

Trauma thorakolumbální páteře - význam radiologických metod, terapie

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Epidemiologie úrazů páteře

- Incidence 64/ 100 000 obyvatel za rok
- 3-6 % všech úrazů
- 20 % úrazů páteře s sebou nese neurologický deficit
- Krční páteř (C0-C7) 20-33 %
- Thorako-lumbální páteř (Th1-L5) 67-80 %

Epidemiologie úrazů páteře

- Mladší lidé – většinou high energy trauma
- Starší lidé (7.-8. dekáda) – často low energy trauma, osteoporóza
- Závažné zdravotní, socioekonomické následky
- Část traumat při primárním vyšetření přehlédnuta
- Polytraumata/ sdružená poranění
 - Nutno myslet na případné poranění páteře
 - Důležitá preventivní imobilizace páteře do vyloučení jejího poranění

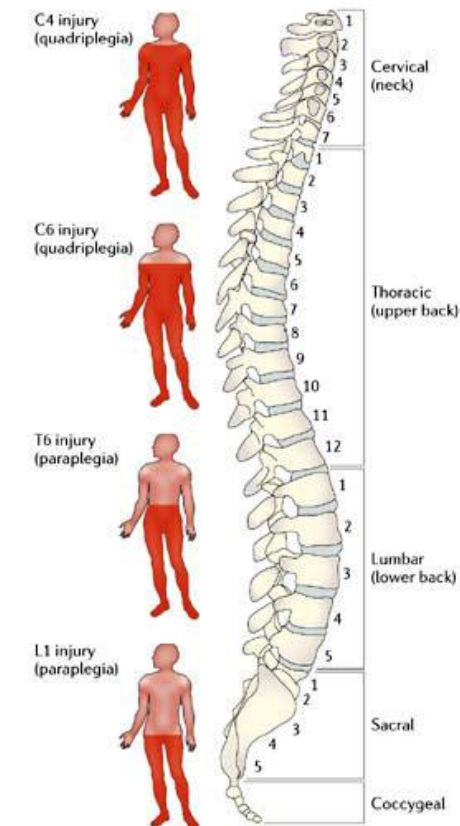
Etiologie

- Dopravní nehody
- Pády z výšky
- Skoky do vody
- Sportovní úrazy
- Penetrující poranění



Poranění míchy – spinal cord injury (SCI)

- Primární (nelze ovlivnit)
 - Komprese míchy fragmenty, hematodem, diskem
 - Torze, distrakce, stříh
 - Ischemie
 - Direktní násilí
- Sekundární (může být léčbou ovlivněno)
 - Cévní změny
 - Snížený průtok
 - Trombóza
 - Vazospazmus
 - Změny elektrolytů
 - Volné O₂ radikály
 - Zánětlivé změny



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Historie - Starověk

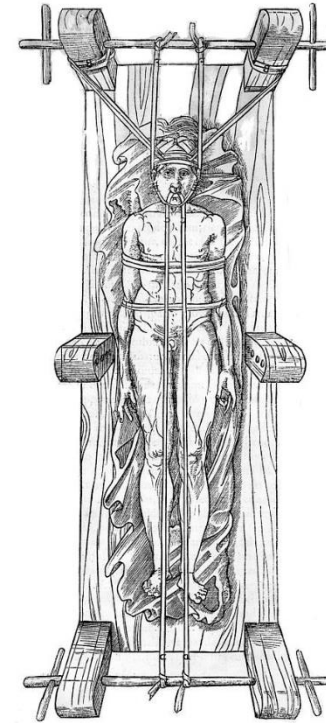
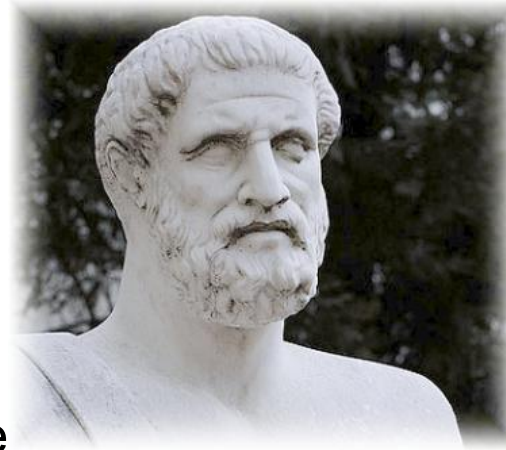
- Imhotep (2 686 - 2 613 př.n.l.)
 - Lékař, stavitel, velekněz Džosera II
 - Pojednání o chirurgii – papyrus Edwina Smitha (přeložen 1930)
 - Poranění míchy v různé úrovni vede k tetra/paraplegii, ale neznal mechanismus



Historie - Starověk

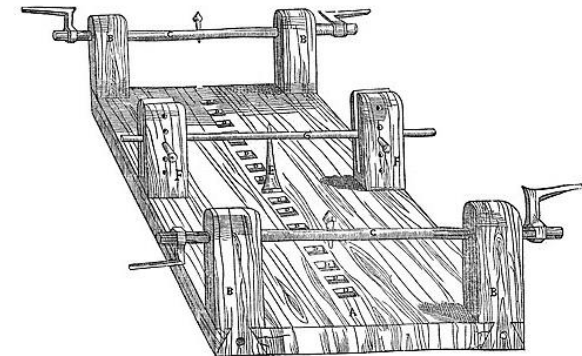
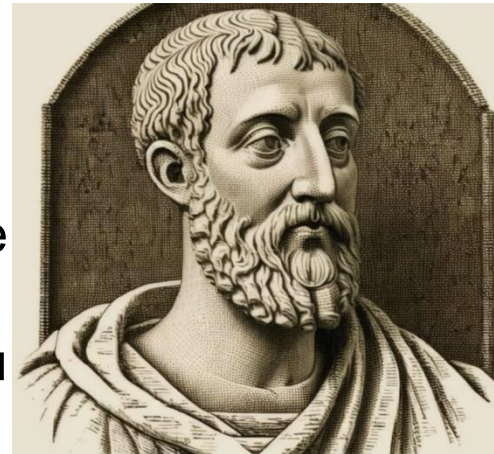
- Hippokrates (460 - 375 př.n.l.)

- Člen Aesculapova kultu
- Napomohl oddělení medicíny od mytologie
- Prevence dekubitů u SCI
- Hippokratova lavice k léčbě úrazů



- Galén (130 - 200 n.l.)

- Anatomické pitvy, experimentální fyziologie
- Vztah mezi nerv. – sval. soustavou
- Lékař gladiátorů – dostatek úrazů ke studiu



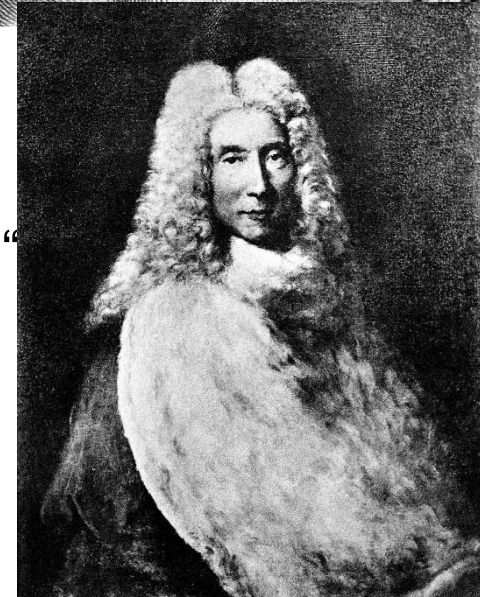
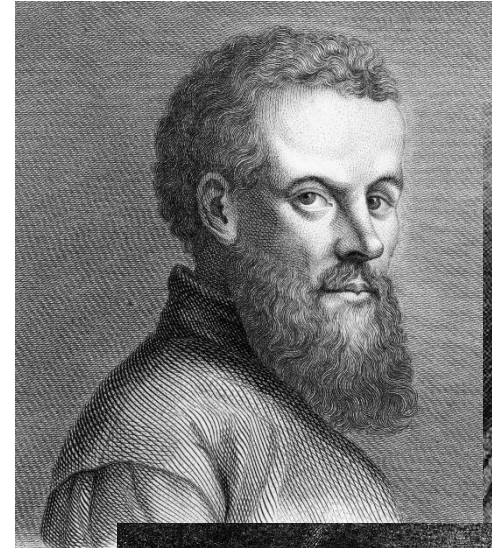
Historie – Starověk a Středověk

- Pavel z Eginy (625 - 690)
 - Kompendium medicíny
 - Použití dlah na repozici zlomenin
 - Pravděpodobně provedl první laminectomii u zlomeniny obratle
 - Poranění míchy nadále zůstávalo fatálním úrazem
- Středověk
 - Temno i na poli medicíny



