



Bildgebende Verfahren

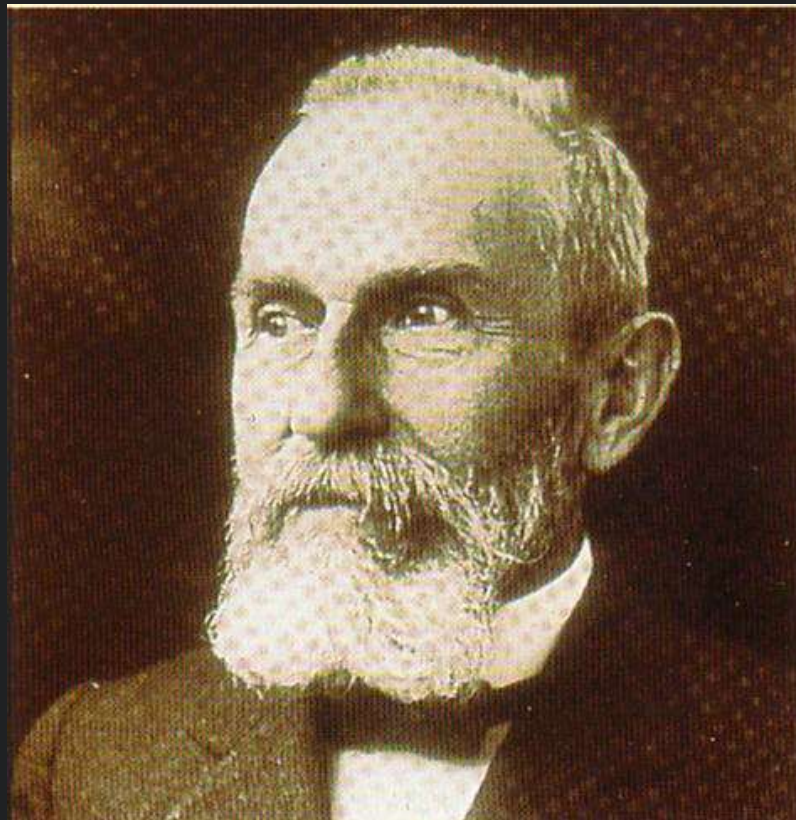
Techniken
Stellenwert in der Schmerztherapie

Markus Berger

SPZ Nottwil

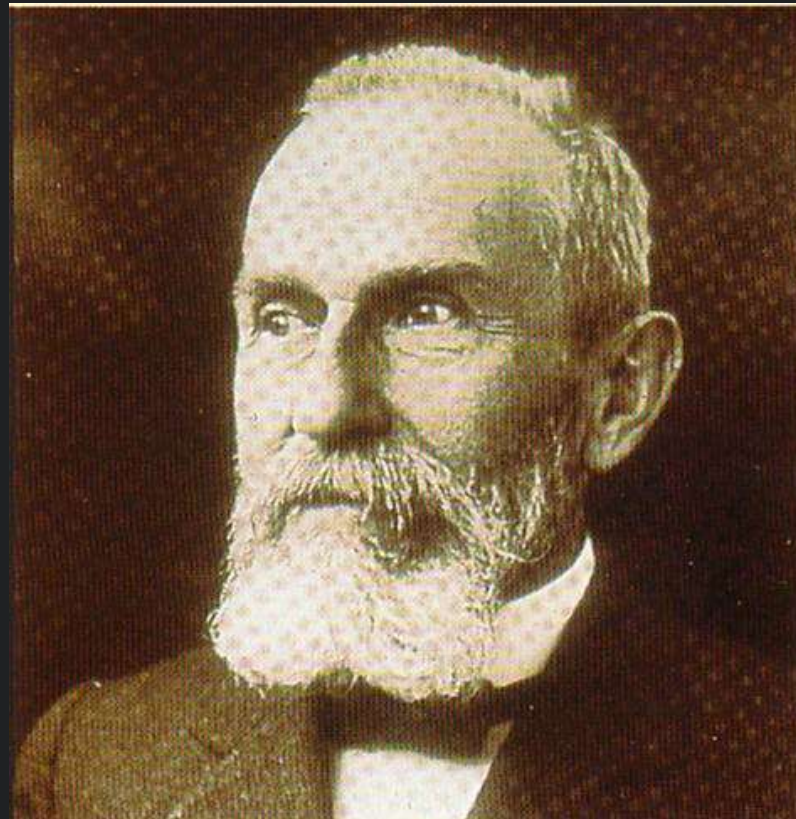
Übersicht

- die gebräuchlichsten technischen Verfahren
- Bilderquiz: Rückenschmerzen
- (selbst)kritische Reflexionen



E. Bleuler (1857-1939)

Direktor Psychiatrie Burghölzli 1898-1927



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Direktor Psychiatrie Burghölzli 1898-1927

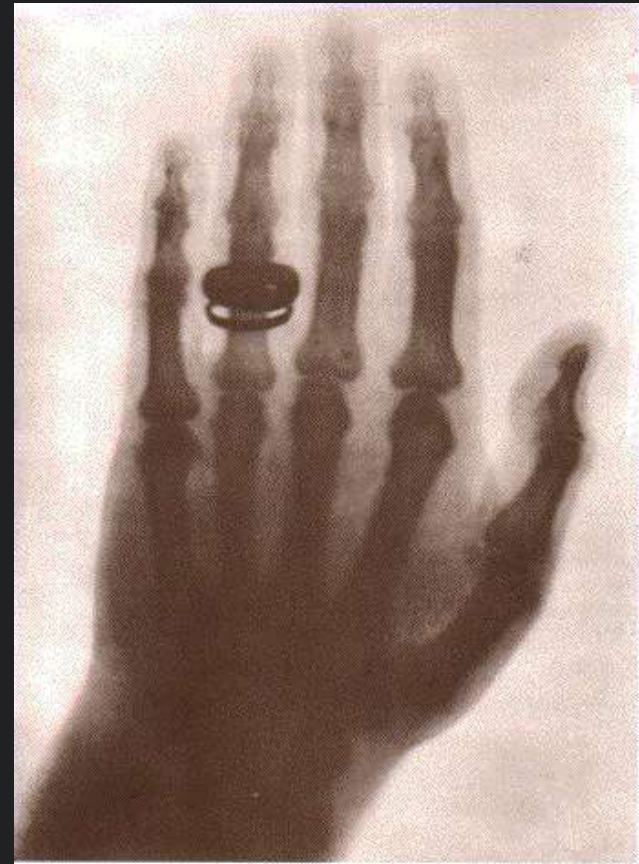
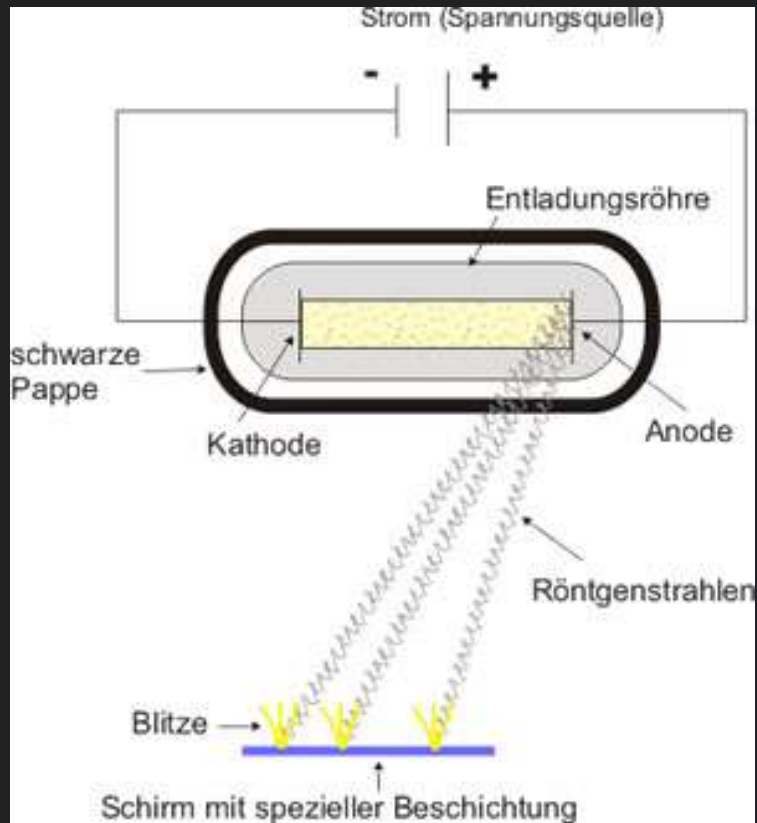


C. W. Röntgen (1845-1923)

Nobelpreis für Physik 1901



Röntgen



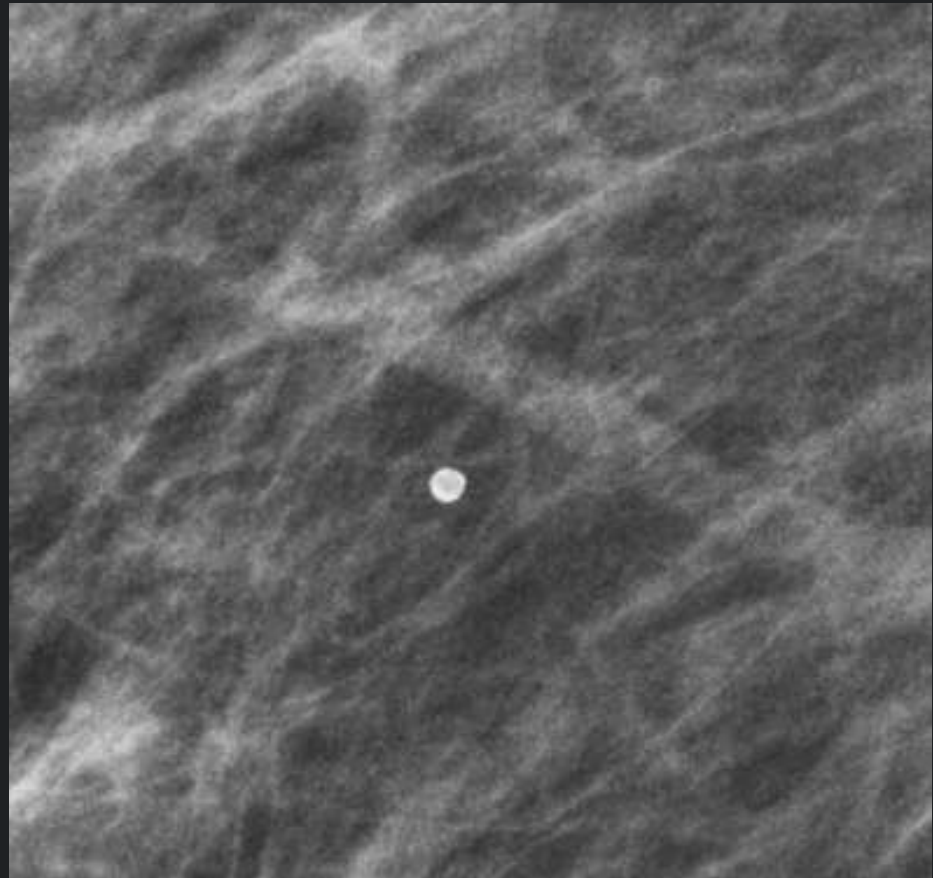
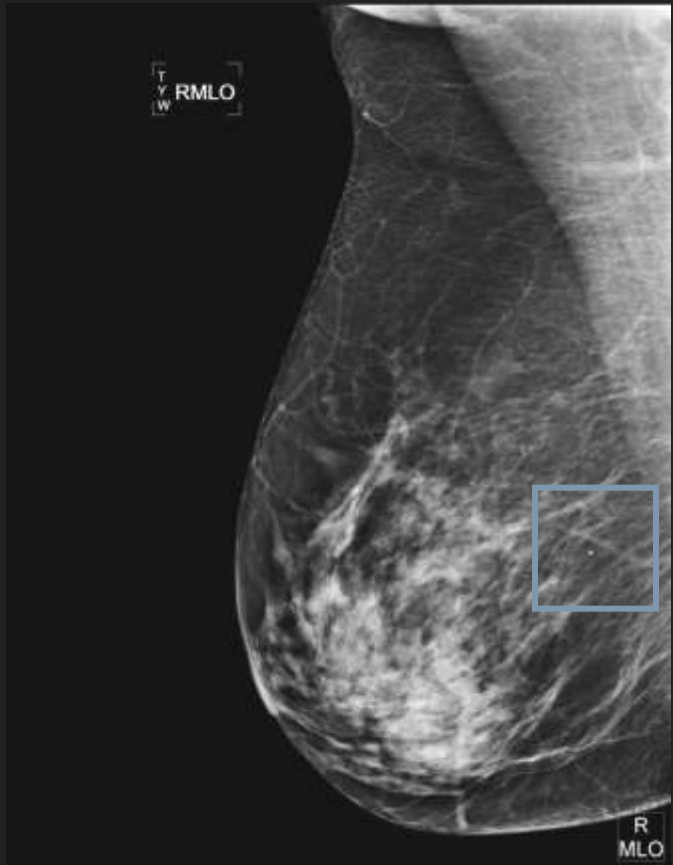
Röntgen



Röntgen



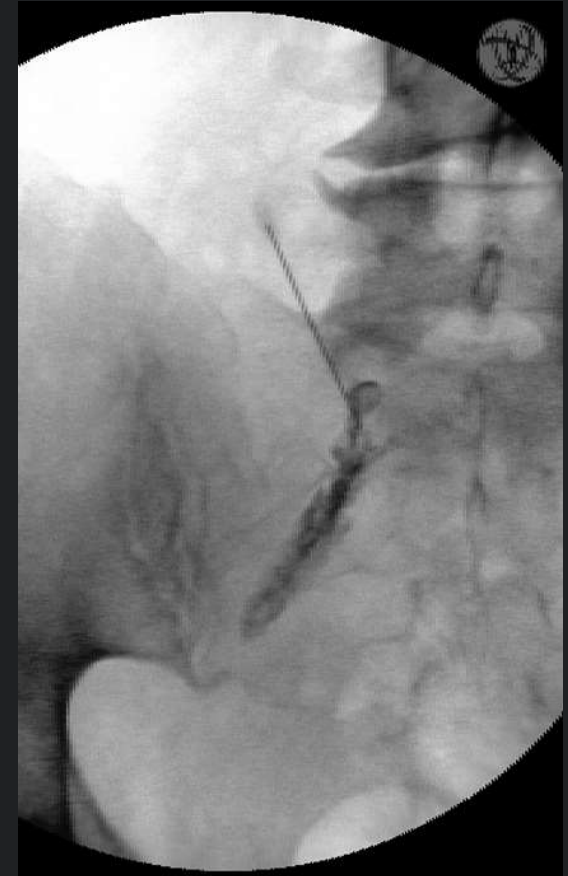
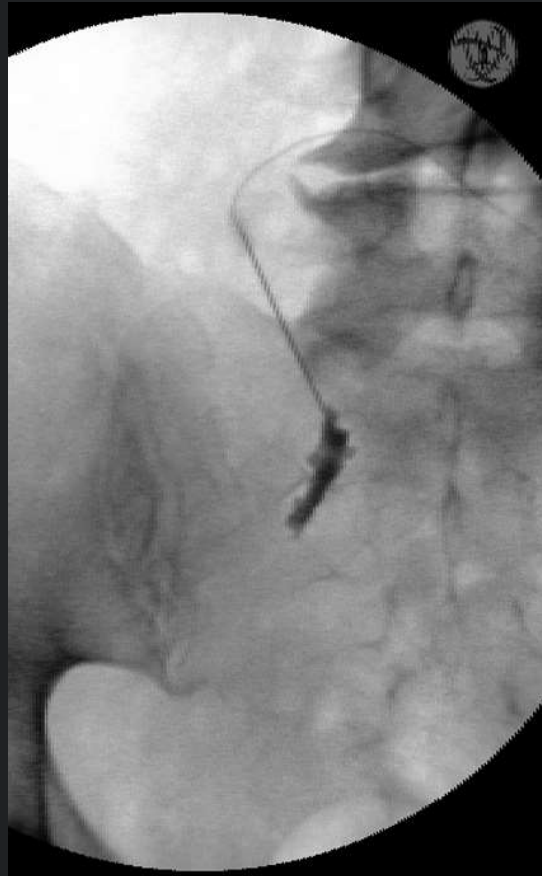
Röntgen



Röntgen Durchleuchtung



Röntgen Intervention



Röntgen/Durchleuchtung

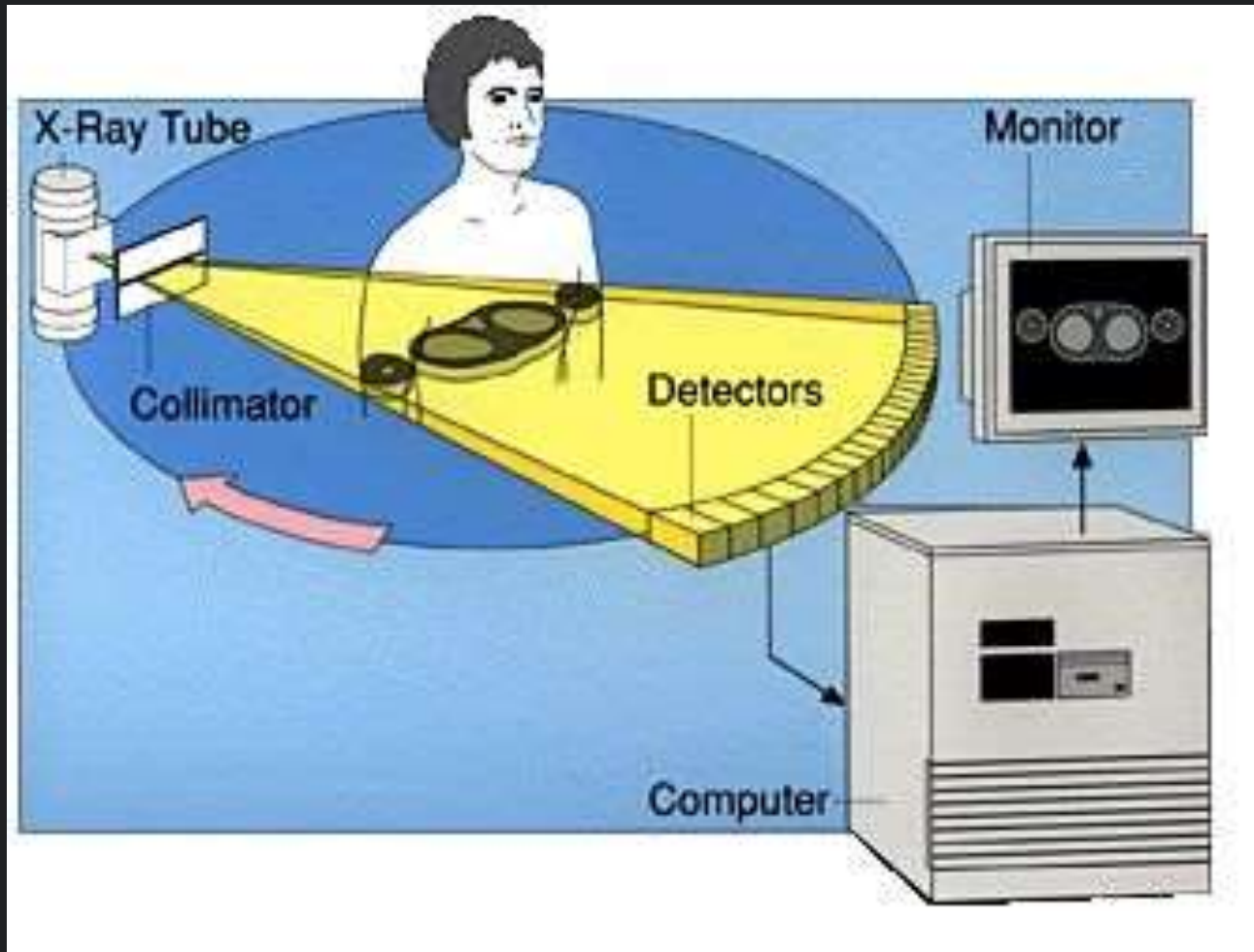
- ionisierende Strahlen
- tiefe Kosten, schnell erhältlich
- kürzeste Datenaquisition (~Bruchteile von Sekunden)
- teilweise mobil
- höchste räumliche Auflösung (10lp/mm)
- unterscheidet Luft, Fett, Wasser, Knochen (Ca) und Kontrastmittel
- wenig empfindlich gegenüber Implantaten
- Trade-offs: Bildqualität/zeitliche Auflösung - Dosis

Godfrey N. Hounsfield (1919-2004)

Nobelpreis für Medizin 1979



Computertomographie



Computertomographie



Computertomographie



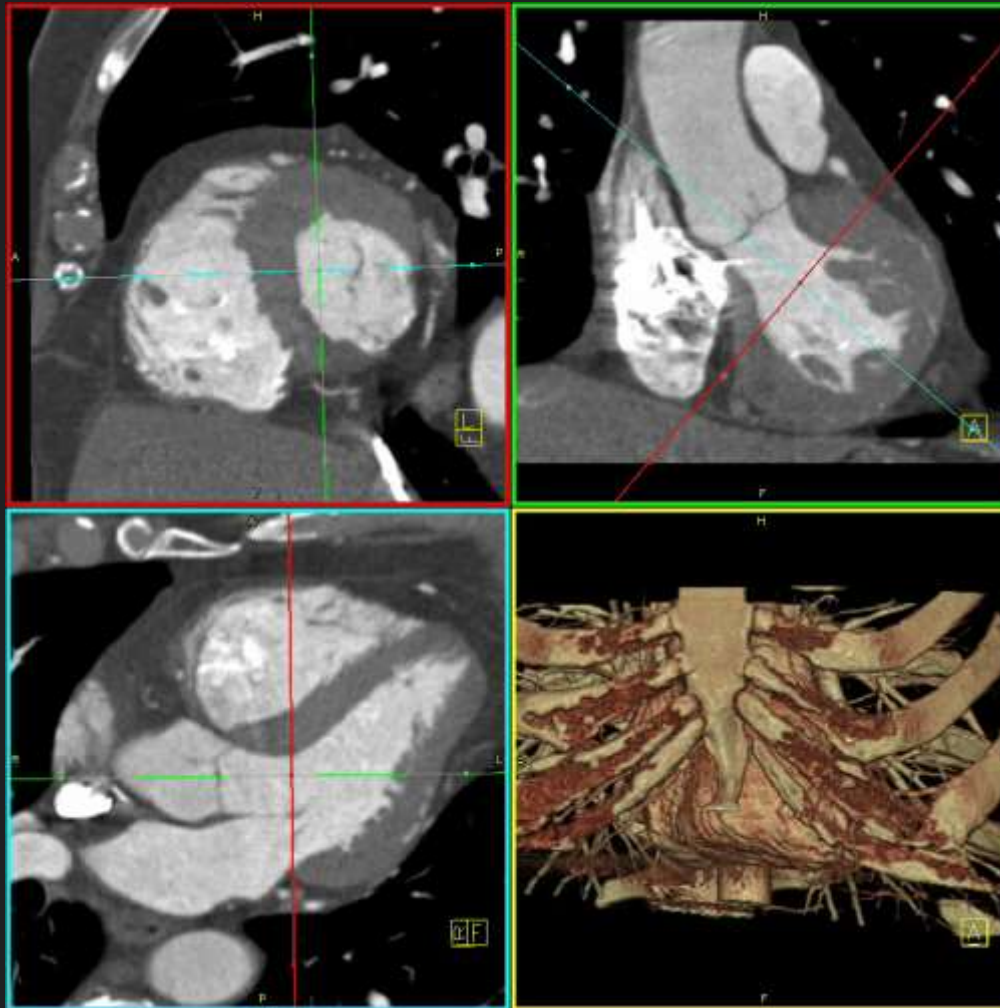
Computertomographie



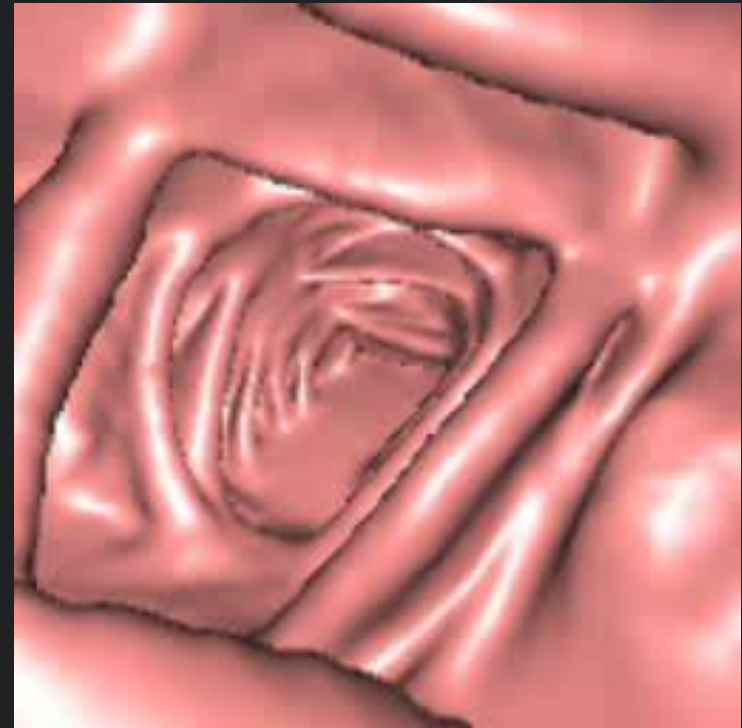
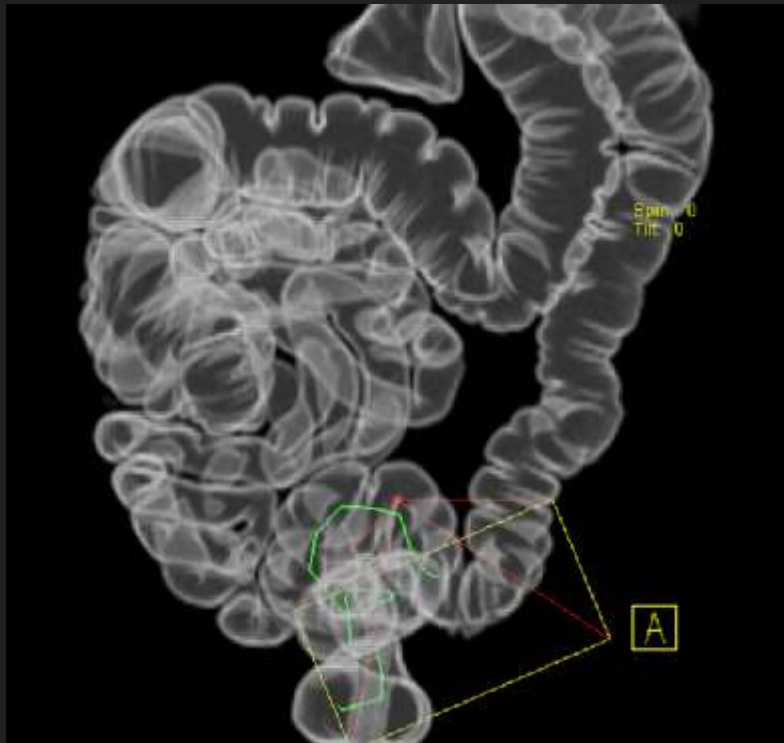
Computertomographie



