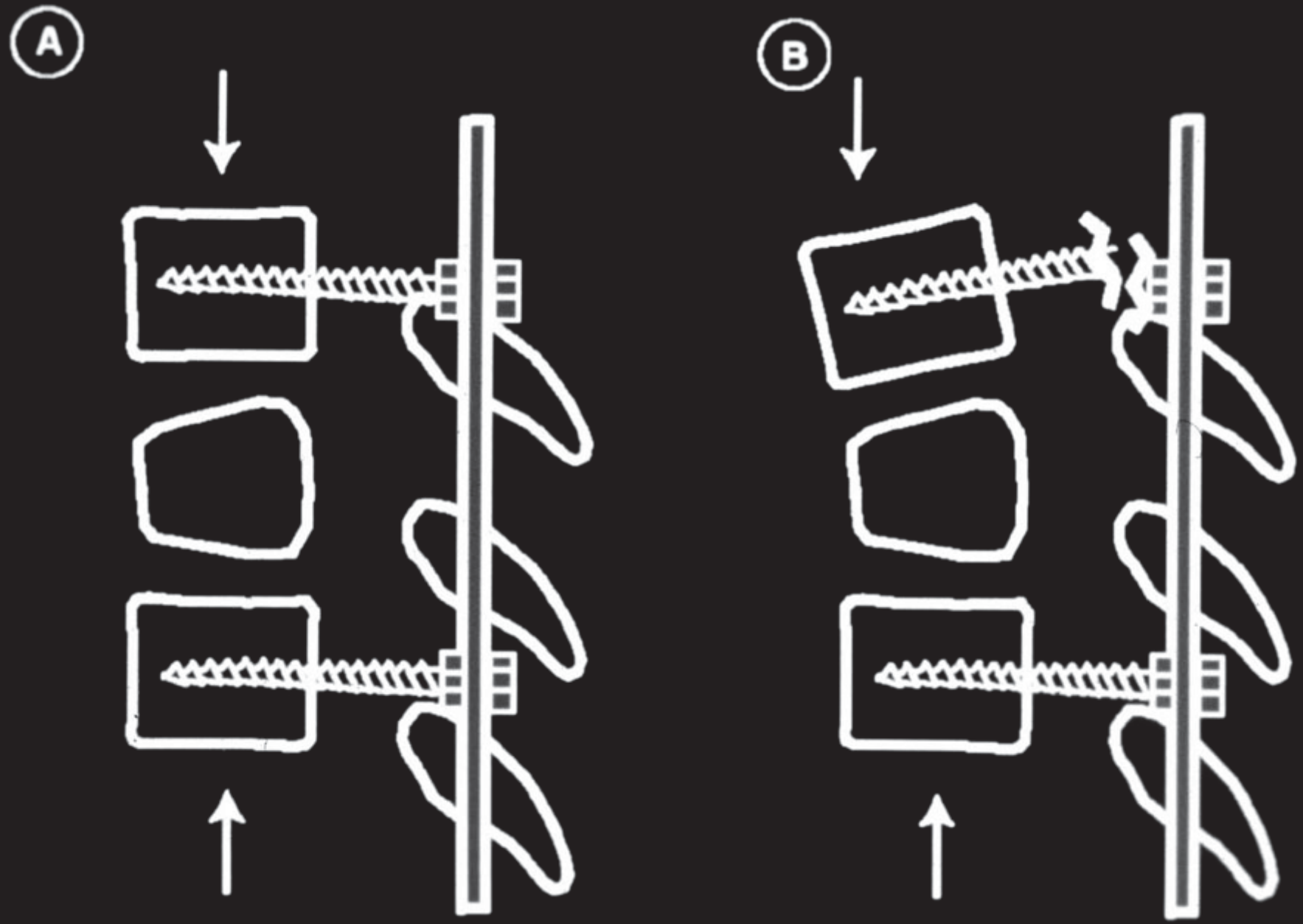


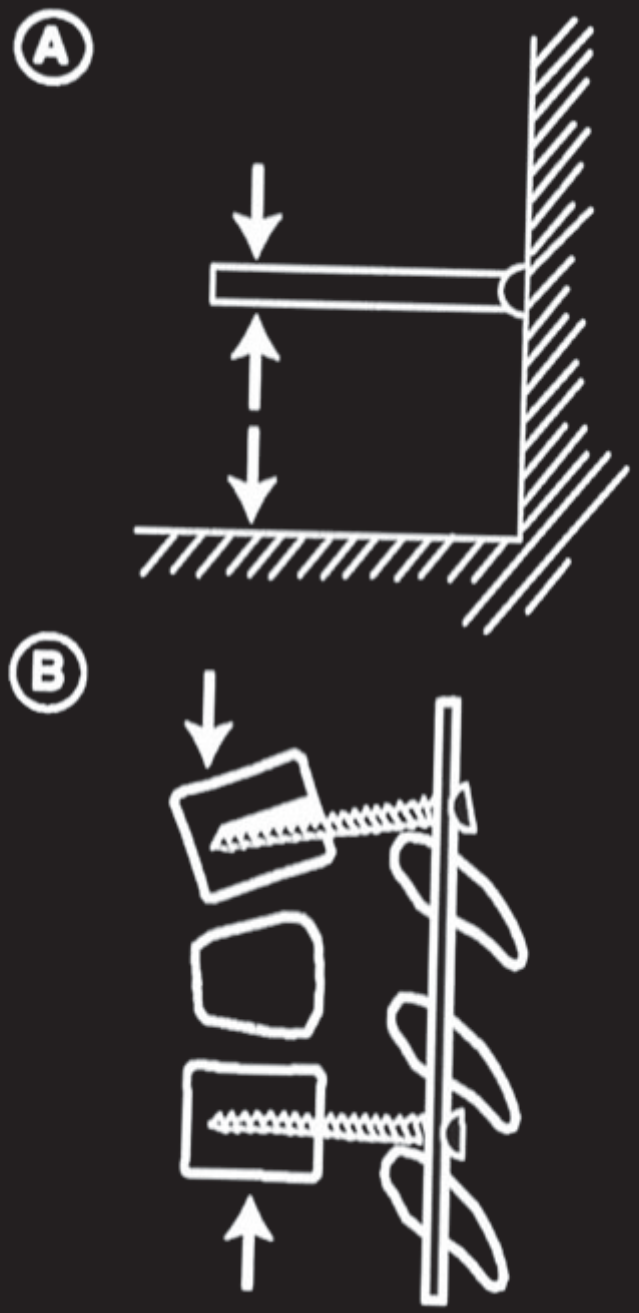

A
B
C
D
E
F
G
C7
C5
C3


A.
B.

Understand Limitations of Strategy


A
B


A
B

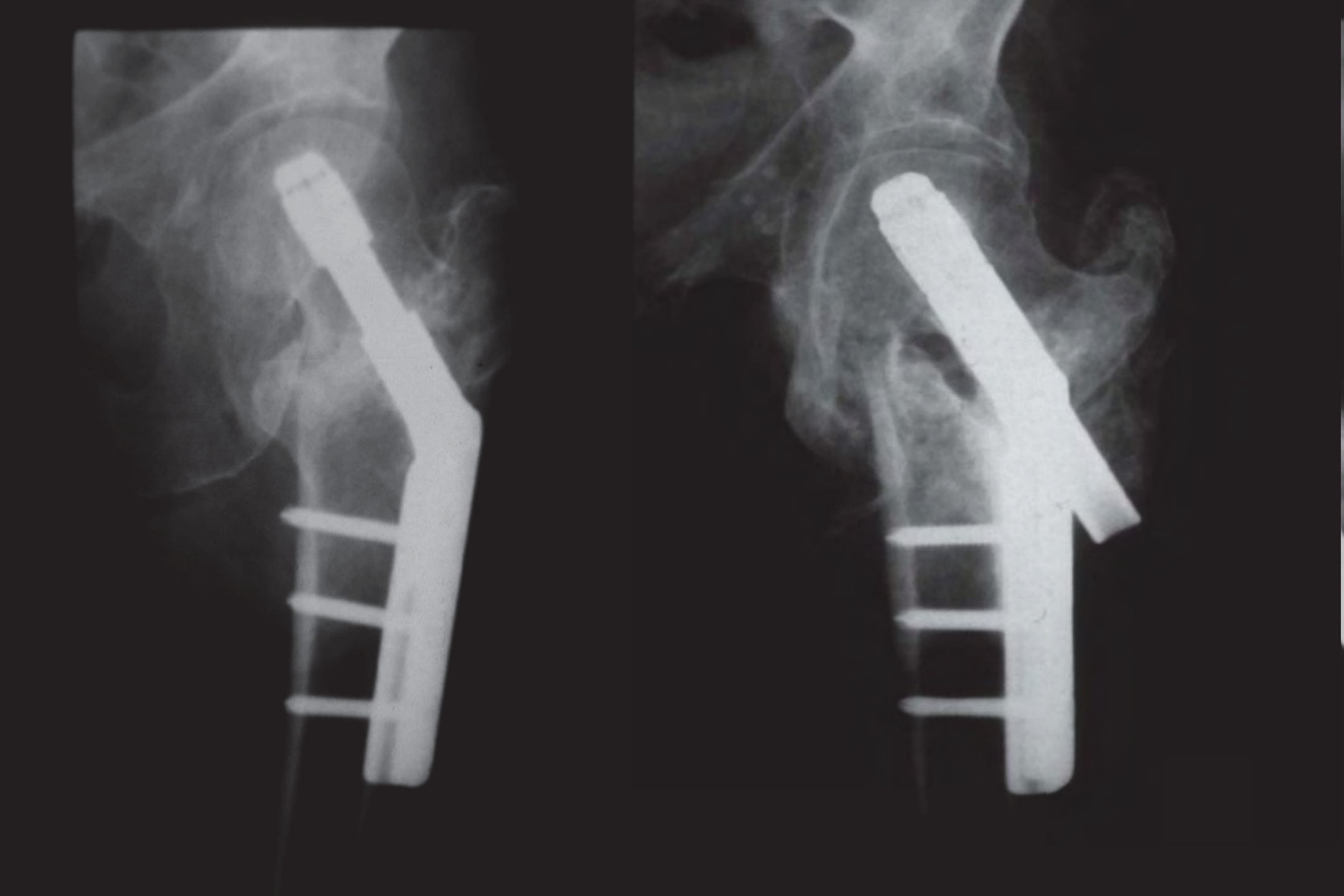

A
B

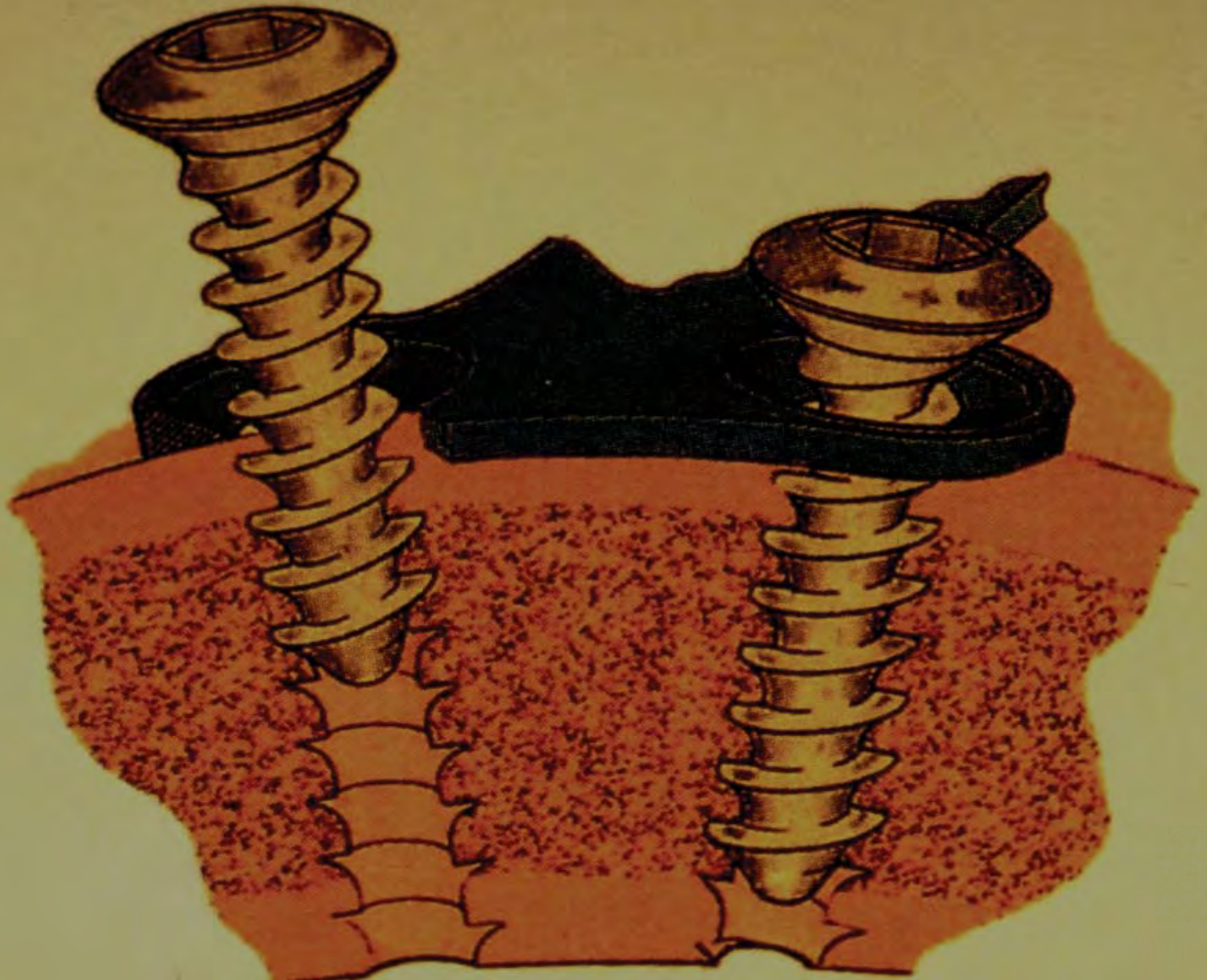
Dynamic Fixation

Wolff's Law

Every change in the form and function of a bone, or of function alone, is followed by specific definitive change in its internal architecture and equally definitive secondary changes in its external configuration, in accordance with mathematical laws.

"Structure is nothing else than the physical expression of function… under pathologic conditions the structure and form of the parts change according to the abnormal conditions of force transmission"

