sense Spine Expert Network for Science & Education™

Controlling forces in trauma indications: How to get the best of the technique

Dr. Patrick A. Weidle

SENSE 2nd International Spine Expert Symposium

June 23 – 25, 2022 / Valencia – Spain

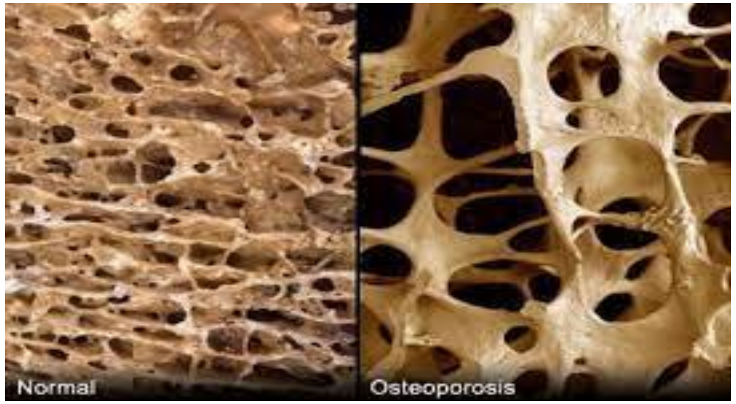
Principle of Fracture Treatment:

A) Reposition

B) Stabilisation

C) Holding of the Stabilisation

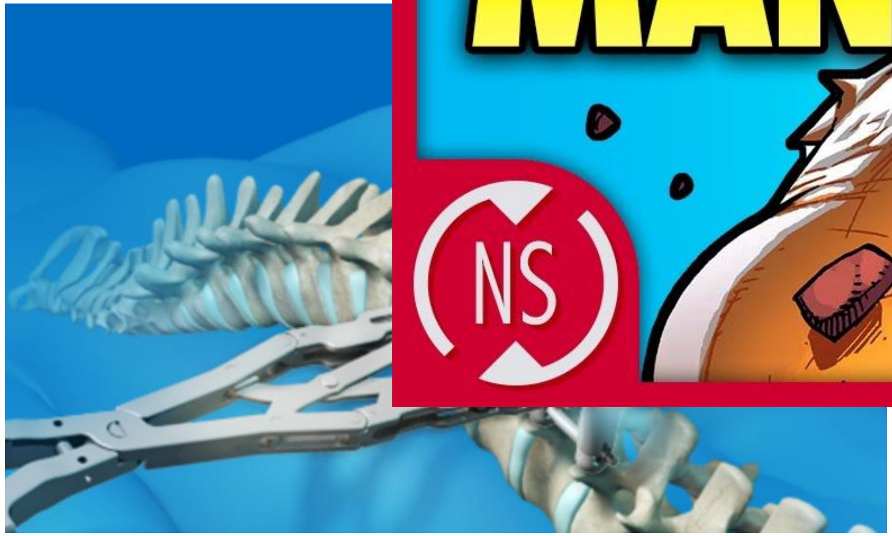
Energy
vs.
Bone Quality

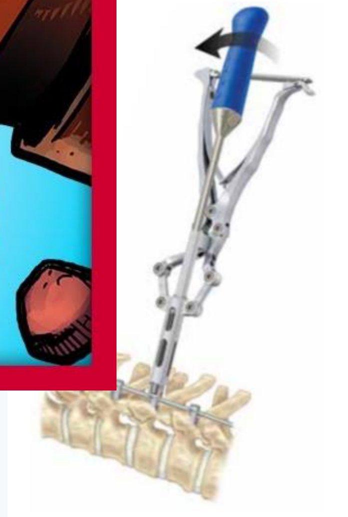


Germany: 80% of the VBF are patients with poor bone quality!

Positioning of the Patient = Repositioning of the Fracture via Ligamentotaxis


POWER
MAN?
NS





Reasons for Revision Surgery – Implant Failure

Spine Deformity
www.spine-deformity.org
Spine Deformity xx (2019) 619–626

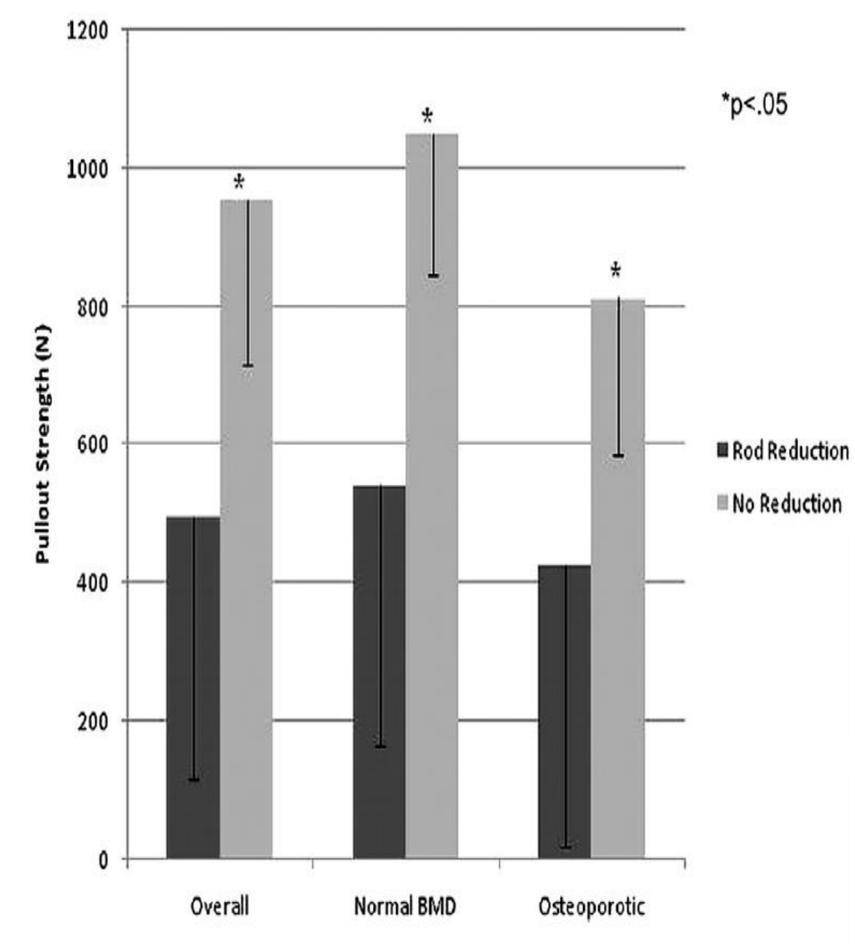
Revision Risk After Primary Adult Spinal Deformity Surgery: A Nationwide Study With Two-Year Follow-up

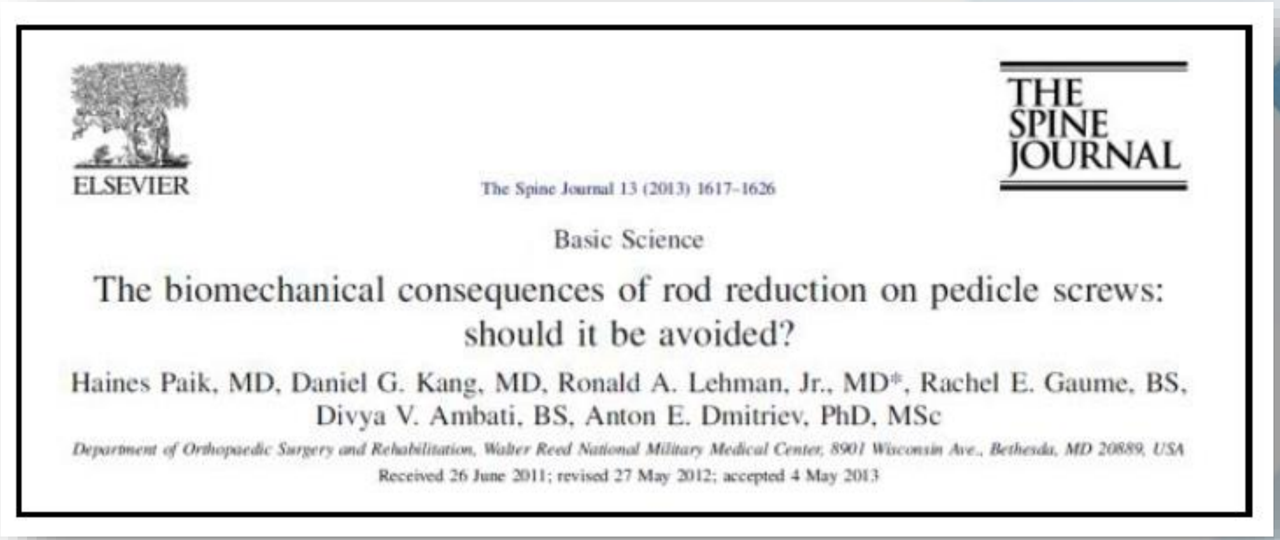
Frederik T. Pitter, MD[a,*], Martin Lindberg-Larsen, MD, PhD[b], Alma B. Pedersen, MD, PhD, DMSc[c], Benny Dahl, MD, PhD, DMSc[d], Martin Gehrchen, MD, PhD[a]

Reasons for revision in the 110 patients.

Reasons	n (%) (95% CI)
Implant failure	42 (38.2)
Infection	13 (11.8)
Curve progression	12 (10.9)
Pseudarthrosis	12 (10.9)
Neurologic deficit	12 (10.9)
Other	9 (8.2)
PJK	8 (7.3)
Unknown	2 (1.8)

Clinical Outcomes – Screw Loosening




ELSEVIER

The Spine Journal 13 (2013) 1617–1626

THE SPINE JOURNAL

Basic Science

The biomechanical consequences of rod reduction on pedicle screws: should it be avoided?

Haines Paik, MD, Daniel G. Kang, MD, Ronald A. Lehman, Jr., MD*, Rachel E. Gaume, BS, Divya V. Ambati, BS, Anton E. Dmitriev, PhD, MSc

Department of Orthopaedic Surgery and Rehabilitation, Walter Reed National Military Medical Center, 8901 Wisconsin Ave., Bethesda, MD 20889, USA

Received 26 June 2011; revised 27 May 2012; accepted 4 May 2013

48% reduced bone anchorage/biomechanical fixation strenghth after attempted reduction using a persuasion device

5-mm-reduction is enough to cause screw loosening

Try to avoid reduction using a persuasion device (osteoporosis)!

1. Kang DG, et al. Effects of rod redu ... 2.

Clinical Outcome – Screw Loosening

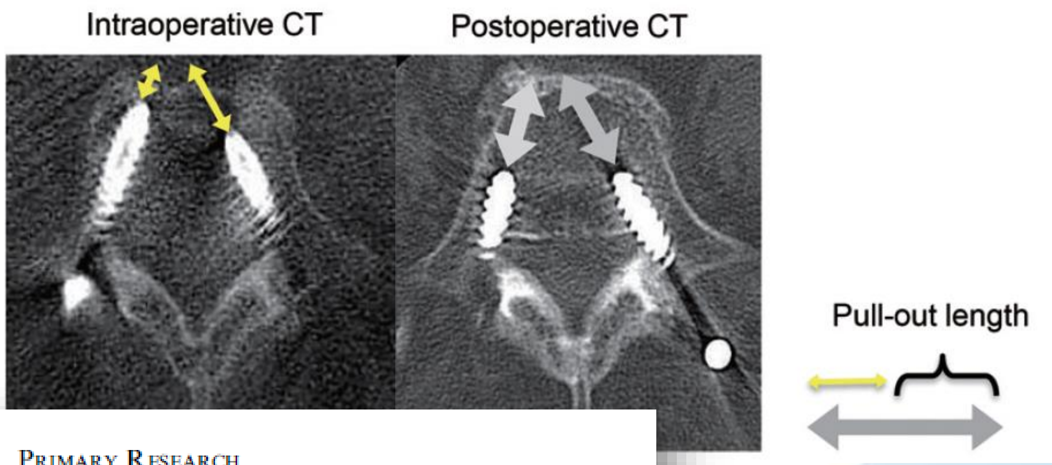
ORIGINAL ARTICLE — SPINE SURGERY AND RELATED RESEARCH

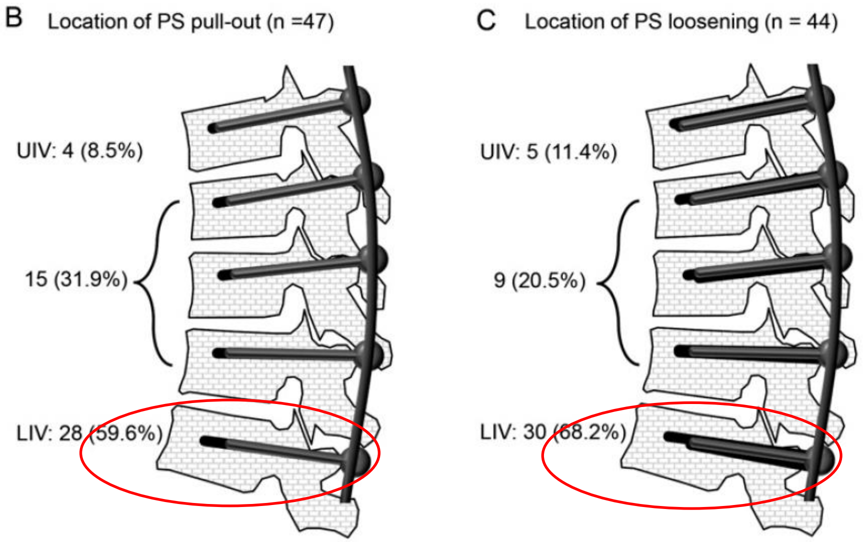
Risk Factors for Clinically Relevant Loosening of Percutaneous Pedicle Screws

Tetsuro Ohba[1], Shigeto Ebata[1], Hiroki Oba[1,2], Kensuke Koyama[1] and Hirotaka Haro[1]

1) Department of Orthopaedic Surgery, University of Yamanashi, Chuou-city, Japan
2) Department of Orthopaedic Surgery, Shinshu University, School of Medicine, Matsumoto-city, Japan

15% - 16% Screw Loosening & Screw Pull-out Rate





PRIMARY RESEARCH

Utility of a Computer-assisted Rod Bending System to Avoid Pull-out and Loosening of Percutaneous Pedicle Screws

82% of loosened screws were pulled out during final rod connection!

