



Hôpitaux de Lyon

Société Française de Radiologie – Rhône-Alpes

2 Avril 2016 – Champagne-au-Mont-d'Or



PRISE en CHARGE des TROUBLES de l'EQUILIBRE RACHIDIEN

Pr C BARREY

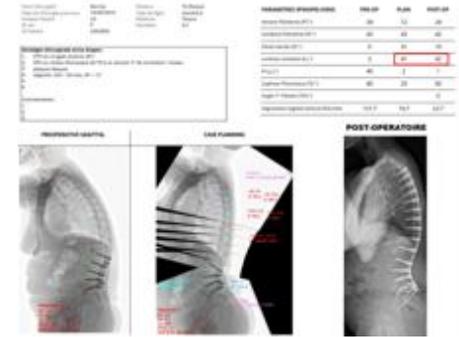
Service de Neurochirurgie C et Chirurgie du Rachis

Université Claude Bernard Lyon 1

Hôpital Neurologique P Wertheimer, Hospices Civils de LYON



Imagerie



Techniques chir. /
Planification

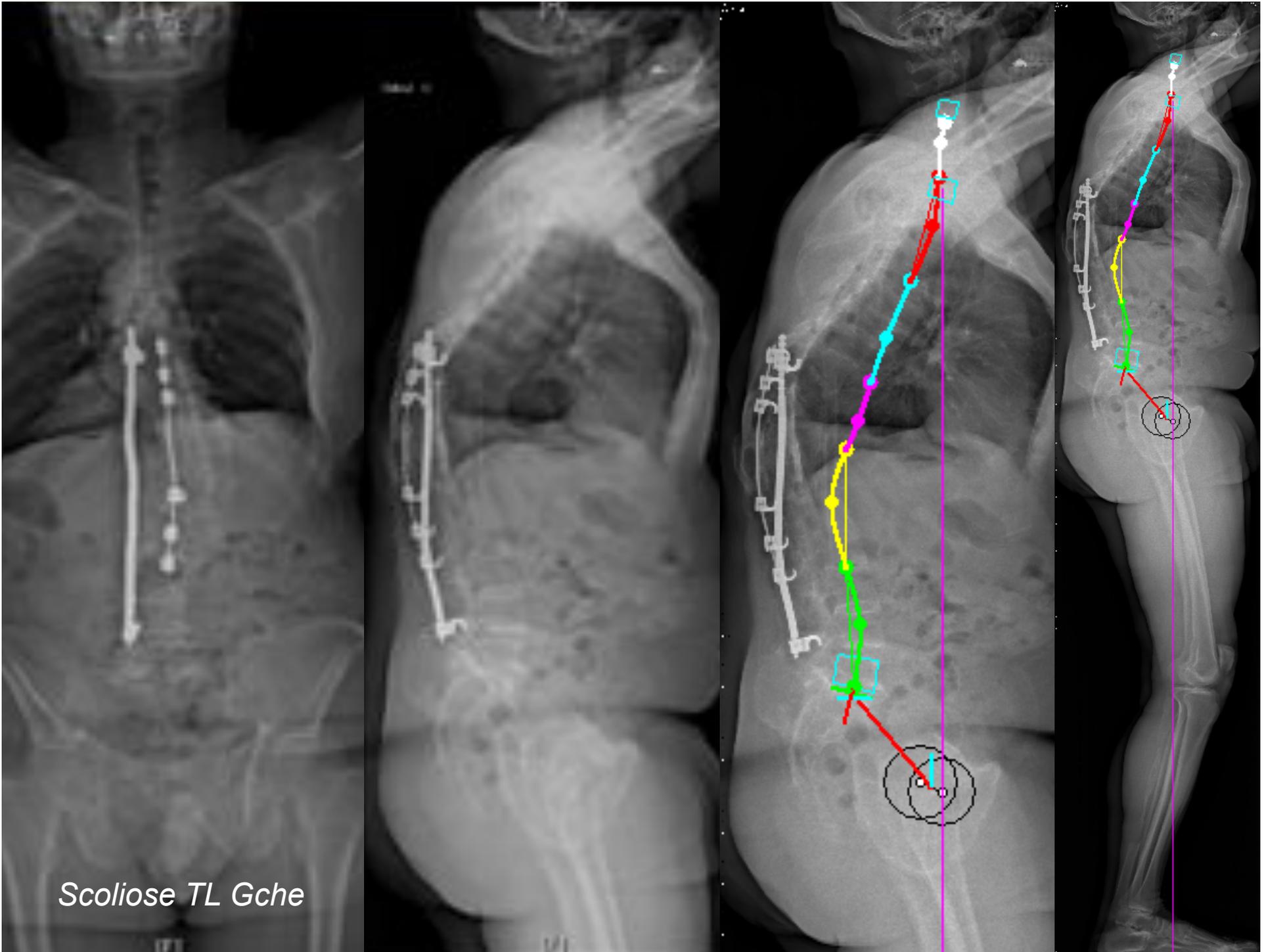
DEFORMATIONS DU RACHIS

Neuromonitoring



Equilibre
sagittal





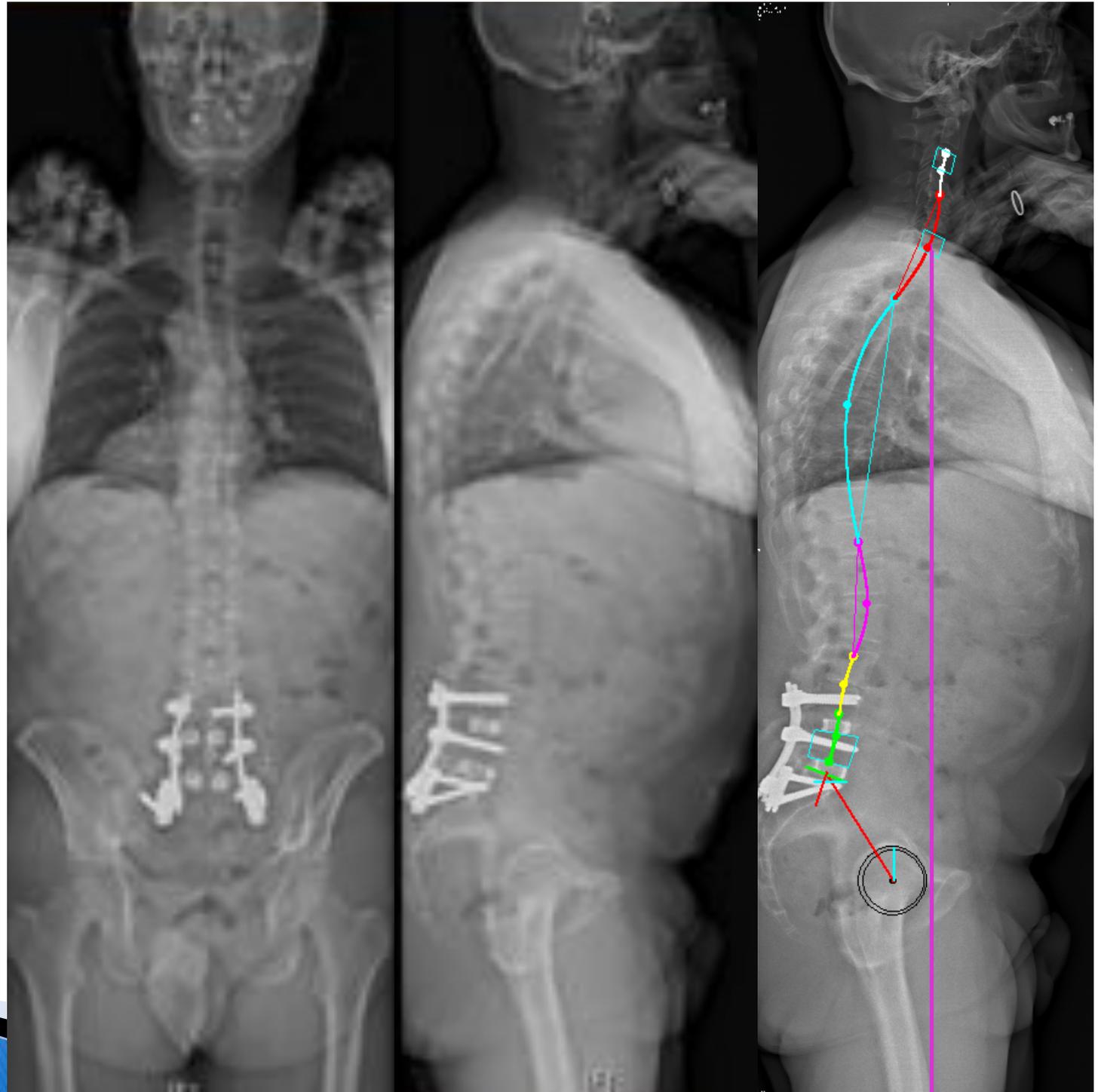
Scoliose TL Gche

M - 55 years-old
Low Back Pain
L4-S1 fused
WD=100m

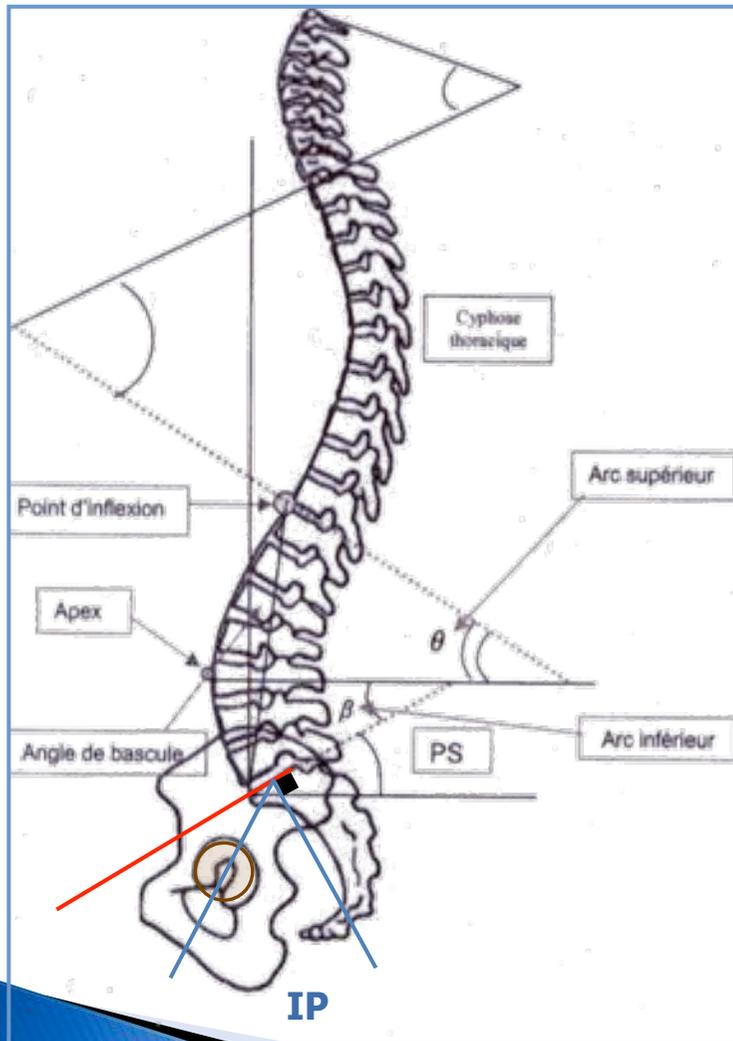
PI: 52°
PT: 32°
SS: 20°

L4-S1: 9°
L3-L4: -15°
T12-L3: 35°
TK: 49°

C7 front of FH



Equilibre sagittal NORMAL



Paramètres

1. Pelviens
2. Rachidiens
3. Equilibre global

Incidence pelvienne ++

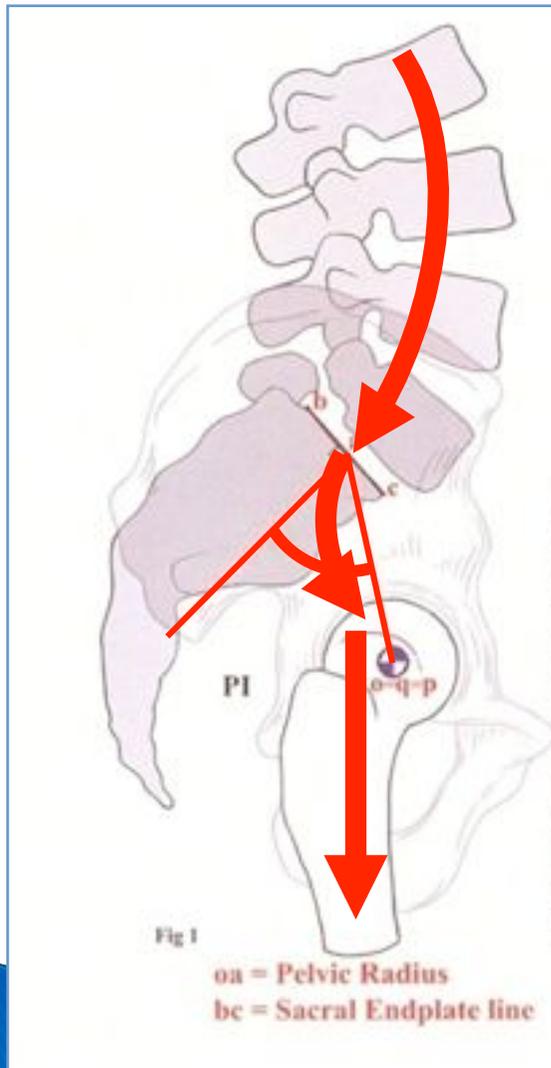
Duval-Beaupère, An Biomed Eng 1992

Nombreuses études dans la population normale

- valeurs physiologiques
- corrélations

Stagnara, Spine 1982; During, Spine, 1985; Legaye, Rachis, 1993; Vaz, Eur Spine J, 2002; Berthonnaud, J Spinal Disord Tech, 2004; Vialle, JBJS Am, 2005