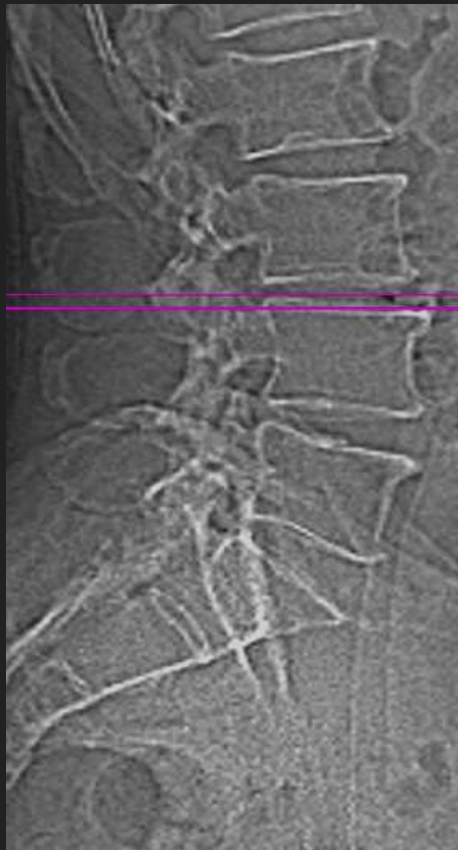
Computertomographie



Computertomographie



Computertomographie



Computertomographie

- ionisierende Strahlung; Dosis!
- mittlere Auflösung (1lp/mm)
- relative kurze Datenaquisition (~Sekunden)
- multiplanare Bildgebung, Volumenaquisition, digitale Nachverarbeitung
- Unterscheidung Luft, Fett, Wasser, Weichteile unterschiedlicher Dichte, Knochen (Ca), Kontrastmittel
- Implantate können empfindlich stören
- Trade-off: Bildqualität – Dosis/Organabdeckung/Untersuchungszeit

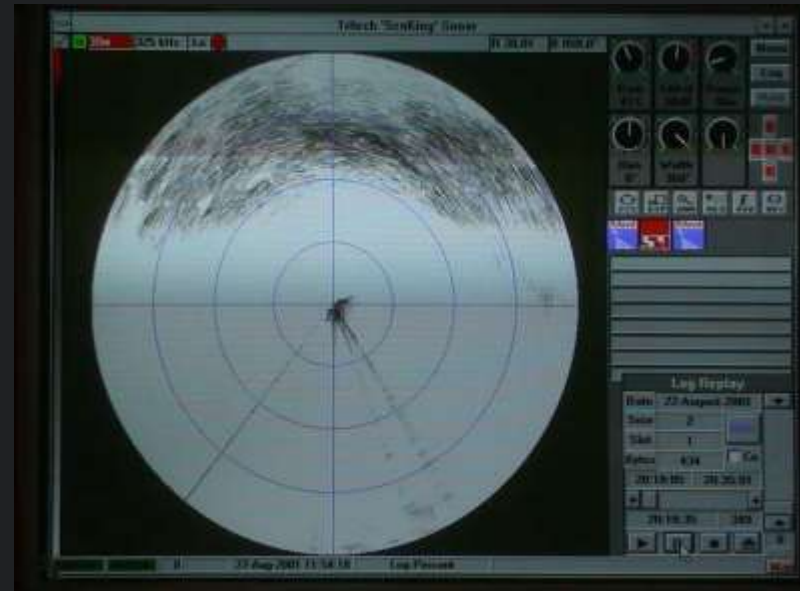
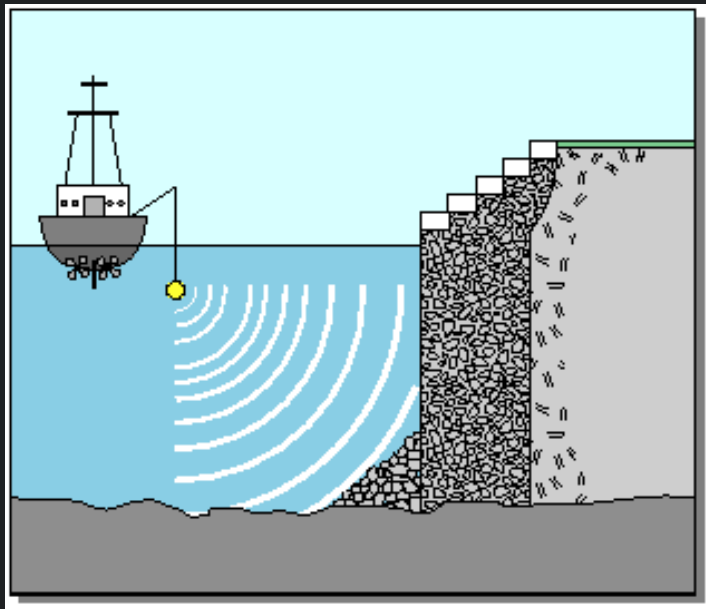
Faustregeln zur Strahlenbelastung (grob!!)

- „natürliche“ Hintergrundstrahlung
(ca. 2 mSv/Jahr)
- Thoraxröntgen: 1/20 davon
(~Transatlantikflug)
- WS-Röntgen: ~10 Thoraxbilder
- CT: ~100 Thoraxbilder

Ian Donald (1910-1987)



Ultraschall



Ultraschall



The pan-scanner in 1957



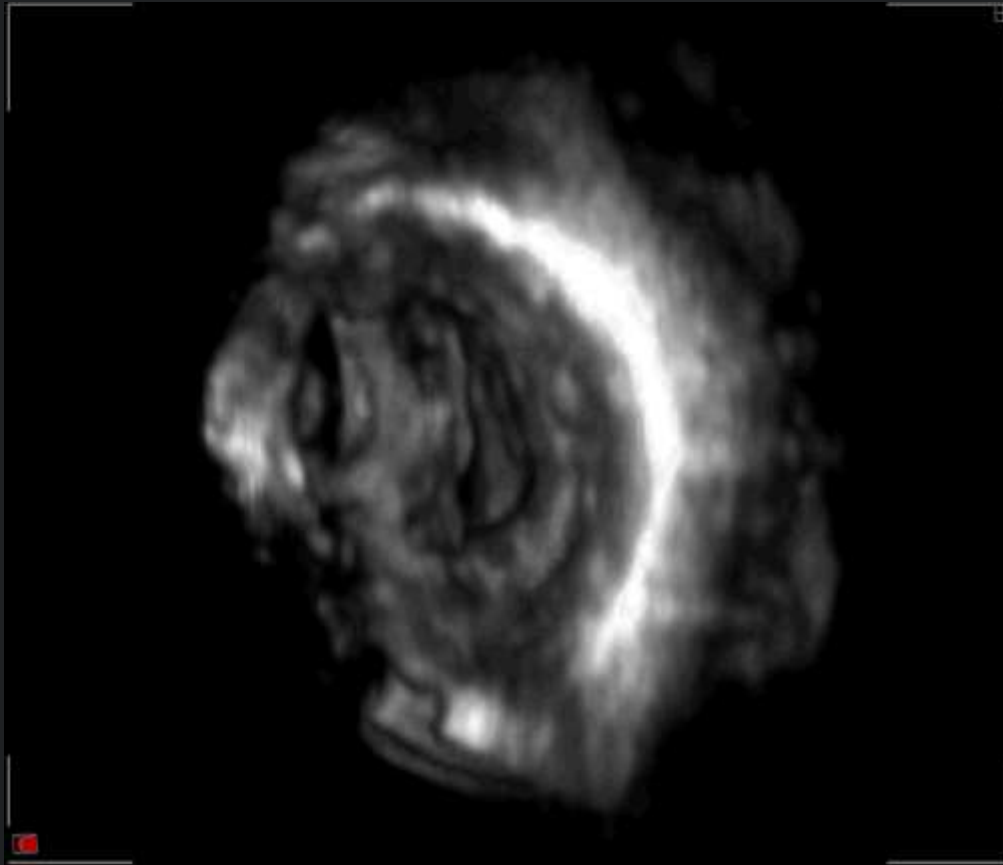
The water-bag B-mode scanning system, the SSD-1, from Aloka in 1960



Ultraschall



Ultraschall



Ultraschall Intervention



Ultraschall

- keine schädlichen Auswirkungen auf den Organismus bekannt („normale“ Diagnostik)
- mobil
- Echtzeitbildgebung
- Unterscheidung Flüssigkeiten und solide Gewebe unterschiedlicher Struktur, Luft/Knochen, Fluss, (Kontrastmittel)
- Luft, Knochen, Implantate stellen eine „Wand“ dar. Tote Winkel!
- Untersucherabhängig. Befunde nicht einfach kommunizierbar
- Trade-off: Bildqualität – Eindringtiefe, zeitliche Auflösung

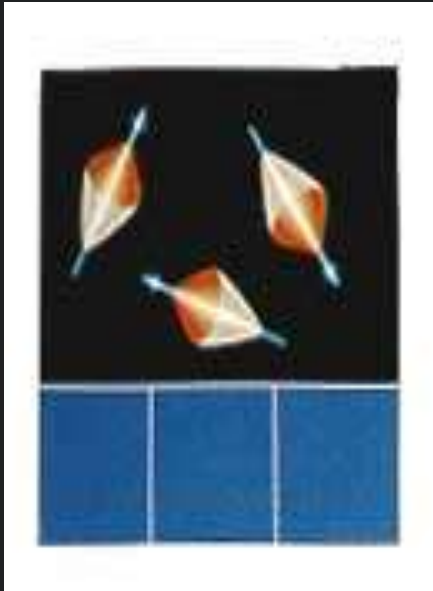
Paul C. Lauterbur (1929-2007)

Peter Mansfield (1933-2017)

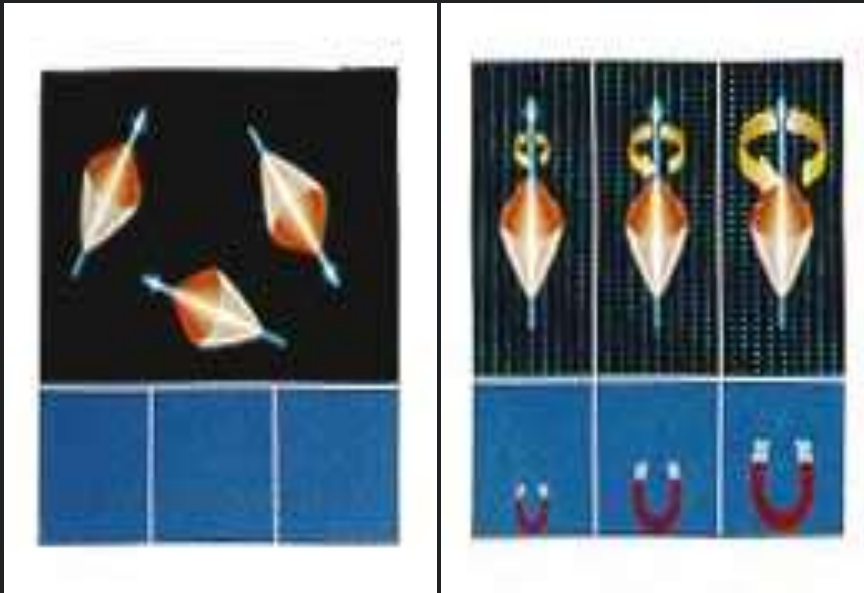
Nobelpreis für Medizin 2003



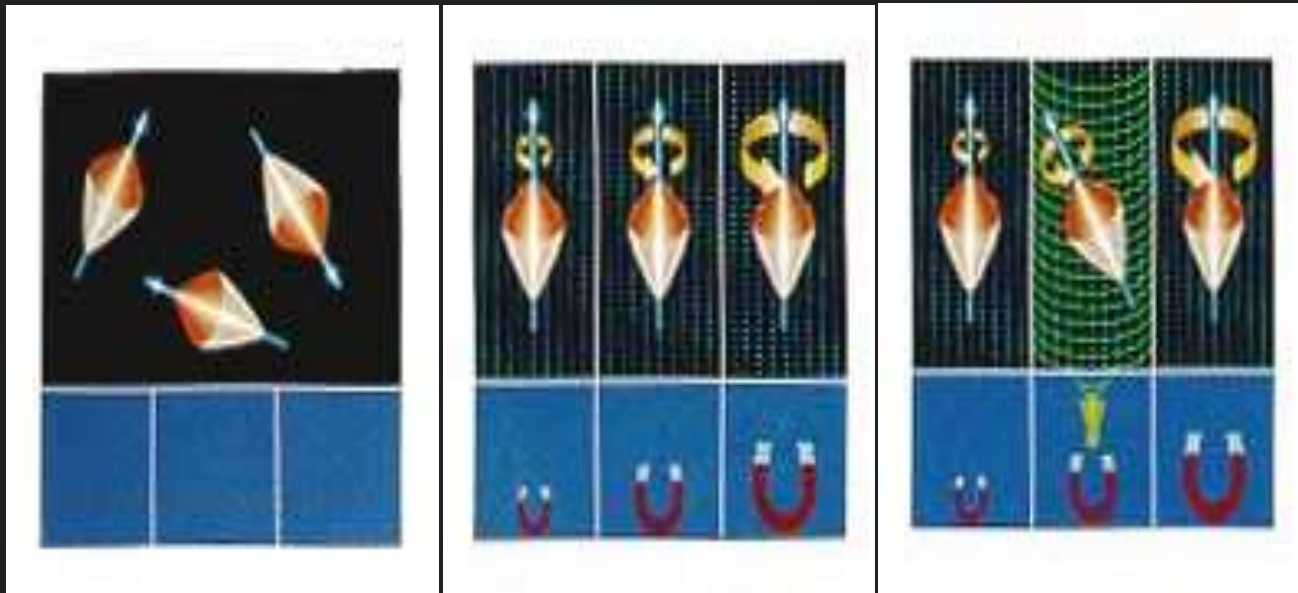
Magnetresonanztomographie



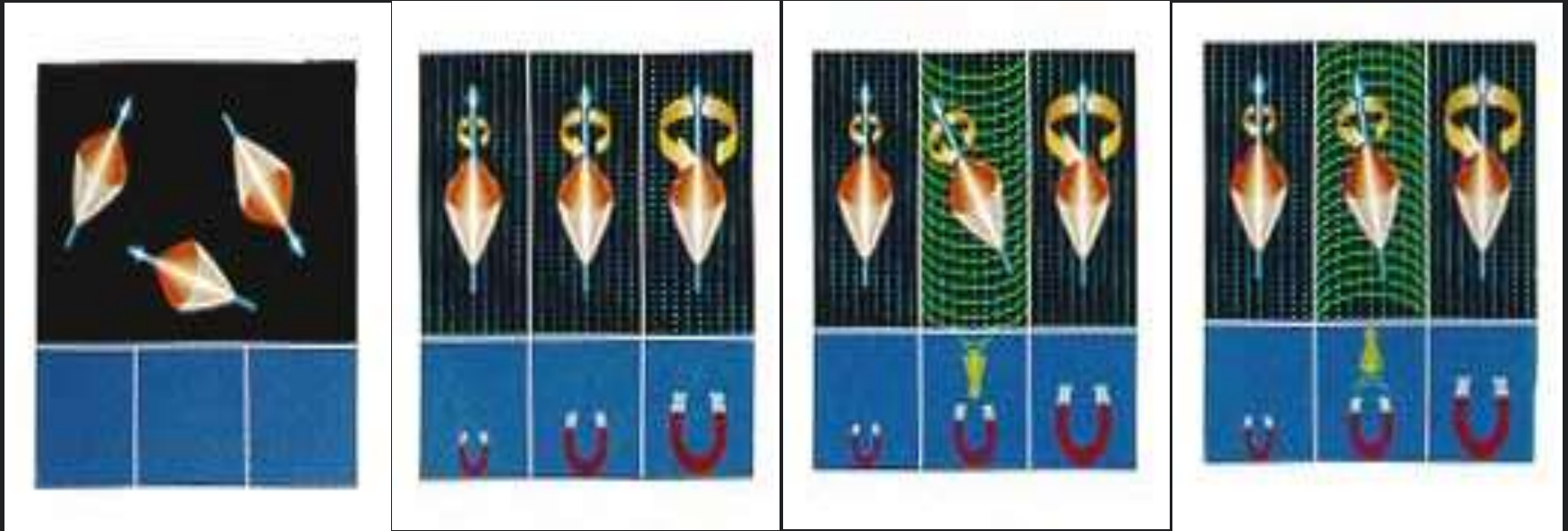
Magnetresonanztomographie



Magnetresonanztomographie



Magnetresonanztomographie



Magnetresonanztomographie



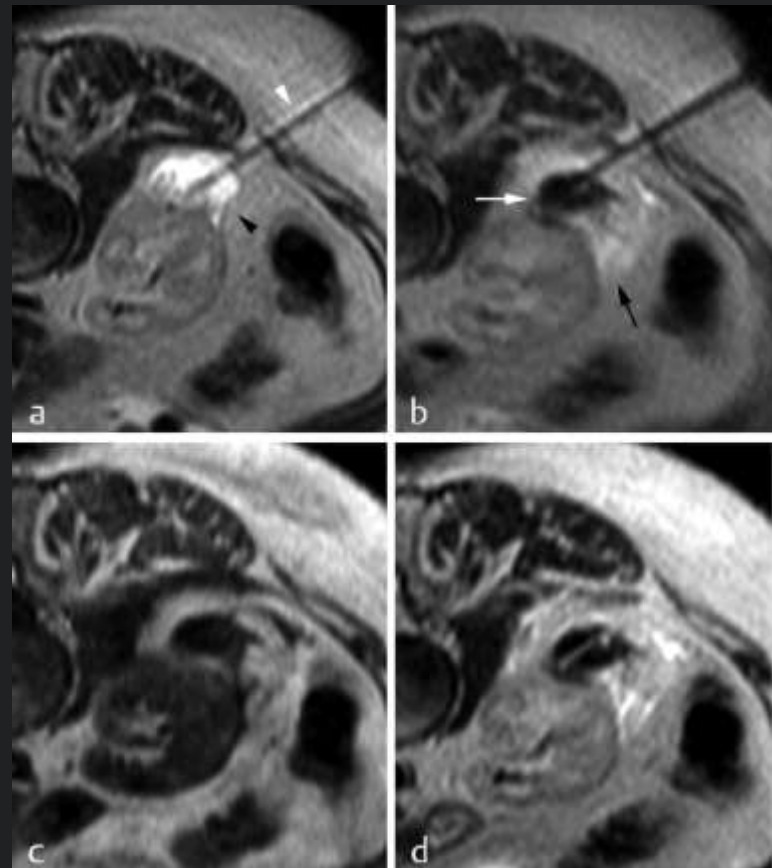
Magnetresonanztomographie



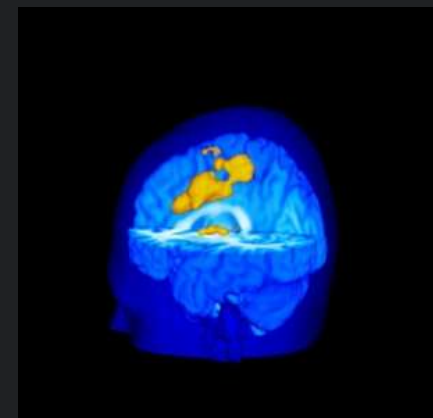
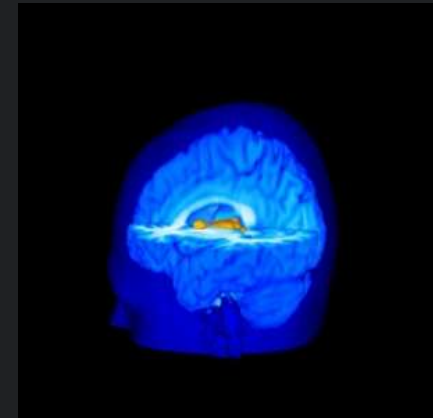
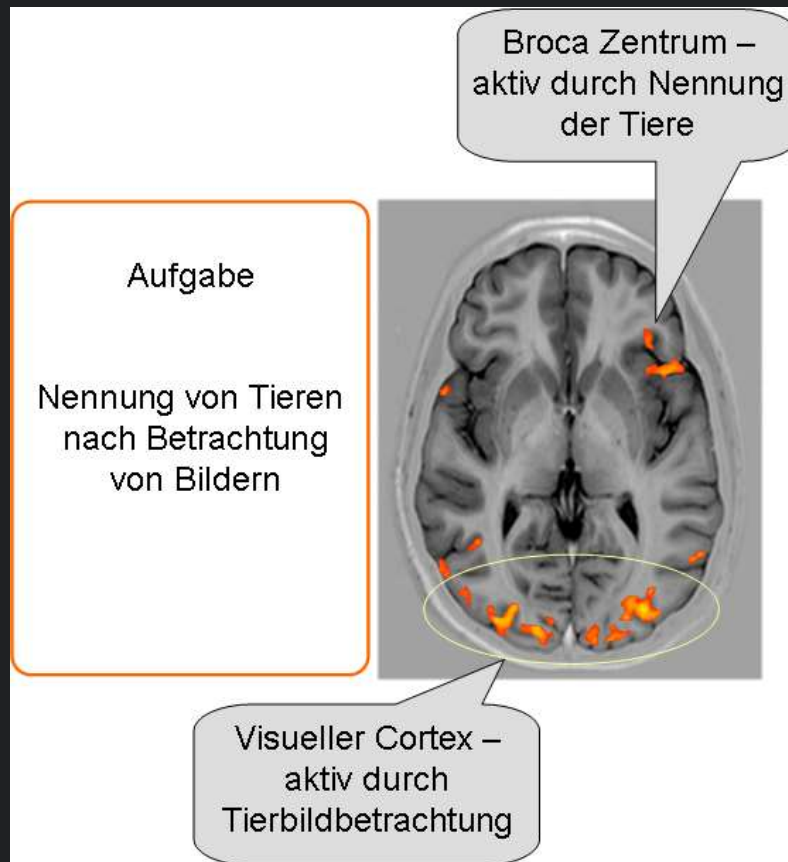
Magnetresonanztomographie



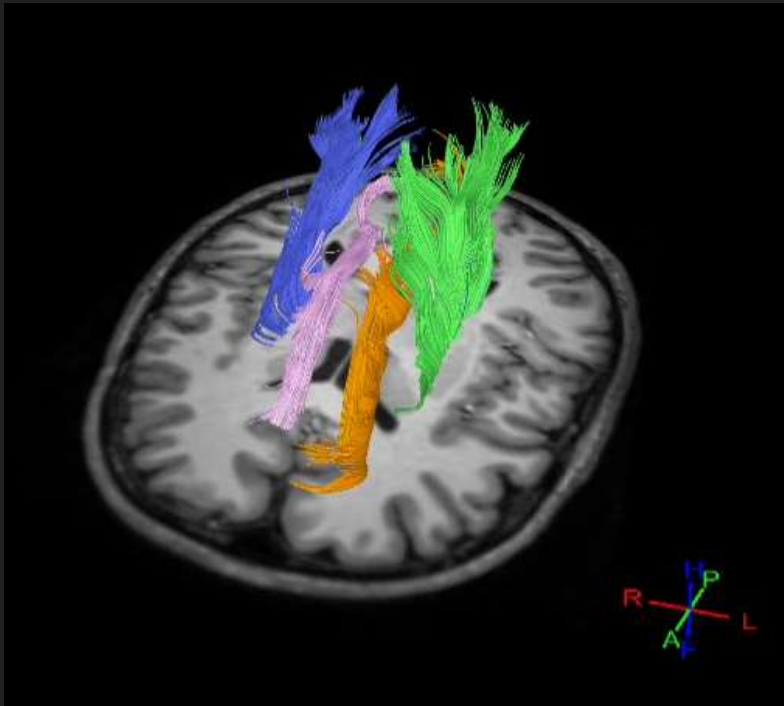
MRT Intervention



MR BOLD Imaging (fMRI)



MR Fiber Tracking (DTI)



Magnetresonanztomographie

- keine systematischen schädlichen Auswirkungen auf den Organismus bekannt
- Auflösung bis 4lp/mm
- lange Datenaquisition (~ Sekunden bis Minuten)
- relativ hohe Kosten
- vielseitig: Unterscheidung Fettgehalt, Wassergehalt, Proteingehalt, Luft, paramagnetische Substanzen (Hämosiderin, Methämoglobin, Melanin), Fluss, Diffusion, Temperatur, Kontrastmittel...
- Empfindlich gegen Metallimplantate
- relativ viele Einschränkungen (Klaustrophobie, Implantate)
- Trade-offs: kompliziert...