48% less screw lossening in computer assisted rod bending!

Forced Fixation ? – A problem of design?

Neo

Heavy Instruments with a high physical center (bad lever!)

Weight: ~0.8 kg - 1.5 kg. reduce the tactile feeling

Bad Lever:
~70% topheavy
~ 35% longer
~40x more mechanical stress

Instruments block polyaxiality

Position of the screw head:
Prohibit the perpendicular alignment Screw - Rod

Reduction power: pulls the spine to the rod – bad anatomical load!

Flat Set Screws

Flat Design: Limited perpendicular alignment – last ½ turn!

Friction: Cold welding – Failure of the stabilisation

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Neo
BEYOND THE EXPECTED

Principles of Controlled Fixation

1

Anatomical Screw Head Position

The Screwheads always bring into reproducible unforced line, when bringing in the rod

2

Keep the Screw Head polyaxial

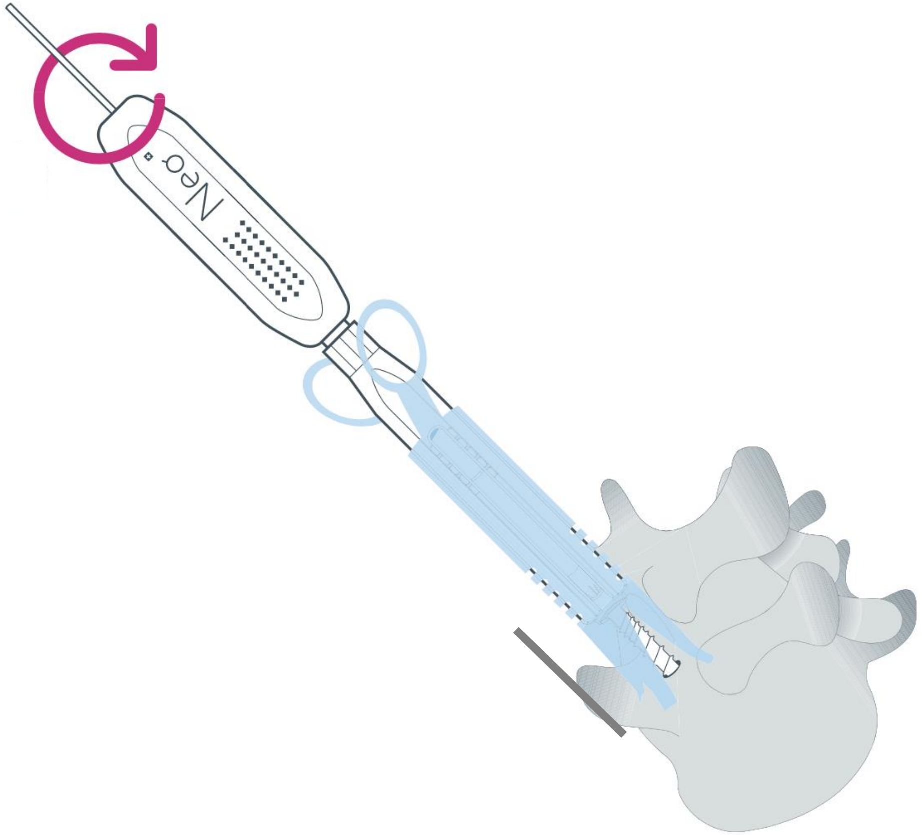
Everything which is blocking the Polyaxiality (Instruments, Anatomy) causes bad loads

3

Controll of the mechanical forces

The system should give a feedback to identify and controll mechanical loads

Implantation of the Screw



CONTROLLED FIXATION DESIGN

- K-Wire and lighth screwdriver for navigation of the screw
- Short lever
- No need of drilling a thread

Cement Augmentation

European Spine Journal (2020) 29:1297–1303
https://doi.org/10.1007/s00586-020-06376-w

ORIGINAL ARTICLE

Reduced cement volume does not affect screw stability in augmented pedicle screws

Lukas Weiser[1] · Kay Sellenschloh[2] · Klaus Püschel[3] · Michael M. Morlock[2] · Lennart Viezens[1] · Wolfgang Lehmann[1] · Gerd Huber[2]

Received: 1 November 2019 / Revised: 5 March 2020 / Accepted: 11 March 2020 / Published online: 23 March 2020

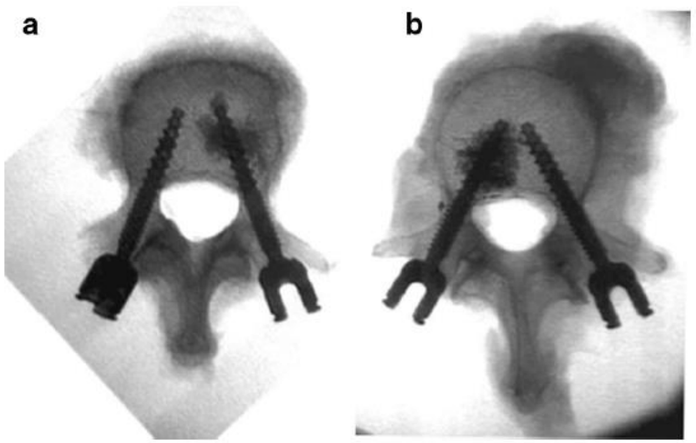
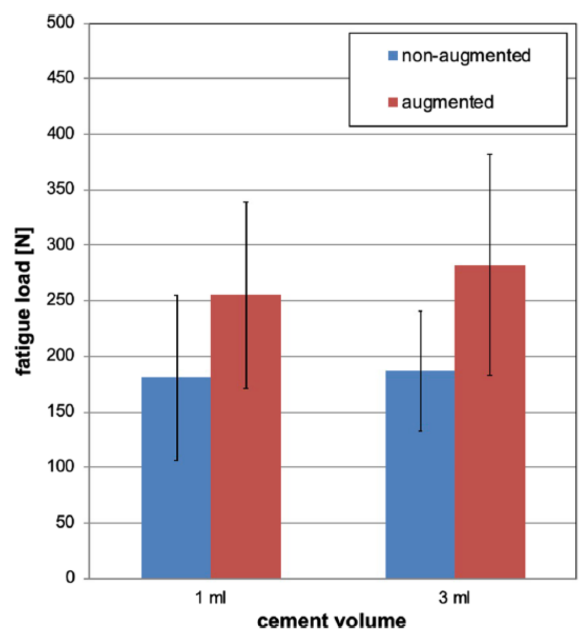


Fig. 1 Radiographs (transversal) showing vertebral body after instrumentation and cement augmentation of one side with 1 ml (**a**) or 3 ml (**b**)



Compared to the non-augmented screws, augmentation with:

- 1 ml bone cement increased the fatigue load by 41%
- 3 ml increased the fatigue load by 51%

There was no significant difference in fatigue loads between the specimens with screws augmented with 1 ml and screws augmented with 3 ml of bone cement ($p = 0.504$).

"A spare usage of bone cement (around 1 ml) for each pedicle screw appears to be recommendable"

Cement Augmentation

ELSEVIER
CrossMark
The Spine Journal 15 (2015) 1432–1445
THE SPINE JOURNAL

Review Article

The biomechanics of pedicle screw augmentation with cement

Benjamin D. Elder, MD, PhD*, Sheng-Fu L. Lo, MD, Christina Holmes, PhD, Courtney R. Goodwin, MD, PhD, Thomas A. Kosztowski, MD, Ioan A. Lina, BS, John E. Locke, Timothy F. Witham, MD
Department of Neurosurgery, The Johns Hopkins University School of Medicine, 1800 Orleans St, Baltimore, MD 21287, USA

Received 26 November 2014; revised 8 January 2015; accepted 16 March 2015

- Systematic Literature Review

CONCLUSION

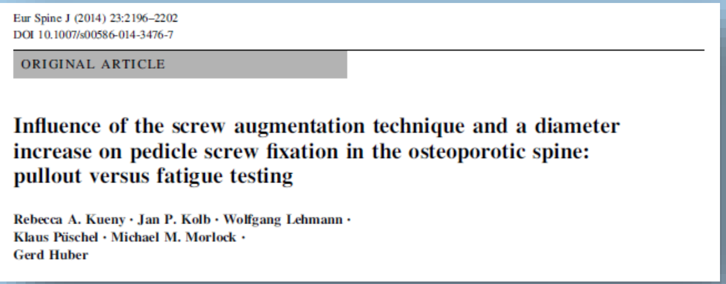
PMMA along with several calcium ceramic materials, are effective materials for enhancing pedicle screw fixation.

Table 2
Biomechanical testing of PMMA screw augmentation with fenestrated or cannulated screws

Study	Subject	Levels	Fixation material	Screw and cement implantation	Volume (cc)	Screw insertion time (min)	Biomechanics	Results	ailure mode	Comments
Becker et al. [12]	Cadaveric spines	L1–L4	PMMA	Solid, fenestrated, vertebroplasty vs. kyphoplasty	2	6	Axial pullout	1.5- to 1.8-Fold increase in pullout strength with cement, no difference between fenestrated screw, vertebroplasty, or kyphoplasty	crew stripping for fenestrated screw, bone-cement interface for solid screws	Epidural cement leakage with fenestrated screw
Chao et al. [13]	Osteoporotic cadaveric spines	T10–L5	PMMA	Fenestrated (prefilled or through screw)	2	0	Axial pullout, stiffness, energy to failure	4- to 5.6-fold increase in pullout strength with cement, prefilling hole with higher failure energy than injecting through fenestration	one-cement interface	Injecting through fenestrated screw with cement only at distal end of screw where fenestration located
Goost et al. [14]	Normal vs. osteoporotic cadaveric v ertebrae	T12–L5	PMMA	Fenestrated, with or without cement	3	NR	Axial pullout	2.1-fold increase in pullout strength for osteoporotic group, 1.5-fold increase in normal group	R	No cement extravasation
Chen et al. [15]	Synthetic bone blocks simulating severe osteoporosis	NA	PMMA	Solid vs. fenestrated, conical vs. cylindrical	3	1	Axial pullout	Prefilling cement had improved pullout strength compared with fenestrated screw injection	one-cement interface	Enhanced initial fixation, no loss of fixation strength when backing screws out 360°
Chen et al. [16]	Synthetic bone	NA	PMMA	Fenestrated screw, with or without radial holes	3	1	Axial pullout	Pullout strength increased with greater number of radial screw holes	one-cement interface	Cement exuded primarily from proximal holes
Waits et al. [17]	Osteopenic cadaveric vertebrae	L1–L5	PMMA	Fenestrated, left in place or replaced before curing	2.5	0	Cephalocaudal toggle displacement, removal torqu	63% motion reduction for cemented screws	R	Removal torque 10-fold higher if fenestrated screw left in place after cement injection
Kueny et al. [18]	Osteoporotic cadaveric vertebrae	L1–L5	PMMA	Fenestrated, prefilled, screw-injected, large diameter nonaugmented	NR	NR	Toggle fatigue testing, axial pullout	Both cement augmentation techniques increased pullout force, but better fatigue resistance in screw-injected group	R	Cement leakage in 6 of 9 vertebrae
Choma et al. [19]	Osteoporotic cadaveric vertebrae	T6–L5	PMMA	Nonaugmented, solid with PMMA, partially fenestrated, fully fenestrated	2	NR	Axial pullout, removal torqu	All augmentation techniques significantly better pullout strength than control; partial fenestration had better pullout strength than solid screw with cement prefilling	crew-cement interface during removal	No difference in pullout strength between high- and low-viscosity cement, no difference in extraction torque for solid screws or fenestrated screws, no vertebral body damage with removal

NA, not applicable; NR, not recorded; PMMA, polymethylmethacrylate.