Incidence pelvienne (IP)



- Paramètre morphologique (propre à l'individu)

NON affecté / patho lombaire dégénérative

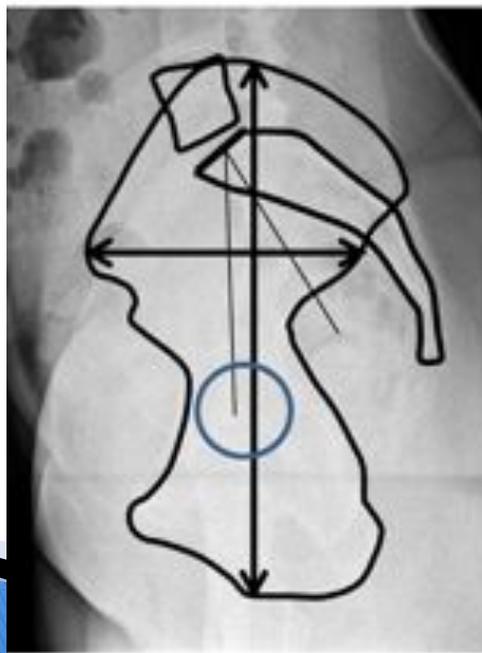


$\Delta ia\theta$ de l'équilibre spino-pelvien

- Corrélation :
 1. Épaisseur du bassin (SF)
 2. Lordose lombaire
- Valeur moyenne = $53^\circ \pm 11$



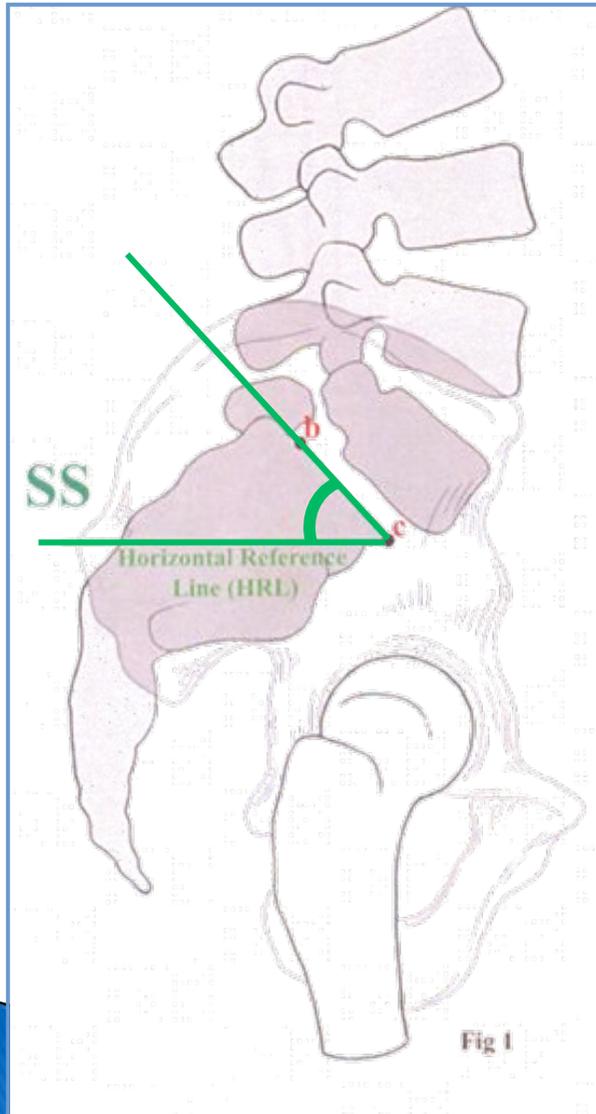
IP
faible



IP
élevée

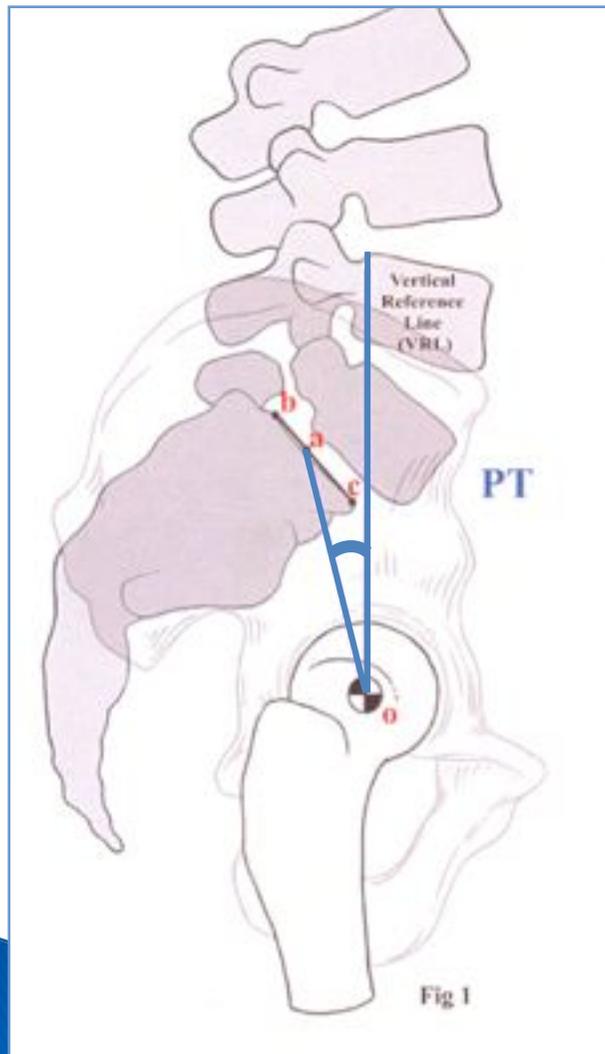


Pente Sacrée (PS)



- Paramètre positionnel
- Corrélation :
Lordose lombaire +++
($r = 0.85$)
- Valeur moyenne = $41^\circ \pm 8$

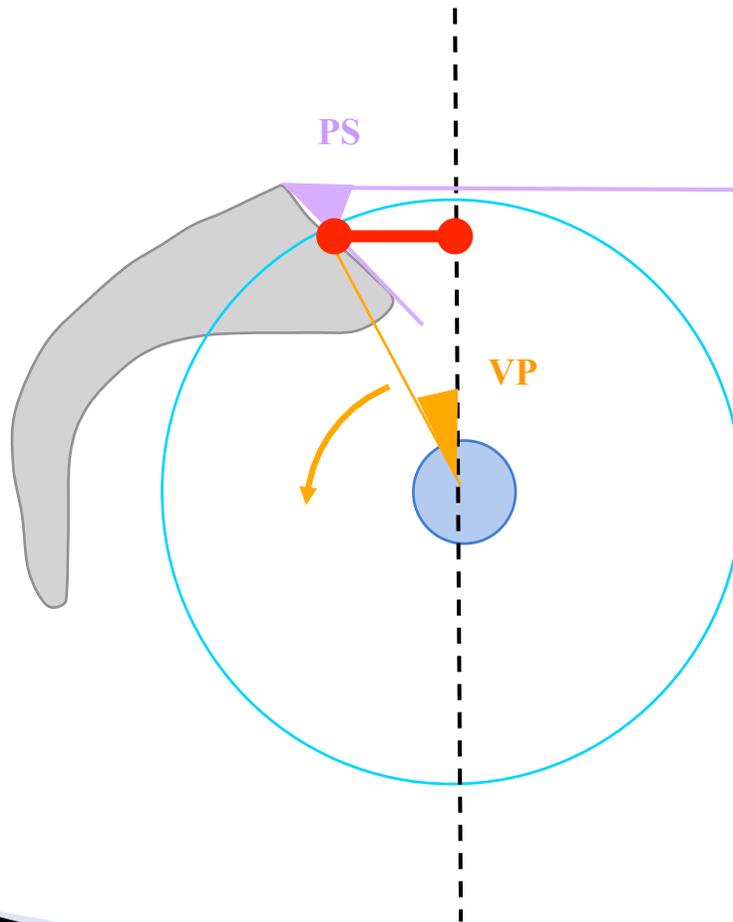
Version pelvienne (VP)



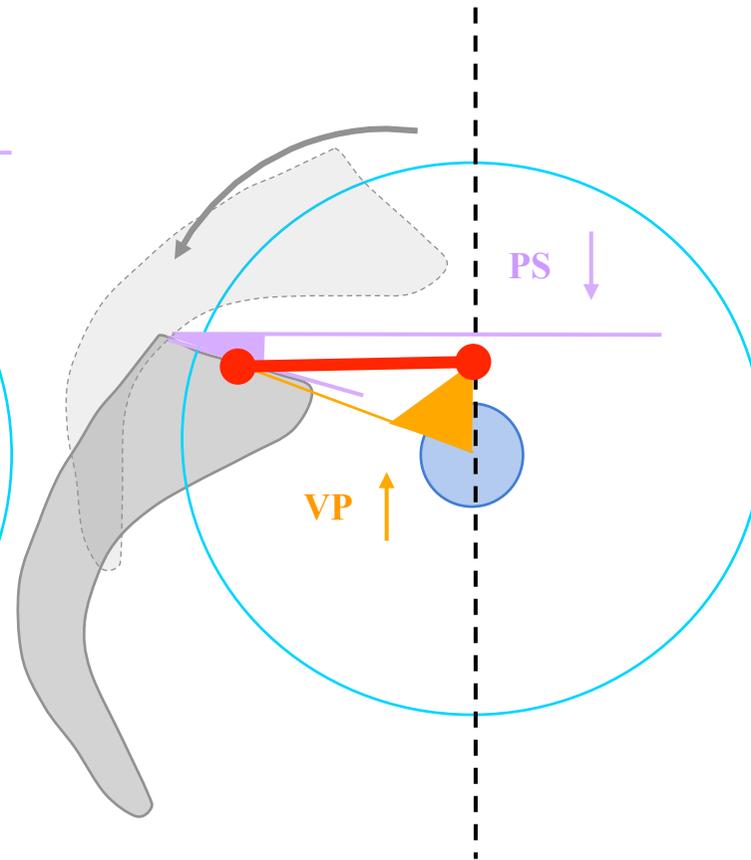
- Paramètre positionnel
- Quand VP augmente :
 1. Rétroversion du bassin
 2. Sacrum se verticalise
 3. PAF augmente
- Valeur moyenne = $12^{\circ} \pm 5$

