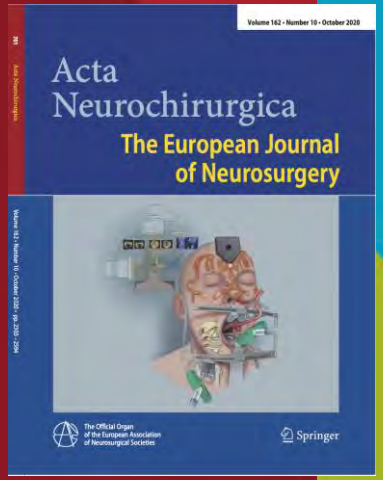
Surgical Advancement in Thoracolumbar Tumors



Miki Katzir, MD
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Department of Neurosurgery
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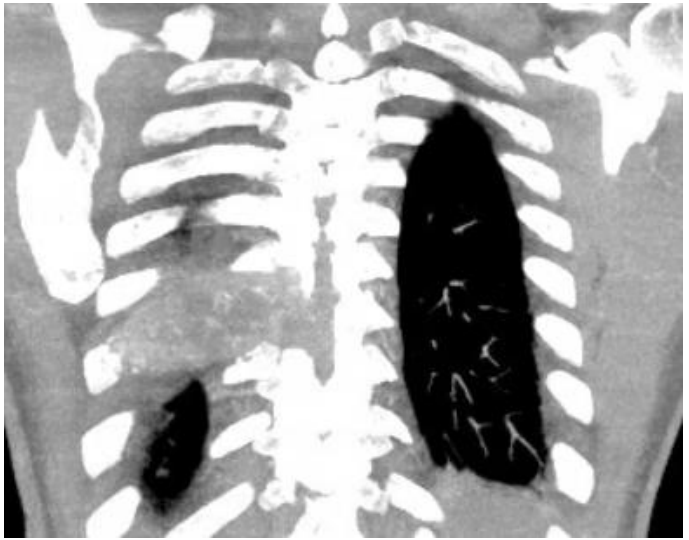
Director, Surgical Spine Oncology

FRED & PAMELA
BUFFETT CANCER CENTER

University of Nebraska
Medical Center

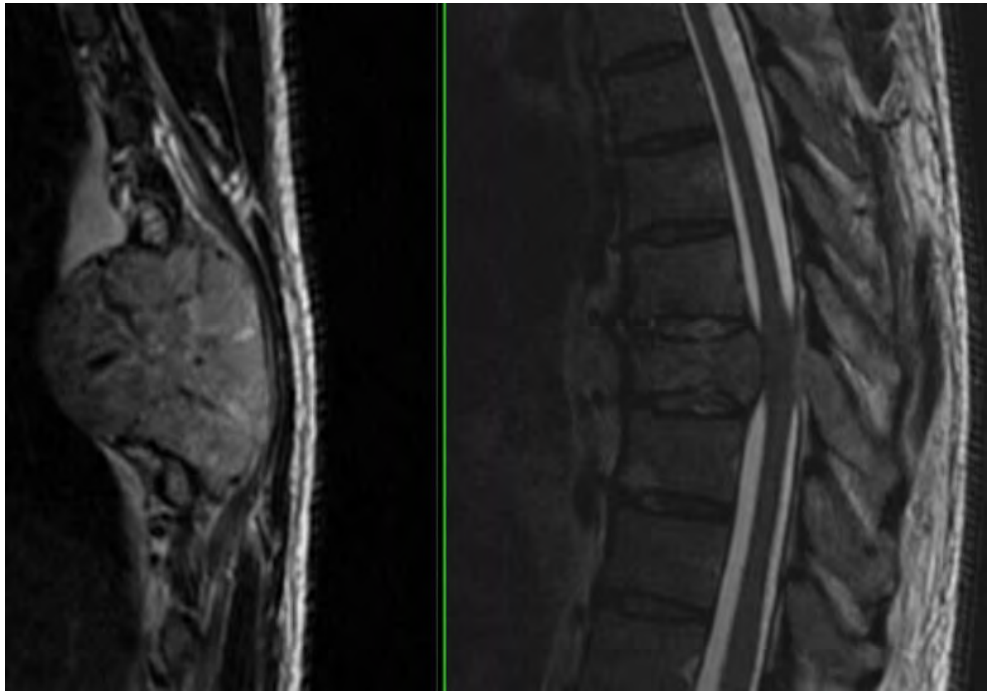
Nebraska
Medicine

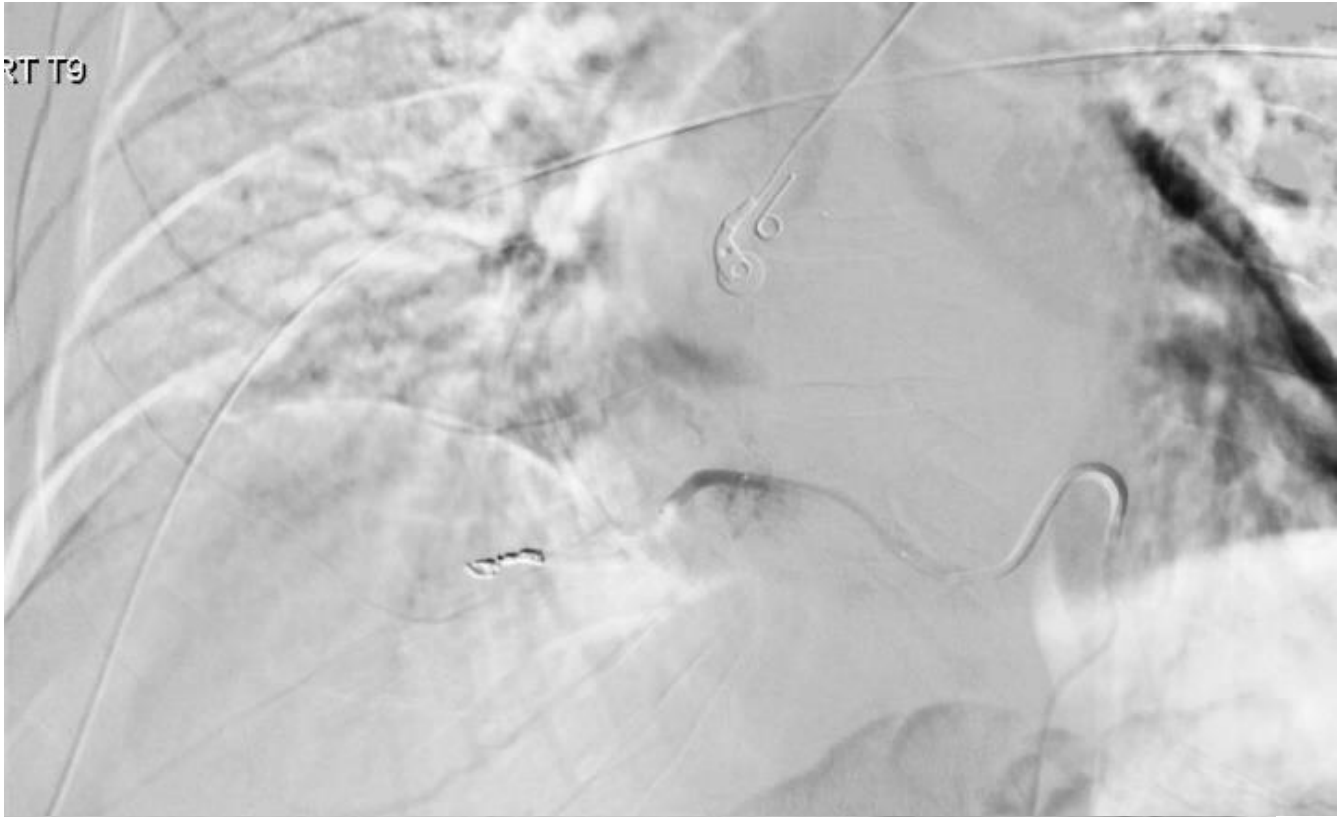


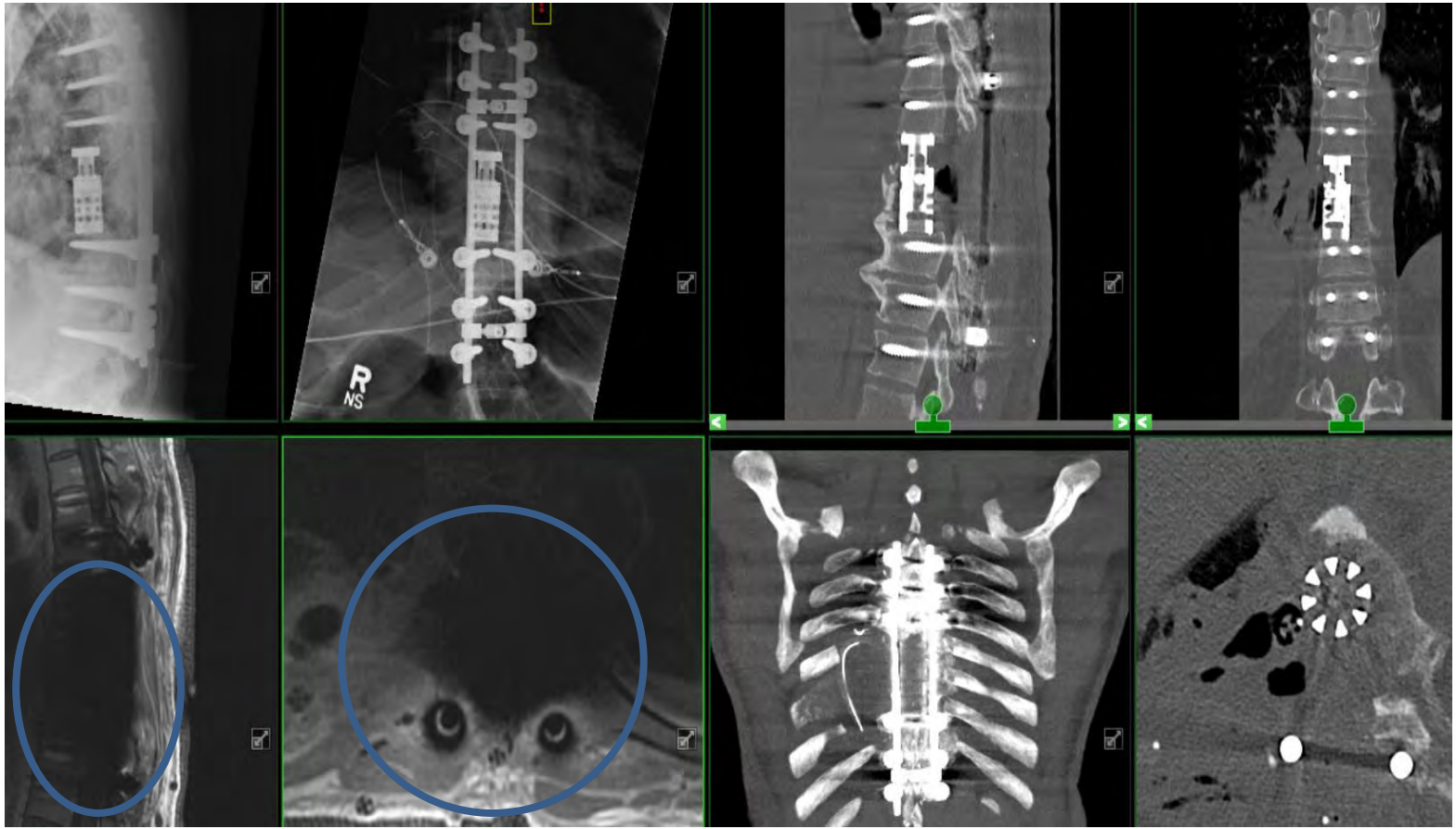
- 58M, 12H paraplegia, huge chest wall mass

- Saw a large lesion in the kidney on the scout image and large vessels in tumor.

- Now what?
- Rush to surgery? Patients is young, paralyzed
- Do anything else before surgery?
- What to expect from an RCC?




RT T9


R
NS

Management goals are

- Improve or maintain neurological function (cord decompression either via surgery, RT or chemo)
- Stabilize the spinal column - SINS
- Cure - single met, benign tumor, primary bone tumor VS. palliation – Metastatic disease
- Pain control - Improve quality of life
- Local tumor control (radiation – cEBRT / SRS)

Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial

THE LANCET

Roy A Patchell, Phillip A Tibbs, William F Regine, Richard Payne, Stephen Saris, Richard J Kryscio, Mohammed Mohiuddin, Byron Young

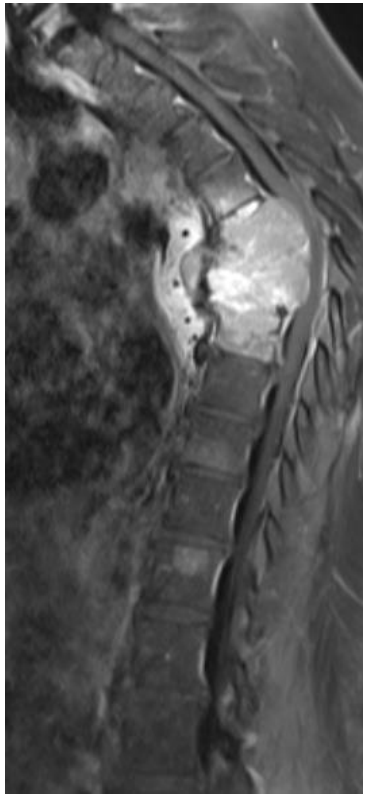
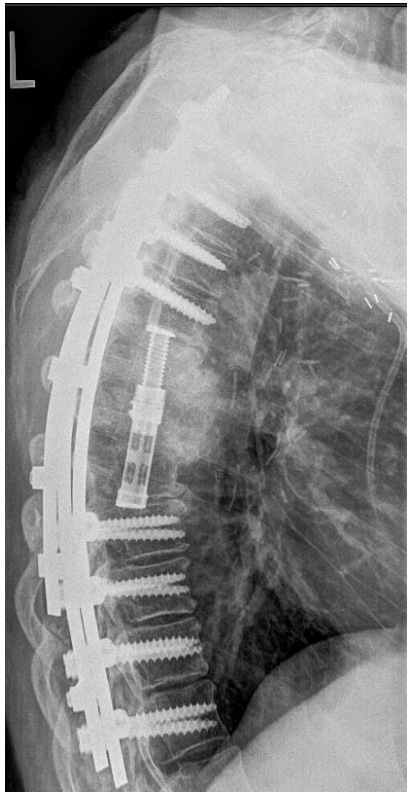
- Randomized, multi-institutional, non-blinded trial
- Surgery + RT VS. RT alone
- N=101
- Primary endpoint: Ability to walk after treatment (4 steps unassisted)
- Secondary endpoint: urinary continence, changes in functional scores, motor scores, use of corticosteroids and opioids and survival time

Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial

THE LANCET

Roy A Patchell, Phillip A Tibbs, William F Regine, Richard Payne, Stephen Saris, Richard J Kryscio, Mohammed Mohiuddin, Byron Young

- Trial was stopped because surgery + RT >>>>> RT alone
- Ability to walk post op: 84% (surgery) VS 57% (RT)
- Unable to walk preop: 62% (surgery) VS 19% (RT)
- Retained ability to walk for 122 days (surgery) VS 13 days (RT)
- 20% of patients in RT group crossed over to surgery group after substantial decline in motor strength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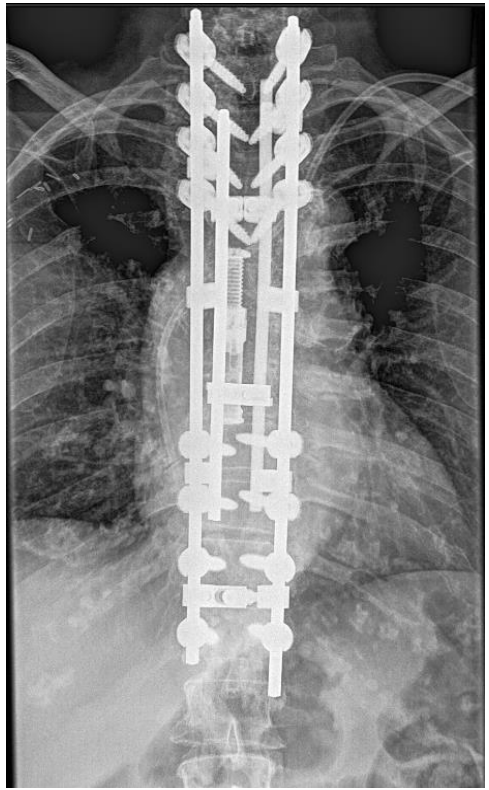
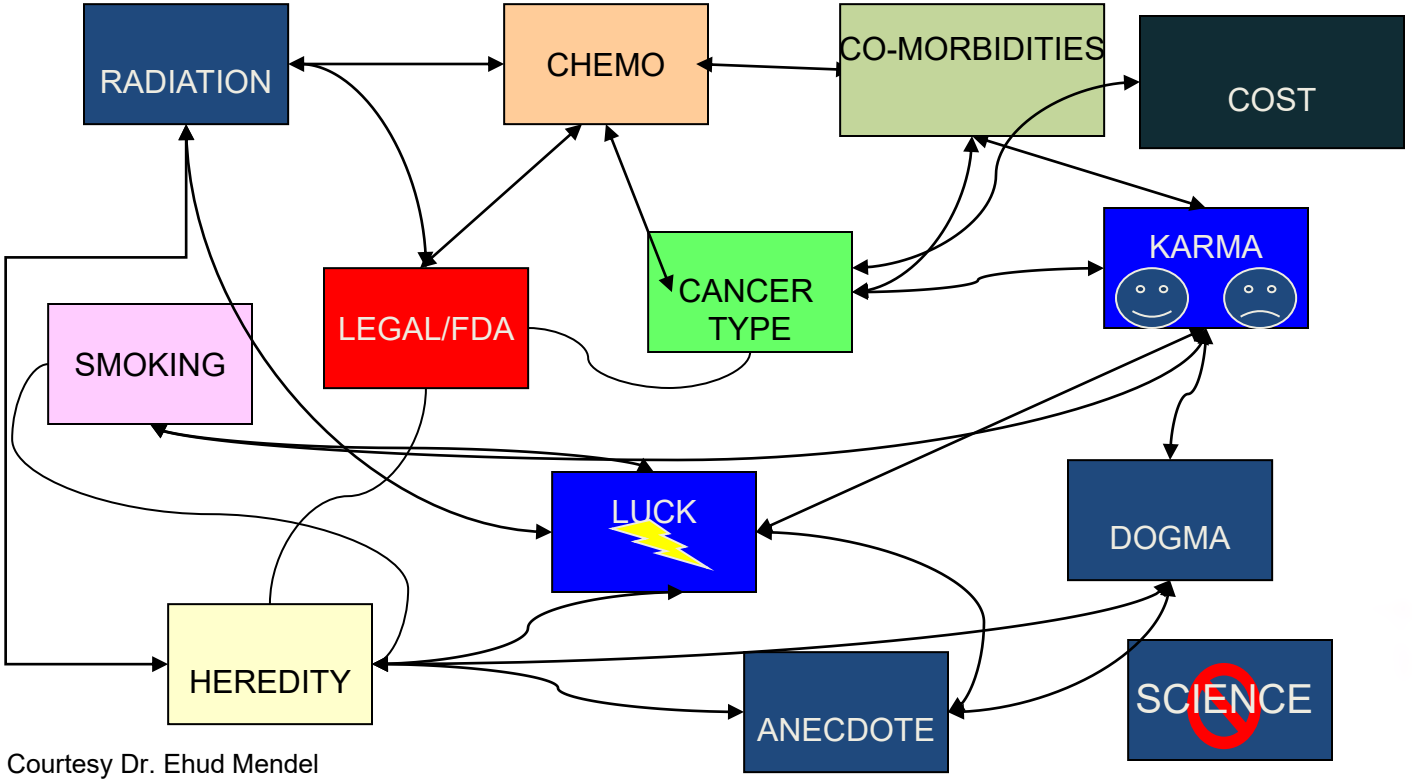


EVIDENCE BASED DECISION-MAKING ALGORITHM

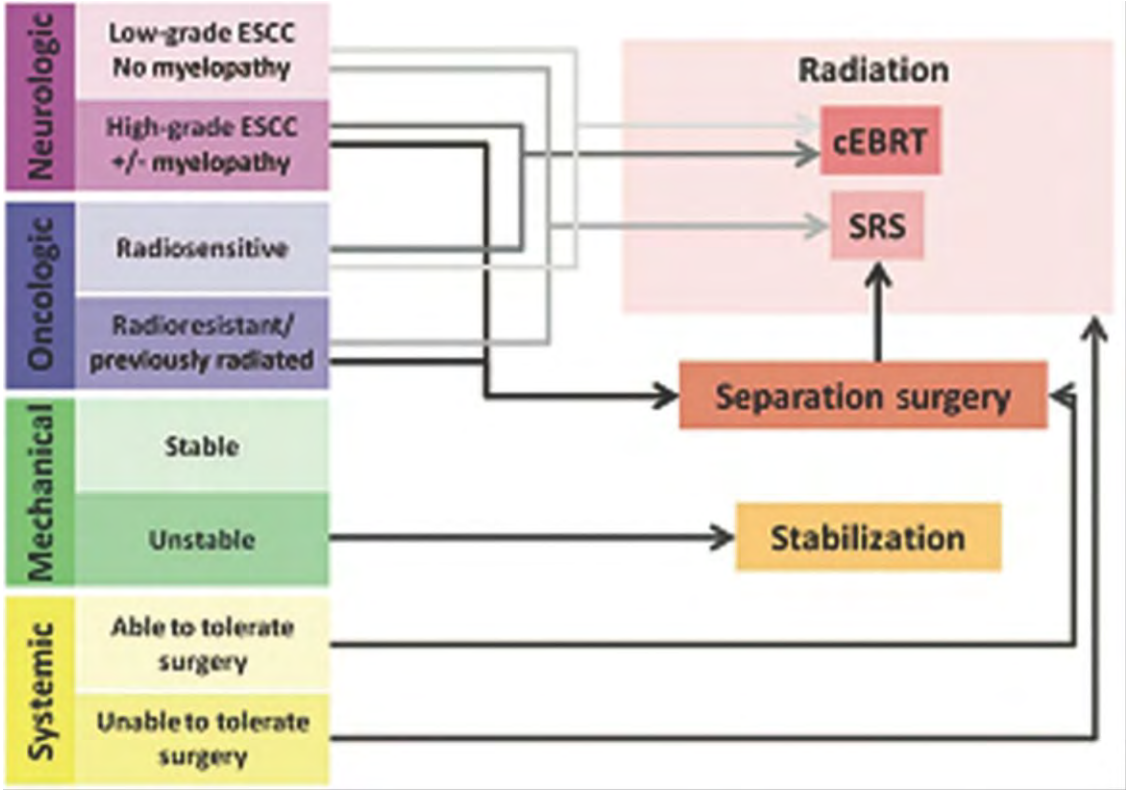


Courtesy Dr. Ehud Mendel

Patient evaluation

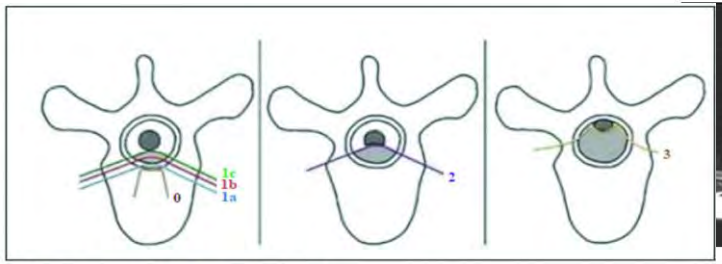
- Medical fitness
- Clinical presentation
- Oncologic status
- Is there any good/viable surgical plain

DECISION MAKING: NOMS



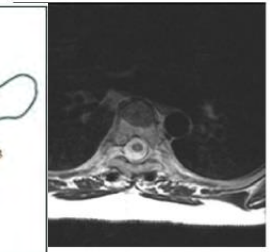
Laufer et al, The Oncologist (2013)

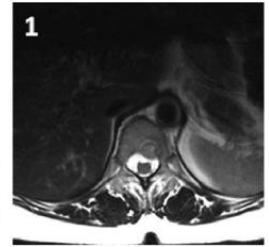
NOMS

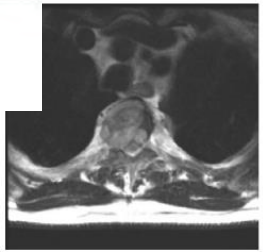


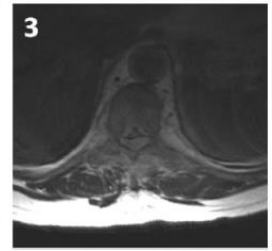
Schematic representation of the 6-point ESCC grading scale.