Cement Augmentation



Eur Spine J (2014) 23:2196–2202
DOI 10.1007/s00586-014-3476-7

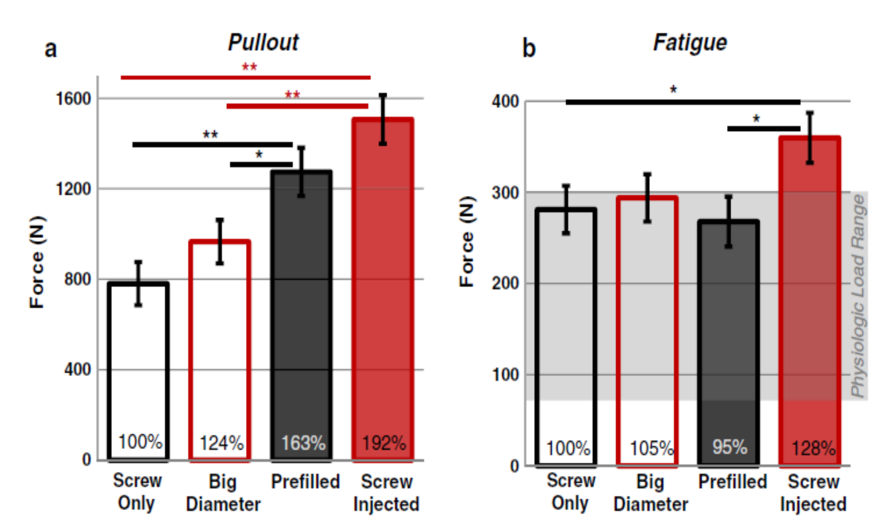
ORIGINAL ARTICLE

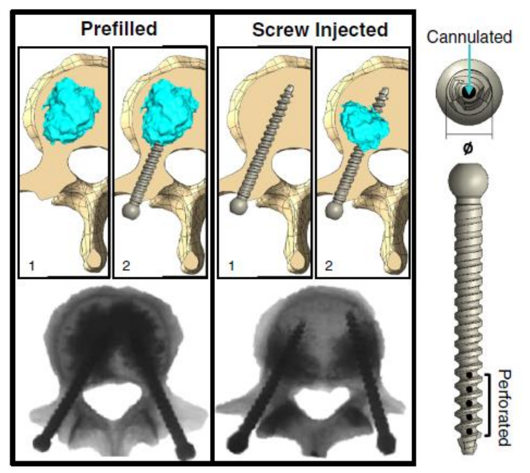
Influence of the screw augmentation technique and a diameter increase on pedicle screw fixation in the osteoporotic spine: pullout versus fatigue testing

Rebecca A. Kueny · Jan P. Kolb · Wolfgang Lehmann · Klaus Püschel · Michael M. Morlock · Gerd Huber

- Biomechanical study in human osteoporotic cadaveric spine
- 39 lumbar vertebrae
- To determine the fixation strength of current fixation techniques

4 treatment groups:
- screw only (control)
- non-augmented, increased diameter
- prefilled augmentation
- screw injected augmentation





- Screw injected augmentation showed the best biomechanical stability.
- Key for achieving stable screw fixation in the osteoporotic spine:

Utilizing screw injected cement augmentation along with a maximal screw diameter.

European Spine Journal (2020) 29:2491–2504
https://doi.org/10.1007/s00586-020-06479-4

REVIEW ARTICLE

Pedicle screw fixation of thoracolumbar fractures: conventional short segment versus short segment with intermediate screws at the fracture level—a systematic review and meta-analysis

Carolijn Kapoen[1] · Yang Liu[2] · Frank W. Bloemers[1] · Jaap Deunk[1]

Systematic review: 21 randomized controlled trials with a total of 1890 patients

European Spine Journal (2020) 29:2491–2504
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Systematic review: 21 randomized controlled trials with a total of 1890 patients

Significantly
- lower pain scores
- better short- and long-term Cobb angles
- less loss of correction
- less implant failures

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Systematic review: 21 randomized controlled trials with a total of 1890 patients

Significantly
- lower pain scores
- better short- and long-term Cobb angles
- less loss of correction
- less implant failures

Significantly
- longer operation time
- more blood loss

Journal of
Clinical Medicine

MDPI

Article

Efficacy and Radiographic Analysis of Minimally Invasive Posterior Mono-Axial Pedicle Screw Fixation in Treating Thoracolumbar Burst Fractures

Jae-Hoon Shim and Eun-Min Seo *

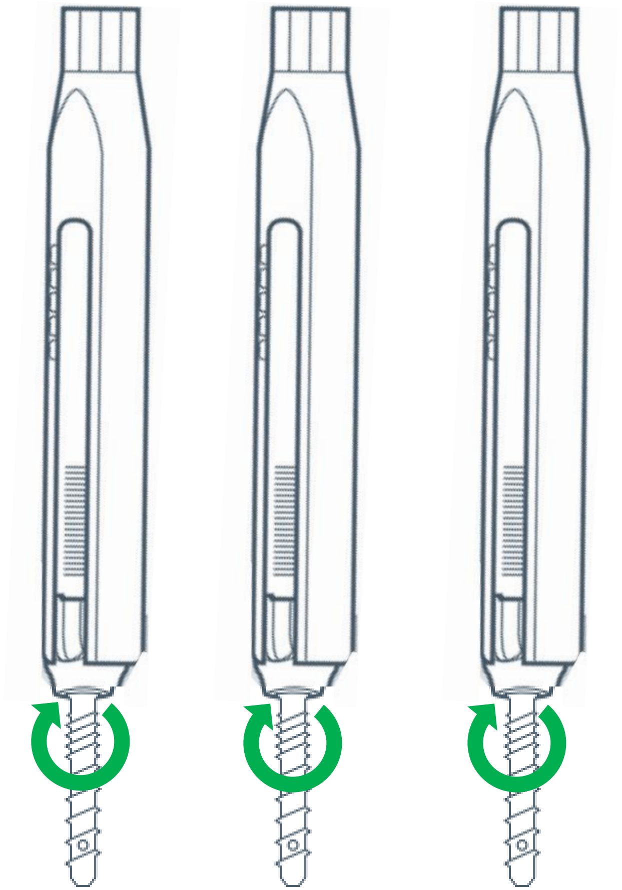
Department of Orthopedic Surgery, Chuncheon Sacred Heart Hospital, Hallym University College of Medicine, Chuncheon 24253, Korea; shim0121@hallym.or.kr
* Correspondence: seoem@hallym.or.kr; Tel.: +82-33-240-5198

Randomized controlled trial with a total of 98 patients; mono-axial vs. poly-axial
Traumatic fractures; healthy bone quality

Mono-Axial PS-Fixation was significantly better in correction of regional angle of kyphosis and maintaining anterior vb height

MO-PS	Correction of path. Kyphosis: 62%	Loss of Correction after 12 Mo: 15%
PA-PSD	Correction of path. Kyphosis: 52%	Loss of Correction after 12 Mo: 33%

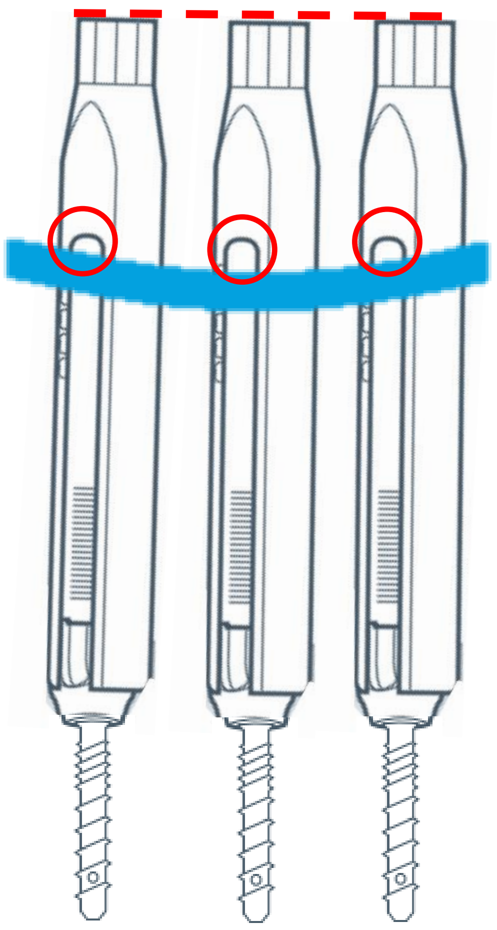
Polyaxiality of the screws



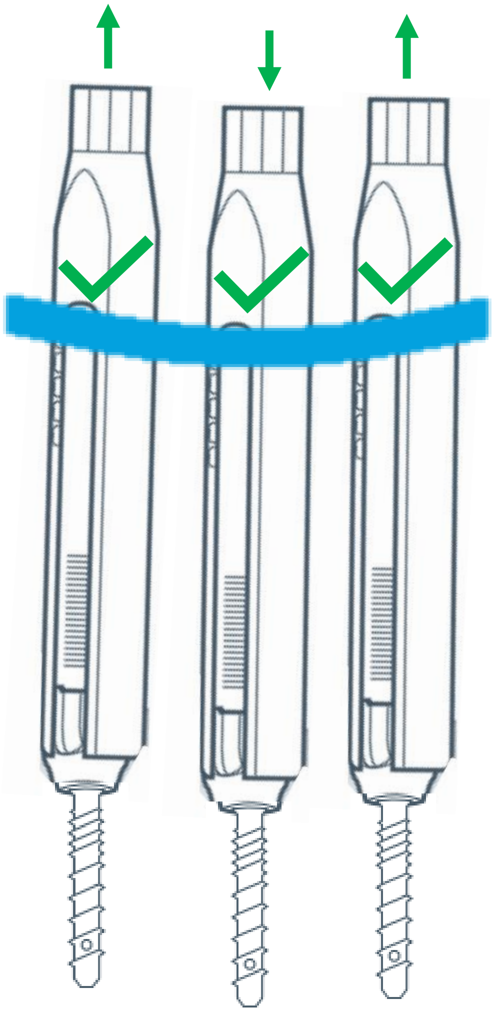
CONTROLLED FIXATION DESIGN

- GuideTower: Enables to ensure polyaxiality

Modification of the rod (or of the screws!?)



Misalignment screw - rod



Perfect Alignment screw – rod!
Controlled Fiaxtion!

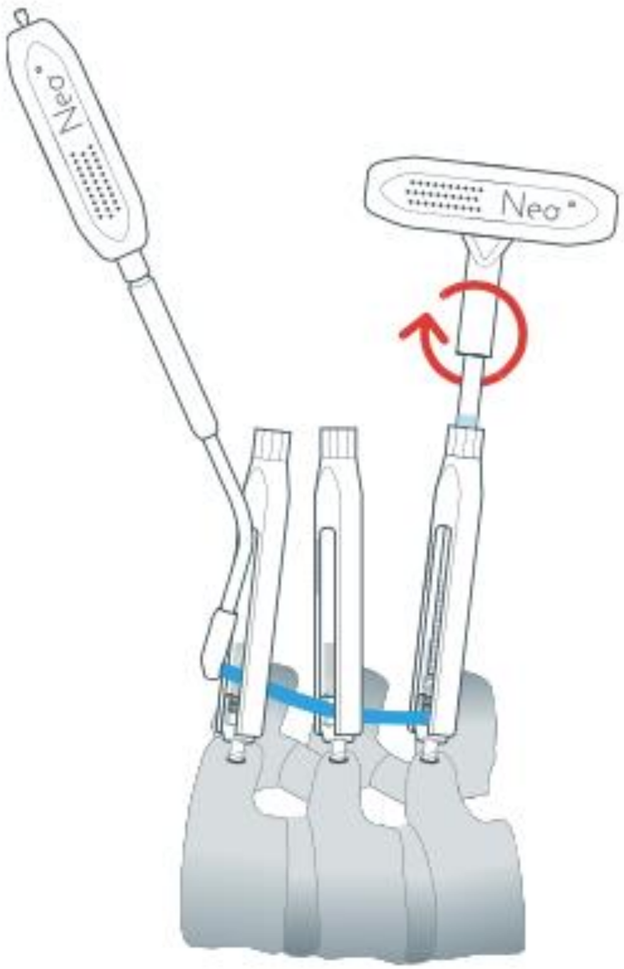
CONTROLLED FIXATION DESIGN

- Inspection of the hight of the guide tower
- Inspection of length and bending of the rot at the domes of the guide

Consequence

- Visuell confirmation of an expected perfect fit of the rod to the screws (Avoidance of bad mech. Loads)
- Visuell controll of reduction at any time point

Pre-Fixation of the rod & Torque limiter



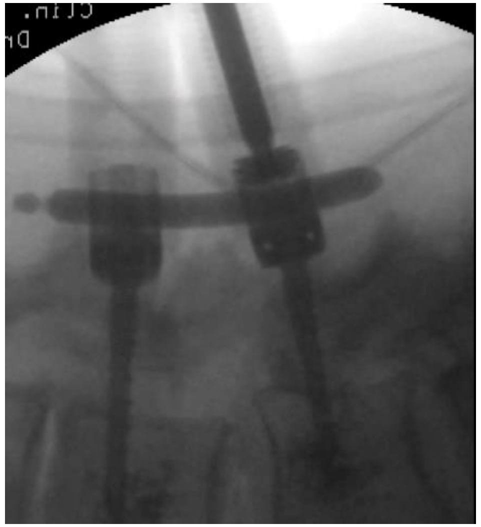
CONTROLLED FIXATION DESIGN

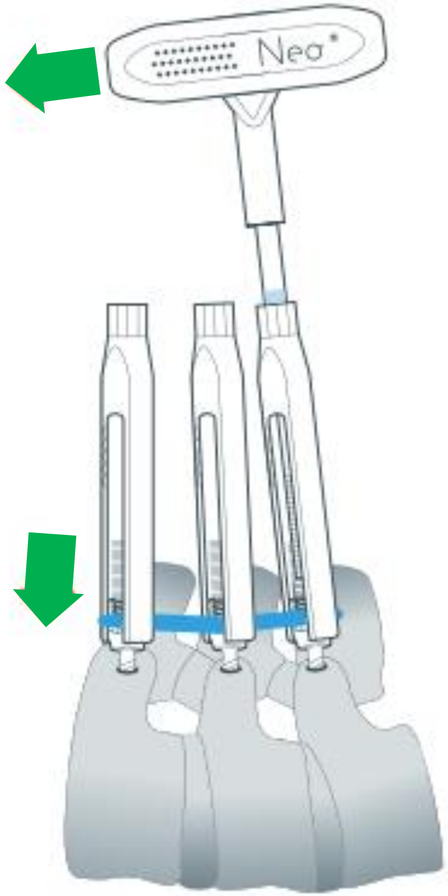
- Light removable rod holder
- Torque limiter to avoid rod migration