Quand VP augmente, PS diminue

Normo-version

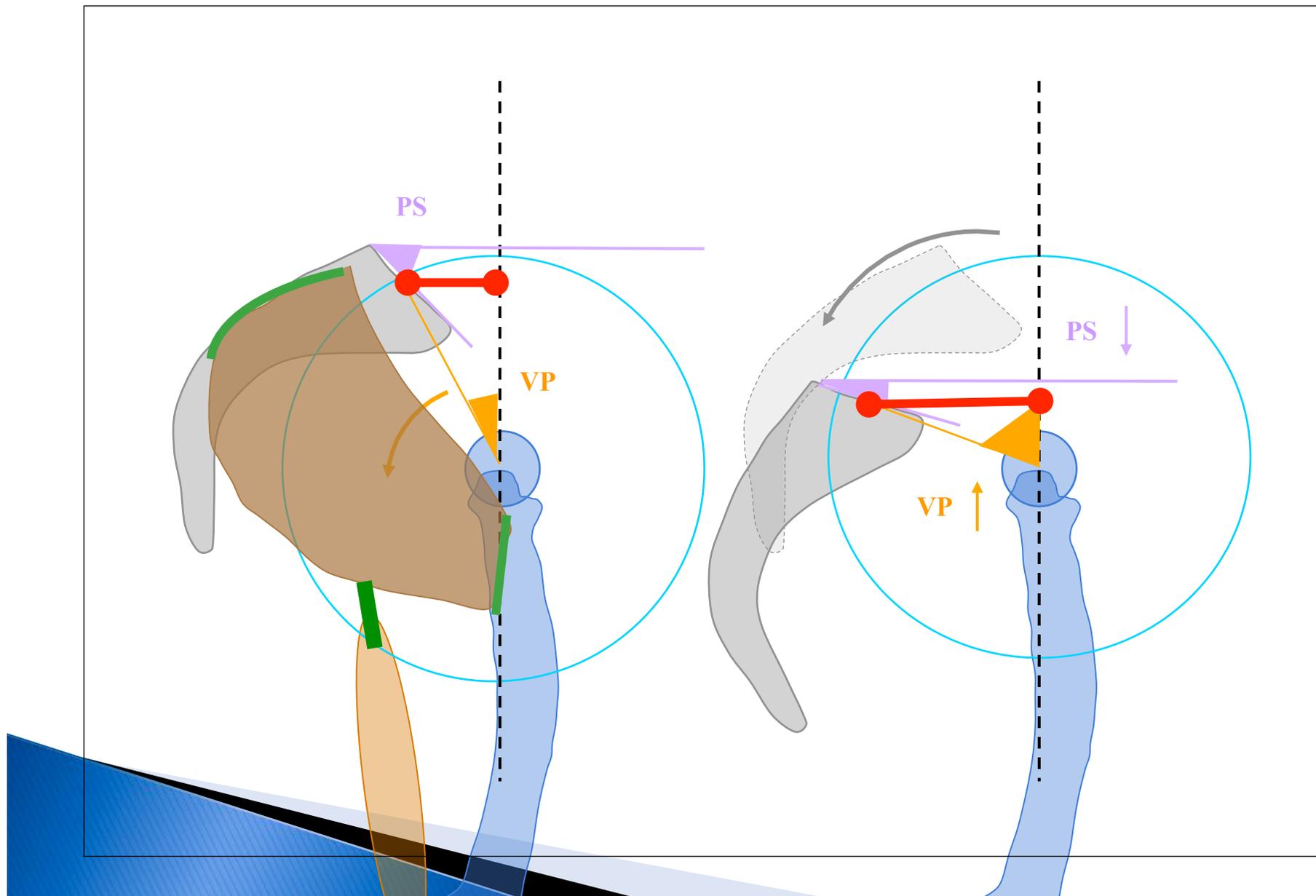


Rétroversion

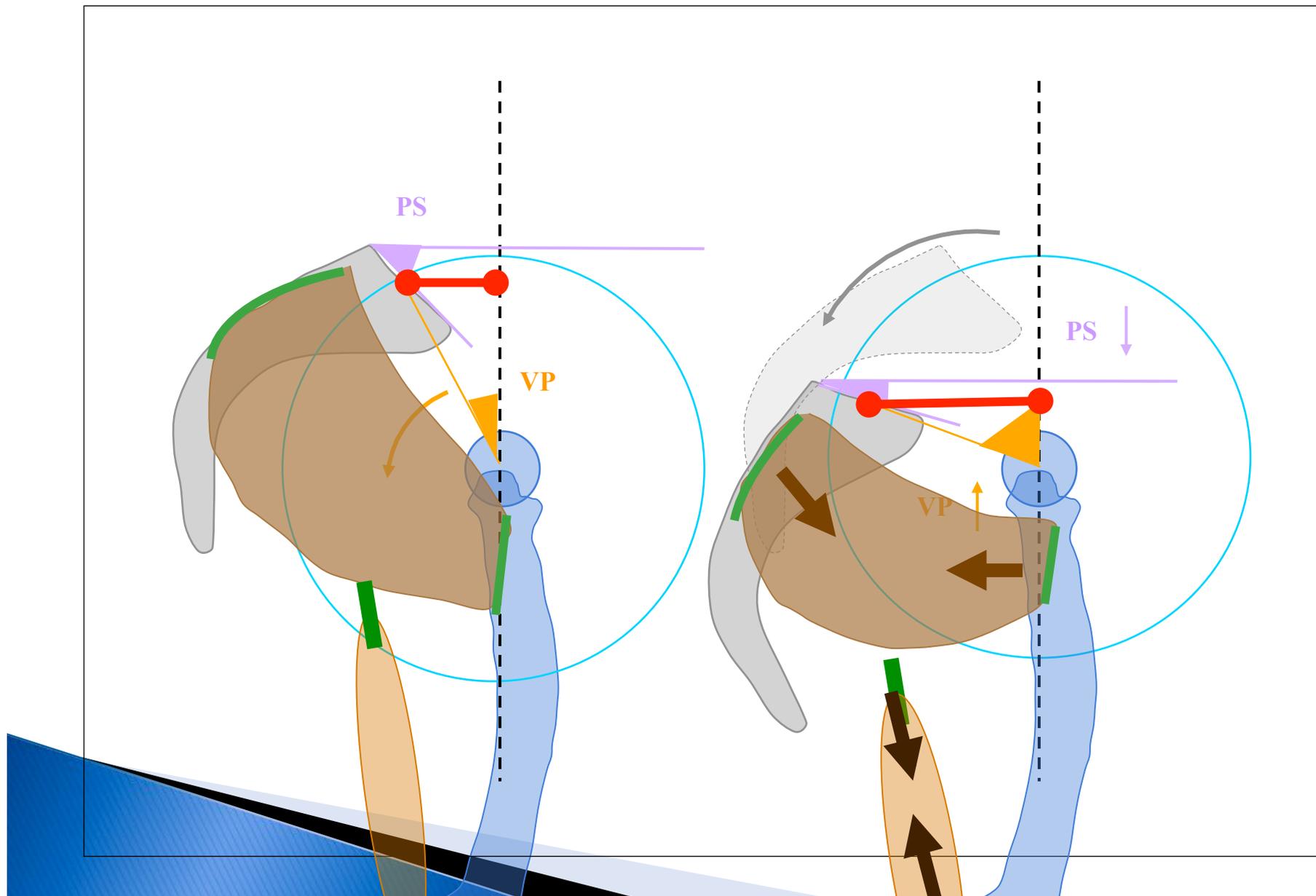


 **Porte-à-faux**

Action des extenseurs de Hanche ++



Action des extenseurs de Hanche ++



Classes d'incidence pelvienne

Population normale subdivisée en 6 classes de I à VI de 10° chacune

Table 1 Classes of pelvic incidence and corresponding values of spino-pelvic positional parameters from a group control of 154 subjects [2]

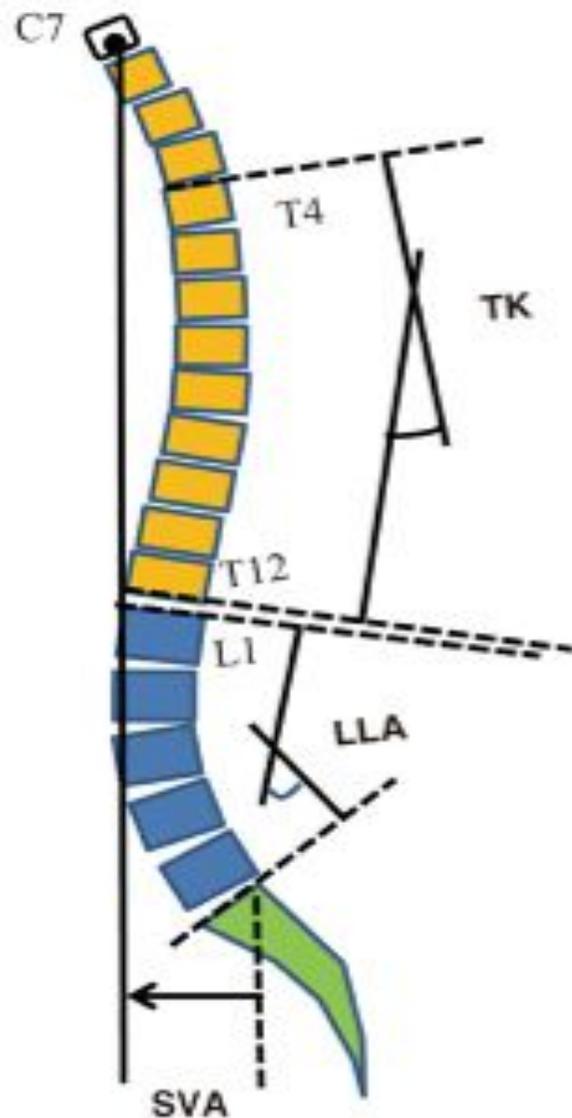
	n	PI	PT	SS	LL	TK
I 28° < PI < 37.9°	12	35.4 ± 1.3 (33.7-37.9)	3.9 ± 4.5 (-1.5-13.3)	31.5 ± 5.2 (21.2-38.5)	53.3 ± 6.6 (41.2-62)	43.8 ± 9.1 (22.5-51.5)
II 38° < PI < 47.9°	44	42.7 ± 2.8 (37.9-47.6)	8.9 ± 4.8 (-5.1-18.2)	33.8 ± 4.8 (23.1-48.4)	55.5 ± 8 (41.5-76.5)	48 ± 8.8 (24-64.7)
III 48° < PI < 57.9°	59	52.6 ± 2.8 (48.2-57.4)	12.5 ± 5.6 (-1.2-23.2)	40.1 ± 5.5 (28.2-52.9)	61.5 ± 8.4 (43.1-81.9)	47.4 ± 10.7 (24-70.3)
IV 58° < PI < 67.9°	26	62.6 ± 2.8 (58.2-67.6)	15.8 ± 4.3 (7.1-26.8)	46.8 ± 4.2 (37.9-58.5)	68.3 ± 5.1 (60.9-76.3)	47.6 ± 7.8 (34.7-64.7)
V 68° < PI < 77.9°	11	72.6 ± 2.8 (69.6-77.4)	19.7 ± 5.5 (12.6-27.9)	52.9 ± 5.2 (46.2-59.6)	74.9 ± 6.8 (62.2-81.6)	46 ± 10.2 (29.7-62)
VI 78° < PI < 87.9°	2	81.4 ± 3.3 (79.1-81.4)	21.9 ± 12.3 (13.2-30.6)	59.5 ± 9 (53.1-65.9)	76 ± 8.3 (70.1-81.9)	44.6 ± 12.2 (36-53.3)

Lordose Théorique

- ▶ Formule de Schwab: $LL_{th} = PI + 9^\circ (\pm 9)$
- ▶ Classes d'incidence

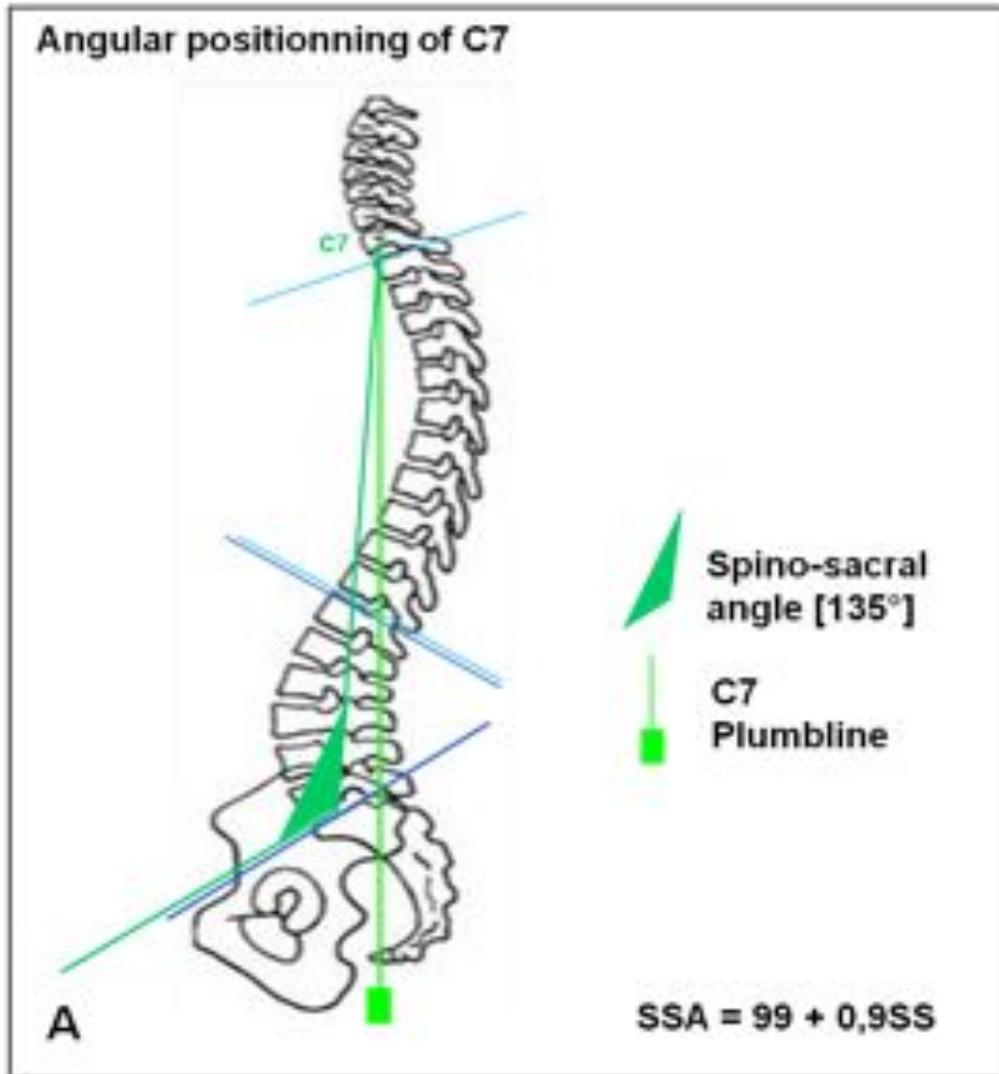
PI group	PI interval	Theoretical PT	Theoretical SS	Theoretical LL
I	<38	4	30	PI + 20
II	38–48	8	35	PI + 15
III	48–58	12	40	PI + 10
IV	58–68	16	45	PI + 5
V	68–78	20	50	=PI
VI	>78	24	55	PI - 5