Grade 0	Bone-only disease
Grade 1a	Epidural impingement, without deformation of thecal sac
Grade 1b	Deformation of thecal sac, without spinal cord abutment
Grade 1c	Deformation of thecal sac with spinal cord abutment, without cord compression
Grade 2	Spinal cord compression, with cerebral spinal fluid (CSF) visible around the cord
Grade 3	Spinal cord compression, no CSF visible around the cord









Neurologic

- 6-pt system for grading

0 = bone only
1a = epidural impingement; no deformation of thecal sac
1b = deformation of thecal sac but w/o cord abutment
1c = deformation of thecal sac; cord abutment, no compression
2-3 = high grade SCC

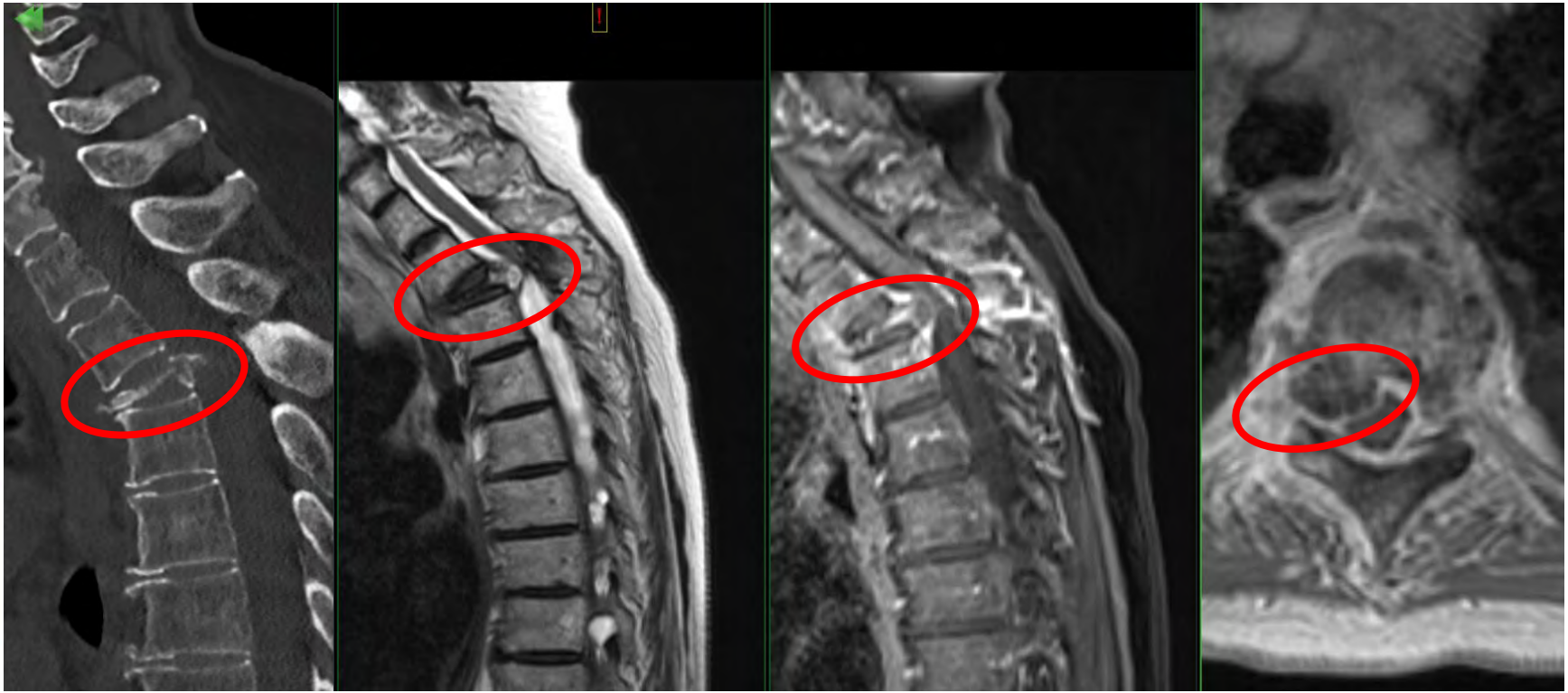
Intervention

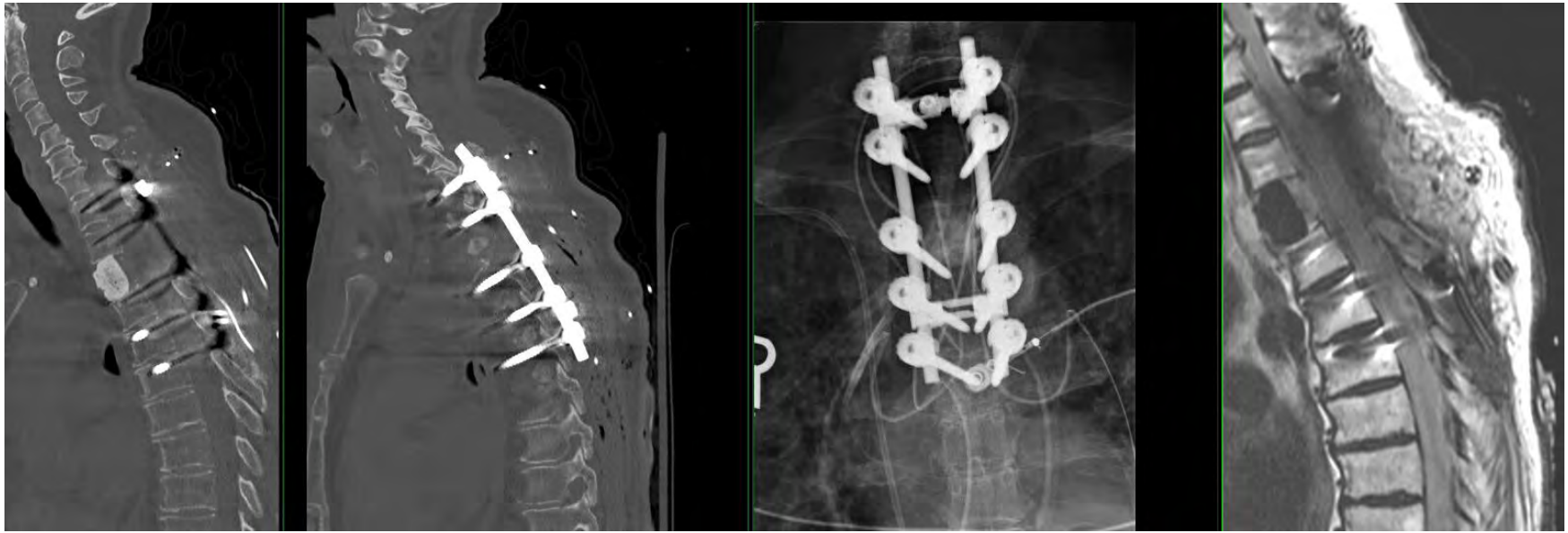
- 0-1b → RT (cEBRT vs. SRT based on histology)
- *1c: unclear role of surg & RT*
- 2-3 (high grade cord compression) → surg + RT (unless highly radiosensitive then RT alone)

The severity of the compression and/or symptoms dictates the urgency and nature of treatment!

Laufer et al, The Oncologist (2013)

Back pain, ,myelopathic signs, T3 vertebra plana. Cord compression





NOMS

Oncologic

- Based on expected tumor response & durability of response to tx (surgery, cEBRT, SRS, chemo, hormones, etc)
  - Major focus is radiosensitivity to cEBRT

Radiosensitive → cEBRT regardless of degree of SCC

(leukemia, lymphoma, myeloma, ovarian, neuroendocrine and choriocarcinoma)

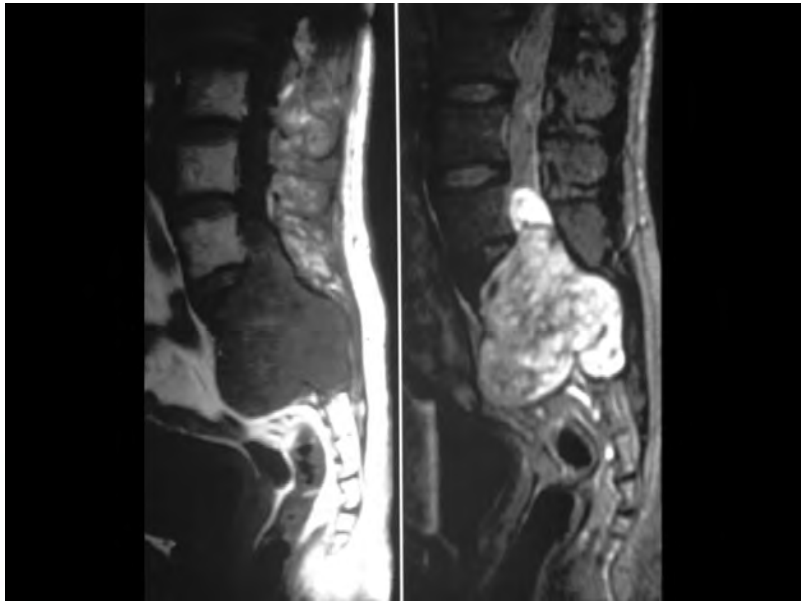
Radioresistant → SRS if Grade 0, 1a, 1b

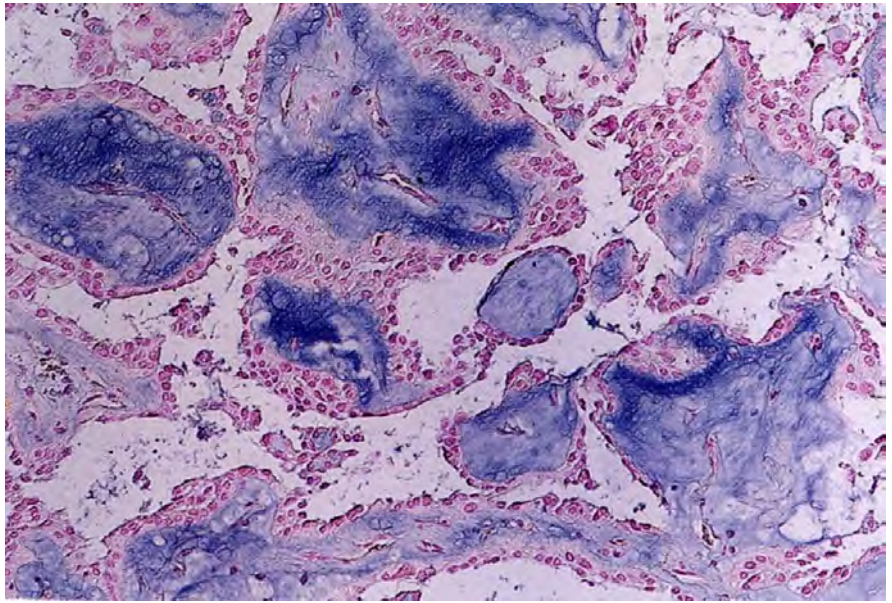
(Melanoma, RCC, NSCLC, thyroid, HCC, sarcoma) Surgery + SRS if Grade 2, 3

Laufer et al, The Oncologist (2013)

Establishing the diagnosis

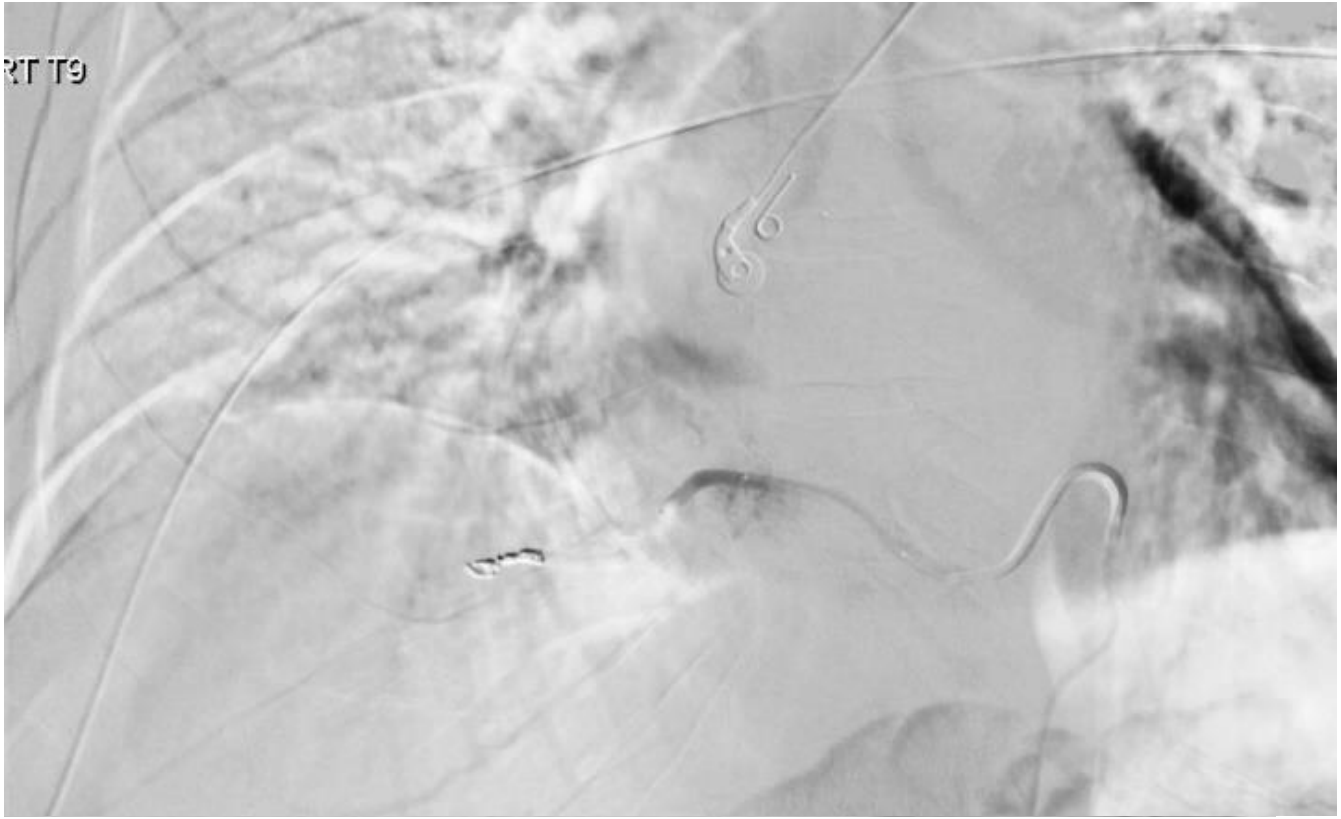
- Metastasis / Primary bone tumor / infection?
- CT chest abdomen pelvis – look for primary
- CT guided Biopsy

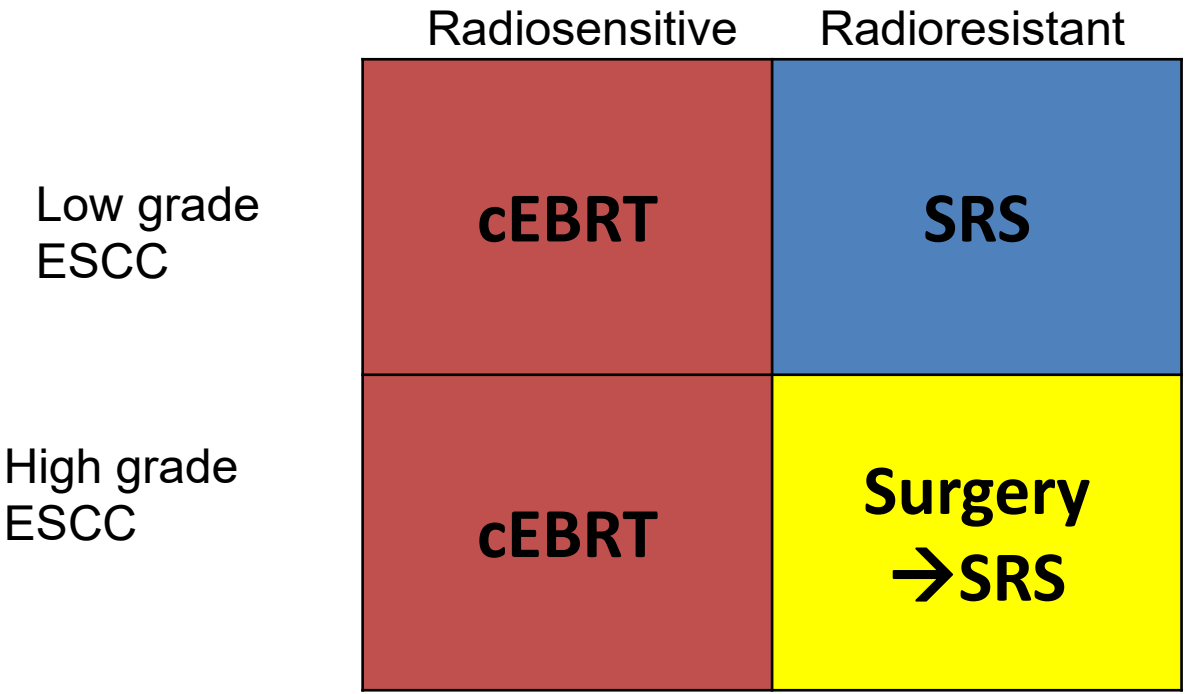




Chordoma? En Bloc surgery?

Know what you are treating because it can get bloody!


RT T9


Radiosensitive
Radioresistant
Low grade ESCC
High grade ESCC
cEBRT
SRS
cEBRT
Surgery →SRS

NOMS

Mechanical Stability

- Use Spinal Instability Neoplastic Score (SINS) criteria to assess stability

0 – 6:	**Stable** (no surgery)
7 – 12:	Indeterminate
13 – 18:	**Unstable** (surgery)

	Score
Location	
Junctional (occiput-C2, C7-T2, T11-L1, L5-S1)	3
Mobile spine (C3-C6, L2-L4)	2
Semirigid (T3-T10)	1
Rigid (S2-S5)	0
Pain	
Yes	3
Occasional pain but not mechanical	1
Pain-free lesion	0
Bone lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Radiographic spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral body collapse	
>50% collapse	3
<50% collapse	2
No collapse with >50% body involved	1
None of the above	0
Posterolateral involvement of spinal elements	
Bilateral	3
Unilateral	1
None of the above	0

Fisher et al, Spine (2010)

NOMS

Systemic Disease

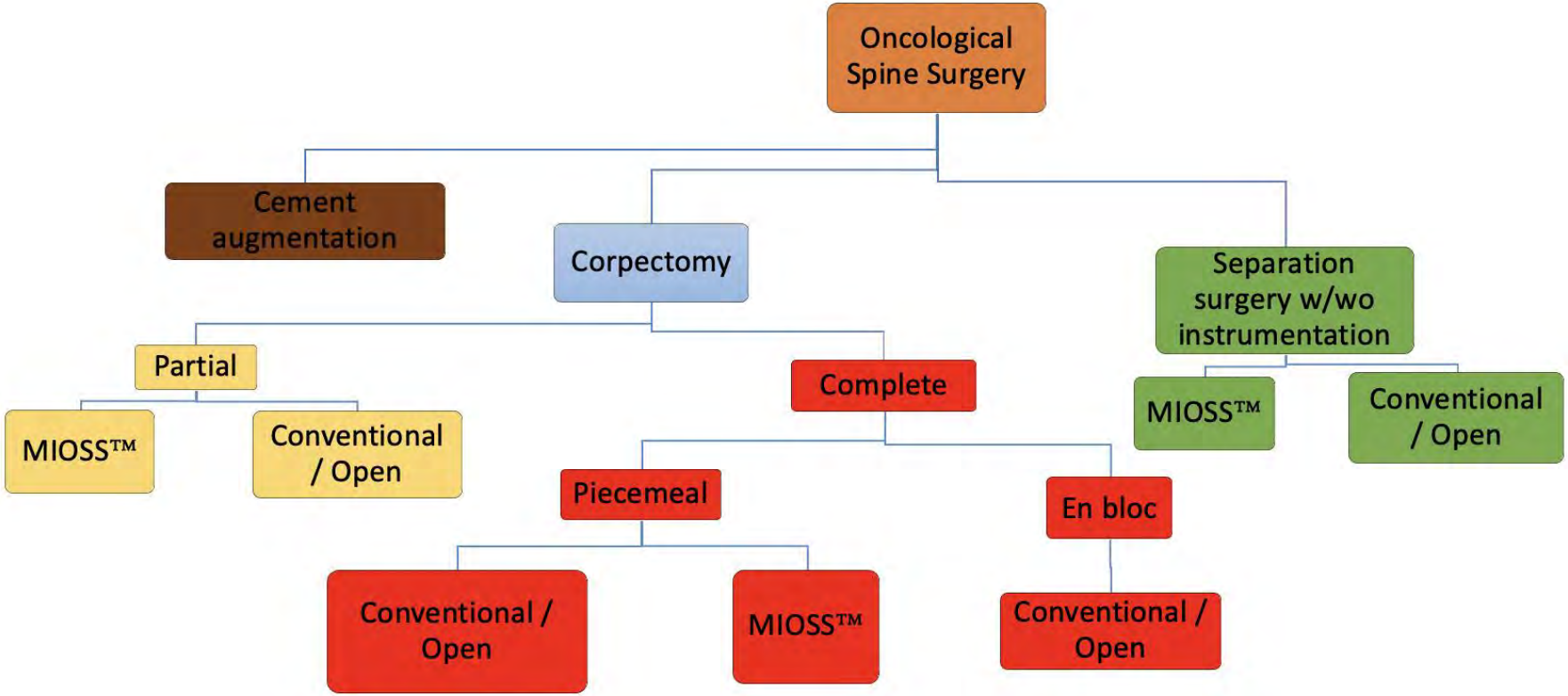
- Assess comorbidities to evaluate if the patient can tolerate the proposed treatment
- Estimate overall expected survival based on extent of disease & tumor histology
- Survival > 6 months
- Several tools available
  - Tokuhasi score, Tomita score

Laufer et al, The Oncologist (2013)

Surgical Treatment

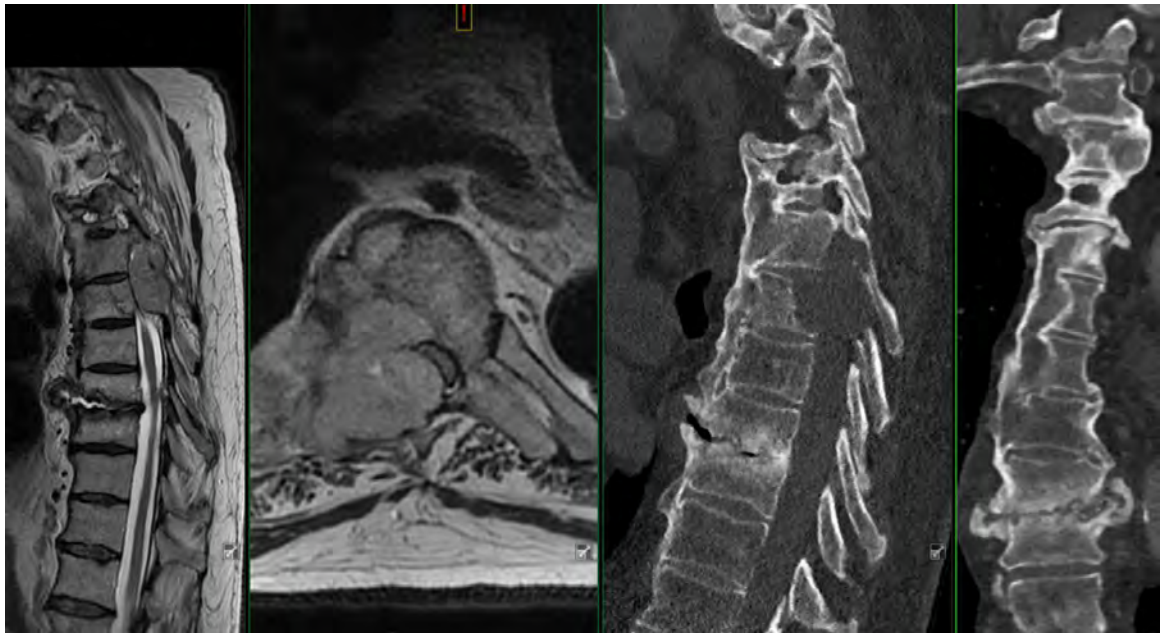
Spine Tumor Surgery
Surgical Planning

- Purpose of Surgery
  - Cure vs. Palliation
- Resection Type
  - Enbloc vs. Intralesional
- Biomechanical Considerations
- Wound Status
- Medical Status of the Patient/Risks of Surgery

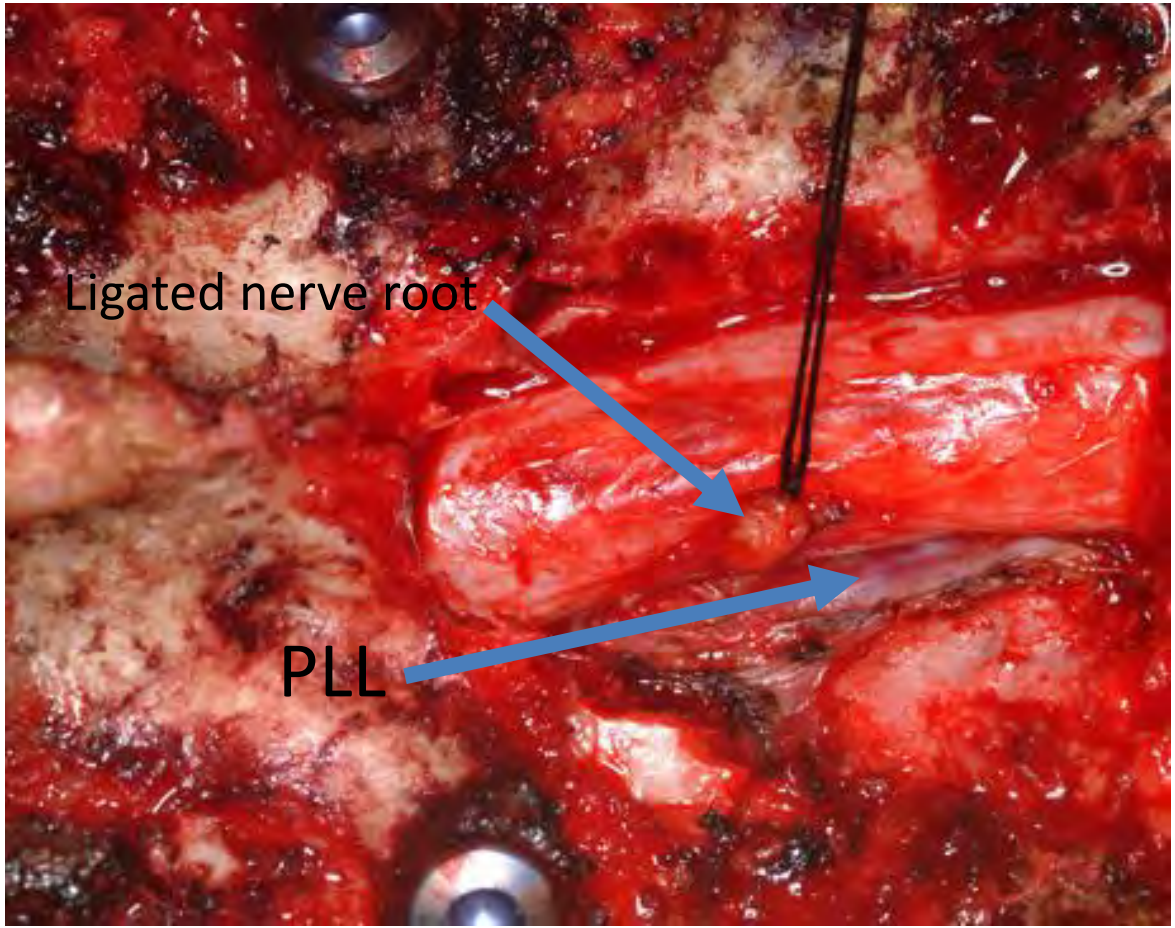

Oncological Spine Surgery
Cement augmentation
Corpectomy
Separation surgery w/wo instrumentation
Partial
Complete
MIOSS™
Conventional / Open
MIOSS™
Conventional / Open
Piecemeal
En bloc
Conventional / Open
MIOSS™
Conventional / Open

Separation surgery

- 78M, dysphagia for weeks, back pain, clonus+

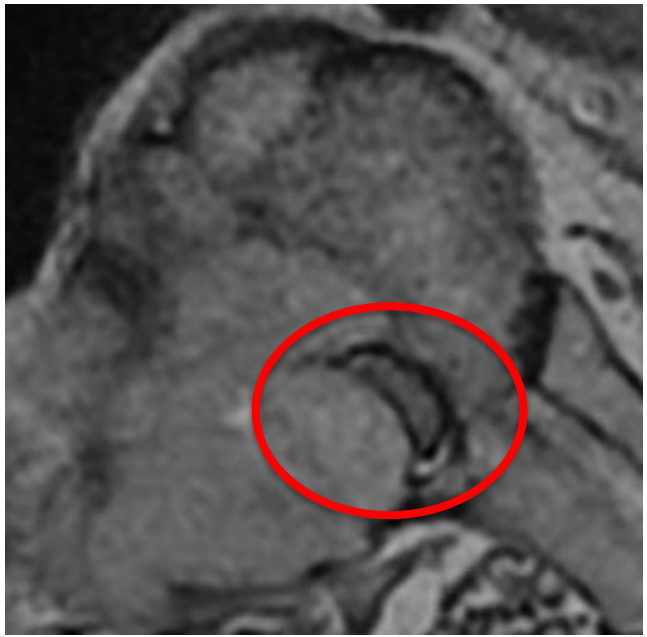


PLL resection is a MUST!