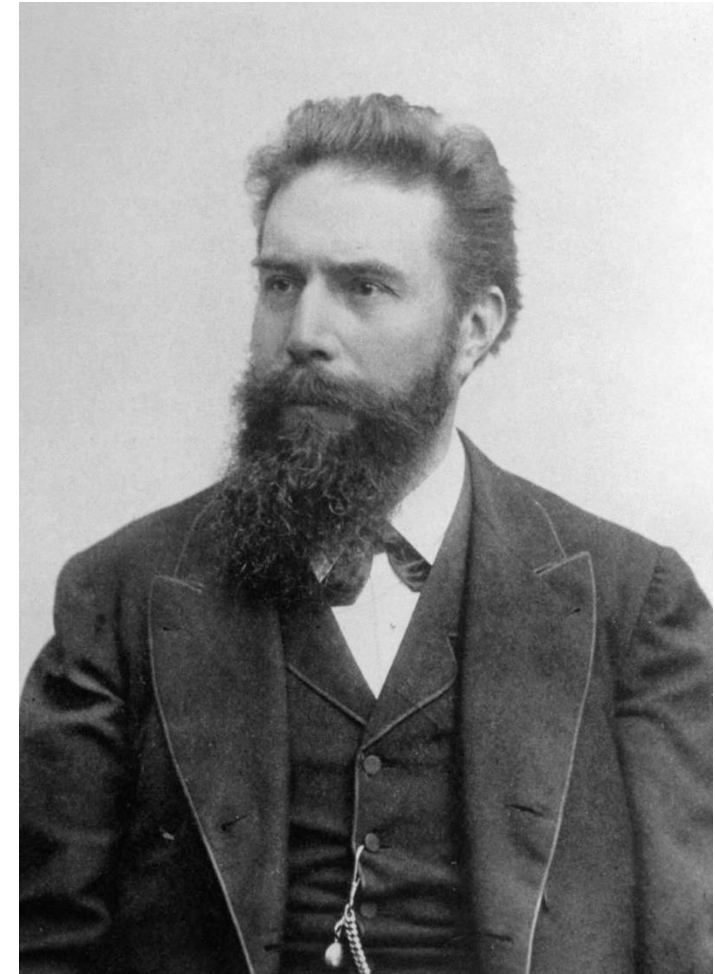
Historie - Renaissance

- Andreas Vesalius (1514 - 1564)
 - „De Humani Corporis Fabrica“ – základy anatomie
- Ambrosie Paré (1510 - 1590)
 - Rozvoj péče o rány
- Nicolas Andry (1658 - 1742)
 - První kniha o muskuloskeletárním systému – „L´Orthopaedie“
 - Léčba deformit páteře
- Parcival Pott (1717 - 1788)
 - 1769 – publikace o podstatě deformit páteře při TBC



Historie - Novověk

- Rozvoj mnoha oborů, které umožnily operační léčbu spondylotraumat
- Pasteur – bakteriologie
- Lister – aseptická chirurgie
- Schimmelbuch a Terrie – sterilizace
- Halstead – gumové rukavice
- Vznik anestezie
- Roentgen – paprsky X (1896)

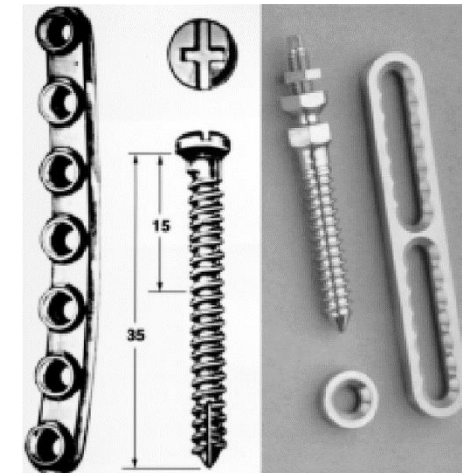
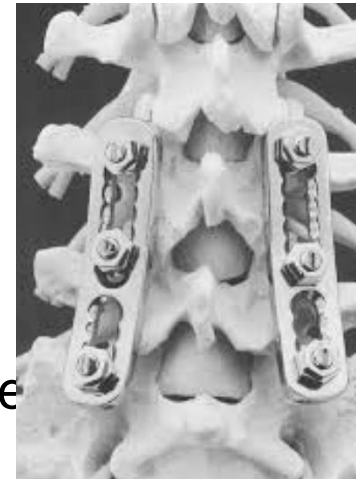
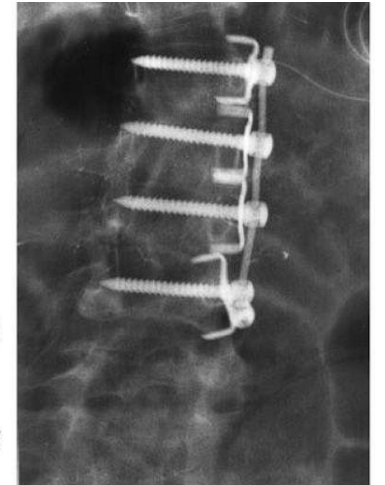
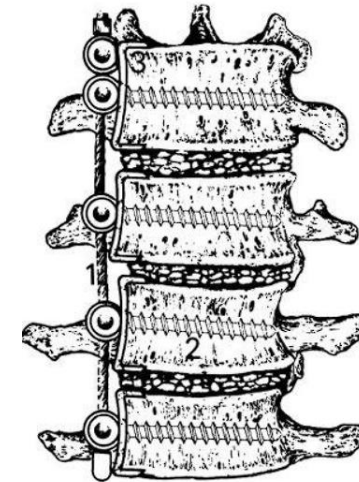


Historie - Novověk

- 1829 – Alban Gilpin Smith – úspěšná laminektomie
- 1847 – Josef Francois Malgaigne - hyperextenze k léčbě dislokace páteře
- 1891 – Bethold Hadra – stabilizace páteře drátem kolem spinálních výběžků
- 1902 – Lorenzo Bonomo – představil hemilaminektomii
- 1908 – Fratz Lange - vnitřní fixace drátem
- 1921 – Sicard a Forestier – myelografie
- 1924 – Von Lakum a DeForest-Smith – operace páteře z předního přístupu
- 1930 – Stryker – otočný rám pro polohování
- 1936 – Donald Mundro – cévkování

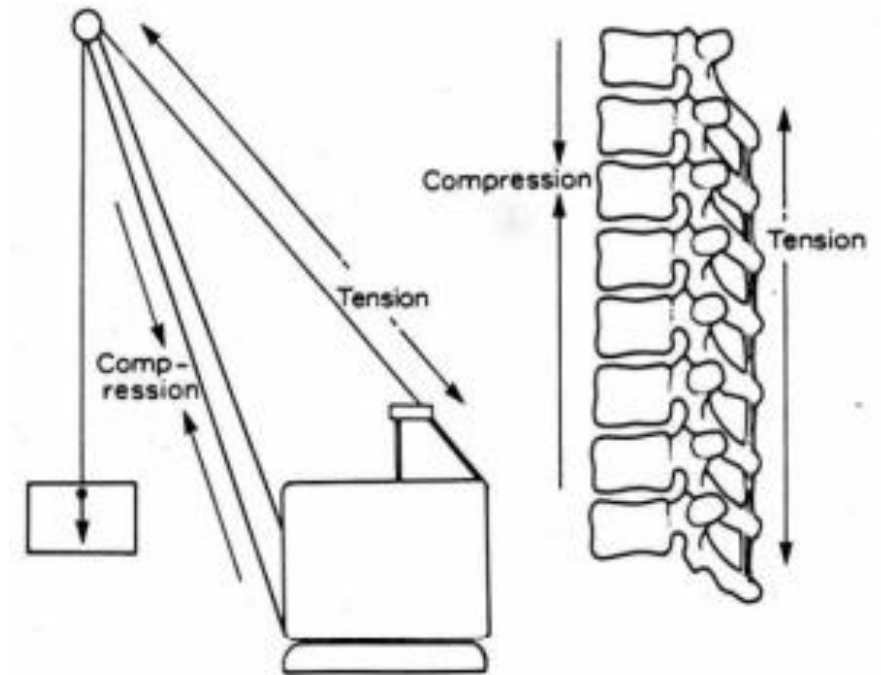
Historie - Novověk

- 1950´ – Guttman – intermitentní cévkování – zlepšení přežití
- 1953 – Paul Harrington - rod-hook system
- 1960´ – Harrington, Roy-Camille – transpedikulární šrouby
- 1964 – Dwyer – přední instrumentace páteře
- 1973 – Haundsfiel – vznik CT
- 1976 – Luque – technika sublaminárních kliček
- 1977 – Mansfield – MRI
- 1970´ – Roy-Camille – dlaha s fixními otvory
- 1980´ – Gaines – variable screw placement plate



Klasifikace

- Watson –Jones 1943
- Nicoll 1949 2sl.
- Holdsworth 1963, 1970 2sl.
- Kelly + Whitesides 1968 2sl.
- Denis 1983 3sl.
- McAfee 1983 3sl.
- Magerl 1994 2sl.



Klasifikace

- Nicoll 1949
 - definice instability jako riziko redislokace (kominuce, ruptura disku, interspinozního vazů)
- Holdsworth 1952
 - zadní ligamentózní komplex, burst fracture
- McAfee 1983
 - Klasifikace na základě CT, Denisův model

FRACTURES OF THE DORSO-LUMBAR SPINE

E. A. NICOLL, MANSFIELD, ENGLAND

From the Orthopaedic and Accident Service of the Mansfield General Hospital

Review Article

Fractures, Dislocations, and Fracture-Dislocations of the Spine*

BY SIR FRANK HOLDSWORTH, M.B., M.CHIR., F.R.C.S.†, SHEFFIELD, ENGLAND

From the Spinal Injuries Centre, Sheffield

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The Value of Computed Tomography in Thoracolumbar Fractures

AN ANALYSIS OF ONE HUNDRED CONSECUTIVE CASES AND A NEW CLASSIFICATION*

BY PAUL C. MCAFEE, M.D.†, HANSEN A. YUAN, M.D.†, BRUCE E. FREDRICKSON, M.D.†, AND JOHN P. LUBICKY, M.D.†, SYRACUSE, NEW YORK