Consequence

- Preservation of mobility
- Reduction of tissue damage because of the early removing of the rod holder

Stressless positioning of the rod





CONTROLLED FIXATION DESIGN

- Rod reduction via polyaxiality of the screw heads
- Segmental removal of the guide towers

Effect: Controlled Fixation

- No uncontrolled forces while bringing in the rod to the screw heads
- Full controll of the rod-position to achieve a specific correction

Locking the set screw

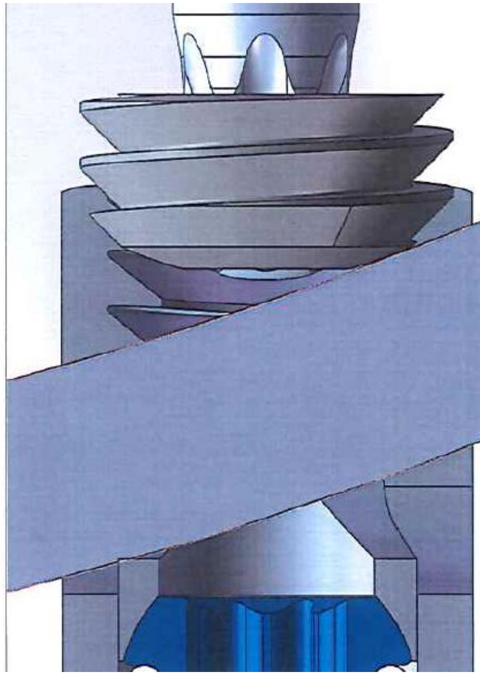


Figure 7 [1] Rod / set screw contact

CONTROLLED FIXATION DESIGN

- Light guide tower
- Convex set screw
- Prominet StainlessSteel-Torx – ’frictionless’ locking

Effect: Controlled Fixation

- Mobility enables the perfectperpendicular adaption of the implants interface
- Reduced cold welding
- Reduced implant failure

Neo
BEYOND THE EXPECTED

Locking the set screw

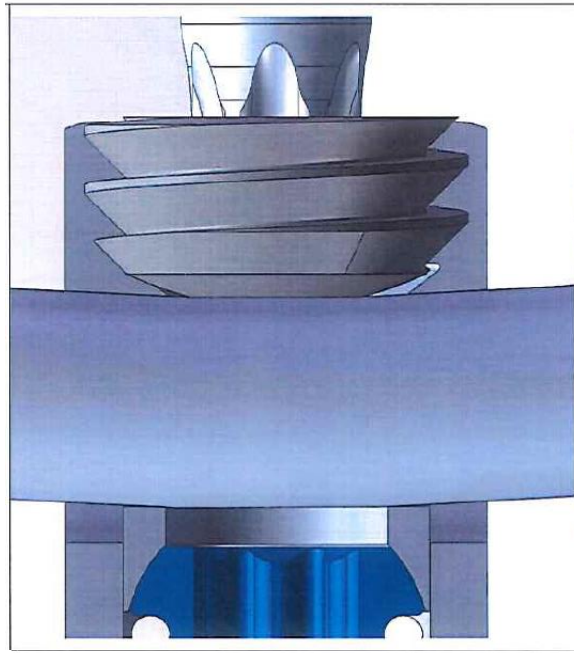


Figure 10 [4] Set screw final tightening

CONTROLLED FIXATION DESIGN

- Light guide tower
- Convex set screw
- Prominet StainlessSteel-Torx – ’frictionless’ locking

Effect: Controlled Fixation

- Mobility enables the perfectperpendicular adaption of the implants interface
- Reduced cold welding
- Reduced implant failure

Locking the construct

!!! Attention – Think different !!!

REDUCTION/LOCKING:

- **PARALLEL**
- **SYMETRIC**
- **ALTERNATING**
- **SEGMENTAL** Removal of the Guide Towers

→ Effect: Controlled fixation

Avoidance of:

- Coronale Deformation
- Sagital Compression / Distraction
- Mal-Rotation

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Thank you for your attention!

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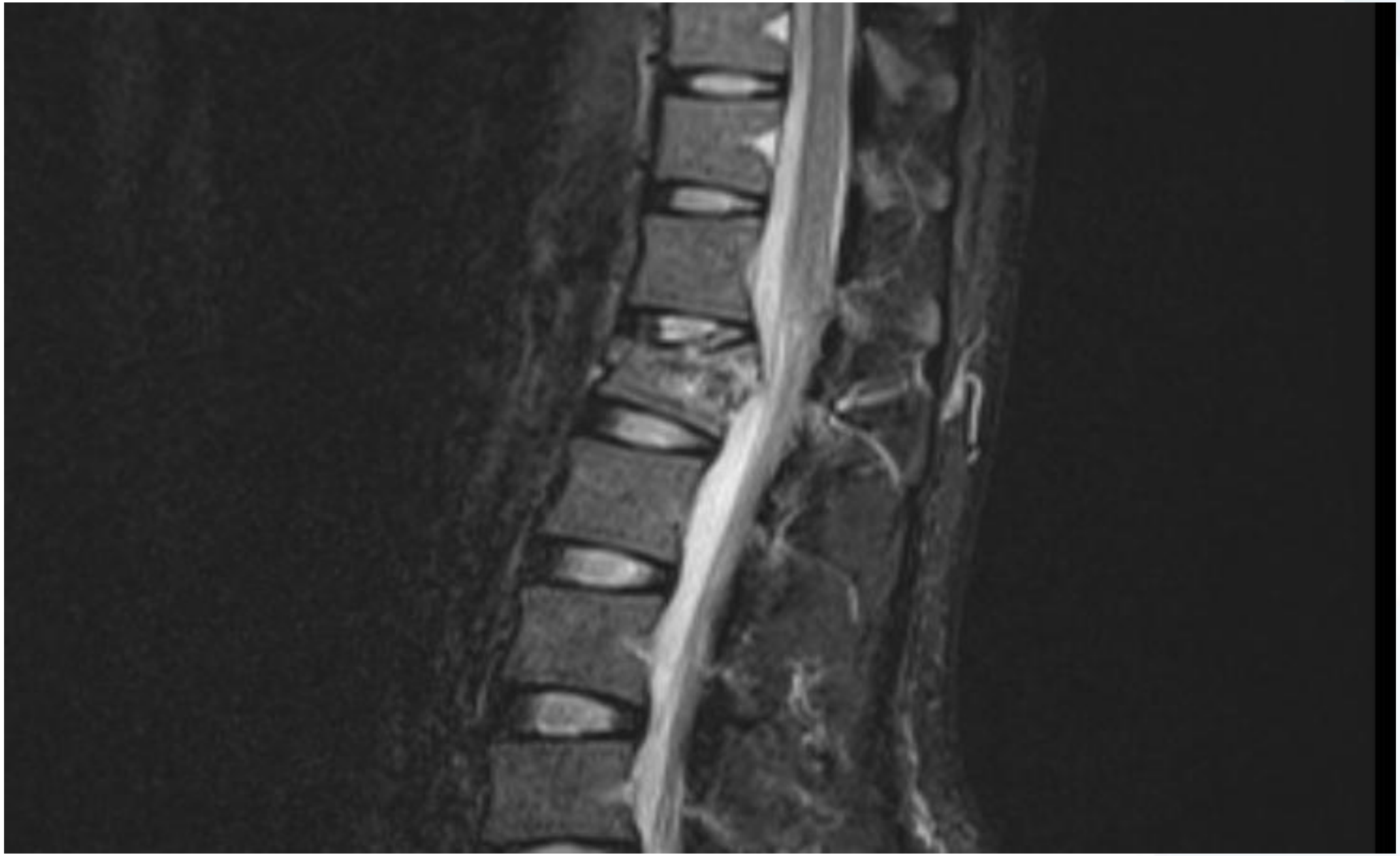
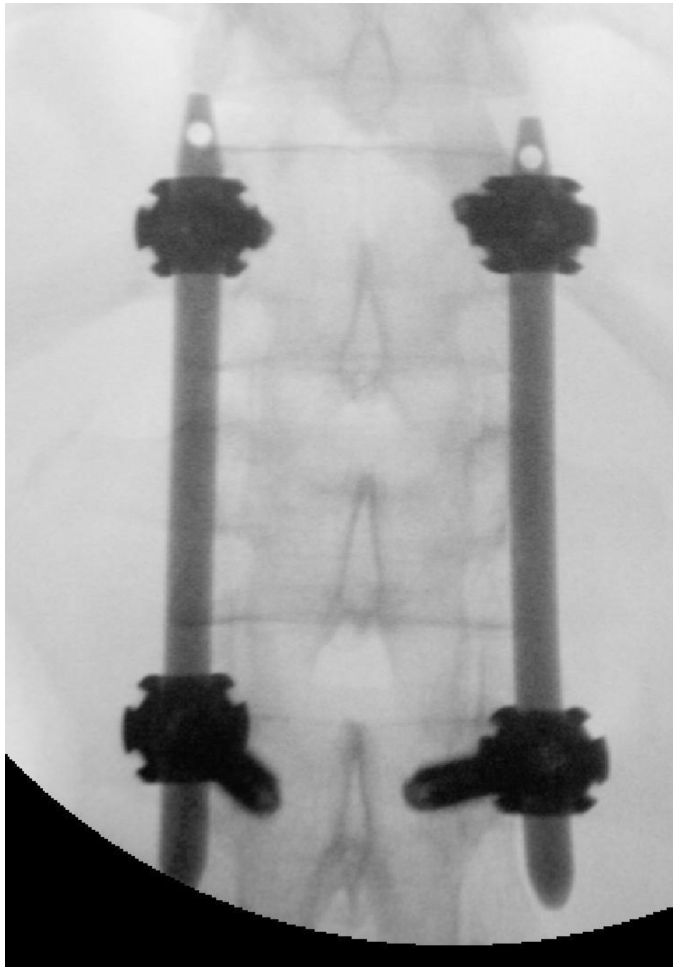
CR I:

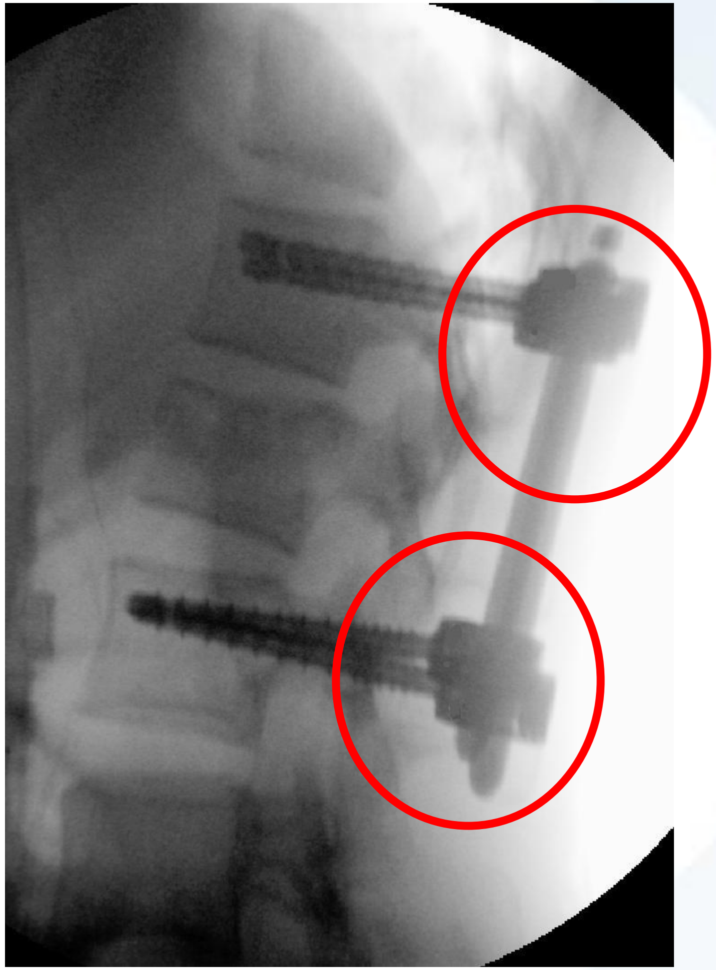
High-Energy-Traum, Healthy Bone Qual.