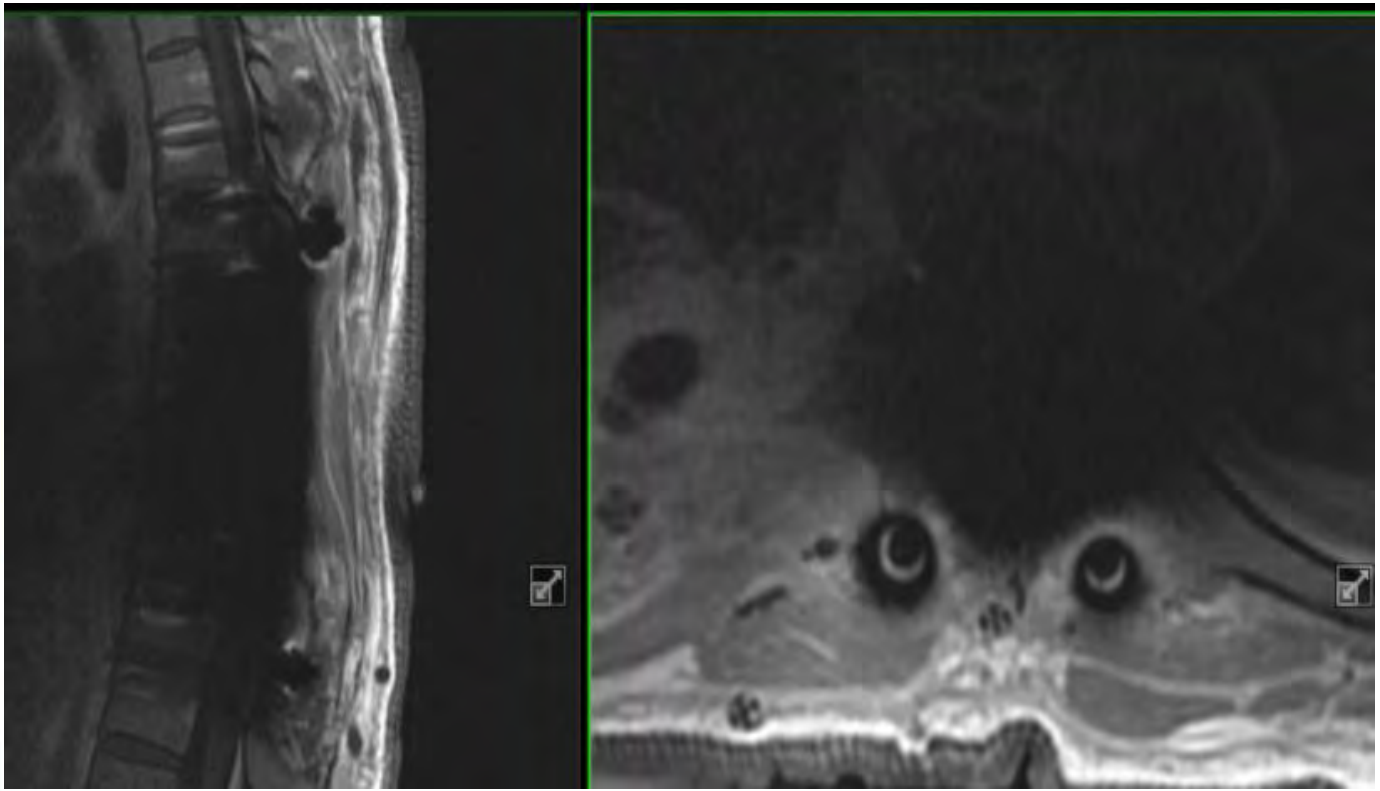


Separation surgery

If you don’t see free space around the cord, it’s not a separation surgery and thus not amenable to SRS!



Following for recurrence



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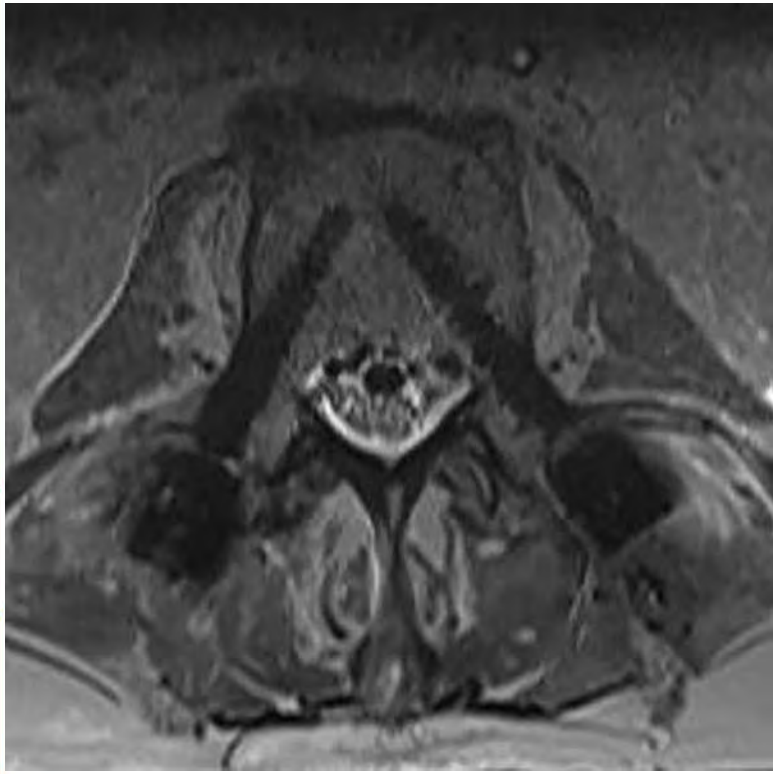
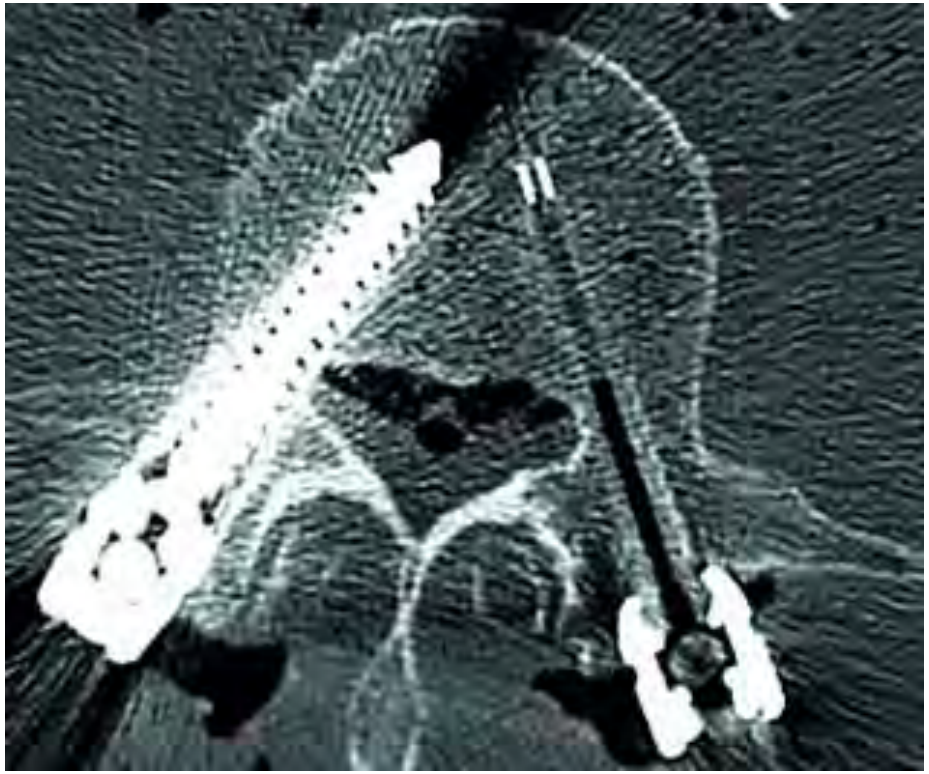




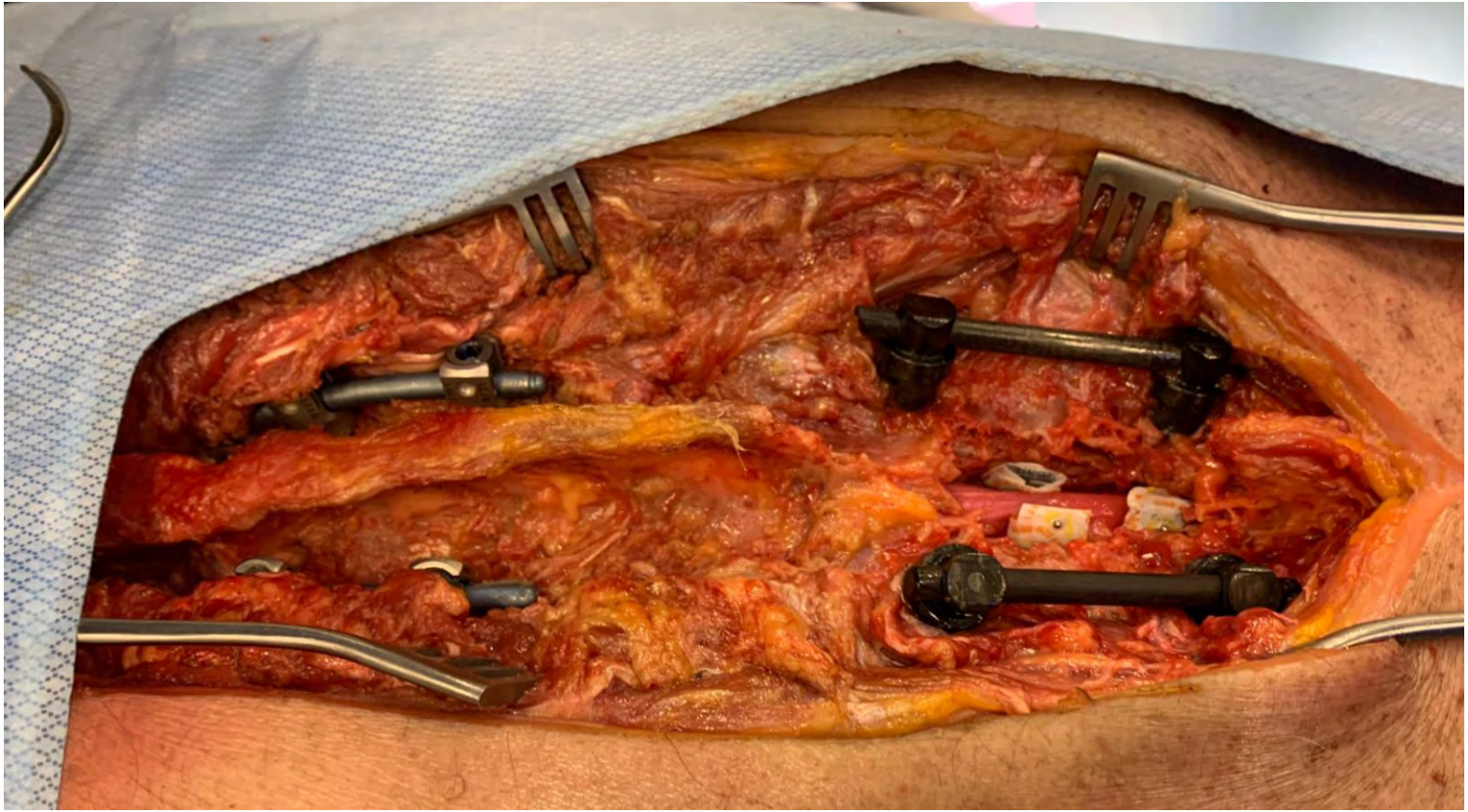
Carbon Fiber Instrumentation with SBRT

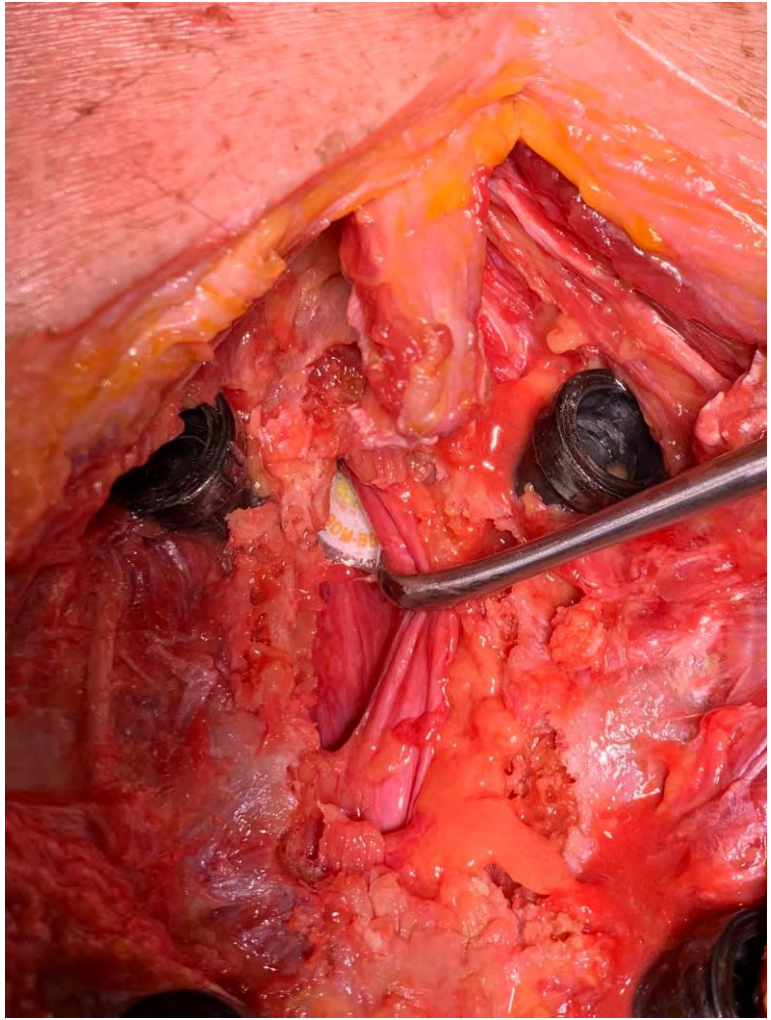
Will dose delivery and accuracy will be improved with Carbon Fiber instrumentation?

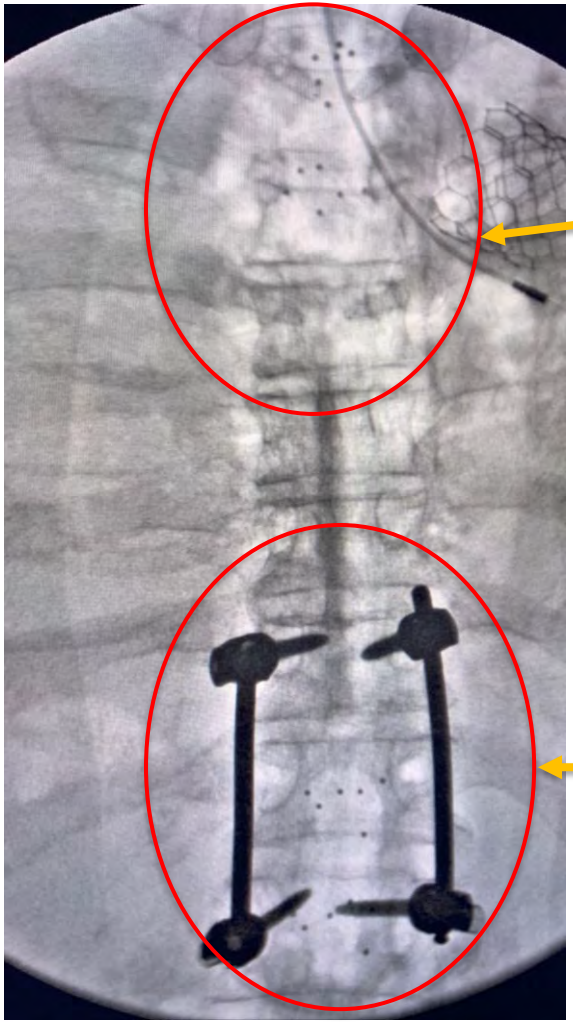
ORIGINAL ARTICLE

In Situ Real-Time Dosimetric Studies for Spine Stereotactic Body Radiation Therapy in a Cadaver Implanted with Carbon-Fiber and Titanium Instrumentation

Chi Zhang[1], *Shuo Wang*[1], *Ahmed Mansi*[2], *Miki Katzir*[2]



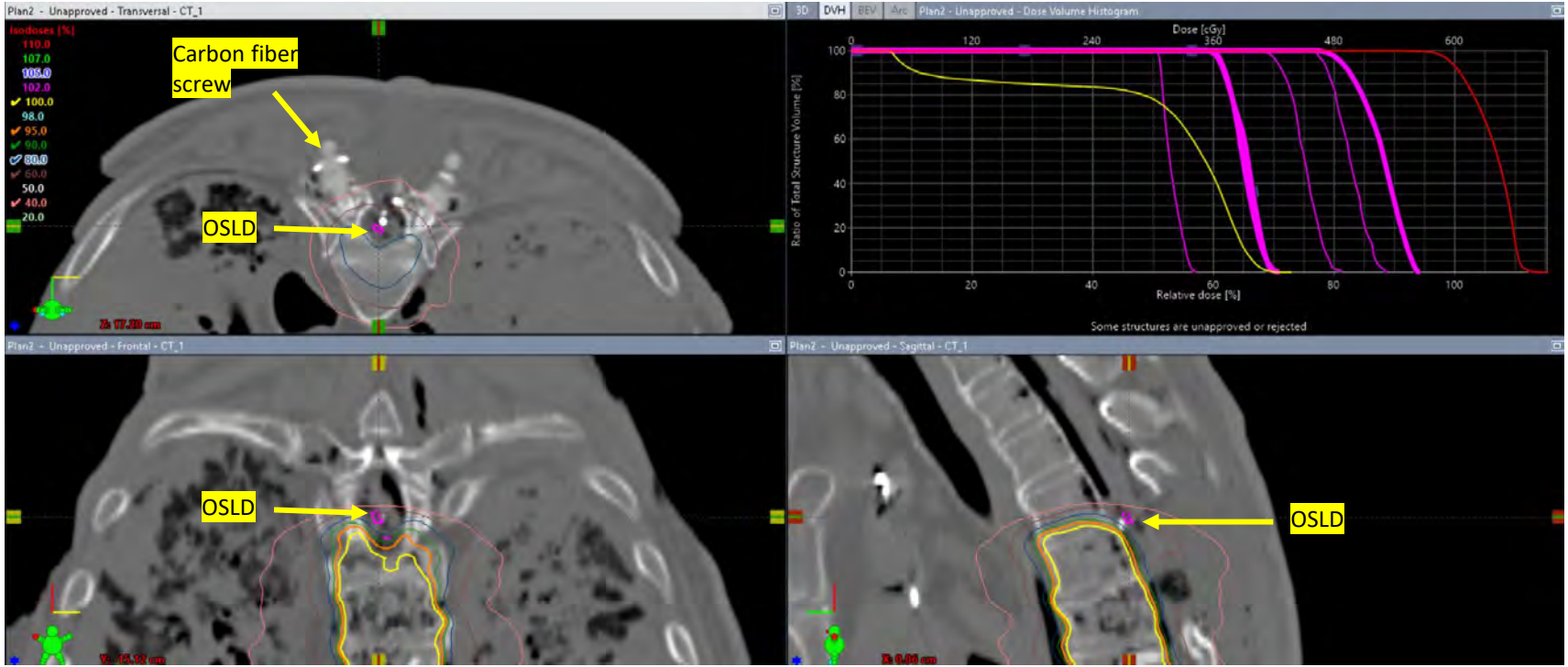




Carbon Fiber

Titanium

Optically Stimulated Luminescence Dosimeter (OSLD) placed in epidural space (pink contours) near the carbon fiber screws



Measured vs. Calculated dosimetry

Table 1. Comparison of Measured versus Calculated Dose of Radiation Therapy Near and Between the Superior and Inferior Screws of Both Titanium and Carbon Fiber Instrumentation

Carbon Fiber					
Carbon Superior (near Screws)	**Superior**	**Chip Number**	**Measured**	**Calculated**	**% Difference**
Left	385.8	771920	385.5	392.2	1.66%
Right	375.986	13293R	375.986	390.1	3.75%
Ventral	545.5	68280T	545.5	527.1	−3.37%
Carbon Inferior (between screws)	**Inferior**	**Chip Number**	**Measured**	**Calculated**	**% Difference**
Left	499.2	15738A	499.2	450.6	−9.74%
Right	276.5	17358H	276.5	318.5	15.19%
Ventral	452.244	01671RT	452.244	496.3	9.74%
Titanium					
Titanium (between screws)	**Superior**	**Chip Number**	**Measured**	**Calculated**	**% Difference**
Left	450.3	19379B	450.3	408.1	−9.37%
Right	374.6	09356M	374.6	369.8	−1.28
Ventral	51.2	17313S	51.2	485.6	848.44% (off liner)
Titanium (near screws)	**Inferior**	**Chip#**	**Measured**	**Calculated**	**% Difference**
Left	452.6	21909E	452.6	424.4	−6.23%
Right	288.9	29665E	288.9	390.6	35.2%
Ventral	629.4	17331X	629.4	525.3	−16.54%

Near the screws group		
	% Difference in measured vs. calculated dosimetry	
Chip location\ type	Carbon Fiber	Titanium
Left	1.66%	-6.23%
Right	3.75%	35.2%
Ventral	-3.37%	-16.54%

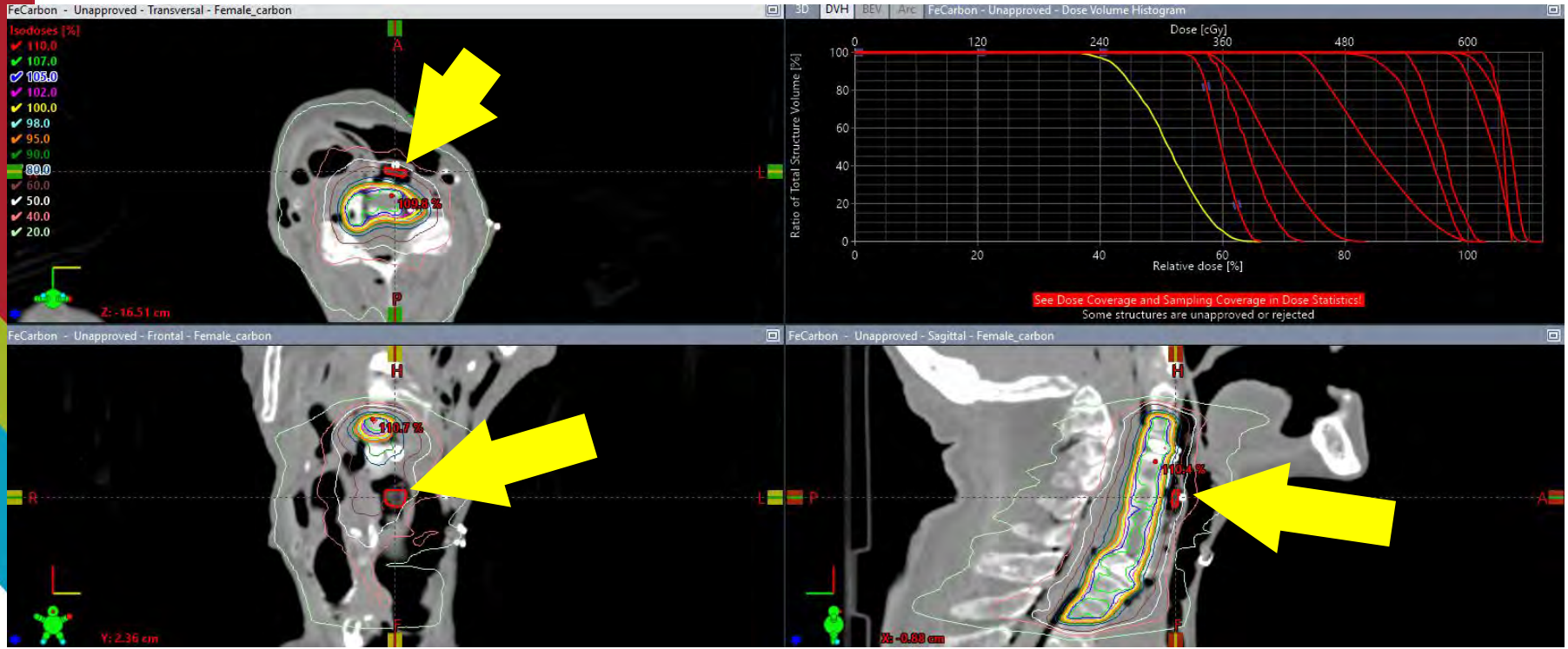
Table 2. Comparison of Mean and Median Values of the Absolute Difference (%) Between Measured versus Calculated Doses of Radiation Therapy Near and Between the Superior and Inferior Screws of Both Titanium and Carbon Fiber (CF) Instrumentation