From the Department of Orthopedic Surgery, Upstate Medical Center, Syracuse

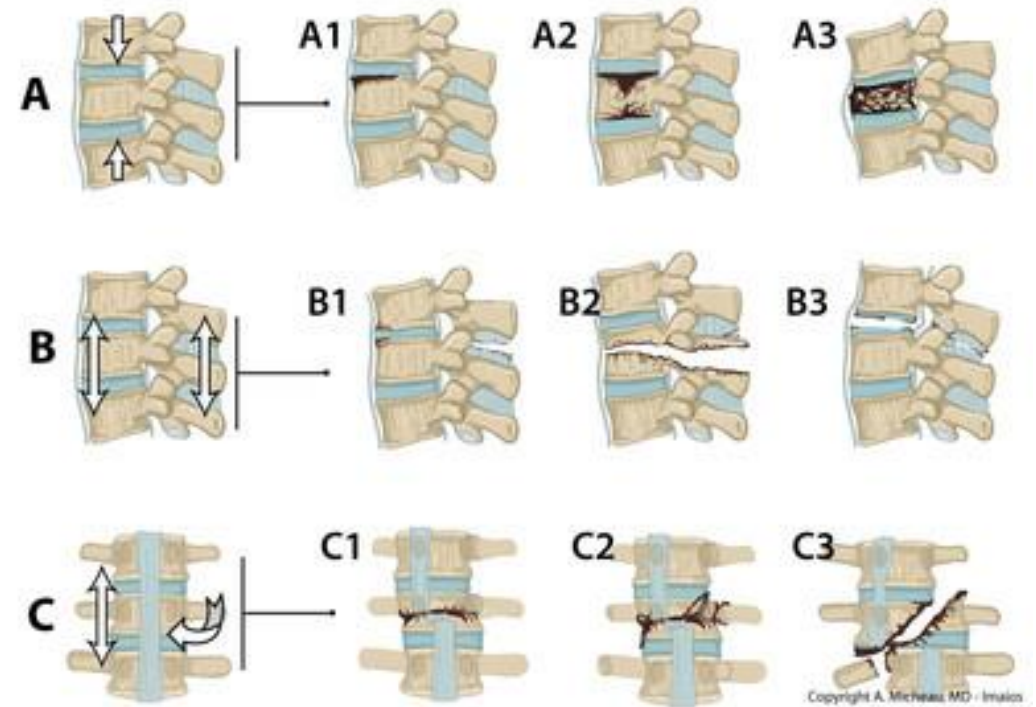
Magerlova AO klasifikace

- založená na patomorfologických kritériích po prostudování 1445 poranění Th, L páteře
- rozdělení zlomenin do hlavních skupin dle mechanismu úrazu
 - A: komprese obratlového těla
 - B: poranění předních a zadních elementů s distrakcí
 - C: léze předních a zadních elementů při poraněních s rotací
- velké množství podtypů zlomenin

Magerlova AO klasifikace

- vytvořena se snahou o jednotný systém klasifikace poranění páteře
- využitelnost pro klinickou praxi a výzkum
- jako výchozí bod využita Magerlova klasifikace (s patrností kritiky Magerlovoy klasifikace pro přílišnou detailnost)

MAGERL CLASSIFICATION



AO klasifikace

AO Spine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers

Vaccaro AR, Oner C, Kepler CK, Dvorak M, Schnake K, Bellabarba C, Reinhold M, Aarabi B, Kandziora F, Chapman J, Shanmuganathan R, Fehlings M, Vialle L;

AOSpine Spinal Cord Injury & Trauma Knowledge Forum. Spine (Phila Pa 1976). 1;38(23):2028-37, Nov 2013.

Reliability analysis of the AO Spine thoracolumbar spine injury classification system by a worldwide group of naïve spinal surgeons

Kepler CK, Vaccaro AR, Koerner JD, Dvorak MF, Kandziora F, Rajasekaran S, Aarabi B, Vialle LR, Fehlings MG, Schroeder GD, Reinhold M, Schnake KJ, Bellabarba C, Cumhur Öner F. Eur Spine J 25(4): 1082-1086, 2016.



AO Spine Thoracolumbar Injury Classification System

Type A	Compression Injuries	Type B	Distraction Injuries	Type C	Translation Injuries
A0	Minor, nonstructural fractures Fractures, which do not compromise the structural integrity of the spinal column such as transverse process or spinous process fractures.	B1	Transosseous tension band disruption Chance fracture Monosegmental pure osseous failure of the posterior tension band. The classical Chance fracture.	C	Displacement or dislocation There are no subtypes because various configurations are possible due to dislocation/dislocation. Can be combined with subtypes of A or B.
A1	Wedge-compression Fracture of a single endplate without involvement of the posterior wall of the vertebral body.	B2	Posterior tension band disruption Bony and/or ligamentary failure of the posterior tension band together with a Type A fracture. Type A fracture should be classified separately.		
A2	Split Fracture of both endplates without involvement of the posterior wall of the vertebral body.			B3	Hyperextension Injury through the disc or vertebral body leading to a hyperextended position of the spinal column. Commonly seen in ankylosing disorders. Anterior structures, especially the ALL, are ruptured but there is a posterior hinge preventing further displacement.
A3	Incomplete burst Fracture with any involvement of the posterior wall; only a single endplate fractured. Vertical fracture of the lamina is usually present and does not constitute a tension band failure.	A4	Complete burst Fracture with any involvement of the posterior wall and both endplates. Vertical fracture of the lamina is usually present and does not constitute a tension band failure.		

Algorithm for morphologic classification

Neurology

Type	Description
N0	Neurology intact
N1	Transient neurologic deficit
N2	Radicular symptoms
N3	Incomplete spinal cord injury or any degree of cauda equina injury
N4	Complete spinal cord injury
NX	Cannot be examined
+	Continued spinal cord compression

Modifiers

Type	Description
M0	Neurology intact
M1	This modifier is used to designate fractures with an indeterminate injury to the tension band based on axial imaging with or without MRI. This modifier is important for designating those injuries with stable injuries from a bony standpoint for which ligamentous modifiers may help determine whether operative stabilization is a consideration.
M2	Is used to designate a patient-specific comorbidity which might argue either for or against surgery for patients with relative surgical indications. Complete or an M2 modifier includes any chronic aortic/aortic or tumor affecting the skin overlying the injured spine.

Classification Nomenclature

Displacement injury of the segment T8/9 with an incomplete burst fracture of T9 incomplete tension band disruption and/or spinous process fracture

T8-T9: C (Primary injury) **LT: A4** (Complete burst fracture of L1 neurologically intact, T2,3 stable and/or)

(T9: A3; N3; M2) (Secondary injury) **(N0; M1)** (No ligamentous and modifiers)

Klasifikace

TLICS 3 independent predictors			
1	Morphology immediate stability	- Compression - Burst - Translation/rotation - Distraction	1 2 3 4 - Radiographs - CT
2	Integrity of PLC longterm stability	- Intact - Suspected - Injured	0 2 3 - MRI
3	Neurological status	- Intact - Nerve root - Complete cord - Incomplete cord - Cauda equina	0 2 2 3 3 - Physical examination
Predicts		- Need for surgery	0 – 3 4 > 4 - nonsurgical - surgeon's choice - surgical

Thoraco-Lumbar Injury Classification and Severity score

1 **2** **3**

Comminution

- >30% comminution
- 30%-60% comminution
- >60% comminution

1 **2** **3**

Apposition of fragments

- Minimal displacement
- $\leq 2\text{mm}$ displacement involving $<50\%$ of the cross section of the body
- $\geq 2\text{mm}$ displacement involving $> 50\%$ of the cross section of the body

1 **2** **3**

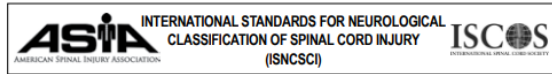
Deformity correction

- Kyphotic correction $\leq 3^\circ$
- Kyphotic correction $4^\circ-9^\circ$
- Kyphotic correction $\geq 10^\circ$

Score (3 to 9)	Suggested surgical plan
<6	Short segment posterior stabilization
≥ 7 without translation	Anterior instrument and strut-graft
≥ 7 with fracture-dislocation	Staged surgery; posterior SSPS followed by anterior column support. or Long segment posterior stabilization

McCormac Load-sharing Classification

Klasifikace



Patient Name _____ Date/Time of Exam _____
 Examiner Name _____ Signature _____

RIGHT		MOTOR KEY MUSCLES		SENSORY KEY SENSORY POINTS		MOTOR KEY MUSCLES		LEFT	
		Light Touch (LTR)	Pin Prick (PPR)	Light Touch (LT)	Pin Prick (PPL)				
		C2		C2		C2		C2	
		C3		C3		C3		C3	
		C4		C4		C4		C4	
		C5		C5		C5		C5	
		C6		C6		C6		C6	
		C7		C7		C7		C7	
		C8		C8		C8		C8	
		T1		T1		T1		T1	
		T2		T2		T2		T2	
		T3		T3		T3		T3	
		T4		T4		T4		T4	
		T5		T5		T5		T5	
		T6		T6		T6		T6	
		T7		T7		T7		T7	
		T8		T8		T8		T8	
		T9		T9		T9		T9	
		T10		T10		T10		T10	
		T11		T11		T11		T11	
		T12		T12		T12		T12	
		L1		L1		L1		L1	
		L2		L2		L2		L2	
		L3		L3		L3		L3	
		L4		L4		L4		L4	
		L5		L5		L5		L5	
		S1		S1		S1		S1	
		S2		S2		S2		S2	
		S3		S3		S3		S3	
		S4-5		S4-5		S4-5		S4-5	
		RIGHT TOTALS (MAXIMUM)		LEFT TOTALS (MAXIMUM)					
		(50)	(56)	(56)	(56)	(50)	(56)	(112)	(112)
		MOTOR SUBSCORES		SENSORY SUBSCORES					
		UER	+UEL	= UEMS TOTAL	LER	+LEL	= LEMS TOTAL	PPR	+PPL
		MAX (25)	(25)	(50)	MAX (25)	(25)	(50)	MAX (56)	(56)
		NEUROLOGICAL LEVELS		3. NEUROLOGICAL LEVEL OF INJURY (NLI)		4. COMPLETE OR INCOMPLETE?		6. ZONE OF PARTIAL PRESERVATION	
		1. SENSORY	R	L				R	L
		2. MOTOR							
		Steps 1-6 for classification as on reverse							

Muscle Function Grading

- 0 = Total paralysis
- 1 = Palpable or visible contraction
- 2 = Active movement, full range of motion (ROM) with gravity eliminated
- 3 = Active movement, full ROM against gravity
- 4 = Active movement, full ROM against gravity and moderate resistance in a functional muscle position expected from an otherwise unimpaired person
- 5 = (Normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person
- NT = Not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal ROM)
- 0*, 1*, 2*, 3*, 4*, NT* = Non-SCI condition present *

Sensory Grading

- 0 = Absent
- 1 = Altered, either decreased/impaired sensation or hypersensitivity
- 2 = Normal
- NT = Not testable
- 0*, 1*, NT* = Non-SCI condition present *

Note: Abnormal motor and sensory scores should be tagged with a "" to indicate an impairment due to a non-SCI condition. The non-SCI condition should be explained in the comments box together with information about how the score is rated for classification purposes (at least normal / not normal for classification).