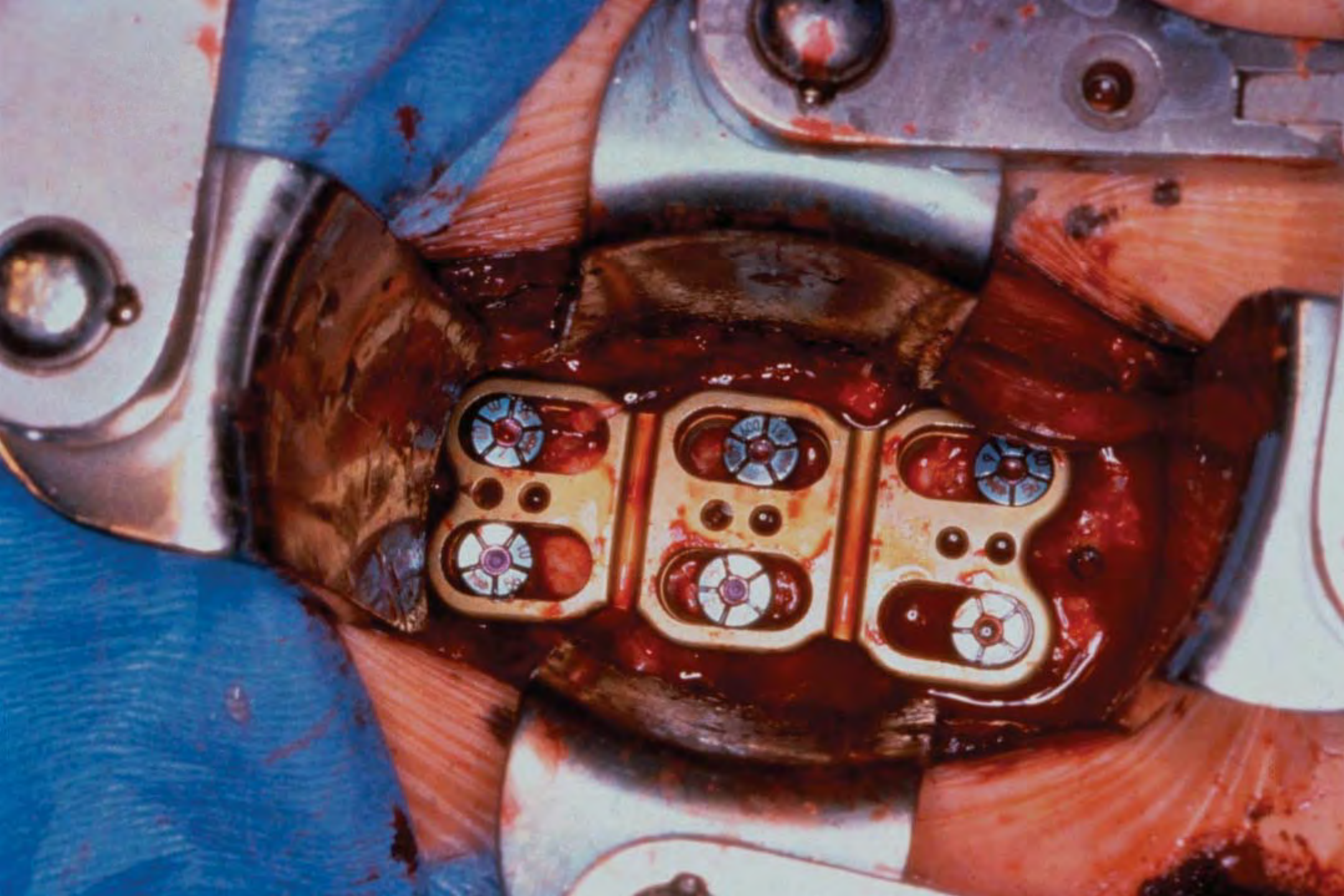


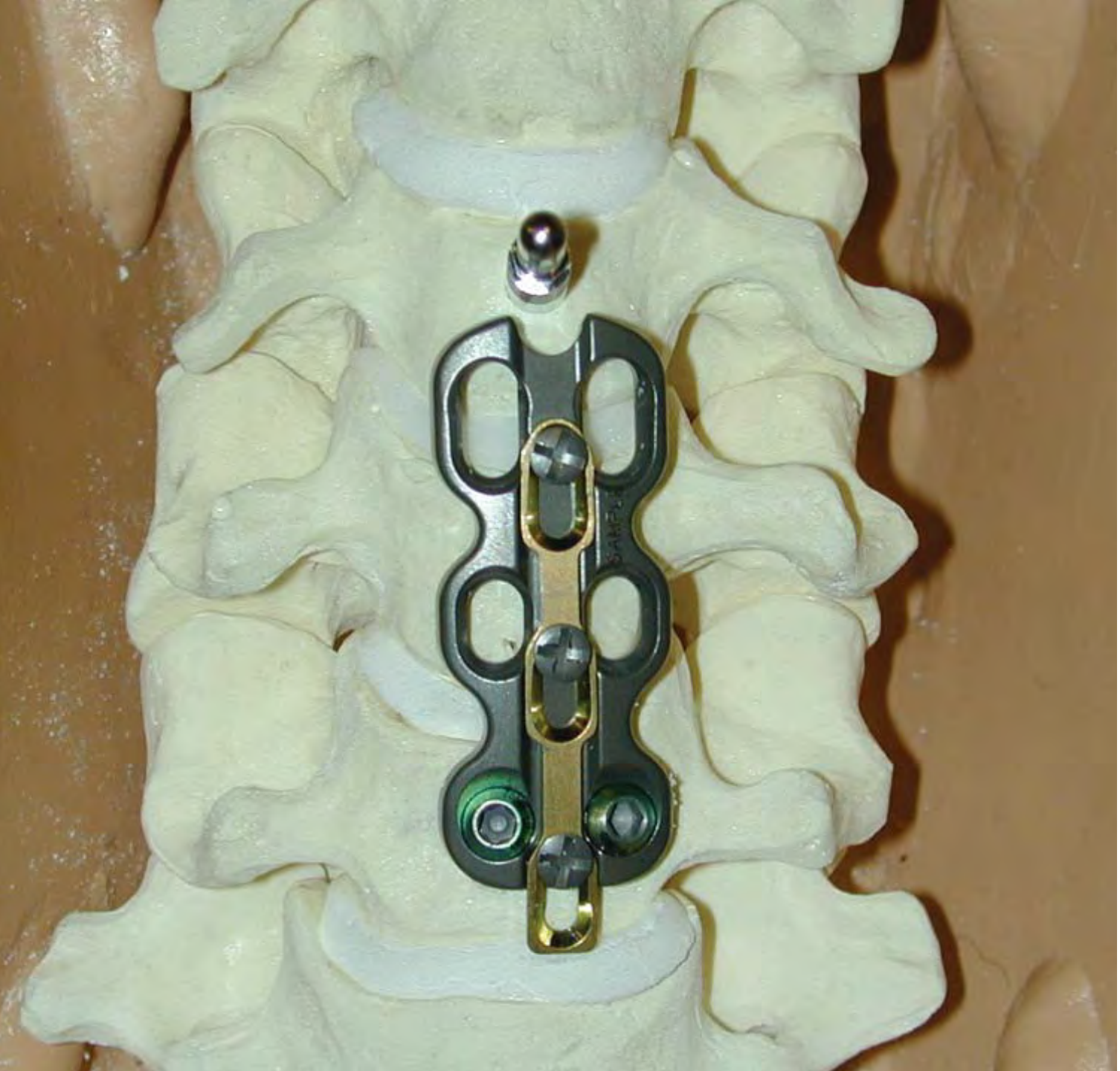



-0130


4 T 20°
-0130


4 T 20°
-01130
0175R



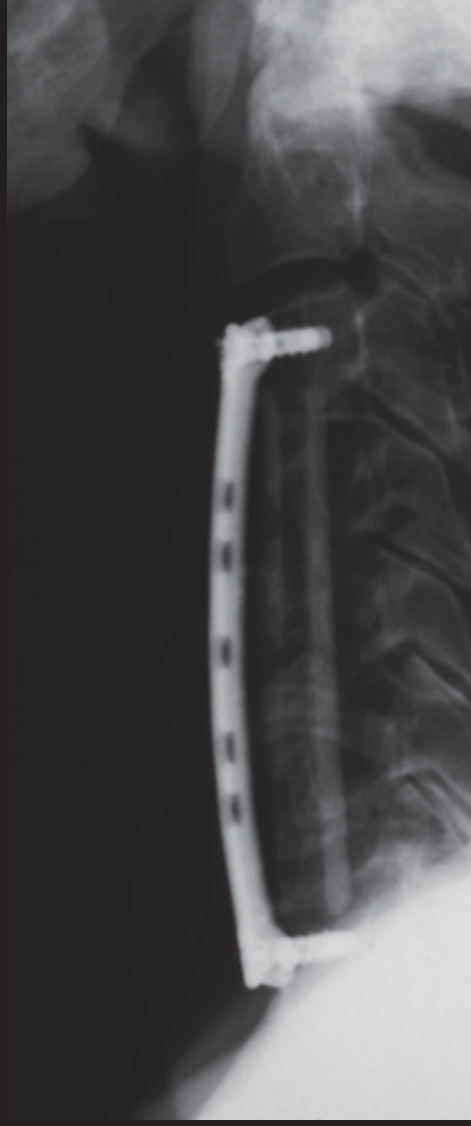


LOADING THE BONE GRAFT

Significant Loading and Unloading
in
Flexion
and
Extension

Buffered by Dynamic Implant

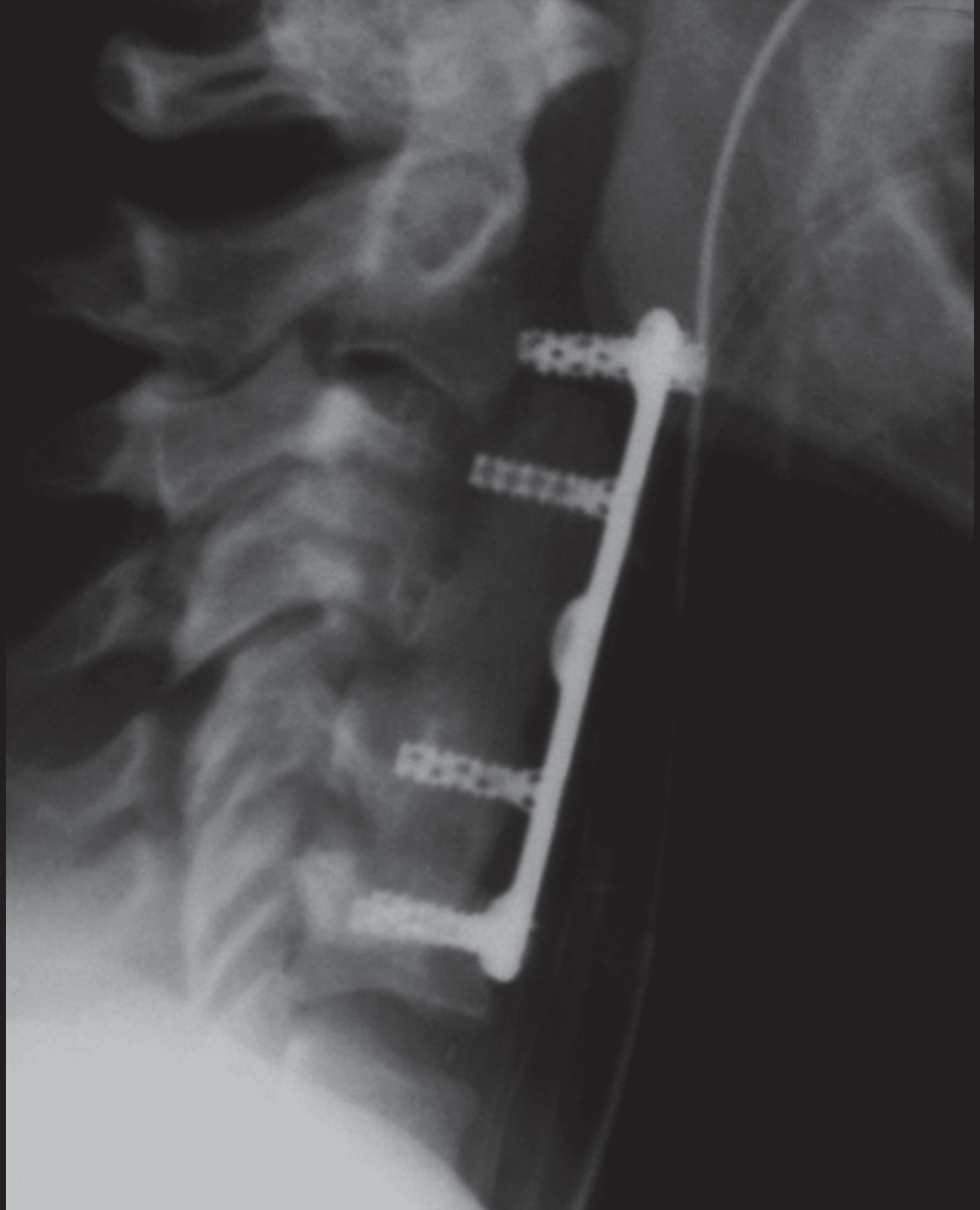
DiAngelo and Foley

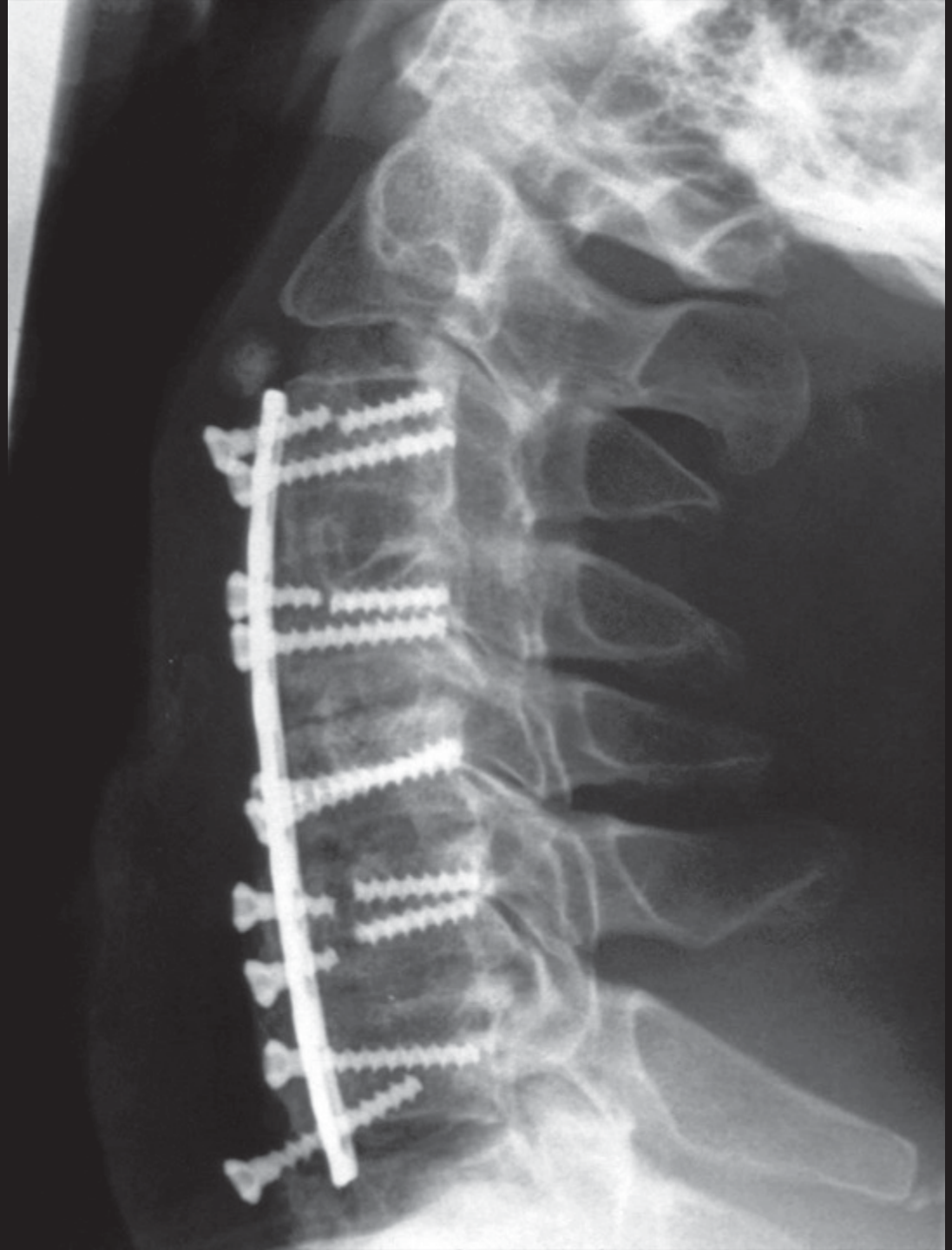


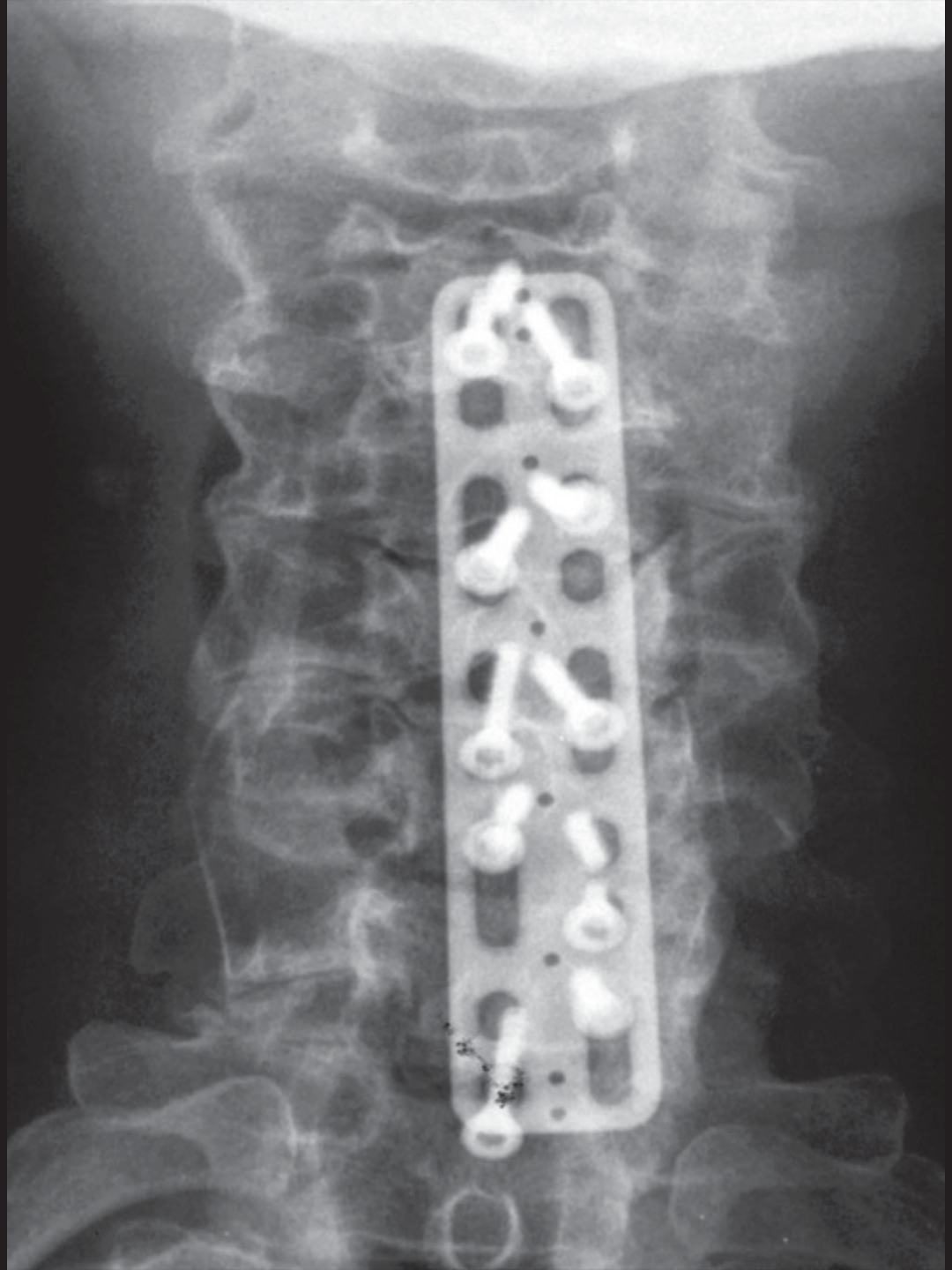
CONSTRUCT / SURGEON FAILURE

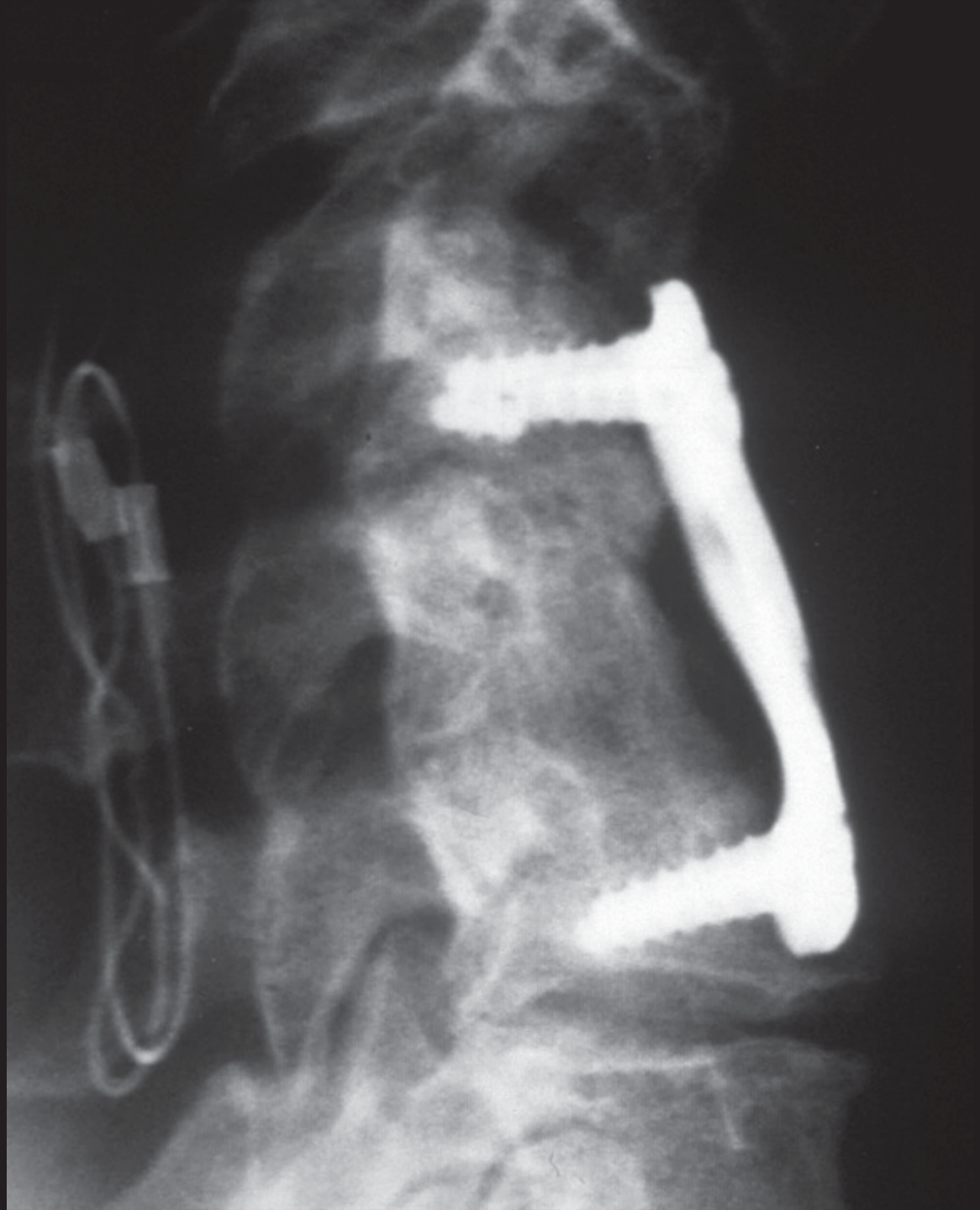
MODES OF CONSTRAINED CONSTRUCT / SURGEON FAILURE

Construct Dislodgement
Implant Fracture
Stress Shielding

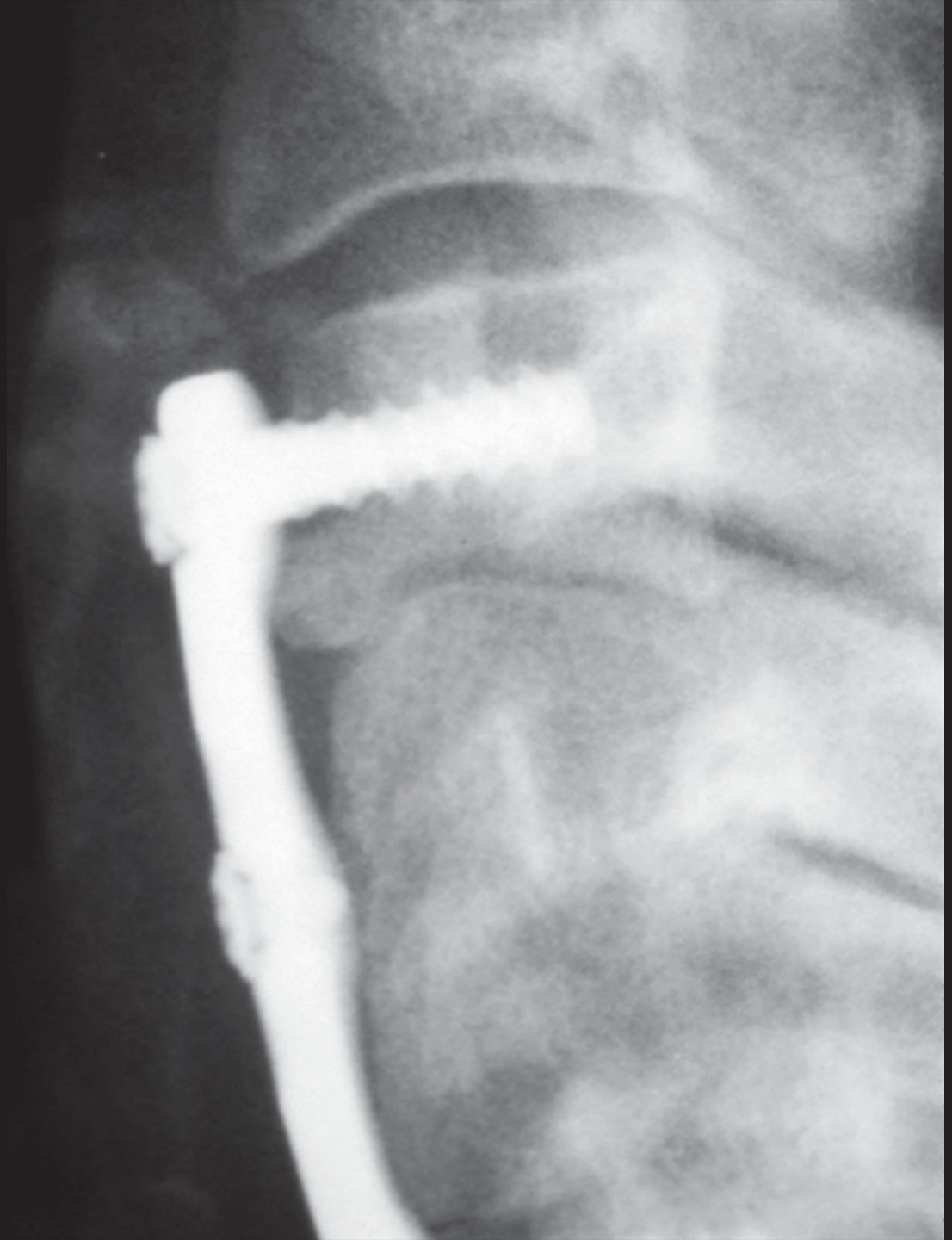




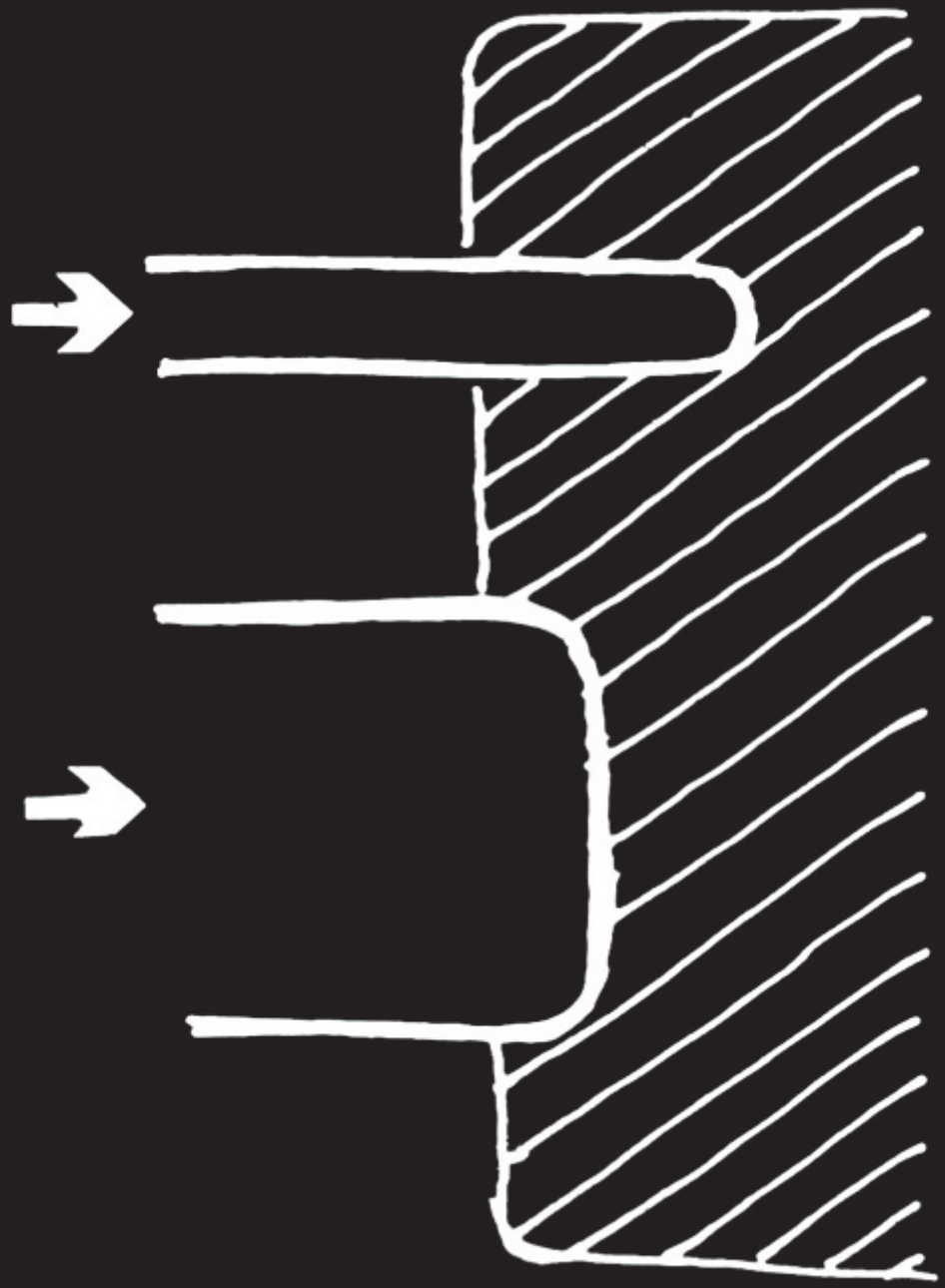


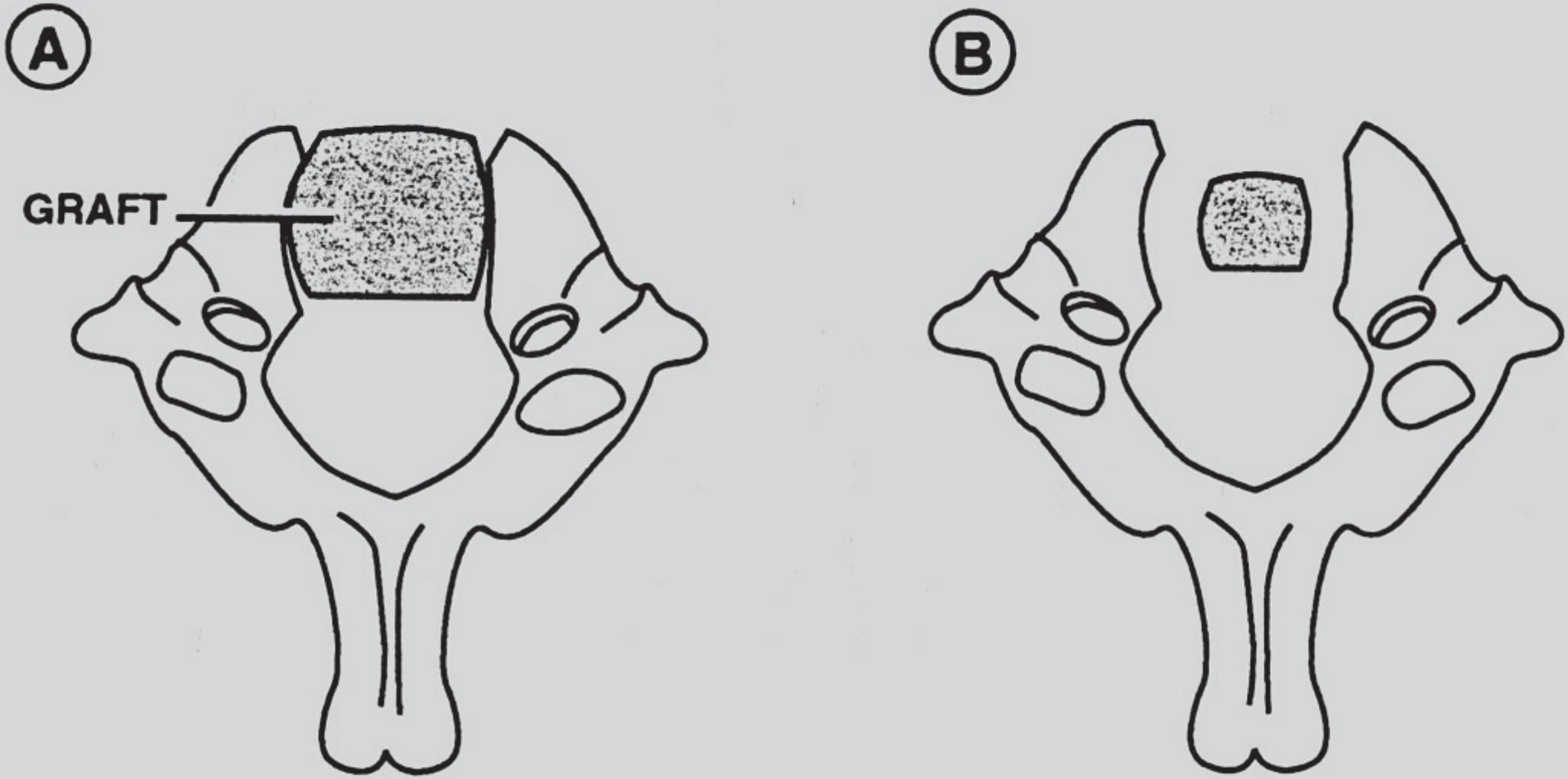


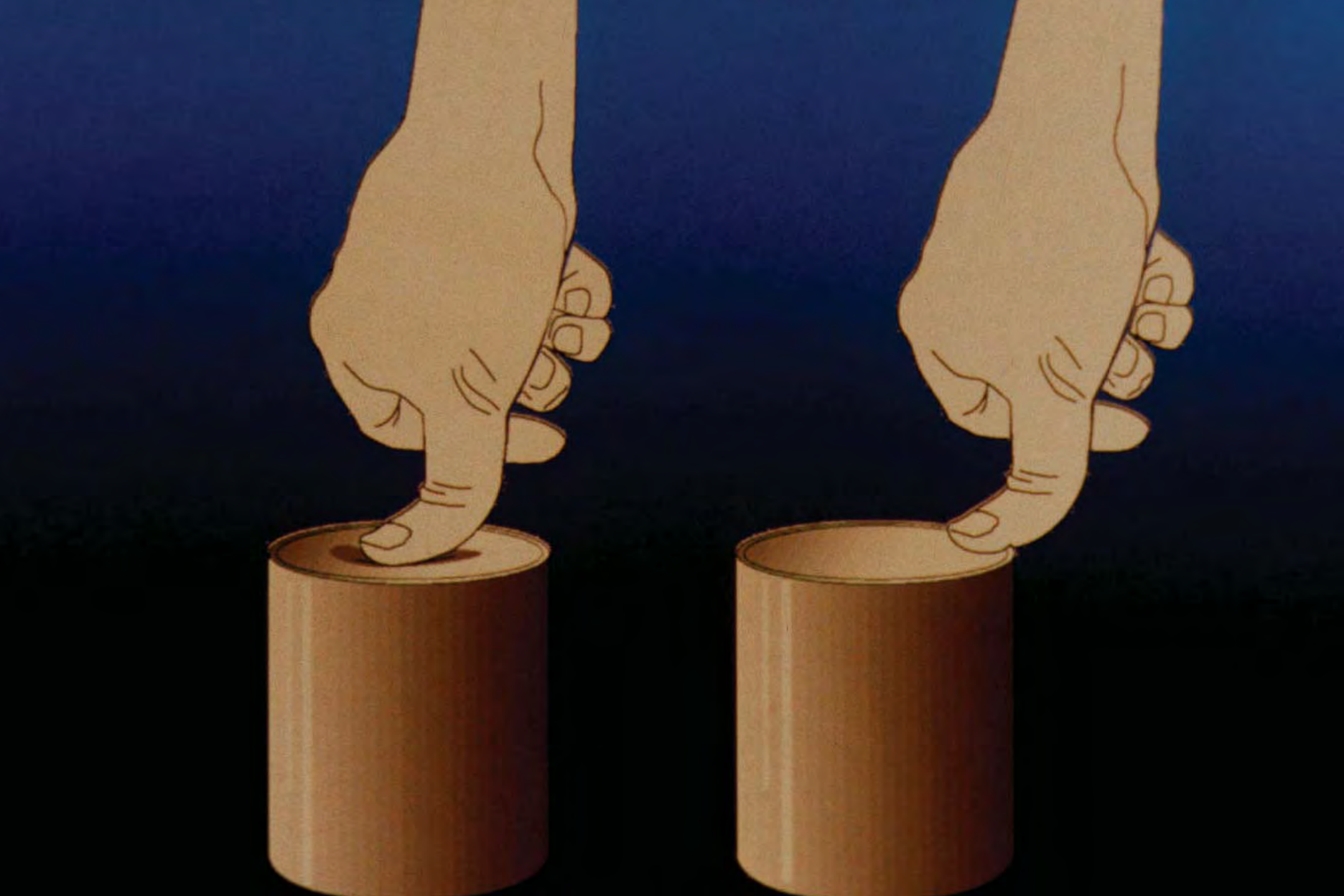
LOAD SHARING
versus
LOAD BEARING

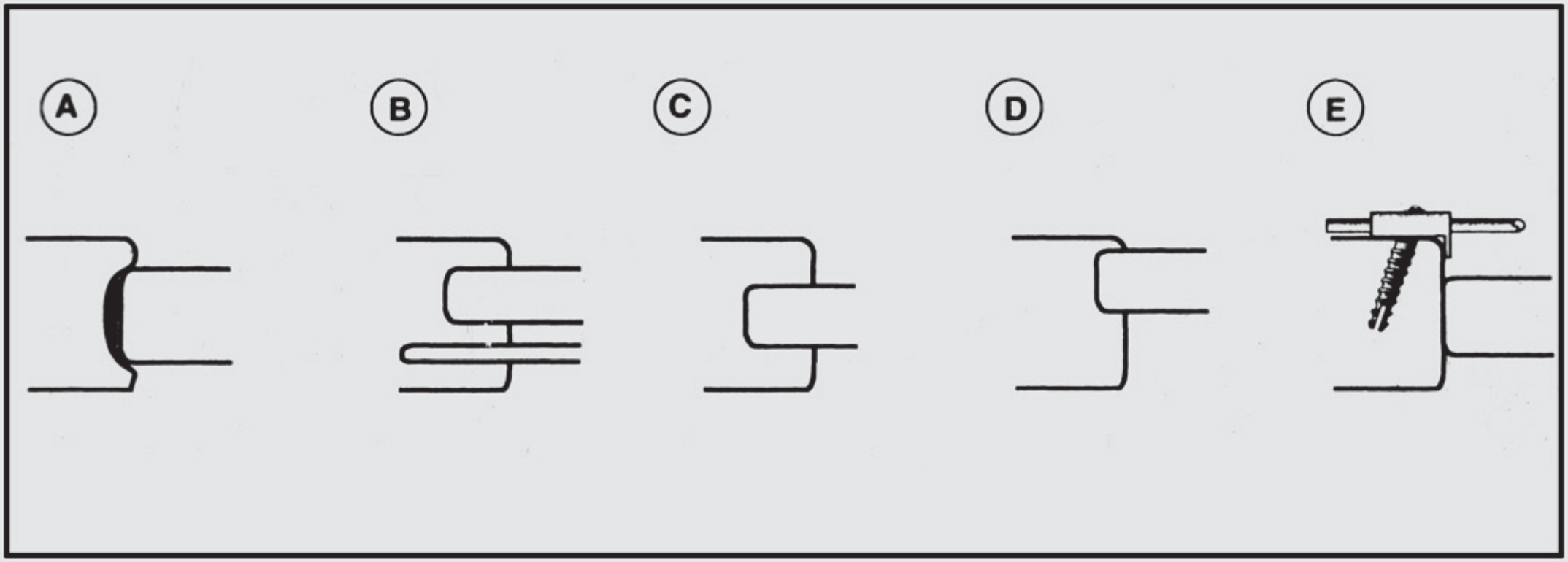


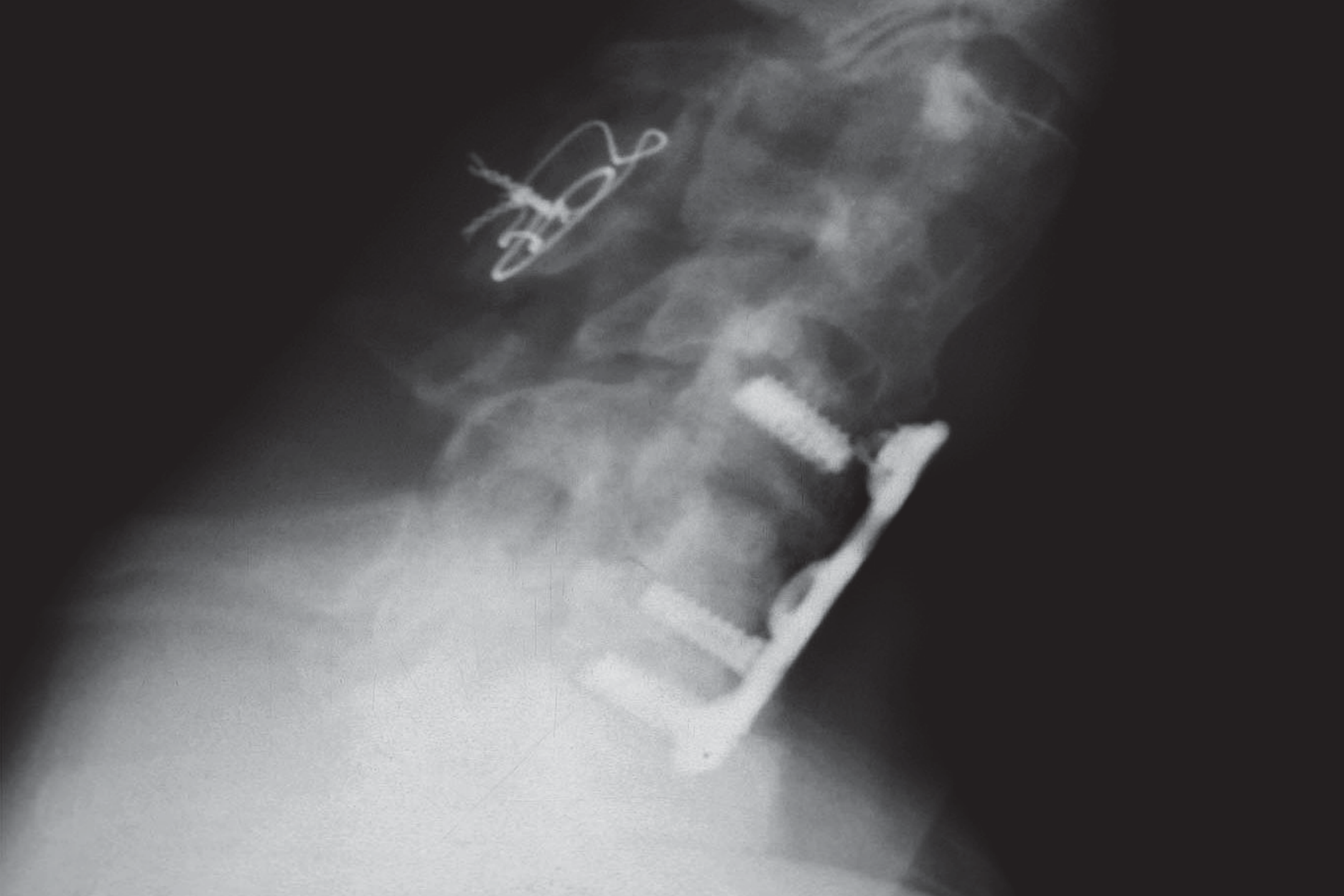