	Absolute % Difference (Mean)	*P* Values	Absolute % Difference (Median)	Interquartile Range
CF near screws	2.93	0.11	3.37	1.04
CF between screws	11.56		9.74	2.72
TI between screws	5.33	0.27	5.33	3.41
TI near screws	19.32		16.54	14.49
CF near screws	2.93	0.0057	3.37	1.04
TI near screws	19.32		16.54	14.49
CF between screws	11.56	0.21	9.74	2.72
TI between screws	5.33		5.33	3.41
All CF	7.24	0.032	6.74	6.37
All TI	13.73		9.37	10.31

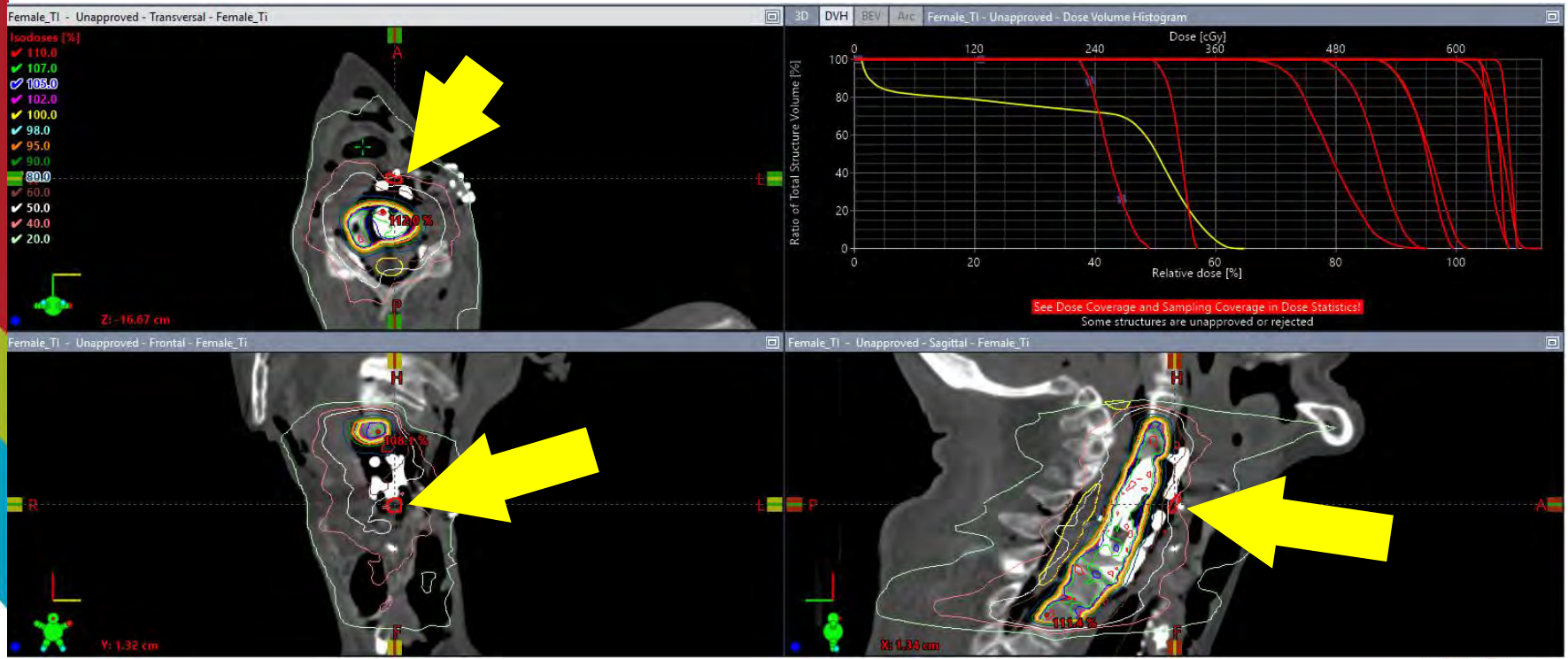
TI, titanium.


Nebraska Medicine

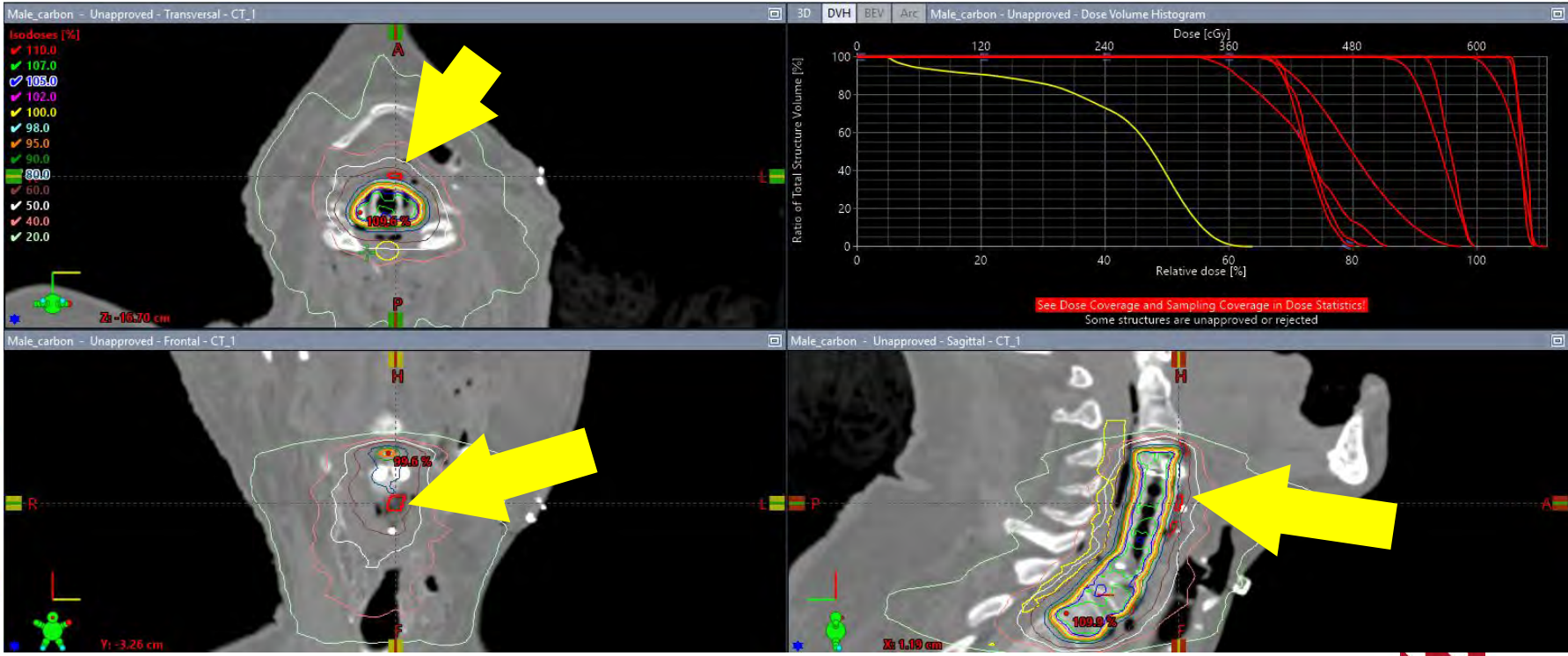
Female Carbon Fiber



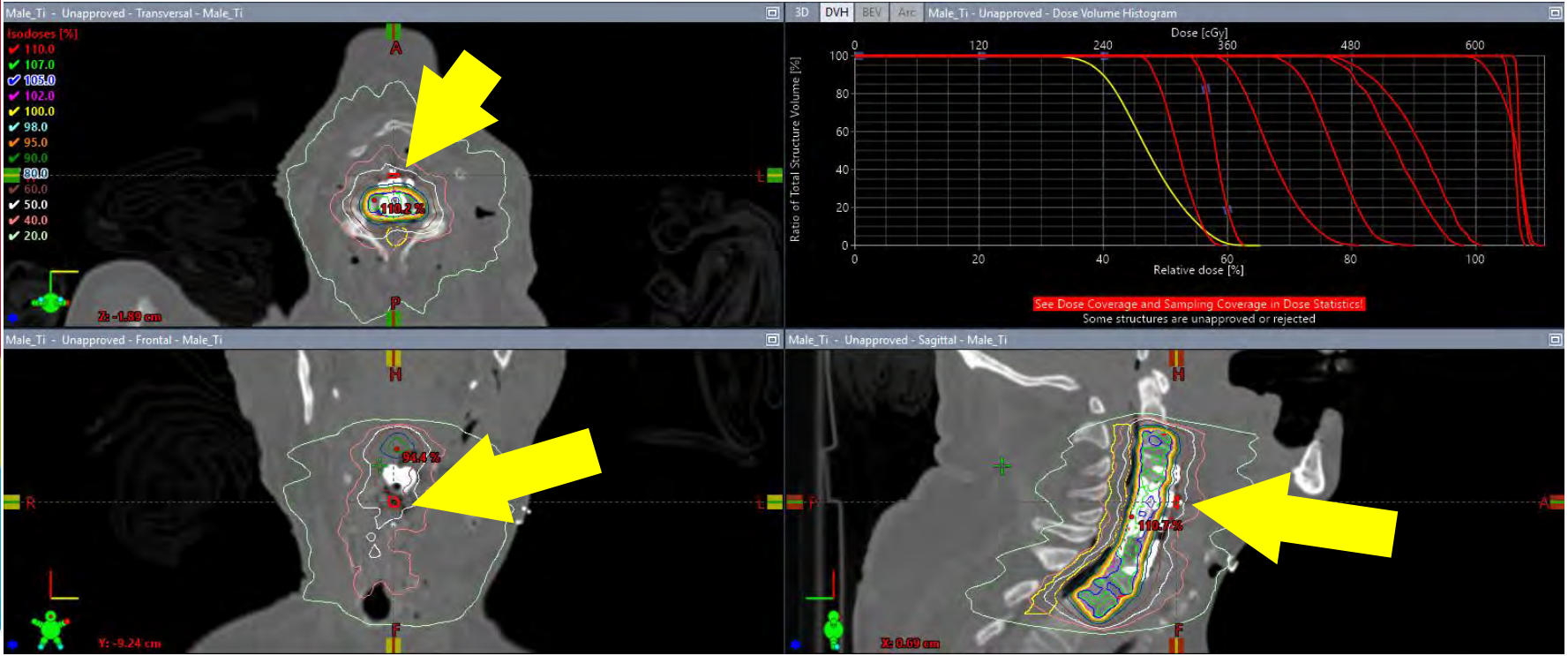
Female Titanium



Male Carbon Fiber



Male Titanium



Measured vs. Calculated dosimetry

SET 1

Male C4-5 Titanium

Chip #	Location	Serial#	Calculated from VMAT (cGy) (mean)	Measured from chips (cGy) (mean)	Diff%	Abs Diff%
1	Esophagus sup	06188J	349.4	345.842	-1.03%	1.03%
2	Esophagus inf	10590u	312.7	331.418	5.65%	5.65%
3	Right lateral (to cage)	401353	643	786.755	18.27%	18.27%
4	Left lateral	09350Y	636.6	653.973	2.66%	2.66%
5	Cord 1 (sup)	200515	544.7	590.87	7.81%	7.81%
6	Cord 2 (inf)	02706P	522.5	568.961	8.17%	8.17%
7	Control (top)	10883L	462.7	475.043	2.60%	2.60%
8	Control (inf)	07018T	403.2	405.832	0.65%	0.65%
						5.85%

Female C4-5 Carbon Fiber

Chip#	Location	Serial#	Calculated from VMAT (cGy) (mean)	Measured from chips (cGy) (mean)	Diff%	Abs Diff%
9	Esophagus sup	05822L	358.9	362.614	1.02%	1.02%
10	Esophagus inf	18681I	384.7	360.939	-6.58%	6.58%
11	Right lateral	06298G	633.8	608.39	-4.18%	4.18%
12	Left lateral	83840P	621.6	664.428	6.45%	6.45%
13	Cord 1 (sup)	78381P	557.3	575.807	3.21%	3.21%
14	Cord 2 (inf)	17305T	574.4	572.19	-0.39%	0.39%
15	Control (top)	06277K	410	484.875	15.44 %	15.44%
16	Control (inf)	09802O	506.7	534.197	5.15%	5.15%
						5.30%

SET 2

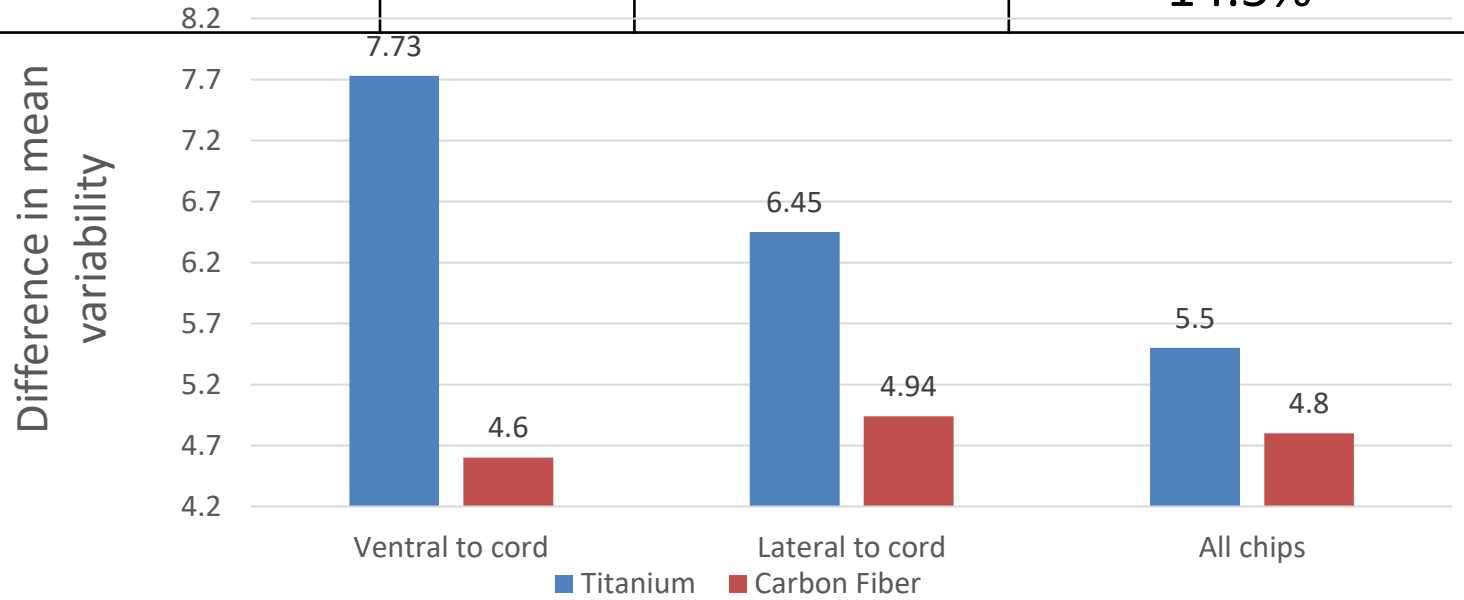
Male C4-5 Carbon fiber

Chip#	Location	Serial#	Calculated from VMAT (cGy) (mean)	Measured from chips (cGy) (mean)	Diff%	Abs Diff%
17	Esophagus sup	68271S	435.5	471.132	7.56%	7.56%
18	Esophagus inf	156889	440.2	460.543	4.42%	4.42%
19	Right lateral	21957D	645.4	685.611	5.86%	5.86%
20	Left lateral	02409M	642.8	664.637	3.29%	3.29%
21	Cord 1 (sup)	15199E	574.1	534.876	-7.33%	7.33%
22	Cord 2 (inf)	03498D	563.4	608.984	7.49%	7.49%
23	Control (top)	011615	431.2	470.992	8.45%	8.45%
24	Control (inf)	60441Y	480.3	517.12	7.12%	7.12%

Female C4-5 Titanium

Chip#	Location	Serial#	Calculated from VMAT (cGy) (mean)	Measured from chips (cGy) (mean)	Diff%	Abs Diff%
25	Esophagus sup	60444S	254.9	256.47	0.61%	0.61%
26	Esophagus inf	01663Q	324.2	331.158	2.10%	2.10%
27	Right lateral	71876A	634.2	625.331	-1.42%	1.42%
28	Left lateral	33808M	641.4	664.3	3.45%	3.45%
29	Cord 1 (sup)	718786	571.7	611.378	6.49%	6.49%
30	Cord 2 (inf)	09824I	568.2	620.627	8.45%	8.45%
31	Control (top)	69145O	475.3	474.503	-0.17%	0.17%
32	Control (inf)	047497	519.9	447.759	-16.11%	16.11%

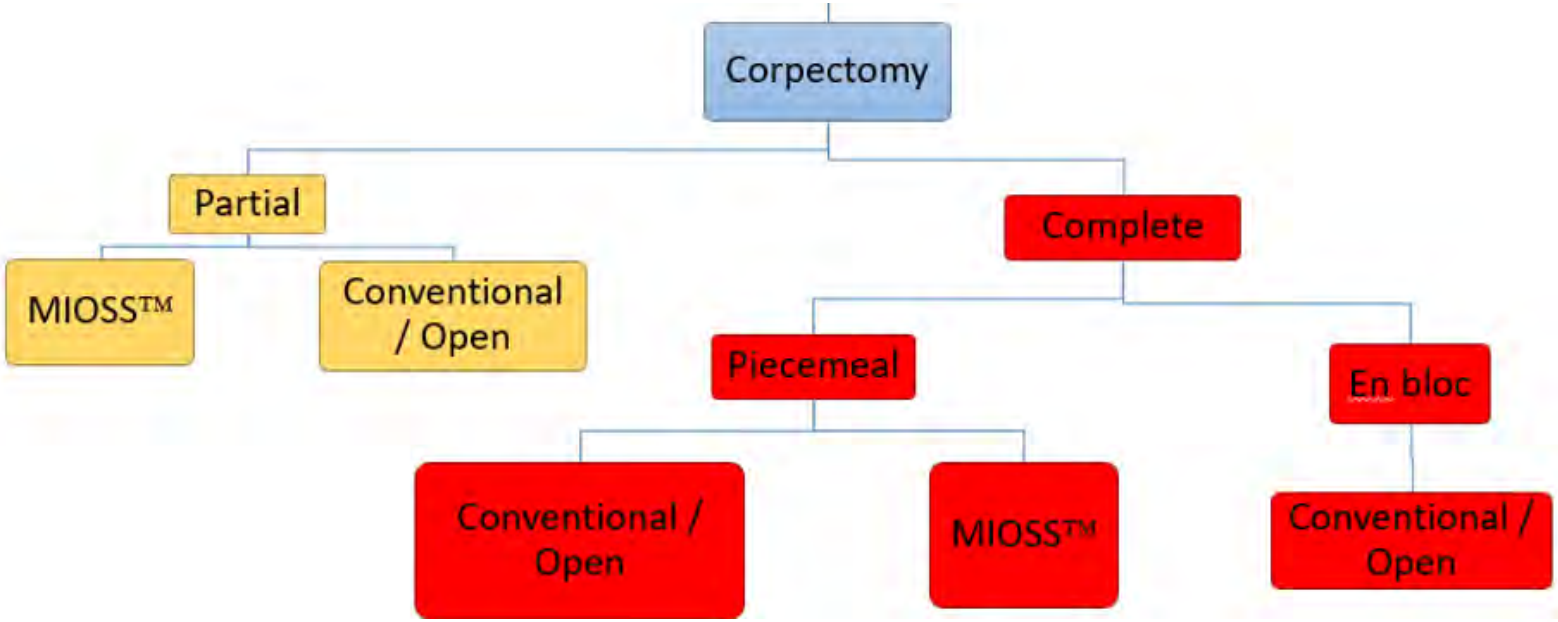
Dosimeter group	Mean variation		Difference in mean variability	p value
	Titanium	Carbon Fiber		
Ventral to spinal cord	7.73%	4.6%	68%	0.048
Lateral to spinal cord	6.45%	4.94%	30%	0.02
All w/o control	5.5%	4.8%	14.5%	0.03



Conclusion

Less variation in calculated and measured dose of RT in post-corpectomy patients with carbon fiber instrumentation may lead to improved RT delivery, less overdosing or underdosing a tumor or an eloquent area and better complication avoidance.

Corpectomy


Corpectomy
Partial
Complete
MIOSS™
Conventional / Open
Piecemeal
En bloc
Conventional / Open
MIOSS™
Conventional / Open

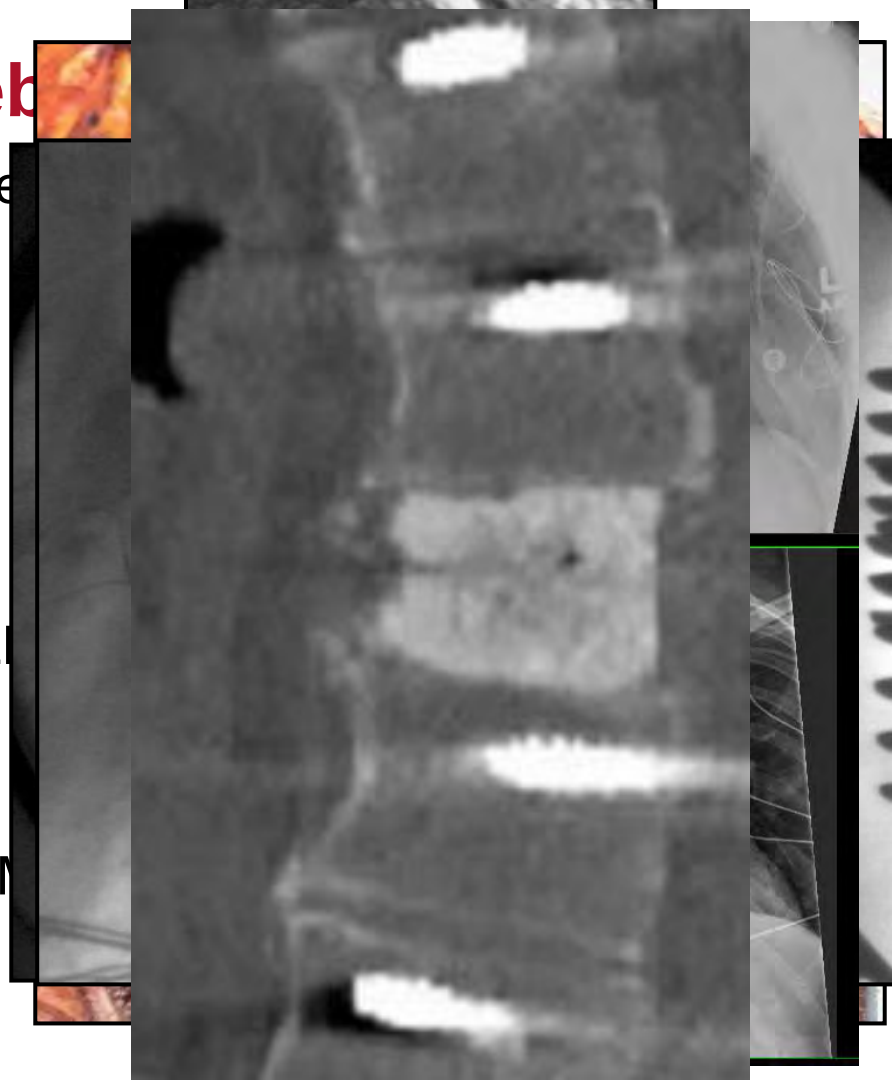
Technique Thoracic verteb

- Pedicle Screw placement: 2-3 leve
- Laminectomy

- Ligation of roots
- Finding the plane

- Pediculectomy- vetebrectomy- PL
- End plate prep

- Anterior column reconstruction- P
- Rods and compression



65 y/o F
Presents with metastatic Lung Carcinoma
Severe Back Pain

University of Nebraska Medical Center

Nebraska Medicine


50 mm

Element of SINS	Score
Location	
Junctional (occiput-C2, C7–T2, T11–L1, L5–S1)	3
Mobile spine (C3–C6, L2–L4)	2
Semi-rigid (T3–T10)	1
Rigid (S2–S5)	0
Pain relief with recumbency and/or pain with movement/loading of the spine	
Yes	3
No (occasional pain but not mechanical)	1
Pain free lesion	0
Bone lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Radiographic spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral body collapse	
>50% collapse	3
<50% collapse	2
No collapse with >50% body involved	1
None of the above	0
Posterolateral involvement of the spinal elements (facet, pedicle or CV joint fracture or replacement with tumor)	
Bilateral	3
Unilateral	1
None of the above	0