Male, 28 LY, no secondary diagnosis

Unstable L1-Burst-Fracture







Reposition via hyperlordotic Positioning of the Patient and Ligamentotaxis

+

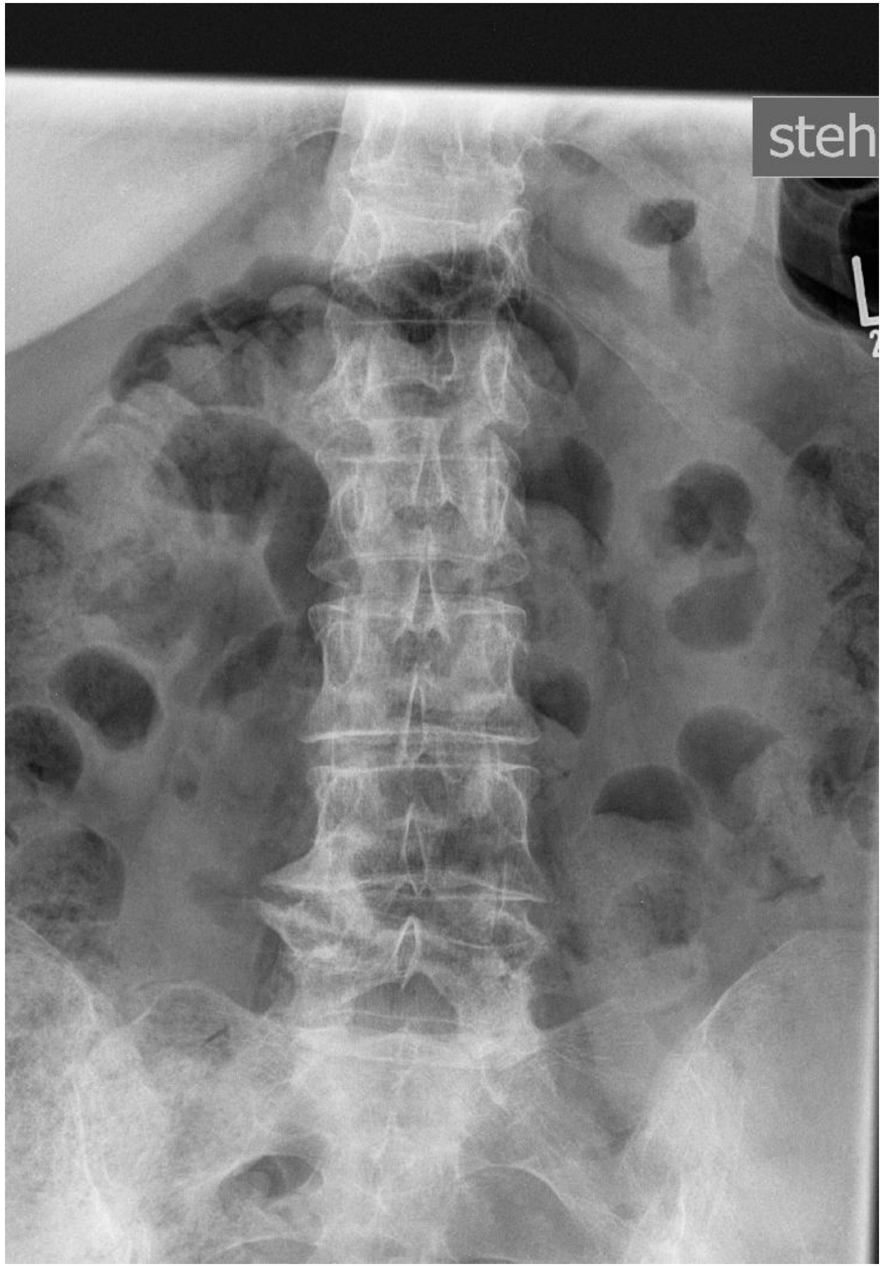
Monoaxial Screws

CR II:

High-Energy-Traum, Healthy Bone Qual.

Female, 41 LY, no secondary diagnosis

Unstable T12-Burst-Fracture with Disc-Tear-Drop and PF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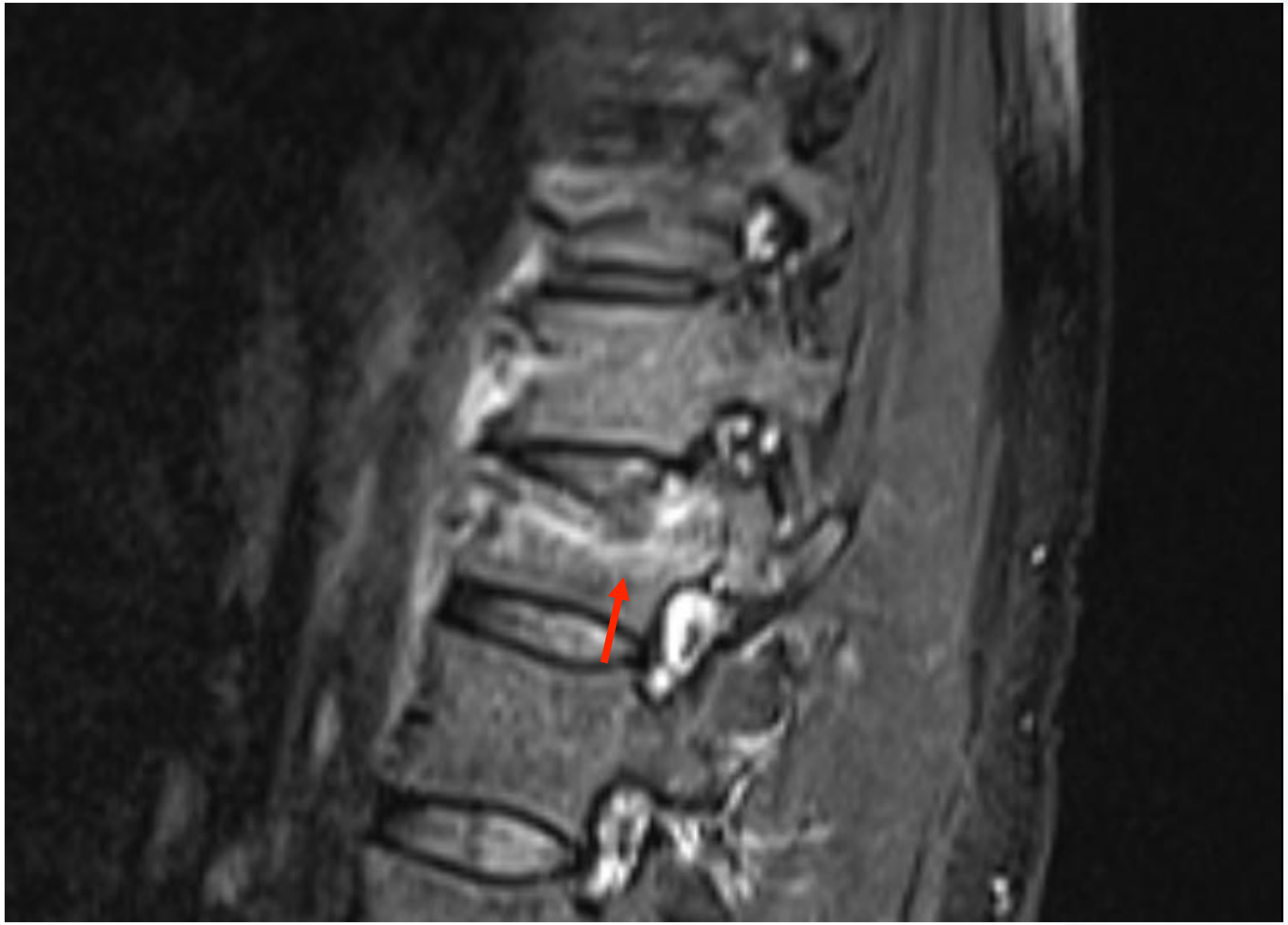
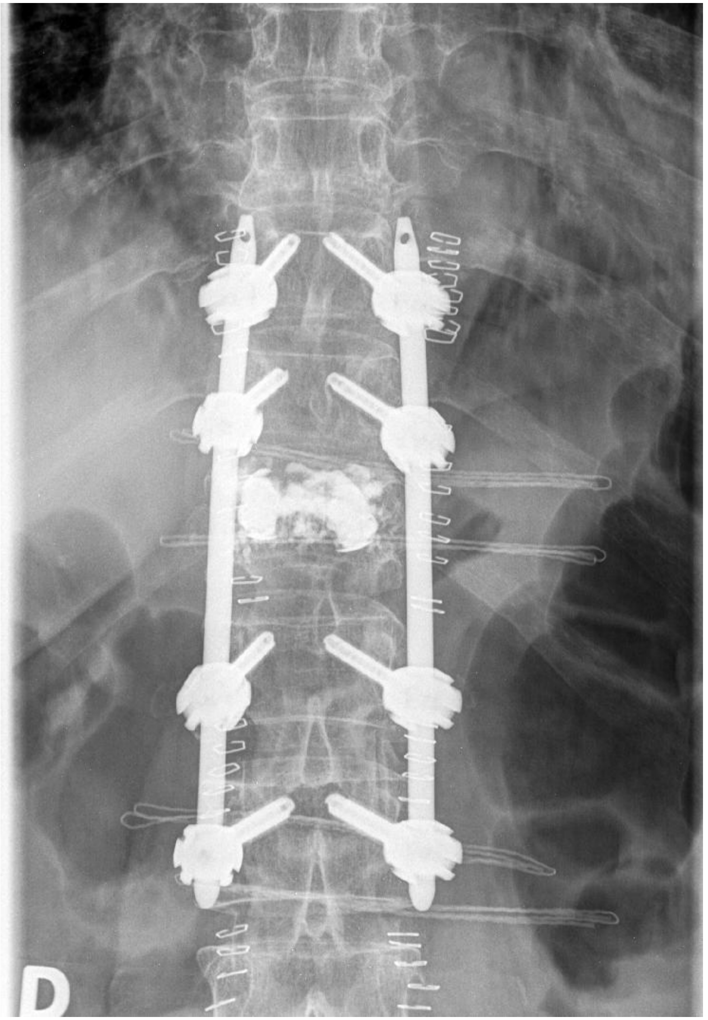
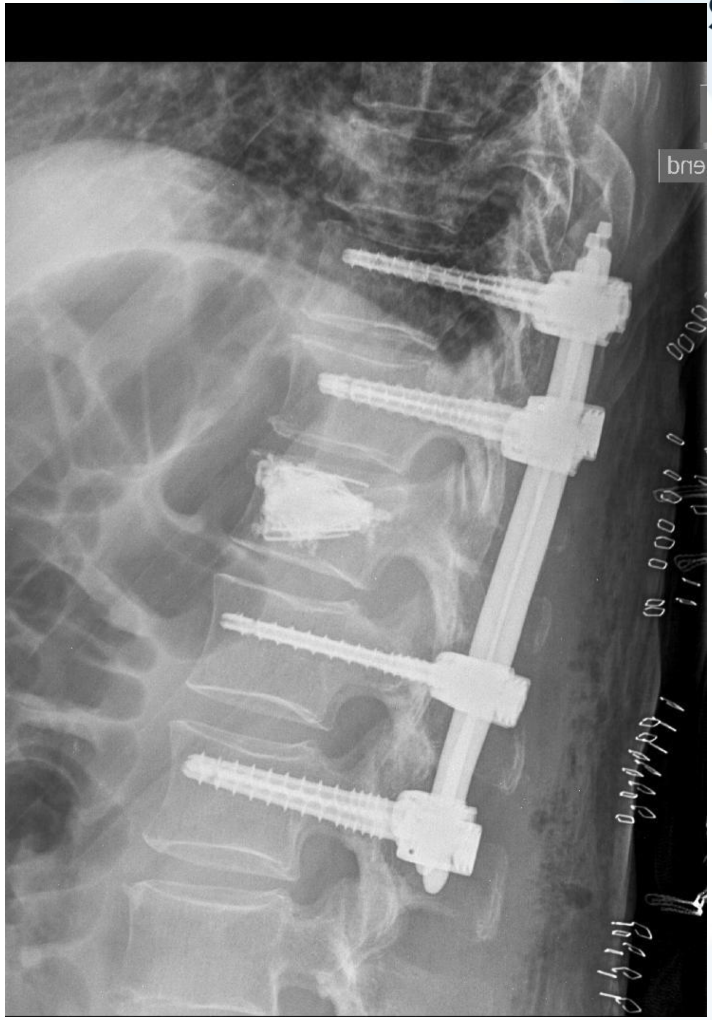


VB-Replacement???