THE BIOMECHANICS OF FAILURE

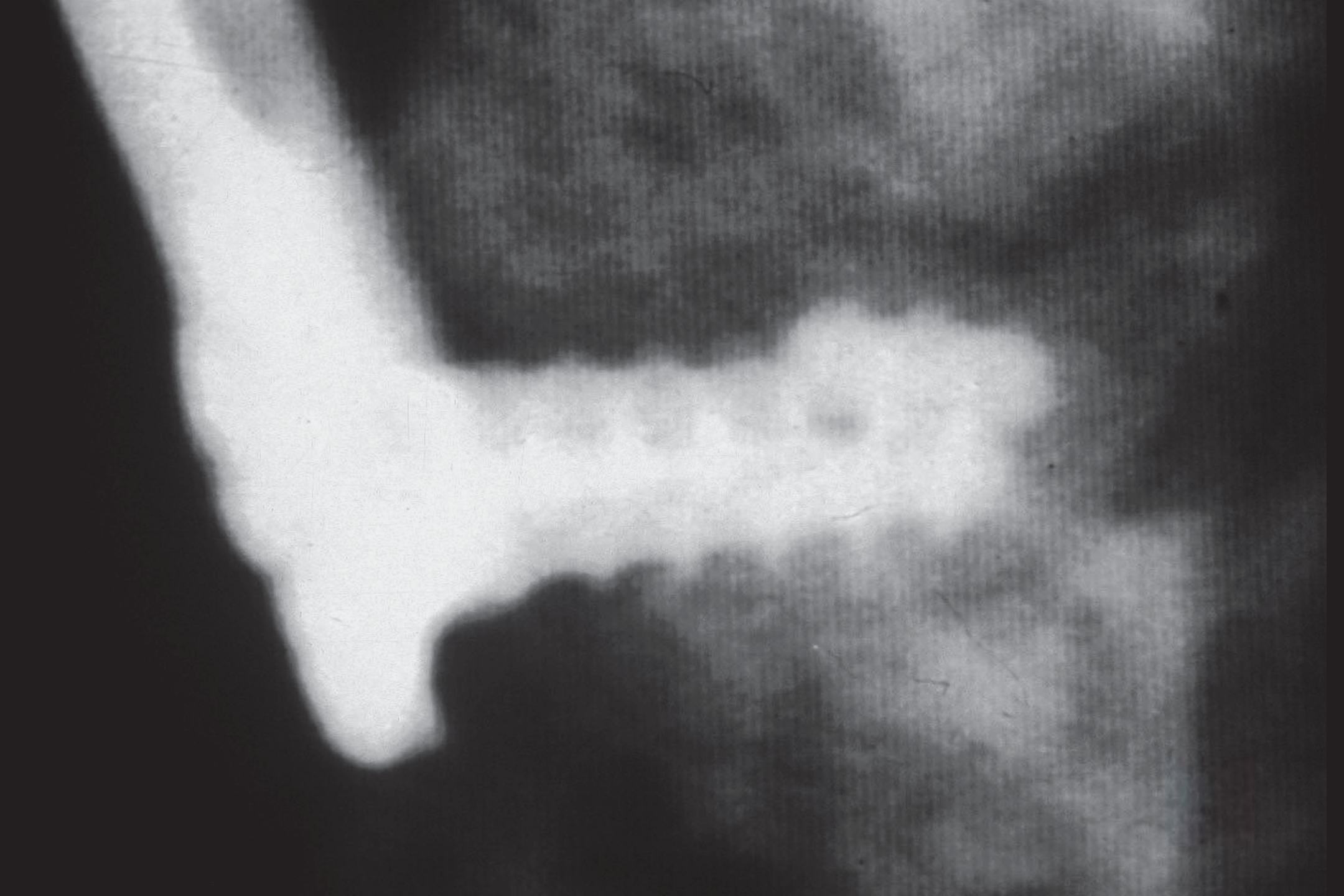



A
GRAFT
B



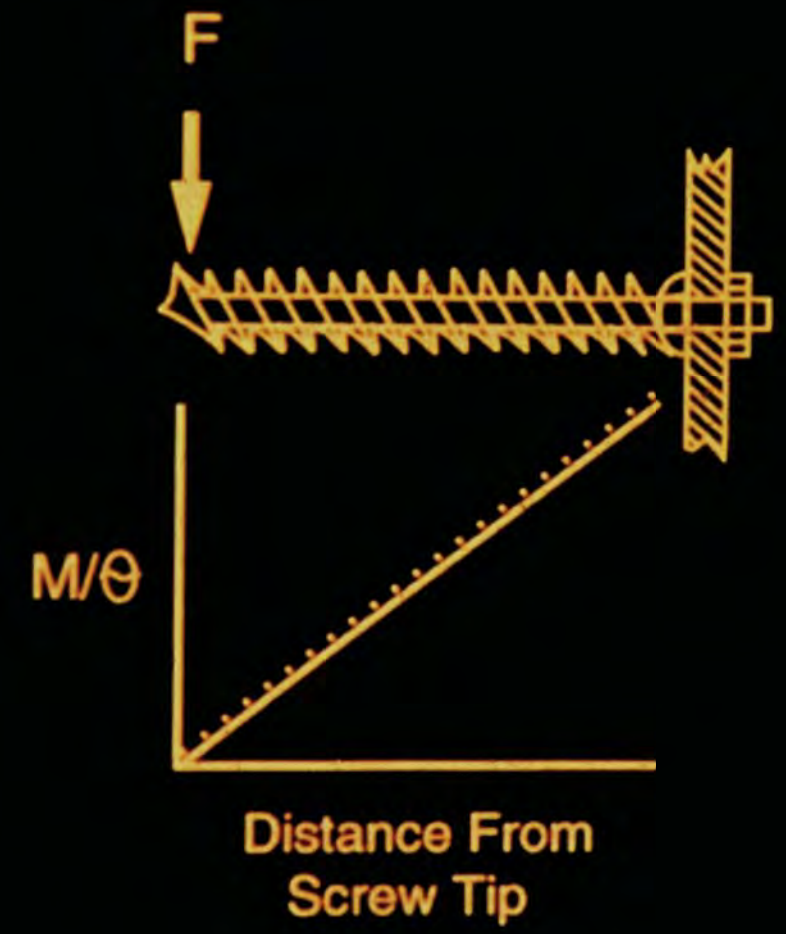

A
B
C
D
E





$$Z \sim D^3$$

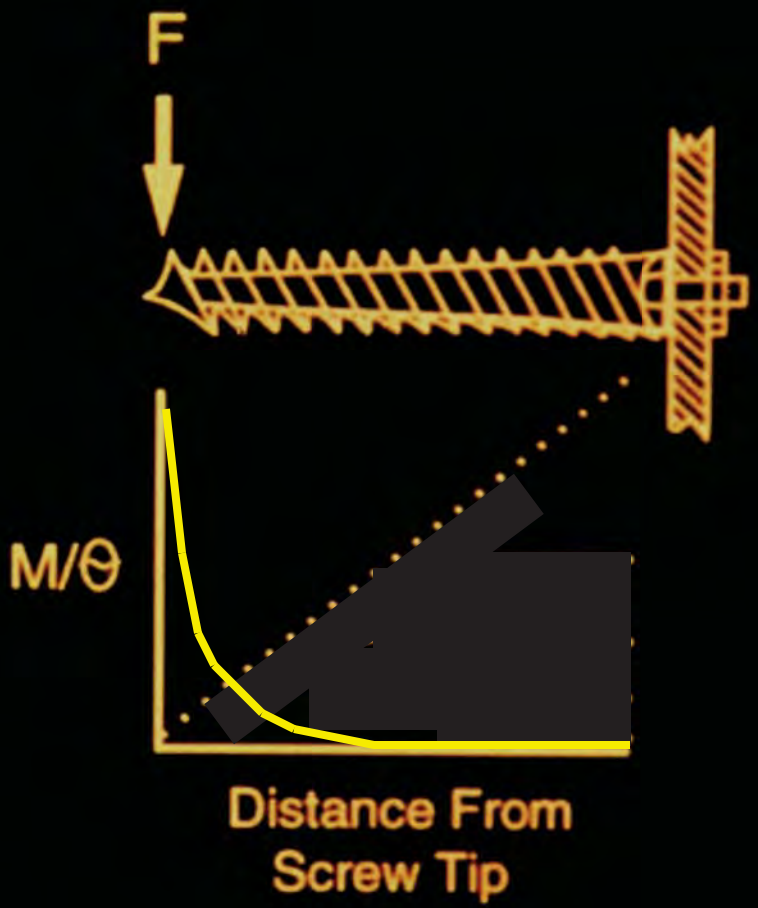
$$\theta = \frac{M}{Z}$$

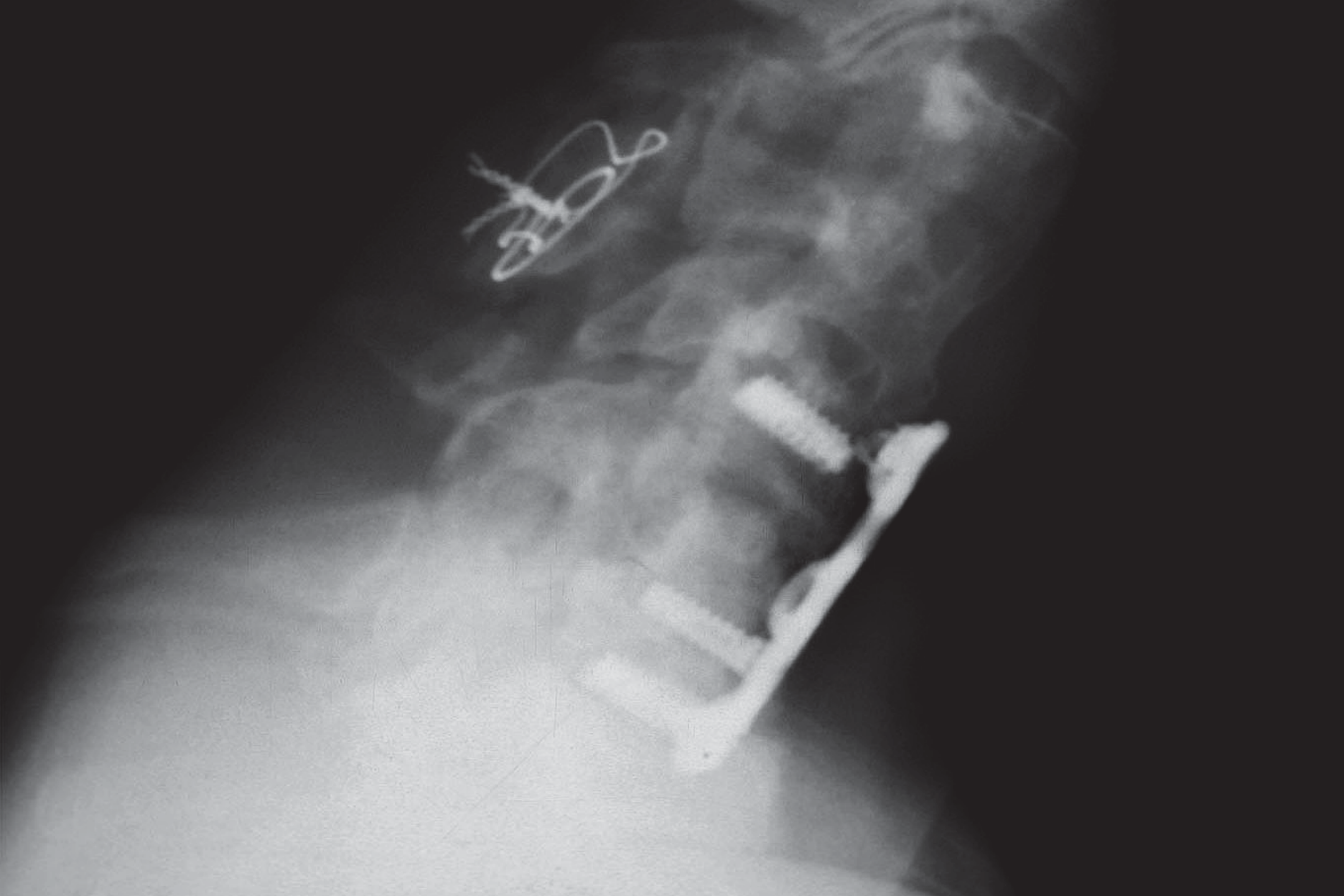


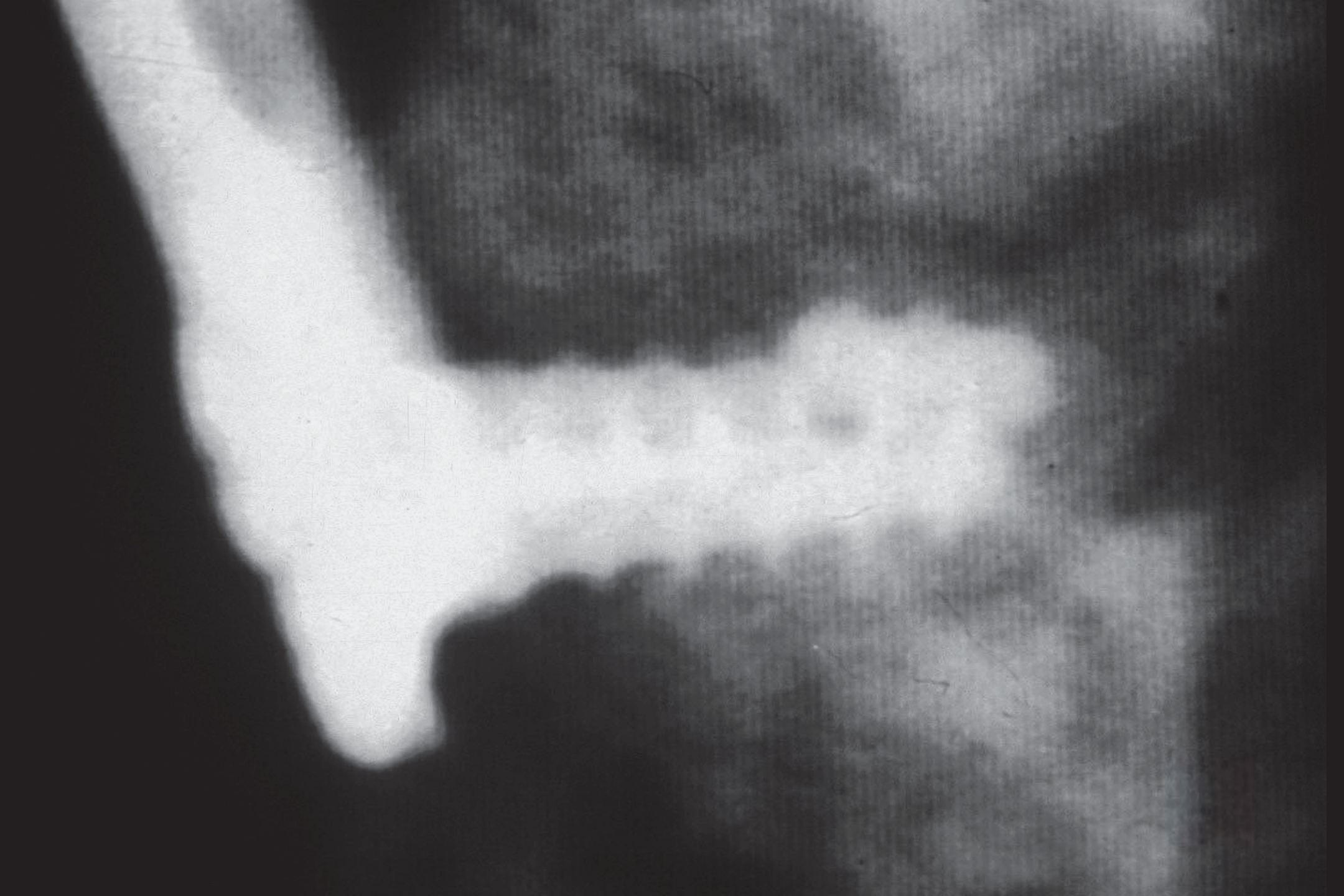
$$\theta = \frac{M}{Z}$$

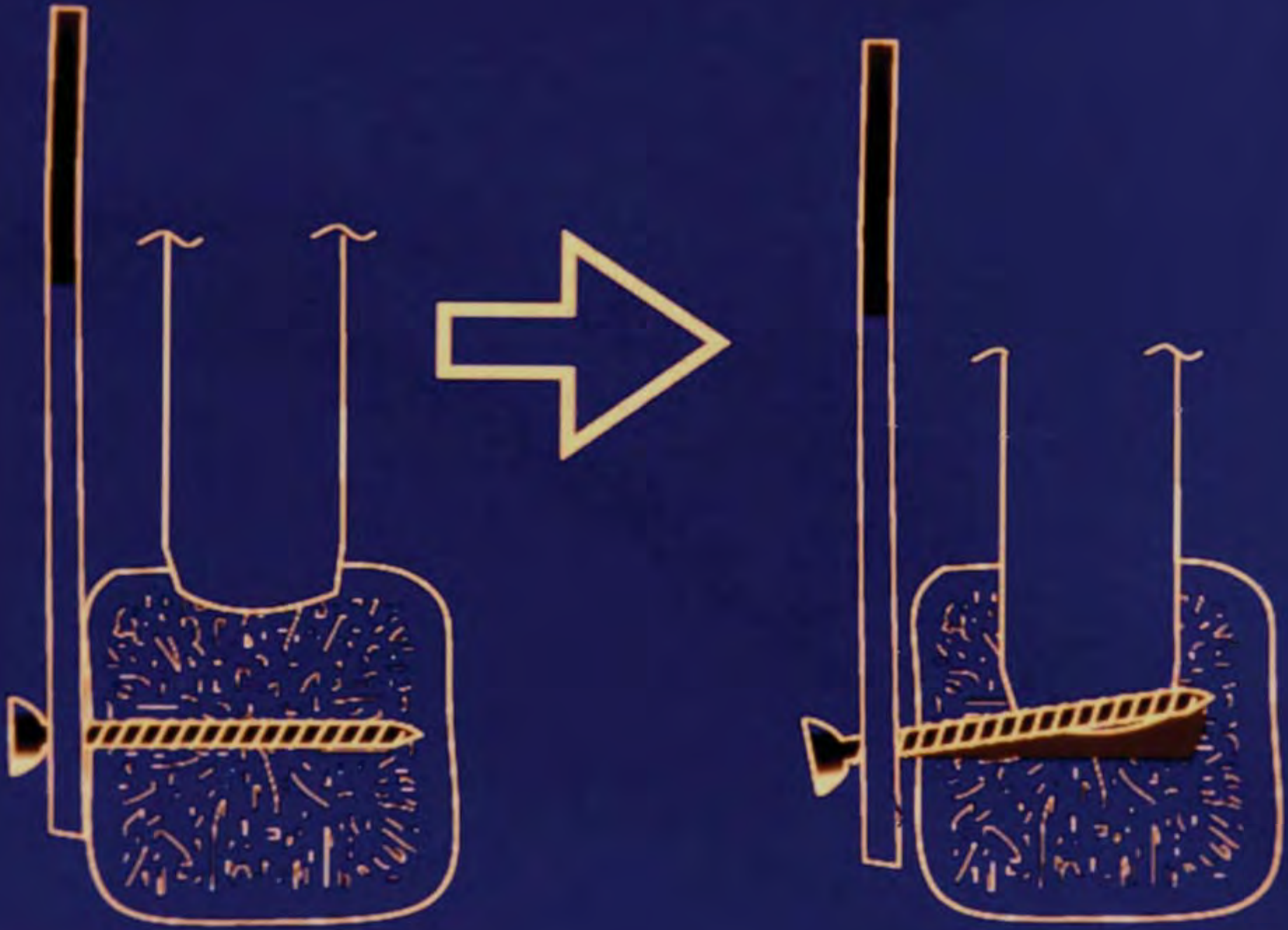
M = ·····

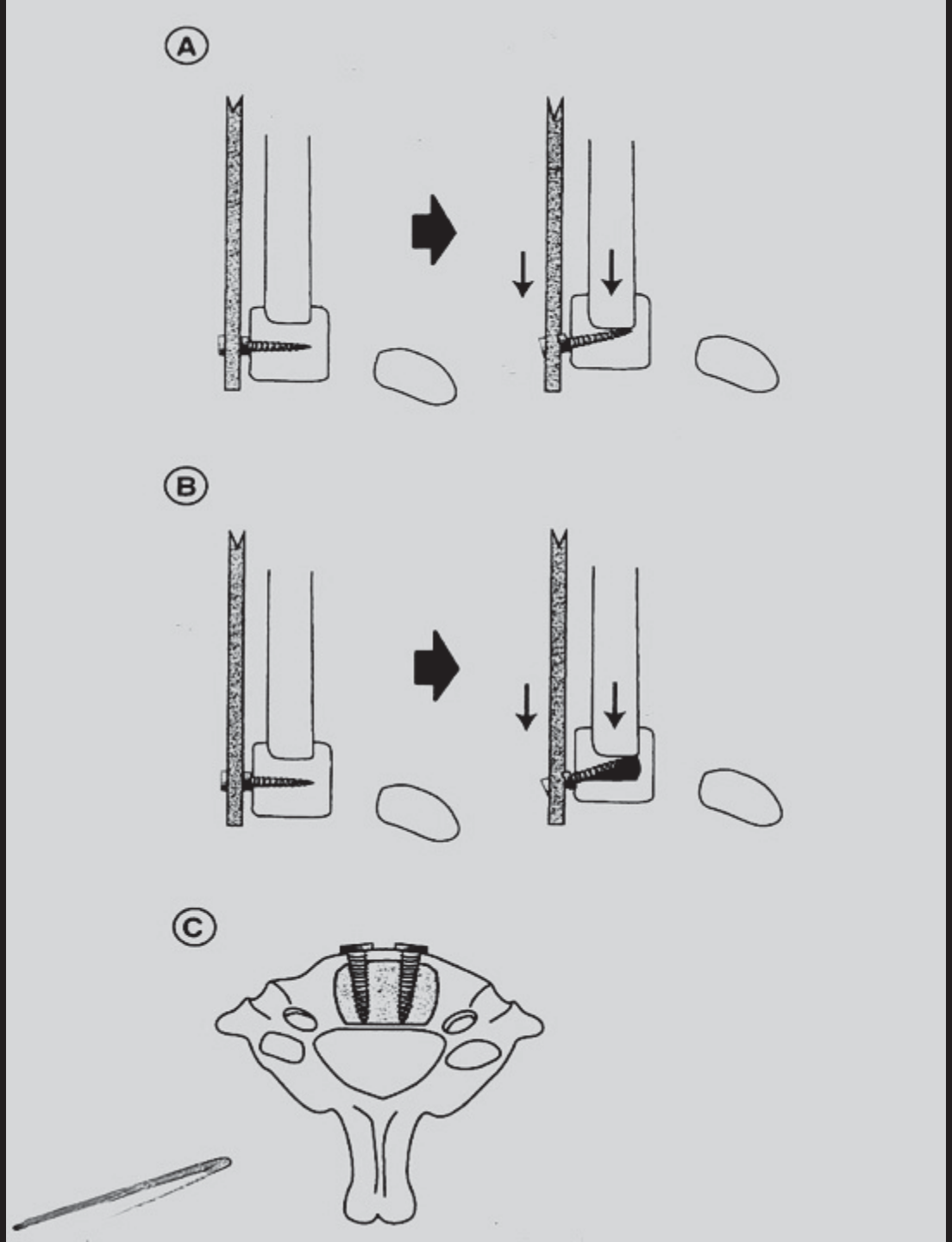
θ = ——

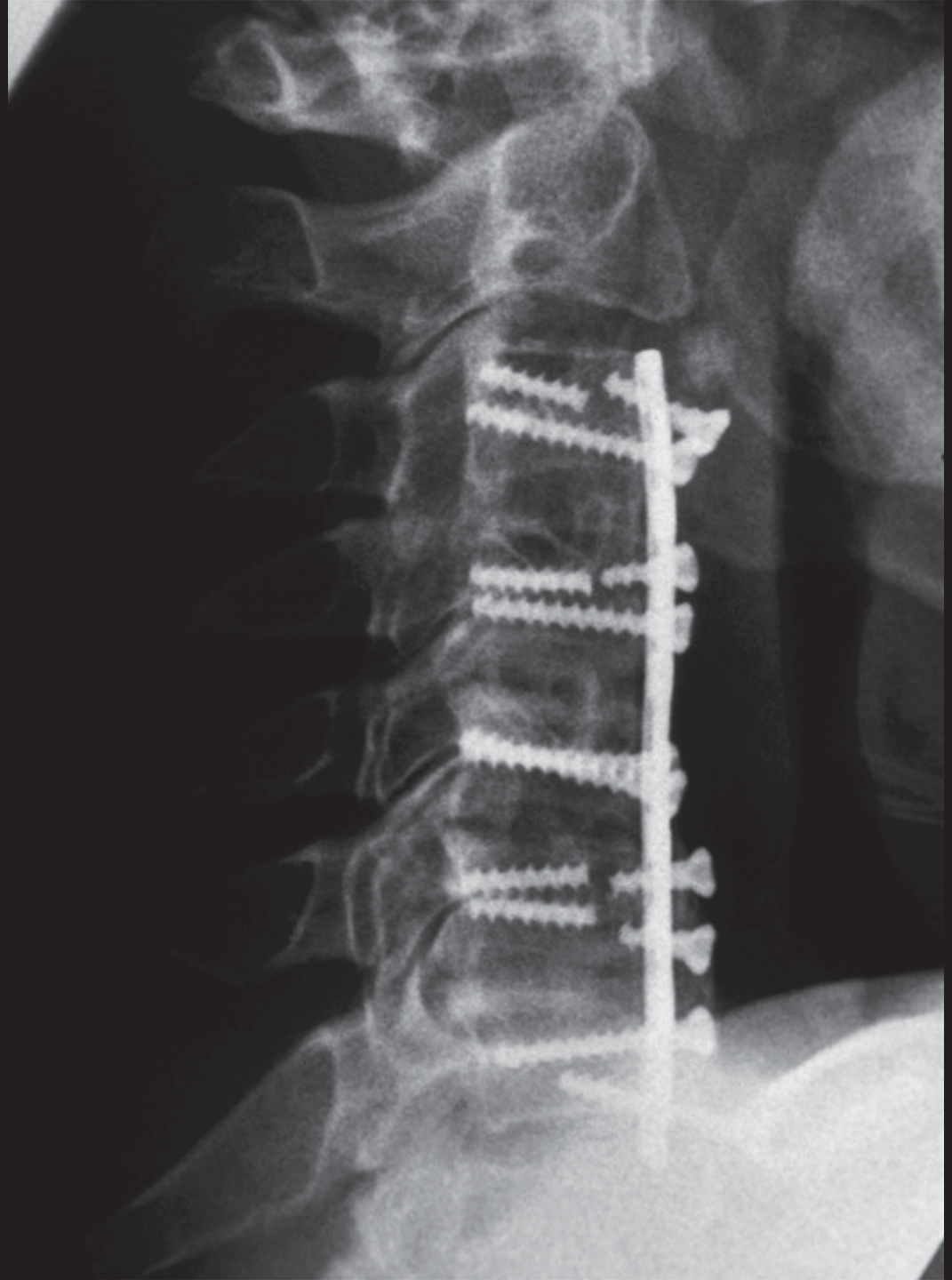


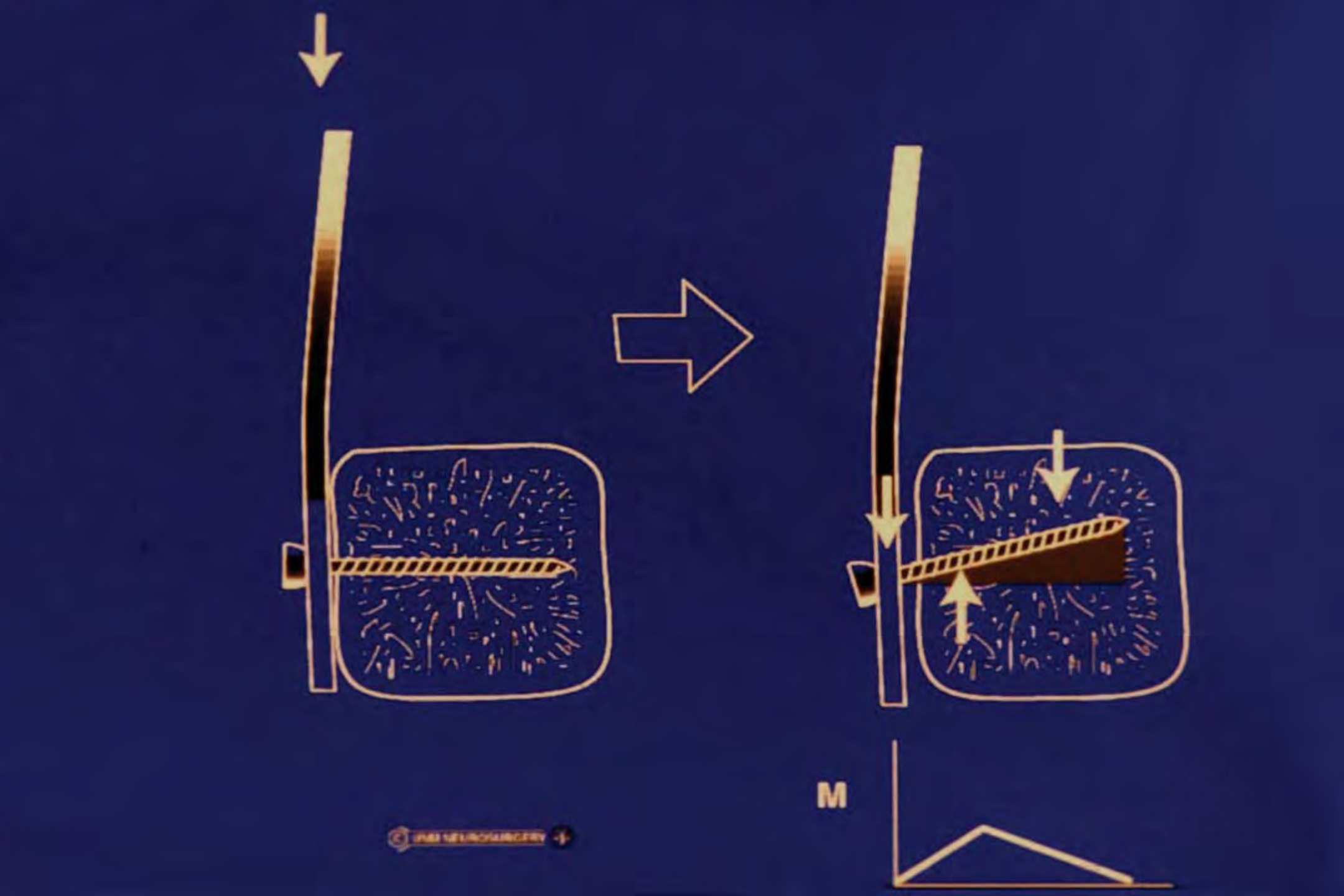


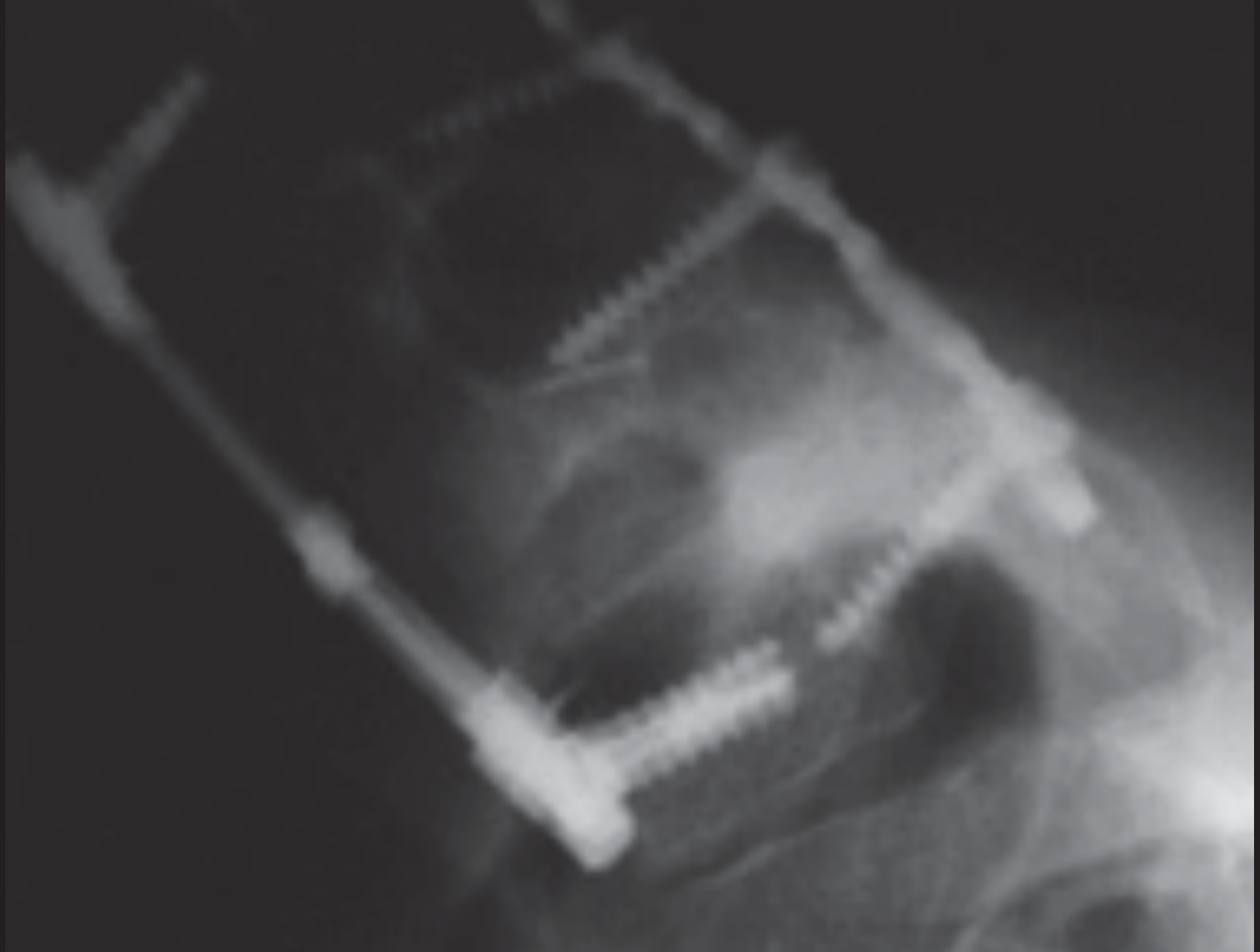


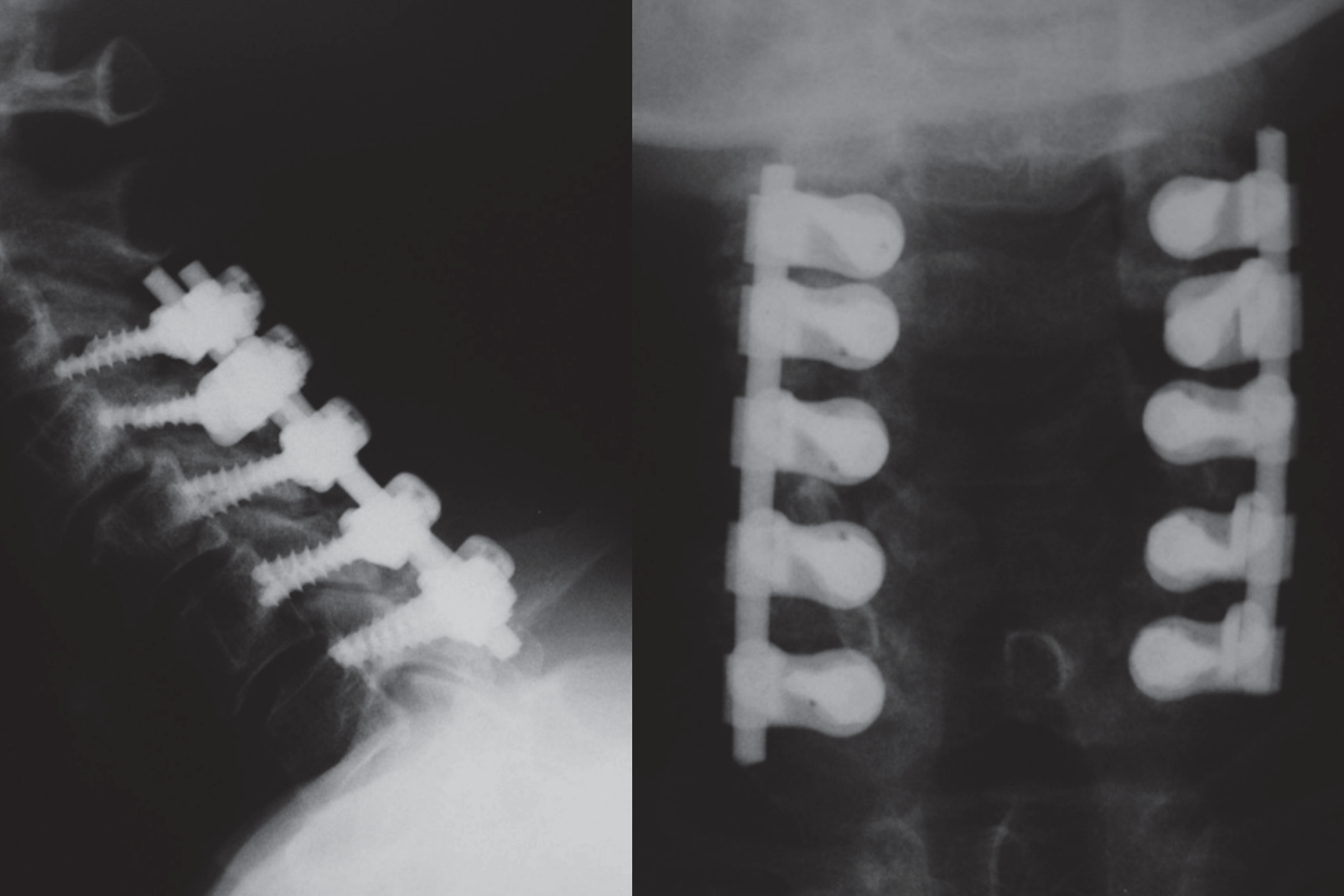



A
B
C

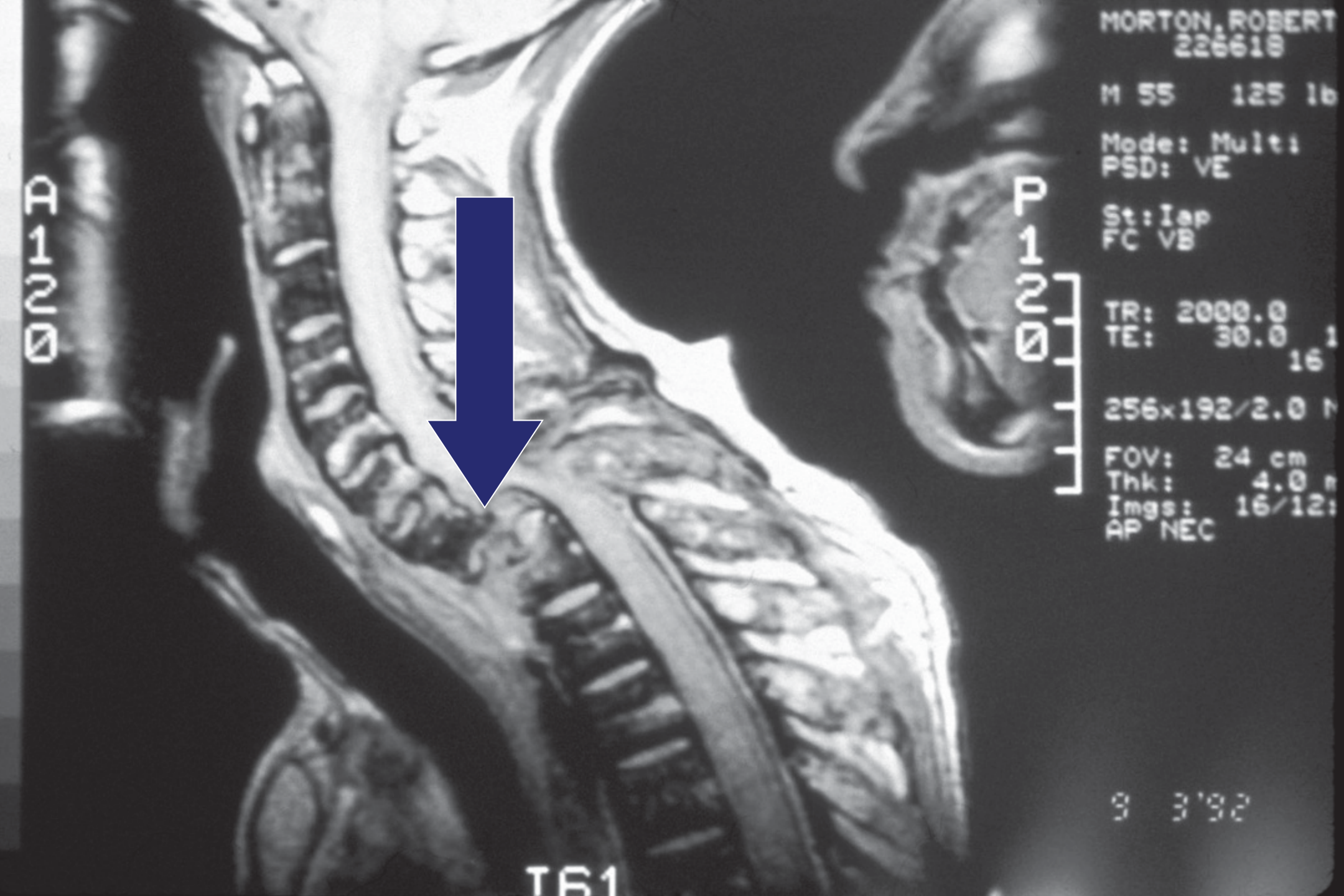



M





Orientation of C7 – T1 Disc Interspace or Pathology


MORTON,ROBERT
226618
M 55 125 lb
Mode: Mult:
PSD: VE
St:Iap
FC VB
TR: 2000.0
TE: 30.0
16
256x192/2.0
FOV: 24 cm
Thk: 4.0
Imgs: 16/12
AP NEC
A
P
I61