When to Test Non-Key Muscles:

In a patient with an apparent AIS B classification, non-key muscle functions more than 3 levels below the motor level on each side should be tested to most accurately classify the injury (differentiate between AIS B and C).

Movement	Root level
Shoulder: Flexion, extension, abduction, adduction, internal and external rotation	C5
Elbow: Supination	C5
Elbow: Pronation	C6
Wrist: Flexion	C6
Finger: Flexion at proximal joint, extension	C7
Thumb: Flexion, extension and abduction in plane of thumb	C7
Finger: Flexion at MCP joint	C8
Thumb: Opposition, adduction and abduction perpendicular to palm	C8
Finger: Abduction of the index finger	T1
Hip: Adduction	L2
Hip: External rotation	L3
Hip: Extension, abduction, internal rotation	L4
Knee: Flexion	L4
Ankle: Inversion and eversion	L4
Toe: MP and IP extension	L4
Hallux and Toe: DIP and PIP flexion and abduction	L5
Hallux: Adduction	S1

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) OR the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments S4-5 by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body. (This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C - less than half of key muscle functions below the single NLI have a muscle grade \geq 3.

D = Motor Incomplete. Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade \geq 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

Using ND: To document the sensory, motor and NLI levels, the ASIA Impairment Scale grade, and/or the zone of partial preservation (ZPP) when they are unable to be determined based on the examination results.

Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
 The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
 Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
 Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI).
 This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
 The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
 (i.e. absence or presence of sacral sparing)
 If voluntary anal contraction = No AND all S4-5 sensory scores = 0 AND deep anal pressure = No, then injury is Complete.
 Otherwise, injury is Incomplete.

5. Determine ASIA Impairment Scale (AIS) Grade.
 Is injury Complete? If YES, AIS=A
 NO ↓
 Is injury Motor Complete? If YES, AIS=B
 NO ↓ (No=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?
 NO ↓ YES ↓
 AIS=C AIS=D

If sensation and motor function is normal in all segments, AIS=E
 Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact and the ASIA Impairment Scale does not apply.

6. Determine the zone of partial preservation (ZPP).
 The ZPP is used only in injuries with absent motor (no VAC) OR sensory function (no DAP, no LT and no PP sensation) in the lowest sacral segments S4-5, and refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated. With sacral sparing of sensory function, the sensory ZPP is not applicable and therefore "NA" is recorded in the block of the worksheet. Accordingly, if VAC is present, the motor ZPP is not applicable and is noted as "NA".



Terapie

- Konzervativní

- Stabilní poranění
- Bez neurologického deficitu

- Operační

- Absolutní indikace
 - neurologický deficit
 - otevřené poranění

- Relativní indikace

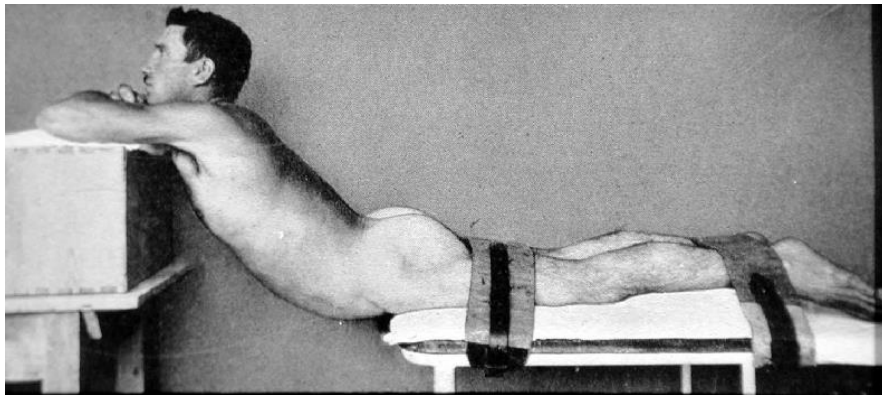
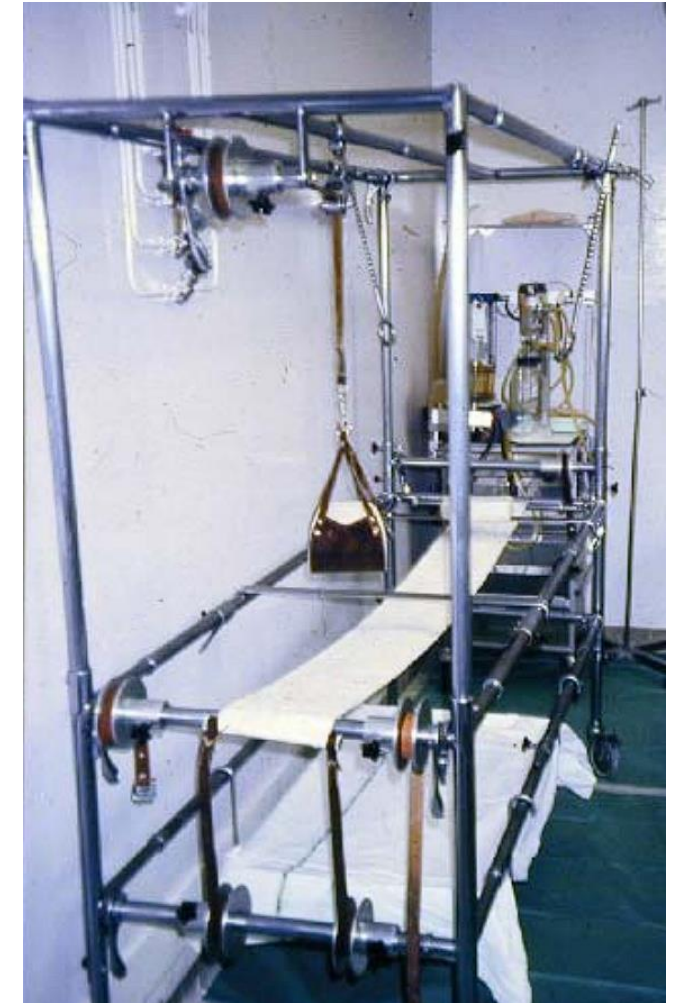
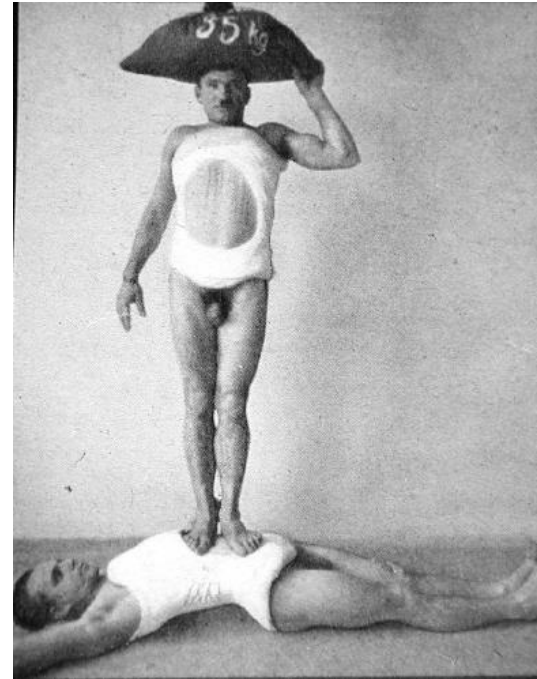
- Instabilita
- Kyfóza 15-20°
- Stenóza >50%
- Snížení těla >50%
- Mnohočetné klínovité zlomeniny

Konzervativní léčba

- Absolutní kontraindikace:
 - Poranění s převahou diskoligamentózní léze – do budoucna nestabilní
 - Luxace kloubů
 - Translační zlomeniny
 - Neurologický deficit
 - Zhoršující se neurologický stav
- Relativní kontraindikace:
 - Obezita
 - Popáleniny
 - Nestabilní zlomeniny
 - Vícečetné zlomeniny
 - Vlající hrudník (u Th páteře)
 - Plicní poranění (u Th páteře)

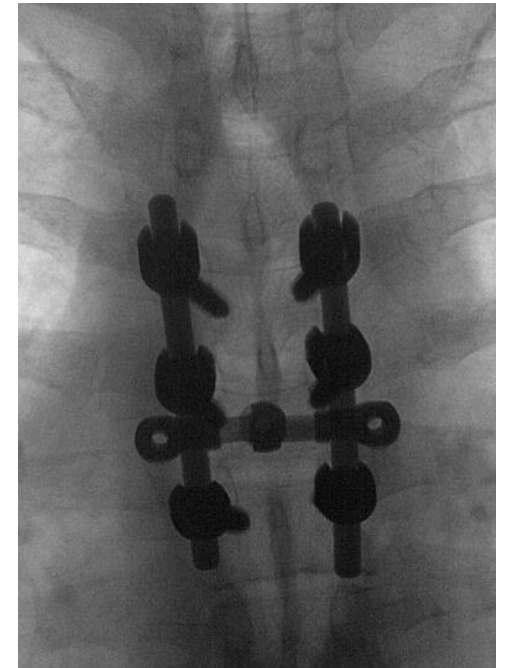
Konzervativní léčba

- Zavřená repozice a fixace
 - trojbodové trupové ortézy – typu Jewettovy ortézy
 - bederní pás
 - Sádrový korzet
- 3 měsíce