Evaluer l'équilibre global

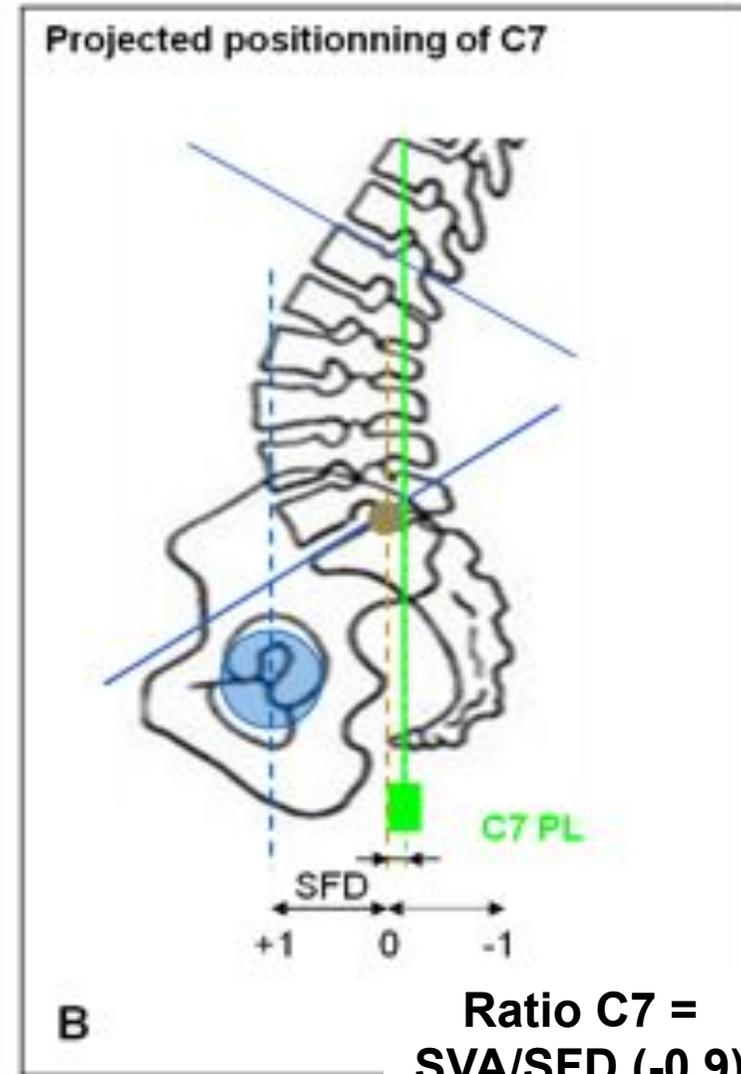


SVA < 40 mm
Sagittal Vertical Axis

Evaluer l'équilibre global

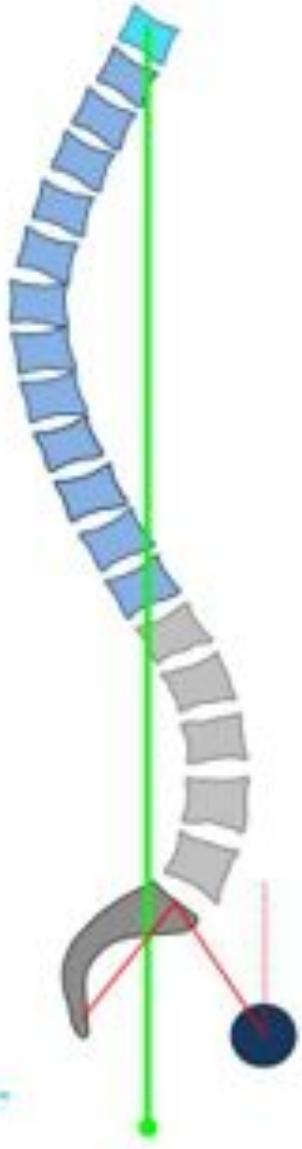


Roussouly, Spine 2005



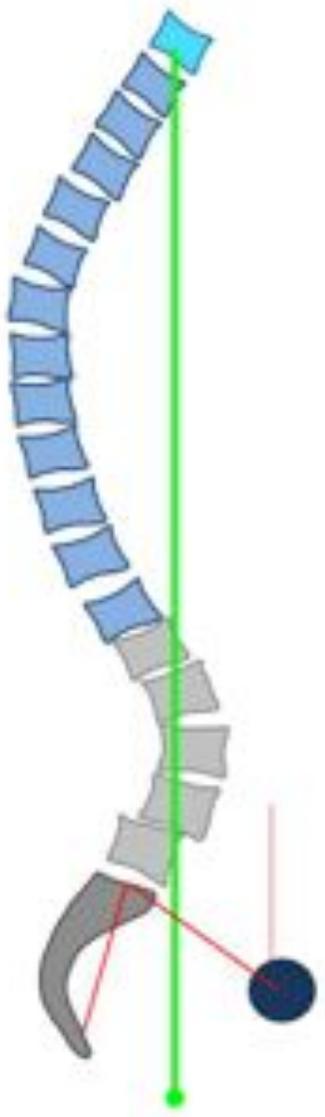
Barrey, European Spine J 2007

Equilibré



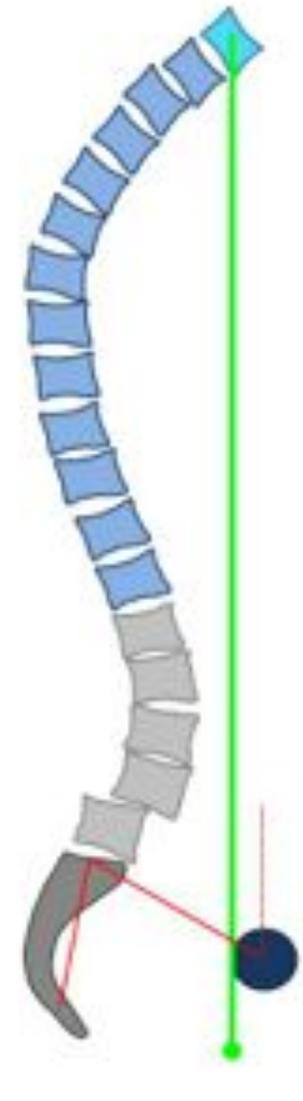
$SVA/SFD < 0.5$

Equilibre compensé



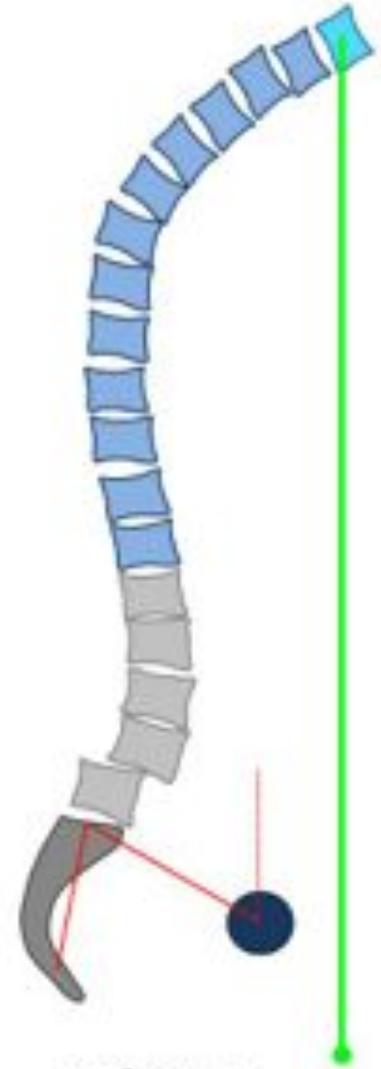
$SVA/SFD < 0.5$

Equilibre compensé partiellement



$SVA/SFD > 0.5$

Déséquilibré



$SVA/SFD > 1$



RACHIS

BASSIN

**MEMBRES
INFERIEURS**

Hyperlordose
cervicale

Réduction
cyphose thoracique

Rétrolisthésis

Hyperextension

Rétroversion

Flexion genoux

Extension
tibio-tarsienne

EOS™

Barrey, Eur Spine J 2011

DEFINITION SRS-Schwab

3 Sagittal modifiers

PI minus LL

0 : within 10°

+: moderate 10°–20°

++ : marked >20°

Global alignment

0 : SVA < 4cm

+: SVA 4 to 9.5cm

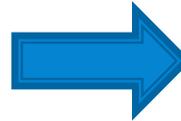
++ : SVA > 9.5cm

Pelvic tilt

0 : PT < 20°

+: PT 20°–30°

++ : PT > 30°



LL < IP-10°

et/ou

SVA > 40 mm

et/ou

VP > 20°

Spine

DEFORMITY

SPINE Volume 38, Number 19, pp 1663-1671
©2015, Lippincott Williams & Wilkins

Change in Classification Grade by the SRS-Schwab
Adult Spinal Deformity Classification Predicts
Impact on Health-Related Quality of Life Measures

Adult Spinal Deformities

- ▶ Strong Correlation between spino–pelvic parameters and functional outcomes and QoL scores
- ▶ ODI, SRS–22, SF36...

- ▶ *Glassman, Spine 2005*
- ▶ *Lafage V, Spine 2009*
- ▶ *Smith JS, Spine 2013*
- ▶ *Protopsaltis T, JBJS 2014*

TABLE 7. For Each Sagittal Modifier Independently, Comparison of Change in HRQOL Between Patients Who Sustained a Modifier Improvement Versus Those Who Sustained Deterioration

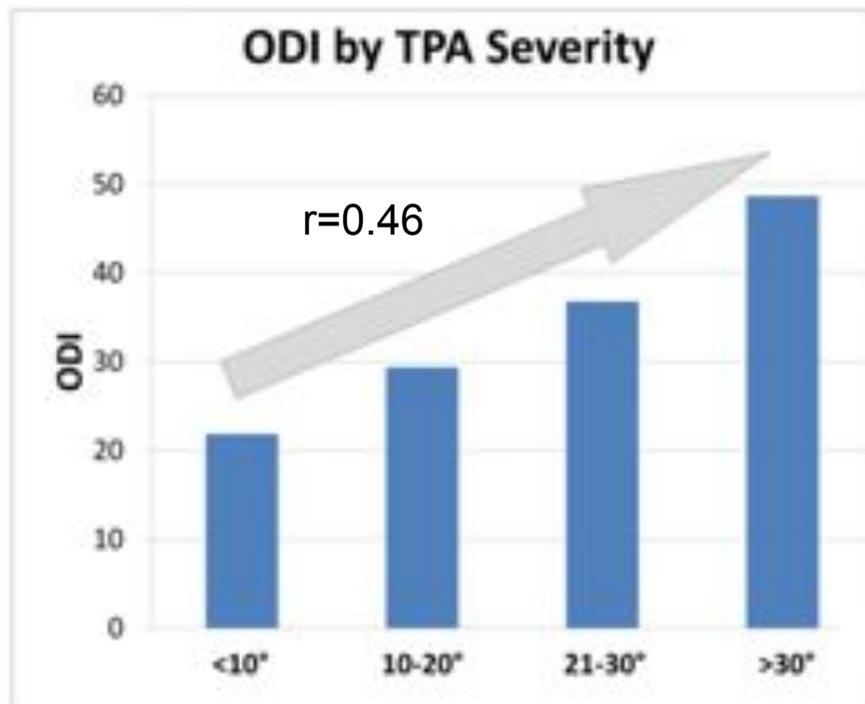
Modifier	Score	Modifier Deterioration		Modifier Improvement		t Test P
		Mean	SD	Mean	SD	
PT	Δ ODI	-9.55	14.95	-12.40	18.34	0.024
	Δ SF-36 PCS	3.81	10.07	8.82	11.60	No
	Δ SF-36 MCS	3.43	12.60	4.32	11.10	No
	Δ SRS activity	0.31	0.70	0.50	0.74	No
	Δ SRS pain	0.81	0.87	0.86	0.84	No
	Δ SRS appearance	0.62	0.92	1.28	1.09	0.002
	Δ SRS mental	-0.27	0.68	0.38	0.76	No
Δ SRS total	0.48	0.62	0.79	0.86	0.017	
SVA	Δ ODI	-6.37	16.14	-12.88	16.13	0.031
	Δ SF-36 PCS	1.34	9.89	7.28	10.91	0.008
	Δ SF-36 MCS	4.39	10.78	4.24	12.04	No
	Δ SRS activity	0.23	0.69	0.52	0.81	0.037
	Δ SRS pain	0.98	0.91	0.84	0.82	No
	Δ SRS appearance	0.26	0.88	1.23	1.04	<0.001
	Δ SRS mental	0.29	0.84	0.33	0.82	No
Δ SRS total	0.34	0.69	0.80	0.70	0.001	
PLL	Δ ODI	-7.86	16.42	-12.87	19.09	No
	Δ SF-36 PCS	1.76	9.40	7.12	11.41	0.024
	Δ SF-36 MCS	2.70	11.12	4.49	13.42	No
	Δ SRS activity	0.21	0.80	0.33	0.70	0.030
	Δ SRS pain	0.88	0.89	0.86	0.86	No
	Δ SRS appearance	0.31	0.94	1.26	1.03	0.001
Δ SRS mental	0.23	0.67	0.46	0.81	No	
Δ SRS total	0.44	0.67	0.83	0.86	0.006	

The T1 Pelvic Angle, a Novel Radiographic Measure of Global Sagittal Deformity, Accounts for Both Spinal Inclination and Pelvic Tilt and Correlates with Health-Related Quality of Life

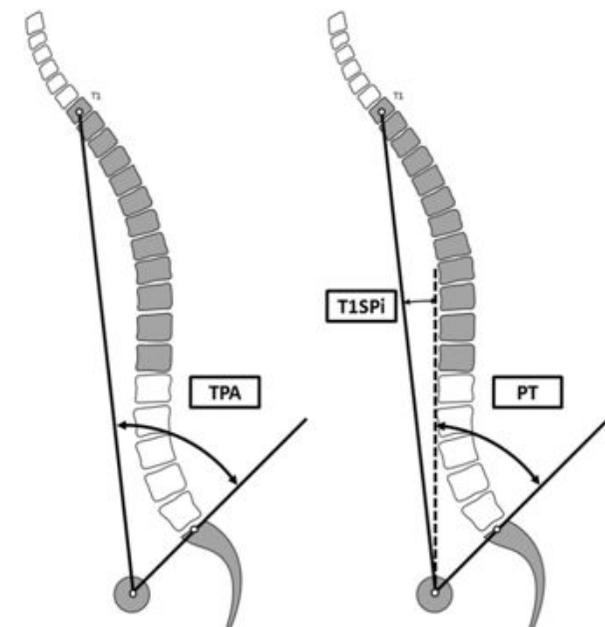
Themistocles Protopsaltis, MD, Frank Schwab, MD, Nicolas Bronsard, MD, Justin S. Smith, MD, PhD, Eric Käneberg, MD, Gregory Mundis, MD, Devon J. Ryan, BA, Richard Hostin, MD, Robert Hart, MD, Douglas Burton, MD, Christopher Ames, MD, Christopher Shaffrey, MD, Shay Bess, MD, Thomas Errico, MD, and Virginie Lafage, PhD, on behalf of the International Spine Study Group