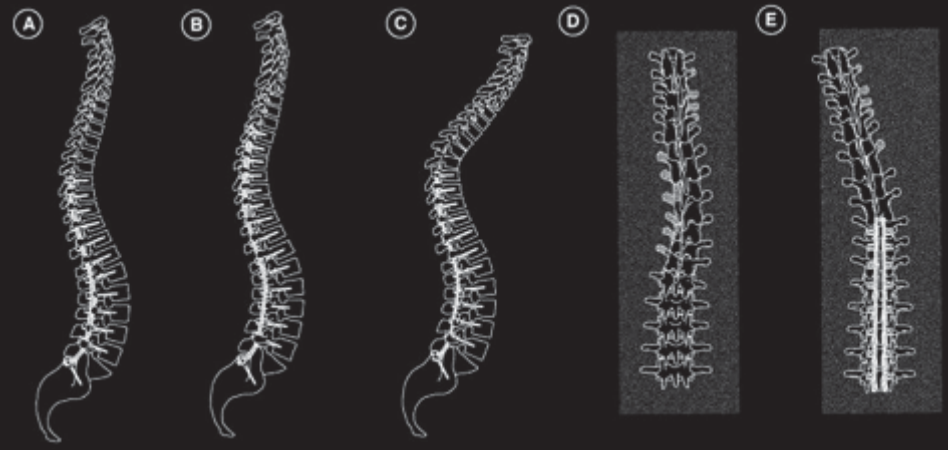
Where to End??

Good

- C5, C6 (from R)
- T1, T2 (from R)
- T3-5 (from C)
- T10-11 (from R or C)
- L1 (± from R)
- L5, S1, I (from R)

Bad

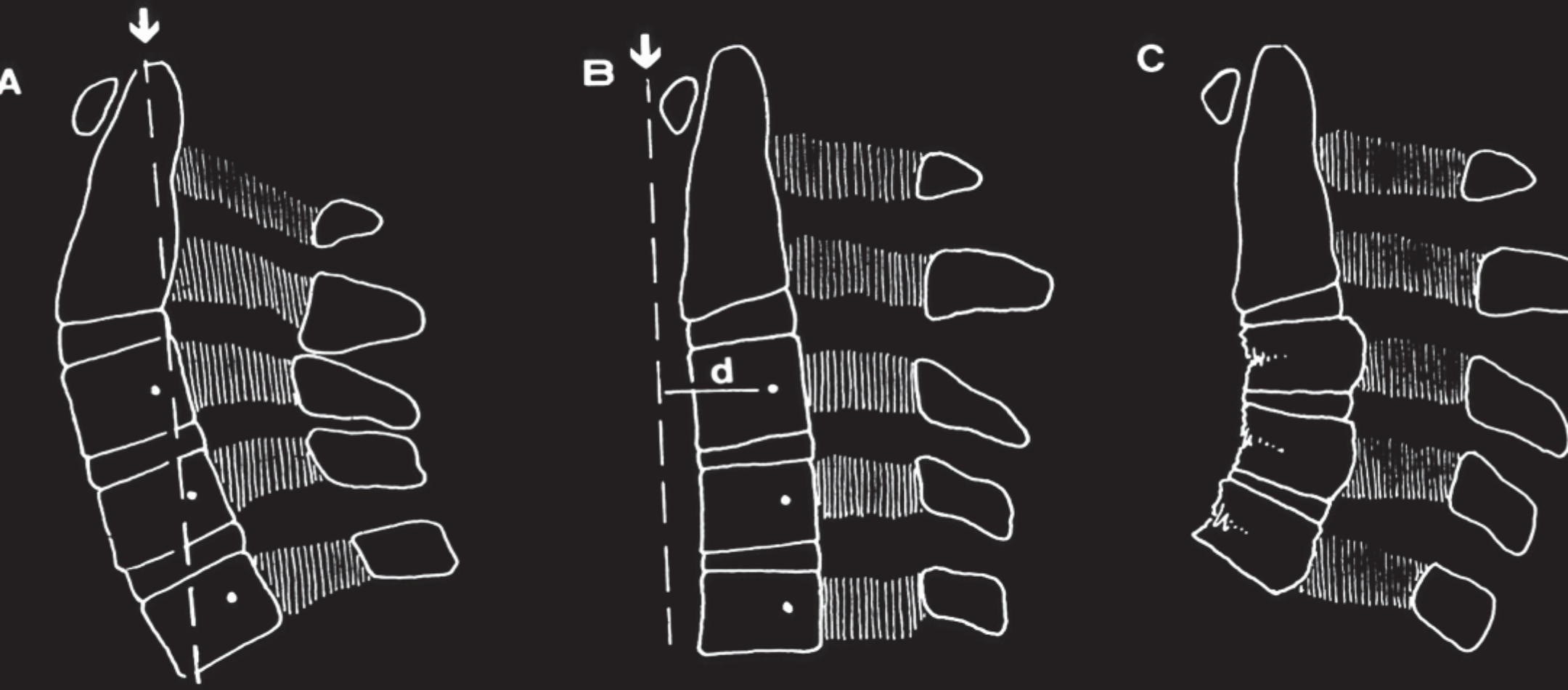
- C7 (± from R)
- T1 (from C)
- T 6-8 (from R or C)
- T12, L1 (from R or C)
- L3-4 (from R)
- L5 (from C if deg or def)



Cervical Spondylosis

Myelopathy
Deformity


M
F
D
IAR


A
B
d
C

ENCROACHMENT
TETHERING

REPETETIVE TRAUMA

SURGICAL STRATEGIES

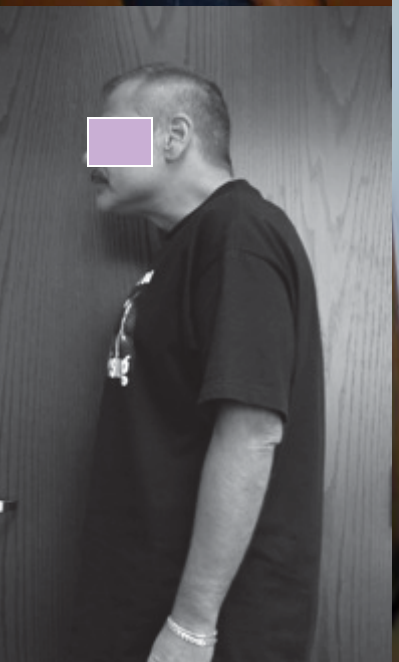
Focus on Deformity

Why?

Neck Pain
Myelopathy
Decrease End Fusion Degenerative Changes
Improve Short-Term Success
Improve Long-Term Success





Kyphosis
Trapezius Sign

Intra-Operative Deformity Correction

Ventral vs Dorsal

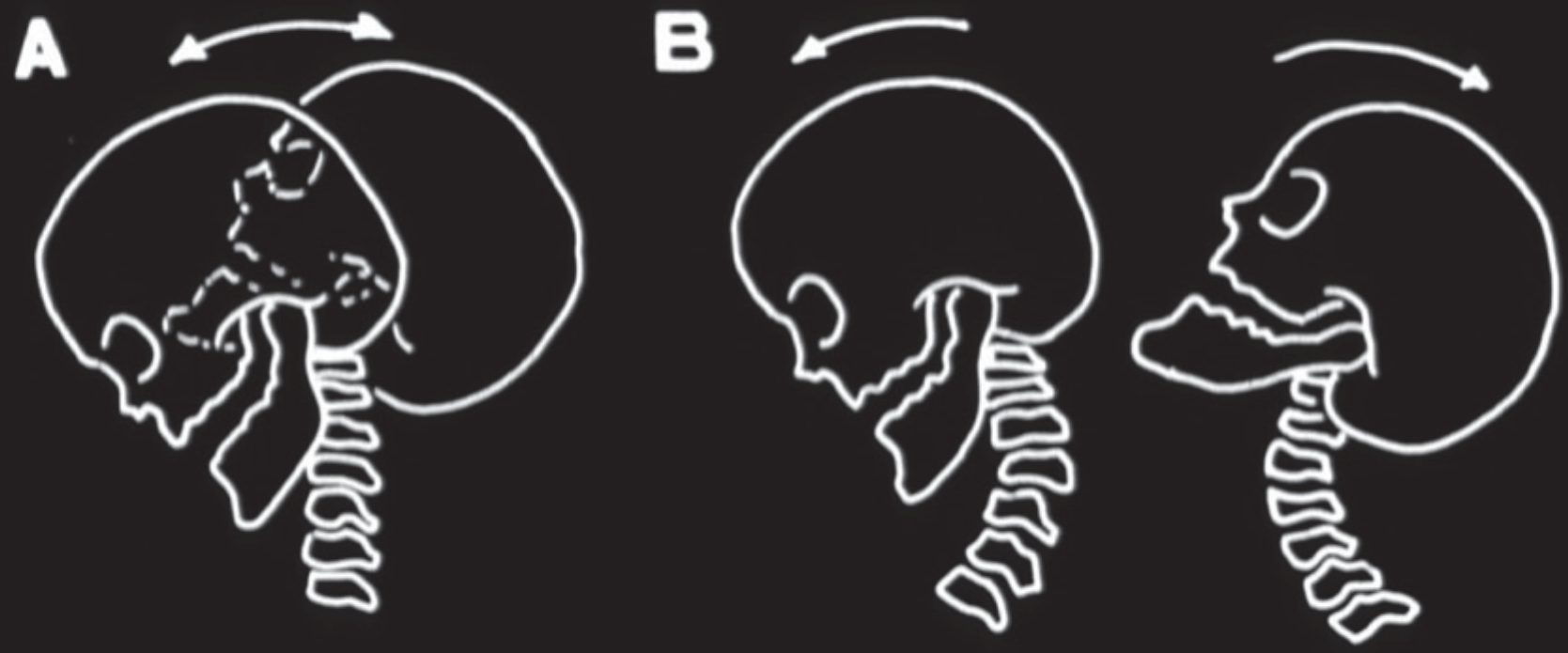
Its all about the leverage!!!

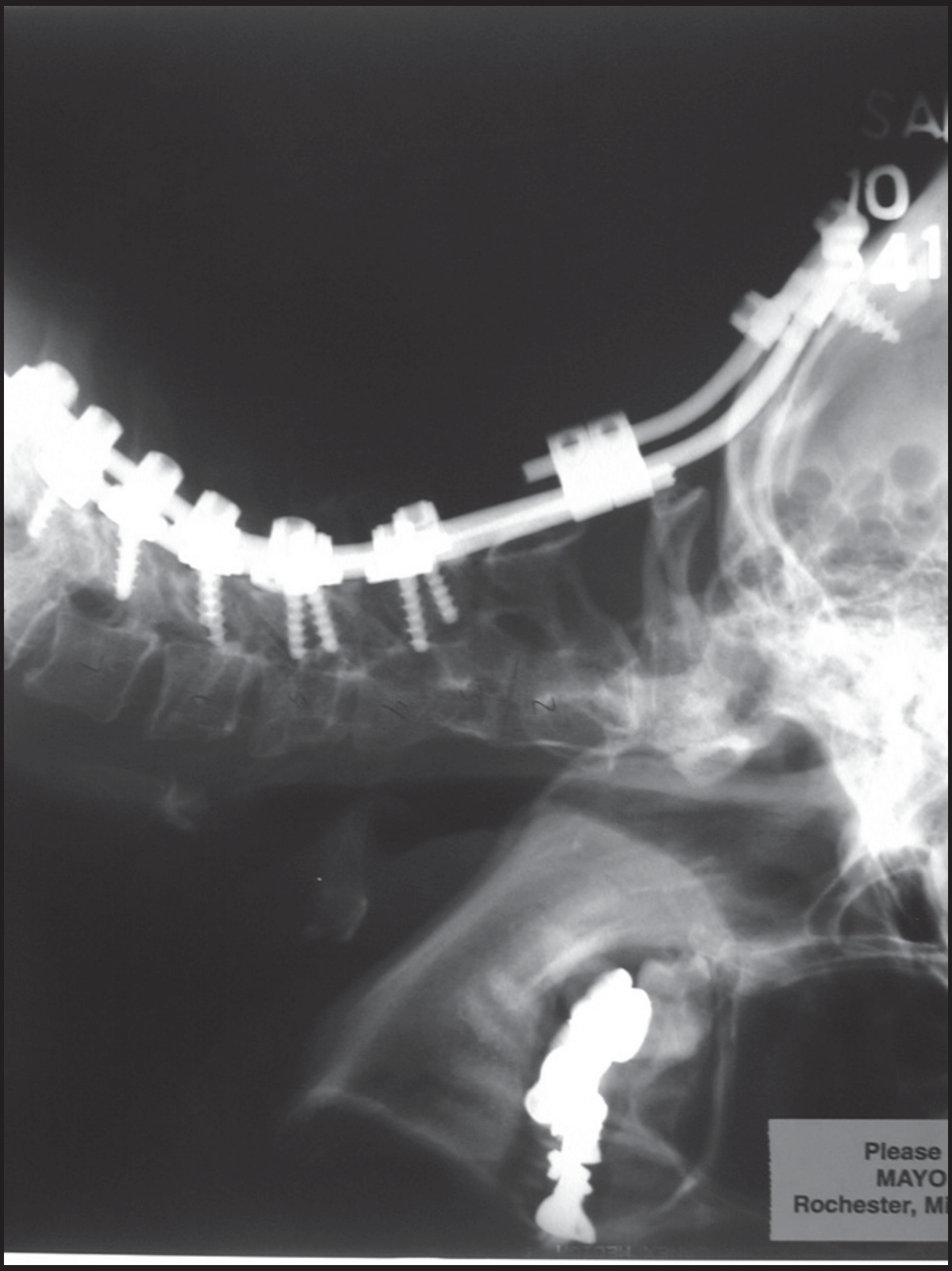
Dorsally, leverage is VEEEERRRYYYY difficult to achieve!!!