Category	Description	Score
Location	Semirigid: T6/T9?	1
Pain		3
Bone Lesion	Lytic	2
Radiographic spinal alignment	Deformity kyphosis	2
Vertebral body collapse	> 50% collapsed	3
Posterior Spinal element Involvement	Bilateral	3
Total Score	Unstable	14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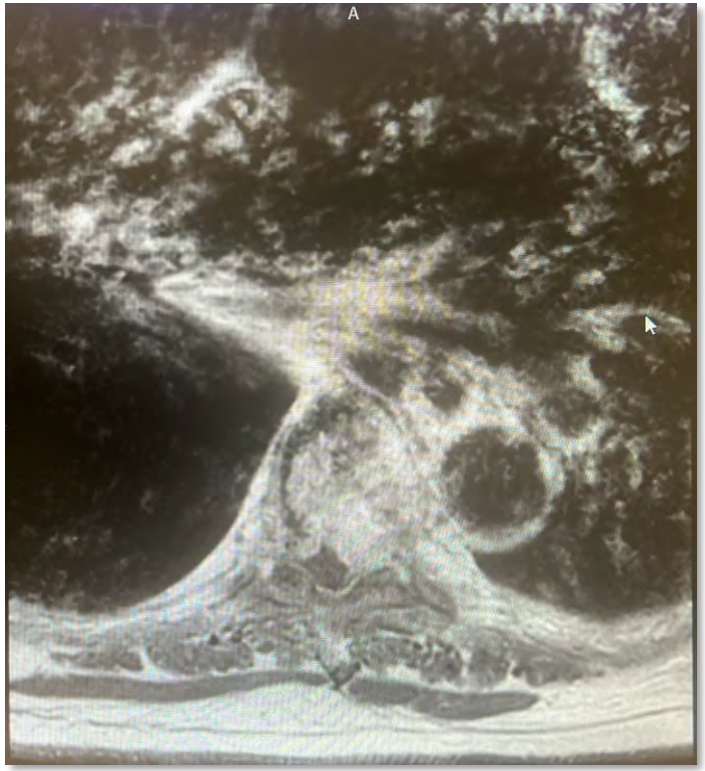
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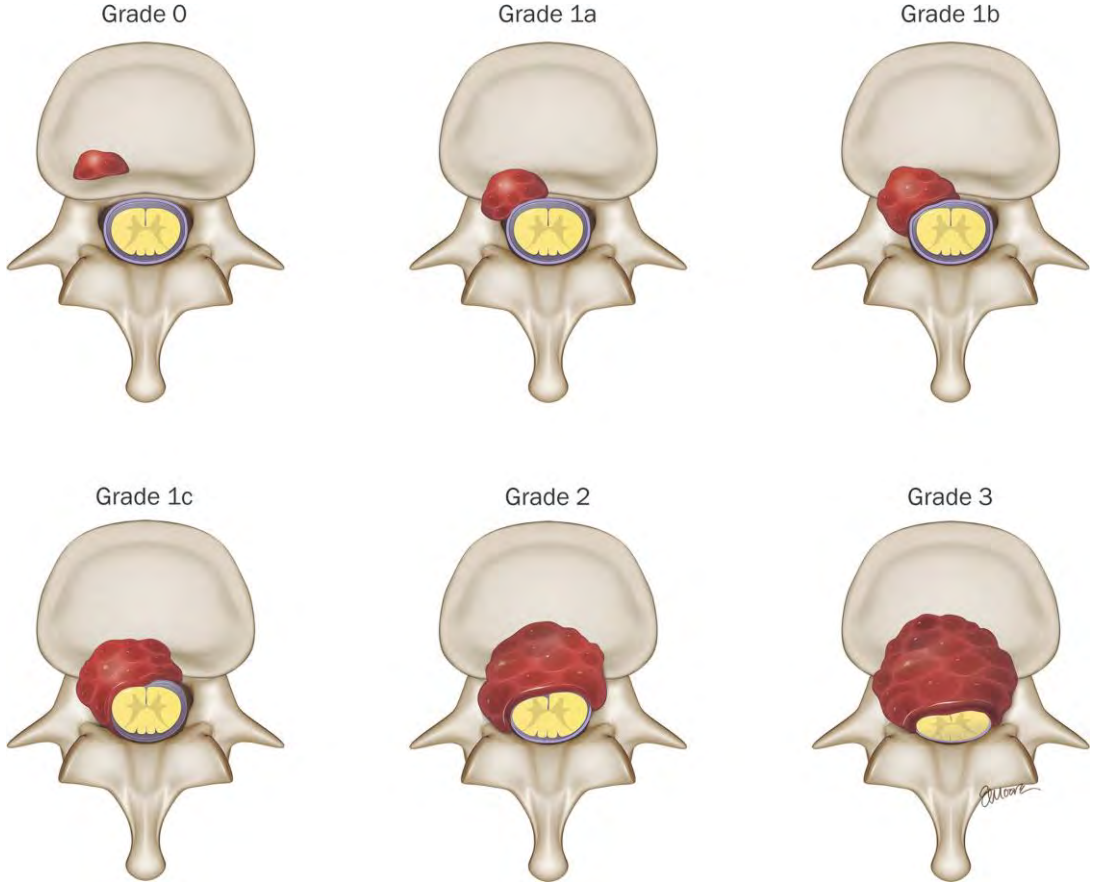
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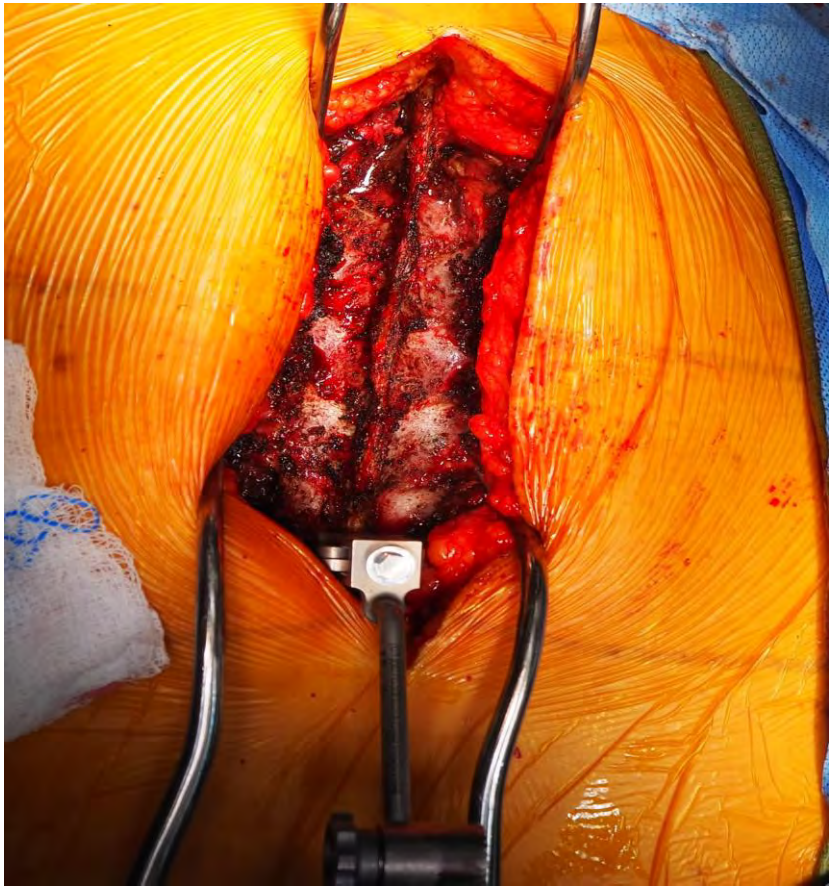
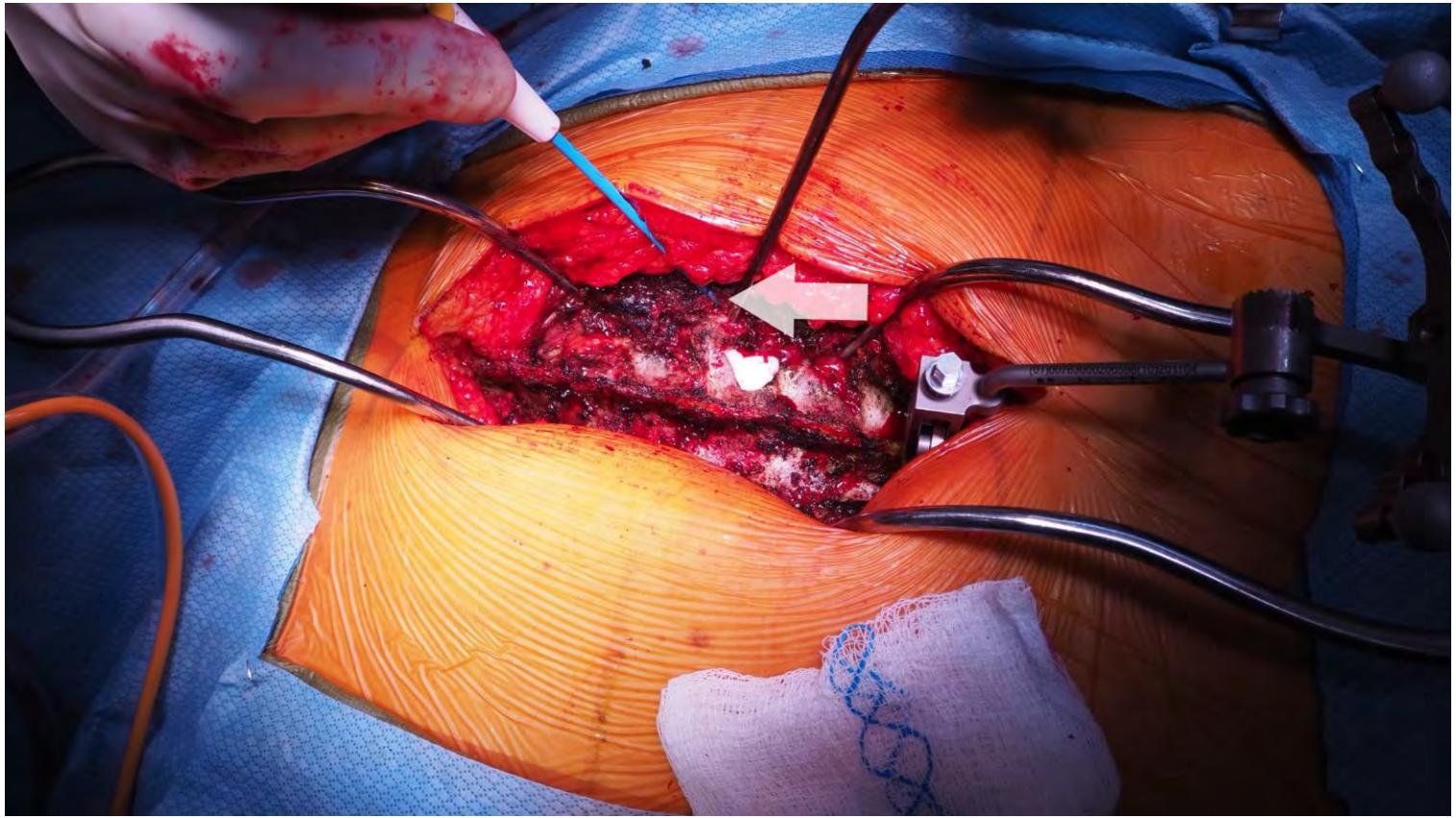
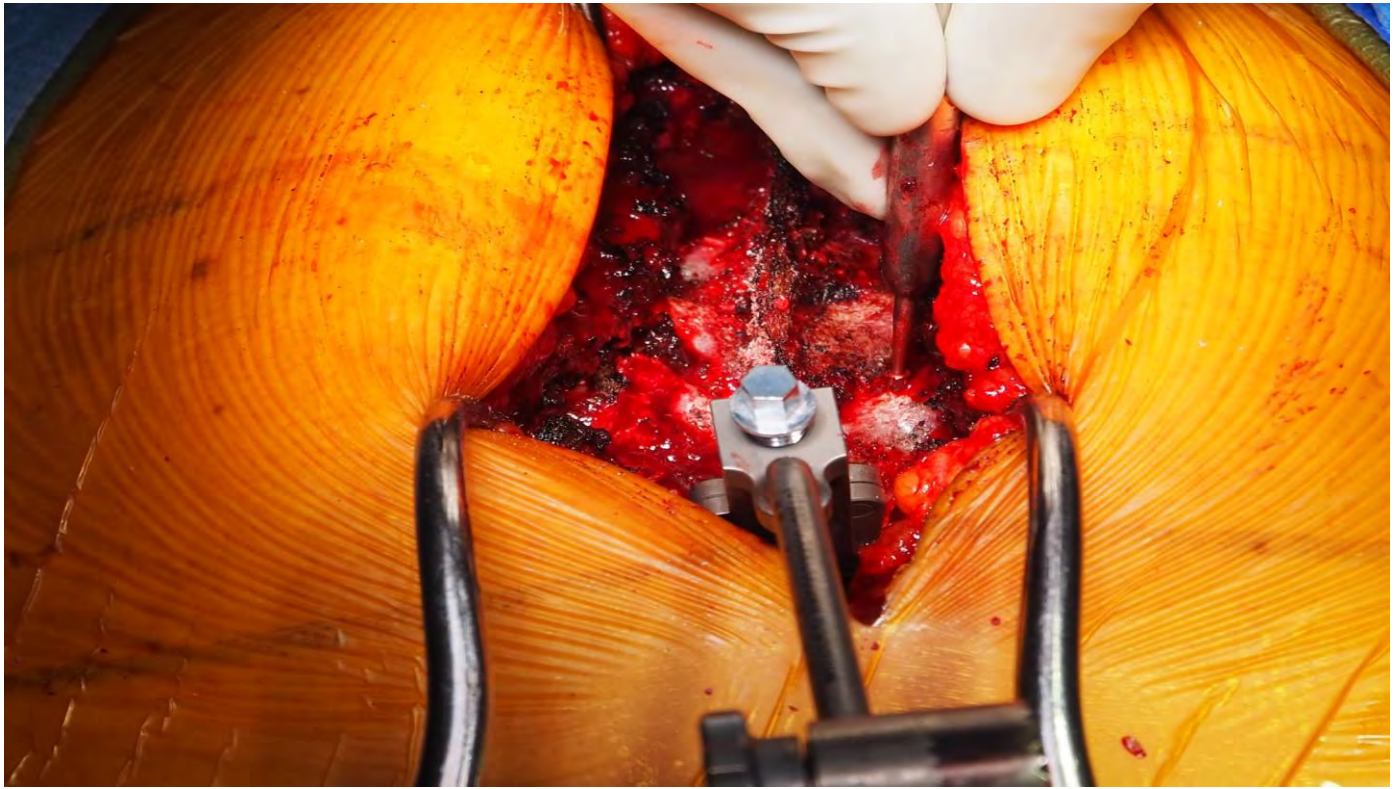
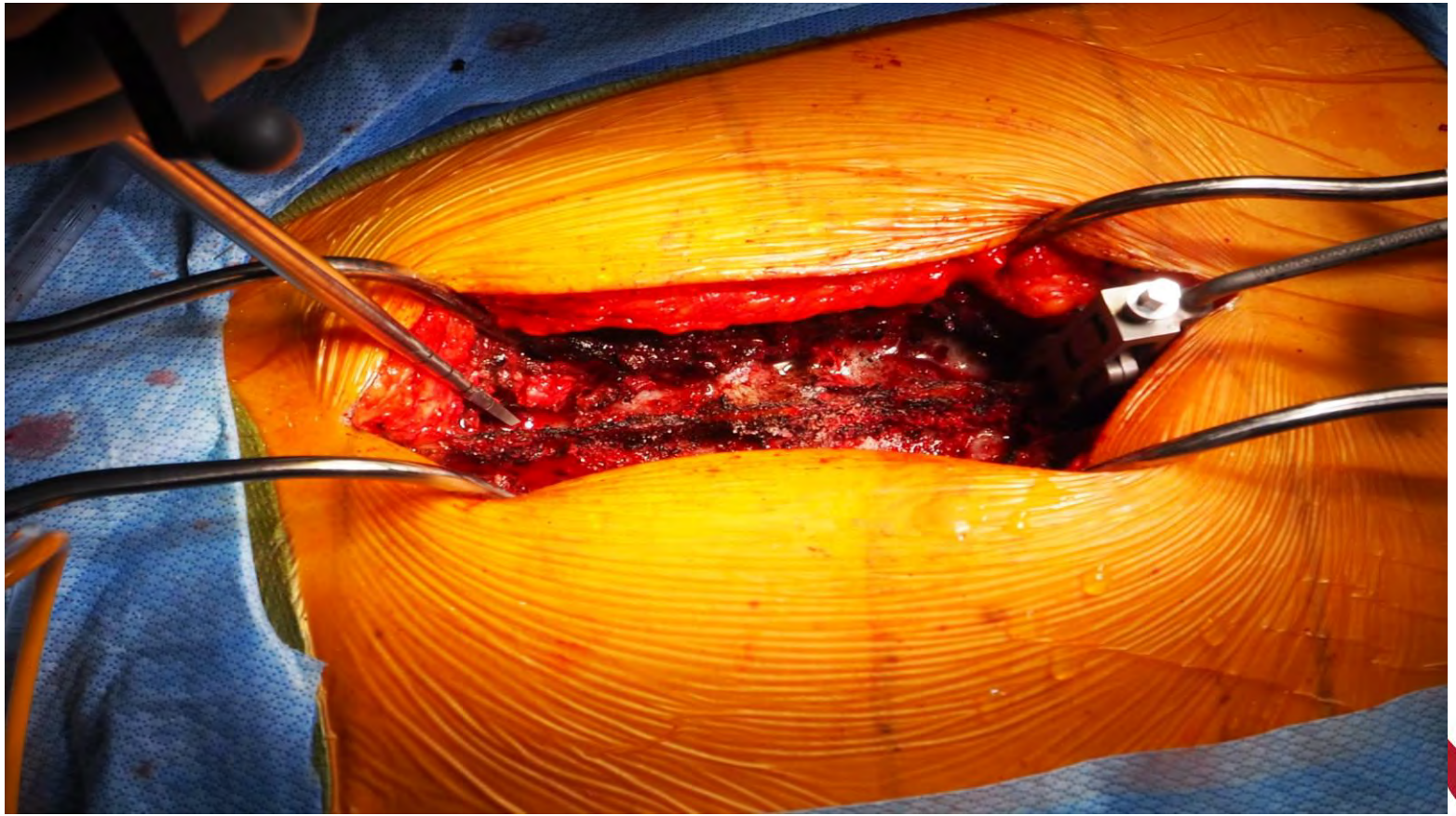
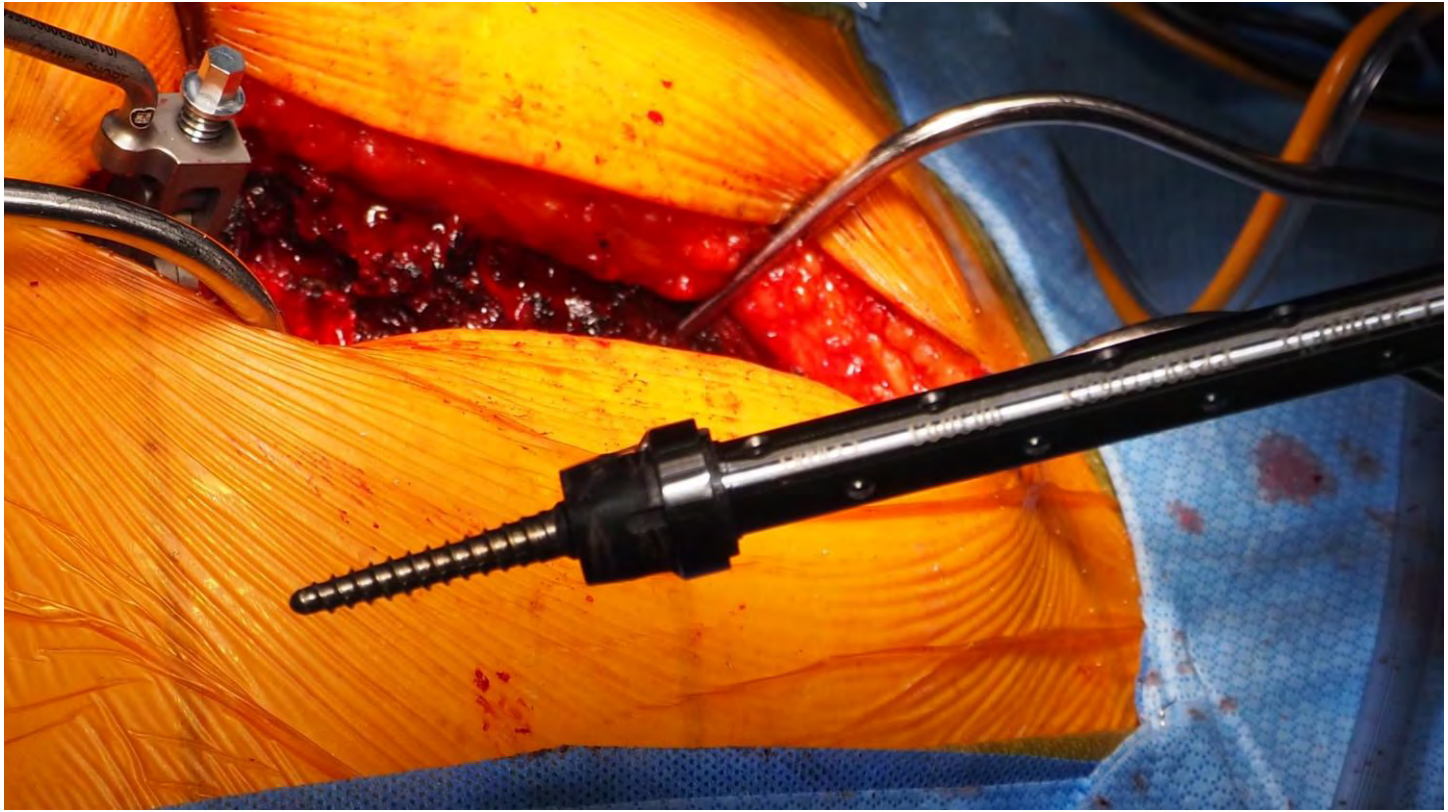
Grade 1a
Grade 1b
Grade 1c
Grade 2
Grade 3