Bildgebung in der Schmerztherapie

- Röntgen
- Computertomographie
- Ultraschall
- Magnetresonanztomographie
- (Nuklearmedizin)

-> Beispiele am Rücken

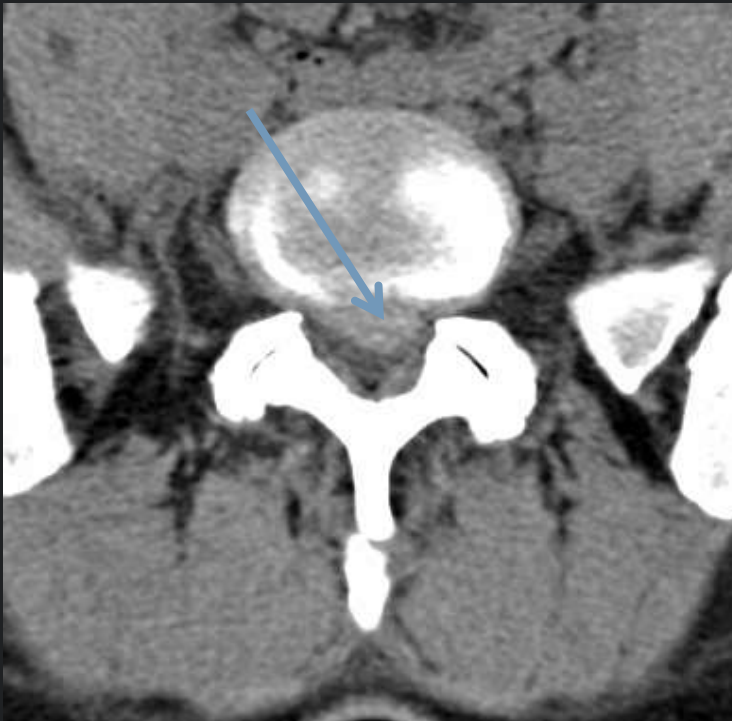
w., 40j, lumboradikuläres Syndrom links



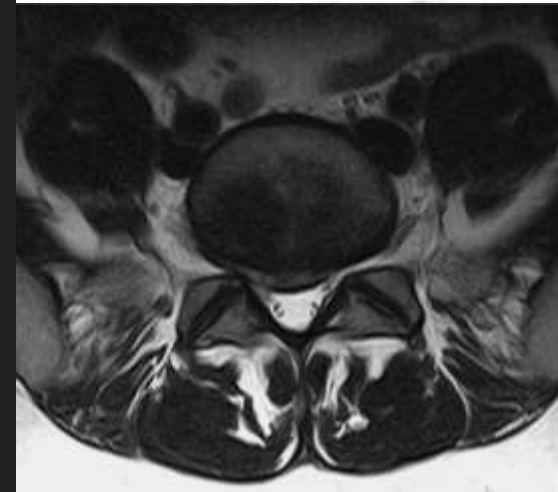
CT: Diskushernie L5/S1



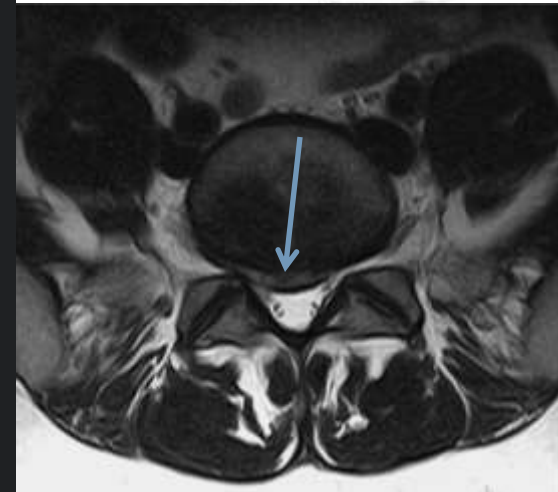
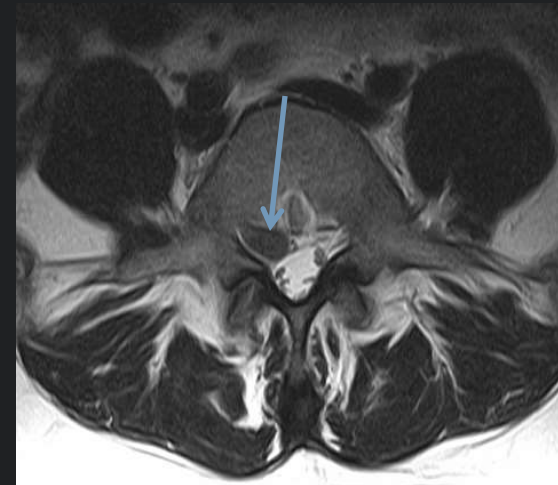
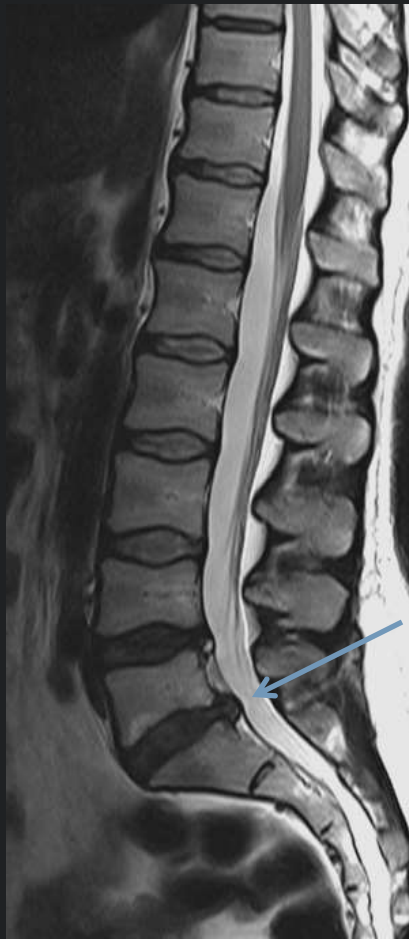
CT: Diskushernie L5/S1



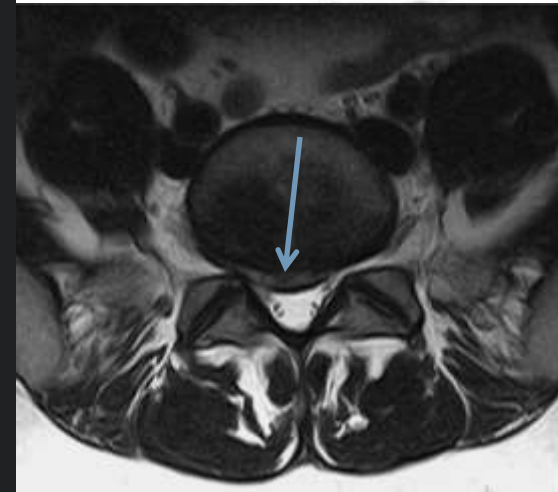
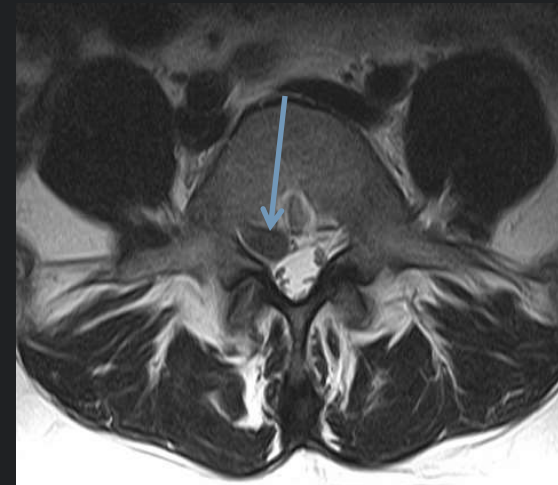
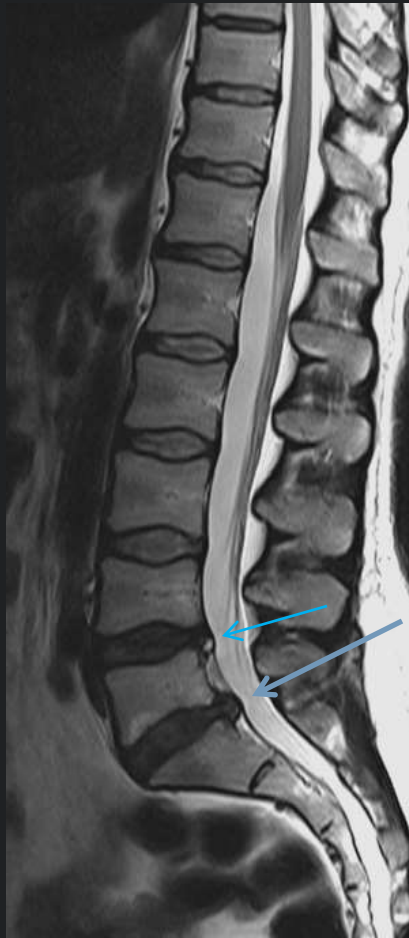
w., 39j, lumbospndylogenes Syndrom



MRI: Diskushernie L5/S1, Migration



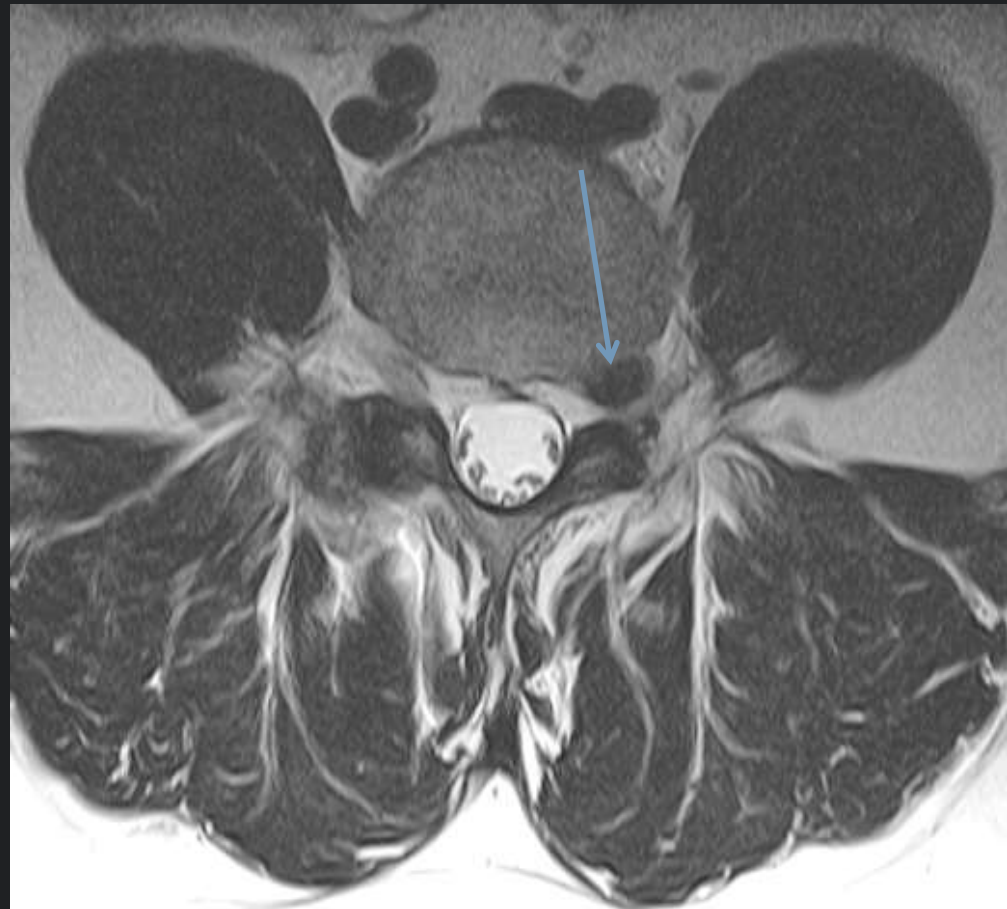
MRI: Diskushernie L5/S1, Migration



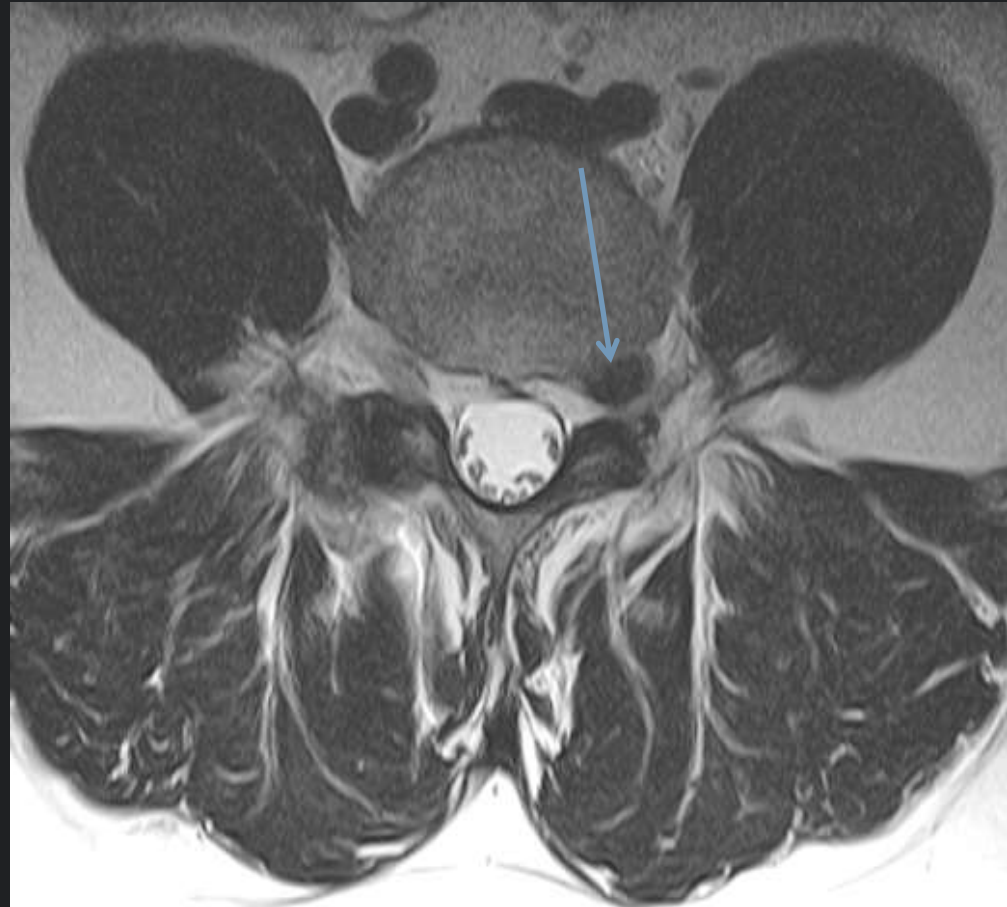
m., 21j, lumboradikuläres Syndrom links



MRI: intraforaminale Diskushernie L4/L5



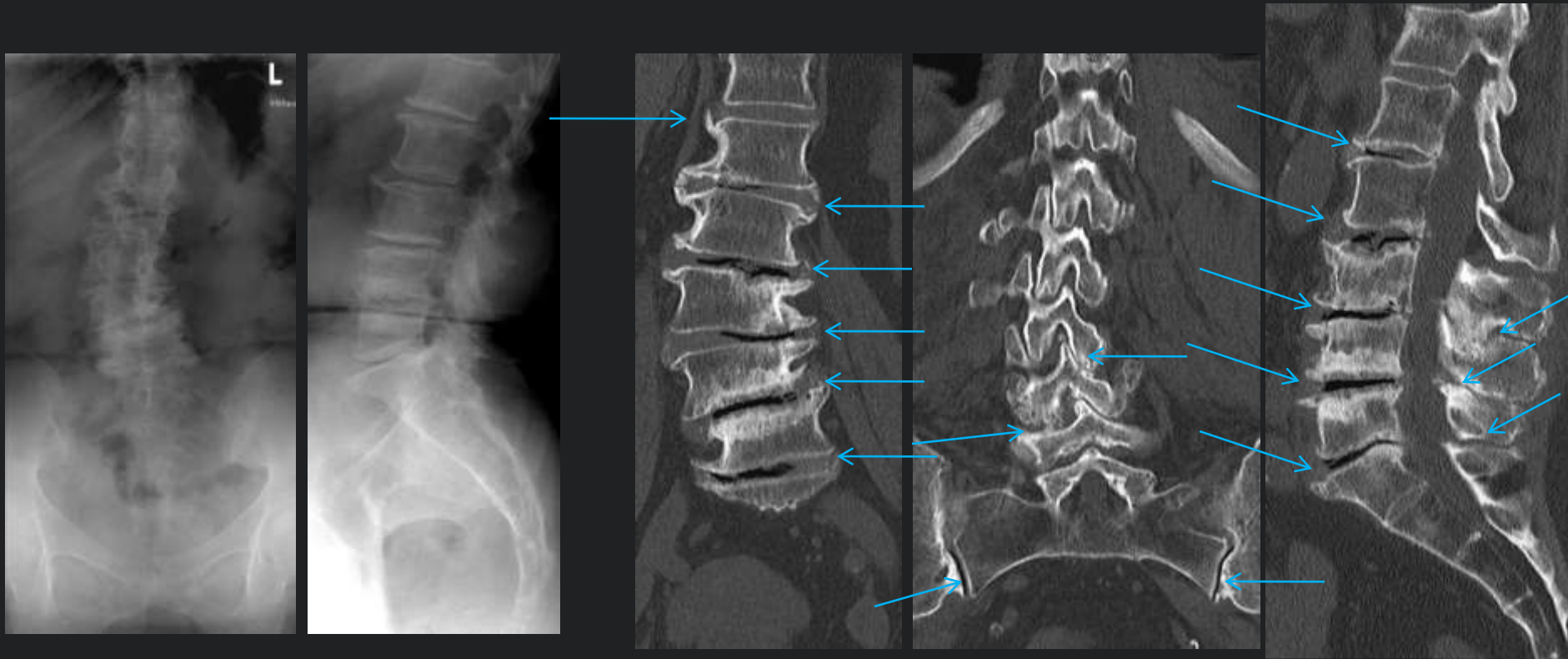
MRI: intraforaminale Diskushernie L4/L5 und Spondylolisthesis L5/S1



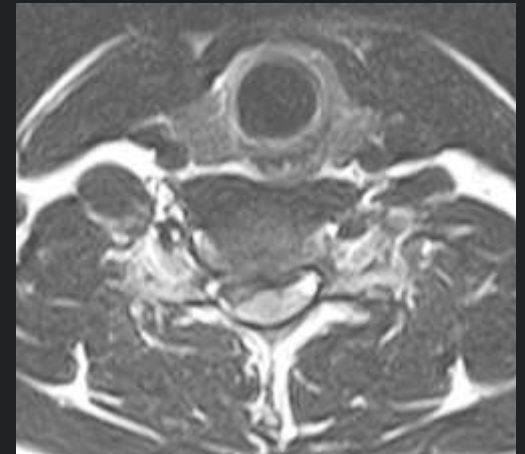
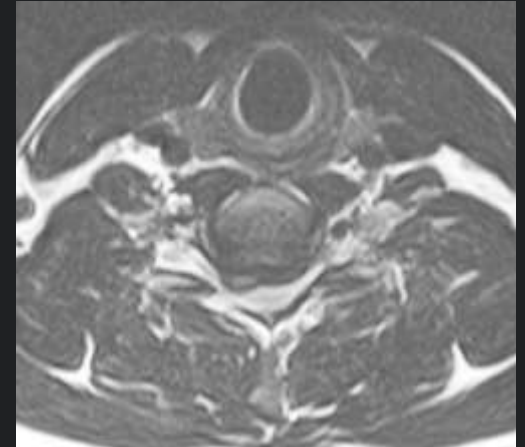
w., 70j, chronische Rückenschmerzen



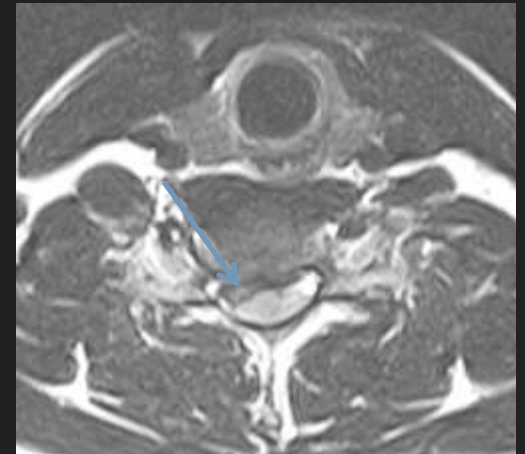
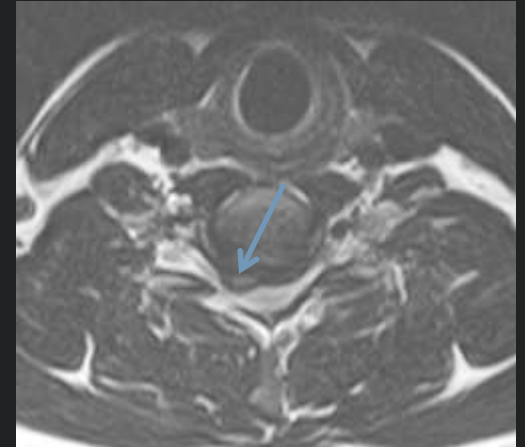
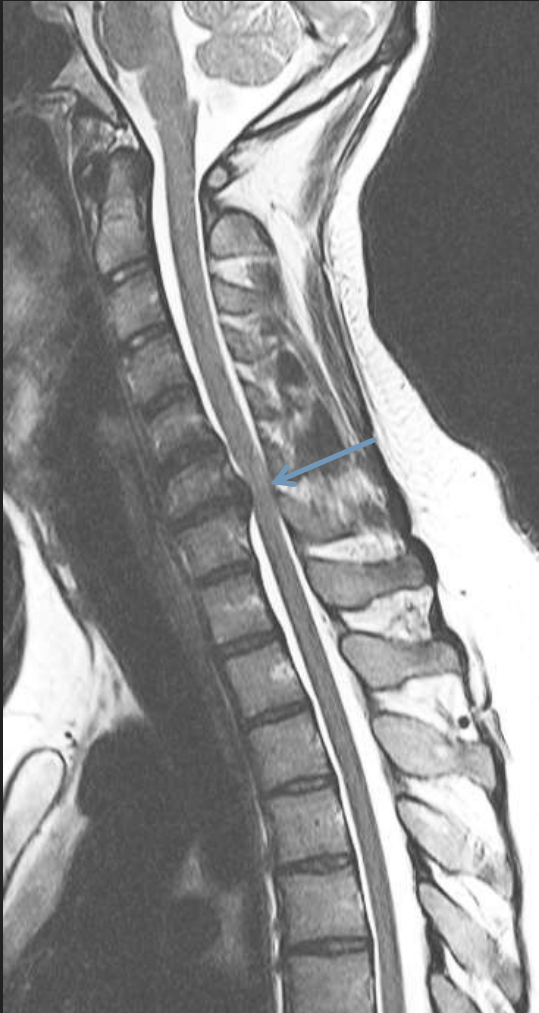
Rx, CT: ausgeprägte Degeneration bei Skoliose