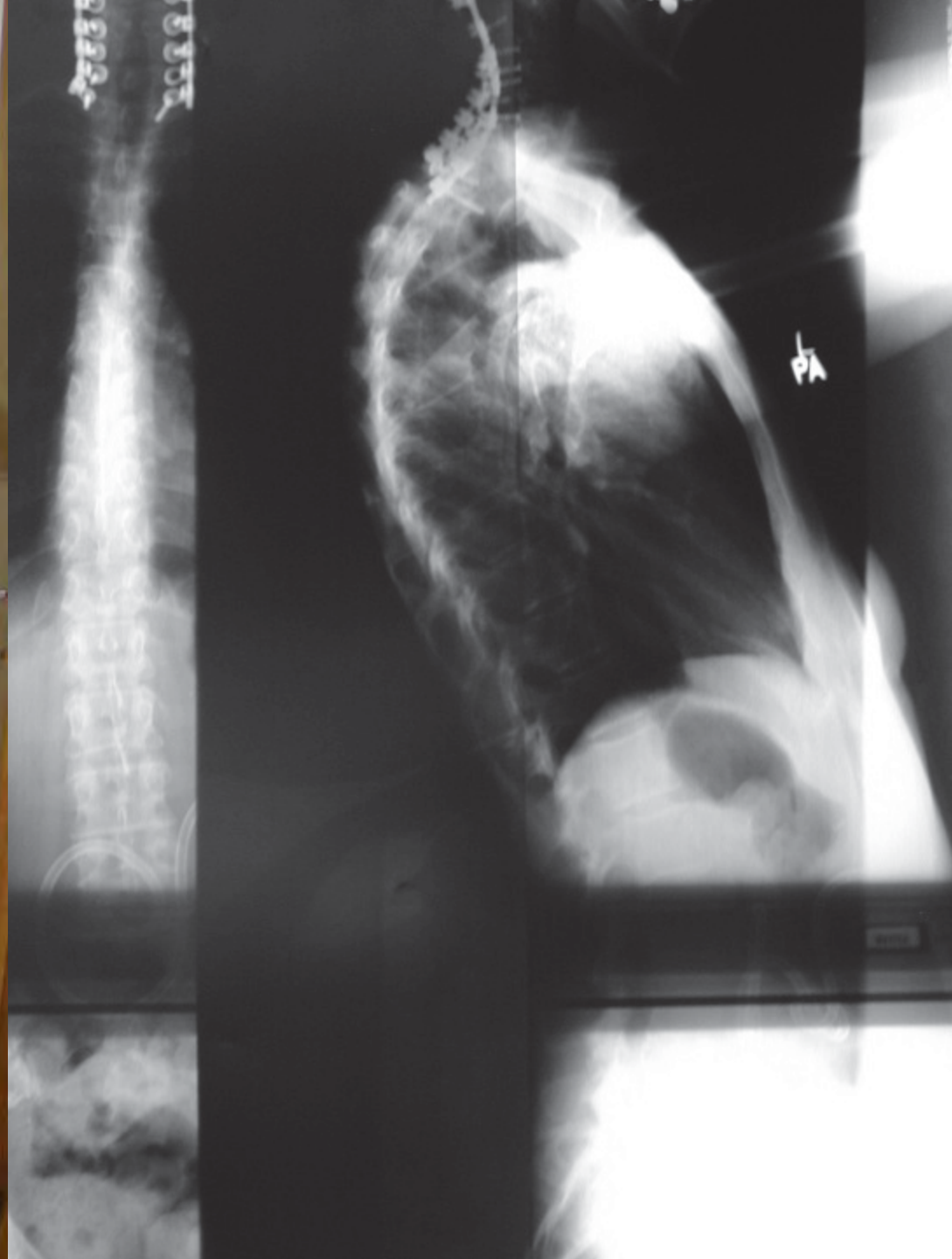
Polyaxial Screws

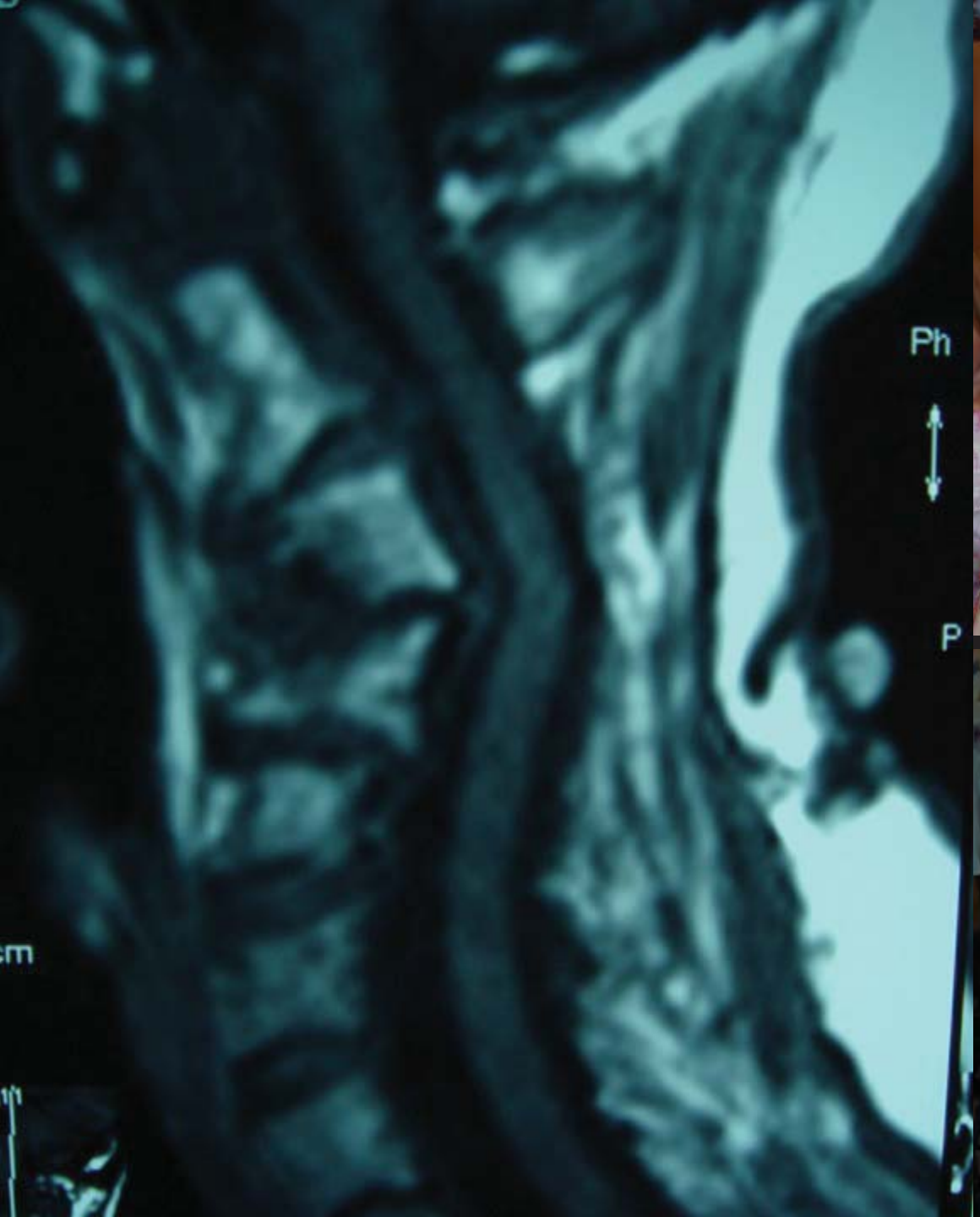
Exception

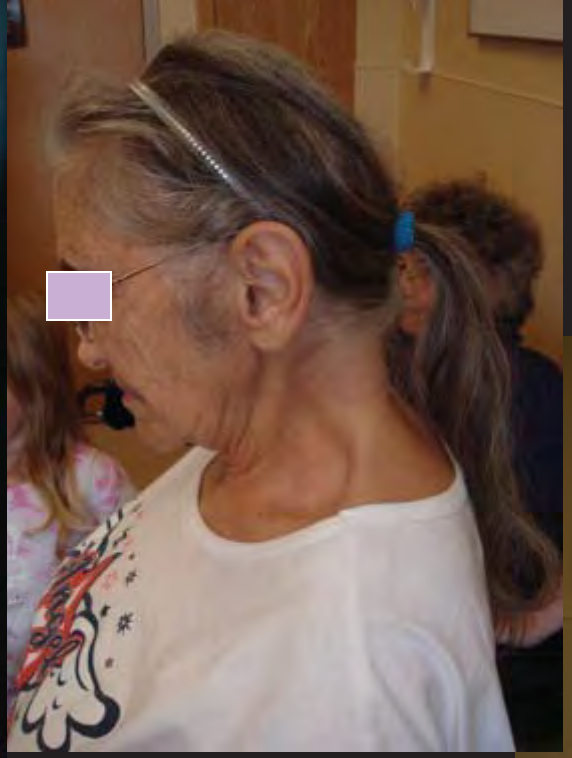
Capital Flexion and Extension

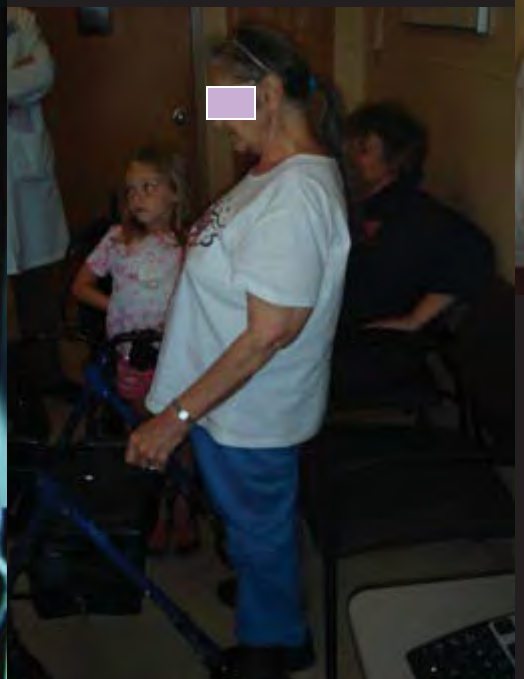

A
B

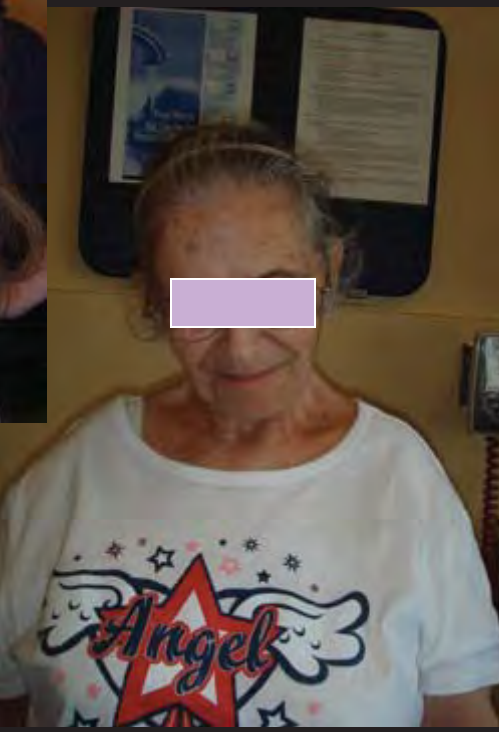

Please
MAYO
Rochester, M

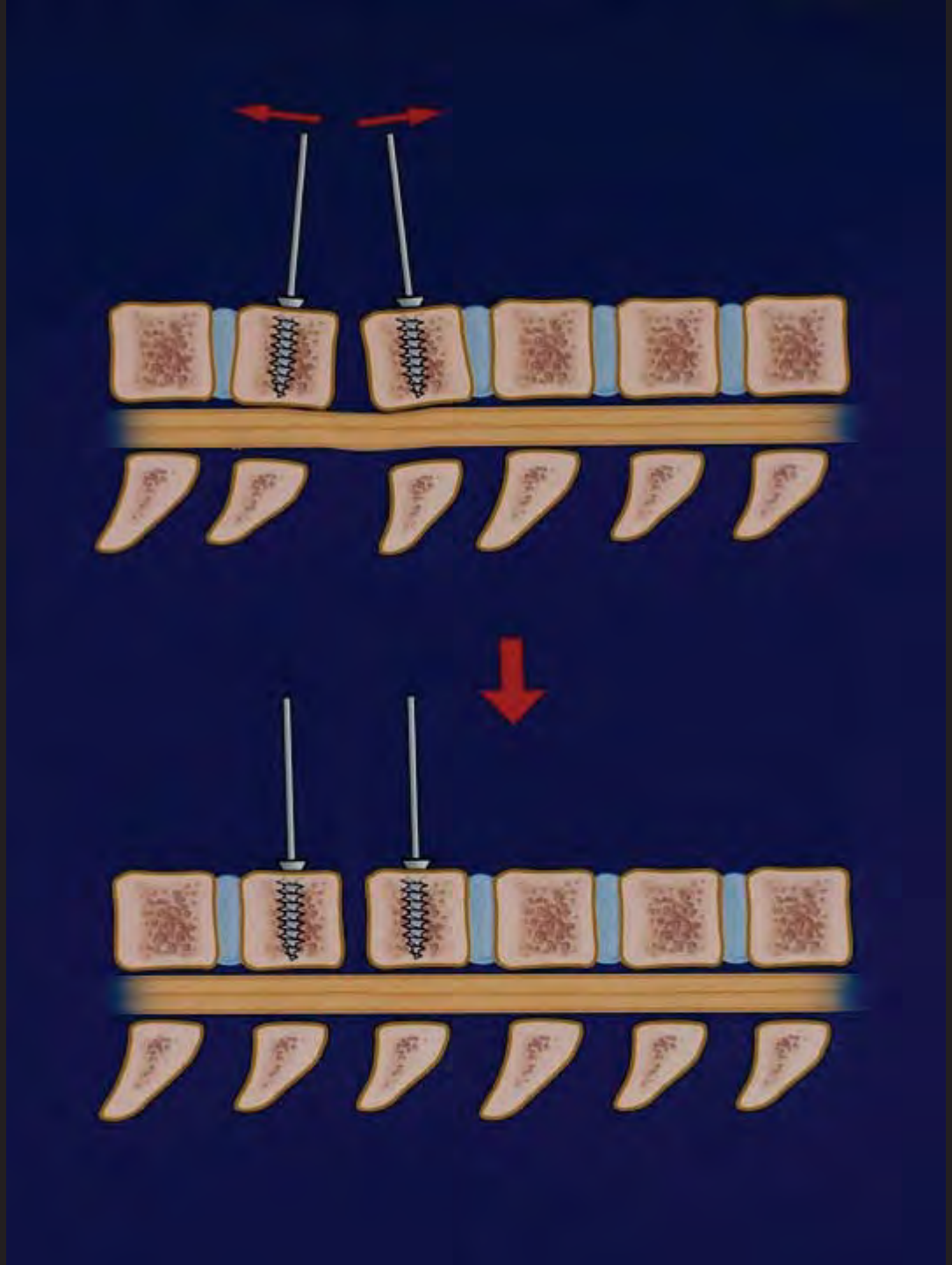

PA

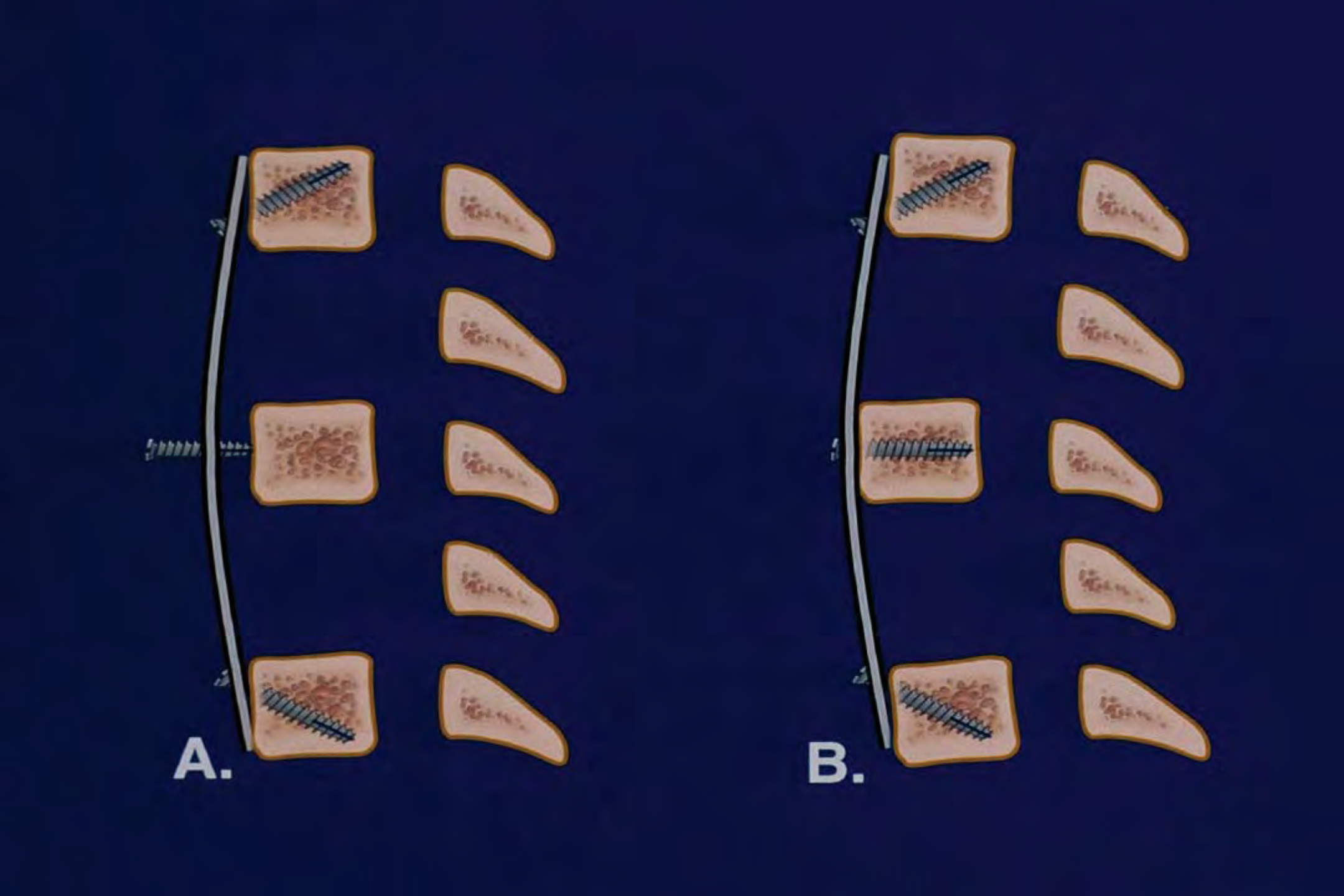

Ph
P

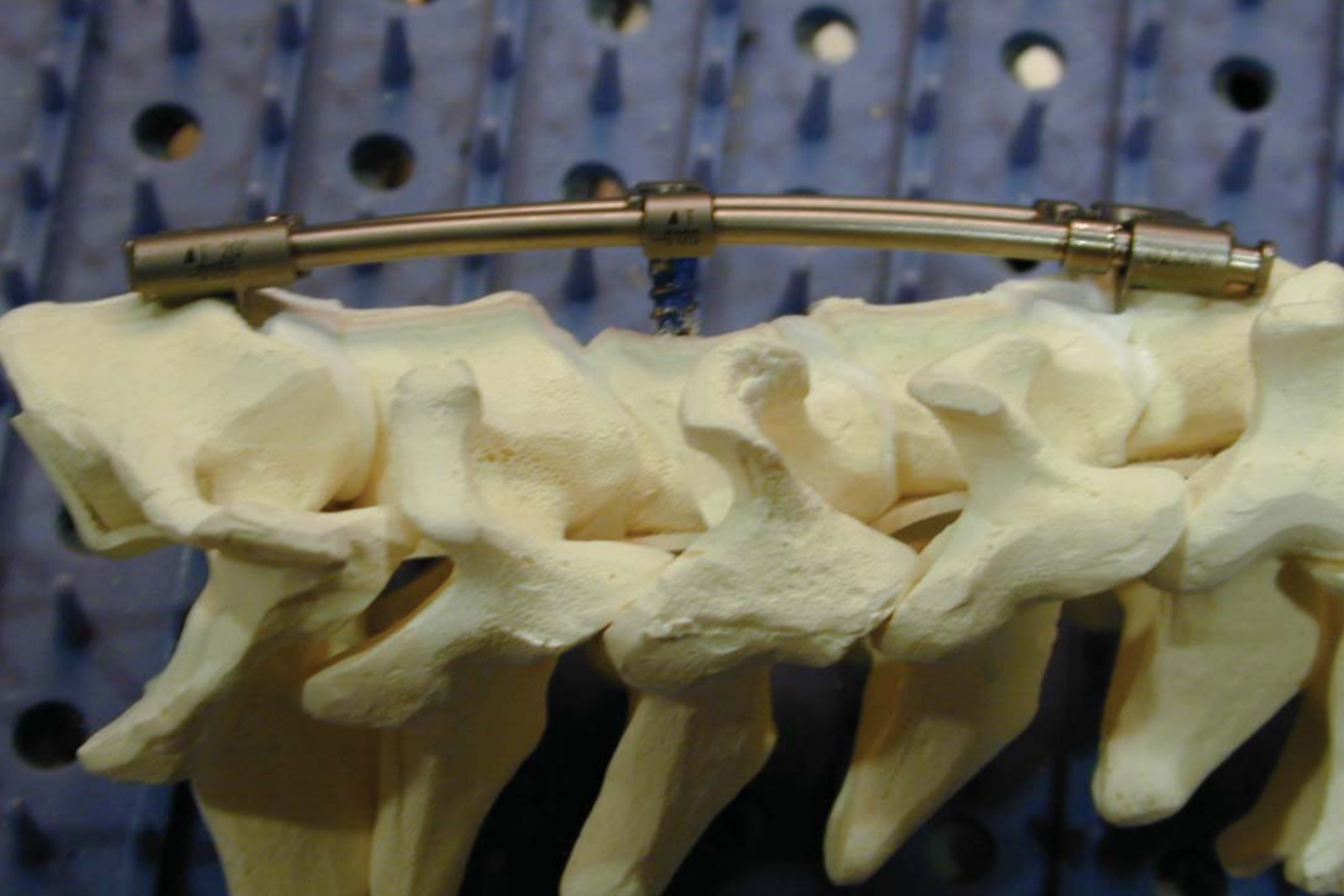


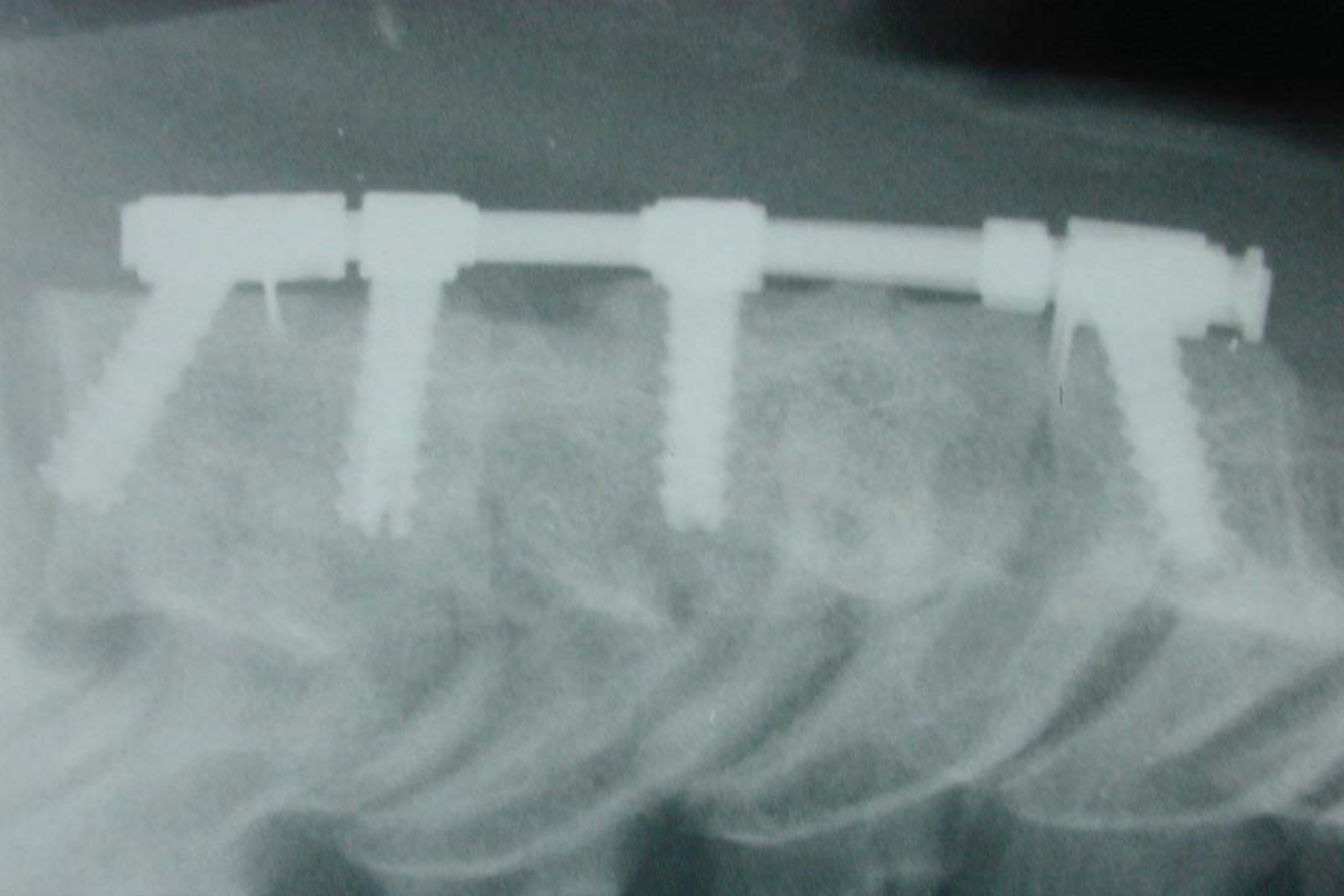



Angel




A.
B.





Gravity


VF


93270349045
25-SEP-1940
11:14
11-SEP-1999
IMAGE 11
SER 1-2
HL
Woodland Diagnostic
H-SP VB33A
+ : F A L
A
tse1_7
*R
1 SAT
TR 4000.0
TE 114.0/1
TA 07:05
AC 2
SP -0.0
SL 4.0
FoV 228*260
182 *256o
Sag>Tra -1
BVOMR
TECH:MLP
W 1162
C 478
93270349045
25-SEP-1940
11:14
11-SEP-1999
IMAGE 12
SER 1-2
HL
Woodland Diagnostic
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+ : F A L
A
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*R
1 SAT
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AC 2
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SL 4.0
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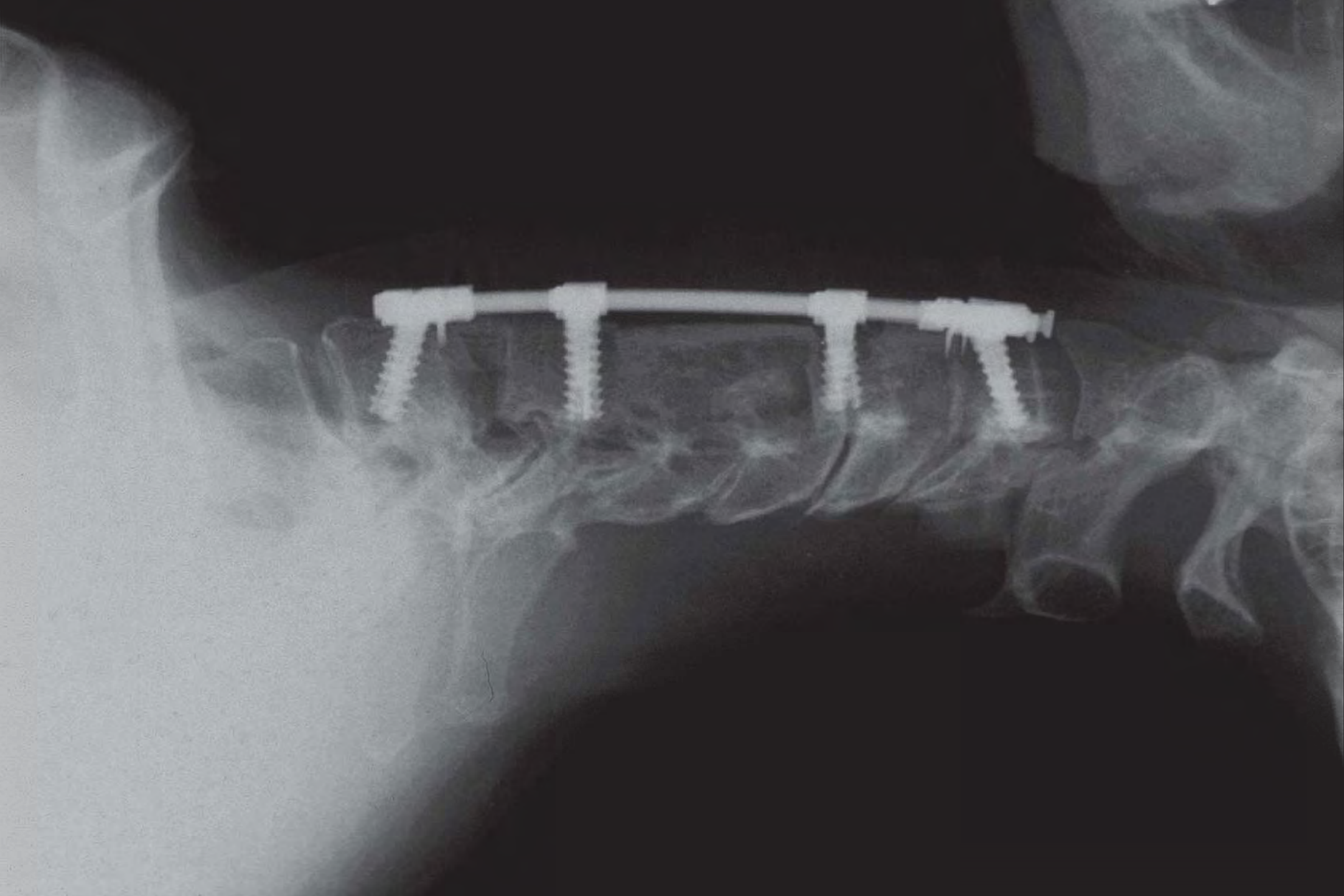
Sag>Tra -1
BVOMR
TECH:MLP
W 1162
C 478