J Bone Joint Surg Am. 2014;96:1631-40

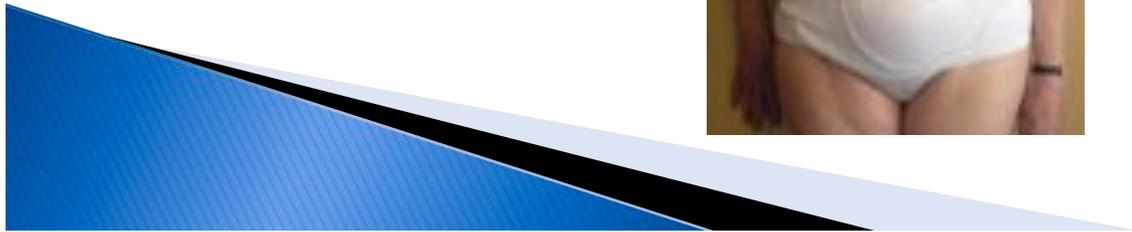
n=559



TPA



EN ECHEC DE TTT CONSERVATEUR



Analyse radio pré-opératoire

1- Canal rachidien (Imagerie en coupes)

2- Equilibre rachidien

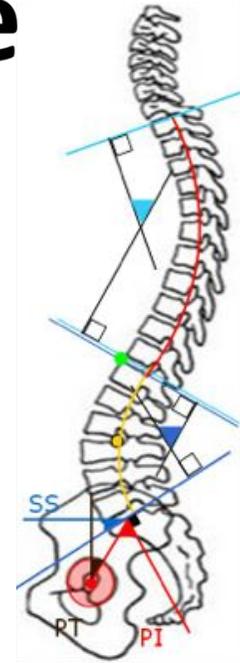
Full spine en position debout (full body)

Algorithme Barrey/LeHuec [\[ESJ 2011\]](#)

- Incidence pelvienne (classe IP)
- Equilibre global (C7)
- Mécanismes de compensation: Rachis/bassin/MI

3- Rigidité de la déformation

- Clichés dynamiques/traction/sur billot ++
- Comparaison des imageries couchées / debout
- Analyse des ponts osseux au scanner MPR





Nom Chirurgien	Barey	Niveau	T4-Étage
Date de chirurgie	10/06/2015	Type de tiges	standard
Initiales Patient	LD	Matériau	Titane
ID cas	0	Diamètre	S.S
ID Patient	238e06f		

PARAMETRES SPINOPELVIENS	PRE-OP	PLAN	POST-OP
Version Pelvienne (PT,°)	34	12	24
Inclinaison Pelvienne (PI,°)	43	43	43
Pente Sacrée (SS,°)	9	31	19
Lordose Lombaire (LL,°)	3	41	42
PI-LL(°)	40	2	1
Cyphose Thoracique (TK,°)	40	25	50
Angle T1 Pelvien (TPA,°)			0
Alignement Sagittal Vertical (SVA,mm)	131,7	10,7	22,7

Stratégie chirurgicale en/ou étapes :

1. ODP en L3 (gain environ 35°)
2. SPO au niveau thoracique de T8 à L2: prévoir 3° de correction / niveau
3. plaques Riposte
4. objectifs: SVA = 50 mm, VP = 12°
- 5.
- 6.

Commentaires :

- 1.
- 2.
- 3.

POST-OPERATOIRE



Objectifs de la chirurgie

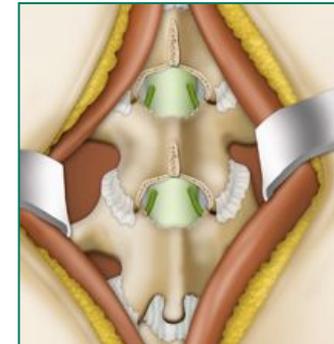
1 – Libérer les structures neurologiques

2 – Stabiliser les glissements

3 – Corriger le déséquilibre

- Frontal: gîte C7, équilibre bassin et épaules
- Sagittal: lordose théorique, C7PL au-dessus du plateau sacré

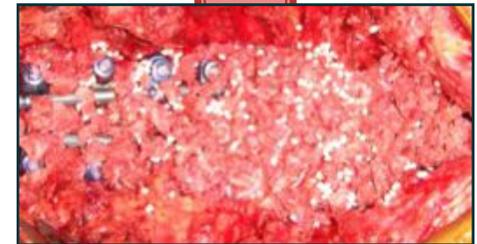
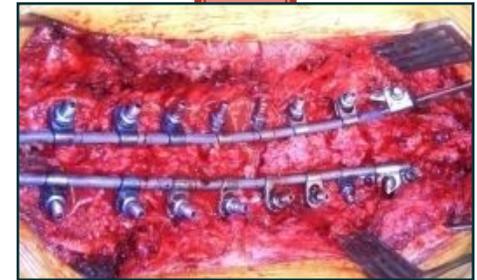
4 – Greffer (pérenniser la correction)



Technique chirurgicale

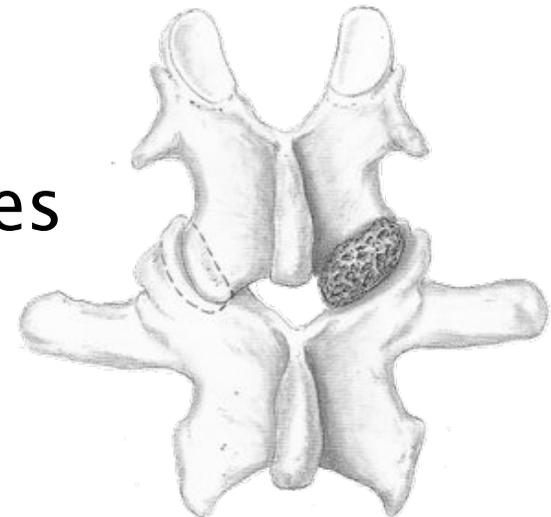
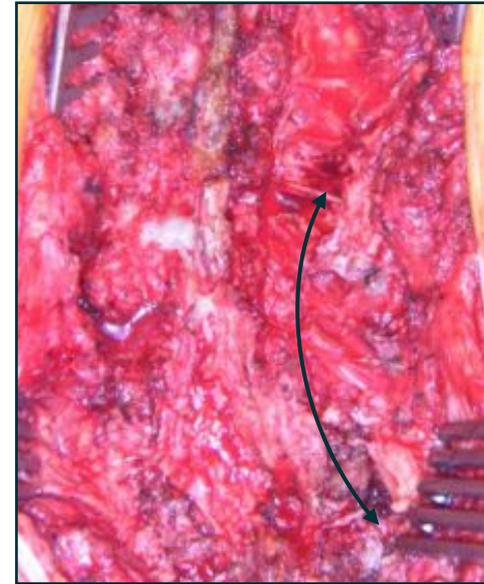
Principales étapes:

- ▶ Gestes de libération
- ▶ Instrumentation
- ▶ Manœuvres de correction
- ▶ Greffe osseuse



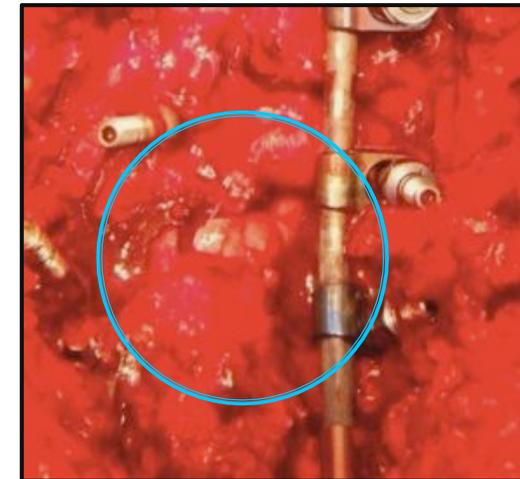
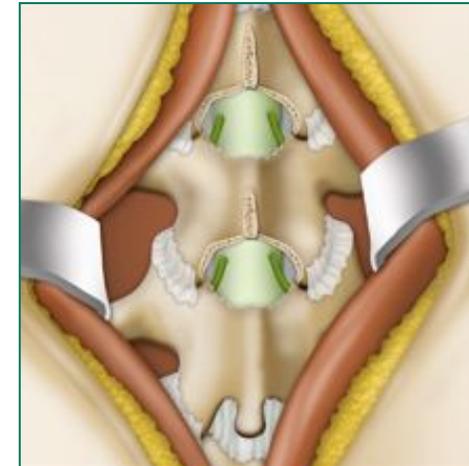
Avant de corriger, il faut **LIBERER** !

- ▶ Libération
 - rétractions tendineuses
 - arthrectomies inf ET sup (pointes)
 - parfois véritable foraminotomie
 - résection ponts osseux ++
 - Épineuses, ostéophytes
- ▶ Permet de **MOBILISER** les vertèbres



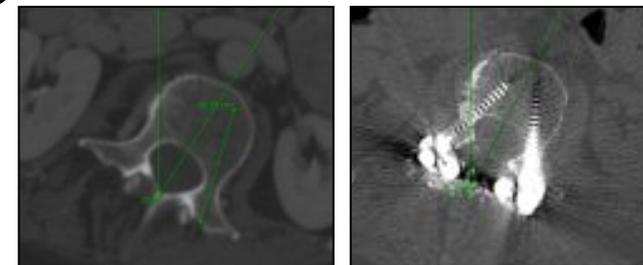
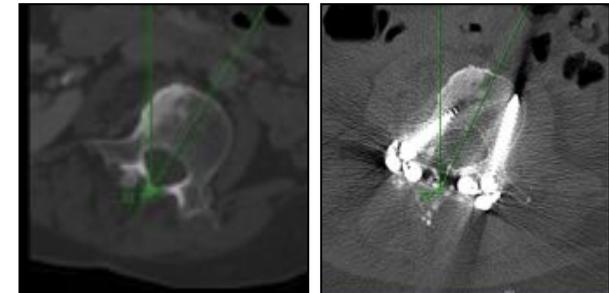
Recalibrage canalaire

- ▶ Résection des éléments compressifs
- ▶ Ciblé en fonction clinique et imagerie
- ▶ Limité « inter-lamaire »
± foraminotomie
- ▶ Après la mise en place des vis et avant la mise en place de la tige



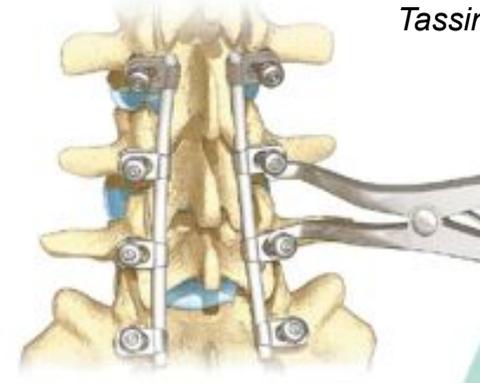
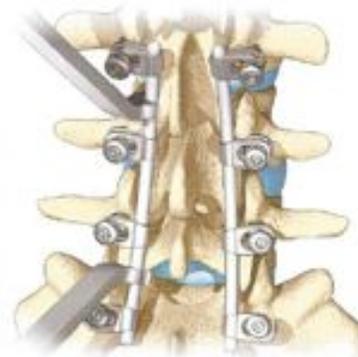
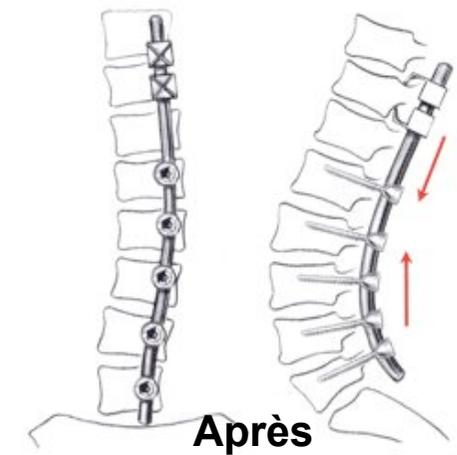
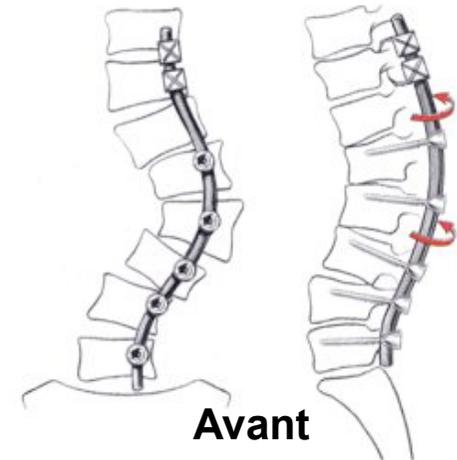
Instrumentation

- ▶ Prise segmentaire
- ▶ Vis pédiculaires +++
- ▶ Ampli face et profil
- ▶ Planification pré-op (CT)
- ▶ Navigation/ imagerie per-op