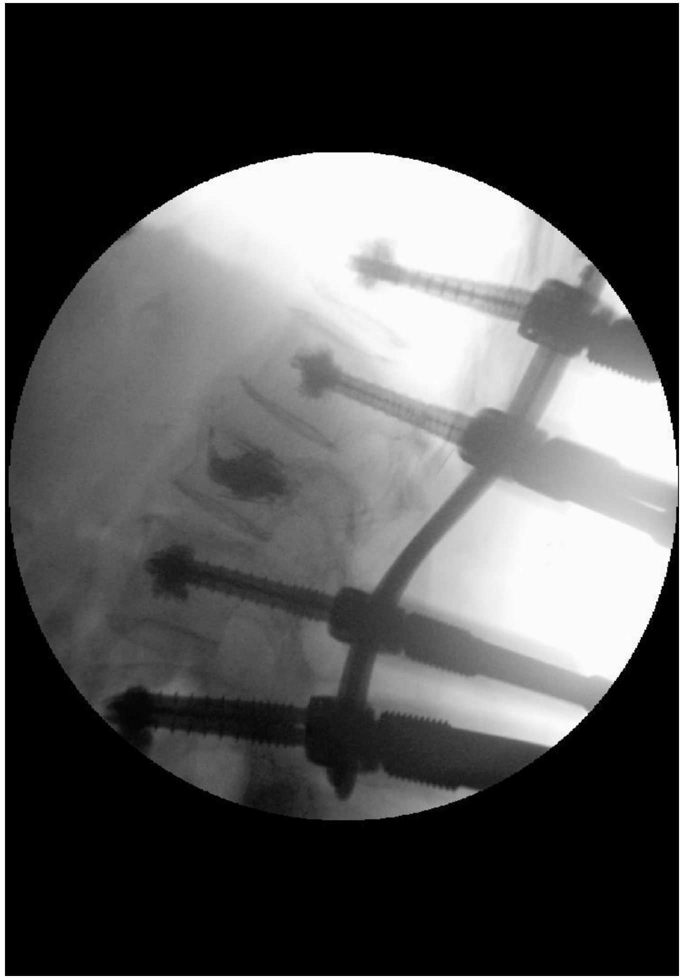


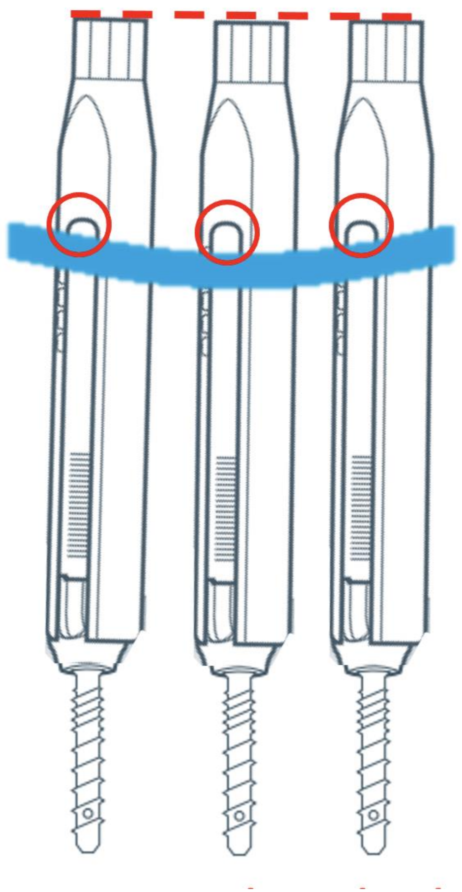


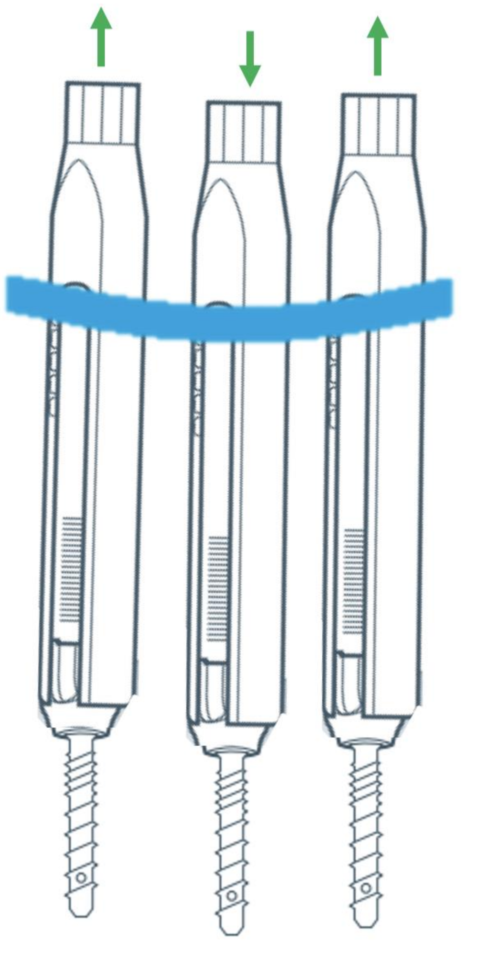
CAD T12 (SJ 5.0mm) with Replacement of the Disc-Material
Temporary: MA-PS T11+L1, PA-PS T10+L2

CR III:

It’s all up to the « rod-bending »!!!





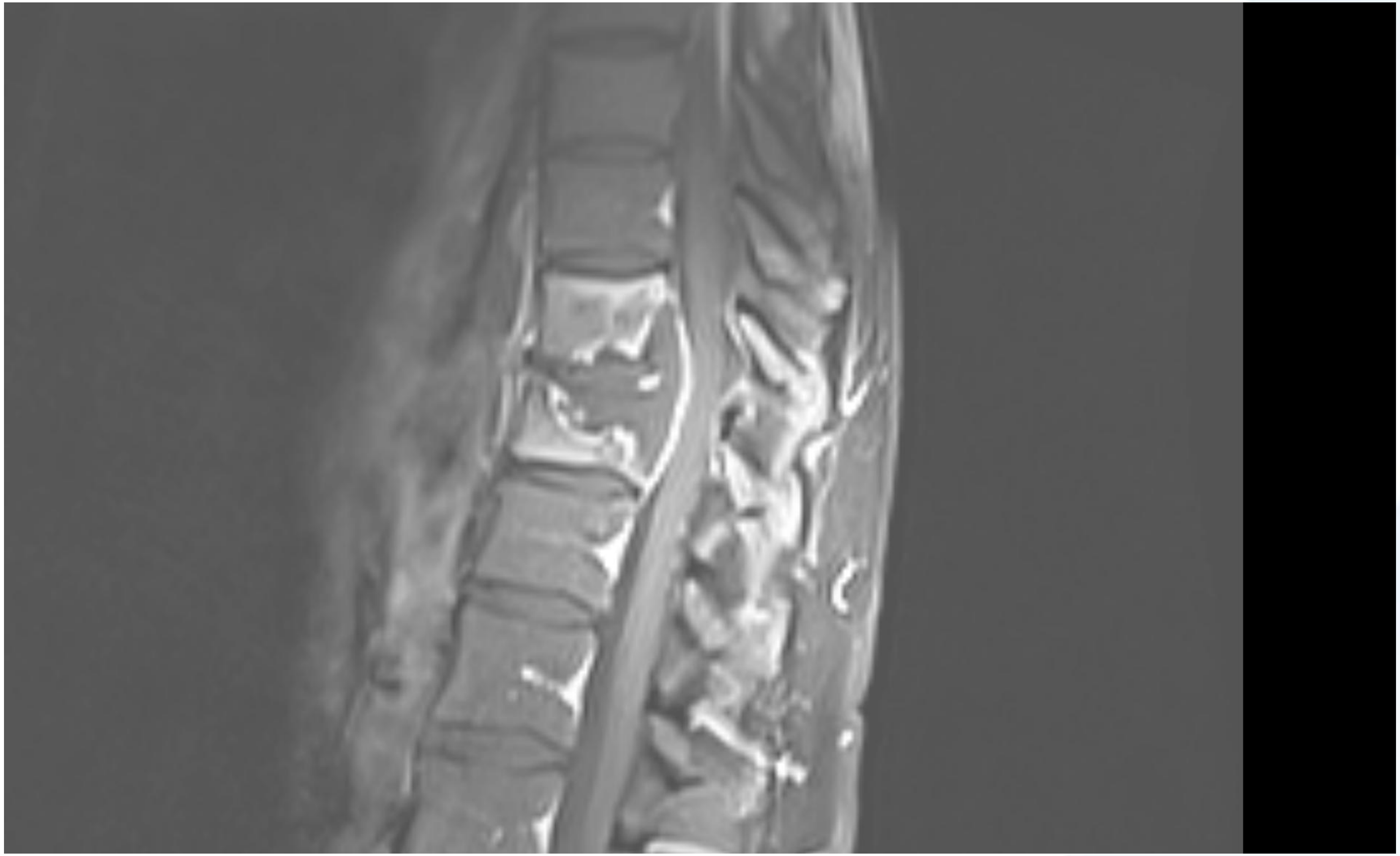


Take your time! ADVISE?

CR IV:

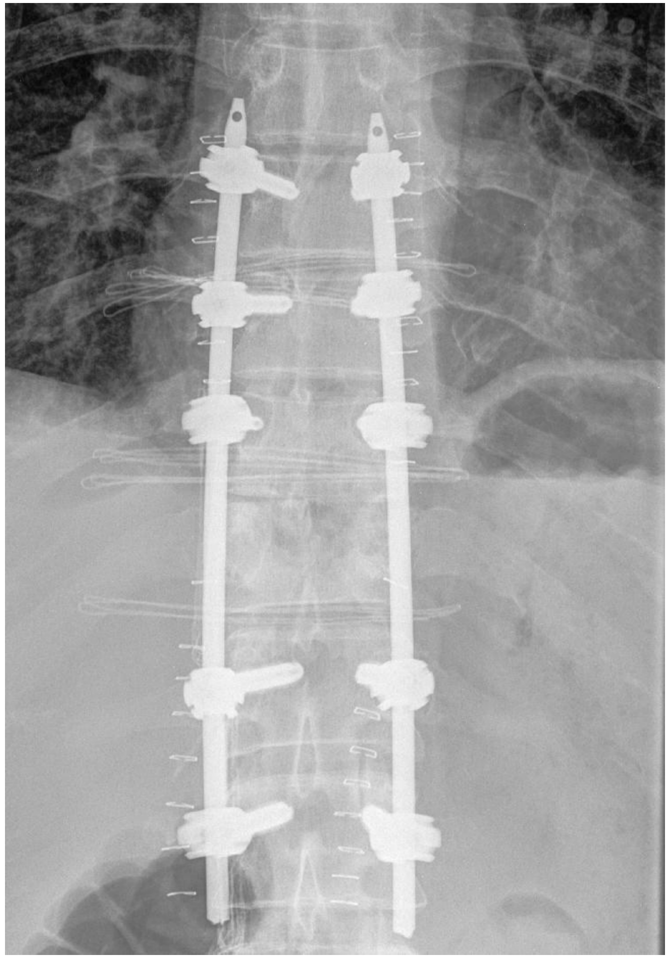
Spondylodiscitis T7/8 after difficult cystitis

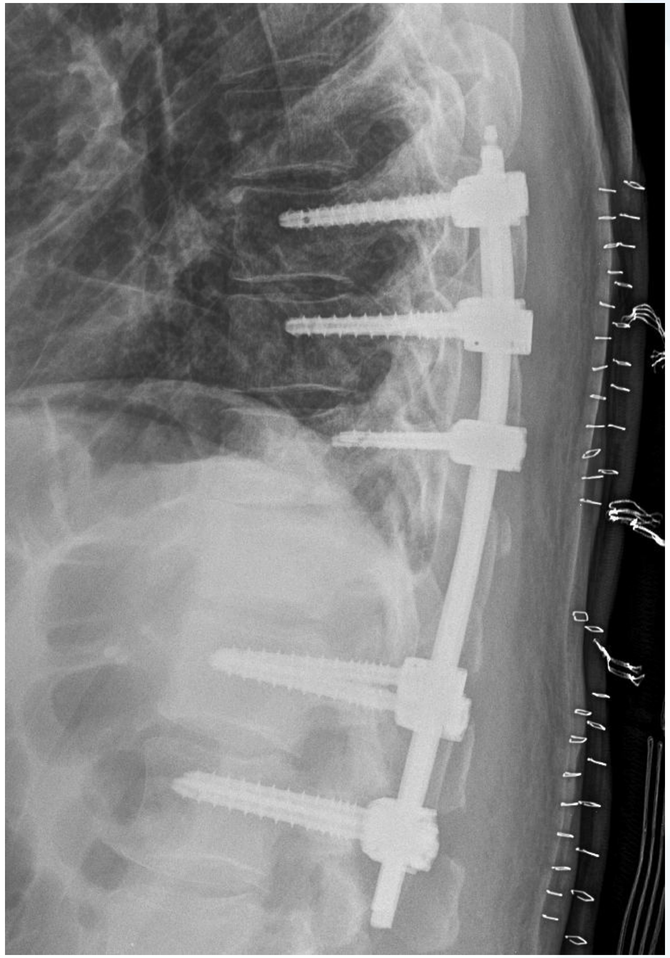
Male, 52 LY, no other secondary diagnosis



Reposition?

But Stability!!!