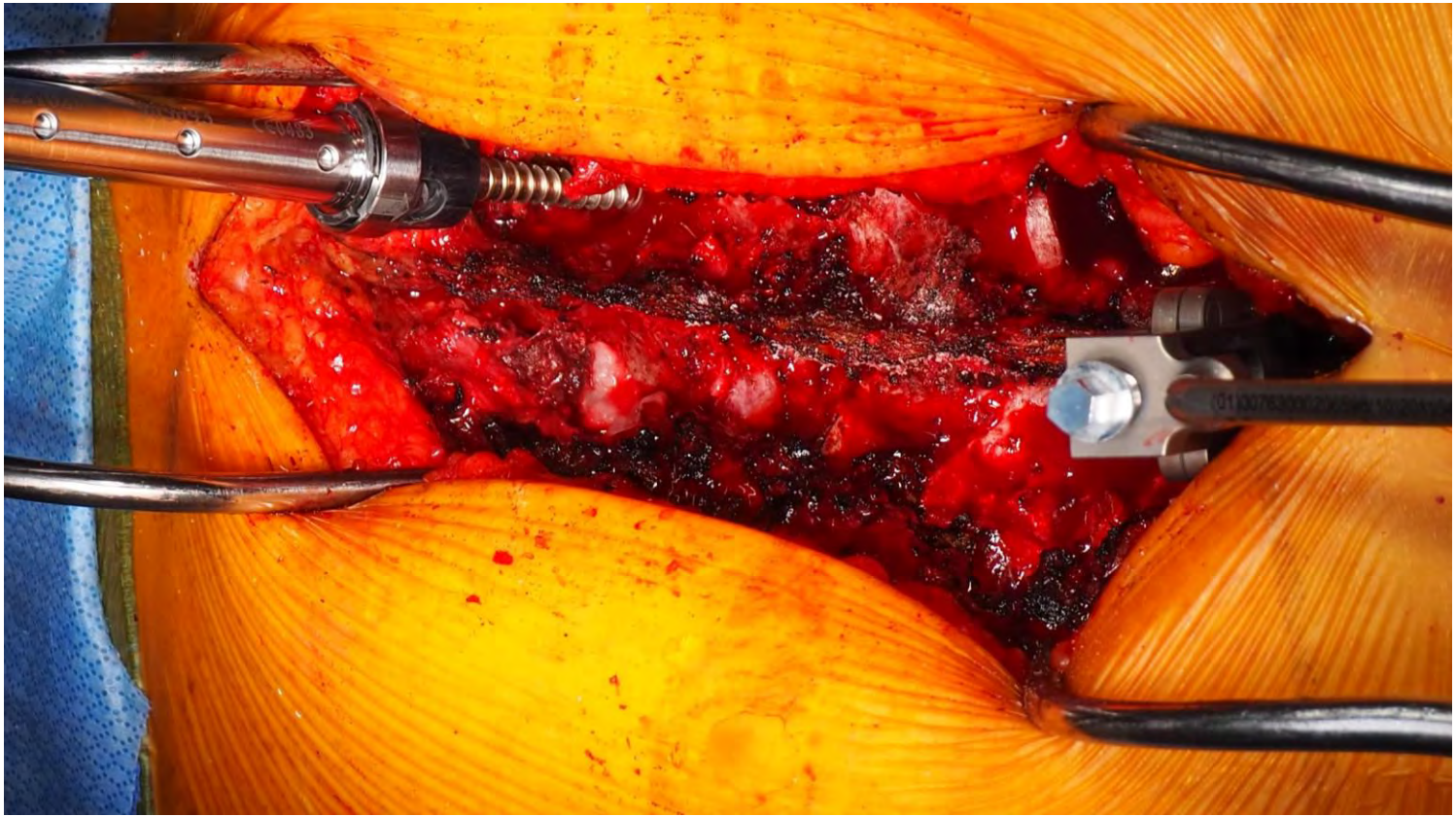


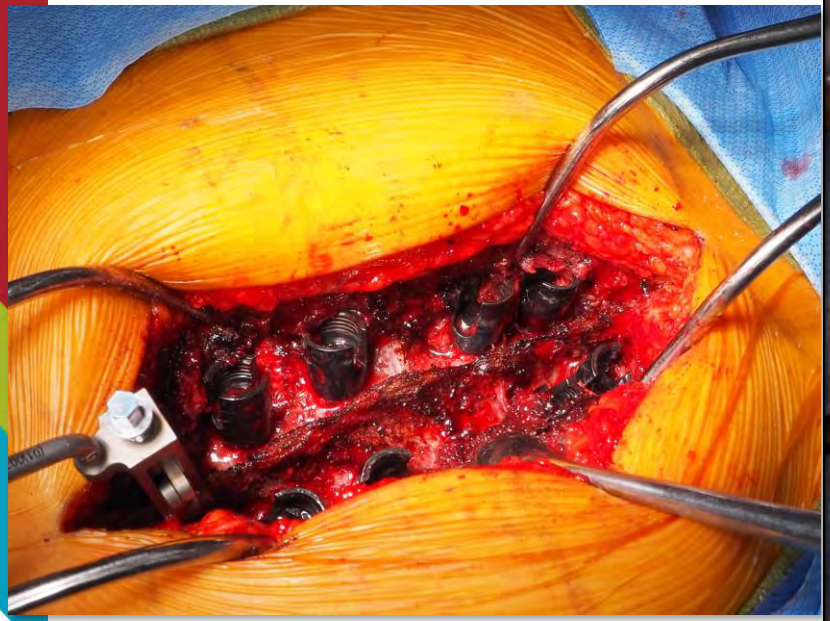


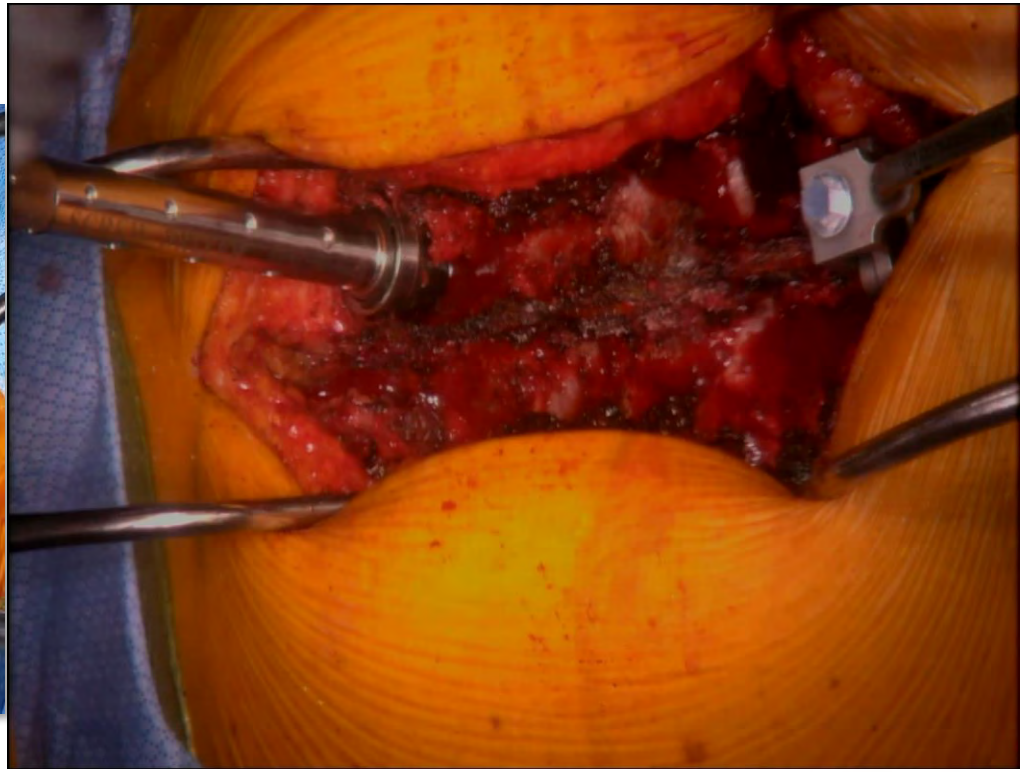


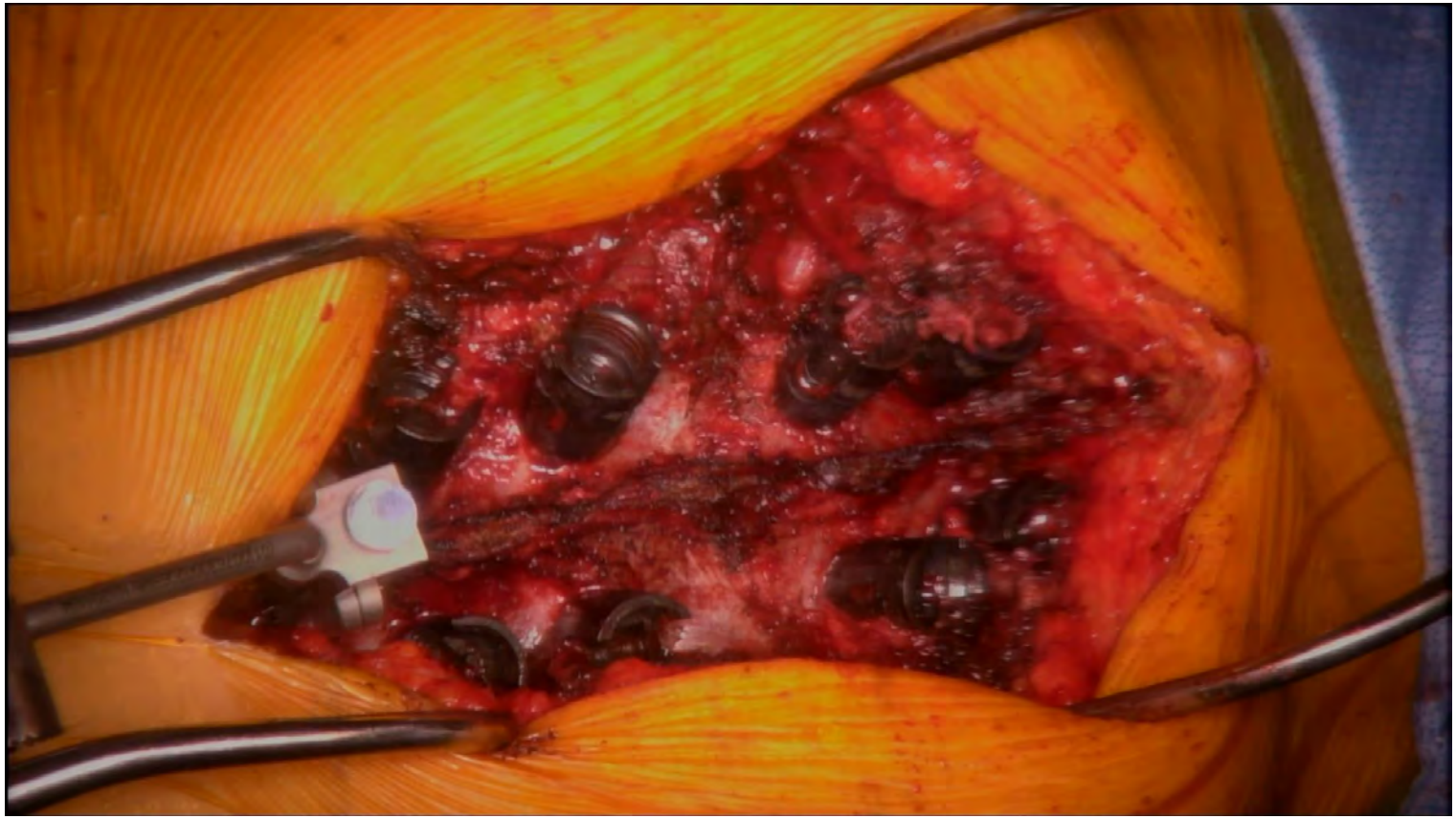


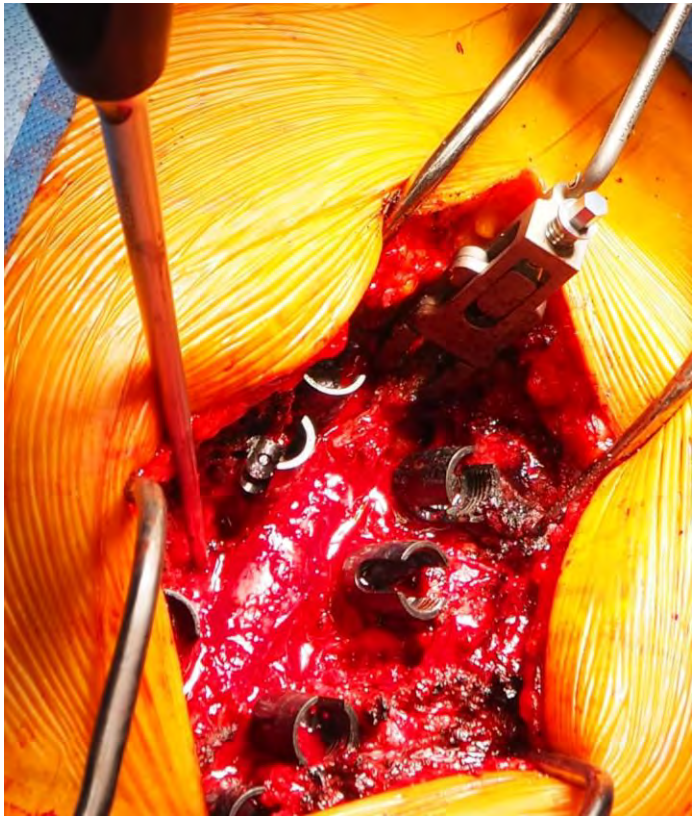


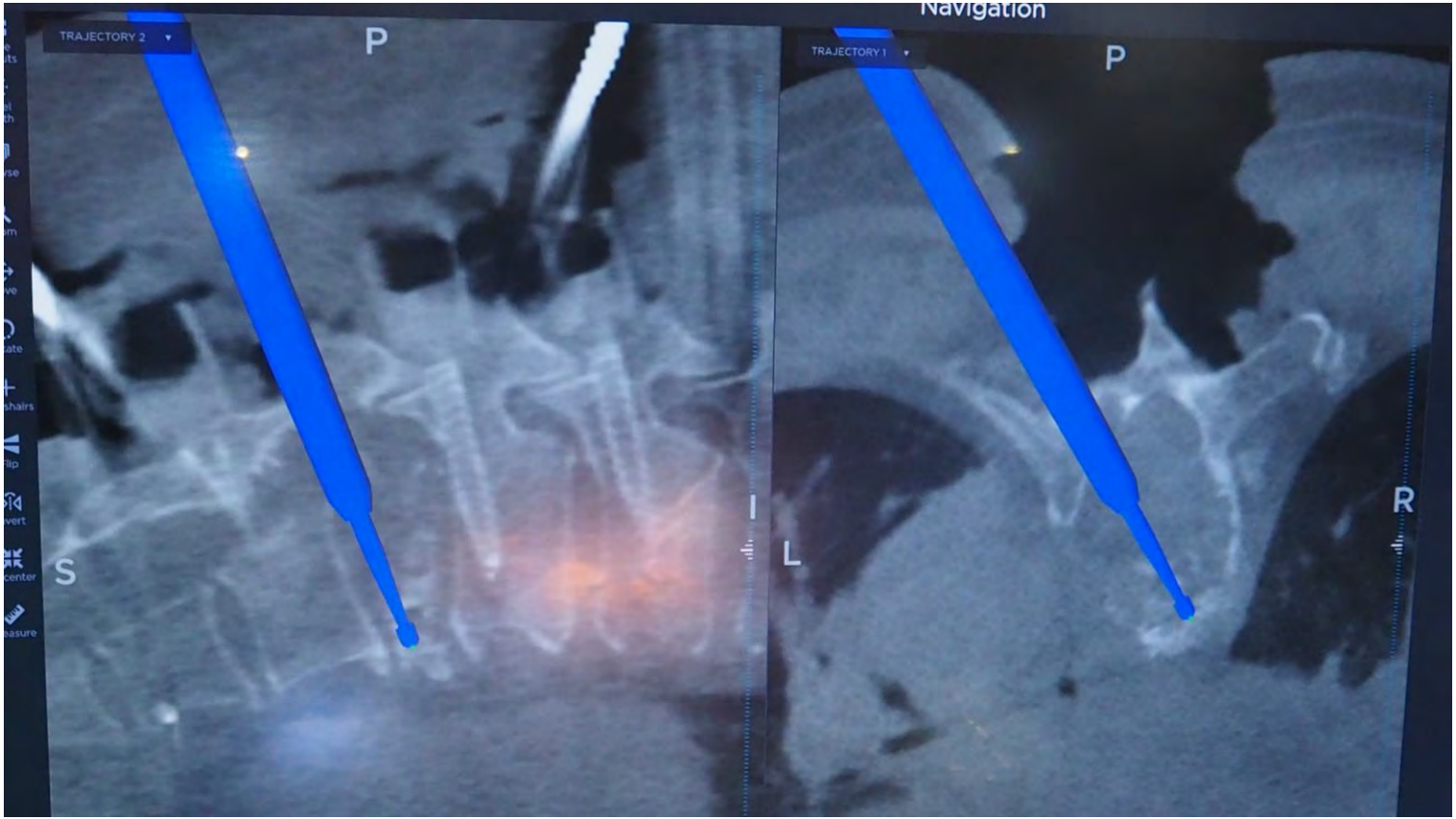








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TRAJECTORY 1
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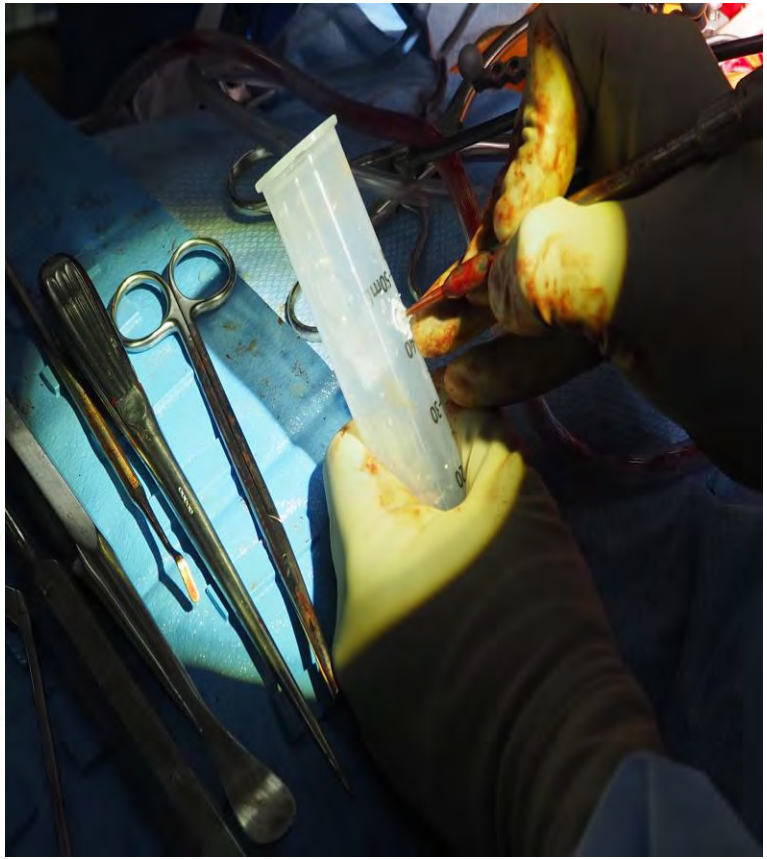
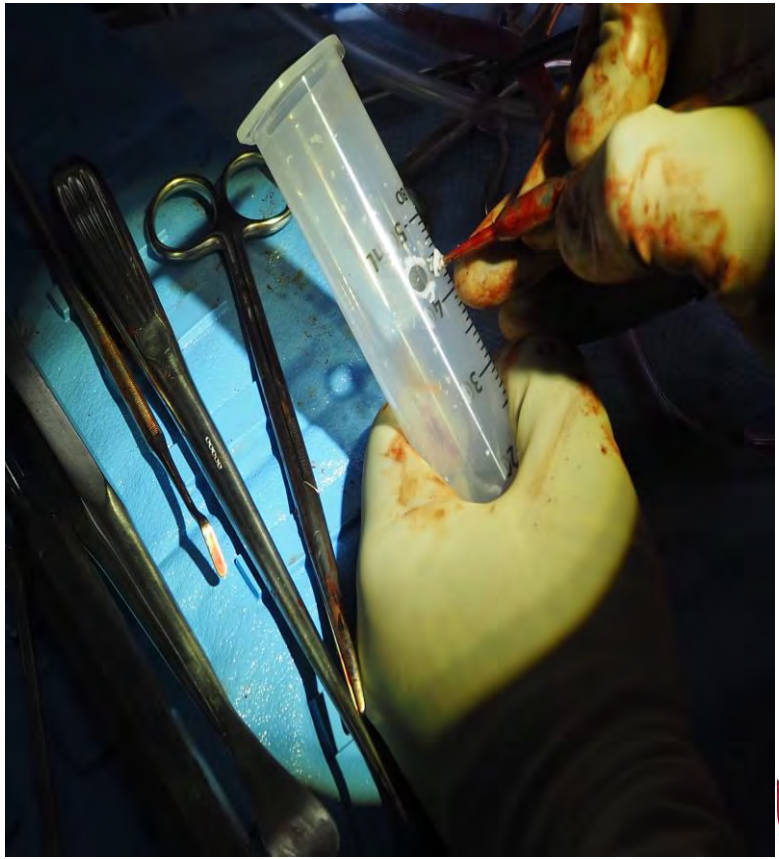
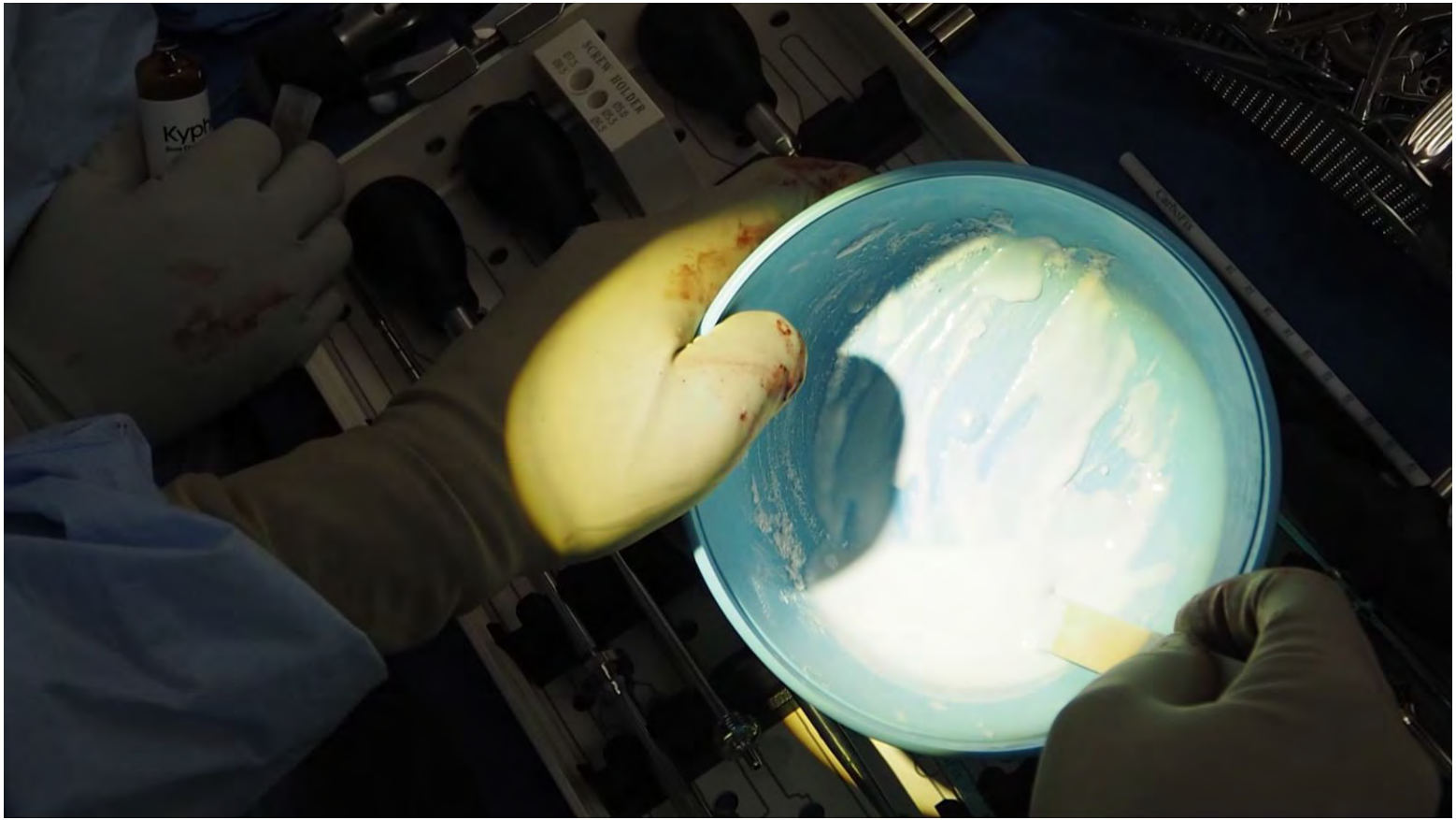
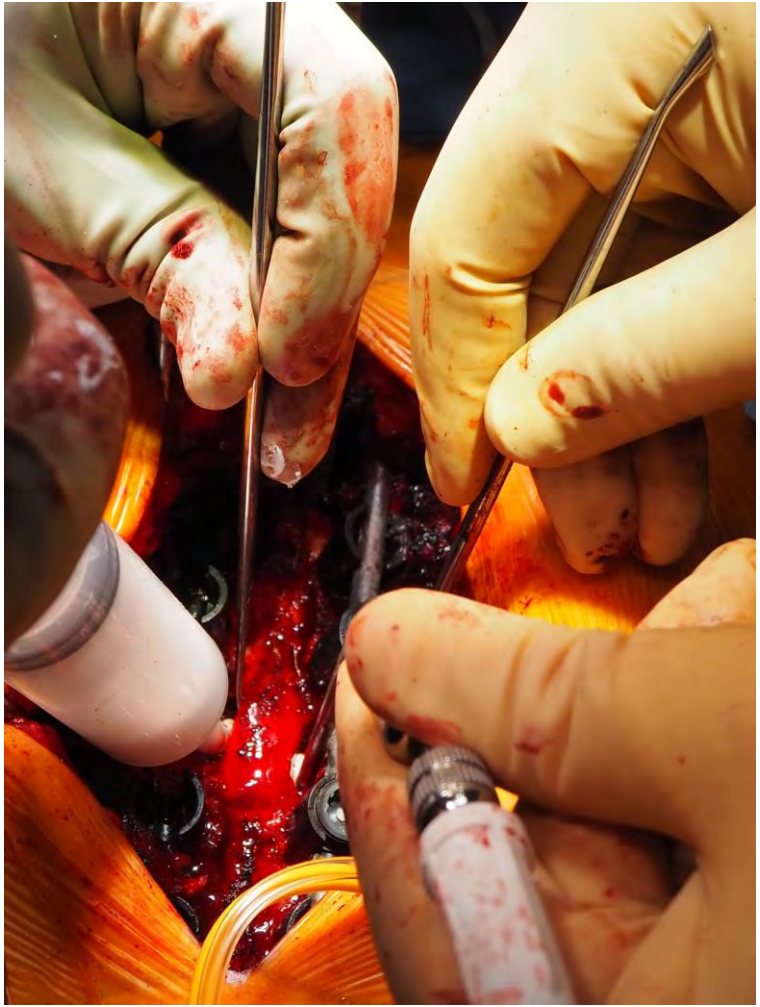
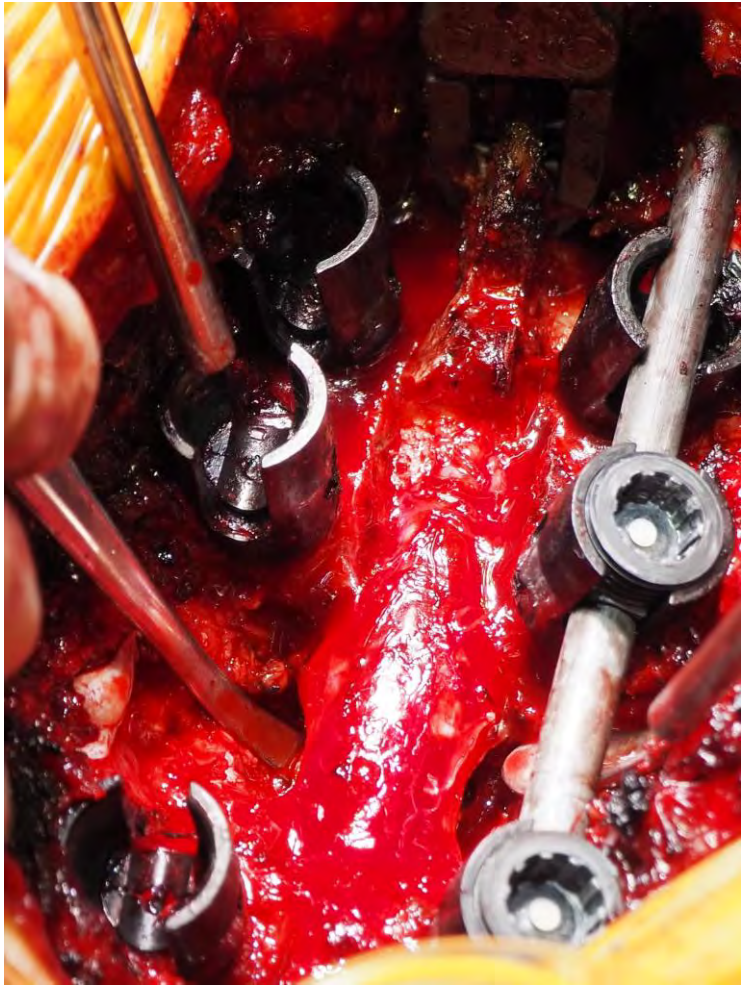
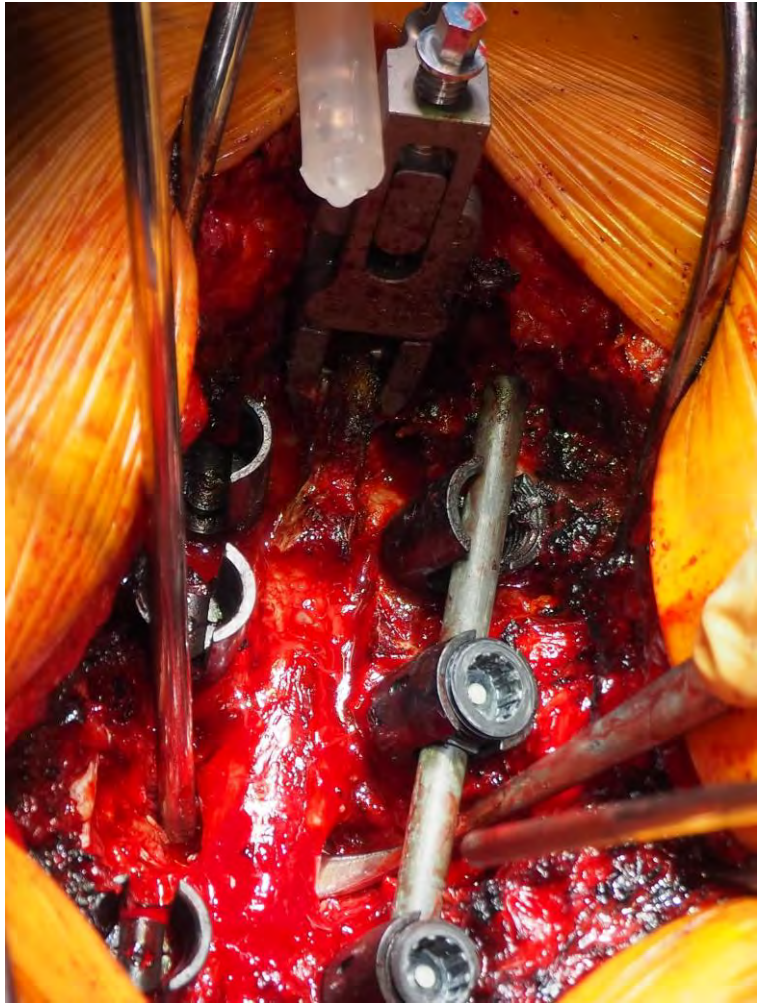