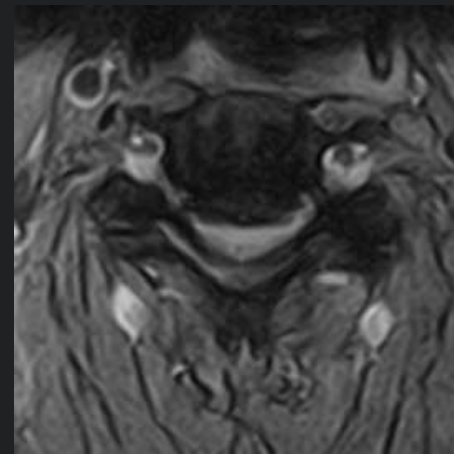
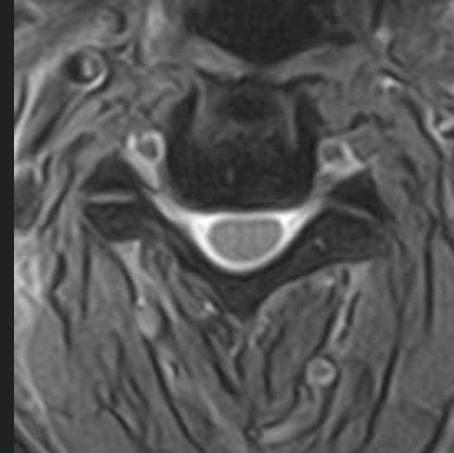
m., 21j, cervicoradikuläres Syndrom rechts



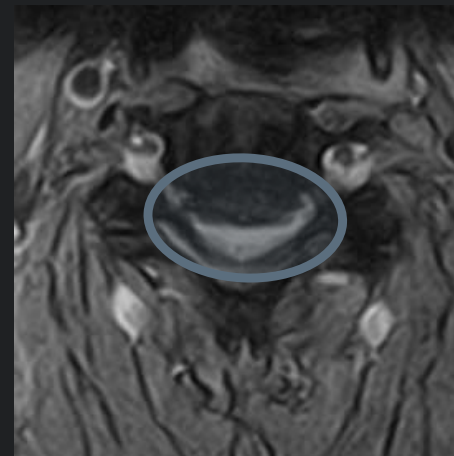
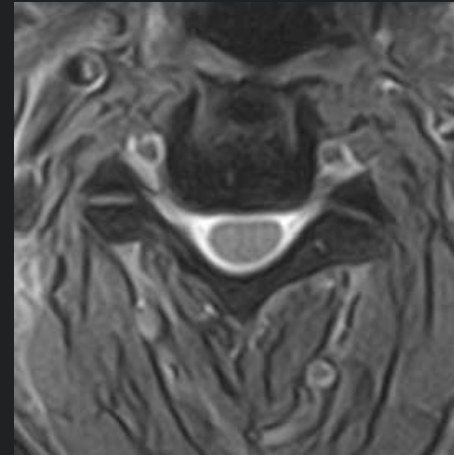
MRI: grosse Diskushernie, Myelonkompression



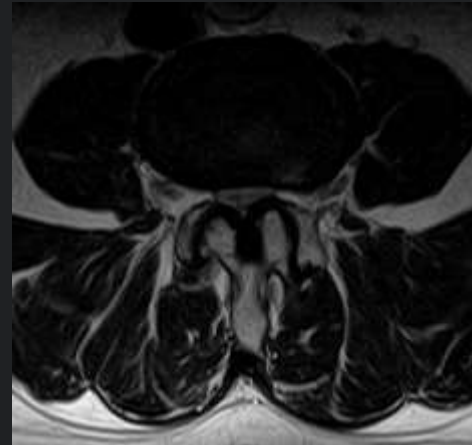
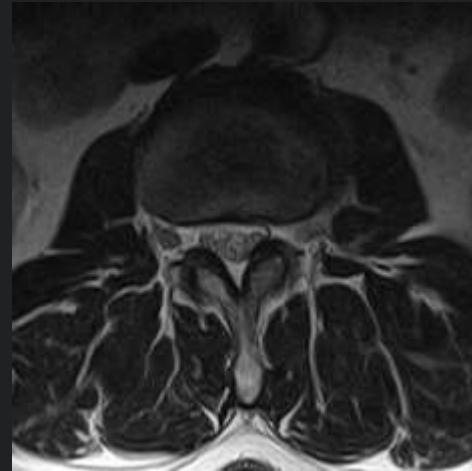
m., 61j, Nackenschmerzen mit Ausstrahlung bds.



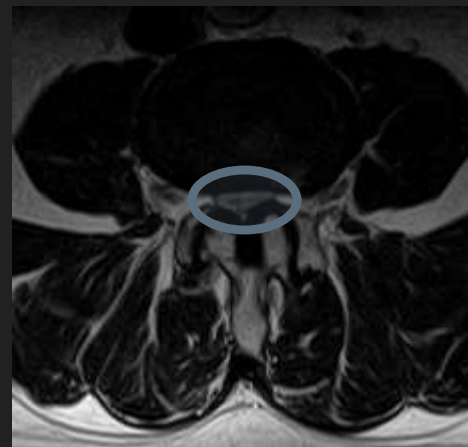
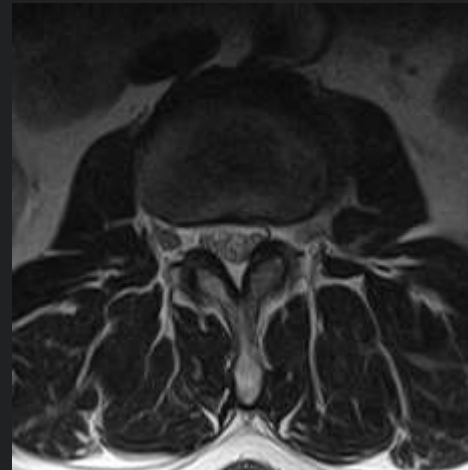
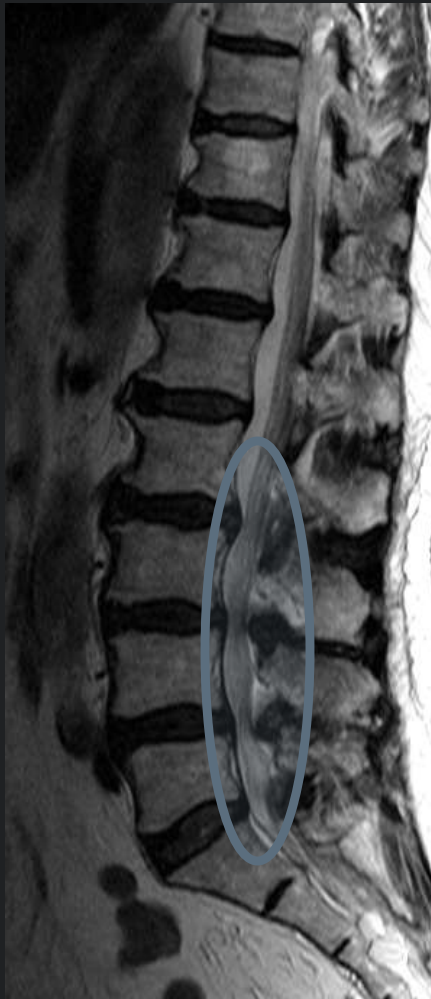
MRI: mehrsegmentale Degeneration mit sekundäres Spinalkanalstenose



w., 65j, V.a. Claudicatio spinalis



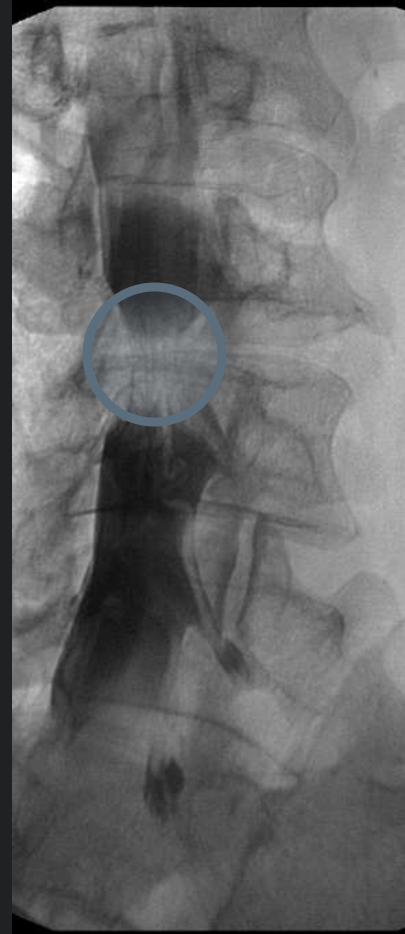
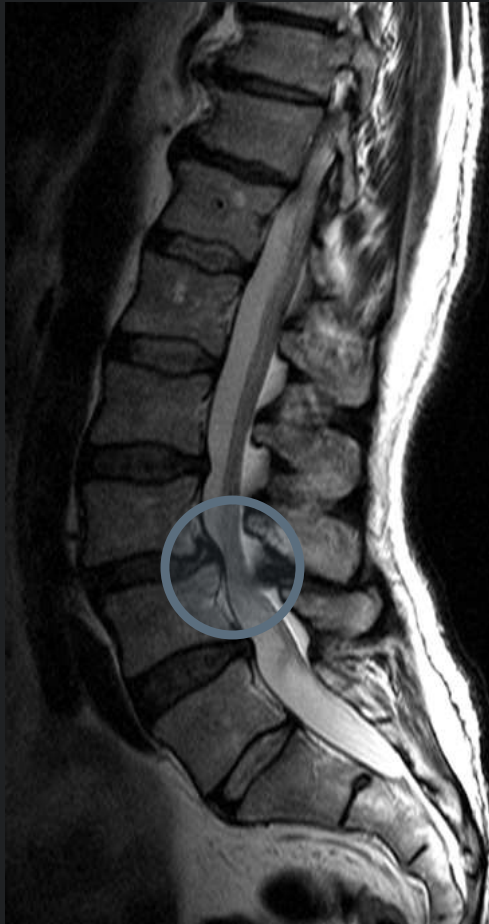
MRI: lumbale Spinalkanalstenose



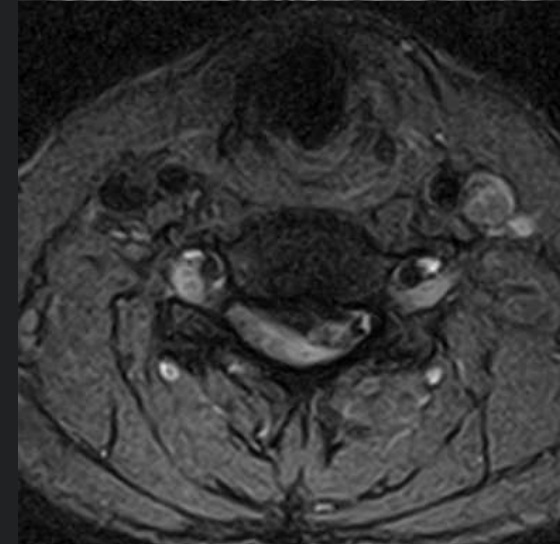
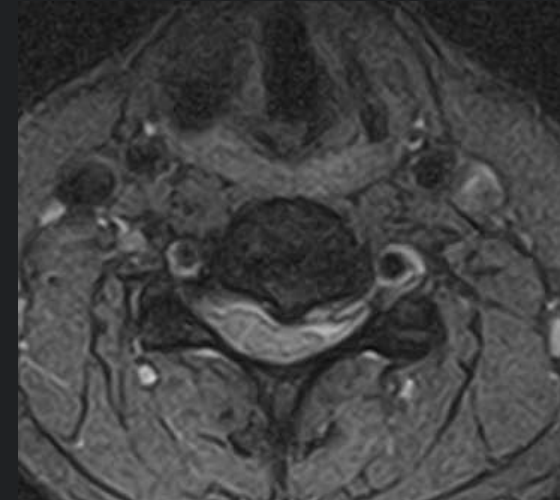
m., 61j, V.a. Claudicatio spinalis



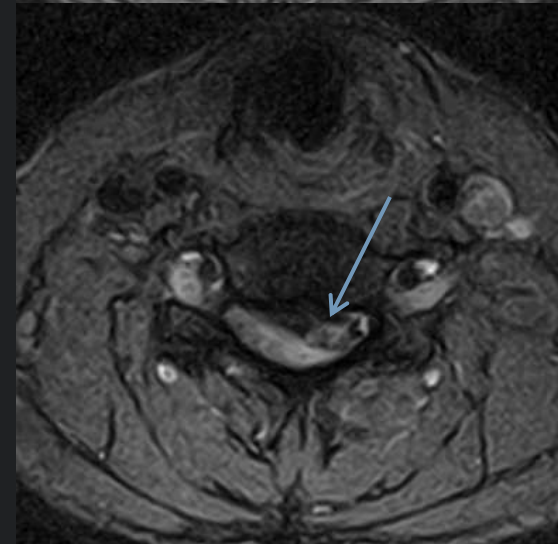
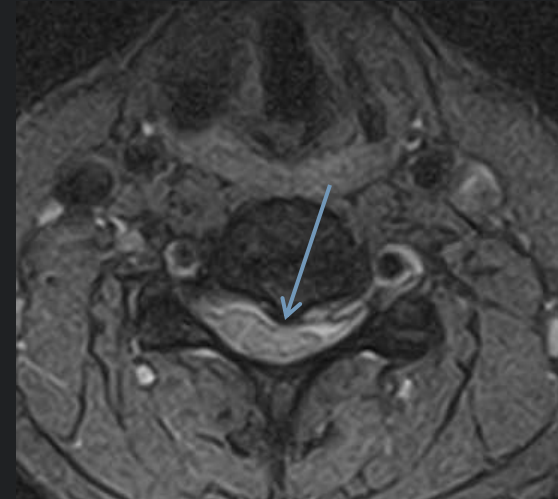
MRI, Myelographie: Spinalkanalstenose bei degenerative Listhesis. Bedeutung der Untersuchung unter Belastung



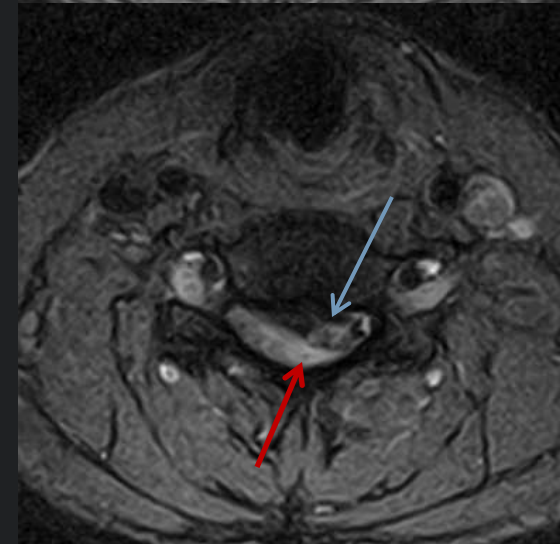
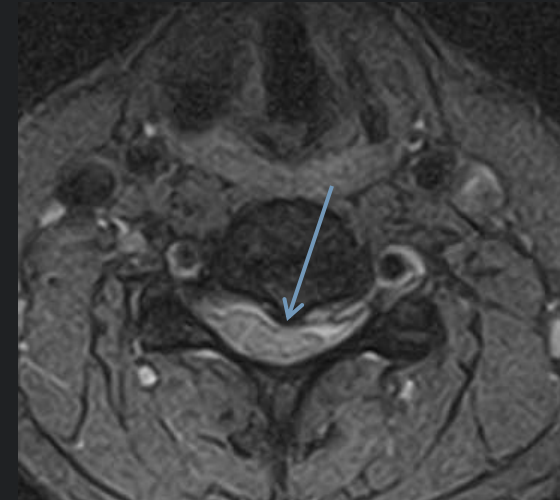
w., 24j, V.a. cervikale Spinalkanalstenose



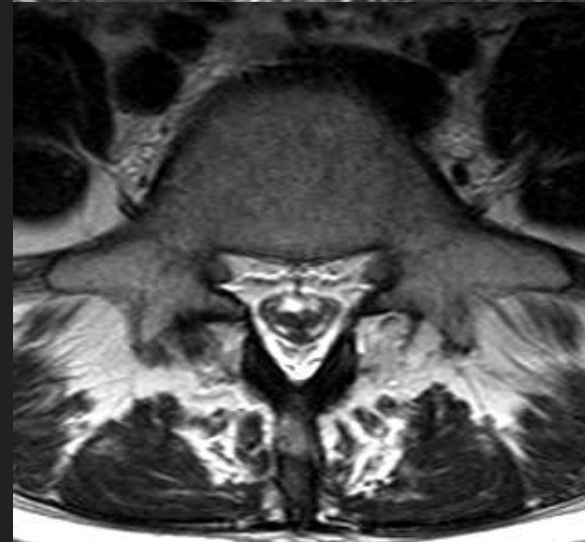
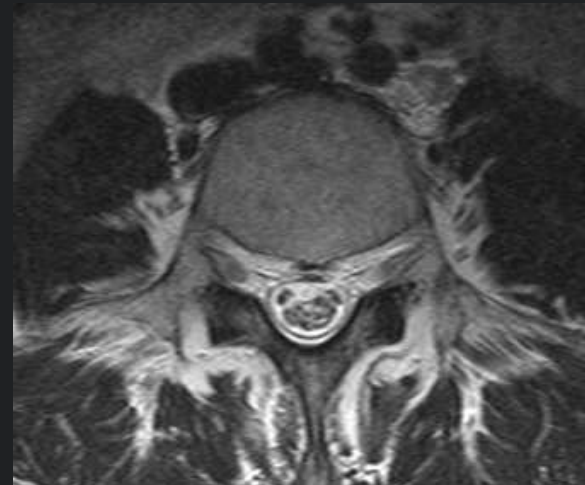
MRI: grosse Diskushernie mit sekundäres Spinalkanalstenose



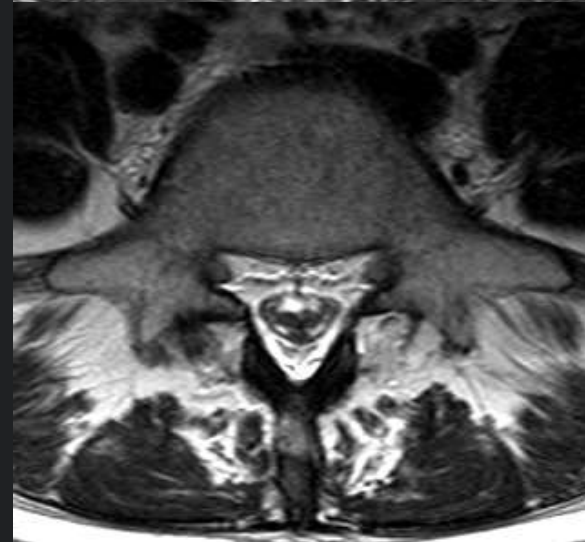
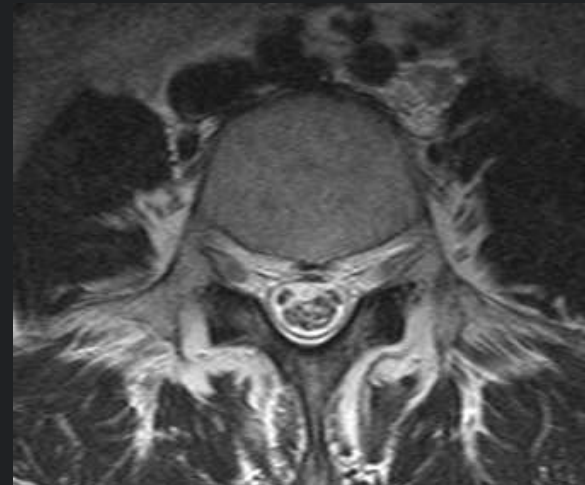
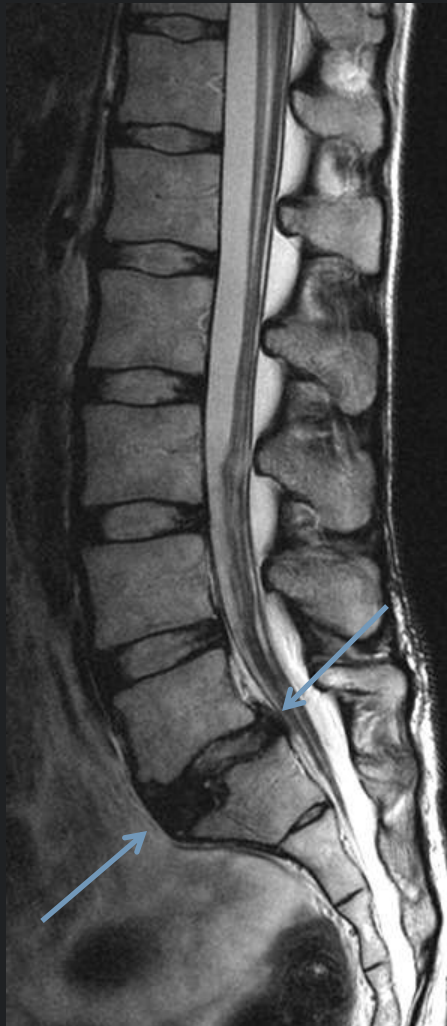
MRI: grosse Diskushernie mit sekundäres Spinalkanalstenose und Kompressionsmyelopathie



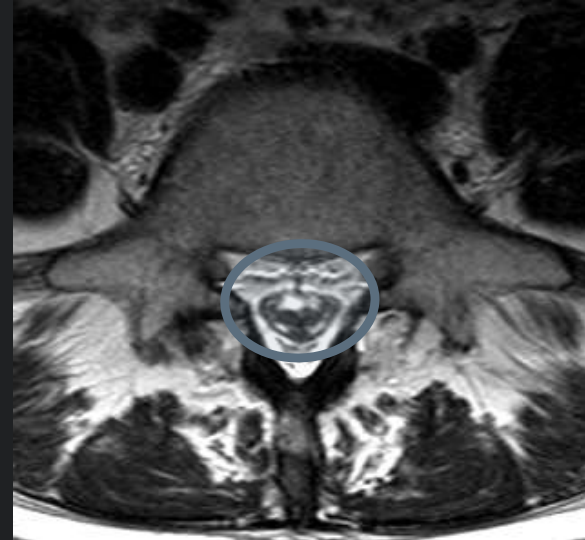
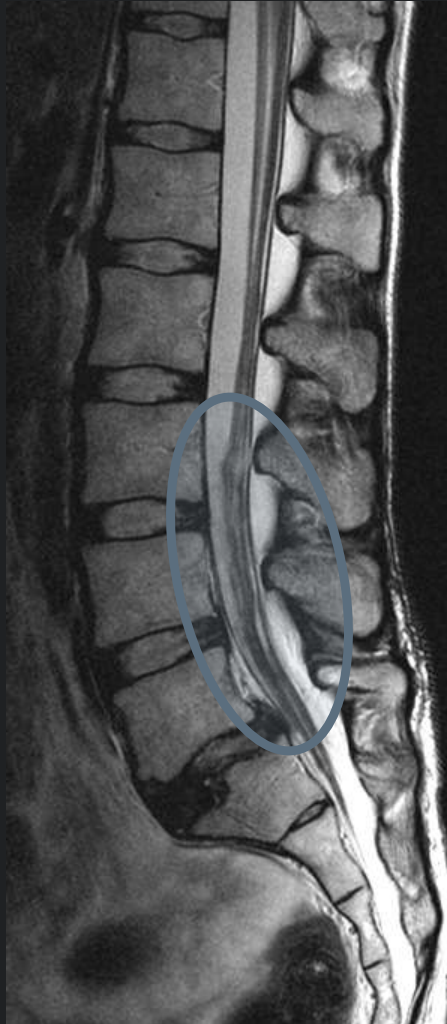
w., 23j, unklares (lumboradikuläres?)
Schmerzsyndrom nach Geburt



w., 23j, unklares (lumboradikuläres?)
Schmerzsyndrom nach Geburt



MRI: ausgeprägte Adhäsionen der Cauda equina



w., 66j, chronische Rückenschmerzen, fragl.
radikuläres Syndrom links



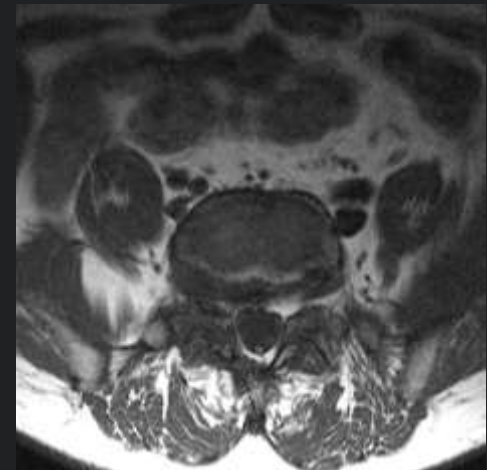
CT: degenerative Listhesis, migrierende Diskushernie, Osteochondrose