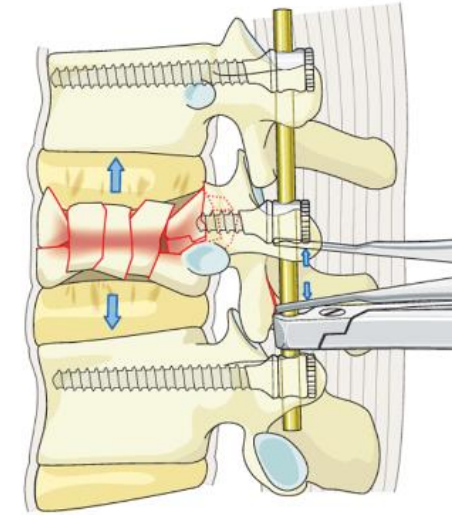
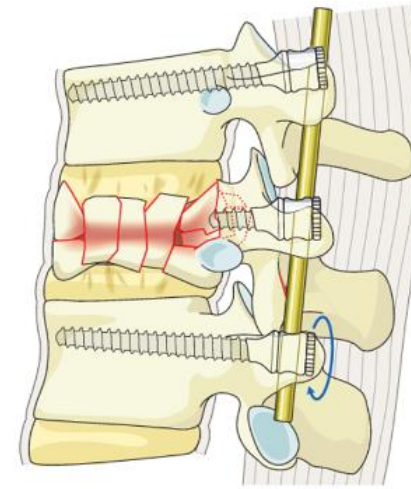
Operační léčba

- Dekomprese nervových struktur
- Obnovení anatomického tvaru
- Stabilizace, vznik kostní fúze
- Zjednodušení ošetřování
- Časná rehabilitace



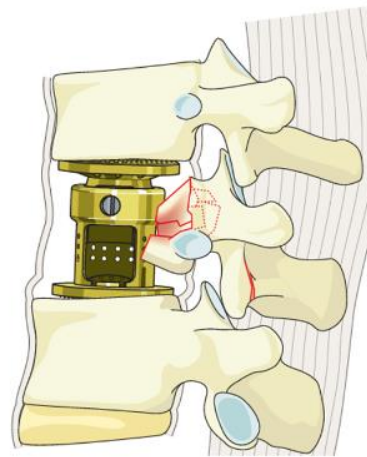
Operační léčba

- Principy – repozice, lordotizace, stabilizace
- Zadní stabilizace – transpedikulární fixace
- Přední fúze
 - Stabilizace x náhrada těla
- Kombinovaný výkon

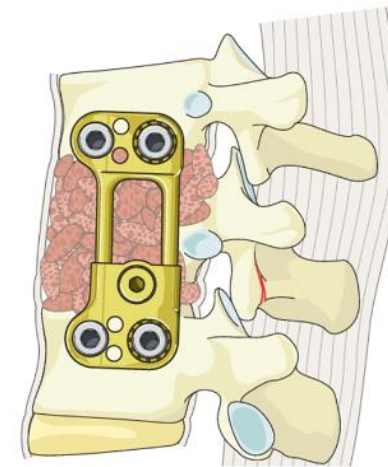


AO

AO



AO



AO

Terapie

- Konzervativní terapie

- A0, A1, stabilní A2
- Ev. B1

- Vertebroplastika/ Kyfoplastika

- Neúspěšná konzervativní léčba A1

- Zadní stabilizace

- A2, A3, A4
- B1, B2, B3 (2+2, ev. 3+3)
- C (2+2)

- Přední stabilizace

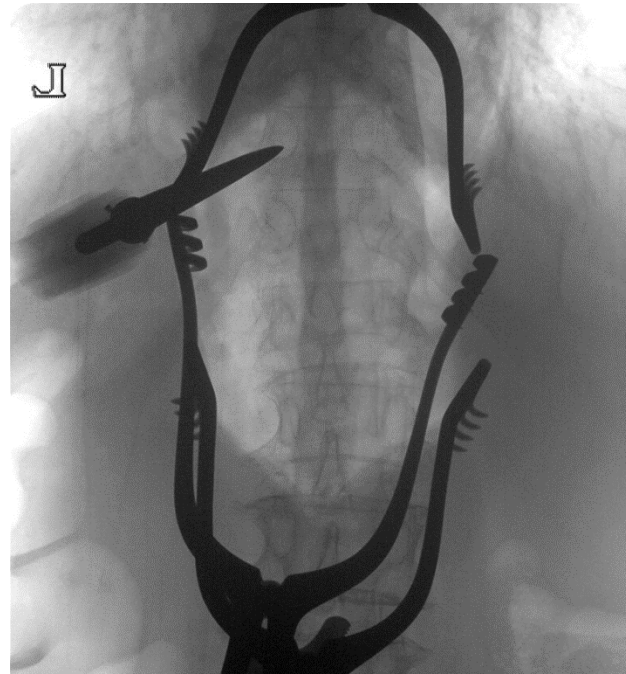
- A2, A3, A4 (neurologické postižení)
- B3

- Kombinovaný výkon

- A3, A4

RTG

- Základní diagnostika
 - Lokalizace
 - Orientace na peroperačních snímcích
- Peroperační vizualizace
 - Peroperační skiagrafie
- Pooperační sledování
 - Dlouhé formáty
 - EOS
 - Funkční snímky



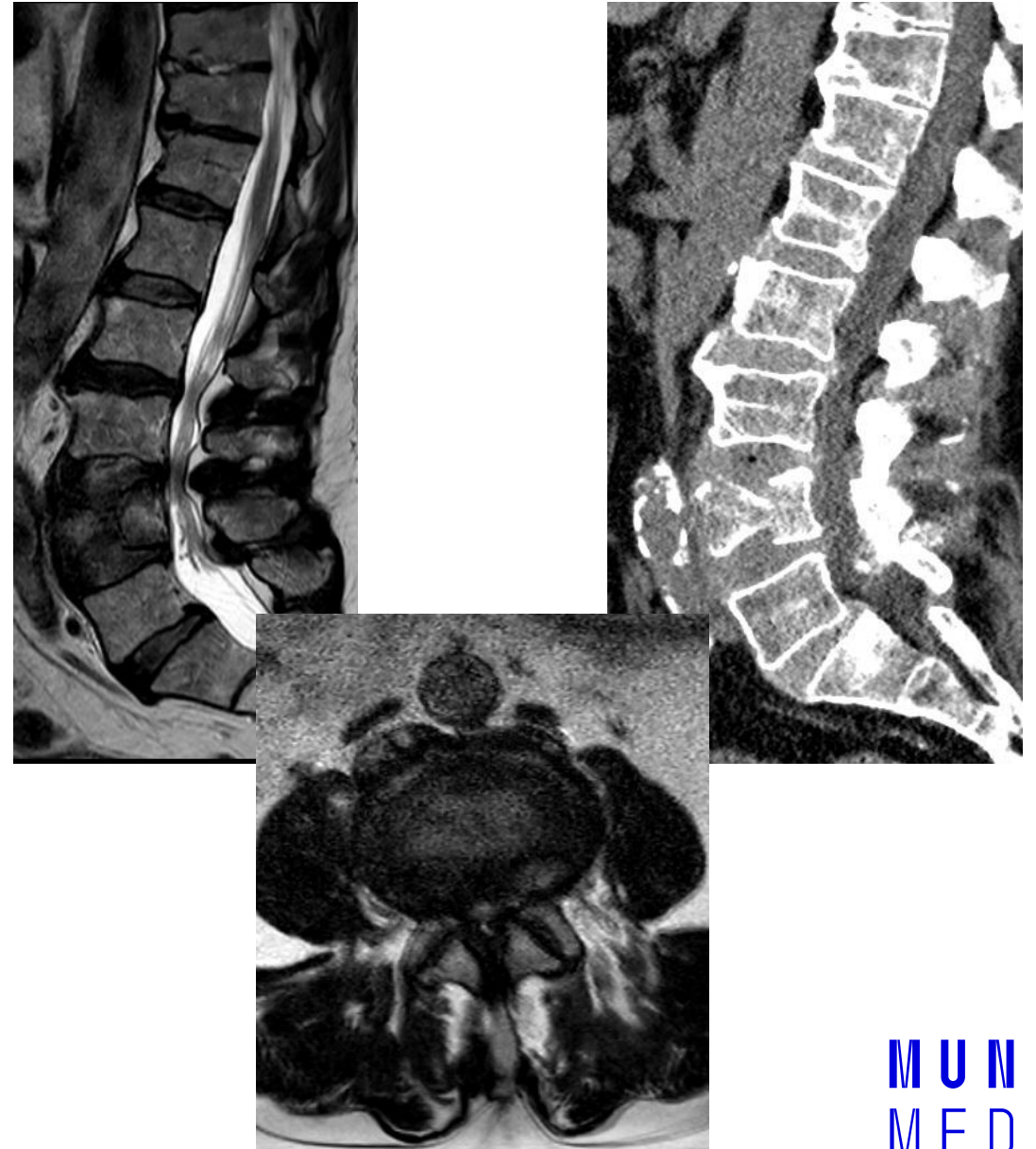
CT

- Základní diagnostika, klasifikace, indikace léčby
- Peroperační navigace
 - O-arm
- Pooperační sledování
 - Stav kostní fúze
 - Malpozice, poškození instrumentaria
 - Uvolnění instrumentaria
- Poloha/ stav okolích struktur