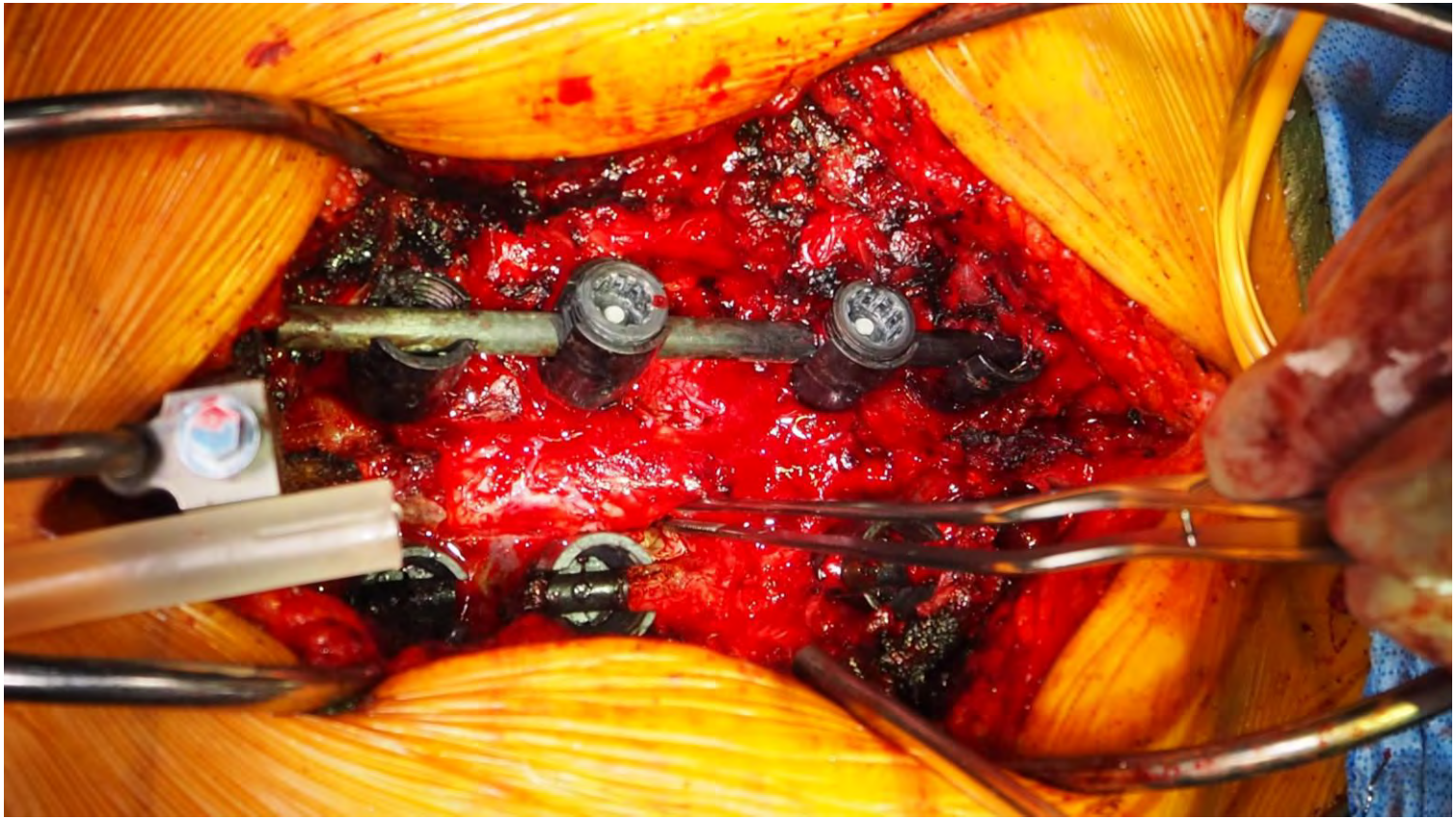


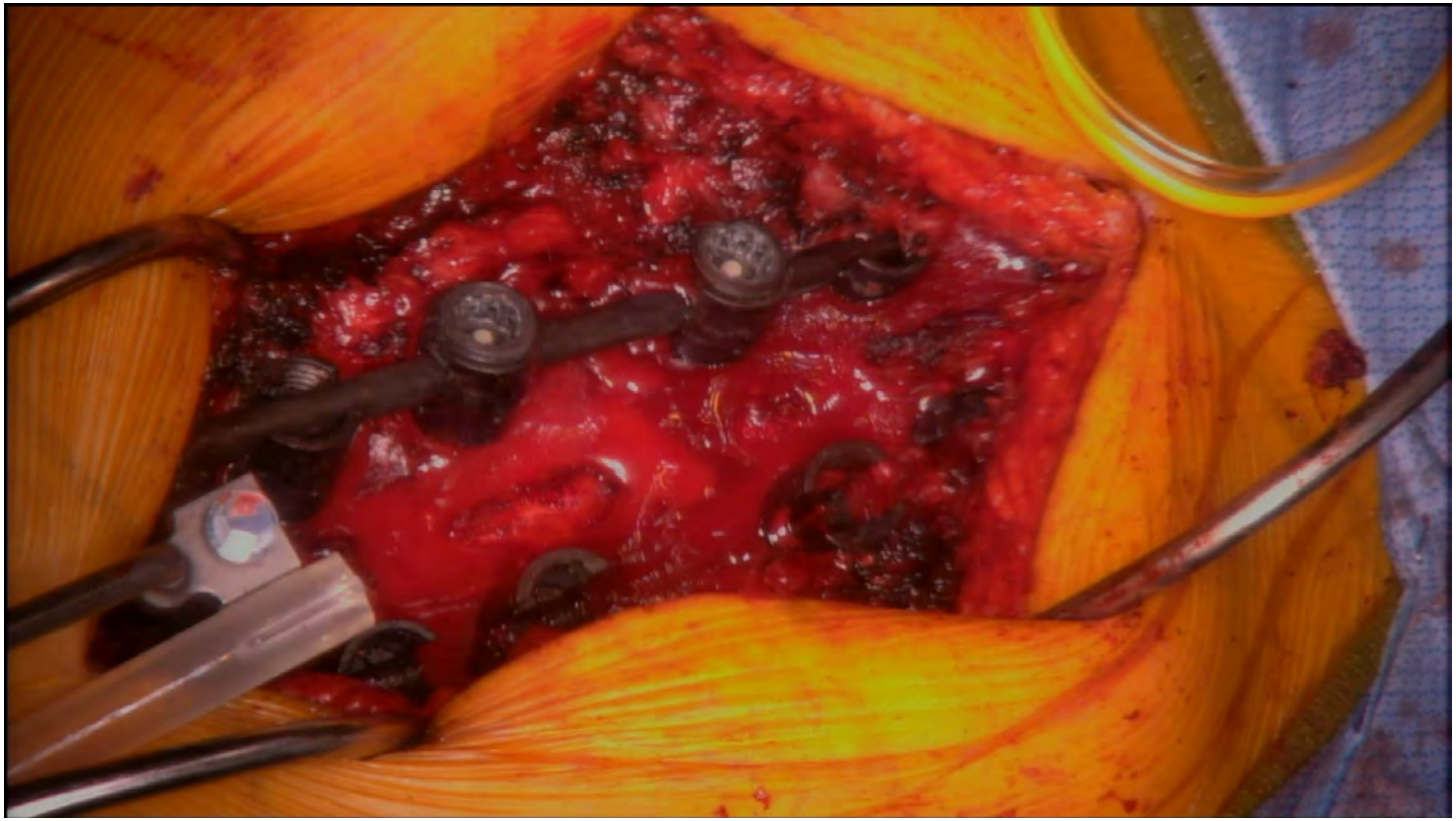

SCREW HOLDER

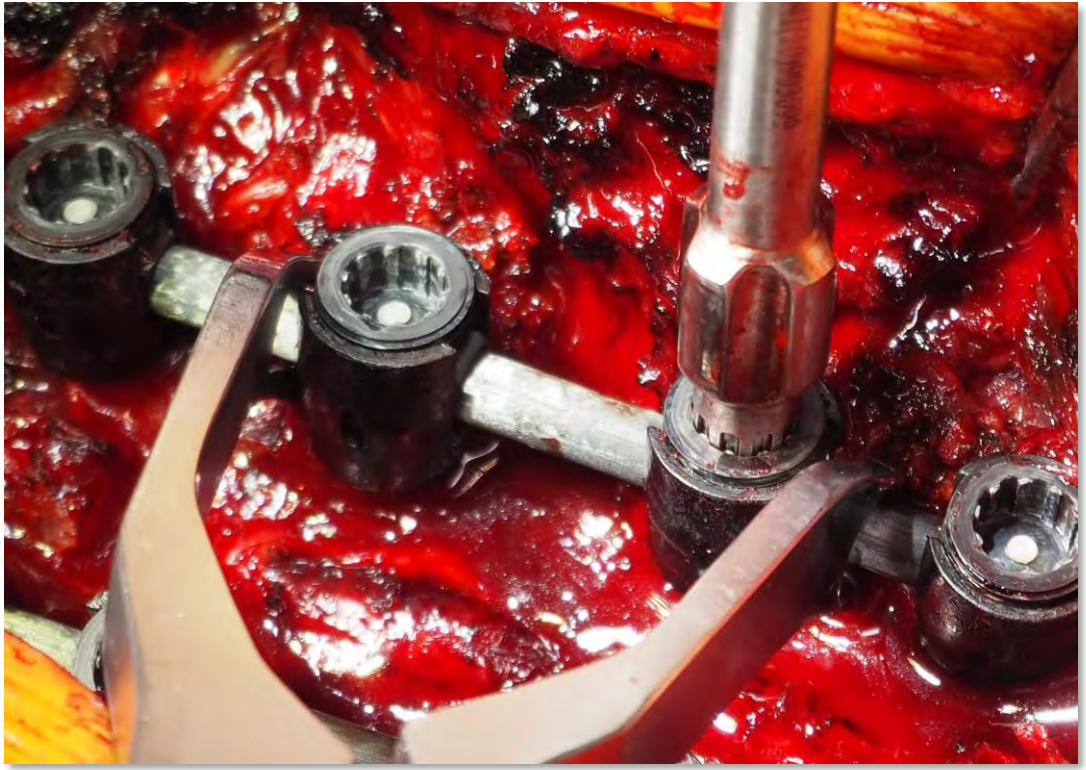


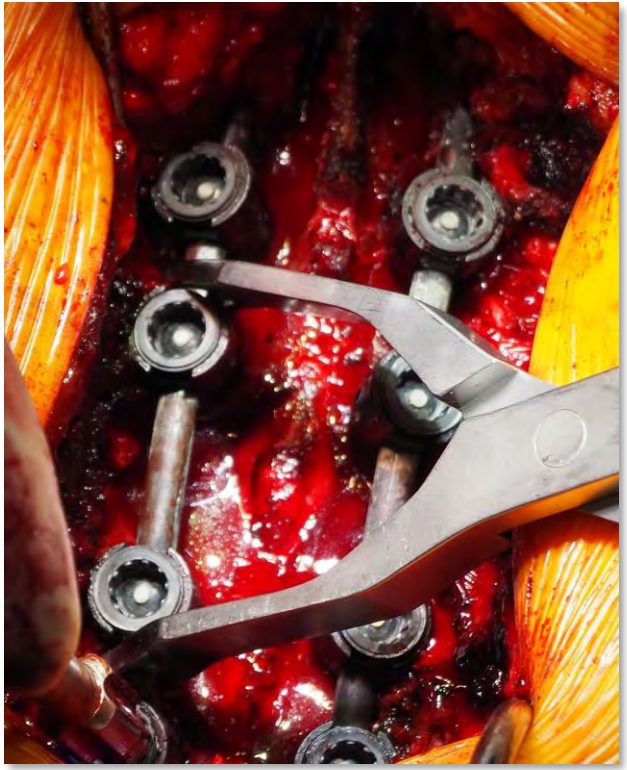


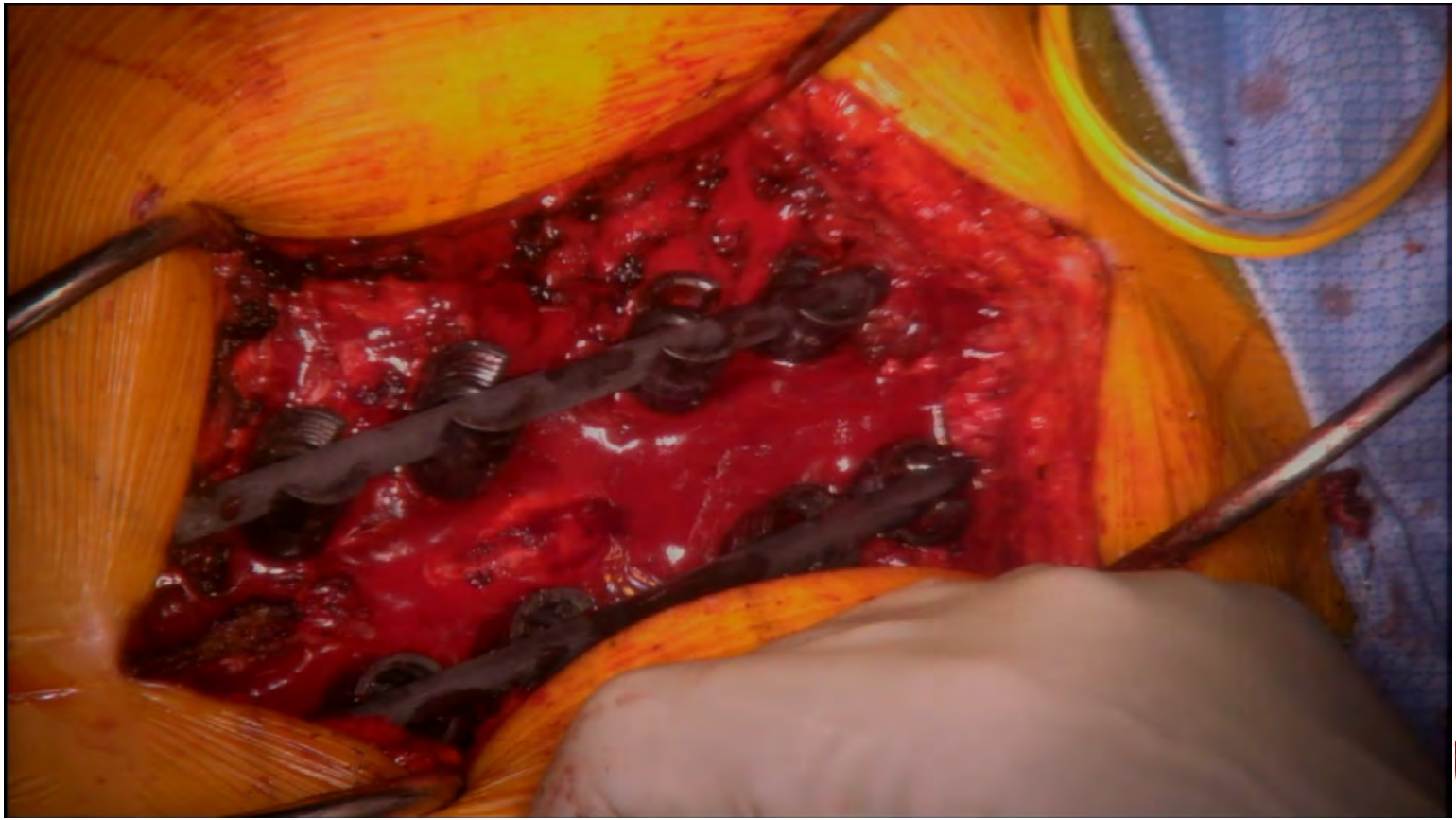


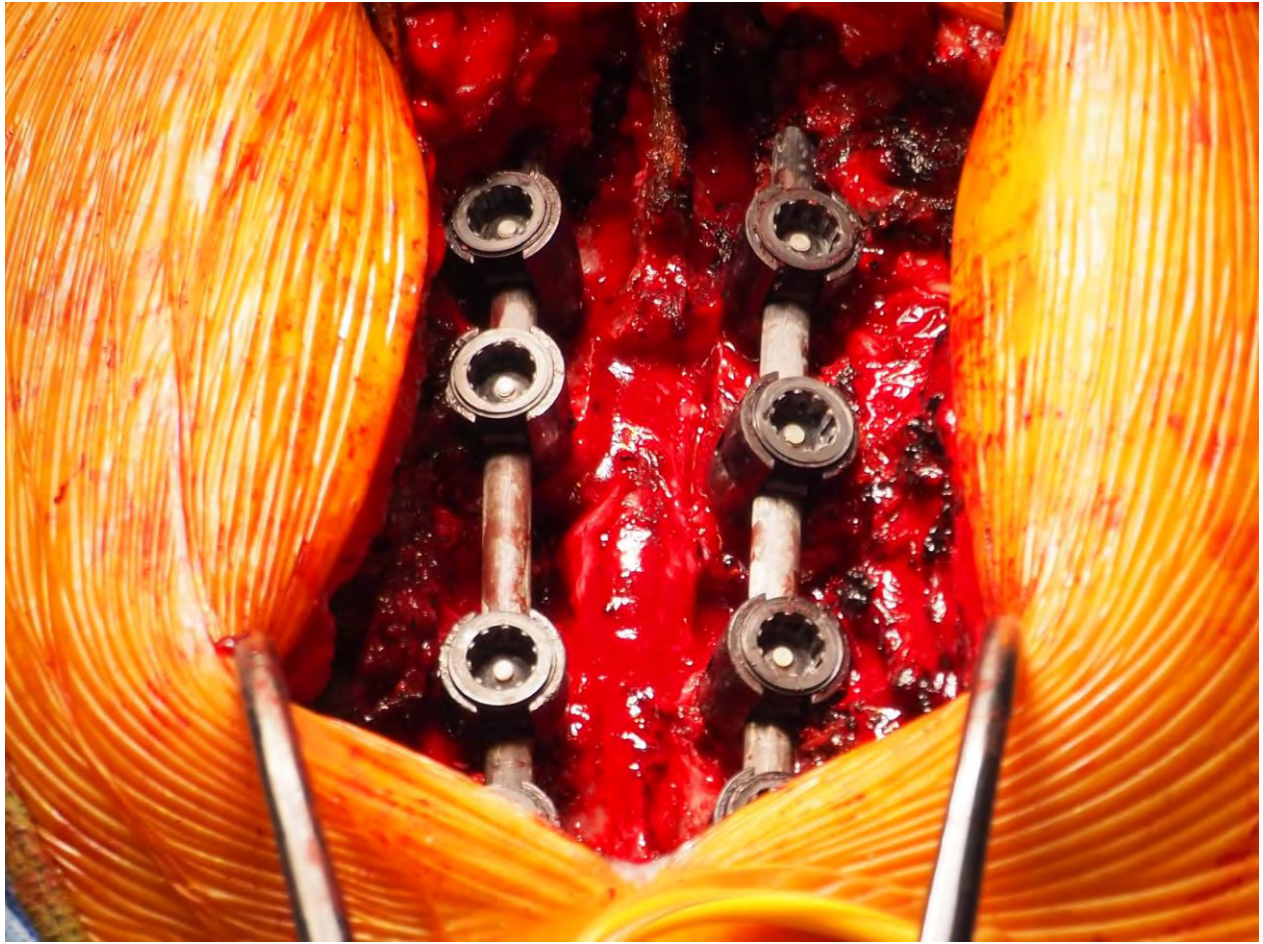


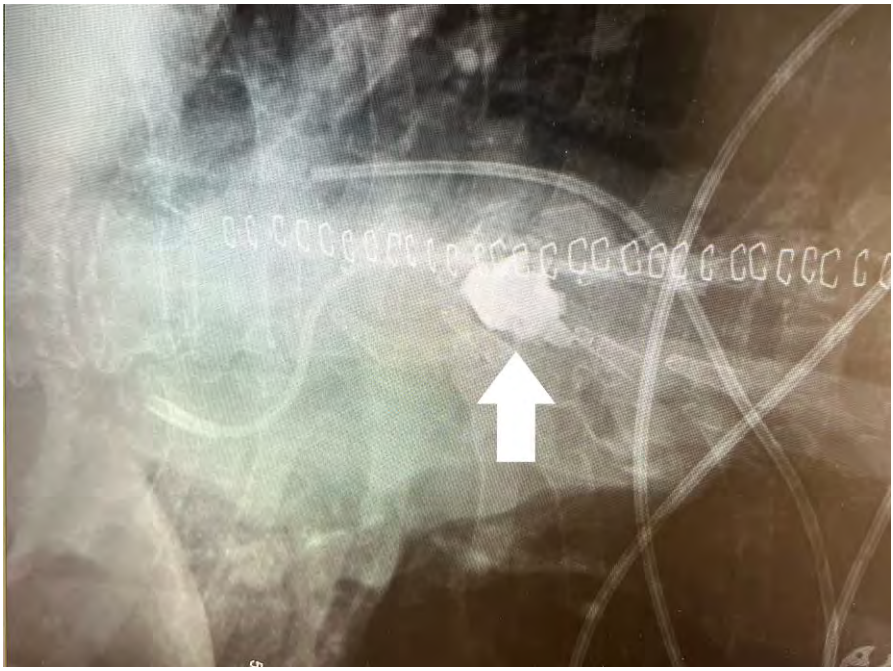


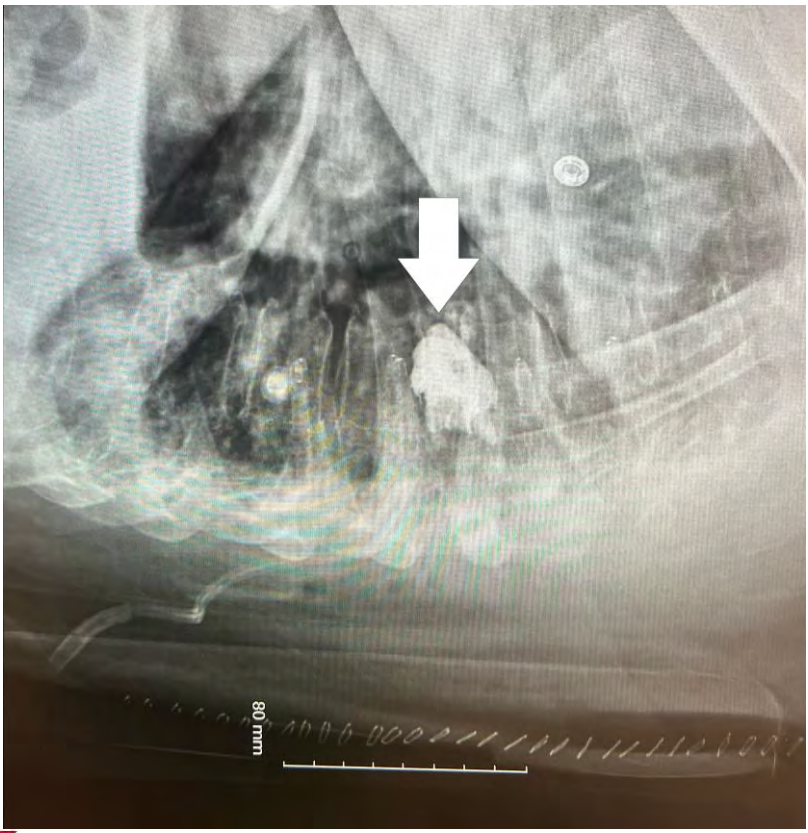








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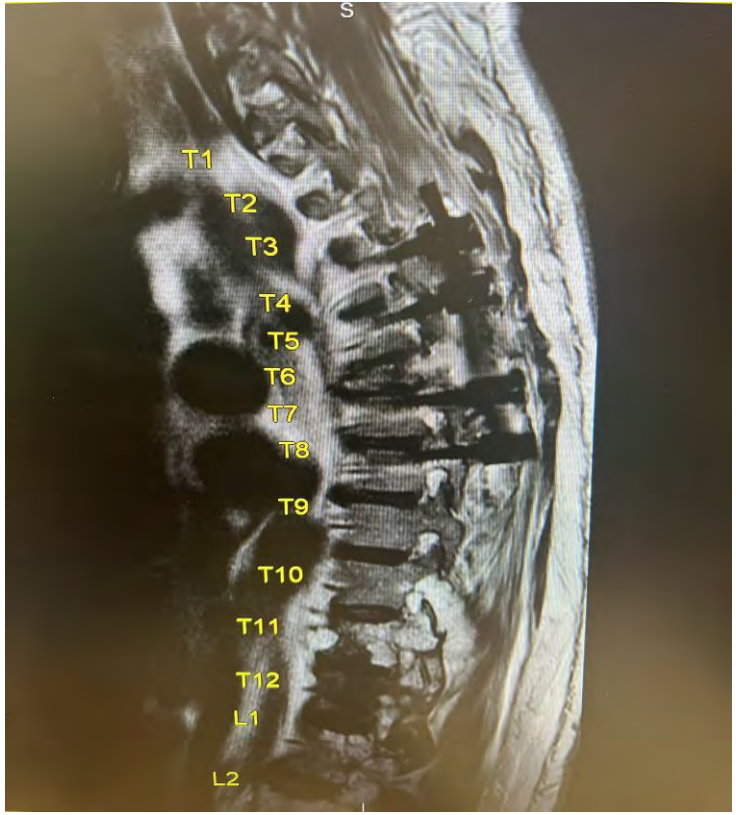
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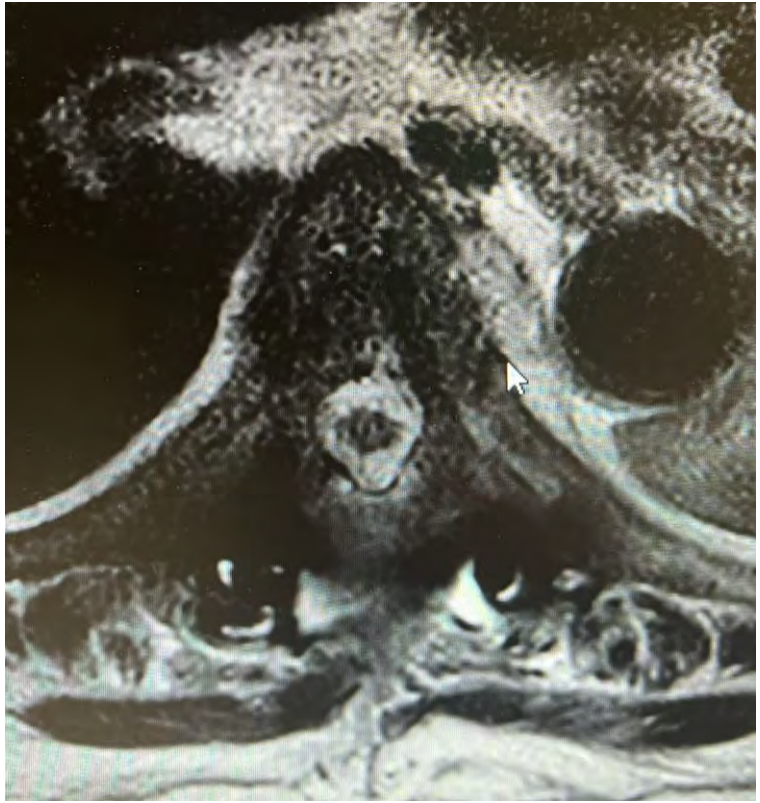


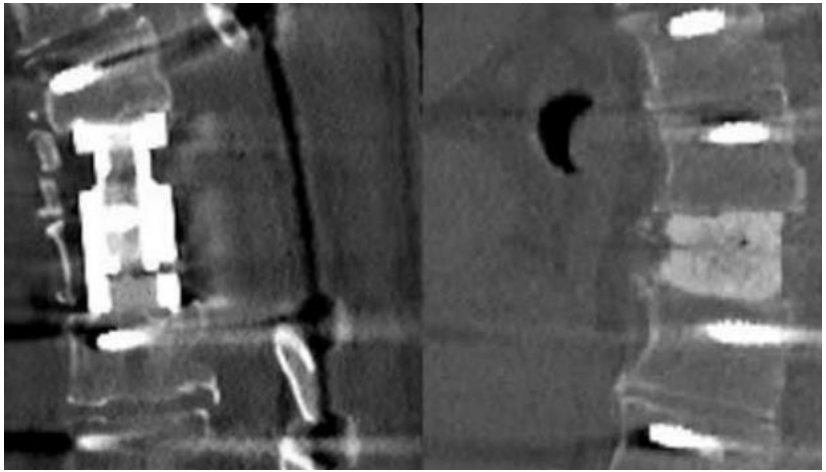
Cage or Cement for corpectomy?