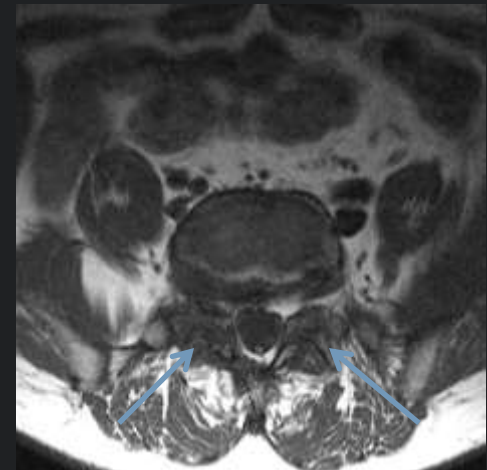
CT: degenerative Listhesis, migrierende Diskushernie, Osteochondrose, Tarlov-Cyste



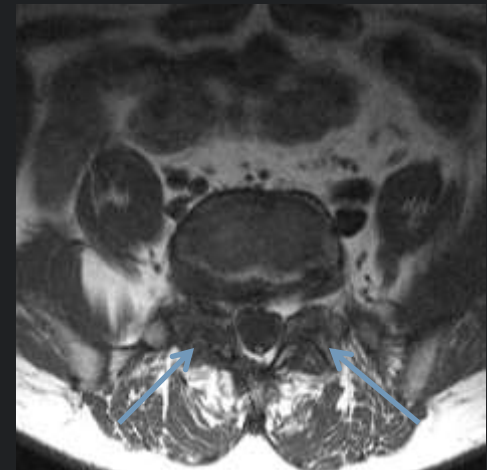
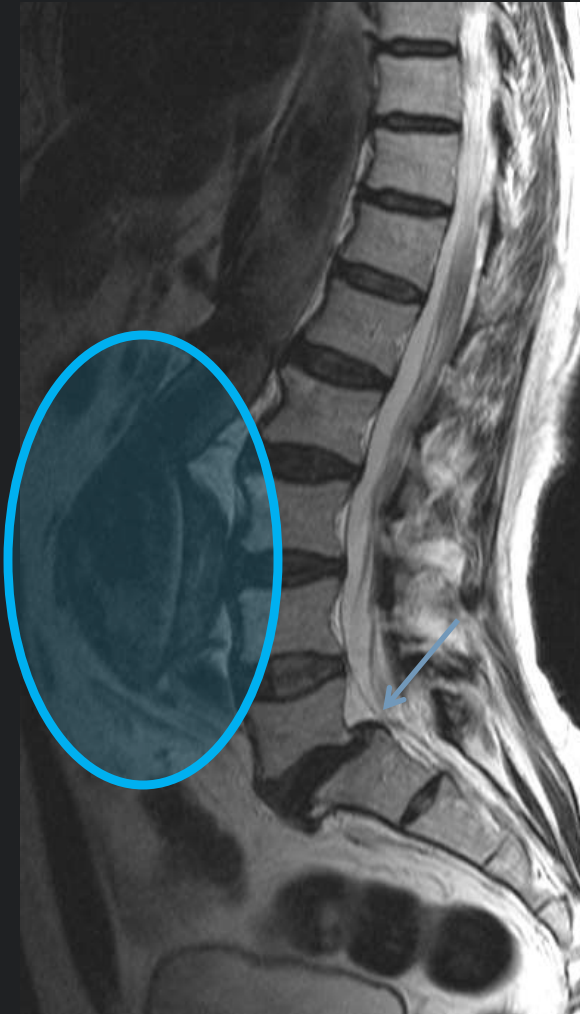
w., 74j, chronische Rückenschmerzen



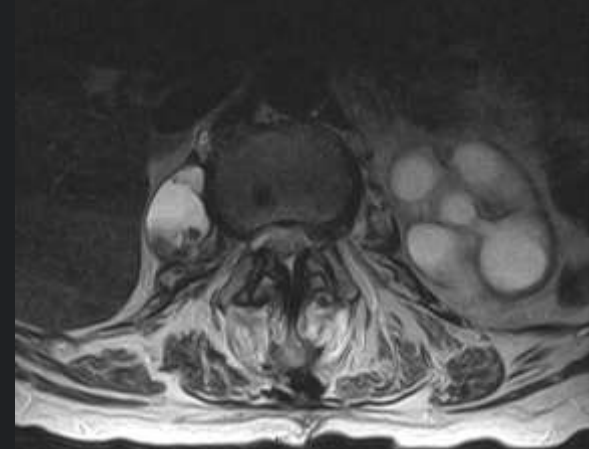
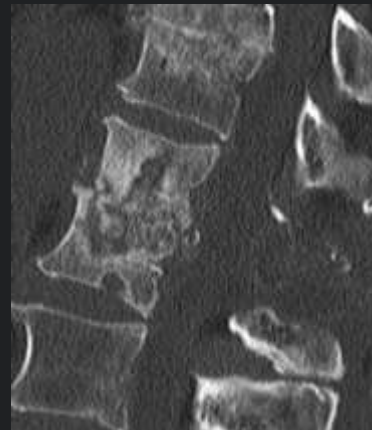
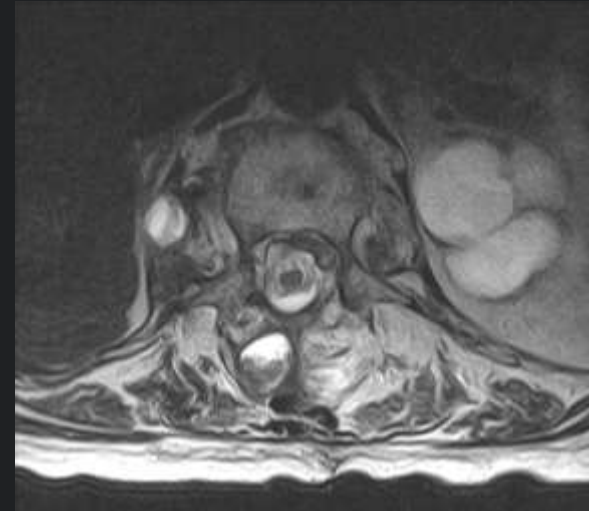
Rx, MRI: Spondylolisthesis L5/S1.



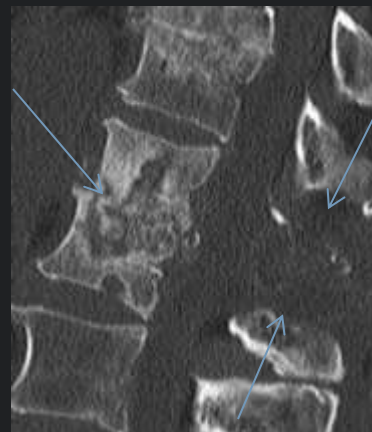
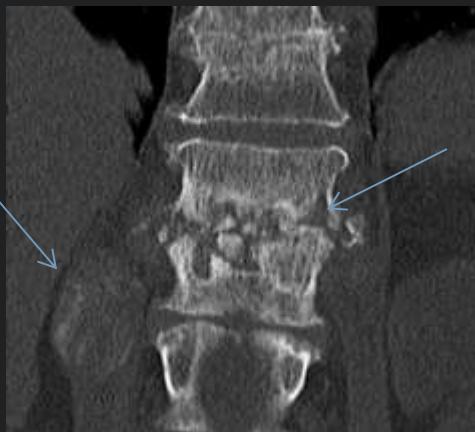
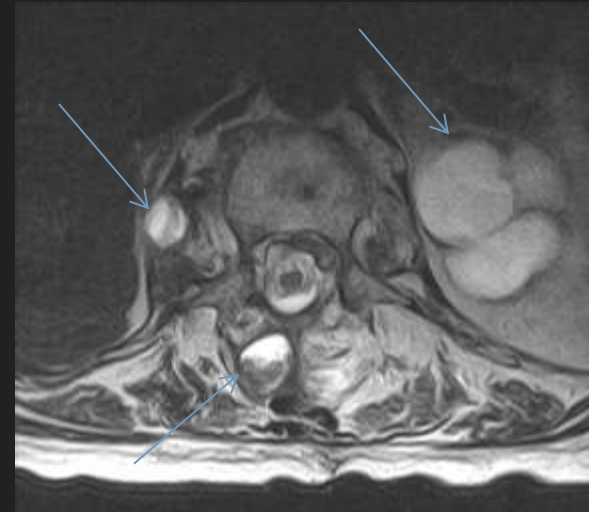
Rx, MRI: Spondylolisthesis L5/S1. Aortenaneurysma!



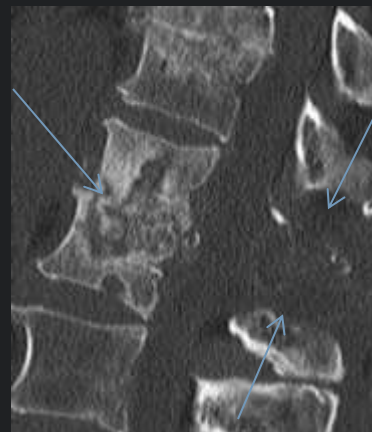
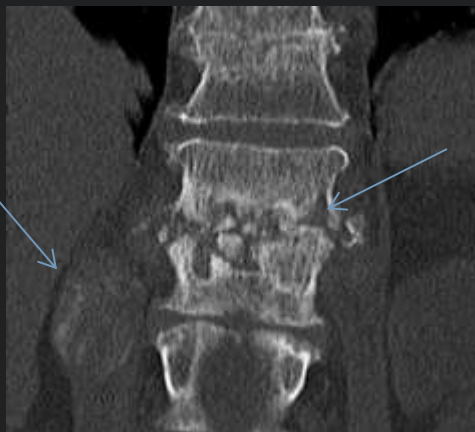
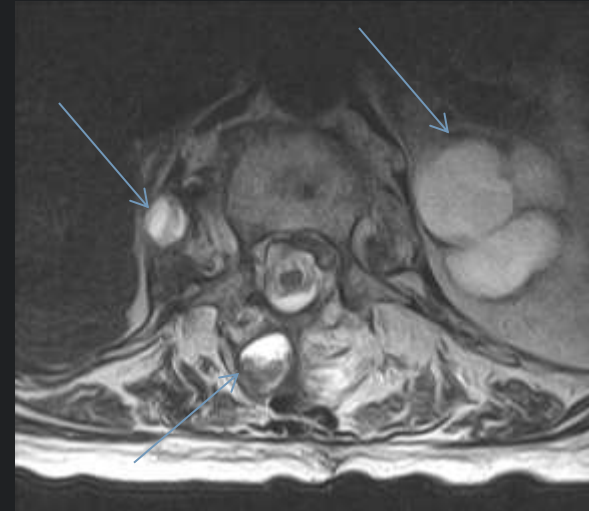
w., 69j, Rückenschmerzen, schlechter AZ



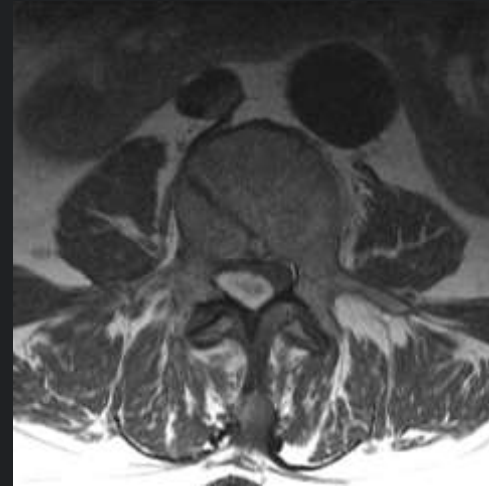
w., 69j, Rückenschmerzen, schlechter AZ



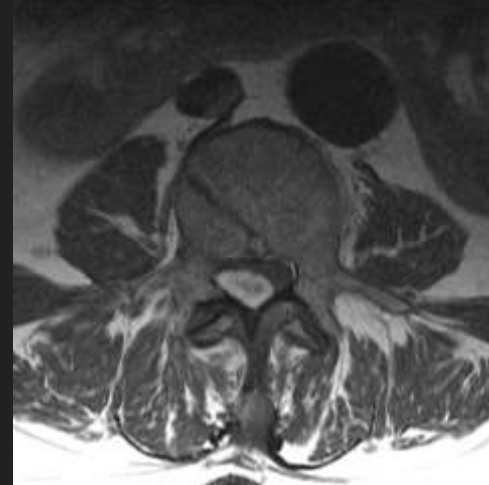
MRI, CT: tuberkulöse Spondylodiscitis, Psoasabszess, Hydronephrose



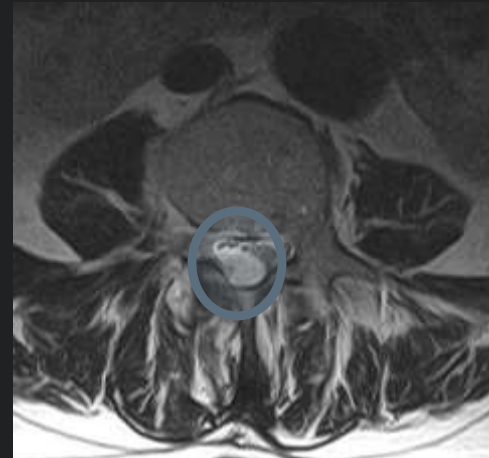
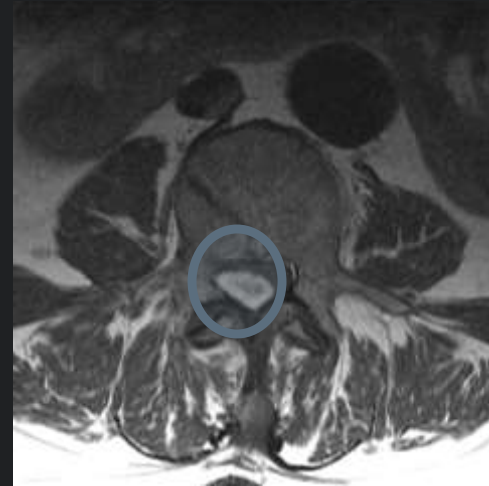
m., 70j, Beinschmerzen und –parese rechts, St. n.
Aortenklappenersatz



m., 70j, Beinschmerzen und –parese rechts, St. n.
Aortenklappenersatz



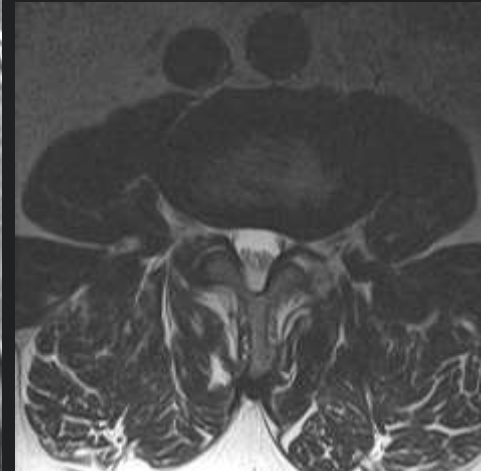
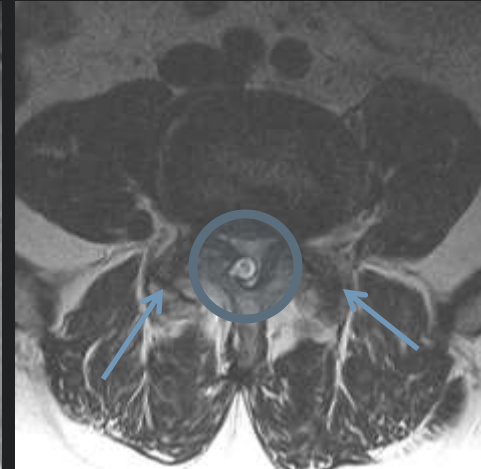
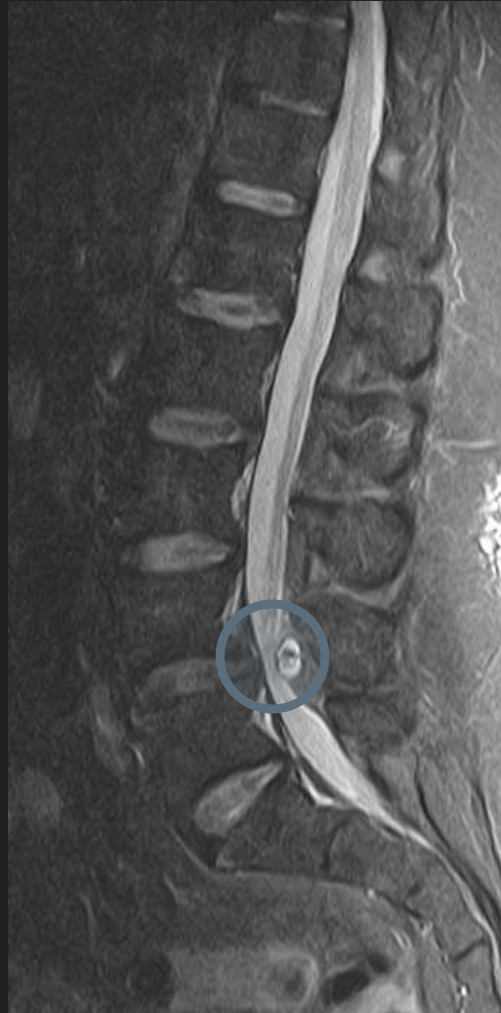
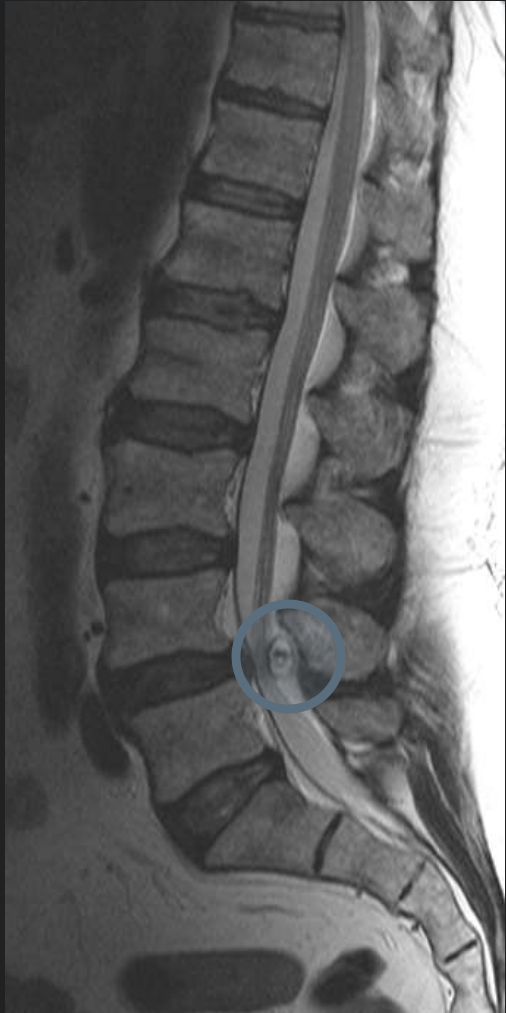
MRI: epidurales Hämatom



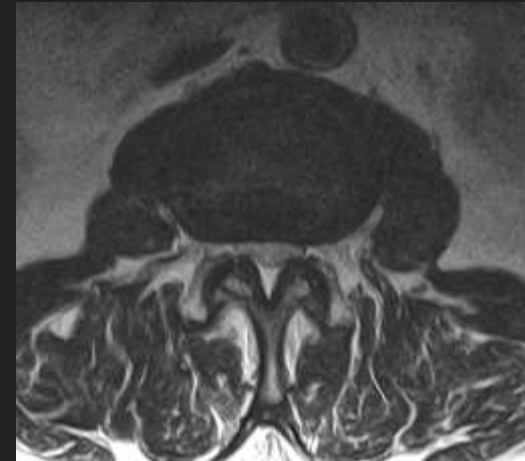
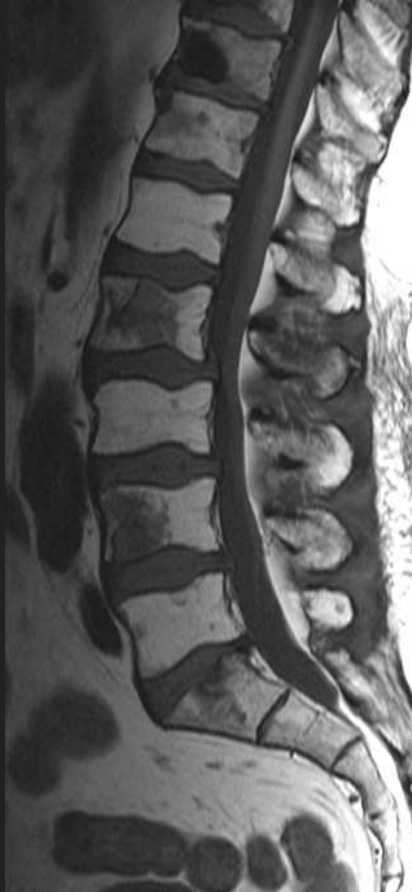
m., 66j, Lumbalgie, V. a. Claudicatio spinalis



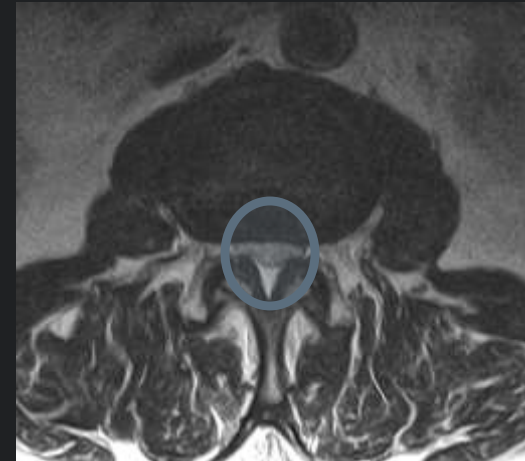
MRI: Spinalkanalstenose, Synovialcyste



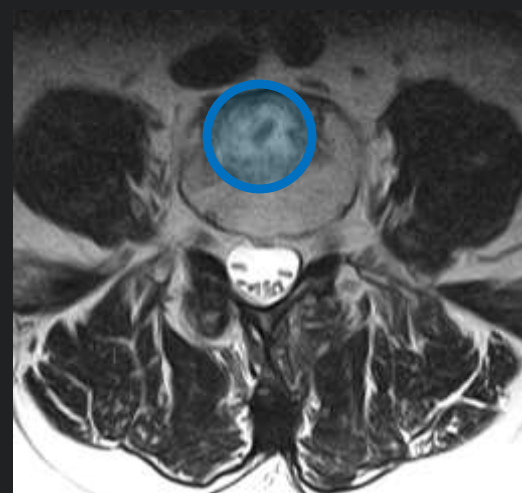
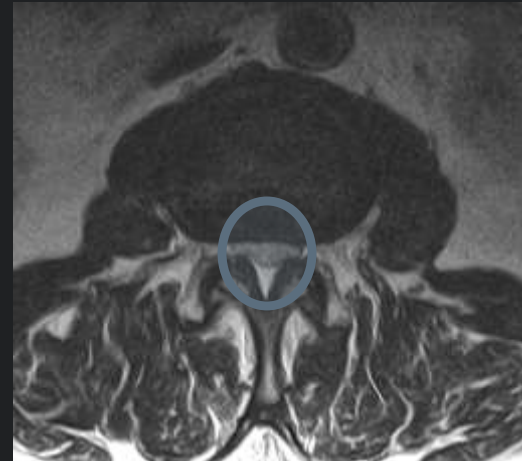
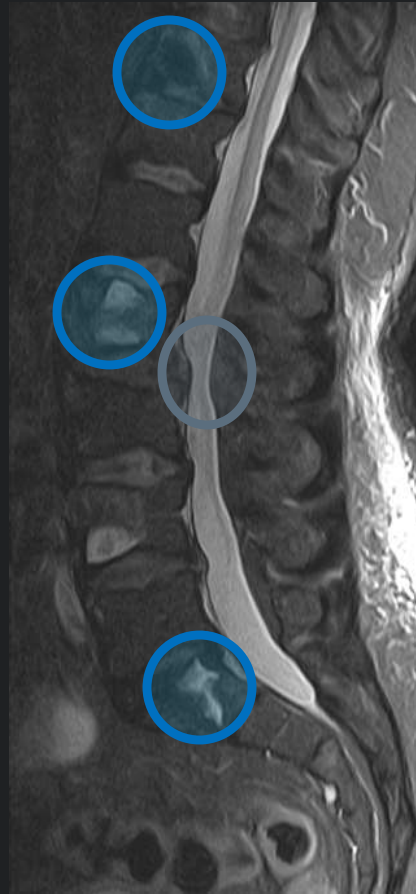
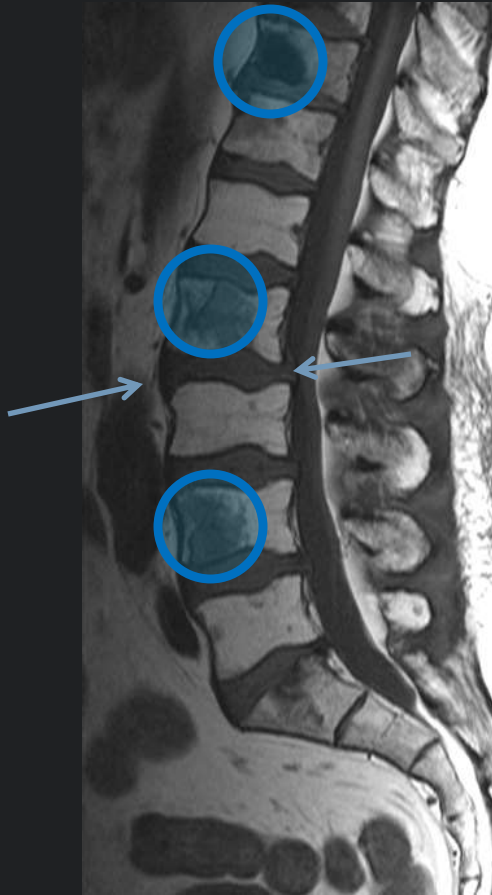
m., 68j, Rückenschmerzen, V. a.
Claudicatio spinalis



m., 68j, Rückenschmerzen, V. a. Claudicatio spinalis



MRI: Spinalkanalstenose. Knochenmetastasen (Prostata-Ca)