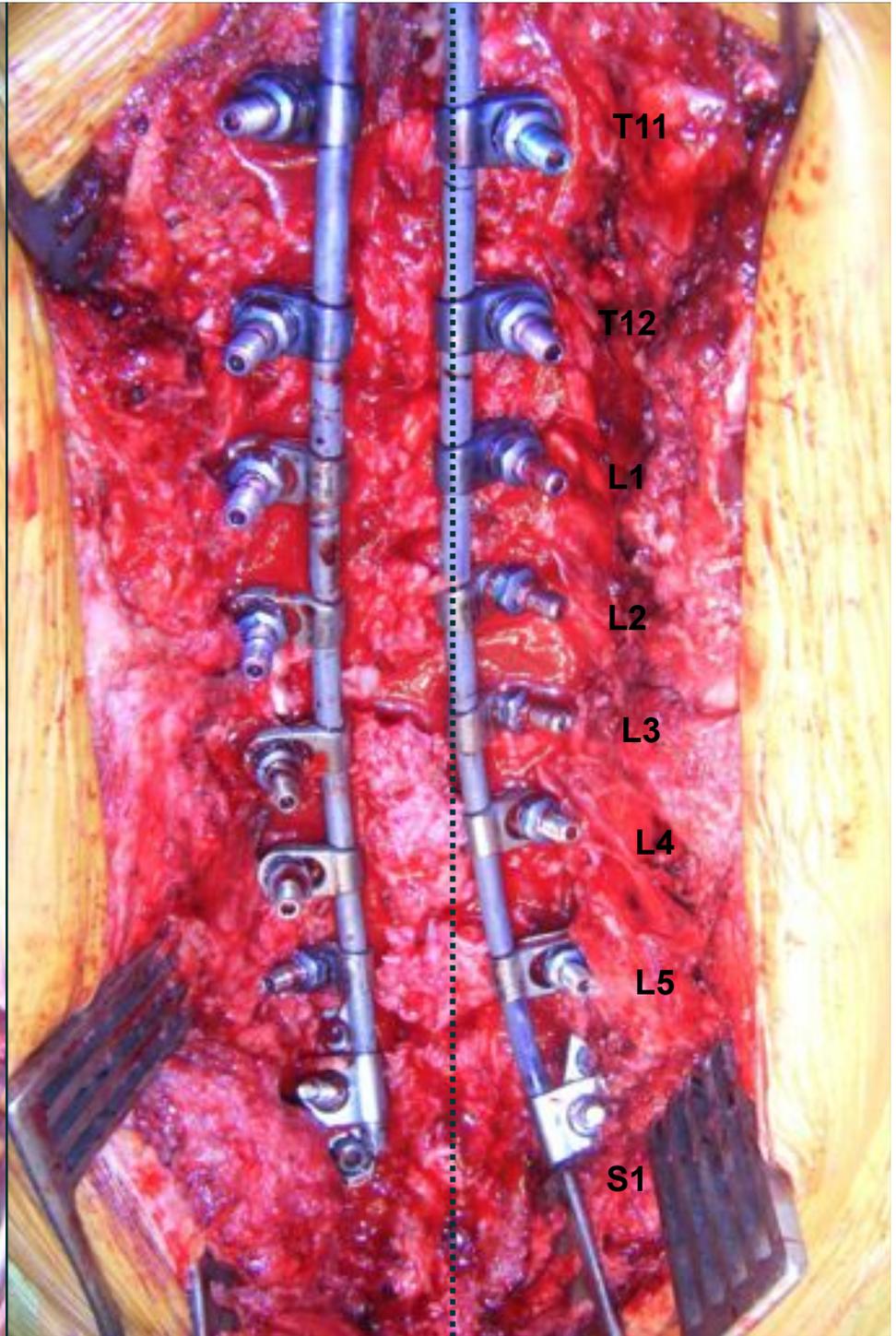
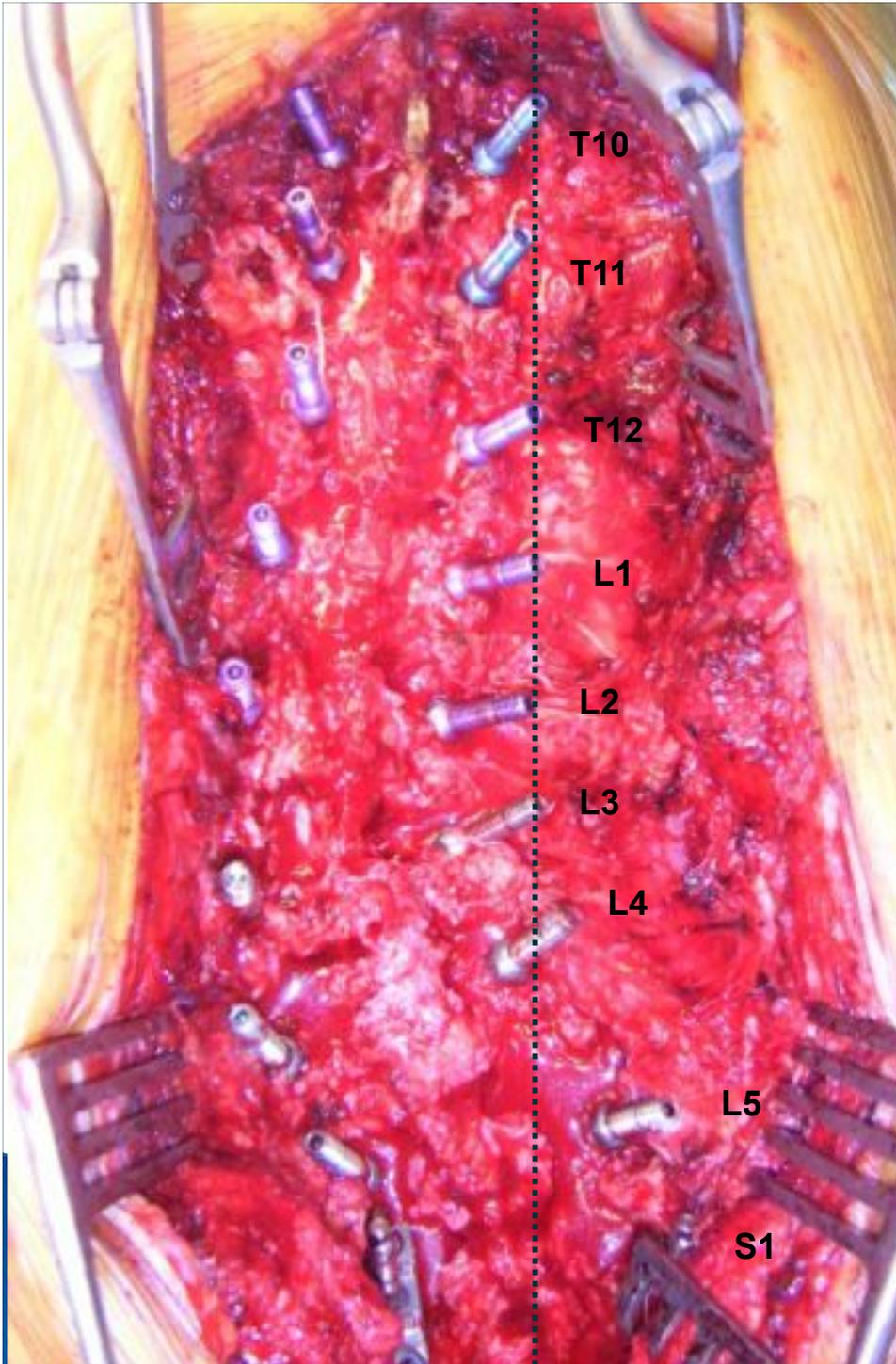


Correction

- ▶ Position opératoire
- ▶ Cintrage de la tige
- ▶ Dérotation - Translation
- ▶ Verrouillage PROGRESSIF
- ▶ Distraction - Compression segmentaire



Tassin, Elsevier



Pérenniser la correction

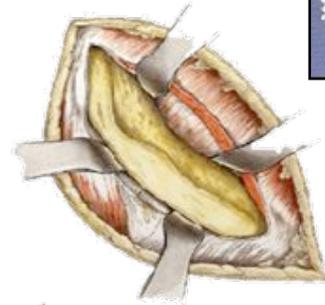
GREFFE OSSEUSE

➤ Matériel de greffe:

- Autologue
- Substituts osseux
- BMP
- Hybrides ++

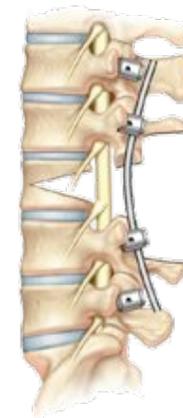
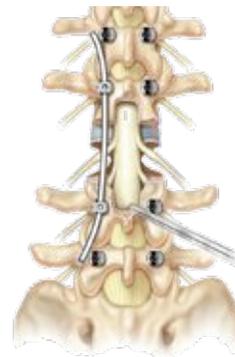
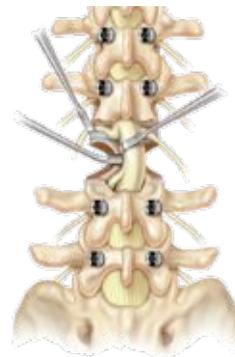
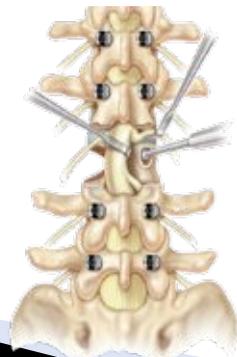
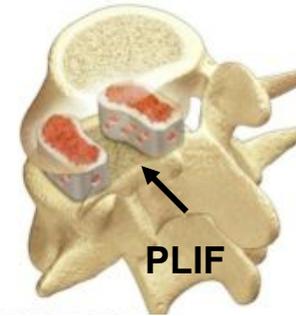
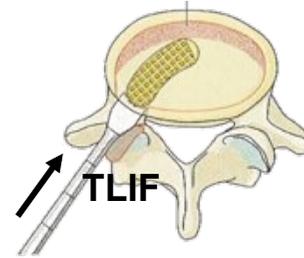
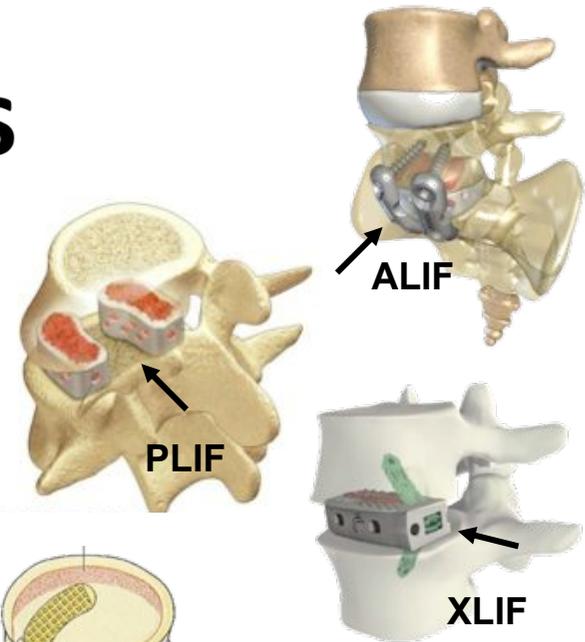
➤ Site de greffe:

- Inter-lamaire ++
- Inter-facettaire ++



Techniques Optionnelles

- ▶ Implants intersomatiques
 - ALIF: correction sagittale
 - XLIF
 - TLIF/PLIF: correction frontale
- ▶ Gestes d'ostéotomie
 - Trans-foraminales ++
 - Trans-pédiculaires



OSTEOTOMIES

Traiter une déformation du rachis en repositionnant le rachis dans une situation d'équilibre la plus physiologique possible

3 grandes catégories :

1- Ostéotomies postérieures de fermeture type SP0

2- Ostéotomies de soustraction trans-pédiculaire (PSO)

3- Techniques de résection vertébrale type PVCR

S'adressent aux déformations **RIGIDES**

Correction par voie **postérieure** exclusive ++



The Comprehensive Anatomical Spinal Osteotomy Classification

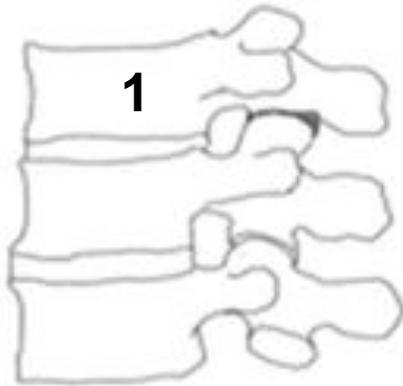
SCHWAB ET AL

NEUROSURGERY

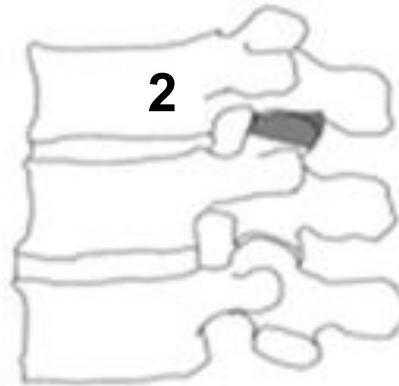
VOLUME 74 | NUMBER 1 | JANUARY 2014 |

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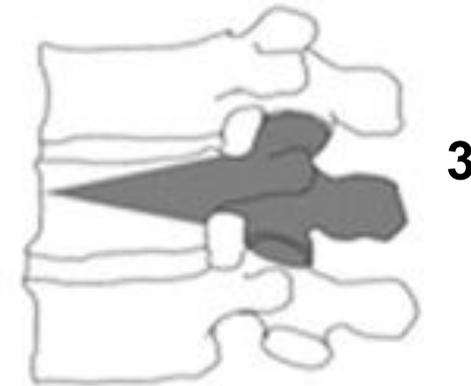
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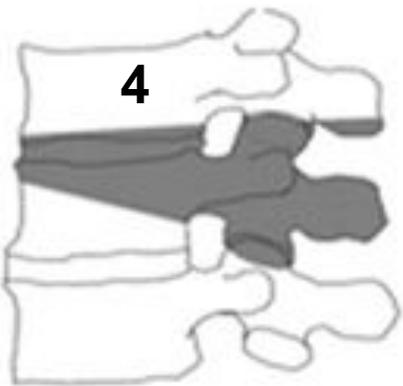
1
Partial facet