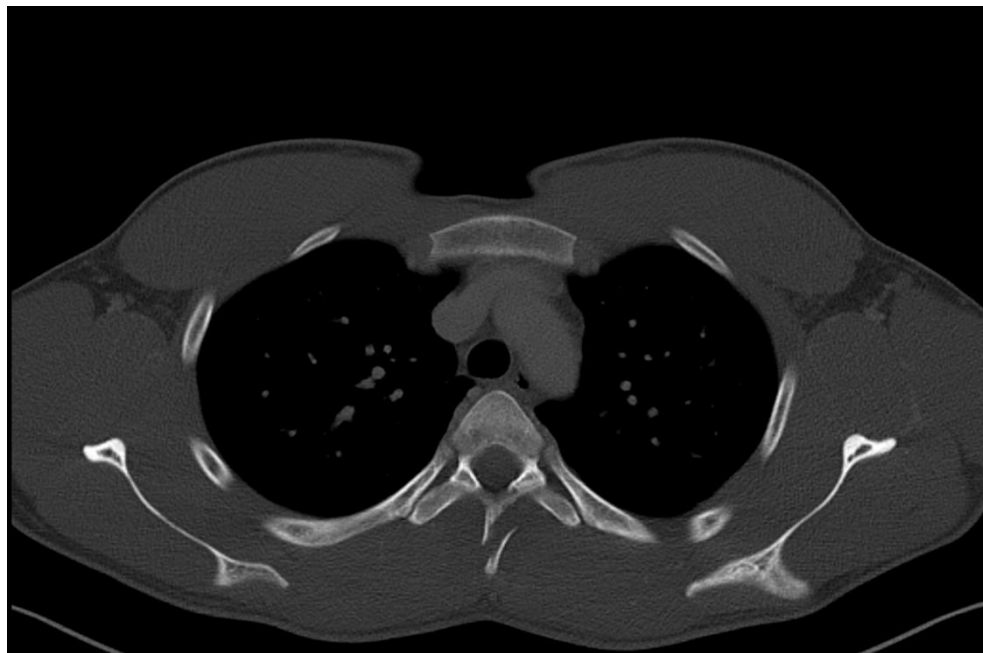
MRI

- Stav měkkotkáňových struktur
 - Diskoligamentózní aparát
 - Komprese nervových struktur
- Otok kostní tkáně
 - Určení stáří zlomeniny
- Vyloučení patologické zlomeniny



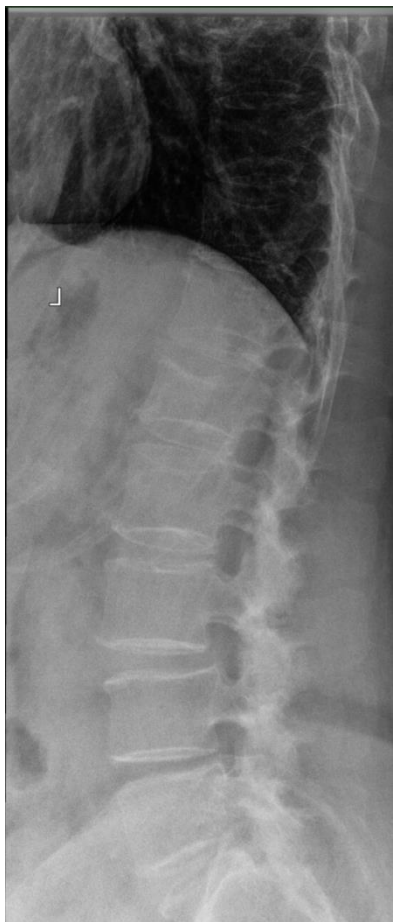
A0

Muž 18r, fr T5 A0, T6 A0, konzervativní léčba



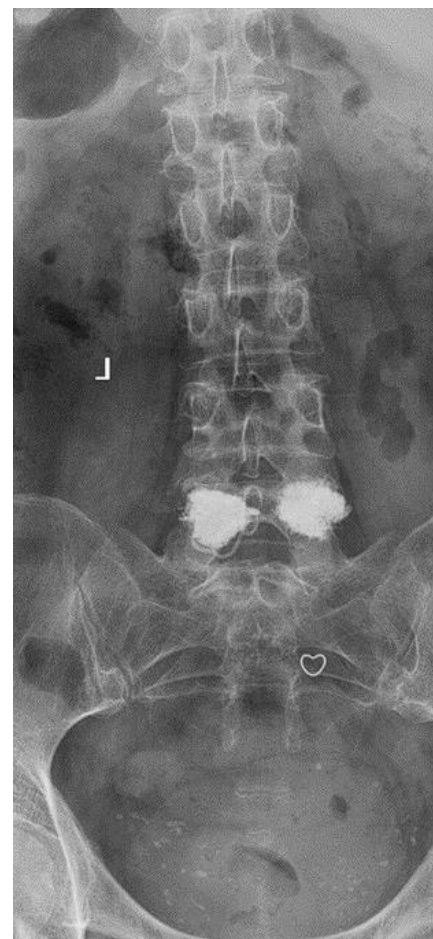
A1

Žena 71r, fr L1 A1, Jewetova ortéza



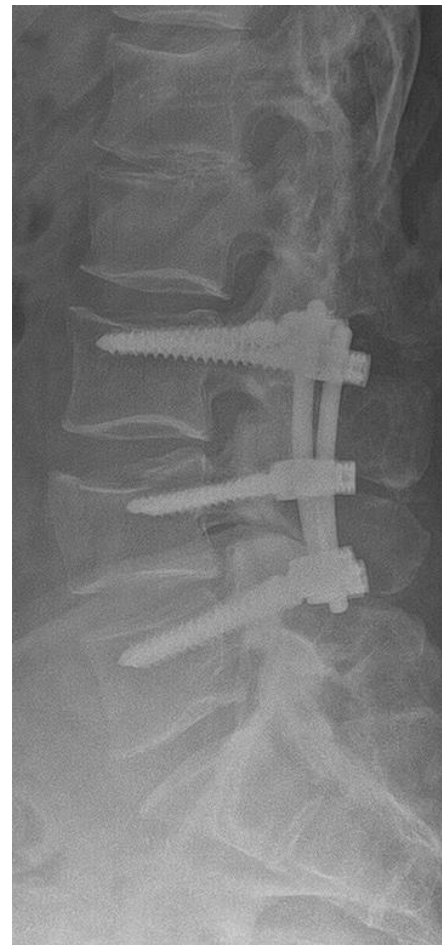
A1

Žena 66r, L5 A1, neúčinná konzervativní terapie



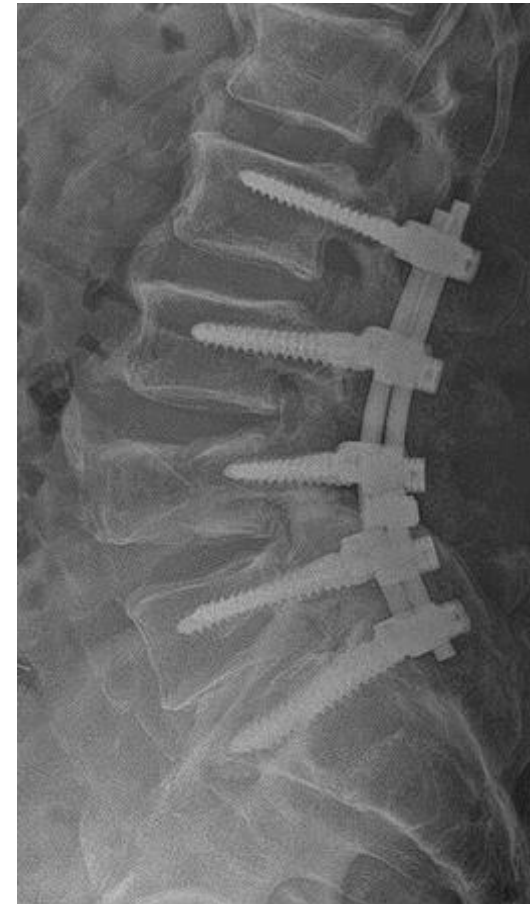
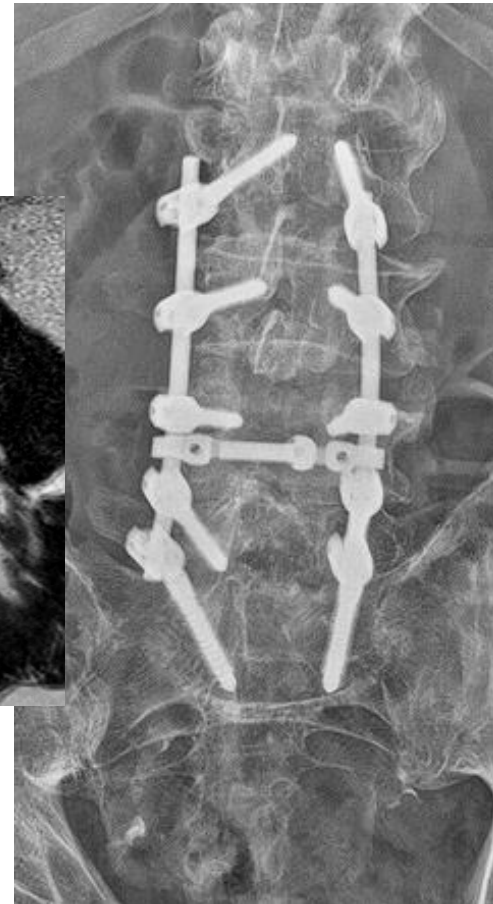
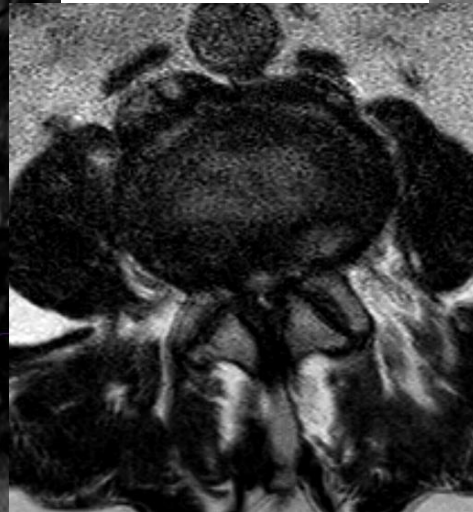
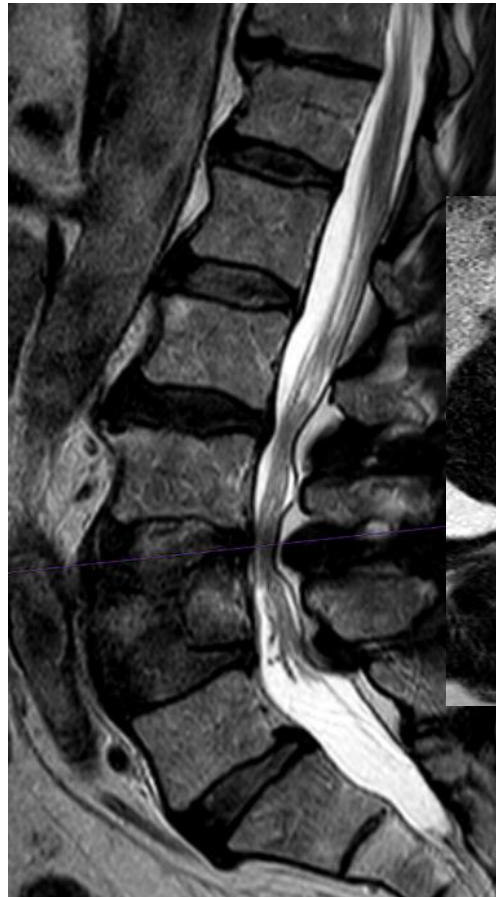
A2