Bildgebung in der Schmerztherapie: Stellenwert

- Röntgen
- Computertomographie
- Ultraschall
- Magnetresonanztomographie
- (Nuklearmedizin)

Bildgebung in der Schmerztherapie: Stellenwert

- Röntgen
- Computertomographie
- Ultraschall
- Magnetresonanztomographie
- (Nuklearmedizin)
- Genauere Diagnose
- Bessere Therapie
- Besseres Outcome

Bildgebung in der Schmerztherapie: Stellenwert

- Röntgen
- Computertomographie
- Ultraschall
- Magnetresonanztomographie
- (Nuklearmedizin)
- Genauere Diagnostik
- Bessere Therapie
- Besseres Outcome

MRI bei akuter Lumbago/LRS

- 246 Patienten mit akuter Lumbago oder lumboradikulärem Syndrom
- alle MRI, ½ über Befunde informiert
- ähnliche Befunde (Bandscheibendegeneration und Diskushernien, Spinalkanalstenosen, Wurzelkompression) bei beiden Patientengruppen
- MRI beeinflusst konservative Therapie nicht
- Patienten, die über ihre Befunde informiert sind, fühlen sich kränker
- Patienten mit Diskushernien erholten sich besser

Hierarchie der diagnostischen Effizienz

Stufe	Typische Messgrößen
1. Technische Qualität	Auflösung (Linienpaare/mm) Signal/Rauschen
2. Radiologische Diagnose	Sensitivität, Spezifität ROC
3. Klinische Diagnose	Anzahl Fälle, in denen die Diagnose geändert wird
4. Einfluss auf Behandlung	Anzahl Fälle, in denen die Behandlung geändert wird
5. Einfluss auf Outcome	Outcome mit/ohne Test QUALYs
6. Gesellschaftlicher Wert	Kosten/Nutzen Analyse bevölkerungsbezogen

MRI macht krank

False Positive Rates for Lumbar MRI

Investigation:	Disc Bulge	Disc Protrusion	Disc Extrusion	Disc Pathology (Bulge, Protrusion, extrusion, sequestration)	Root Deviation or Compression
Boden et al.		20%		NA	
Jensen et al.	52%	27%	1%	64%	
Boos et al. *		63%	13%		4%
Greenberg et al.	39%	18%		57%	
Weishaupt et al.	24%	40%	18%		4%
Wood et al (11) *	53%	37%		63%	
*	Because these investigation used a 'high risk' asymptomatic groups of people, i.e., people whose occupation required frequent heavy lifting, twisting, and bending; frequent exposure to vibration; and sedentary occupations, I have EXCLUDED the results from the averaging below.				
AVERAGES:	38%	29%	9.5%	60.5%	4%

MRI macht krank

Region	Studie/Befunde
LWS div. Studien	60% Bandscheibenpathologien, 4%Nervenzwurzeln verlagert oder komprimiert
Knie Zanetti et al, AJR 2003	100 Patienten mit V.a. Meniskusläsion 57 Läsionen auf der symptomatischen Seite und 36 Läsionen auf der asymptomatischen Seite
Schulter Connor et al, Am J Sports Med 2003	20 asymptomatische Athleten 40% Rotatorenmanschetten-läsionen der dominanten Seite (0% der Gegenseite)
Ellbogen Husarik et al, Radiology 2009	60 asymptomatische Freiwillige 60% T2-Hyperintensität („Oedem“) des N. ulnaris

Bedeutung der Kommunikation



Direct, In-Person Communication Between Radiologists and Acute-Care Surgeons Leads to Significant Alterations in Surgical Decision-Making

Authors: Elliot Dickerson, MD¹; Hasan Alam, MD²; Richard Brown, MD²; Jadranka Stojanovska, MD²; Michigan Radiology Quality Collaborative; Matthew Davenport, MD¹
 1: University of Michigan, Radiology; 2: University of Michigan, Surgery

Purpose: To determine if direct in-person communication between an acute-care surgical team and radiologists alters surgical decision making.

Introduction: Despite many electronic formats for exchanging information, communication between radiologists and clinicians remains imperfect. Nuanced language can impair understanding, reports may not address all relevant questions, and reports created without clinical data can lead to suboptimal interpretation of studies.

Methods: This study was IRB approved and HIPAA compliant. Data collected 1/1/15-10/14/15. This was a combined effort of the abdominal radiology division and acute care surgery team (consults, trauma, emergency, burn, critical care).

The intervention was a semi-weekly 40-60 minute in-person multi-disciplinary discussion in the abdominal reading room with up to 10 cases selected by surgeons.

Written final reports were already available for all patients in this study. Data was compiled with a custom electronic survey completed through consensus.

Results: 86 patients meeting criteria were discussed. In 42% of cases (36/86), the attending surgeon's impression of the case changed. In 41% of cases (35/86), the management plan was changed and most of these changes (54%; 19/35) were changes to acute management.

Substantive discrepancies between opinion of meeting radiologist and final report (RADPEER ≥ 3)¹ were less common (11%; 9/86).



There were multiple examples from this study (at least 10/86) where surgeon recognition of a fixed (rather than multifocal) site of bowel obstruction was facilitated.

Feedback from both radiologist and surgeon participants reported a high-level of satisfaction as well as improved inter-disciplinary communication and rapport.

Discussion: Direct, in-person review of abdominal imaging studies for selected patients leads to substantial changes in surgeon impression of cases as well as management decision making.

This likely represented a complex subset of abdominal imaging studies; surgeons chose cases of interest and the RADPEER major discrepancy rate was above literature reports.^{2,3}

This project was not a one-way street; discussion with surgeons may have assisted the reviewing radiologist to make findings as well as inform the radiologist of pertinent surgical questions.

Ineffective communication in radiology is often unrelated to overlooked imaging findings. Other benefits include education as well as improved rapport.

Conclusion: In-person communication increases the value of abdominal radiologists to general surgeons.

Citations:
 1. Jackson VP, Cushing T, Hingorani H, et al. RADPEER: A Survey of the American College of Radiology. *Am J Roentgenol*. 2006;187:22-25.
 2. Murray J, Klein KA, Chang S, et al. Cross-Sectional Examination Interpretation Discrepancies Between On-Call Diagnostic Radiology Residents and Subspecialty Faculty Radiologists: Implications for Imaging Modality and Subspecialty. *J Am Coll Radiol*. Elsevier Inc.; 2011;8:409-414.
 3. Davenport M, Ellis B, Ghazalati SH, Altman B, Kern KA. Effect of Work Hours, Fatigue, Shift Type, and Experience on Resident Call Performance. *Acad Radiol*. Elsevier Inc; 2010;17:921-927.

Change in management category

Final management category	Initial management category					
	image guided procedures	image guided procedures	image guided procedures	image guided procedures	image guided procedures	image guided procedures
image guided procedures	0	0	0	0	0	0
image guided procedures	1	1	7	0	0	1
image guided procedures	1	11	6	0	1	1
image guided procedures	2	2	11	0	0	1
image guided procedures	1	0	0	0	0	0
image guided procedures	0	0	1	0	1	0
image guided procedures	0	0	1	0	0	1

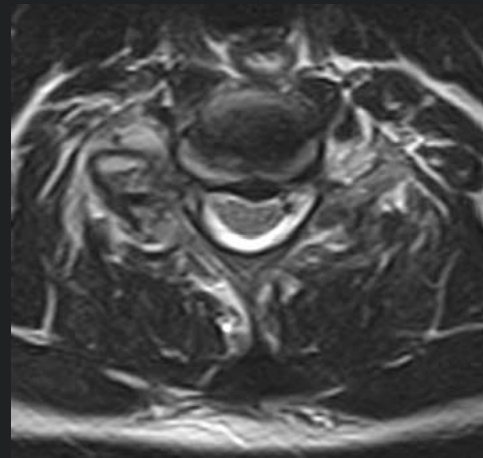
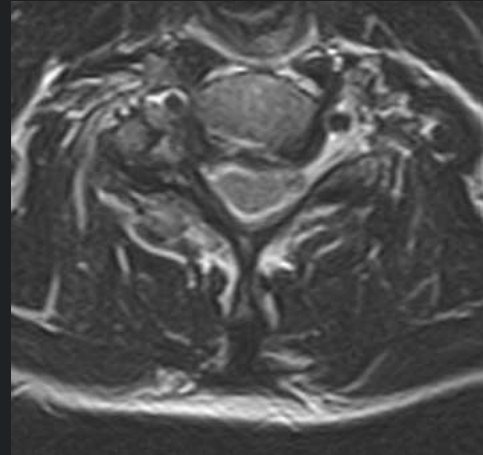
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6. Gesellschaftlicher Wert	Kosten/Nutzen Analyse bevölkerungsbezogen

w., 50j, cervikoradikuläres Syndrom C7
rechts.



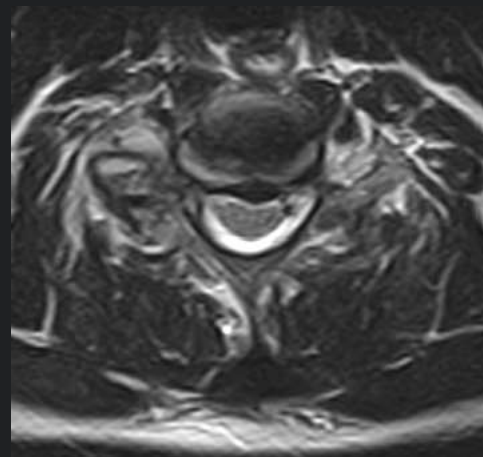
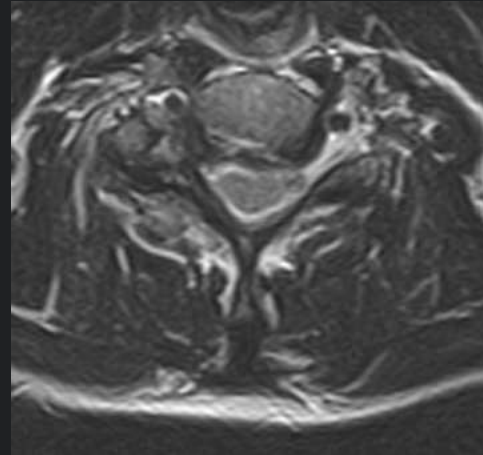
MRI: Einengung im rechten Neuroforamen C6/C7



w., 50j, cervikoradikuläres Syndrom C7
rechts. Vor 2 Wochen gestürzt.



MRI: Einengung im rechten Neuroforamen C6/C7



gleiche Patientin, CT: verhakte Luxationsfraktur,
Knochenfragment im Foramen



[m., 57j]

- Sturz vom Kran, initiale Bewusstlosigkeit
- Notfallstation: CT Schädel, Rx ganze WS, Thorax: alles oB

m., 57j, meldet sich wieder nach dem Wochenende

- AUF 50%

m., 57j, 2 Monate später

- persistierende Schmerzen „am ganzen Rücken und auf der Brust“

m., 57j, St. MRI GWS



m., 57j, St. MRI GWS



multiple, z.T. instabile Wirbelfrakturen,
Sternumfraktur



w, 69j, chronische Rückenschmerzen

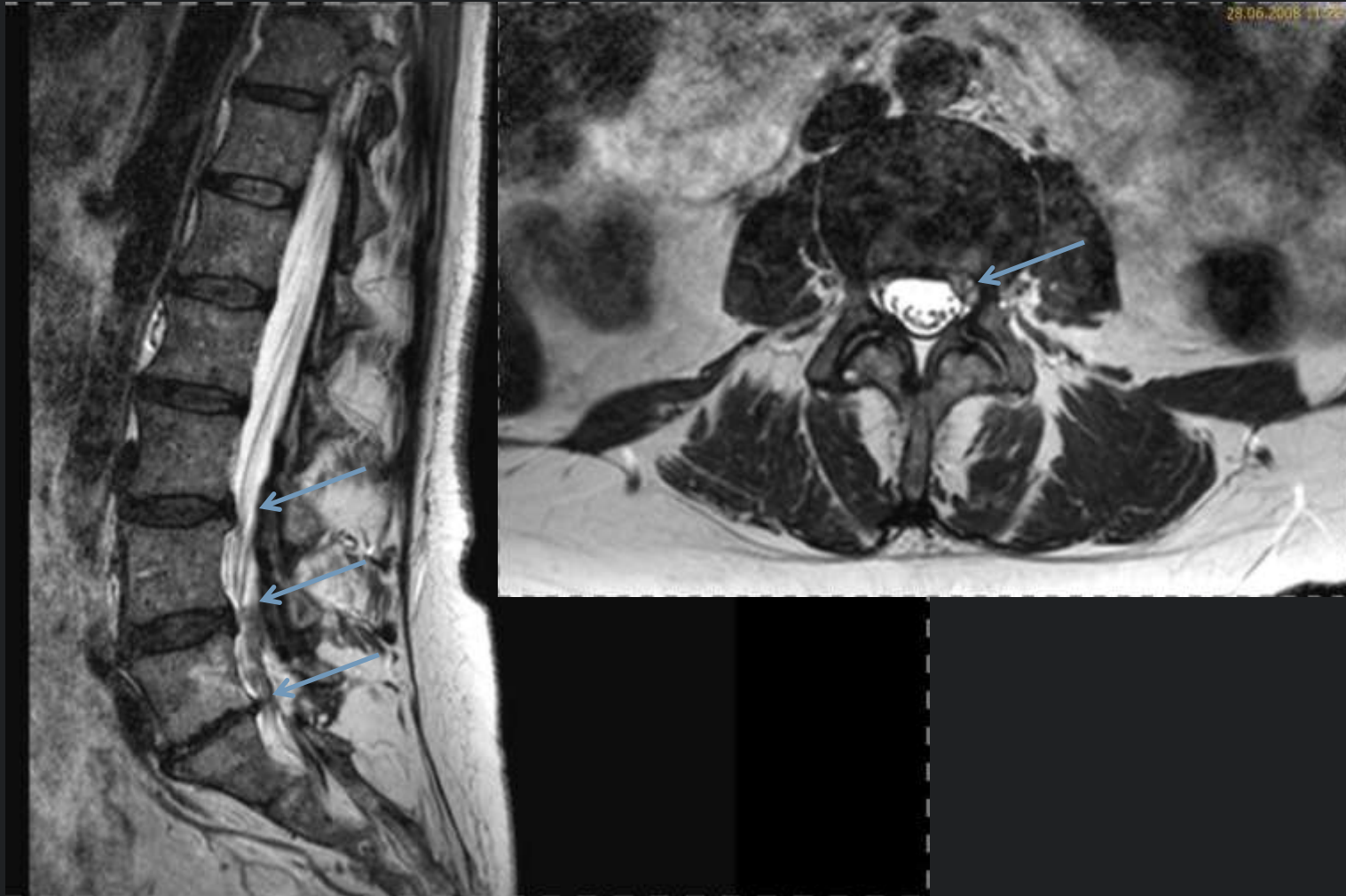
w, 69j, chronische Rückenschmerzen



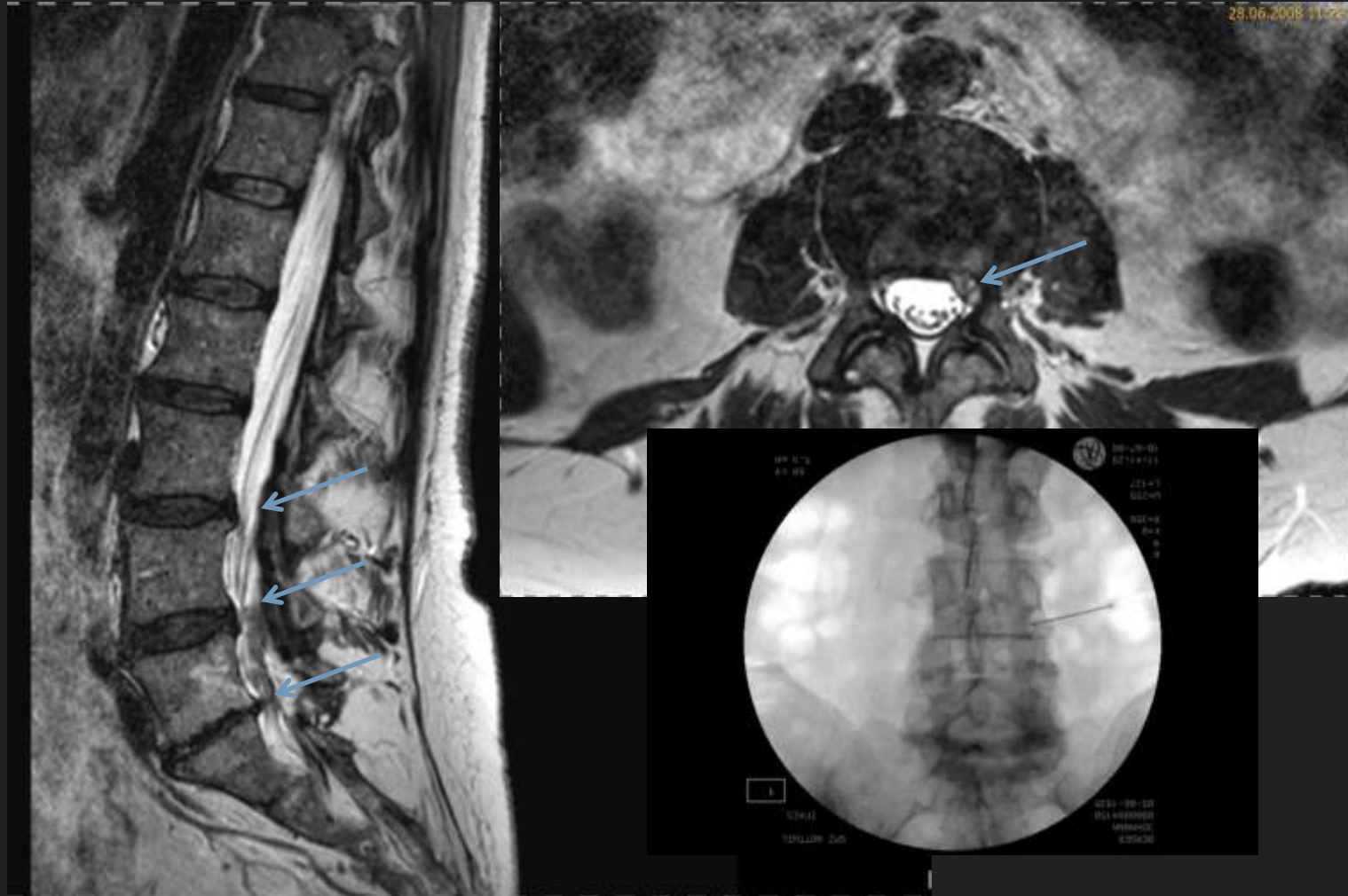
4 Jahre später: w, 73j, chronische Rücken- und Beinschmerzen links



4 Jahre später: w, 73j, Rücken- und Beinschmerzen links



4 Jahre später: w, 73j, chronische Rücken- und Beinschmerzen links, Depression



3 Monate später: rasch progrediente (aktivierte) Coxarthrose links



[M, 17j, Rückenschmerzen]

M, 17j, Rückenschmerzen

LWS ap/lat
20.09.2012

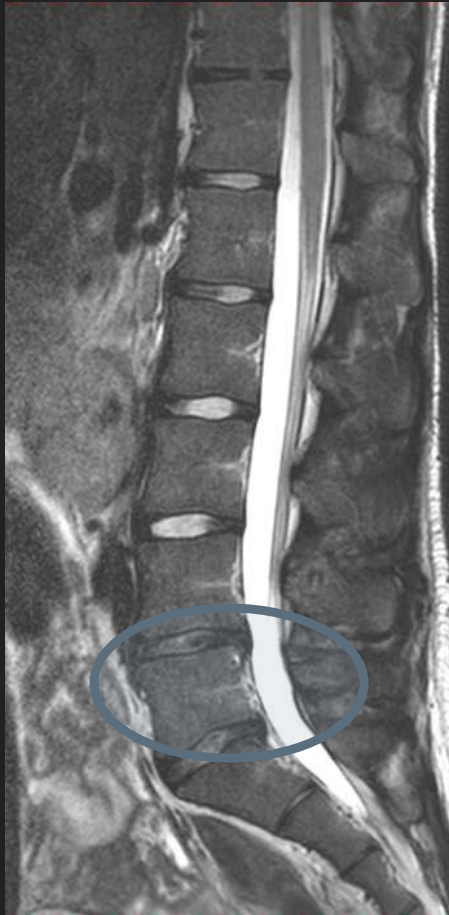


m, 17j, 3 Monate später Rückenschmerzen, CRP

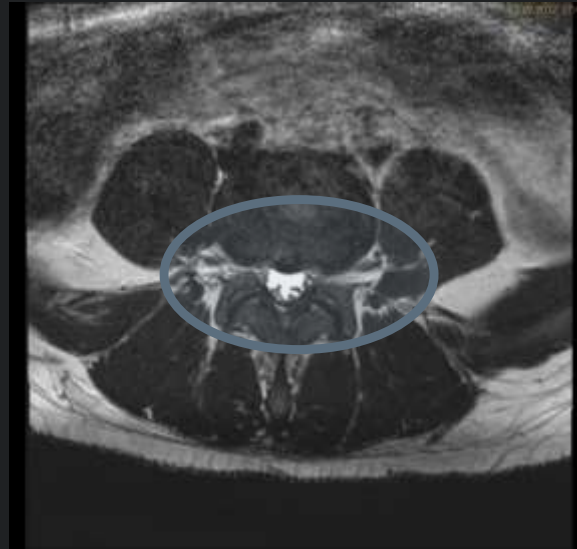
LWS ap/lat
20.09.2012



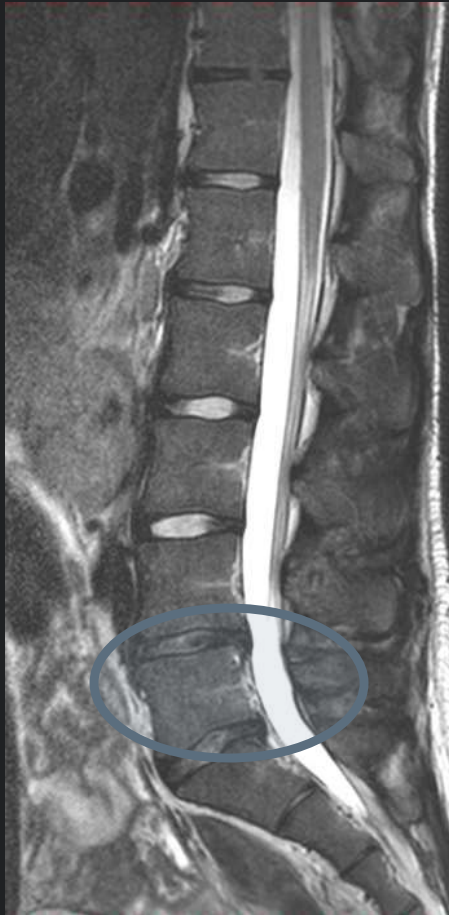
m, 17j, 3 Monate später Rückenschmerzen, CRP



MR LWS und ISG 11.12.2012



m, 17j, nochmals 7 Wochen später,
weiterhin Rückenschmerzen



MR LWS und ISG 11.12.2012



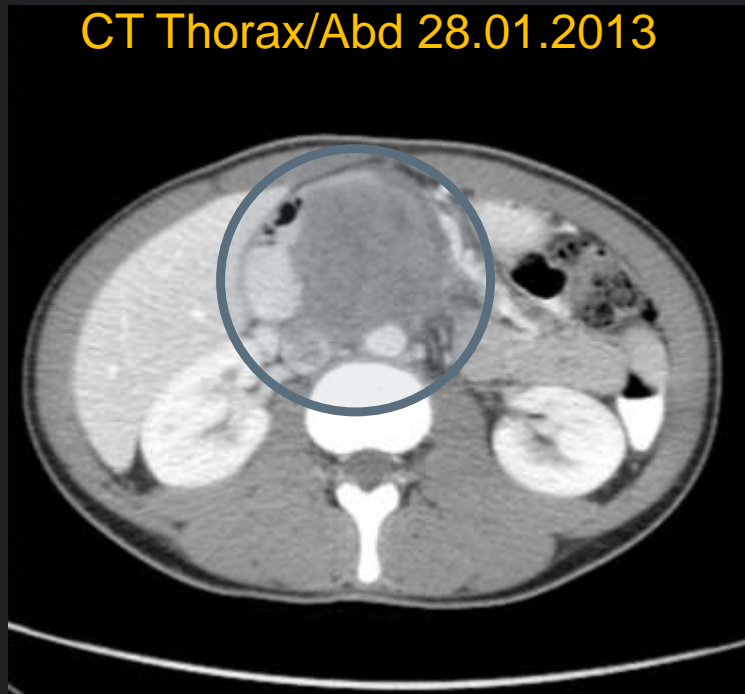
m, 17j, nochmals 7 Wochen später,
weiterhin Rückenschmerzen