2
Complete facet



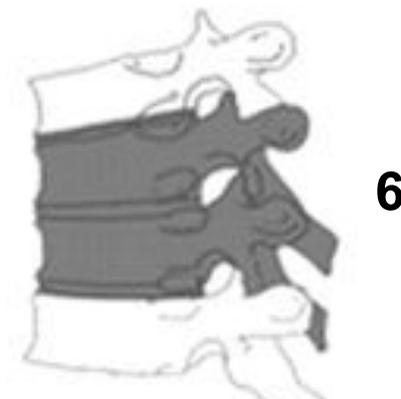
3
Pedicle + partial VB



4
Pedicle + partial VB
+ disc

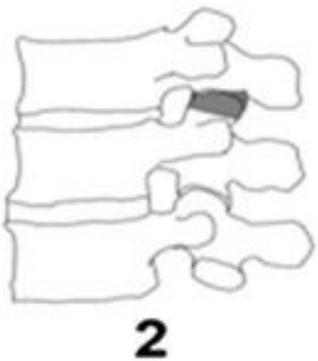
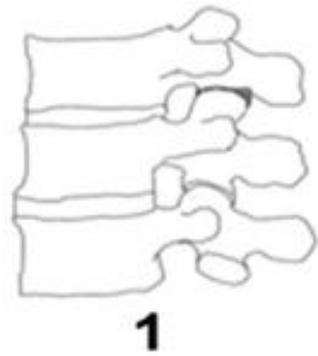


5
Complete VB +
adjacent discs

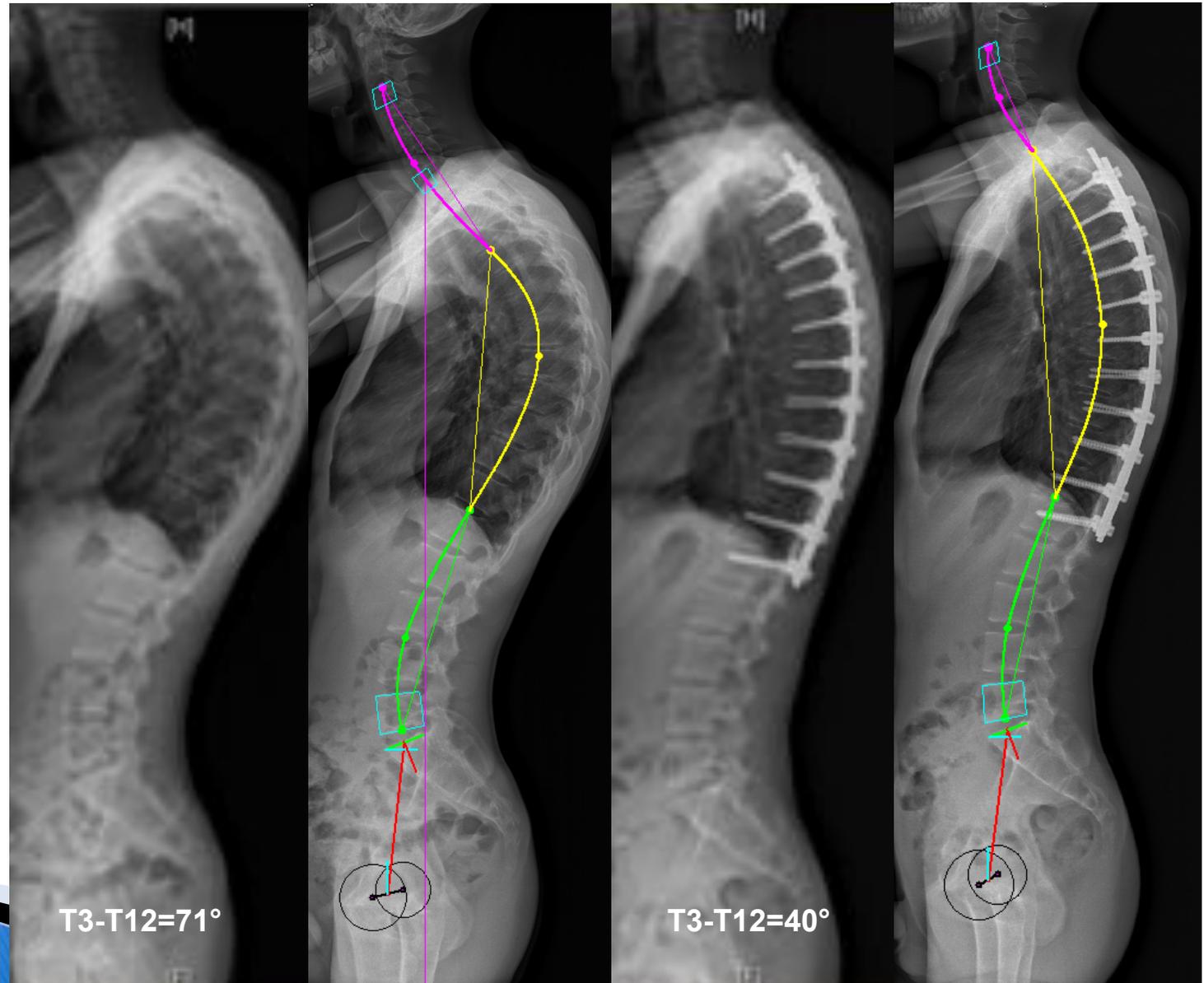


6
Multilevel
complete VB + dics

Ostéotomies de type 1 et 2

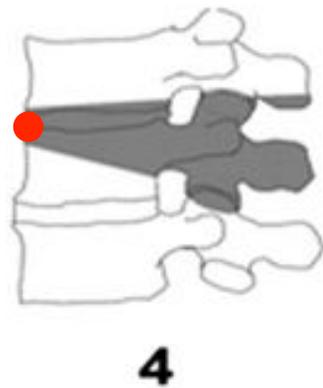
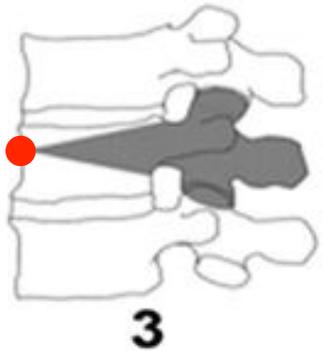