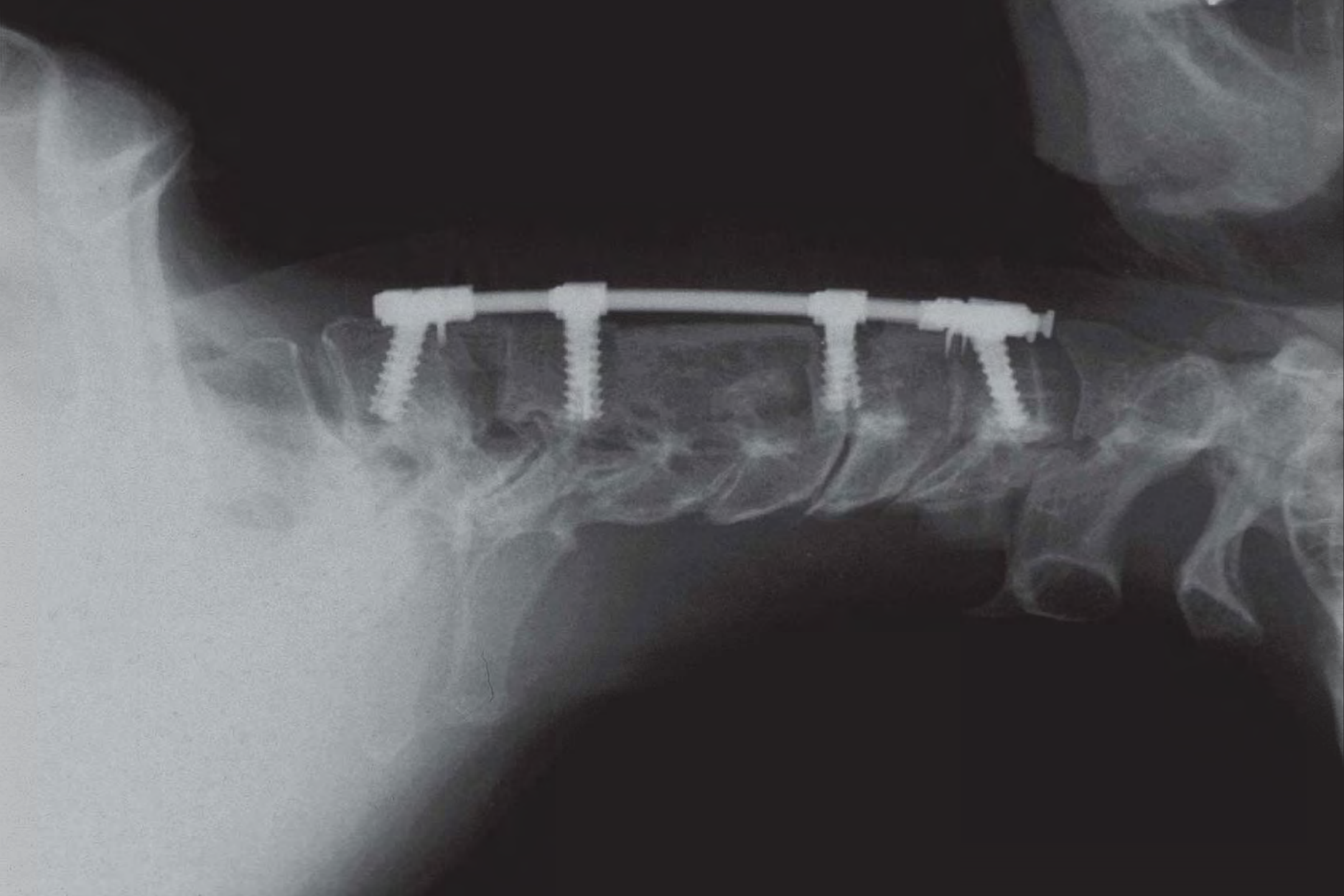
Could Correct Ventrally

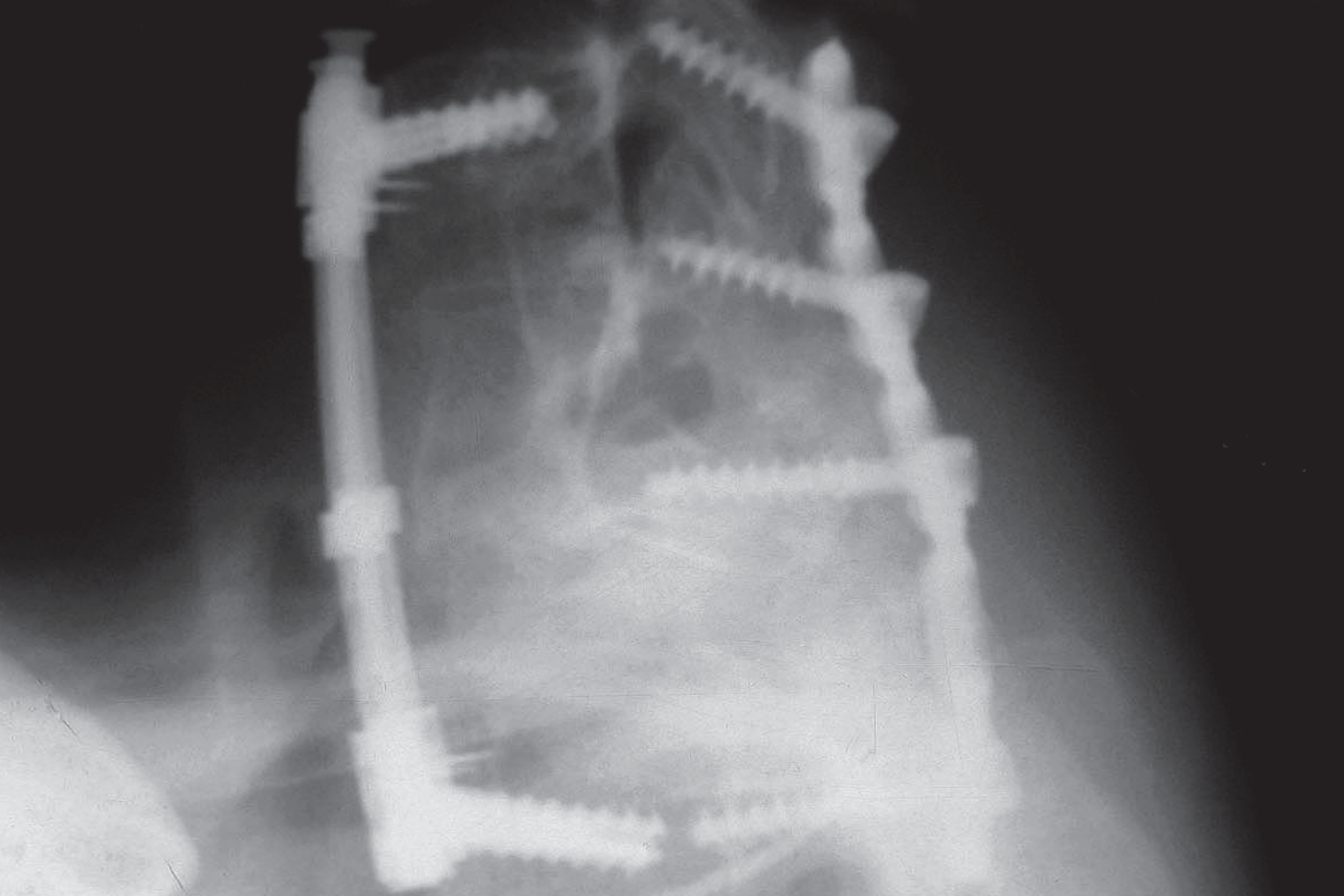
Because Facets not Ankylosed

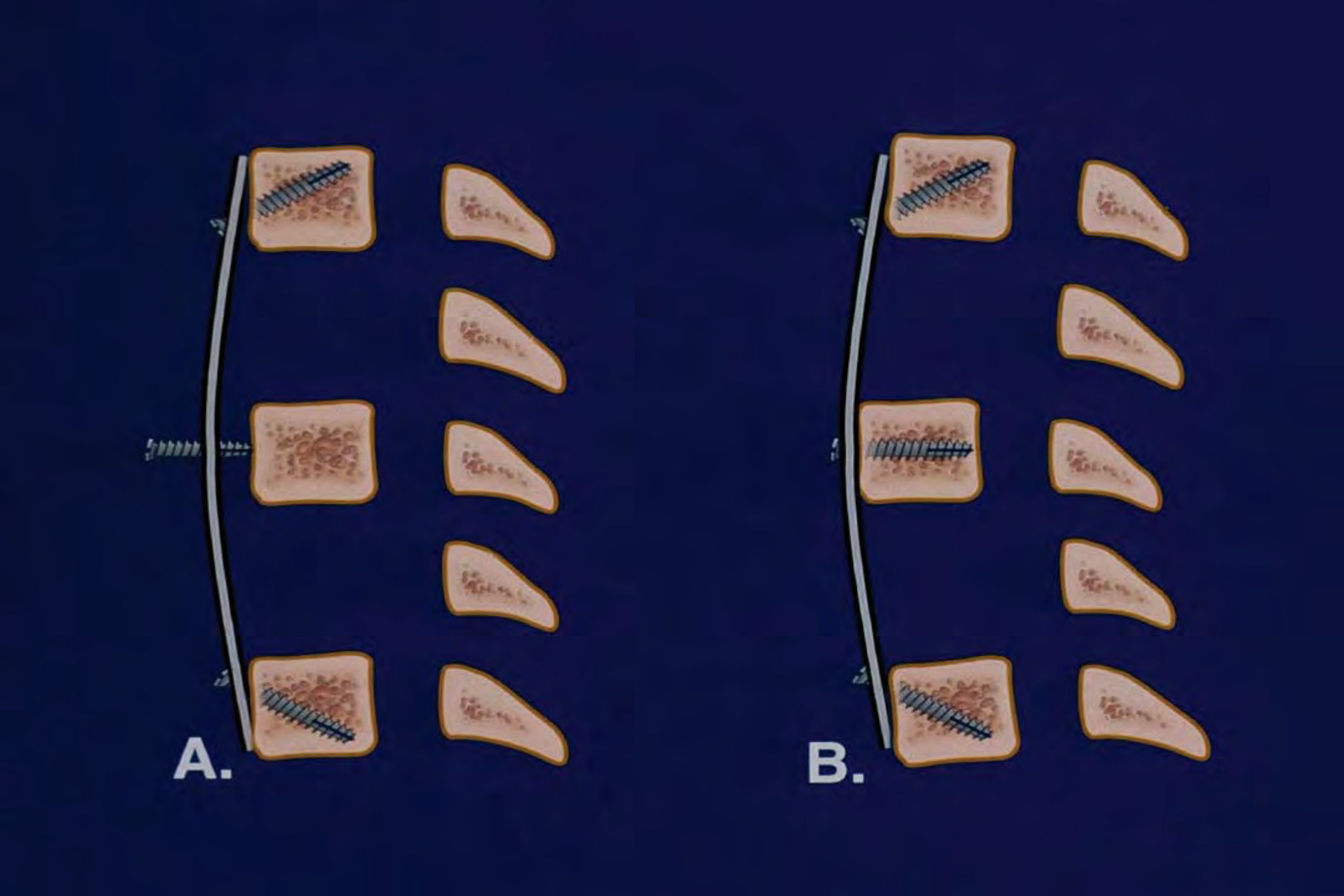


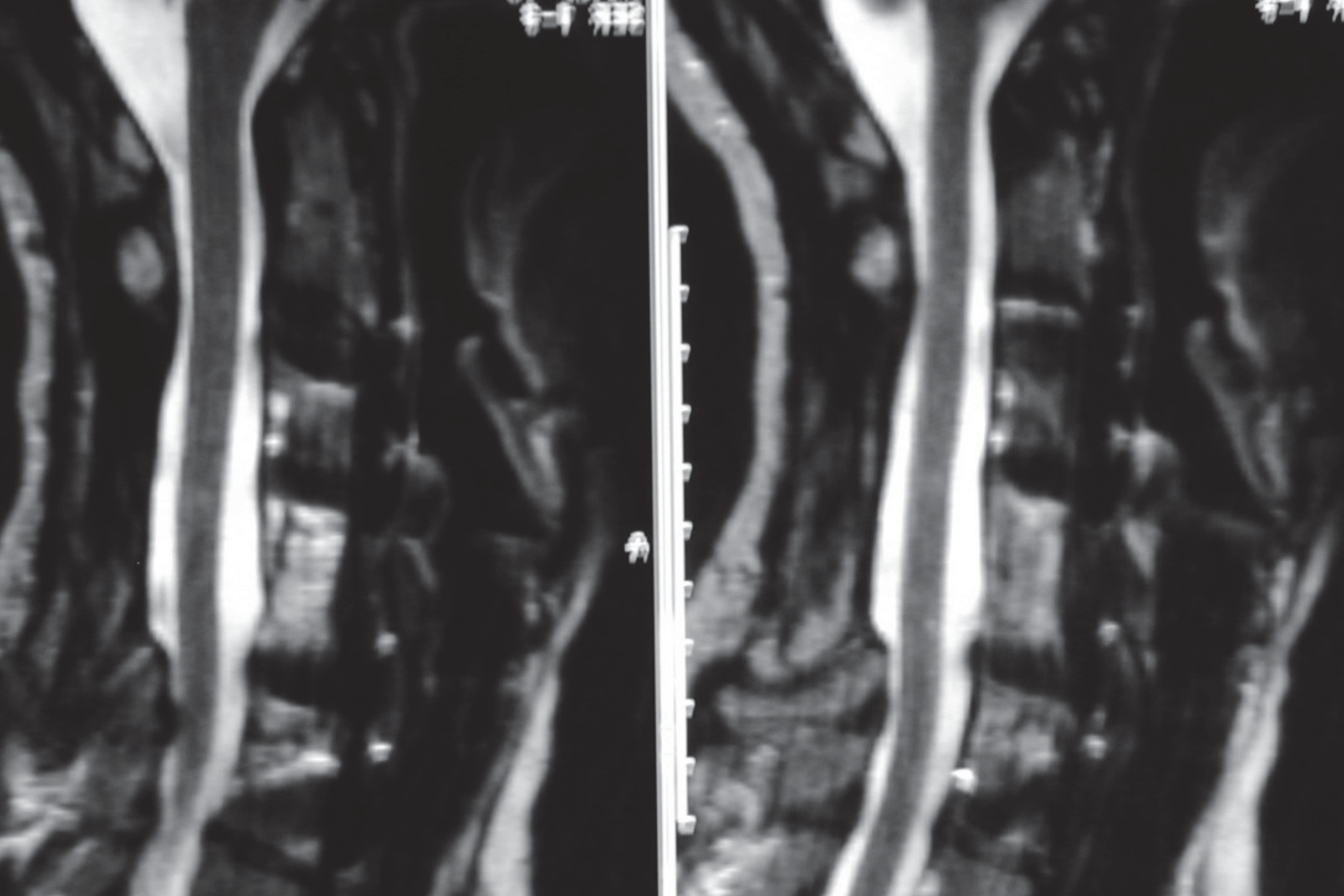
Its all about leverage!!!

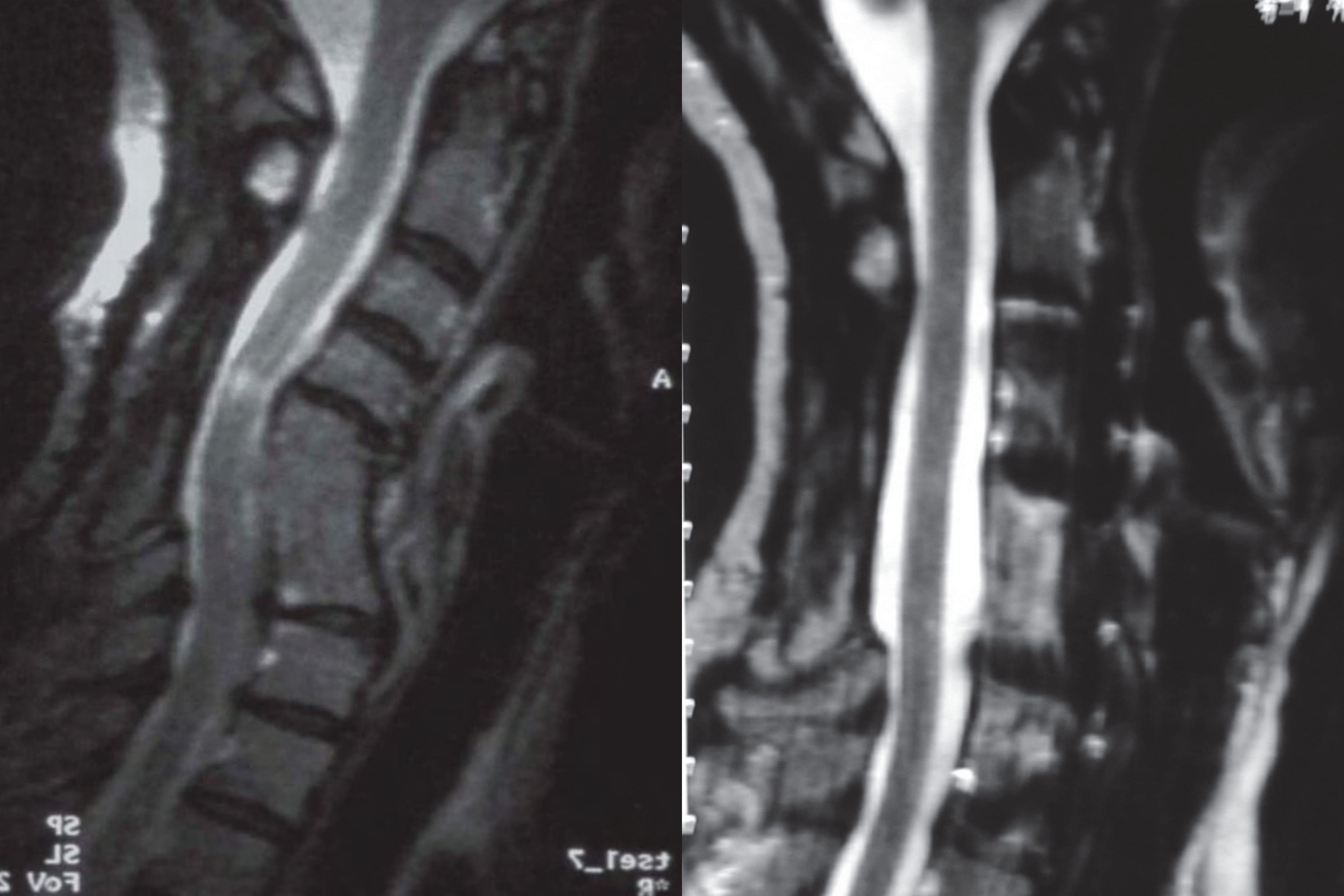
Fixation Follows!!!

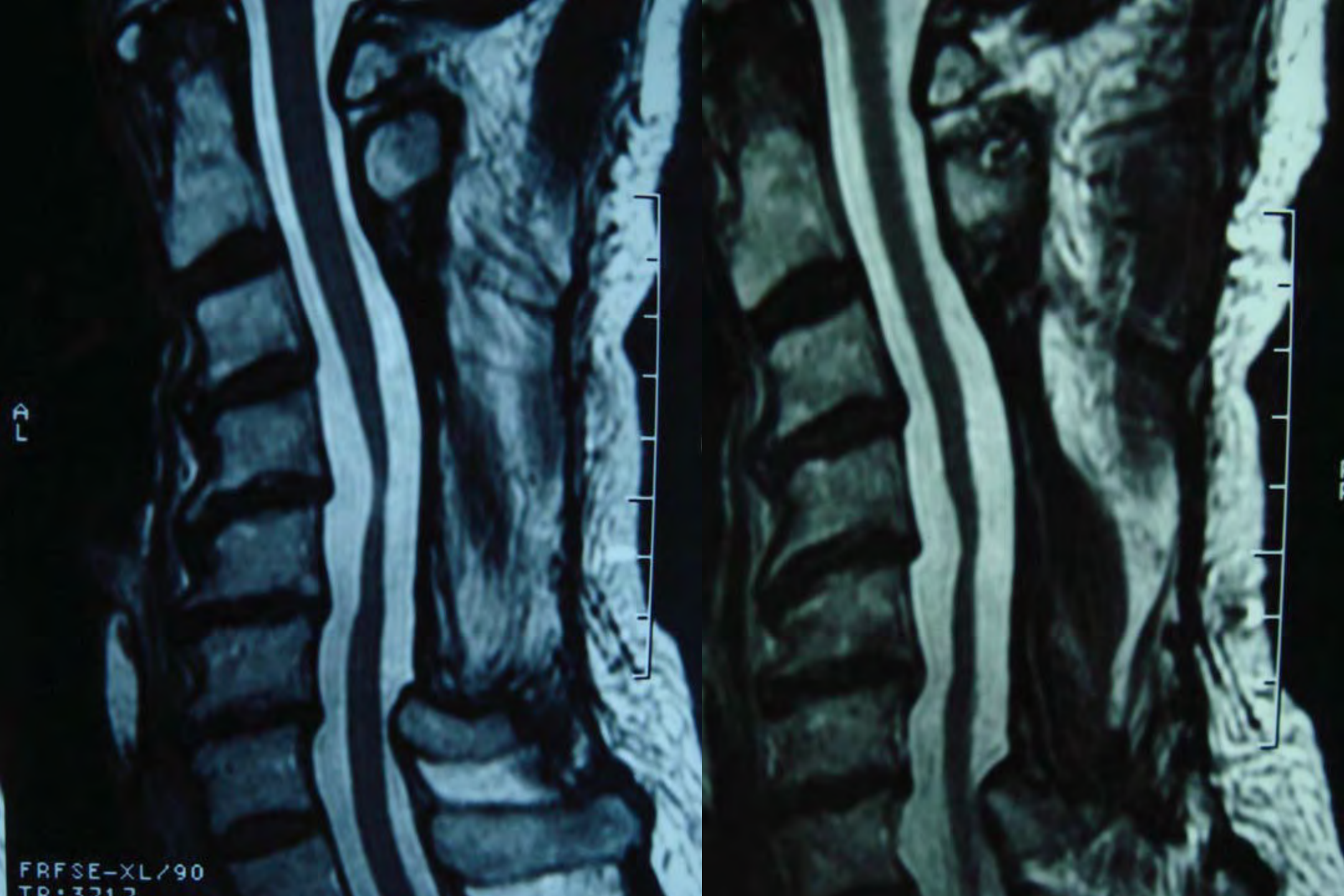





A.
B.

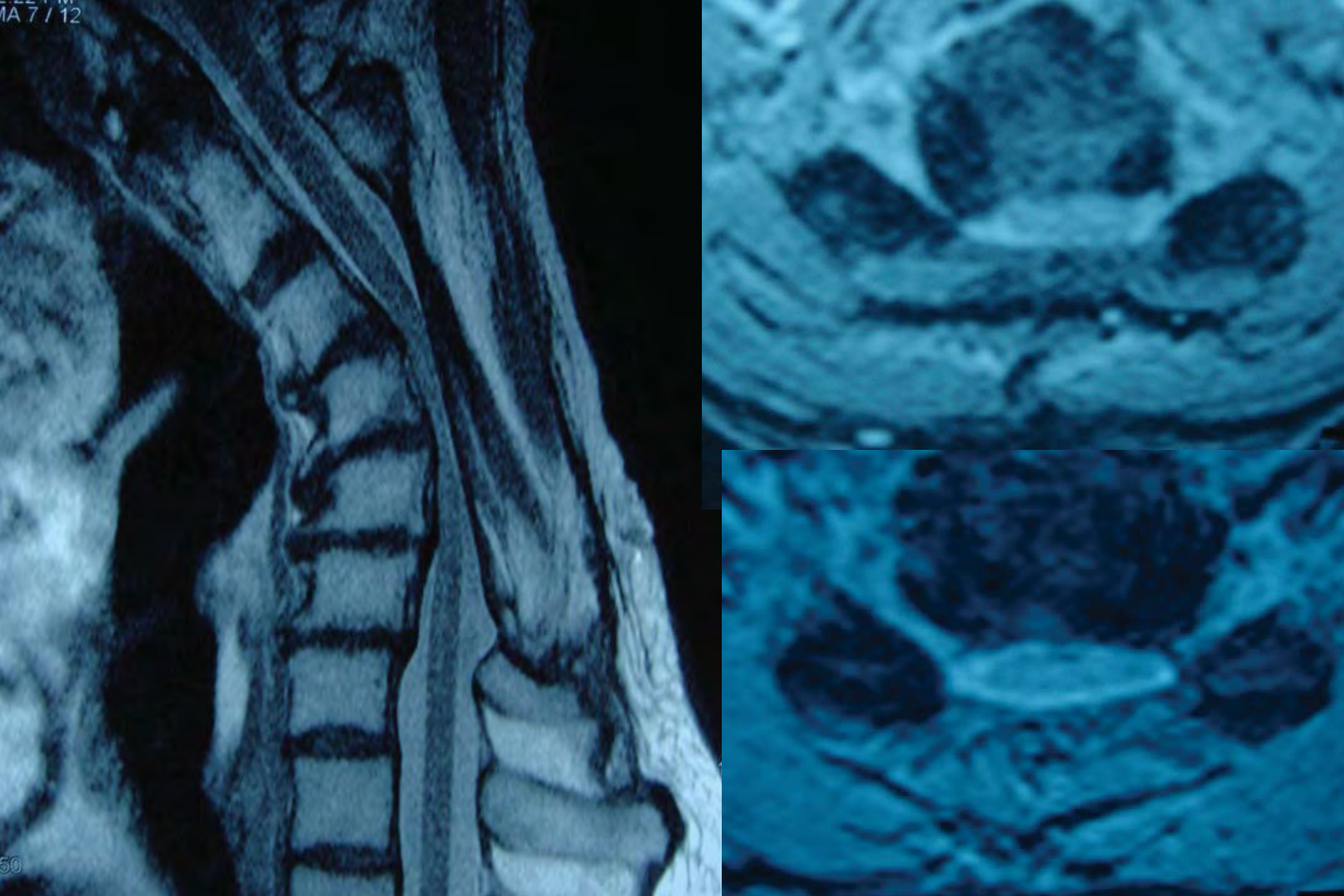


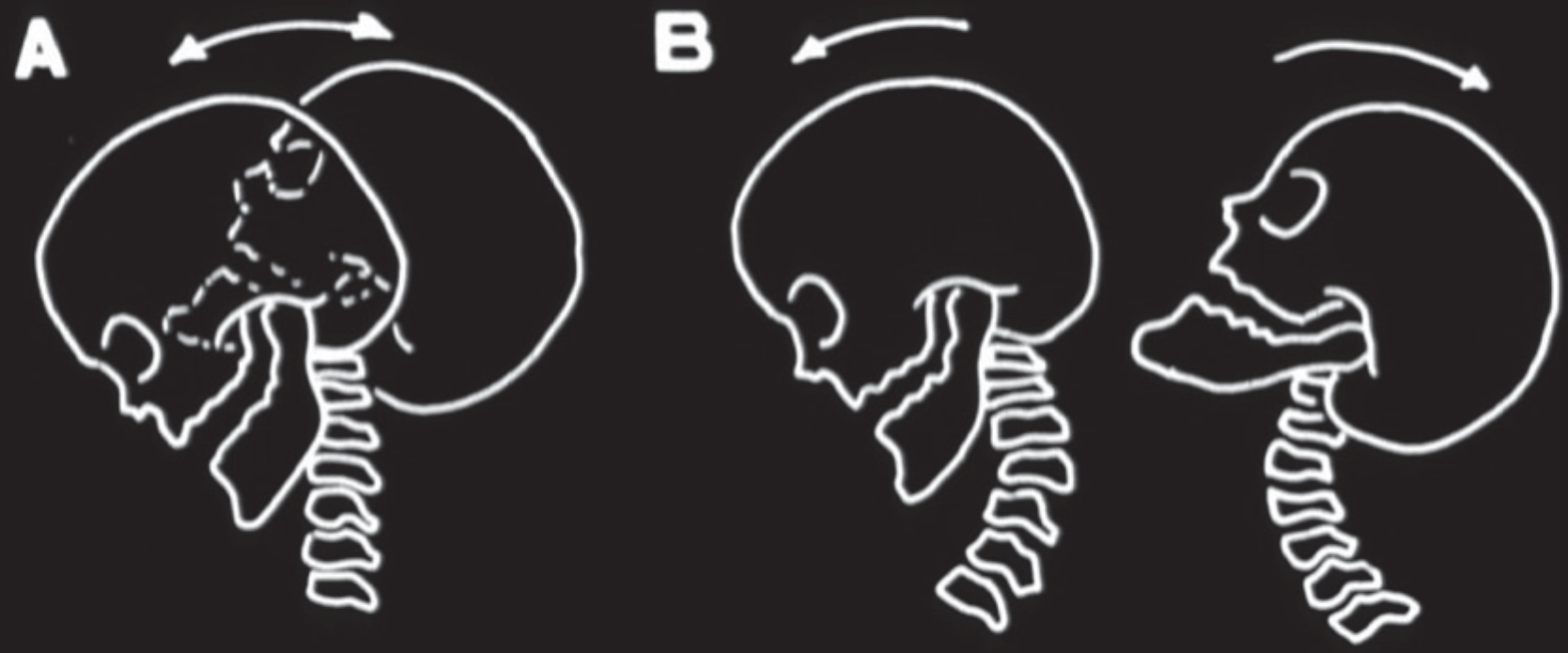



A
L
FRFSE-XL/90

CSM

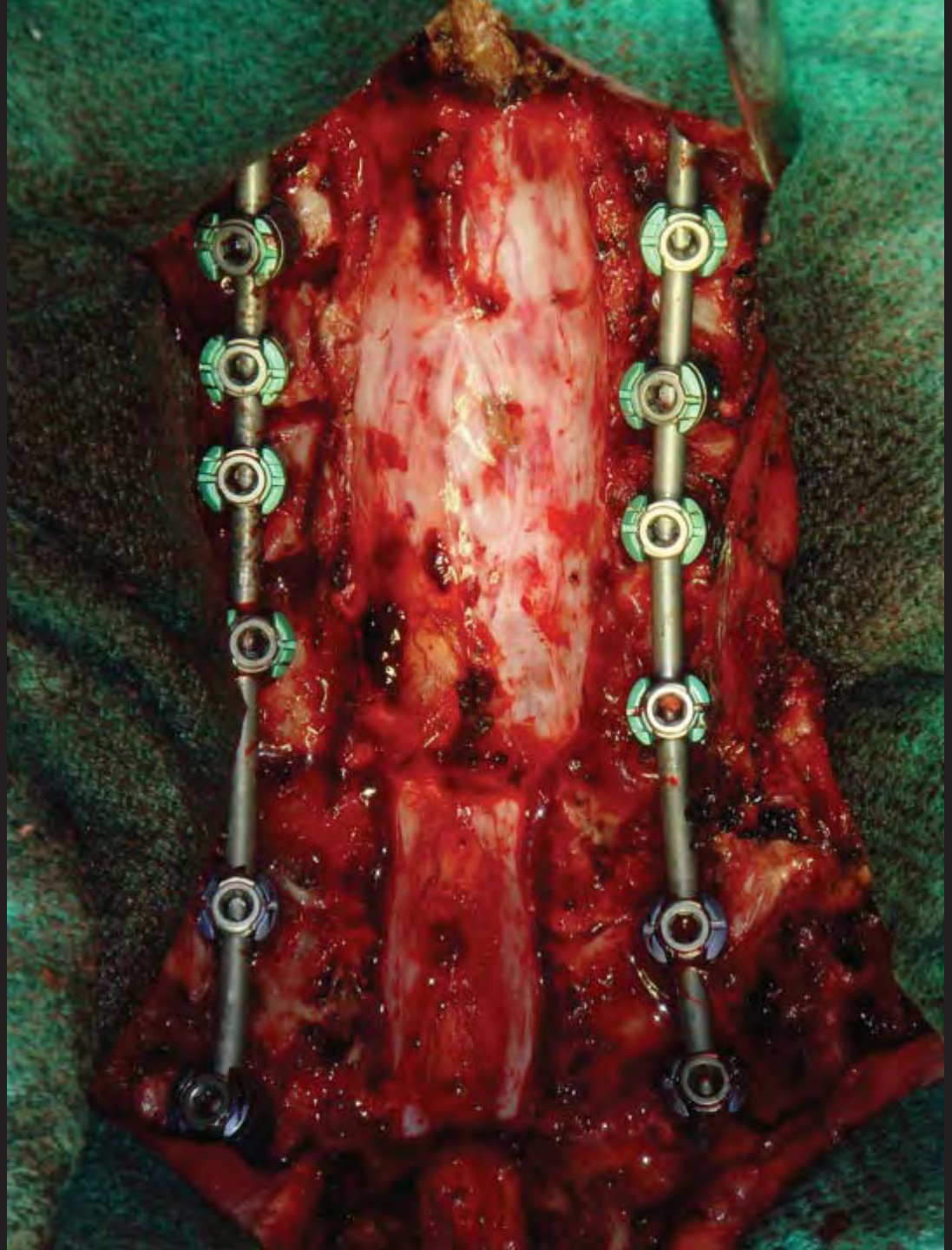
Repetitive Trauma and Tethering / Distraction