CT Thorax/Abd 28.01.2013

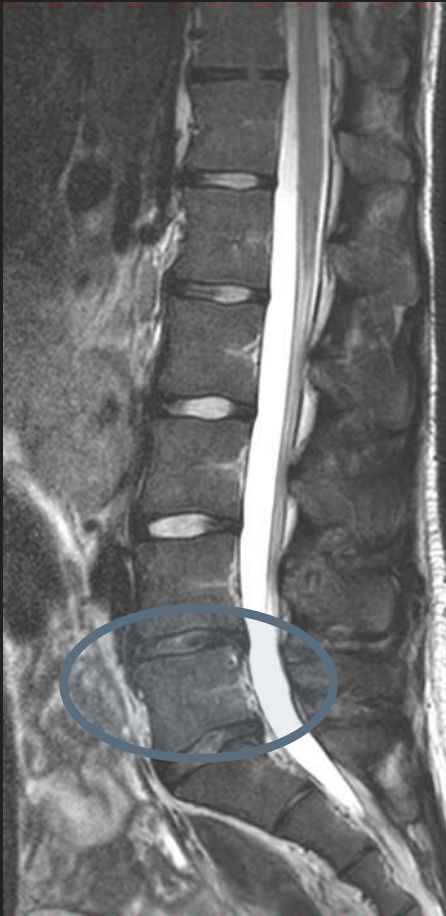


m, 17j, Rückenschmerzen

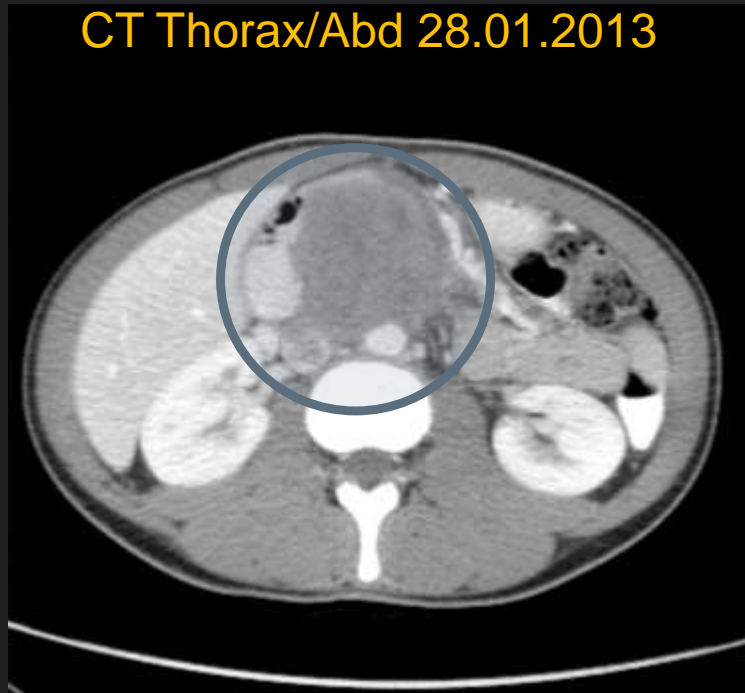
CT Thorax/Abd 28.01.2013



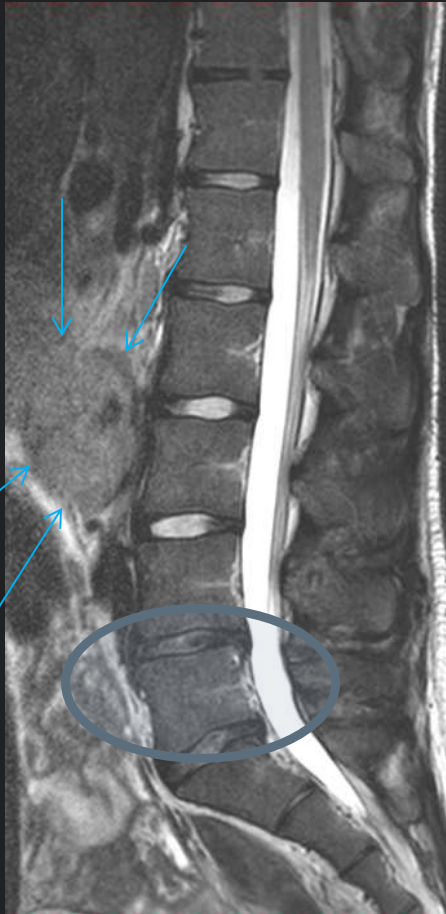
m, 17j, Rückenschmerzen



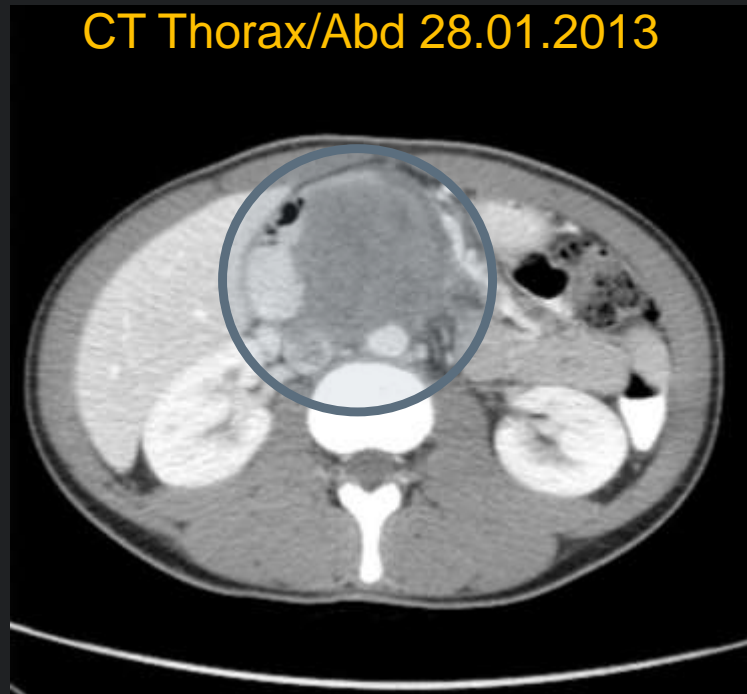
CT Thorax/Abd 28.01.2013



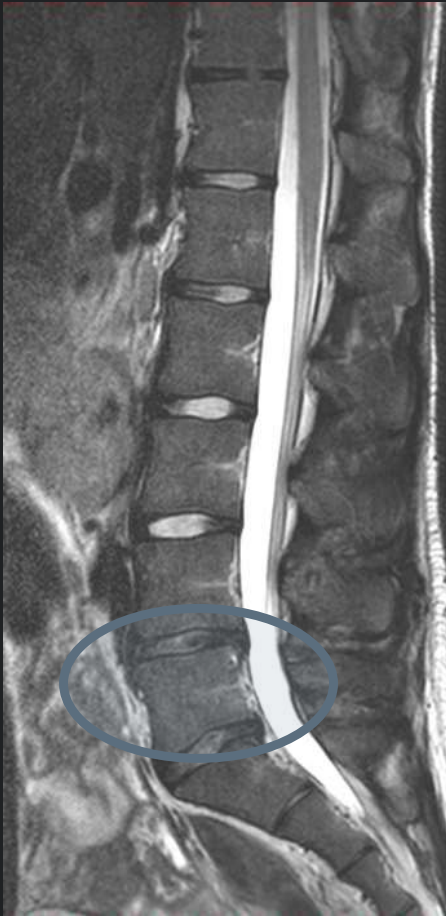
m, 17j, Rückenschmerzen



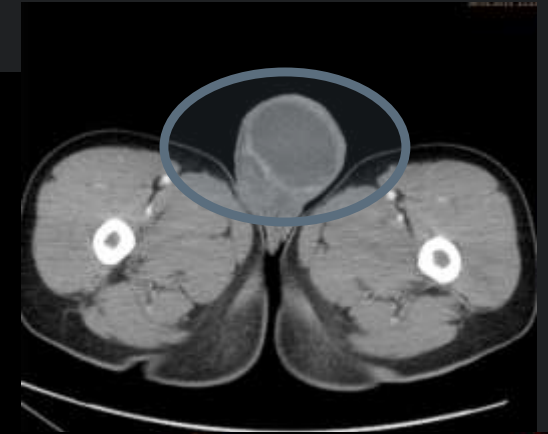
CT Thorax/Abd 28.01.2013



m, 17j, Rückenschmerzen

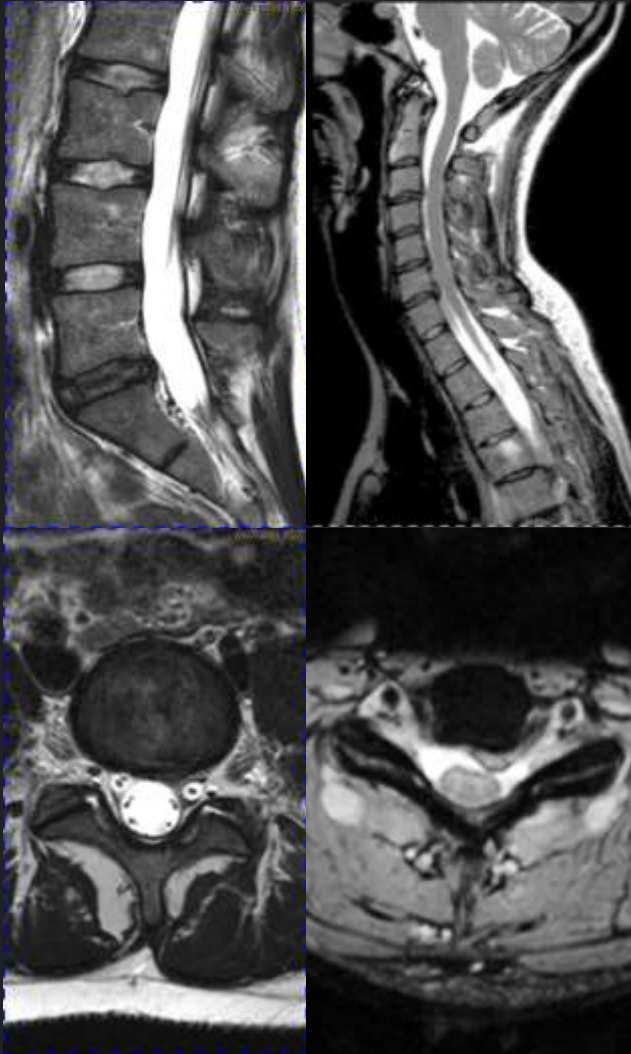


CT Thorax/Abd 28.01.2013

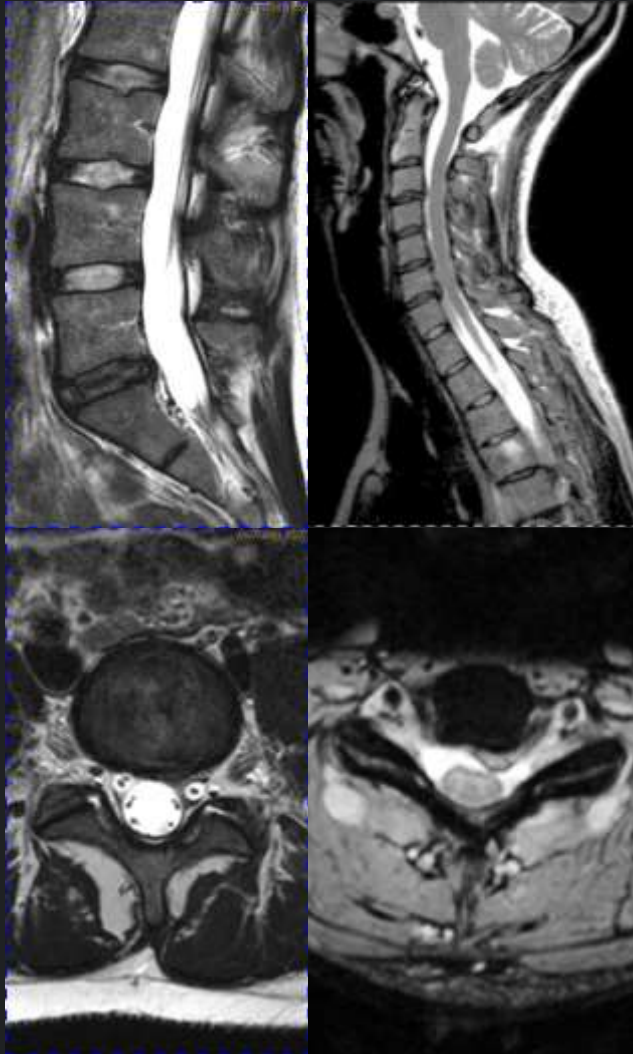


w, 29j, Juli 2011, Lumbalgie

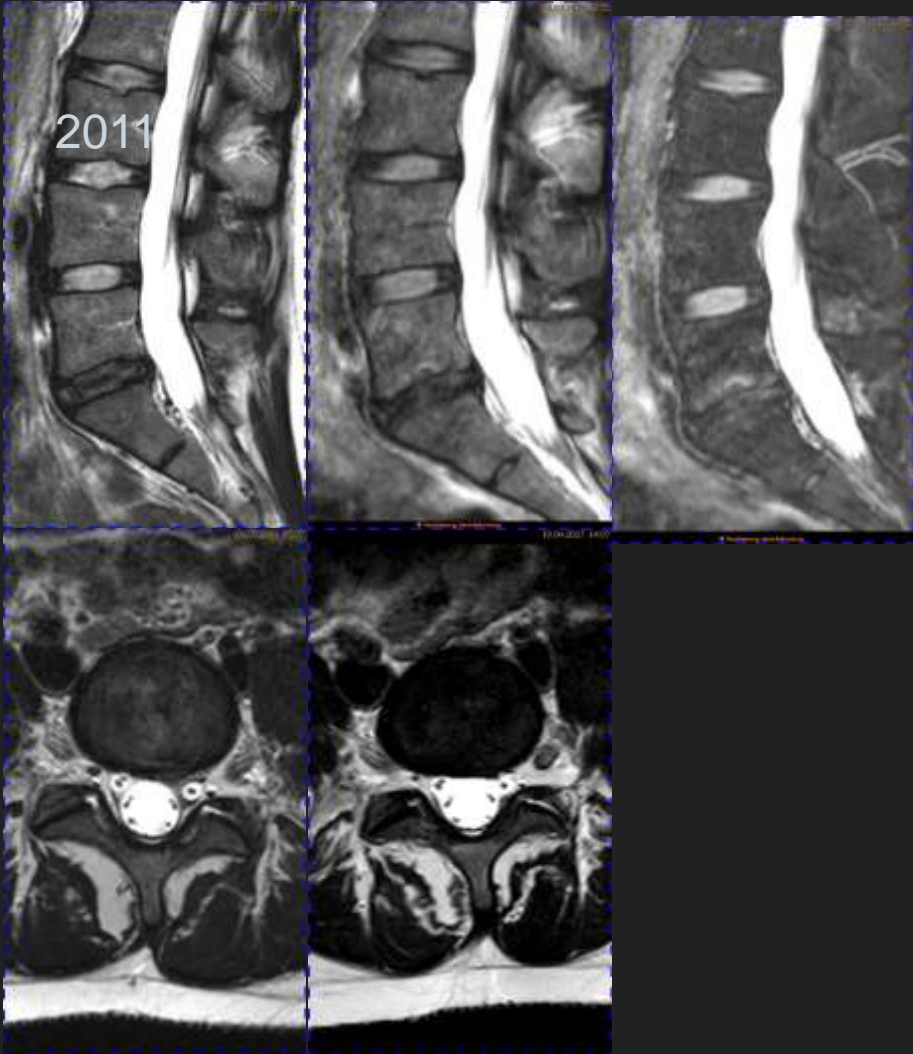
w, 29j, Juli 2011, Lumbalgie,
bekannte cervikale DH



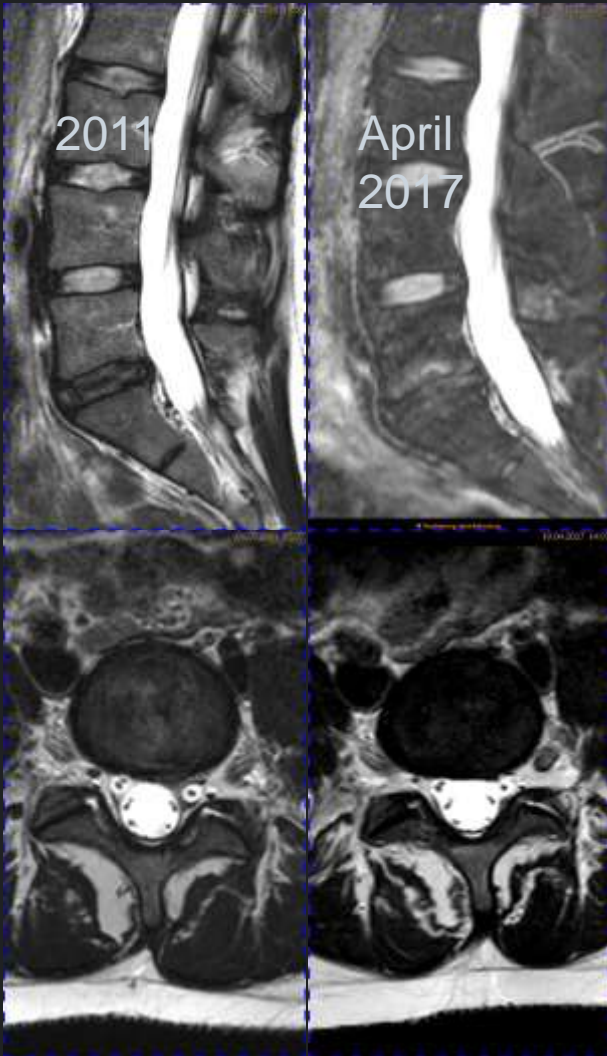
w, 35j, April 2017, heftige Lumbalgie



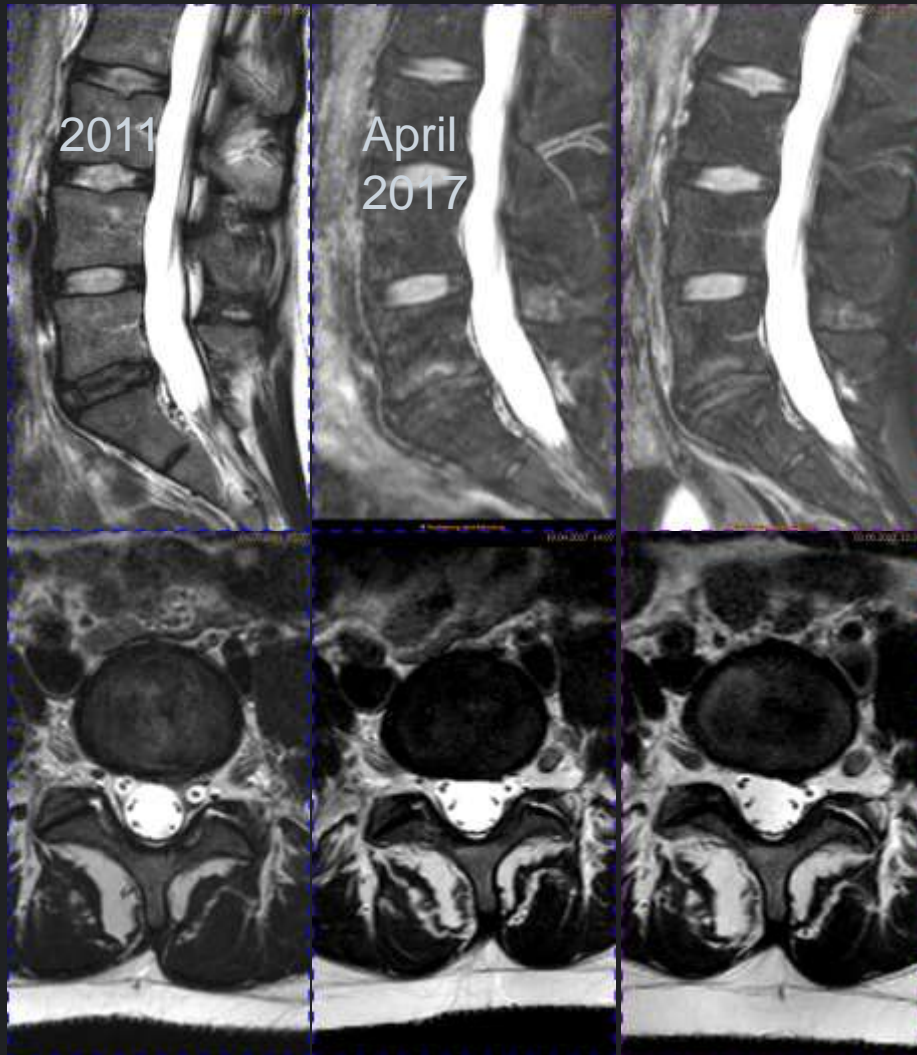
w, 35j, April, 2017, heftige Lumbalgie



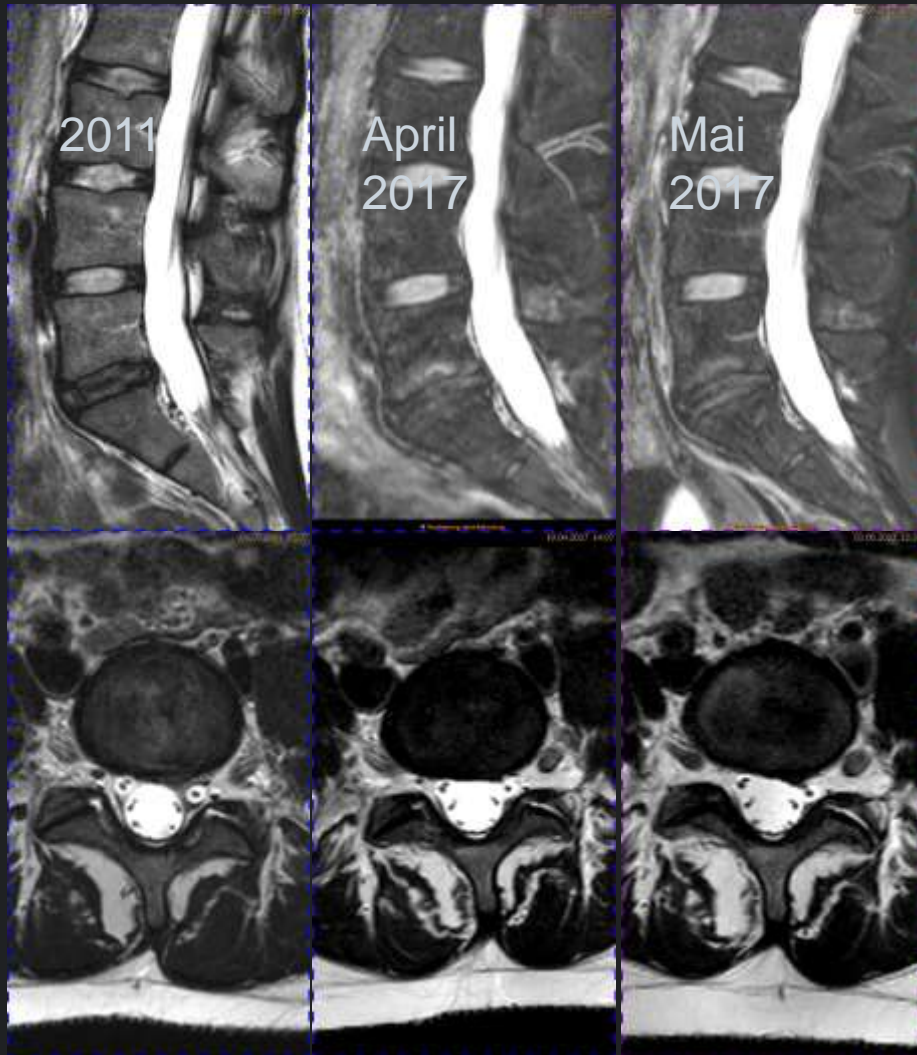
w, 35j, Mai 2017, heftige Lumbalgie,
Ausstrahlung ins Gesäss links