TITLE:

Cost Analysis with Use of Expandable Cage or Cement in Single level Thoracic Vertebrectomy in Metastasis

AUTHORS:

Miki Katzir, MD[1], Tarush Rustagi, MS, DNB[1,2], Jeffrey Hatef, MD[1], , Ehud Mendel, MD[1]



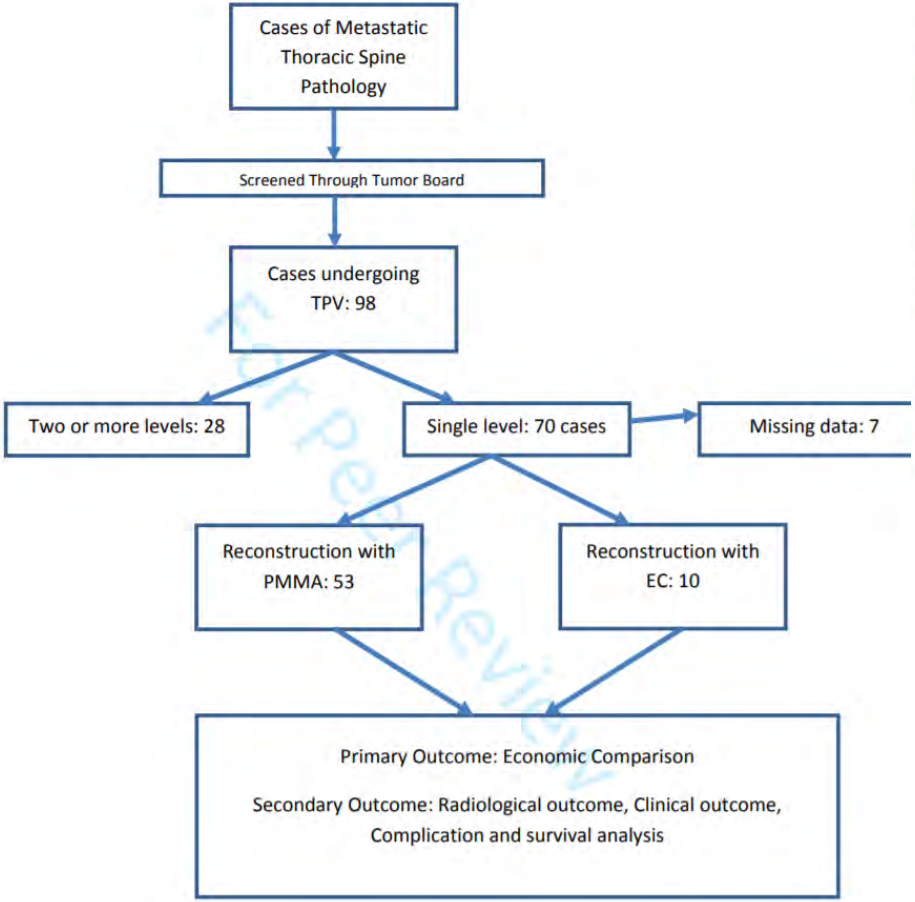


Table 1. Levels resected

Number of tumor levels	Sample Size	Percent (%)
1	**70**	**76**
2	18	20
3	3	3
4	1	1
Total	92	100

Case numbers by number of levels resected.

Table 2. Operating room time for single level surgeries

Construct	Sample Size	Mean OR time (min)	St. Dev.	*p* value
Cage	10	454.5	125.3	0.6193
Cement	53	437.5	93.7	

Detailed comparison of operating room time utilization for cement and cage during one level surgery.

Table 3. Institutional costs

Item	Cost ($)
OR time	200/min
Cage	9,000
Cement	75

Average cost for elements associated with vertebrectomy surgery.

Table 4. Totals costs for single level surgeries

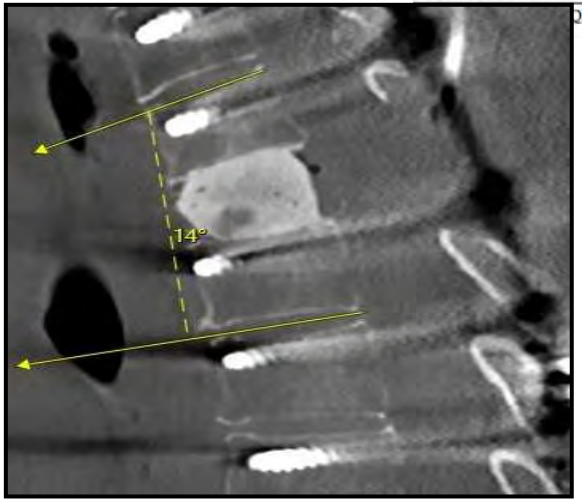
Construct	Sample Size	Total Cost ($)	St. Dev. ($)	*p* value
Cage	10	102,789.28	19,703.75	0.0348
Cement	53	82,280	6,321.39	

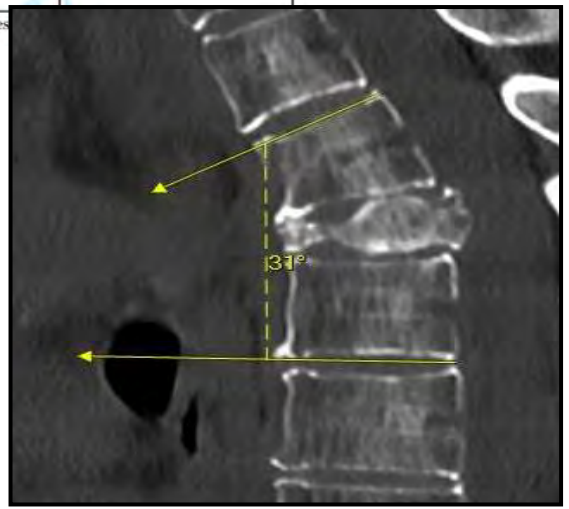
Detailed comparison of total costs for cage or cement use during single level surgery.

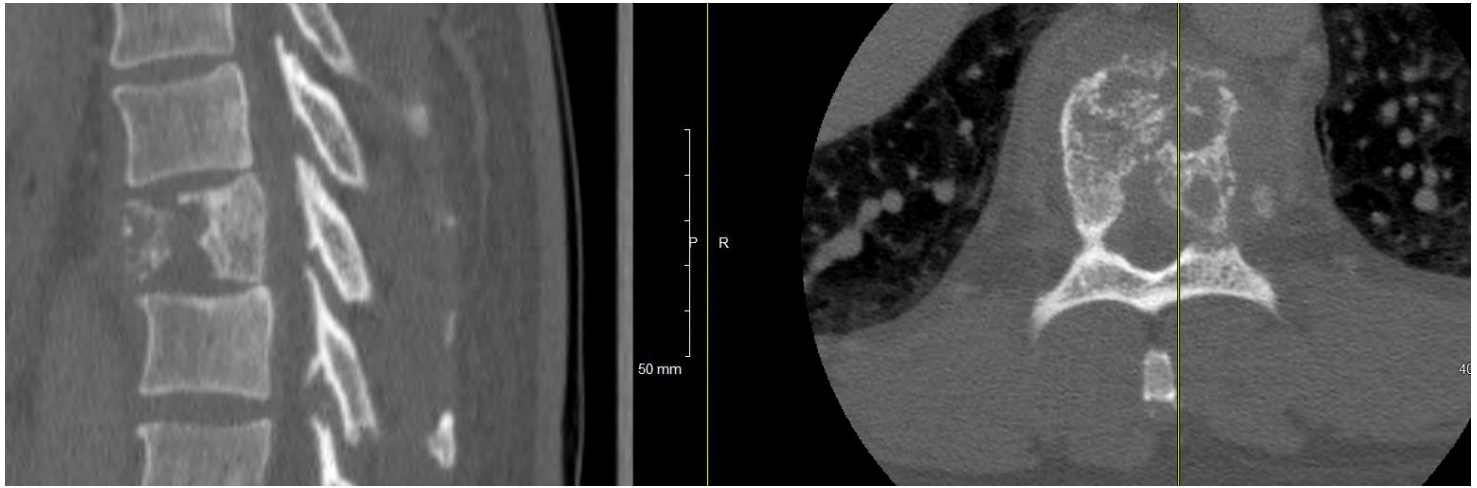
TABLE 5. Operative Outcomes by Construct Type

Variable	Cage (n = 10)	Cement (n = 53)	P-Value
Difference in Frankel grade[#]	0 [0, 0] (–1, 2)	0 [0, 0] (–1, 3)	0.3625
Cord decompression, mm[#]	5 [1.5, 7] (0, 8)	4 [2, 6] (0, 10)	0.8369
Cobb angle difference (Degrees)[#]	0[0,0](-12,0)	-3[-11,0](-18,0)	0.0631 (0.012)
Operative complications[$]	3 (30%)	6 (11.3%)	0.3910
Postoperative complications [$]	4 (40%)	16 (30%)	0.3836

QR] (minimum, maximum). $: Values



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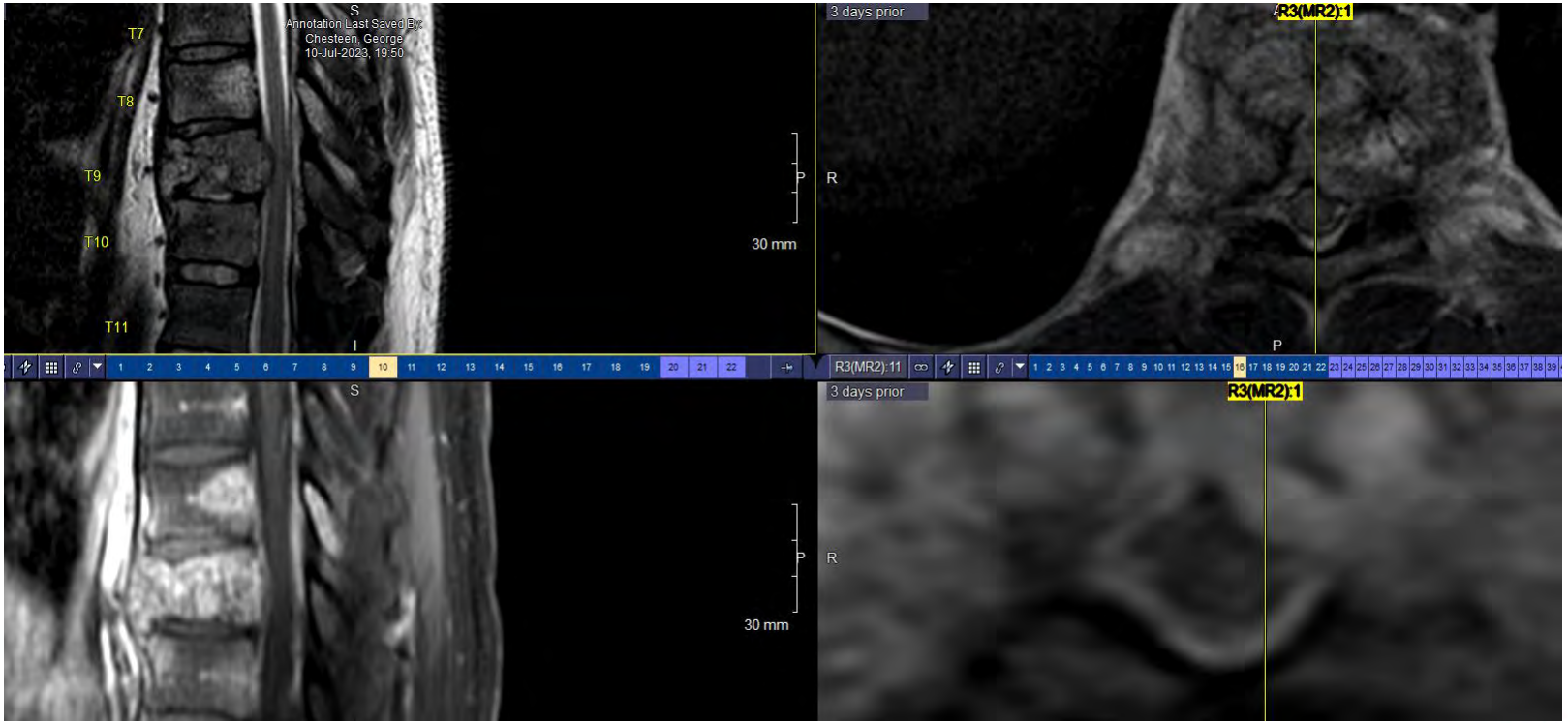
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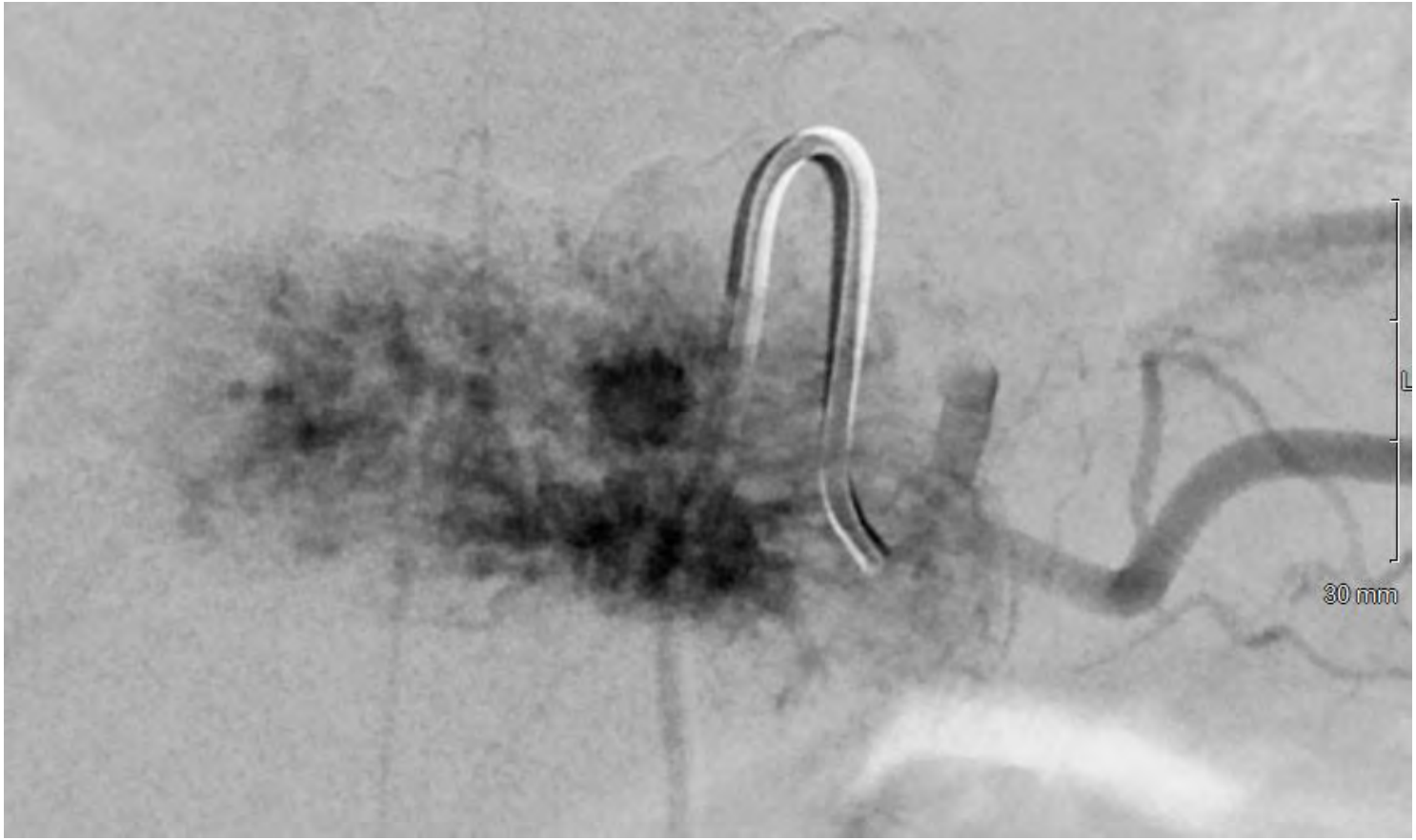
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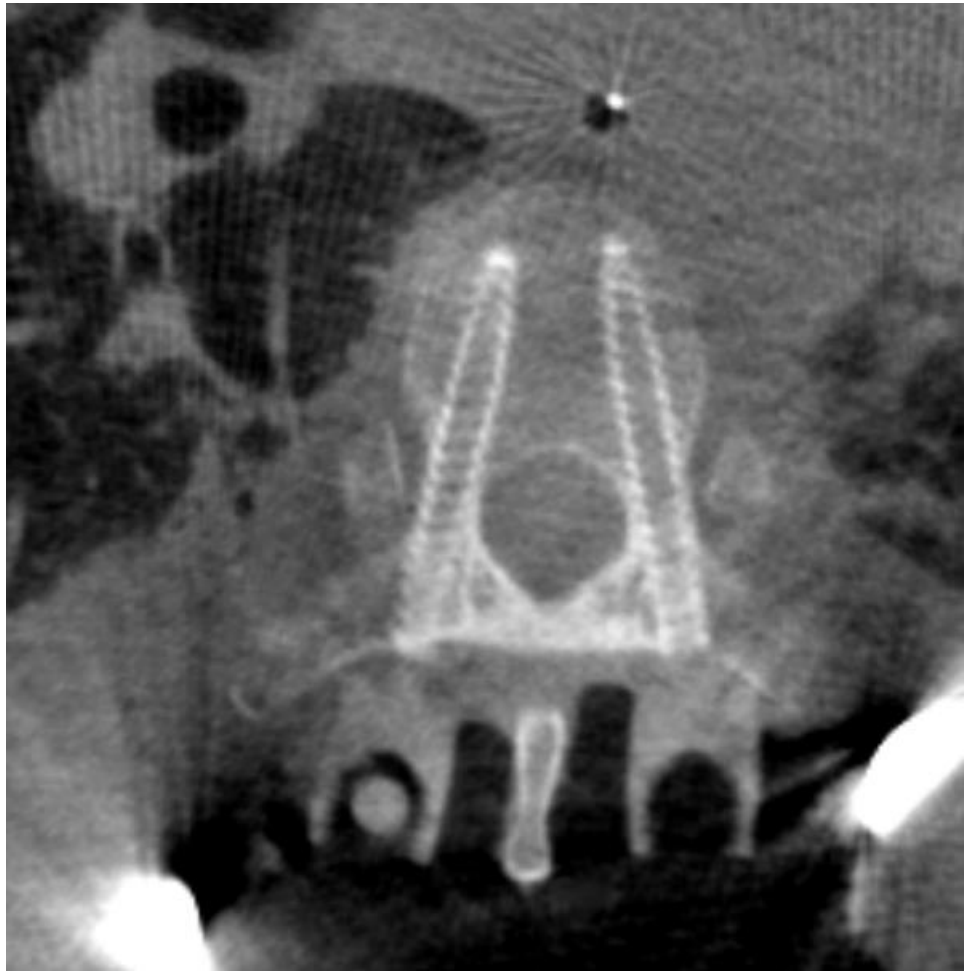


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My Advice to you:

Avoid Operating on spine tumors (Your results will be better)

The most important instrument is your brain-use it!

Beware of the *single Hammer Syndrome*

Never Take Any spine tumor case for Granted Particularly the “Obvious”

Operative indications **to avoid:**

-The Family wants it / We can't make the Patient worse

-His oncologist wants it / We haven’t done one in a while

-Patient is no good the way he/she is

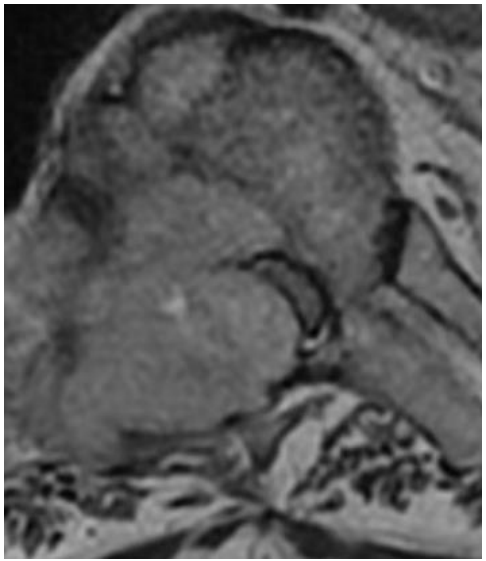
-That will make a nice case report

Courtesy Dr. Ehud Mendel

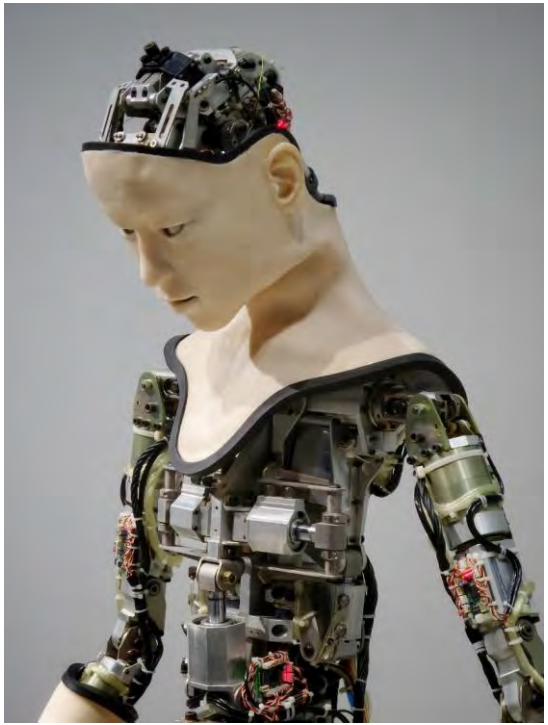
Conclusions

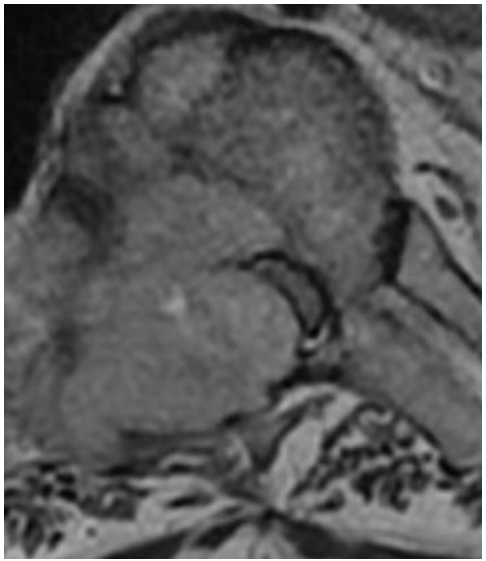
- We can restore/protect neurologic function
- We can improve pain and have a significant impact on the quality of life of the patients
- A multidisciplinary approach is necessary for formulating an individualized management plan but,
- There is no perfect algorithm!

Our patients are part of us



Our patients are part of us





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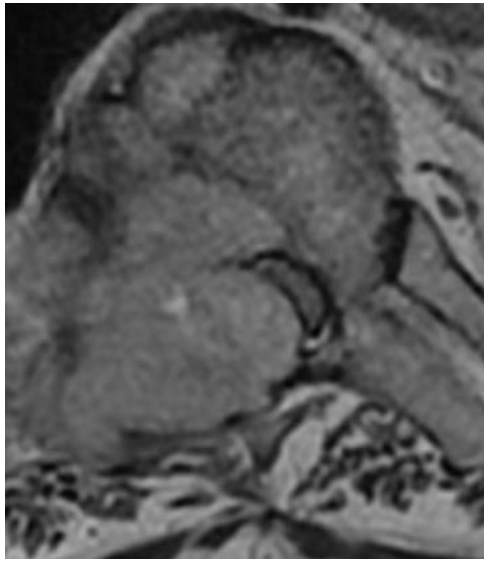

Thank you

FRED & PAMELA
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