A
B

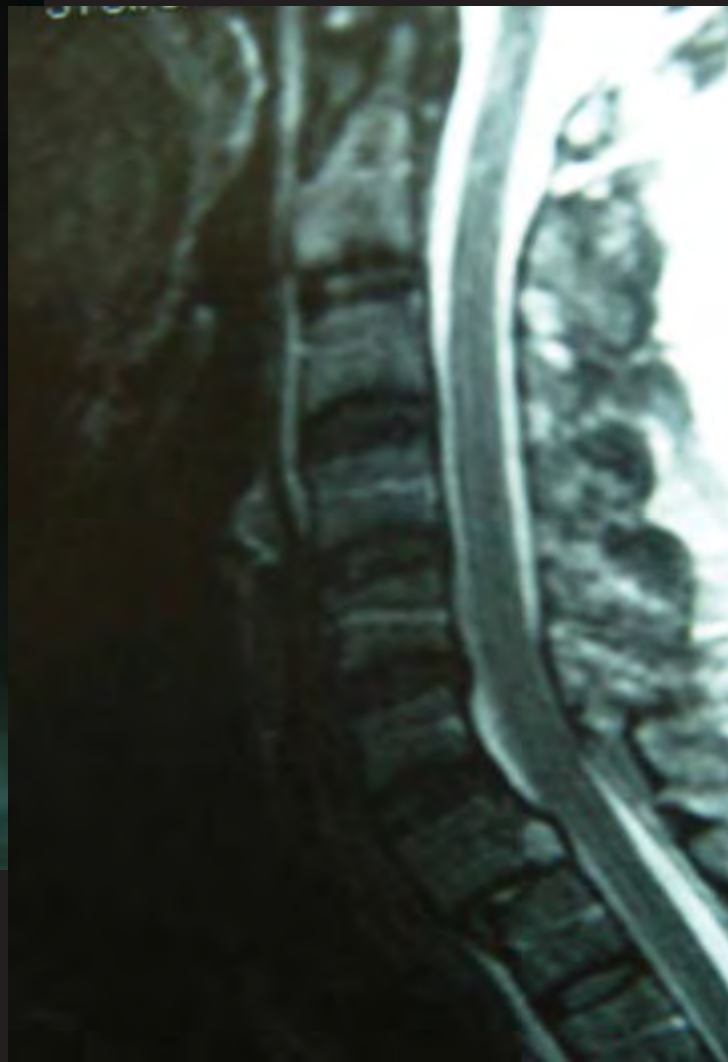
Could Correct Dorsally

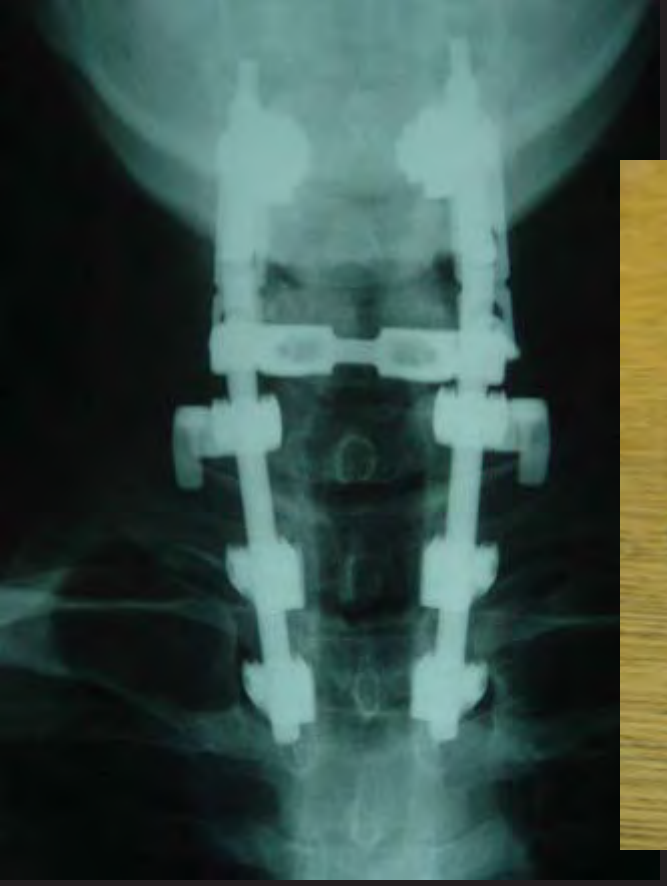
Because Relaxed/Released

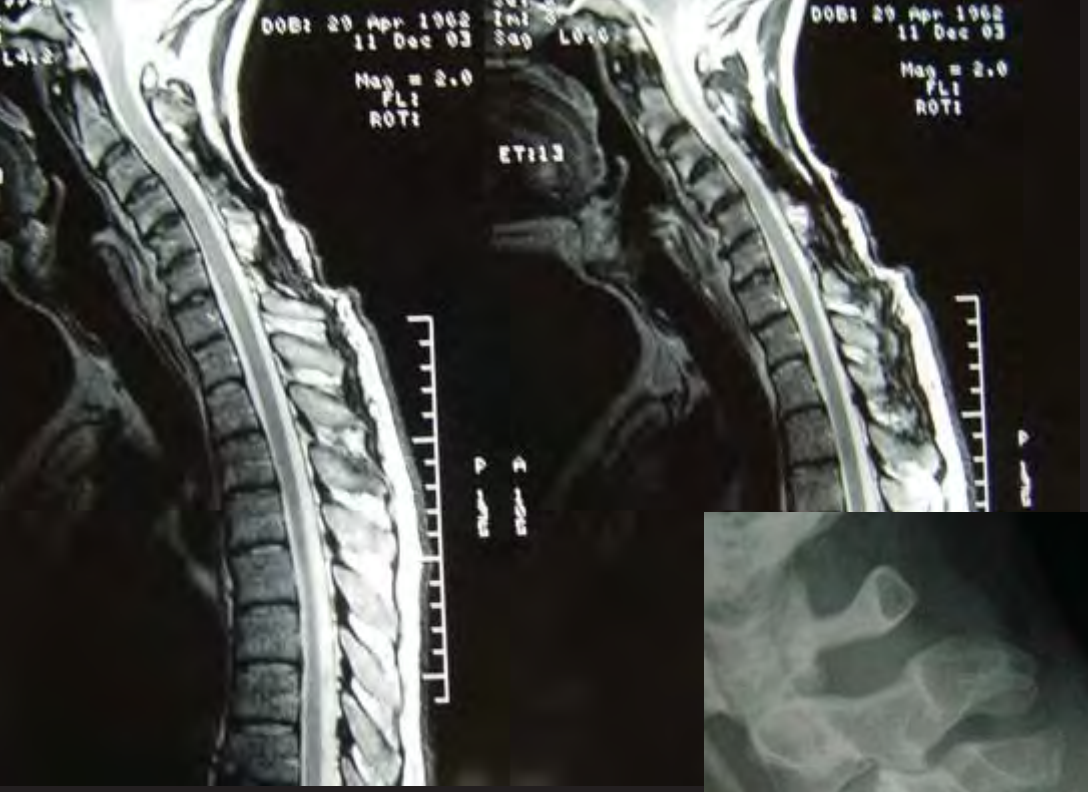



M&
E2008





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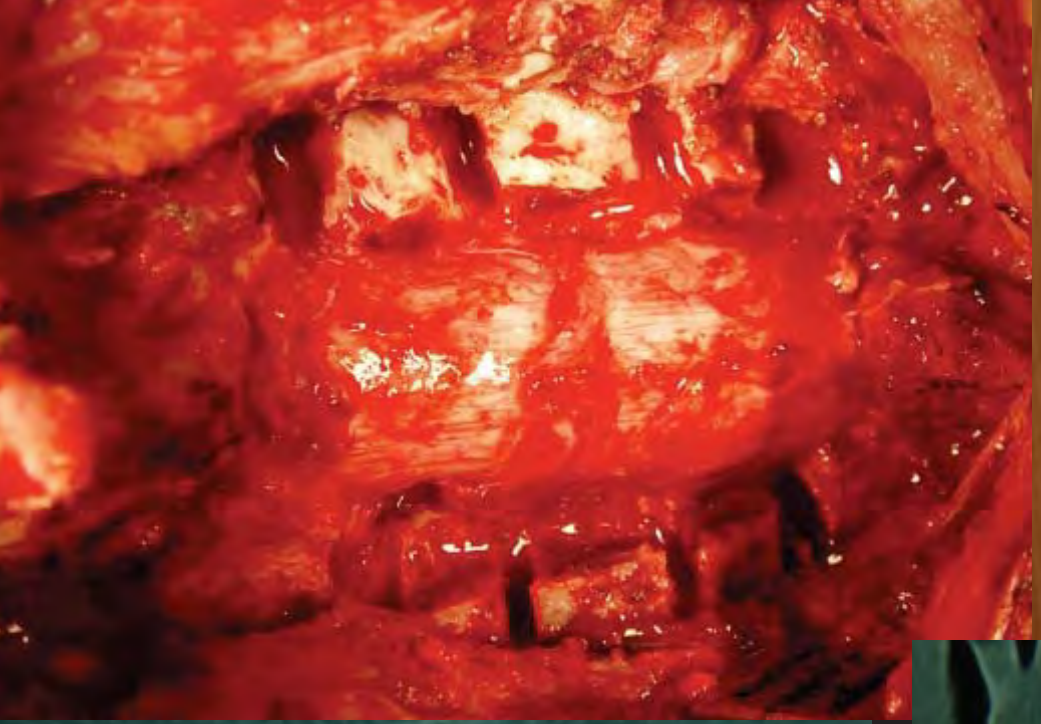
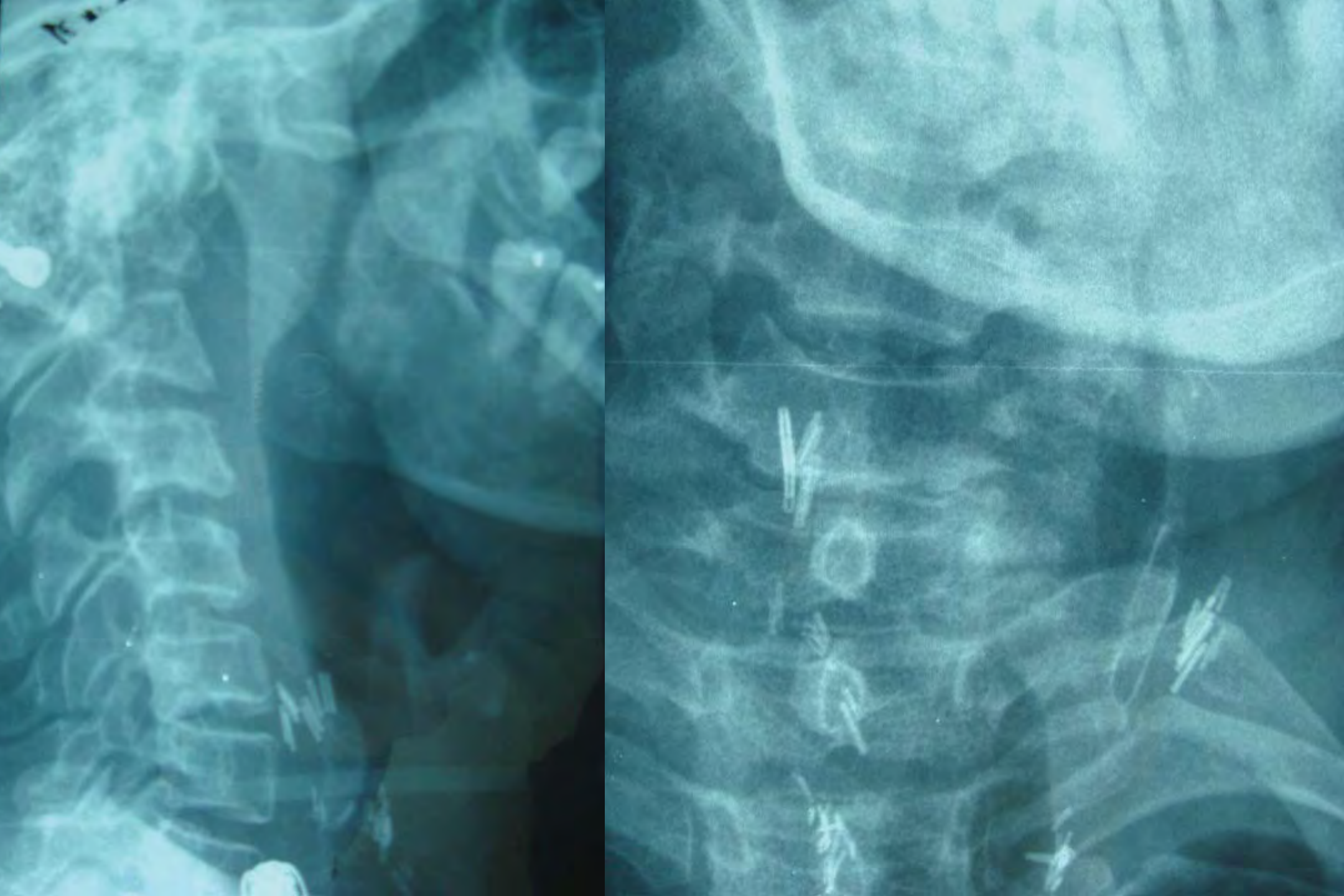
11 Dec 03
Mag = 2.0
FL:
ROT:
ET:13
DOB: 29 Apr 1962
11 Dec 03
Mag = 2.0
FL:
ROT:

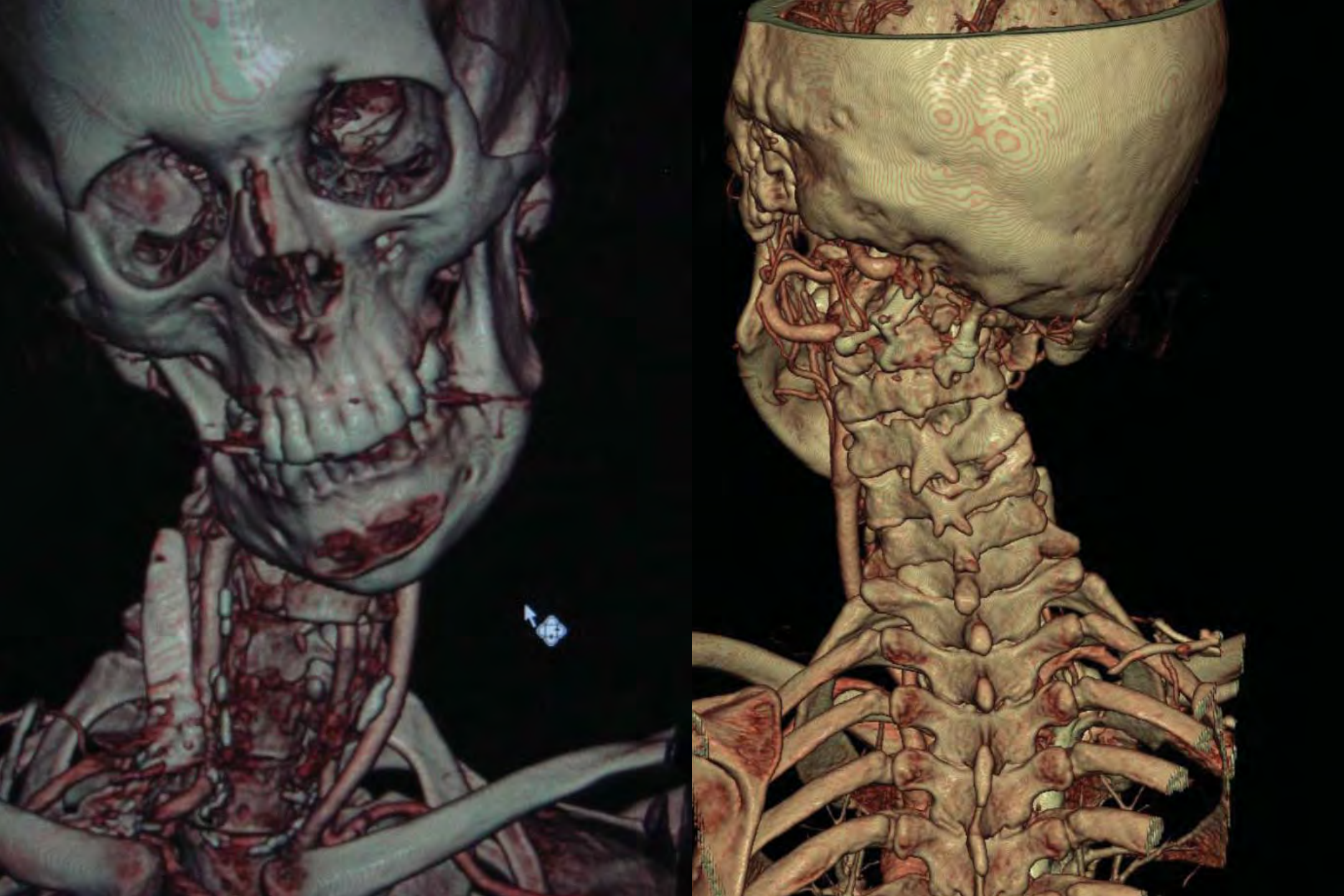


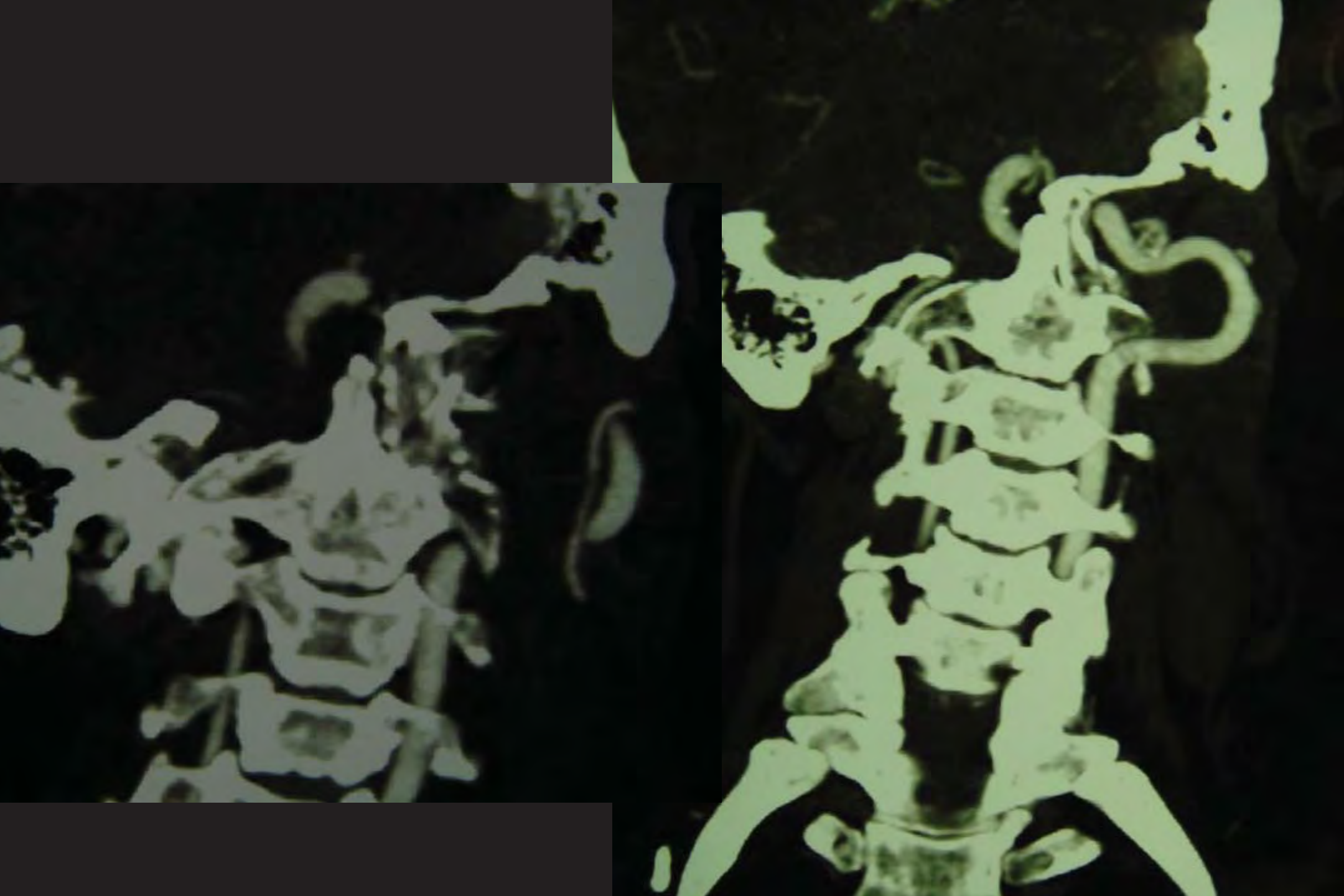

SE STOP AT
ONT DESK
EFORE
VING

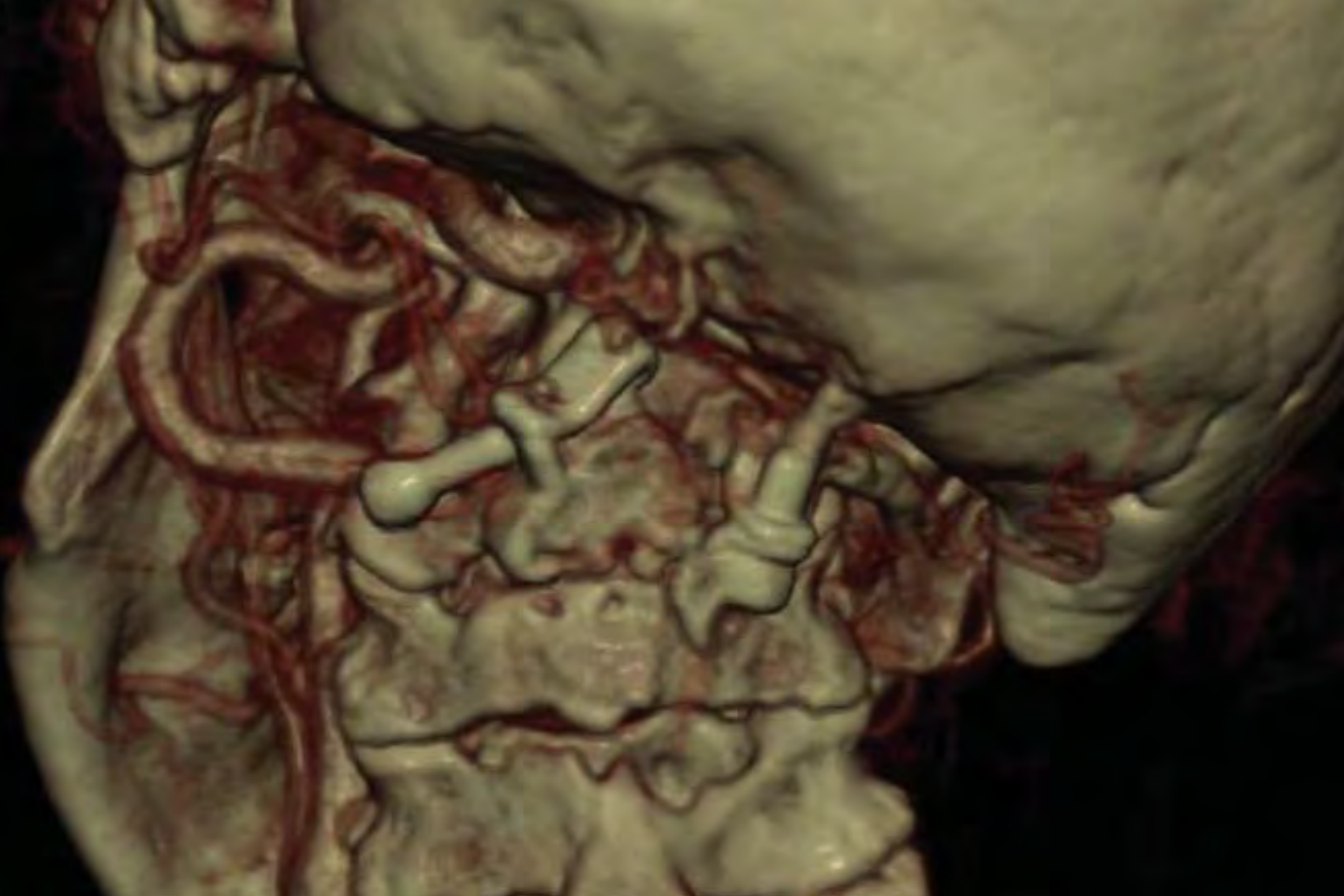

ASE STOP AT
ONT DESK
EFORE
AVING
ASE STOP AT
ONT DESK
EFORE
AVING

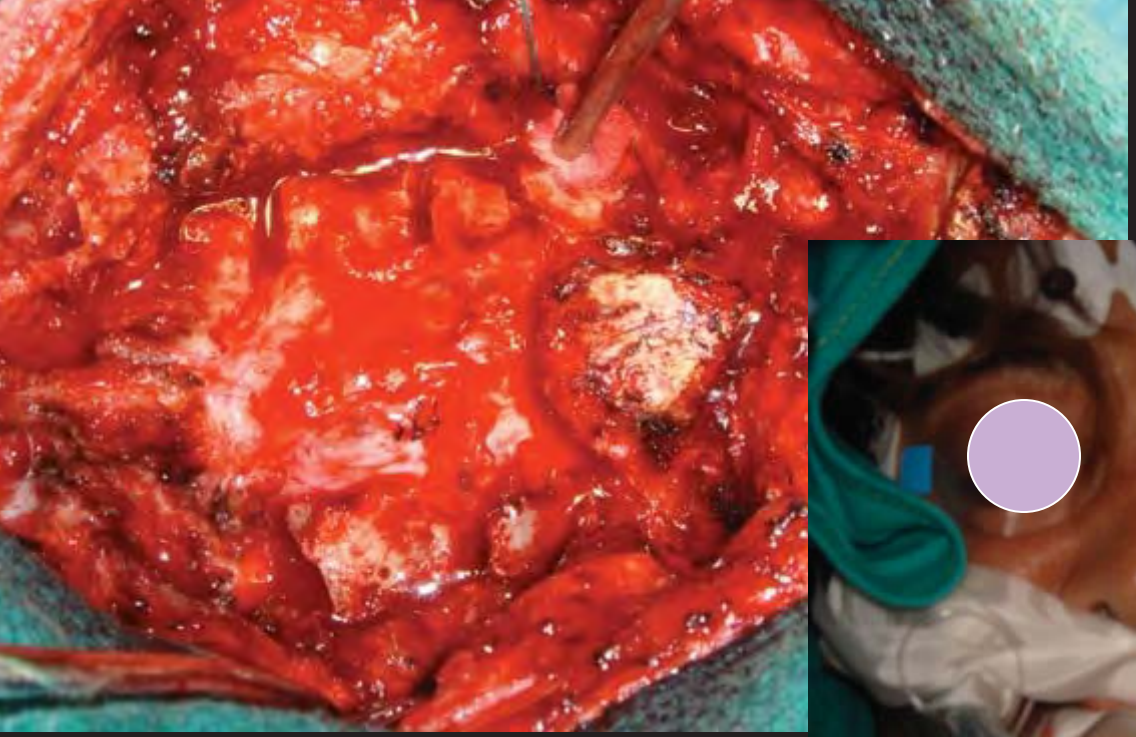
Correct at Another Level

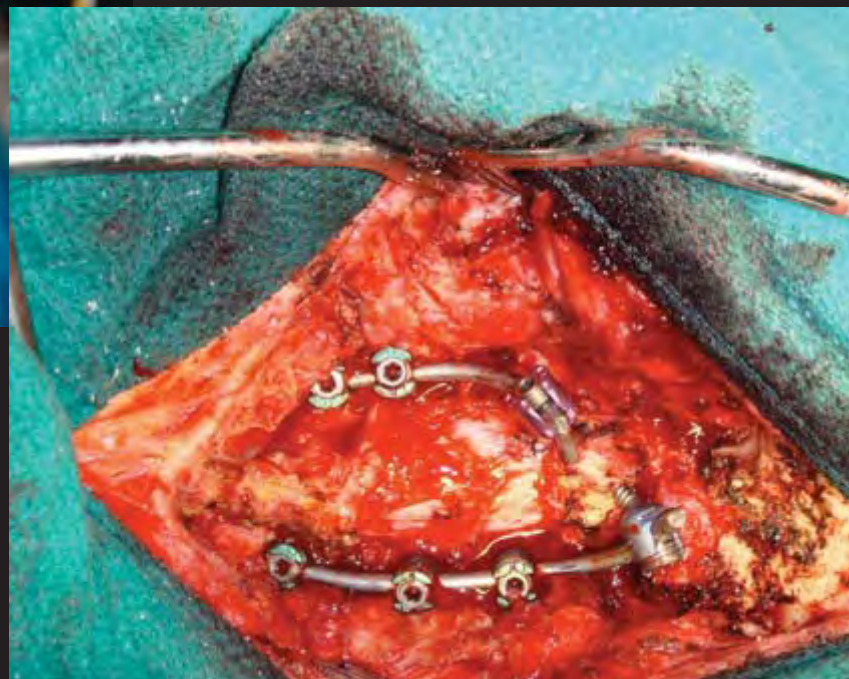













ONT^KAREN^F^^
296523
AROTID 0.75 B20f
and Clinic CT4
tion 64
p-2006
H
F


DUMONT^KAREN^F^^
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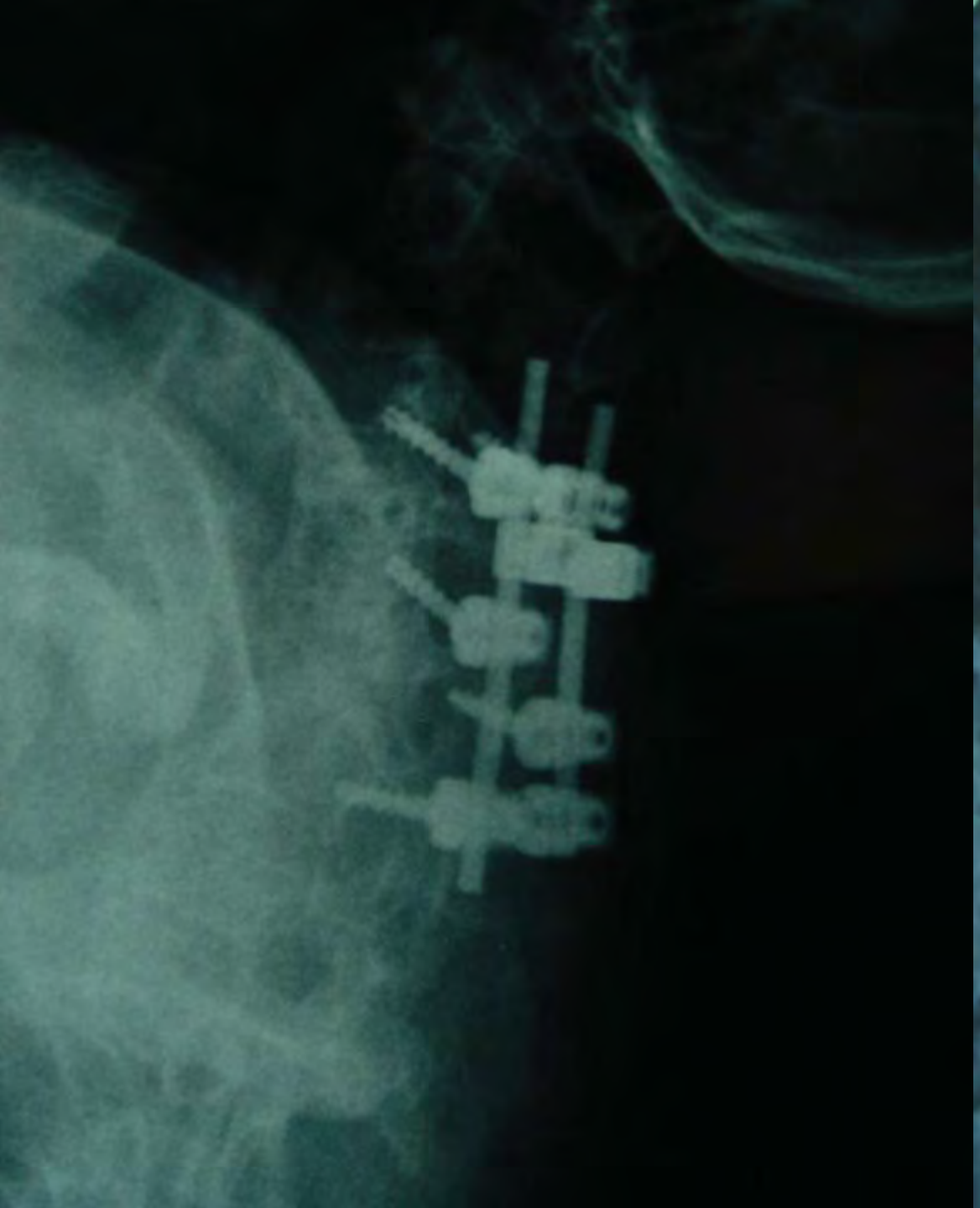
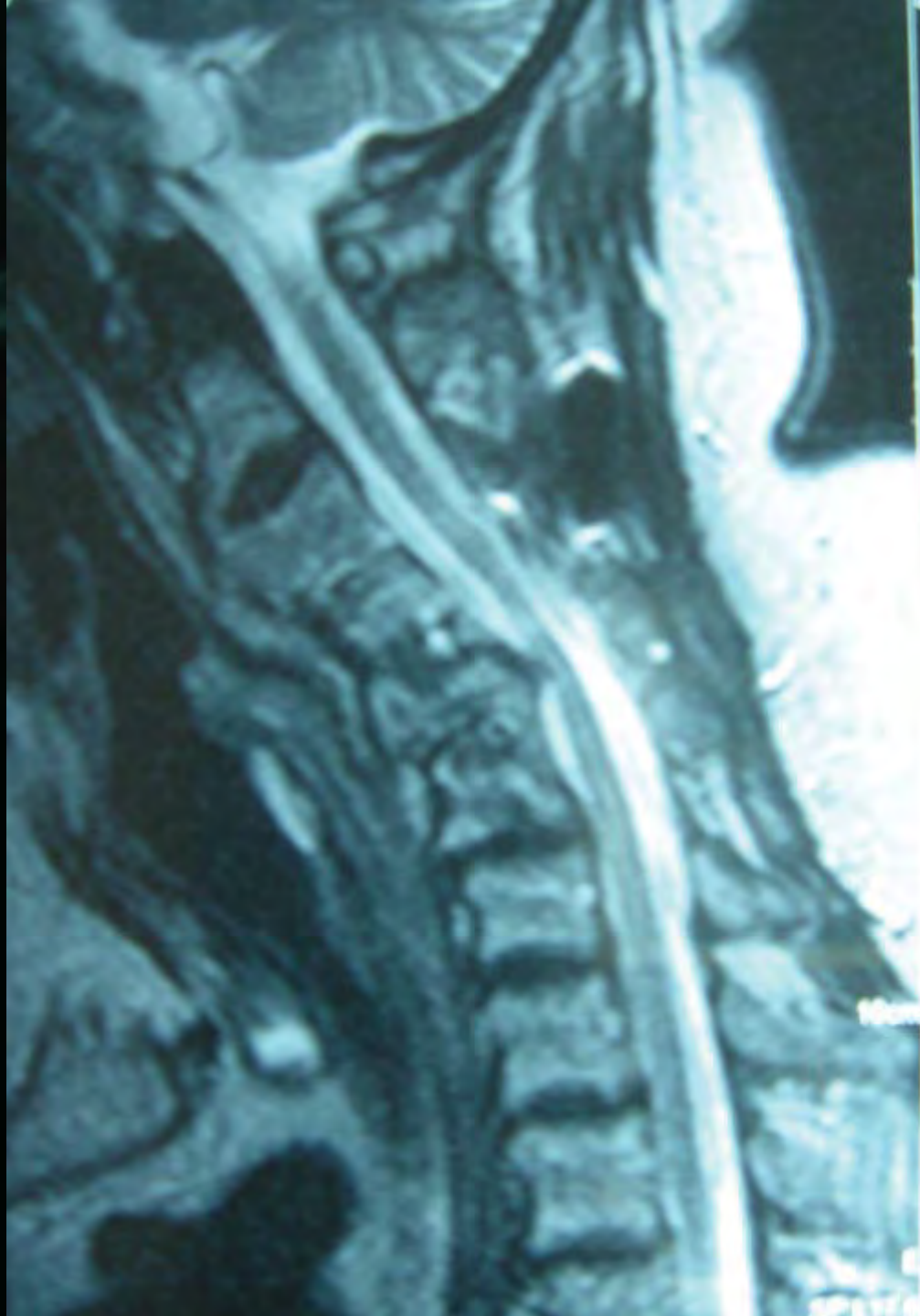
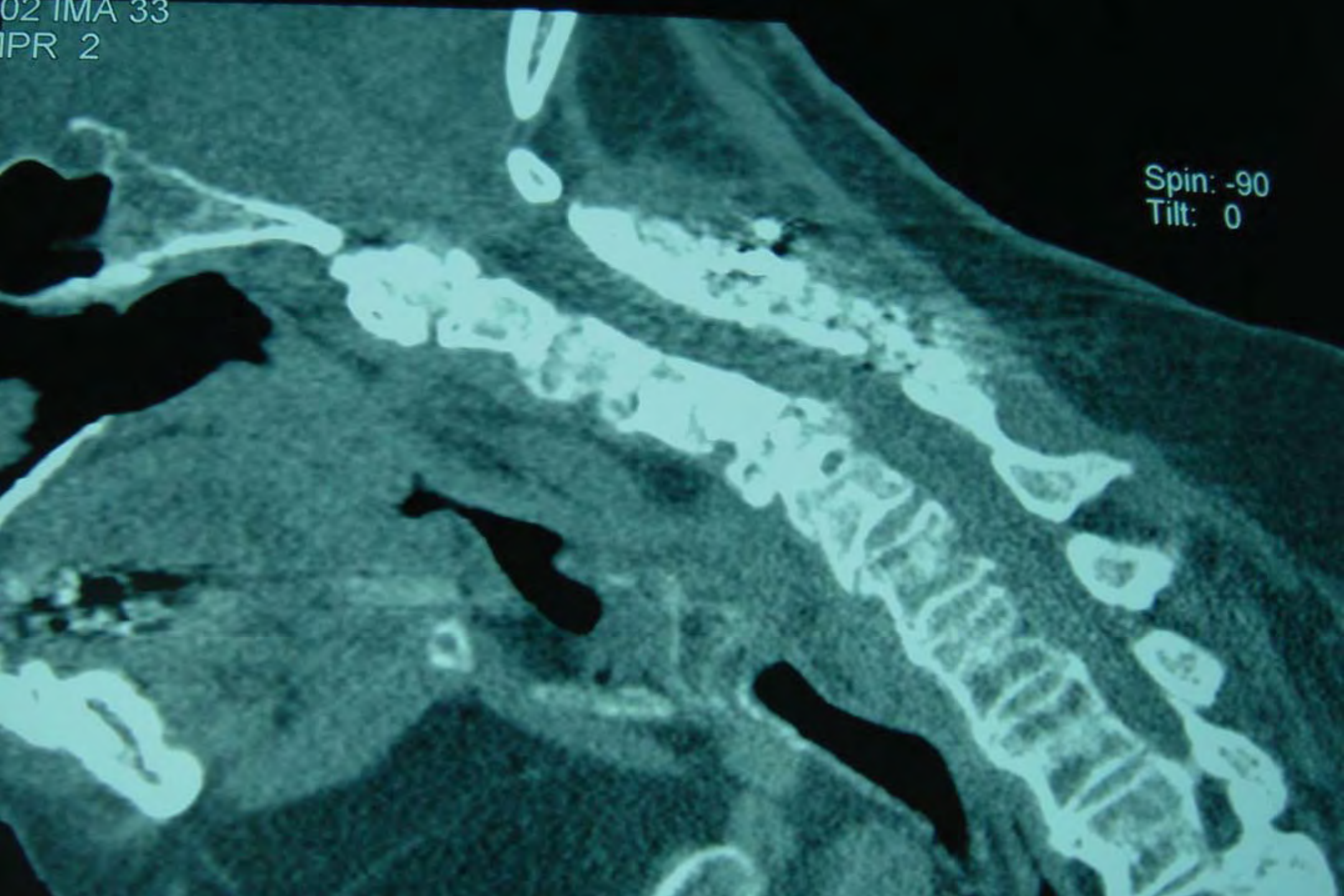
CERVICAL 0.75 B20s
Cleveland Clinic CT3
Sensation 16
18-Oct-2006
CT
H
L
F

STAGING?



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IPR 2
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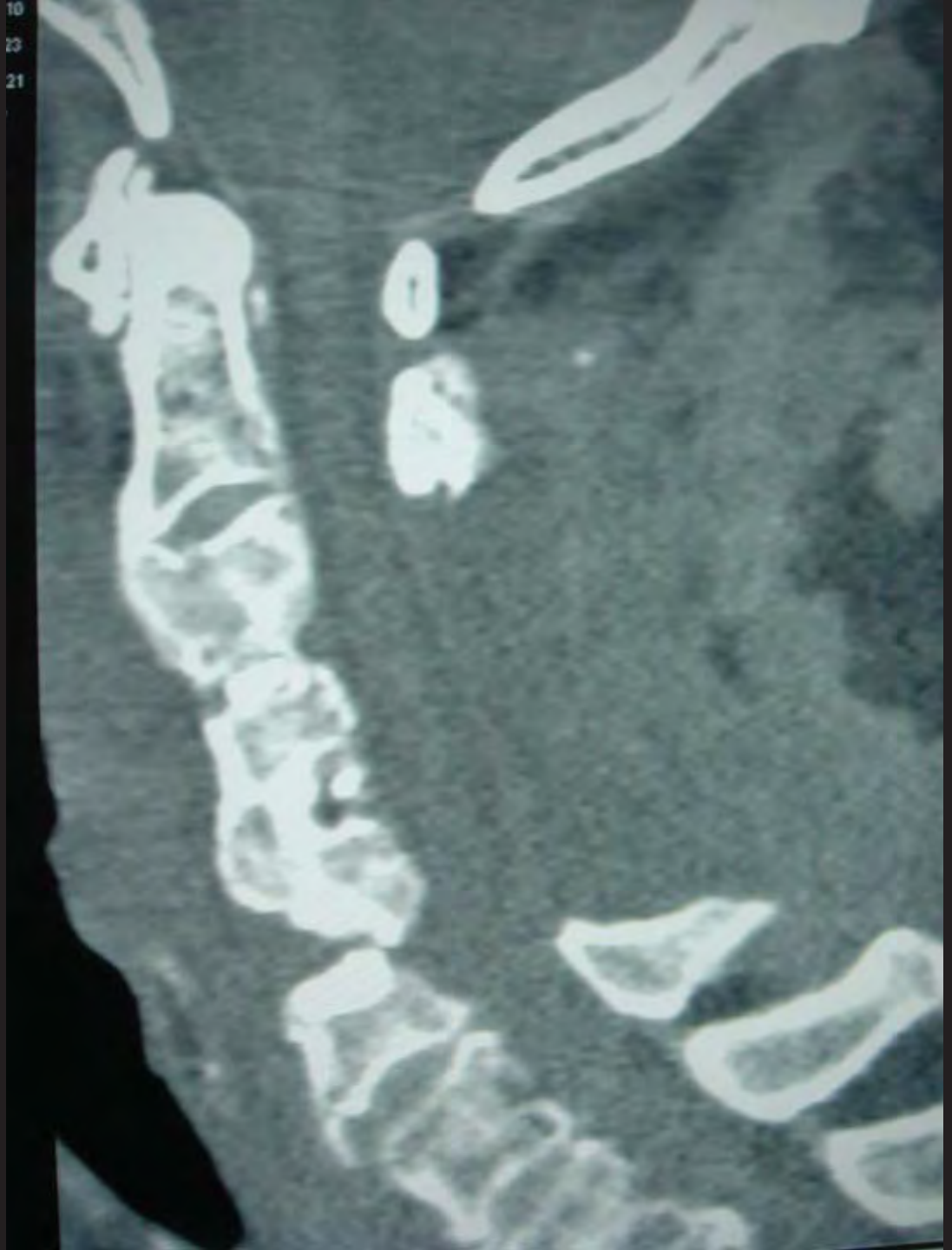
Tilt: 0


10
23
21


H
SHADE/SURF
LAO/RAO 1
CRAN/CAUD -4
R
L
GT 0.0
kV 120
mA 123
SL 0.75
SP 0.7
A
B 100 W 2925
O 80 C 1569
F


H
RES/SHADE/SURF
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CRAN/CAUD -4
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L
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mA 96
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O 80 C 1572
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A
B 100 W 2927
O 80 C 1571
F

Dorsal

Releasing (eg Osteotomy)

Fixation

Ventral

Releasing

Fixation

Correction

Case Against Cervical TDA

Adjacent Segment Degeneration

Adjacent Segment Disease

ASDeg

vs

ASDis

3 Studies – Ave Followup 4.5 Years

Prevelance of ASDis – 9-17%

Prevelance / years followed
Annual Incidence of ASDis Requiring Surgery

1.5 - 4% / year

Hilibrand AS, Robbins M. Adjacent segment degeneration and adjacent segment disease: the consequences of spinal fusion? The Spine Journal 4 (2004) 190S-194S

846 Patients – PLF – f/u 2.8 yrs

Prevalance ASDis - 9%
Annual Incidence ASDis - 3%

Henderson CM, Hennessy RG, Shuey HM, Shackelford EG. posterior lateral foraminotomy as an exclusive operative technique for cervical radiculopathy: a review of 846 consecutively operated cases. Neurosurgery 1983: 13(5):504-12

253 Patients ACD w and w/o F
f/u 3 years

Prevelance ASDis – 7%
Annual Incidence ASDis – 2.5%

No Difference - w and w/o

Lunsford LD, Bissonette DJ,Jannetta PJ, Sheptak PE, Zorub DS. Anterior surgery for cervical disc disease, part 1: treatment of lateral cervical disc herniation in 253 cases. J Neurosurg 1980:53:1-11

Hilibrand AS, Carson GD, Palumbo MA, Jones PK, Bohlman HH. Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. J Bone Joint Surg 1999; 81A(4):519-28

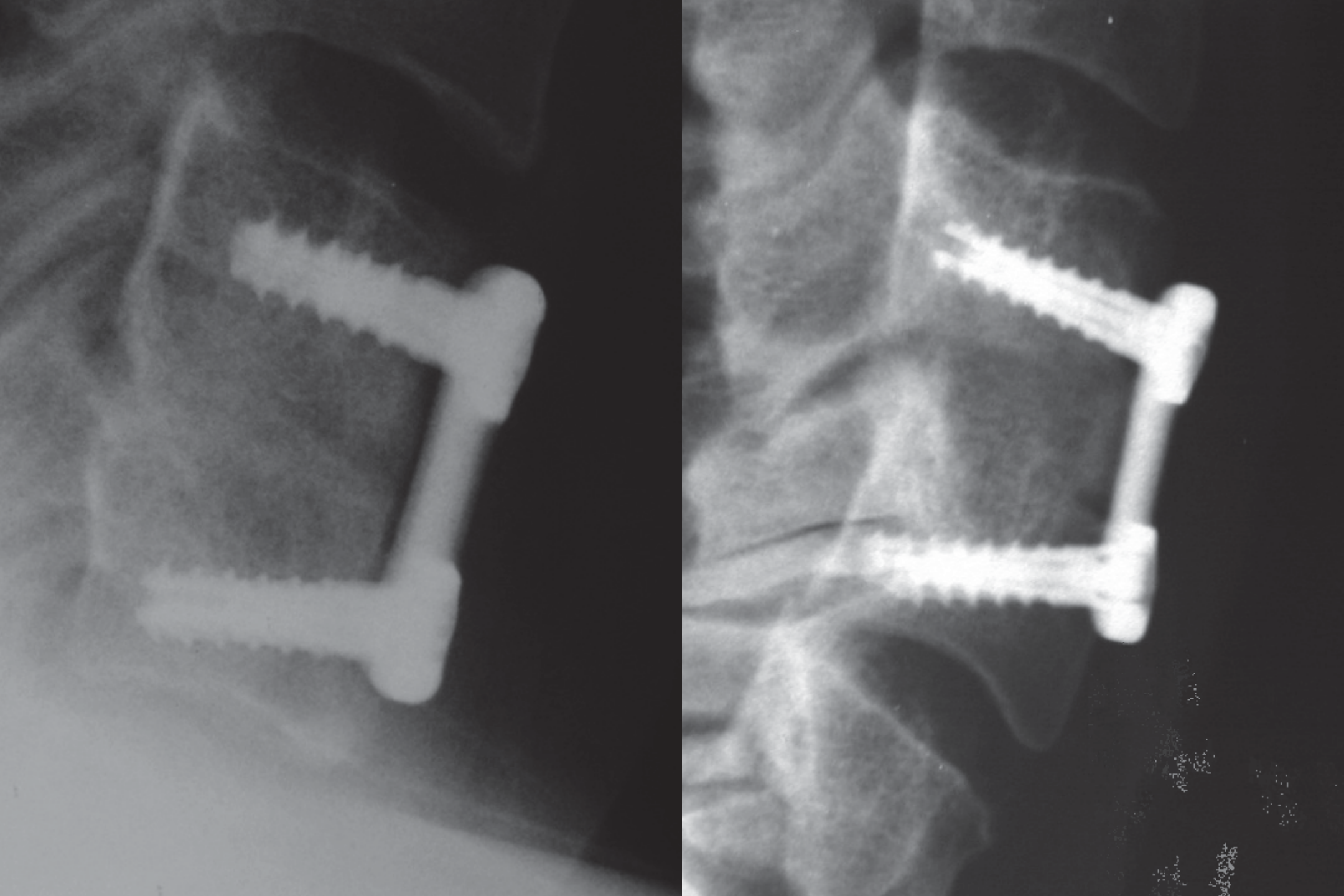
409 ACDF
f/u 2-21 years

Prevelance ASDis – 14%
Annual Incidence ASDis – 3%

Risk Factors
Neural Element Compression at Adjacent Levels
Surgery Adjacent to C56 or C67

Multilevel ACDF Lower Incidence of ASDis
(12% vs 18%, $p \leq 0.001$)

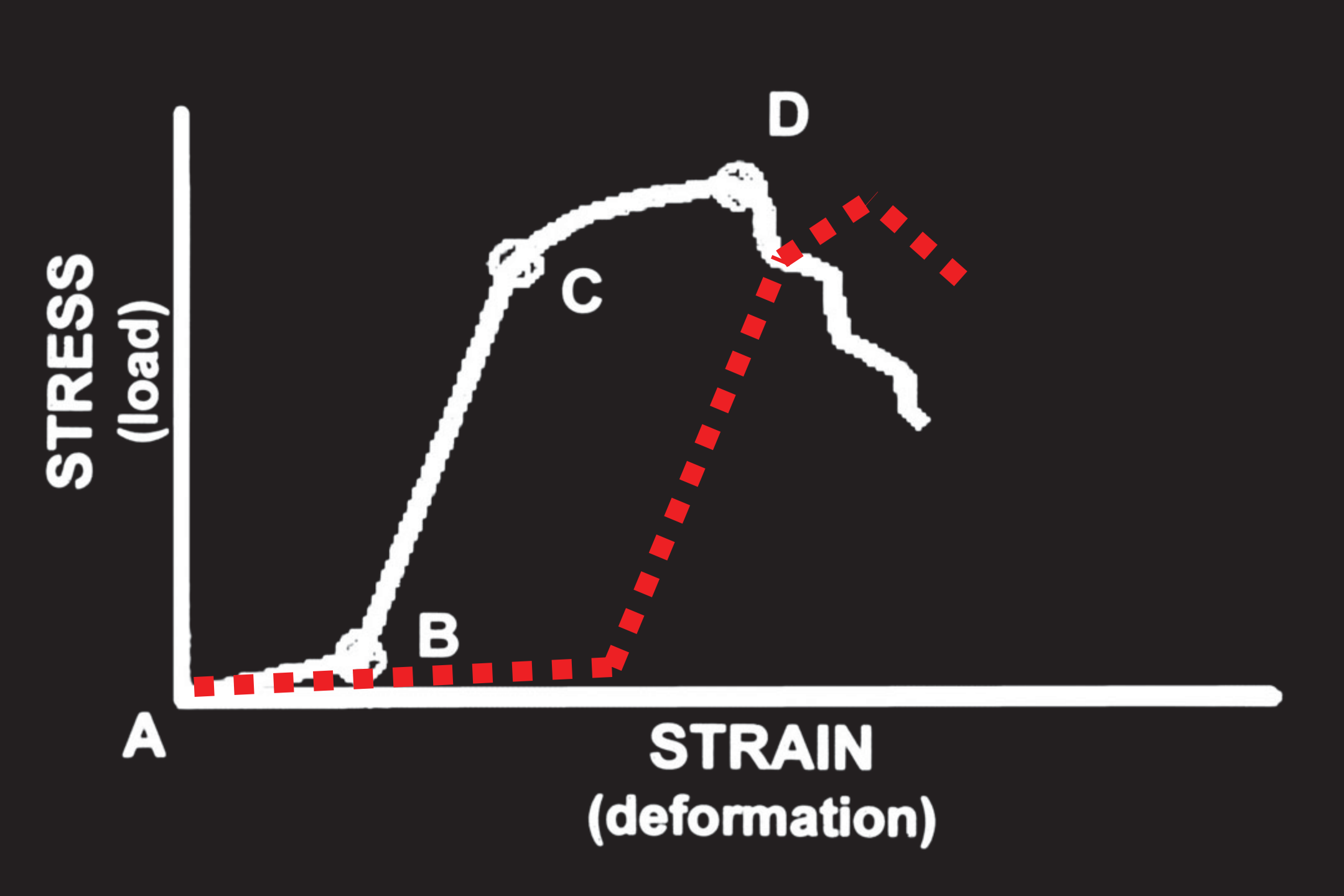
Posture



The art of medicine is amusing the patient until nature cures the disease.

Voltaire

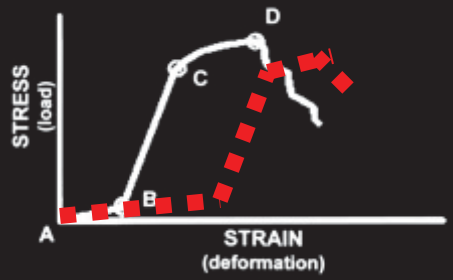
THANKS!!!


D
C
B
A
STRESS
(load)
STRAIN
(deformation)

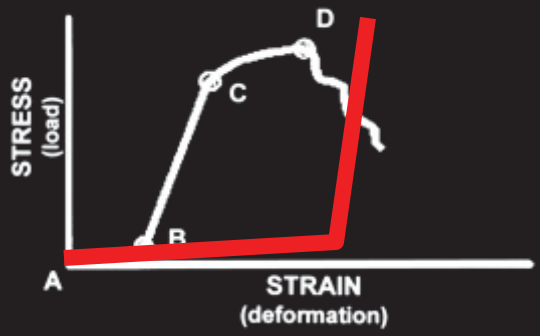
FLEXION AND EXTENSION

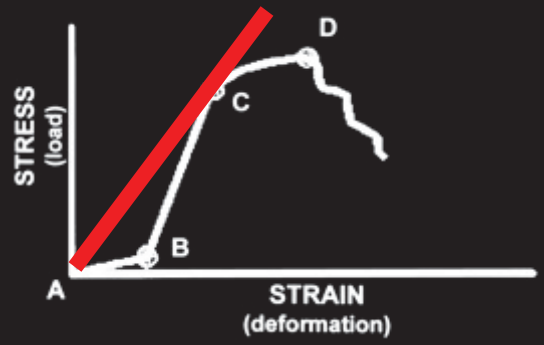
Unconstrained Semiconstrained Constrained

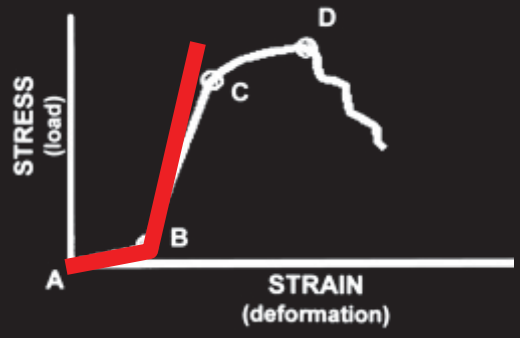
Disengagement

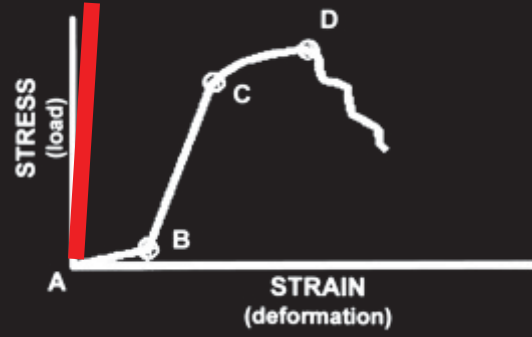


Engagement





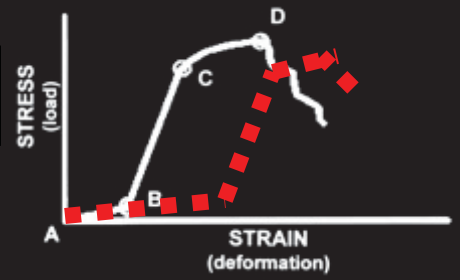




FLEXION AND EXTENSION

Unconstrained Semiconstrained Constrained

Disengagement



Engagement