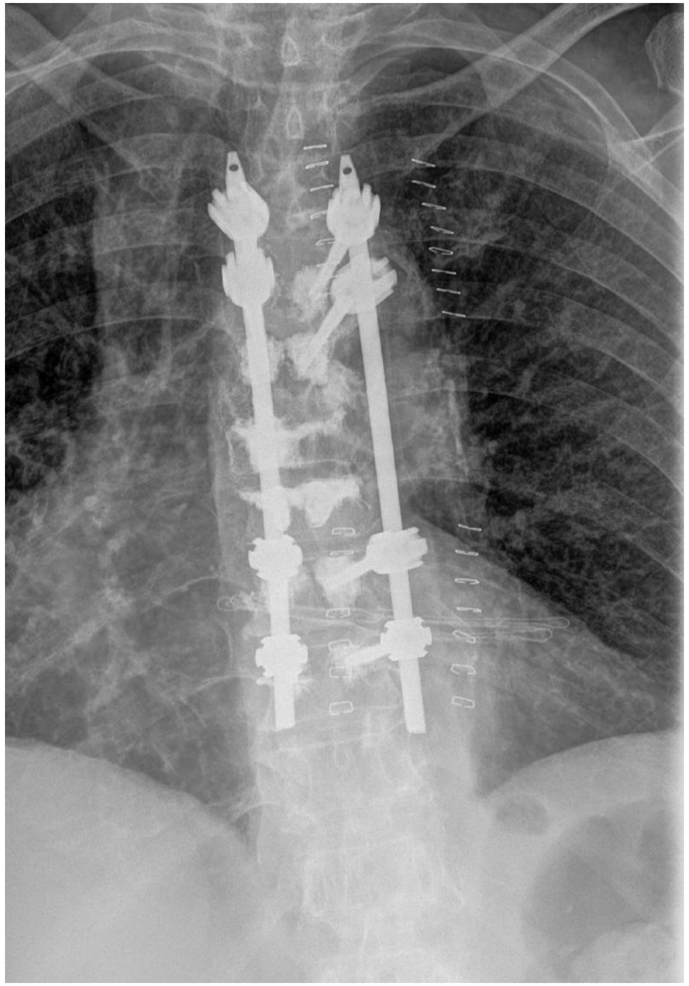
Perc. Instrumentation T5/6 – T7 (Index!) – T9/10
+
M-Hemilaminectomie T7/8 & Epidural Irrigation

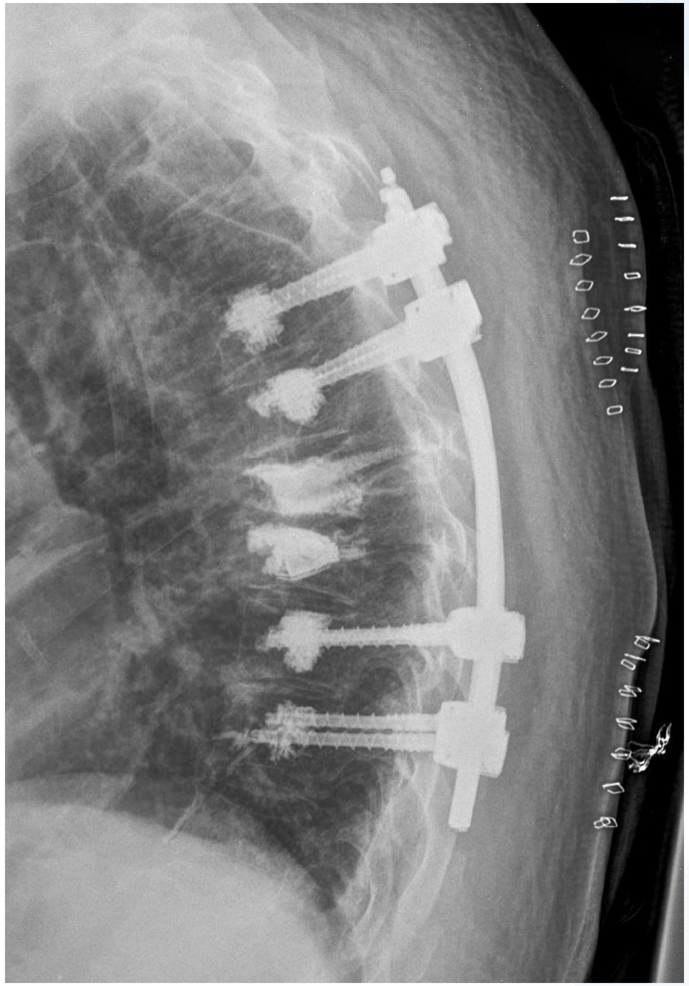
CR V:

Low-Energy-Trauma, Poor Osteoporotic Bone Qual. (T -3,2)

Female, 77 LY, hpb, coronary heart disease, condition after extern T7-BKP

Unstable T8-Fracture (AO A4), PF T8 and DP-Fracture T8+9





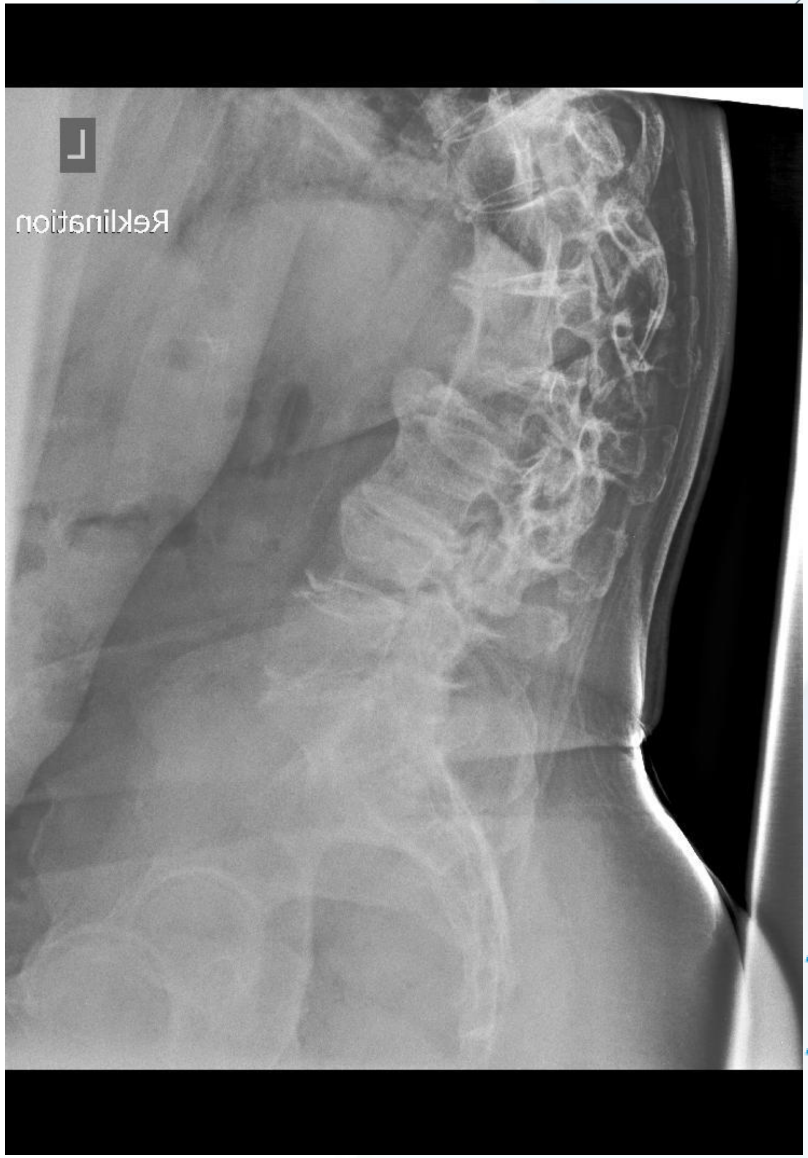
Hybrid-Tech.: CAD (SJ5.0mm) T8, Perc. Instrumentation T5 PA/6 MA – T9 MA/T10 PA
Zementaugmentation of all PS, Kyphotic Rod Bending

CR V: « THE JURASSIC SPINE »

Low-Energy-Trauma, M.Bechterew

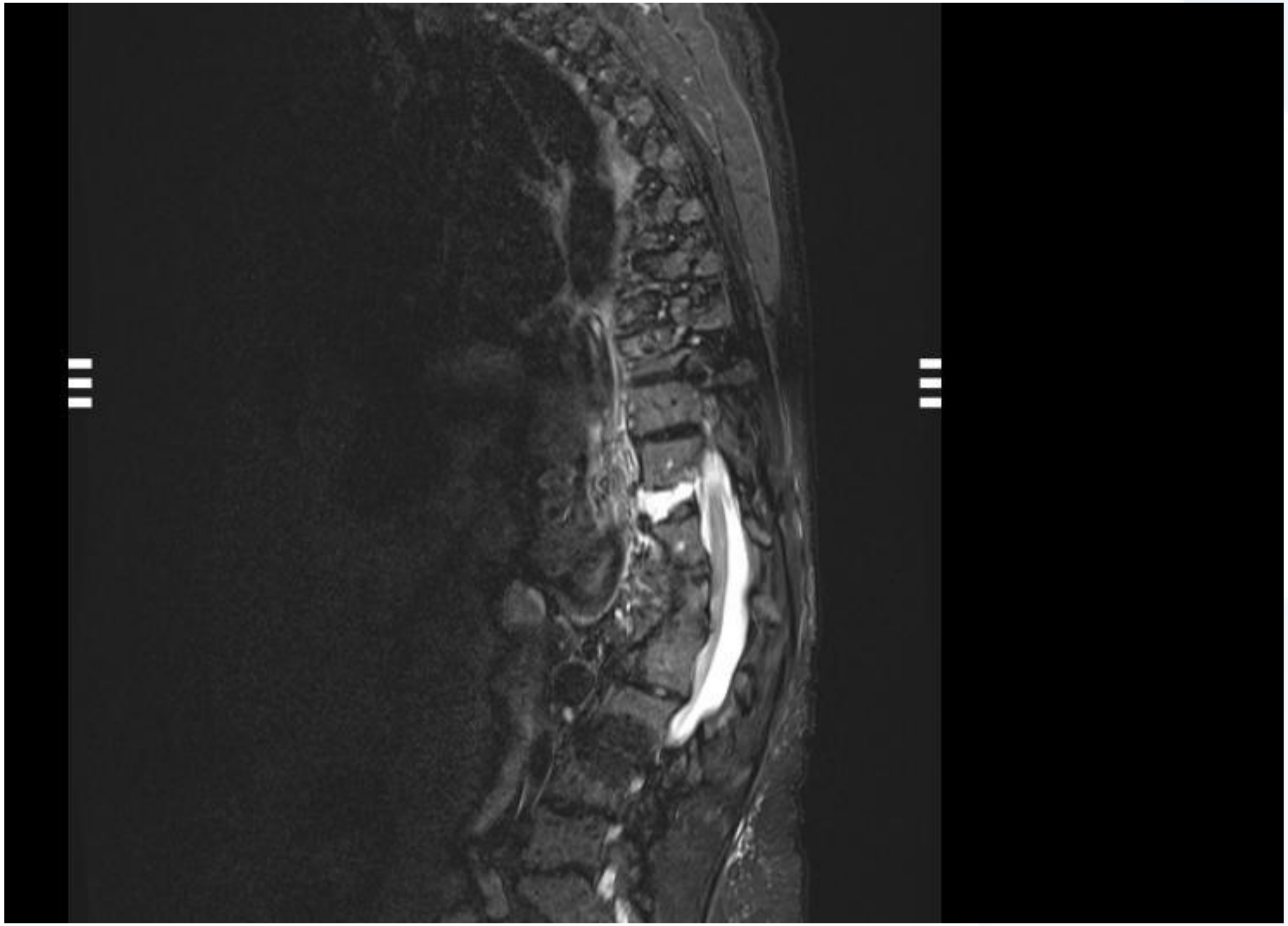
Female, 82 LY, severe sec. diagnosis

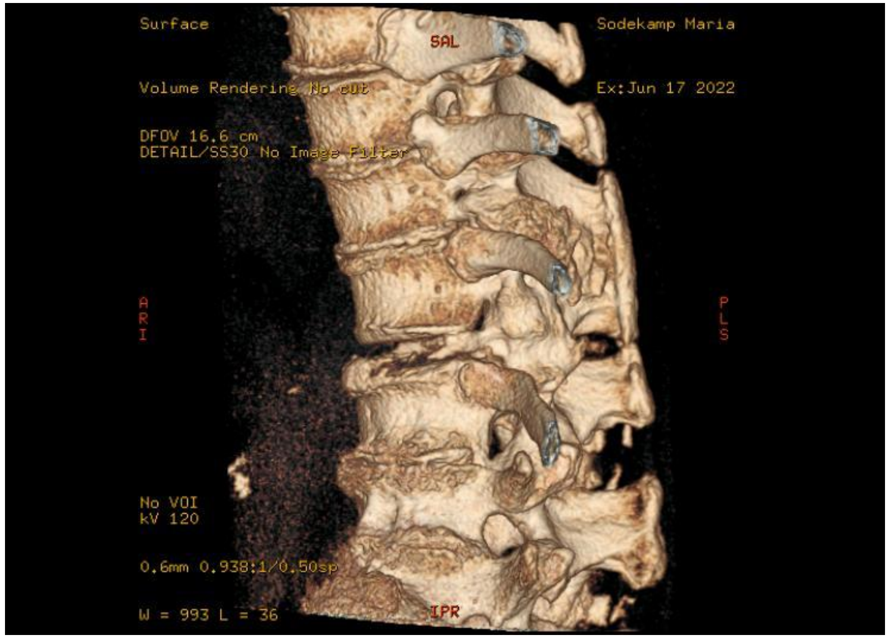
Unstable Gape-Fracture T11/12

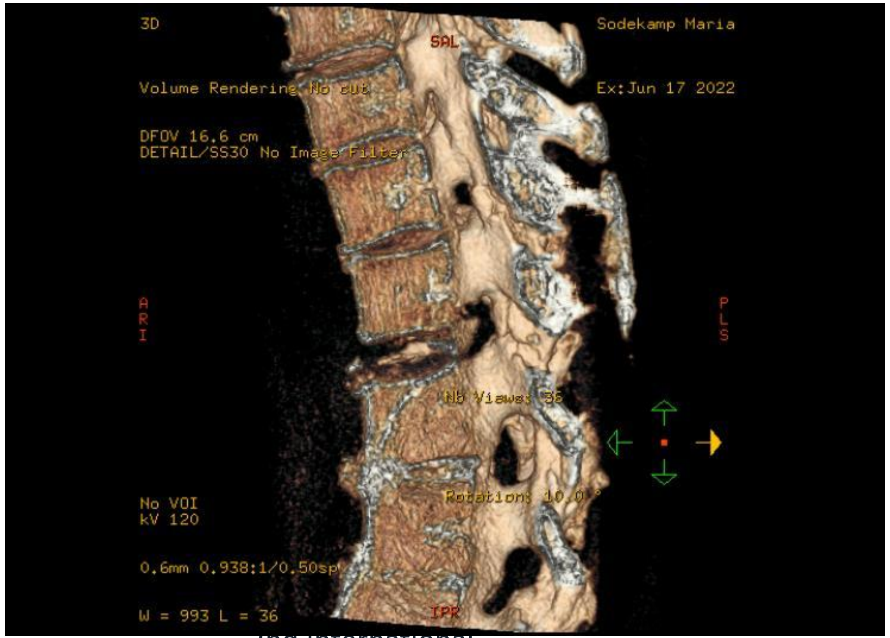

L
Reklination

???