Muž 47r, L4 A2 pod stabilizací před 14 lety



A2

Muž 73r, L4 A2, paréza L4,5 dx



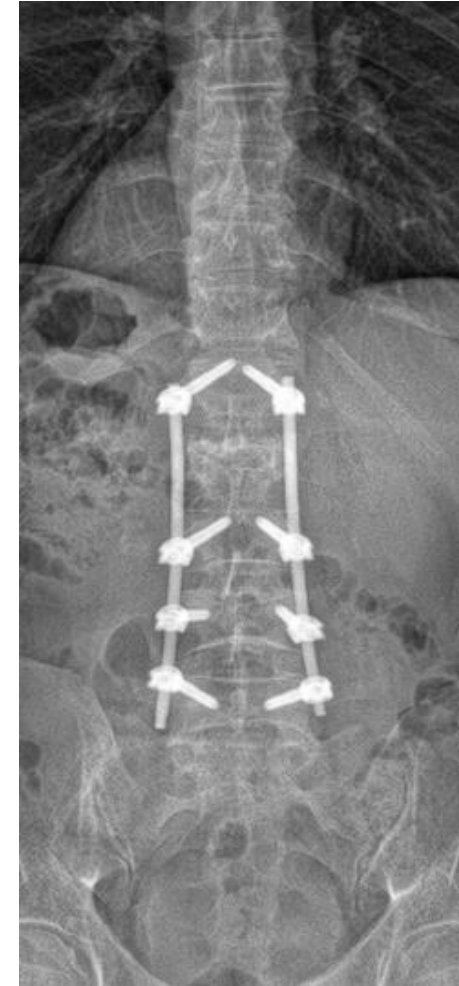
A3

Žena 29 let, T12 A3



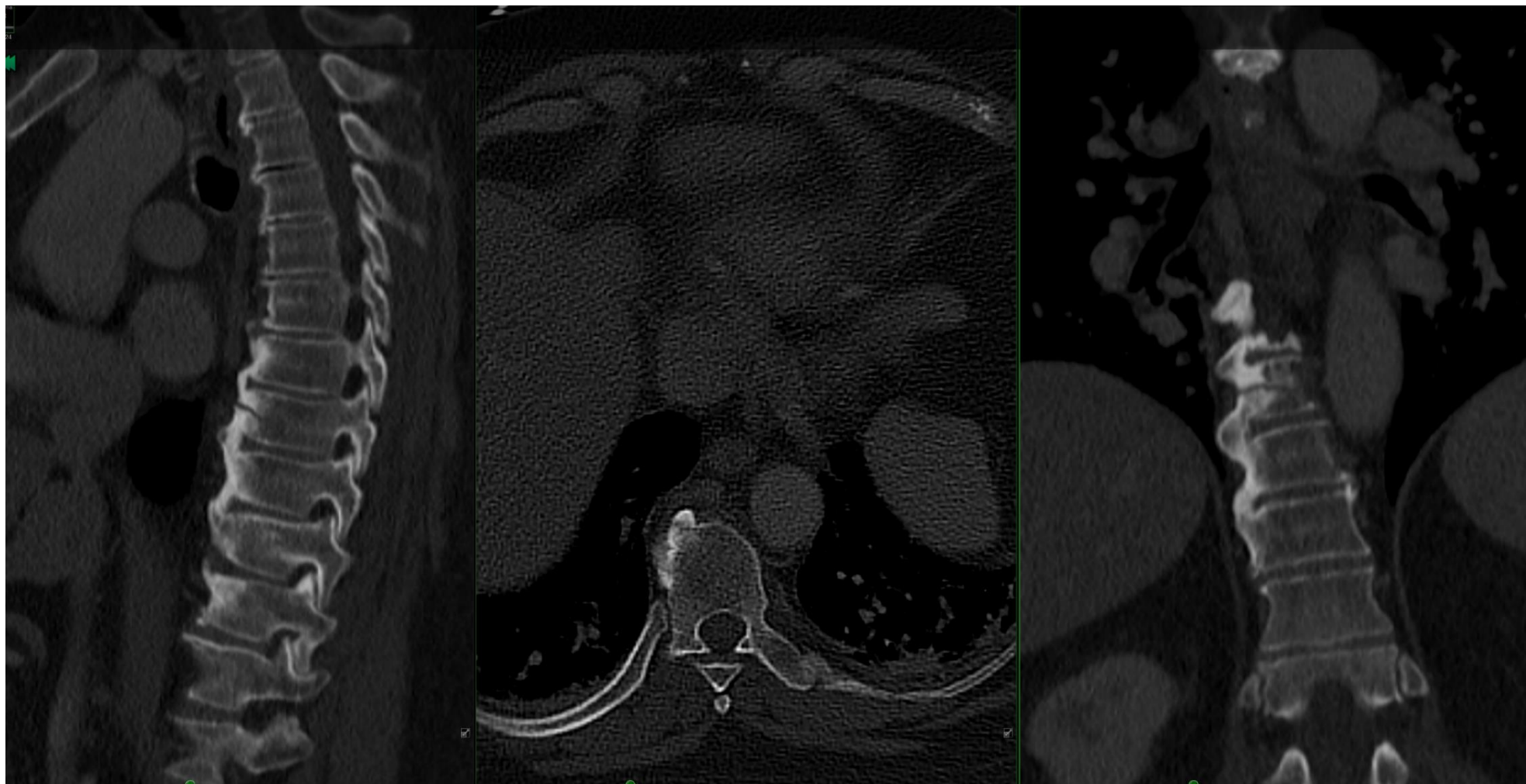
A4

Muž 57 let, L2 A4, L4 A3



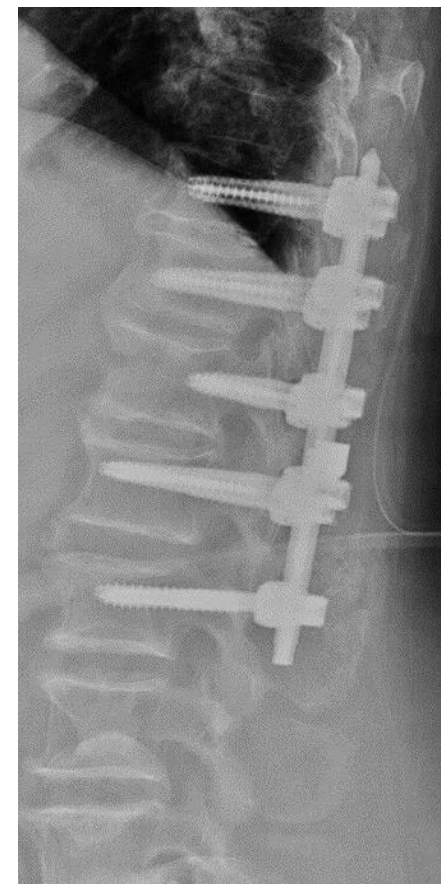
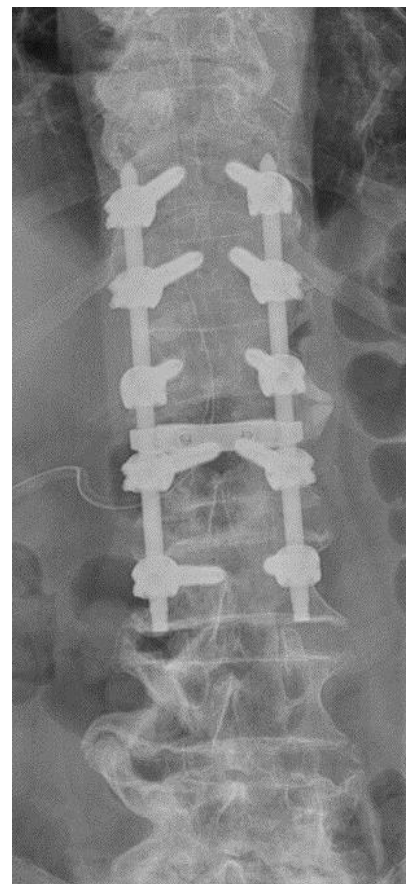
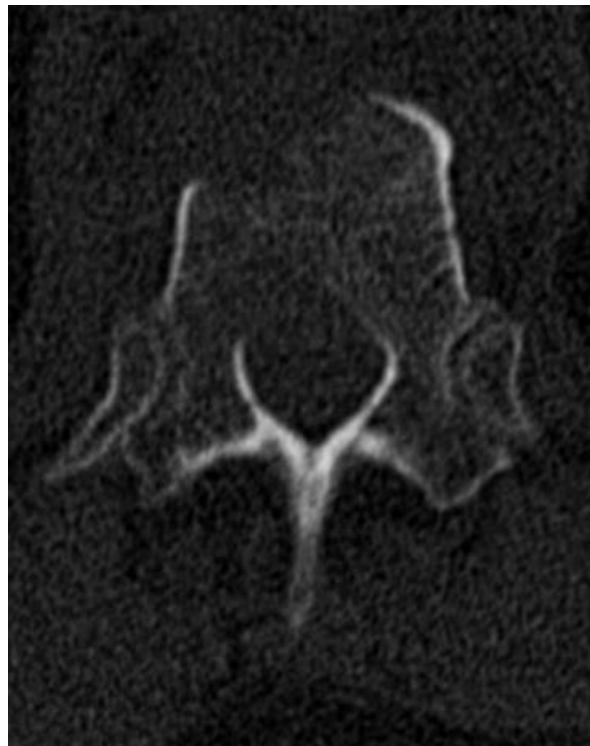
B1

Muž 51r, T7 B1, lomná linie do poloviny těla, konzervativní postup



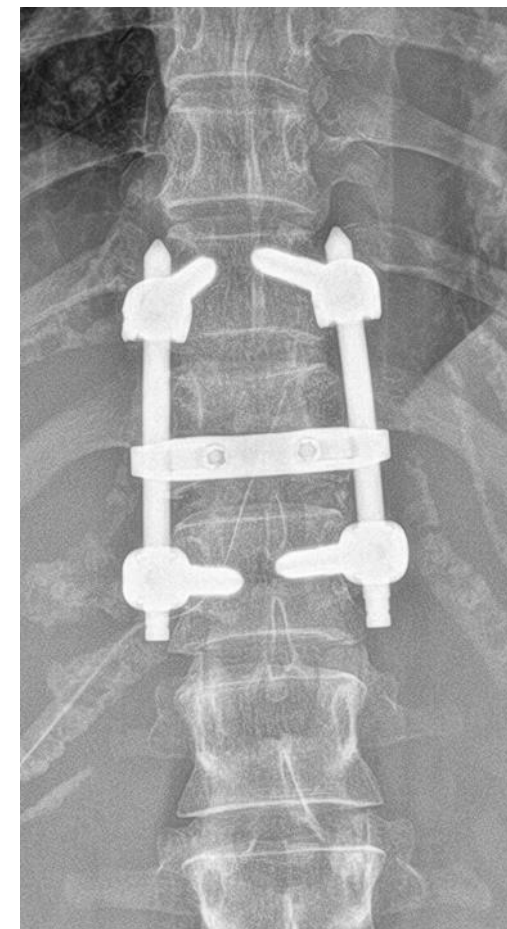
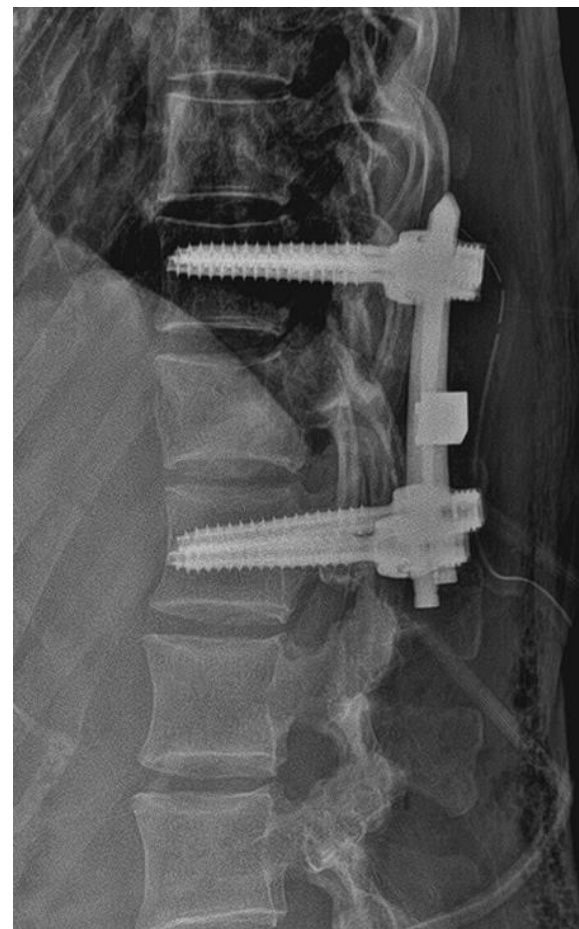
B1

Žena 69r, L1 B1, osteoporóza