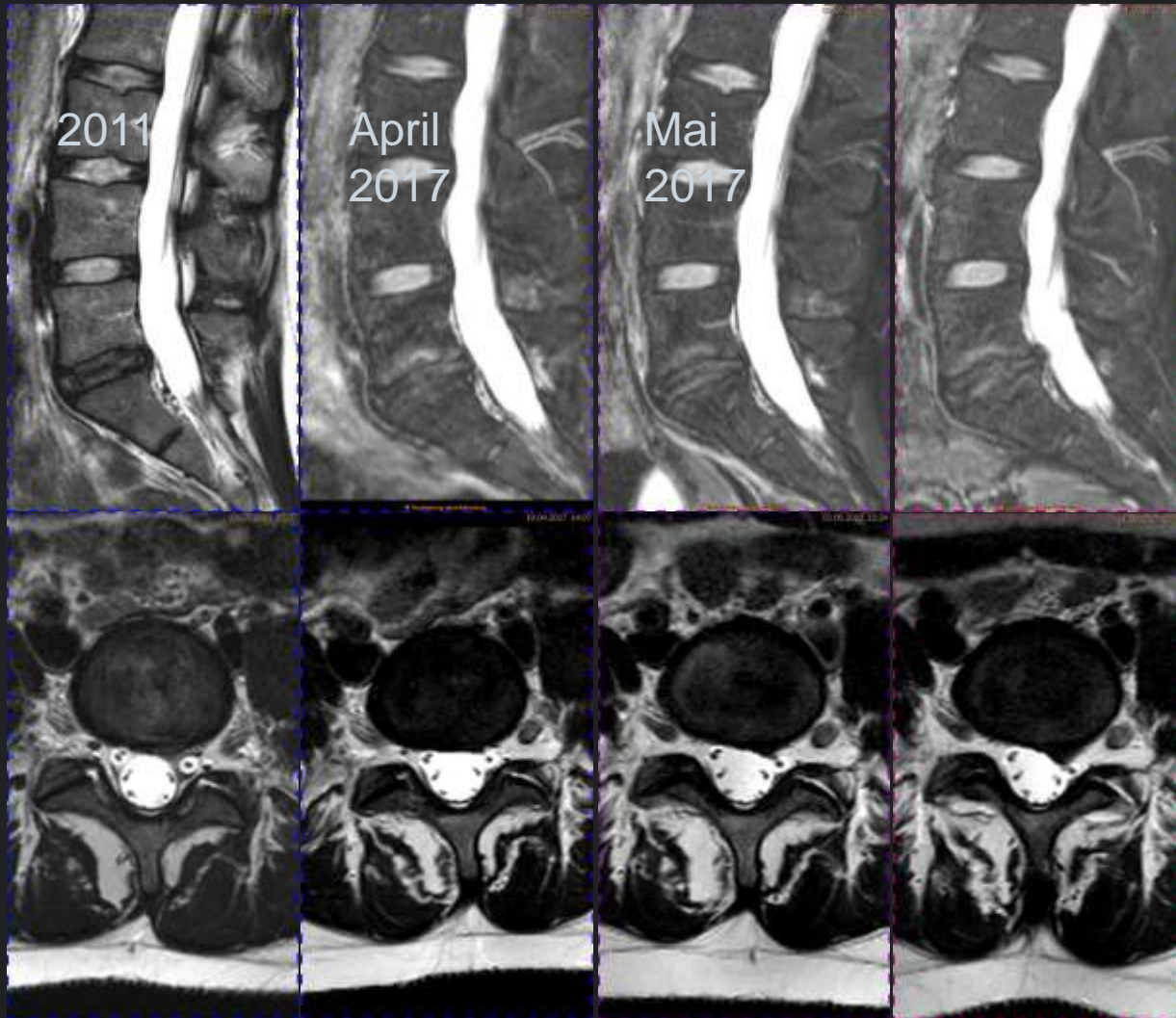
w, 35j, Mai 2017, Lumbalgie, Ausstrahlung ins Gesäss links



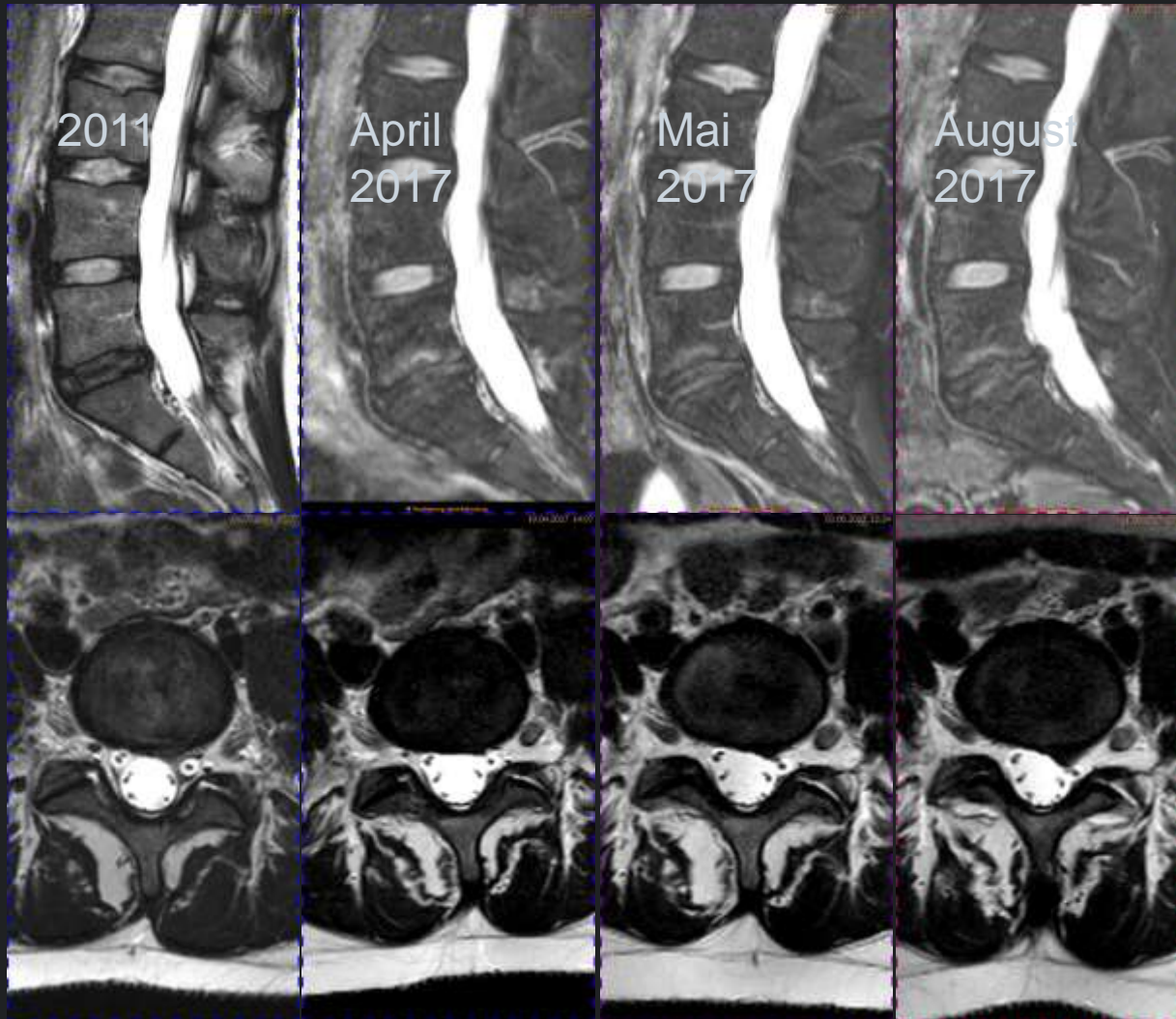
w, 35j, August 2018, Lumbalgie,
Austrahlung ins Gesäss und linke Bein



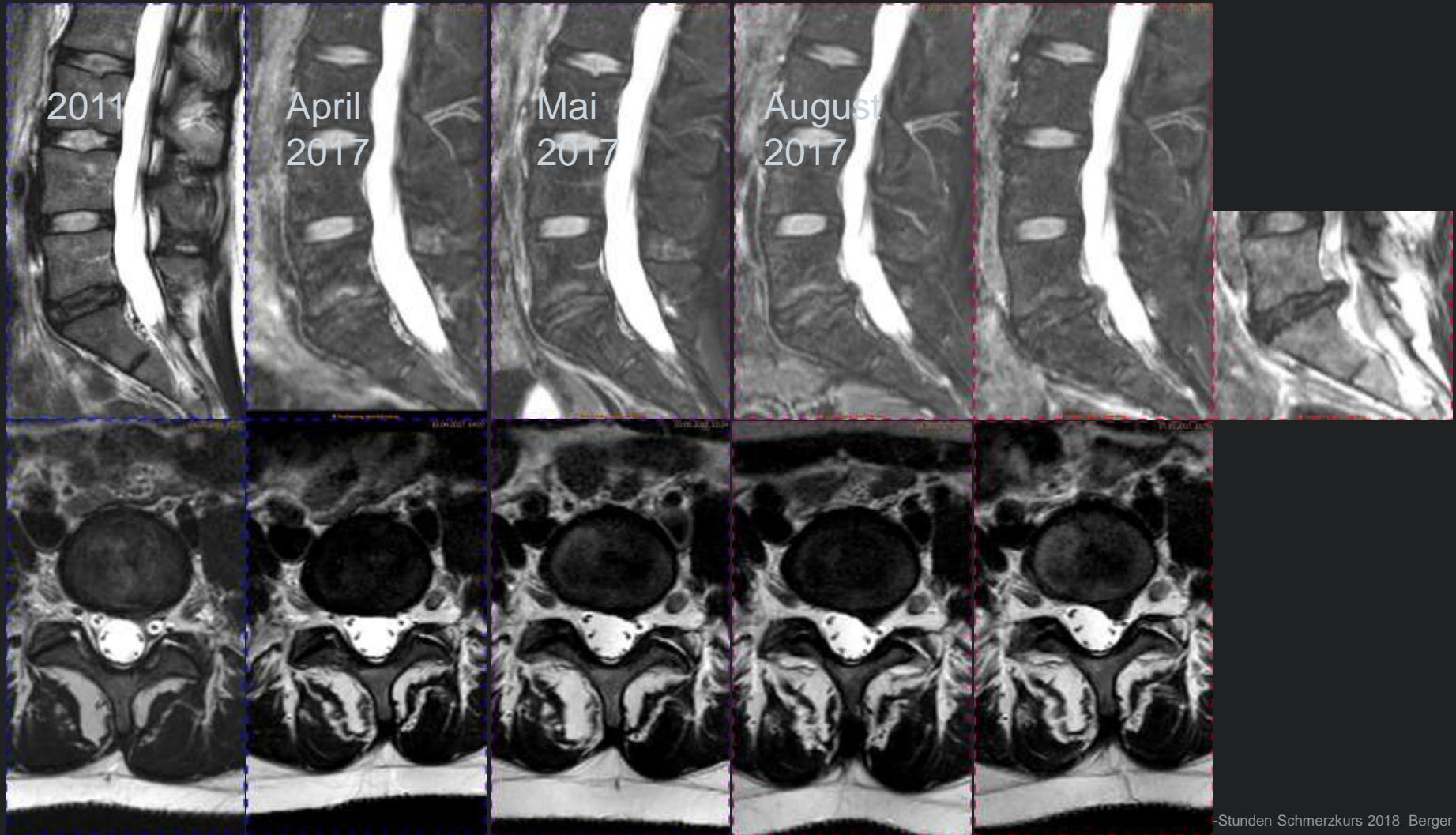
w, 35j, August 2018, Lumbalgie,
Austrahlung ins Gesäss und linke Bein



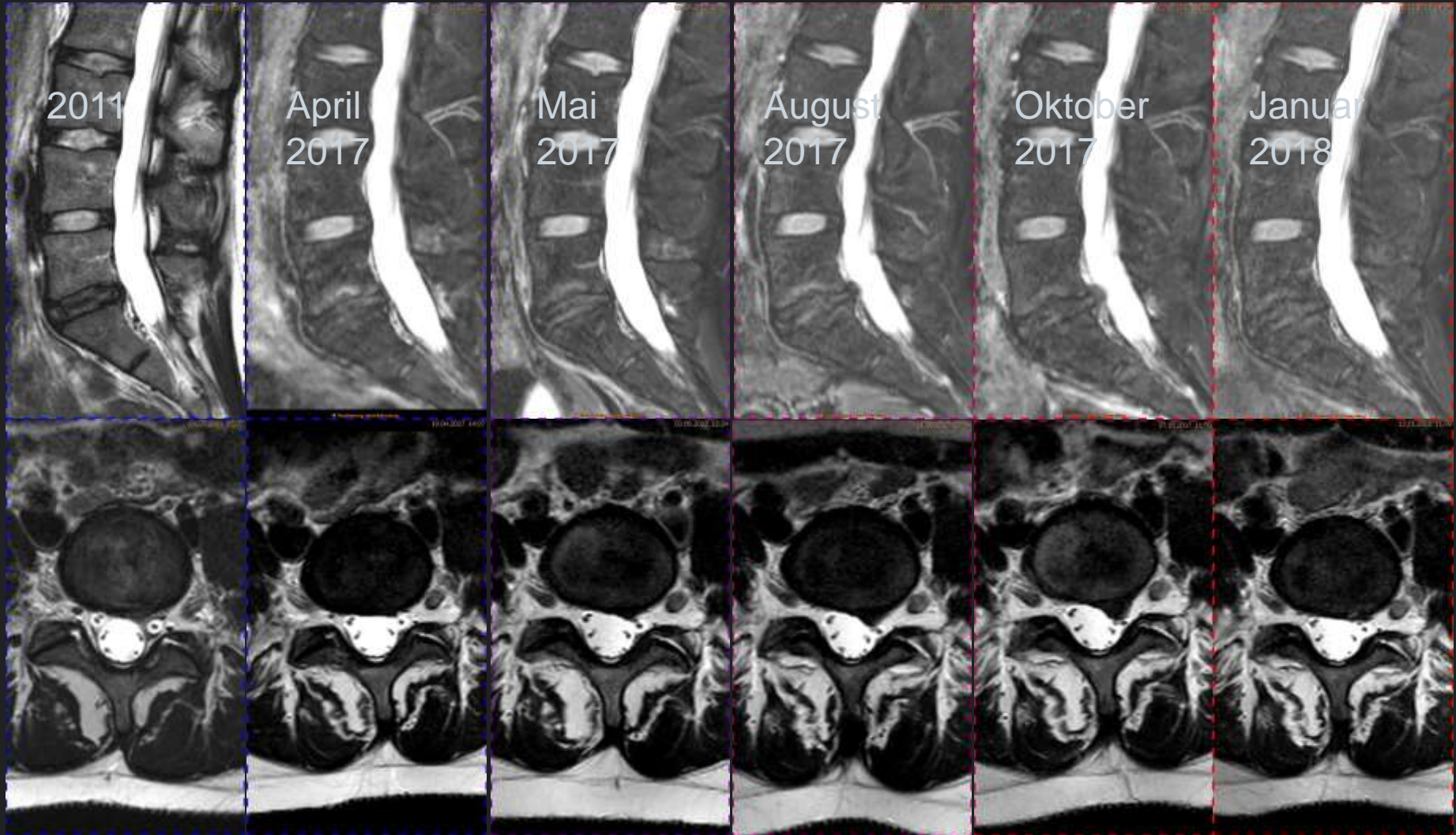
w, 35j, Oktober 2017, Lumbalgie,
persitierend/zunehmend



w, 35j, Oktober 2017, Lumbalgie,
persitierend/zunehmend



w, 35j, Januar 2018, weitgehend
beschwerdefrei



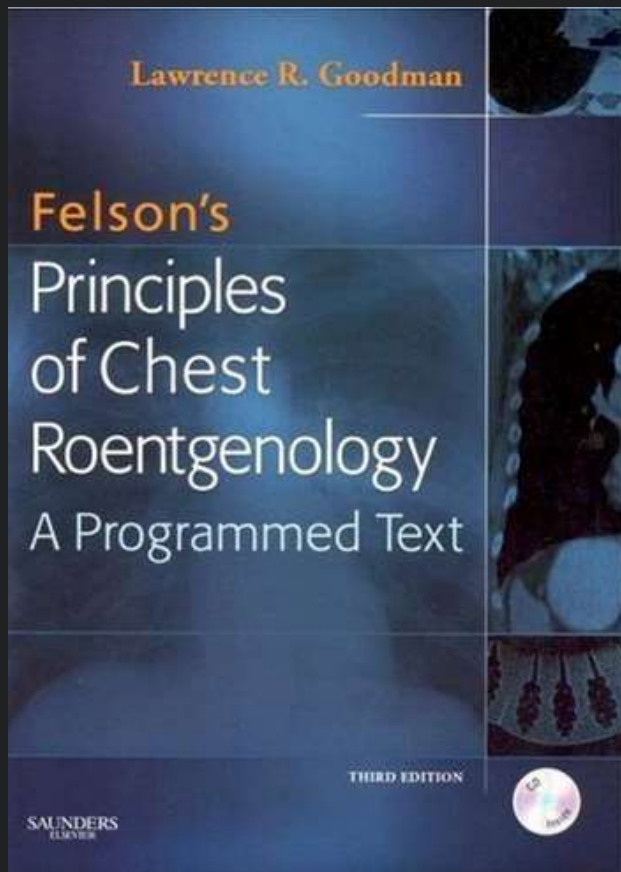
Bildgebung in der Schmerztherapie: Stellenwert

- Ausschluss von Pathologien, die dringend eine spezifische Therapie erfordern
- Identifizierung und Lokalisation wahrscheinlicher Schmerzursachen
- Evidenzbasierte Entscheidungen
- Therapieplanung/ bildgesteuerte Interventionen
- Kommunikation/Führung des Patienten
- Interdisziplinäre Kommunikation

Benjamin Felson (1913-1988)



Benjamin Felson (1913-1988)



„Things are seldom
what they seem
Skim milk
masquerades as
cream“

(William S. Gilbert, engl Lyriker 1836-1911)

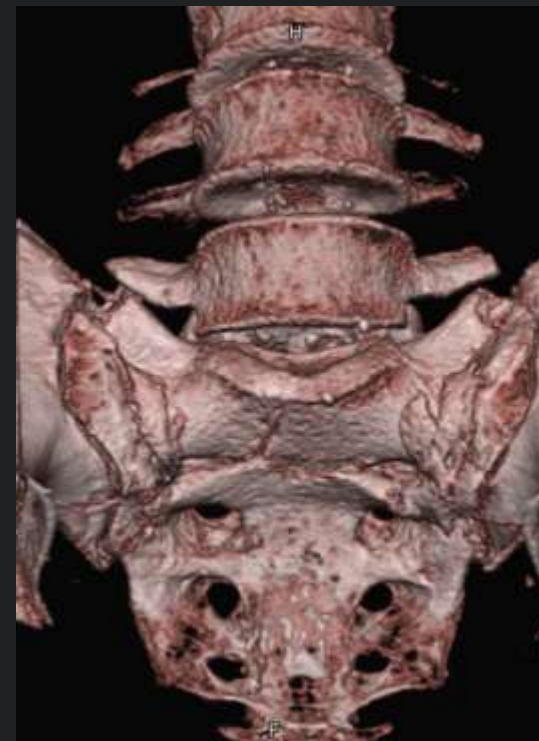
Uf weder luege...



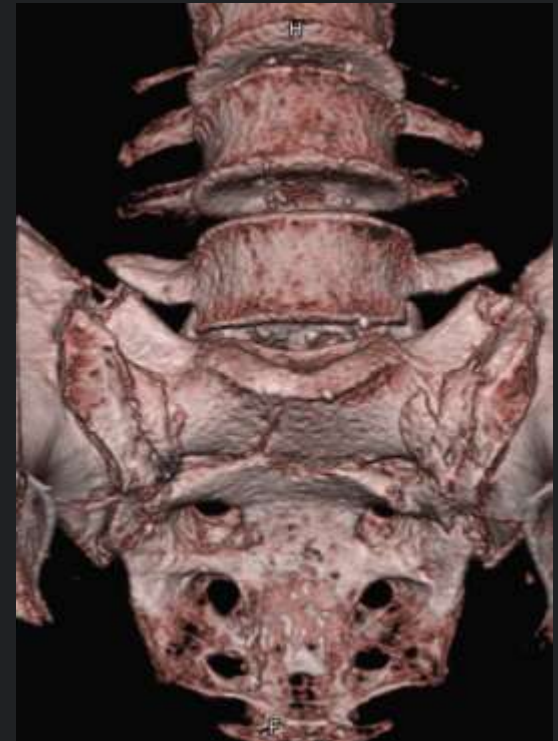




w., 67j, tieflumbale Rückenschmerzen



CT: Insuffizienzfraktur des Sakrums



w., 58j, V.a. ISG Pathologie



CT: ISG Arthrosen



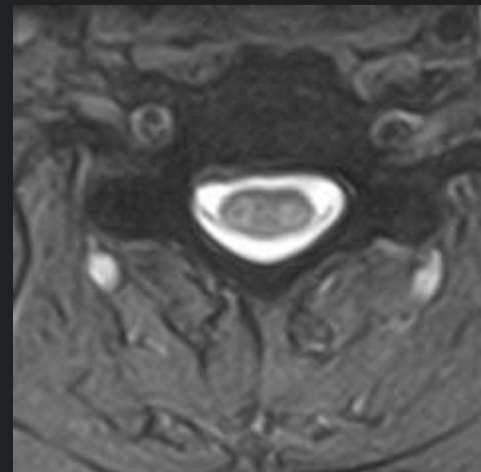
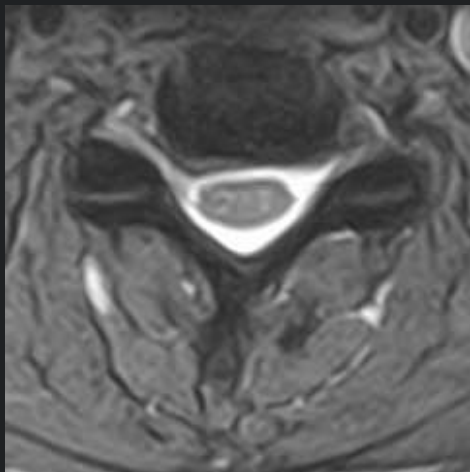
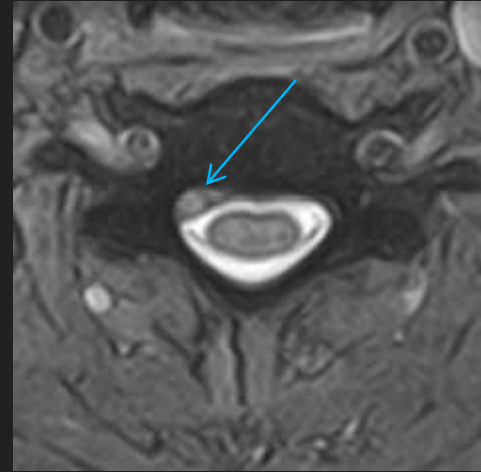
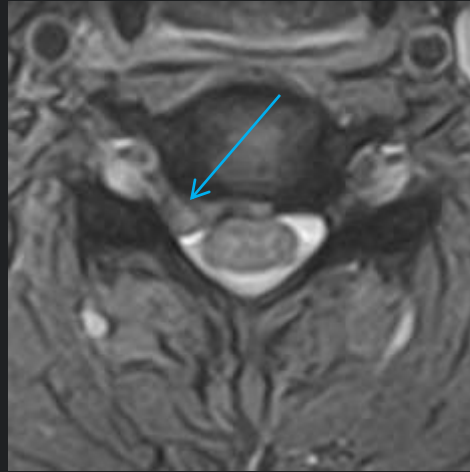
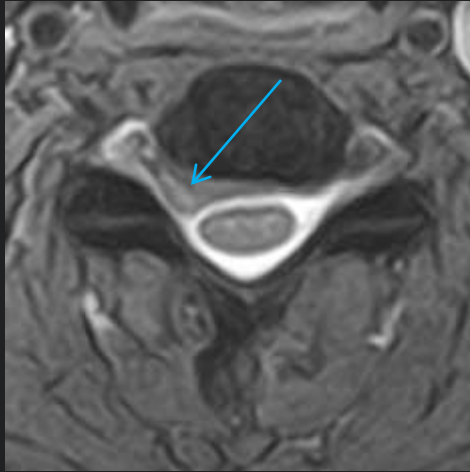
m., 23j, V. a. ISG Pathologie



MRI: rechts betonte aktive Sakroileitis



MRI: Spontanverlauf einer cervikalen Diskushernie;
oben 2003, unten 2005



Strahlendosis

Untersuchung	Effektive Strahlendosis	Hintergrundstrahlung während
Abdomen		
CT Abdomen	10 mSv	3 Jahren
Intravenöse Urographie	1,6 mSv	6 Monaten
Oberer Magendarmtrakt	2 mSv	8 Monaten
Unterer Magendarmtrakt	4 mSv	16 Monaten
Zentrales Nervensystem		
CT Schädel	2 mSv	8 Monaten
Thorax		
Thorax Röntgenaufnahme	0,1 mSv	2 Wochen
CT Thorax	8 mSv	3 Jahren
CT Thorax low dose	1 mSv	
Untersuchungen Kinder		
Zystourethrographie	0,8 mSv	3 Monaten
Untersuchungen Frauen		
Mammographie	0,7 mSv	3 Monaten