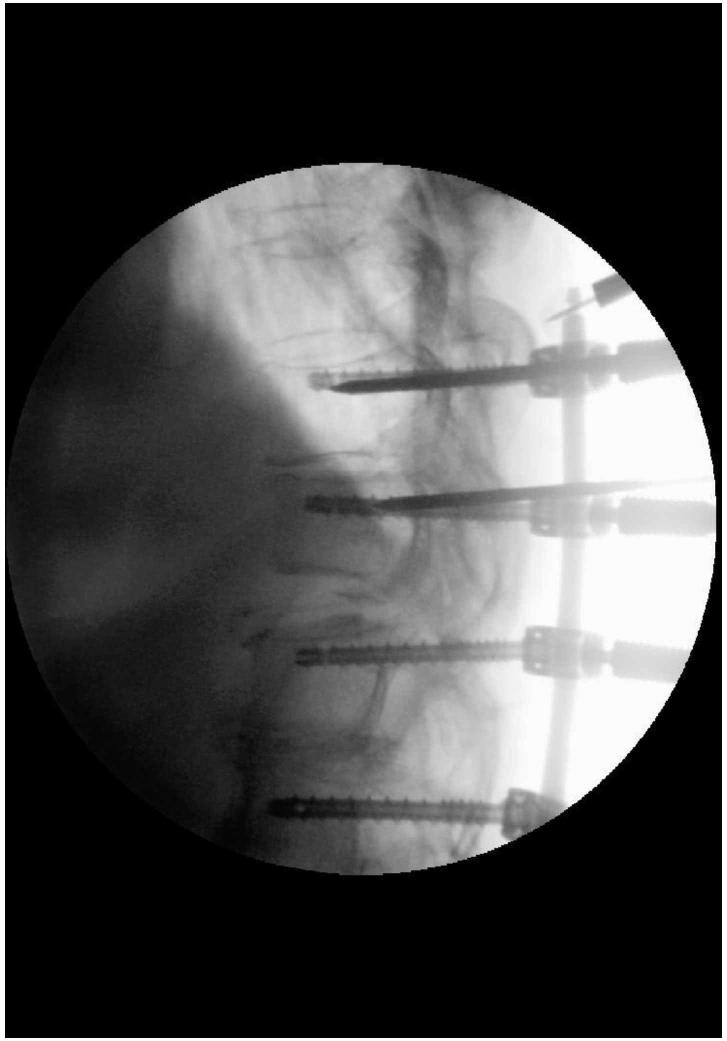
sense Spine Expert Network™ for Science & Education

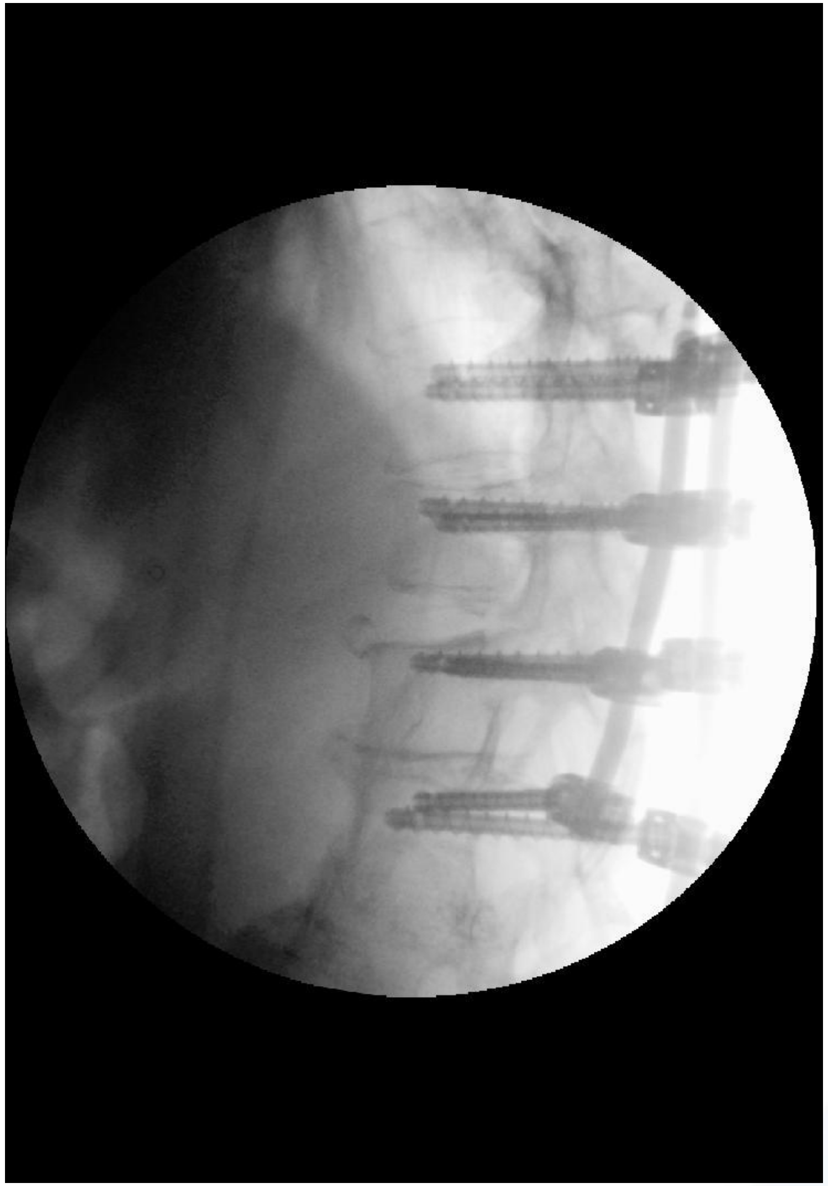


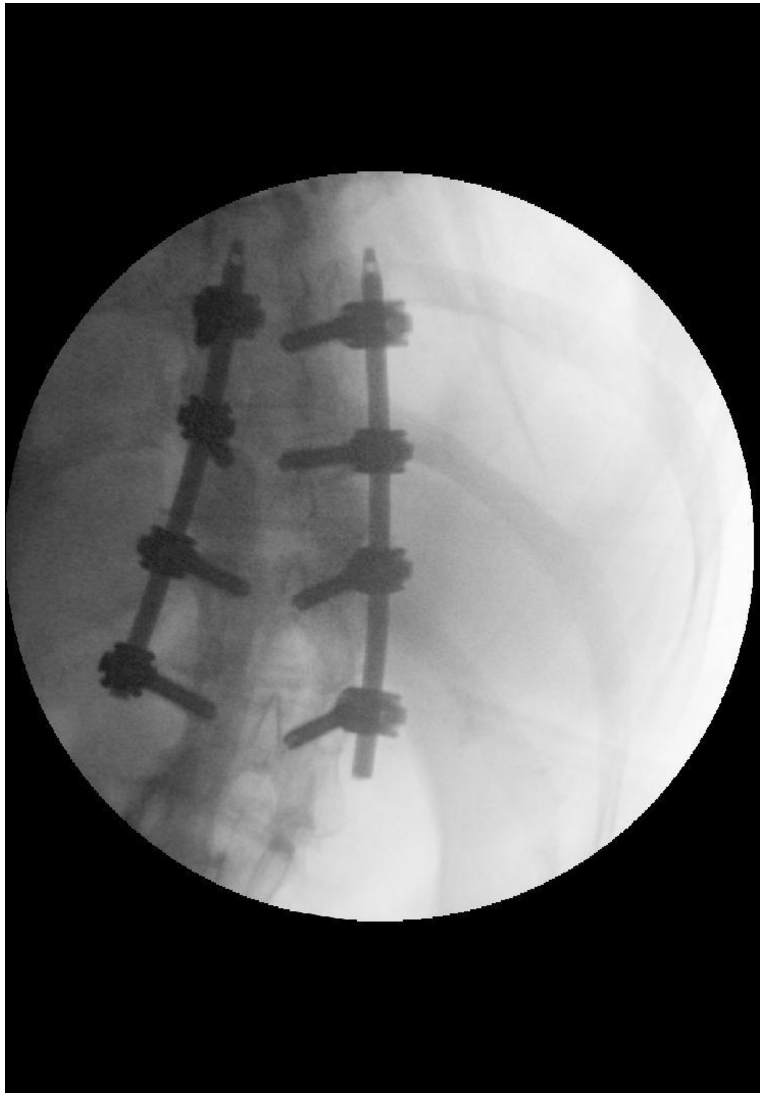

Surface
SAL
Sodekamp Maria
Volume Rendering No cut
Ex:Jun 17 2022
DFOV 16.6 cm
DETAIL/SS30 No Image Filter
A
R
I
P
L
S
No VOI
kV 120
0.6mm 0.938:1/0.50sp
W = 993 L = 36
IPR

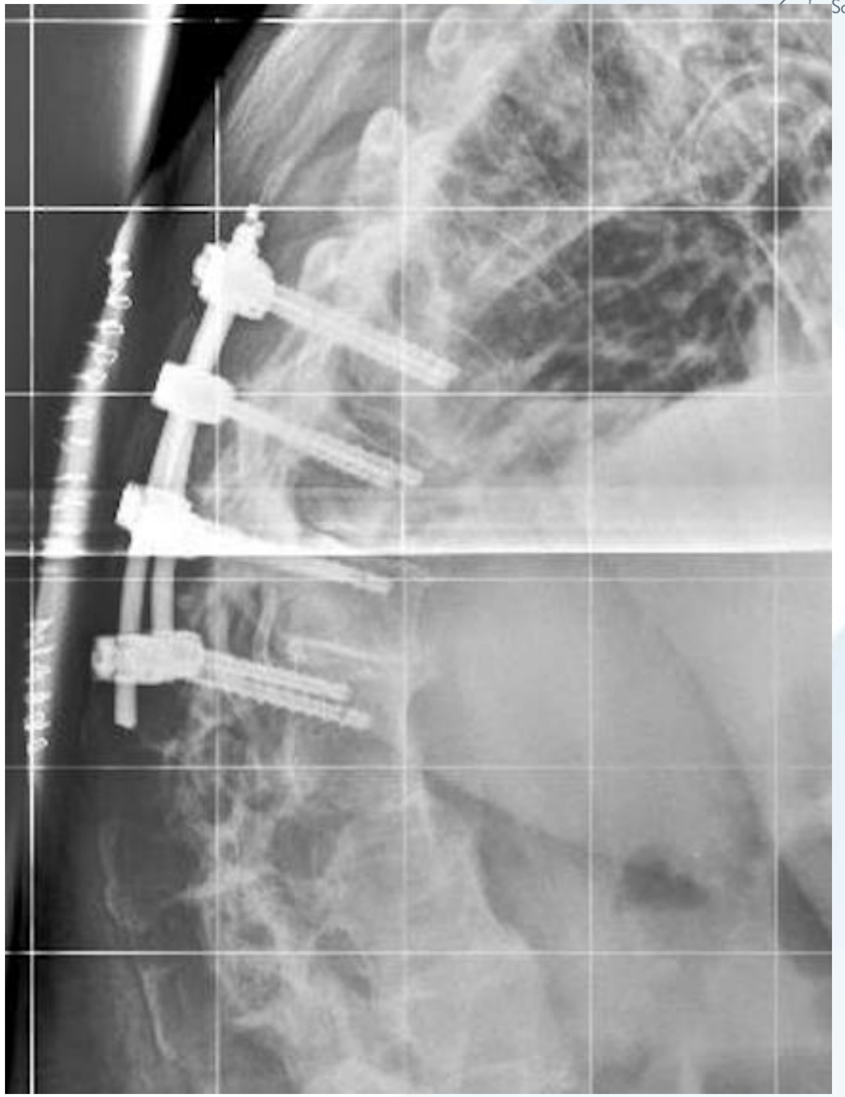

3D
SAL
Sodekamp Maria
Volume Rendering No cut
Ex:Jun 17 2022
DFOV 16.6 cm
DETAIL/SS30 No Image Filter
A
R
I
P
L
S
No Views: 36
Rotation: 10.0°
No VOI
kV 120
0.6mm 0.938:1/0.50sp
W = 993 L = 36
IPR


There is a fracture, I need to fix it
xtra normal









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ST. AUGUSTINUS GRUPPE
Krankenhaus Neuwerk

Thank you for your attention!

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