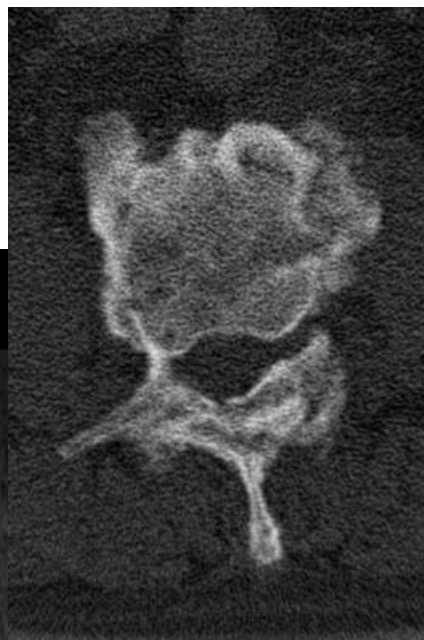
B2

Žena 27r, Th11 B2



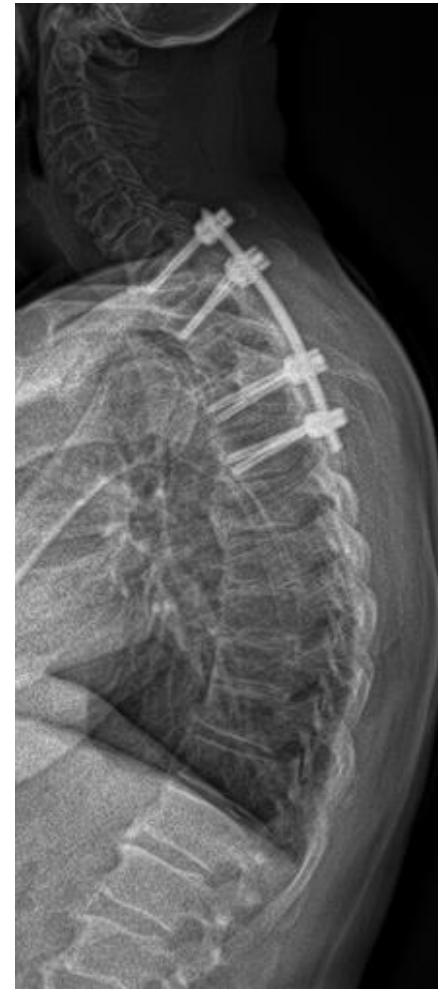
B3

Muž 58r, L2 B3, m. Forestier



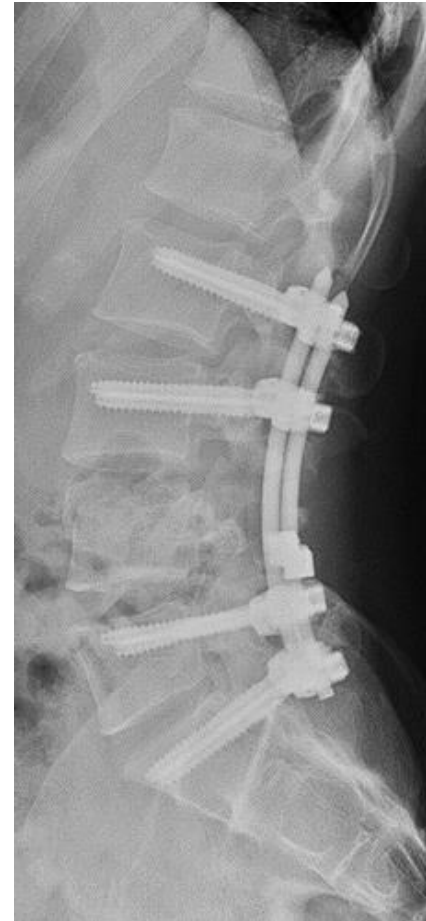
B3

Muž 63r, Th3 B3



C

Muž 26r, L4 C, pooperačně prakticky paraplegie, nyní lehká paraparéza, plegie L4 sin



Závěr

- Koncentrace spondylotraumat do spondylocenter
- Systém konziliární služby
- Multioborová spolupráce
- Přesná diagnostika poranění
- Adekvátní terapeutický postup
- Timing operačního řešení

Děkuji za pozornost