correction 5-10°
variants: SPO/Ponte

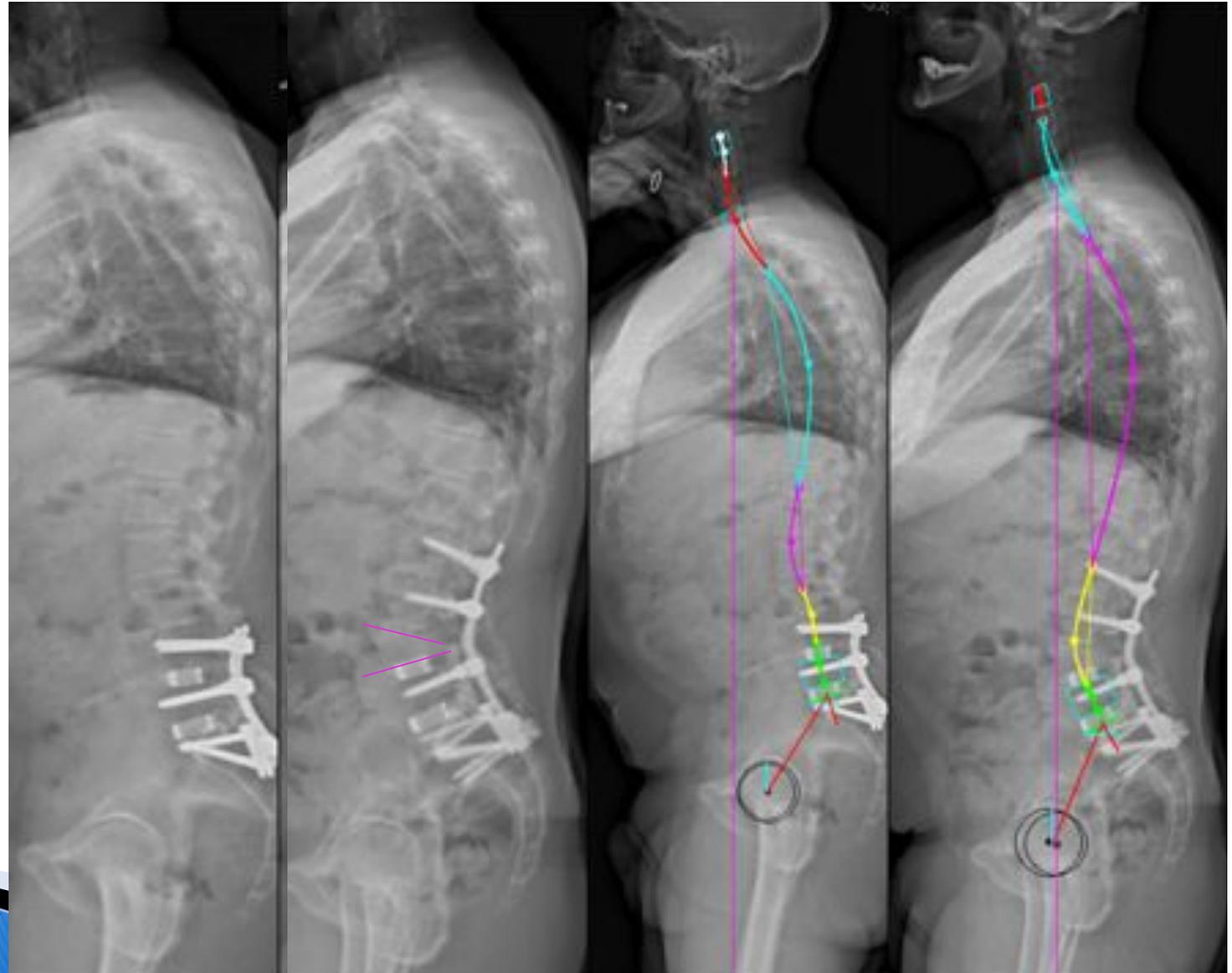


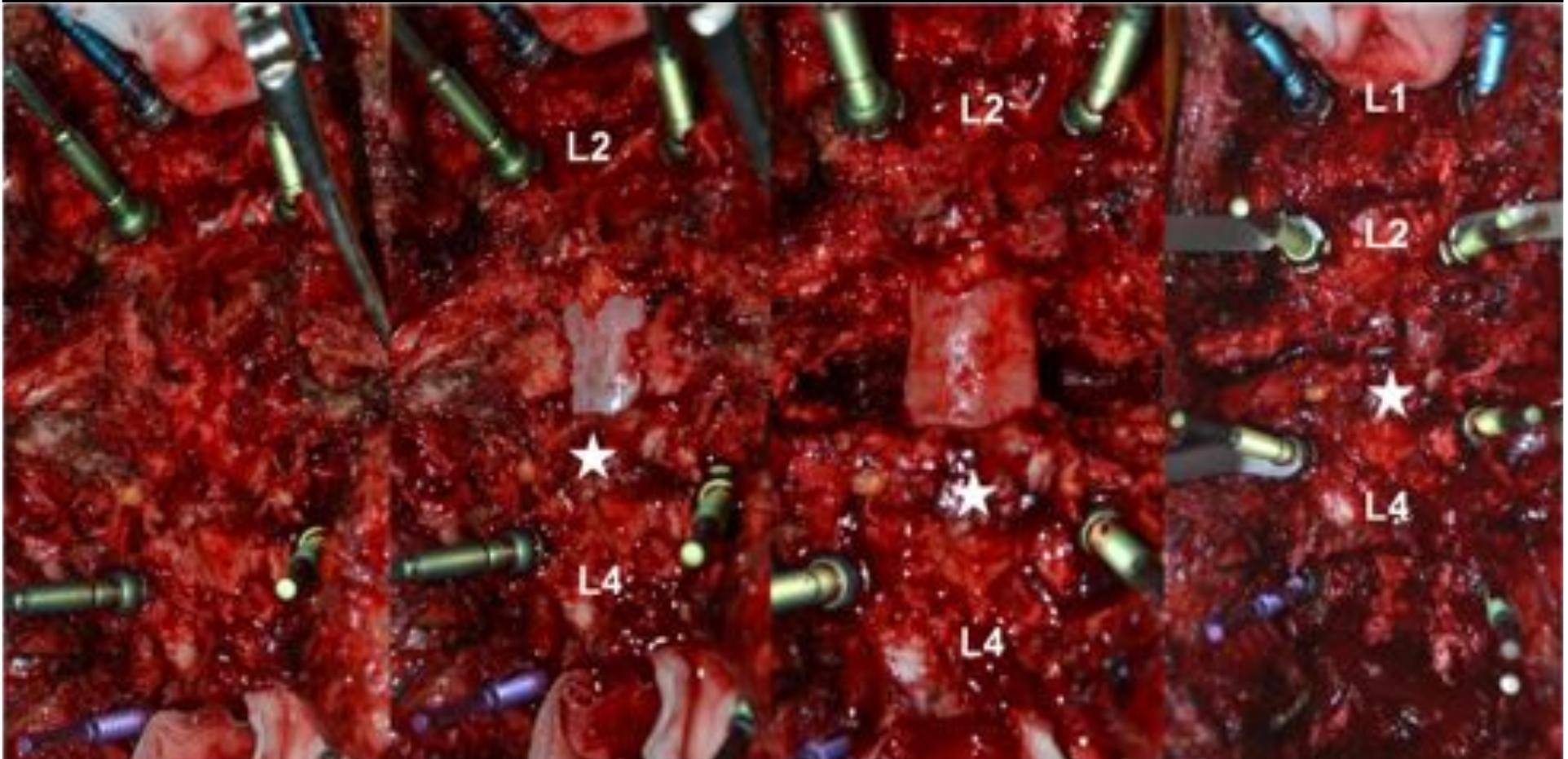


Ostéotomie trans-pédiculaire

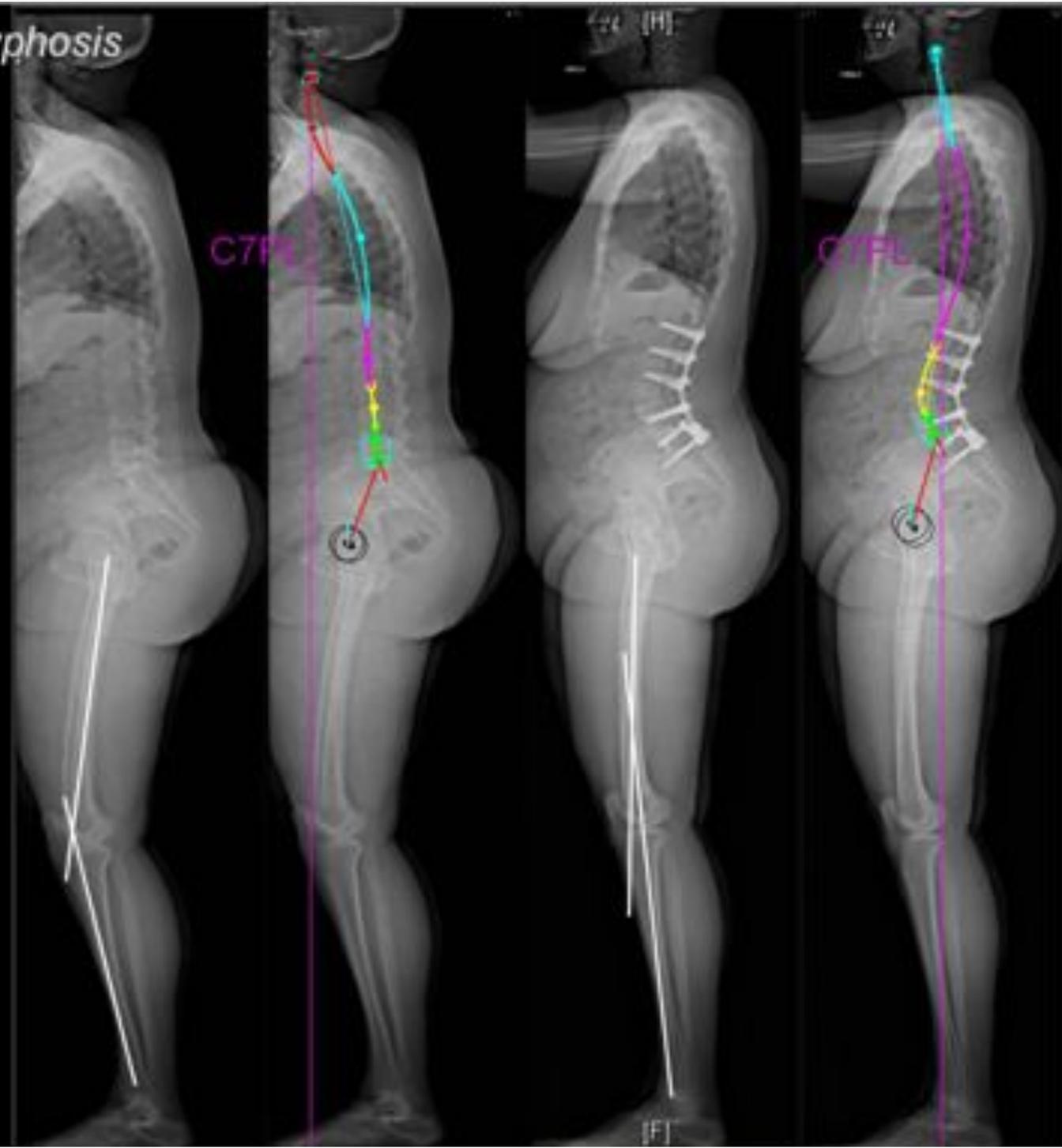


correction 25-35°
All done posteriorly





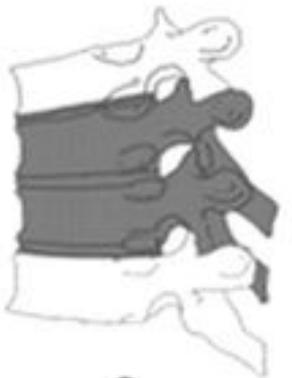
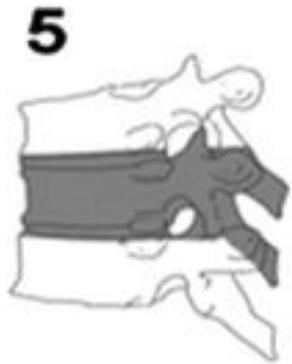
Lumbar Kyphosis



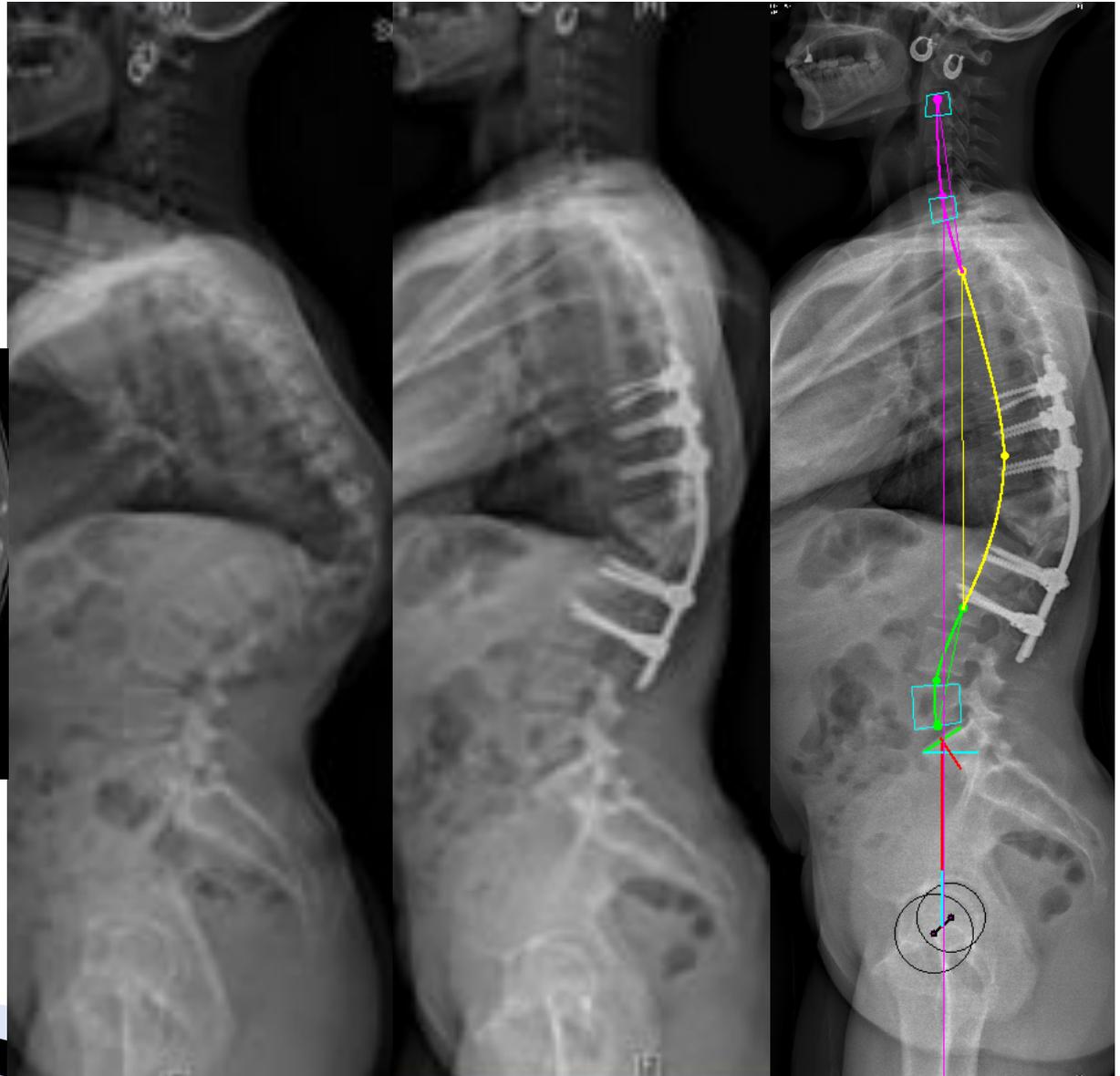
PI=40°
PT=26°
SS=14°
LL=0°
KF=25°

PI=40°
PT=18°
SS=22°
LL=46°
KF=6°

Résection vertébrale (VCR)



Correction 30-45°
Sharp/rigid deformity

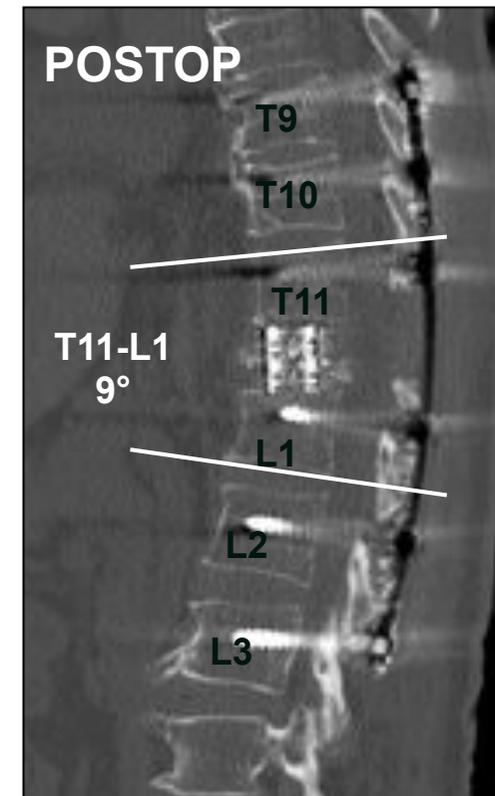
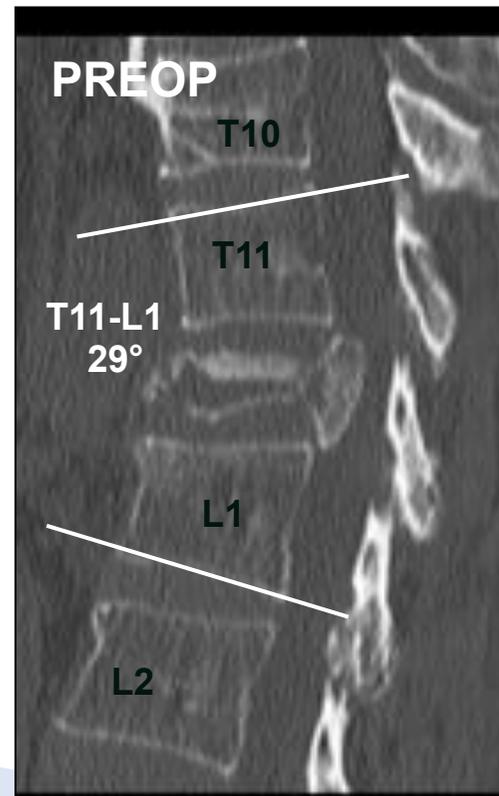
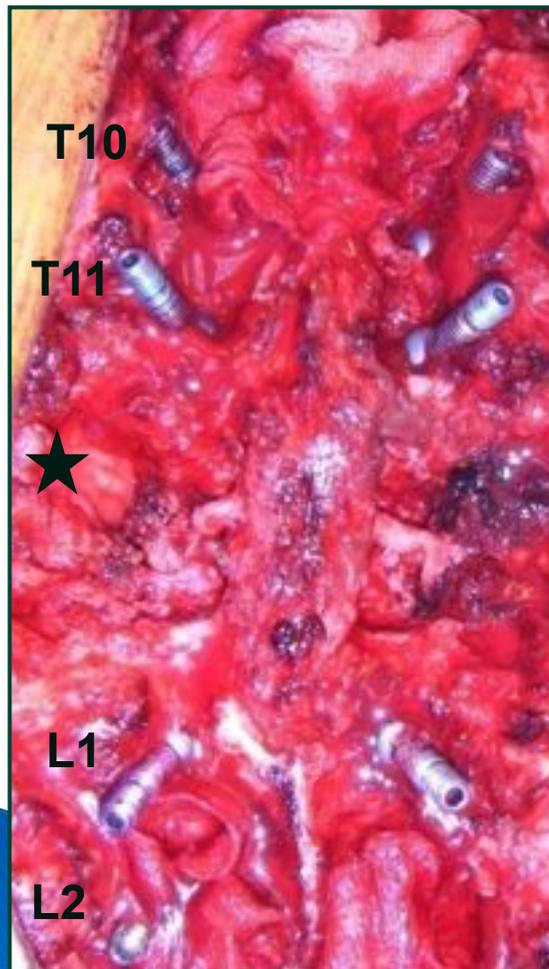
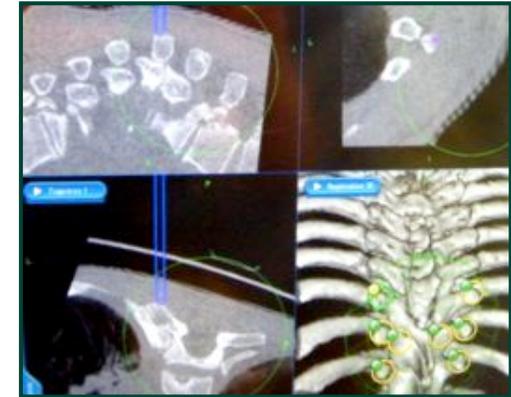
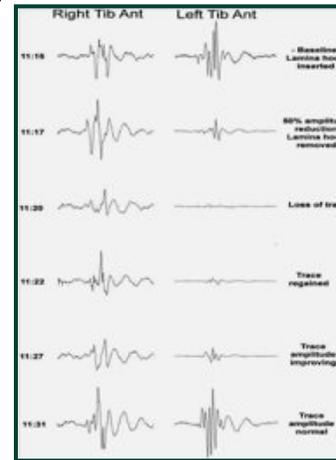


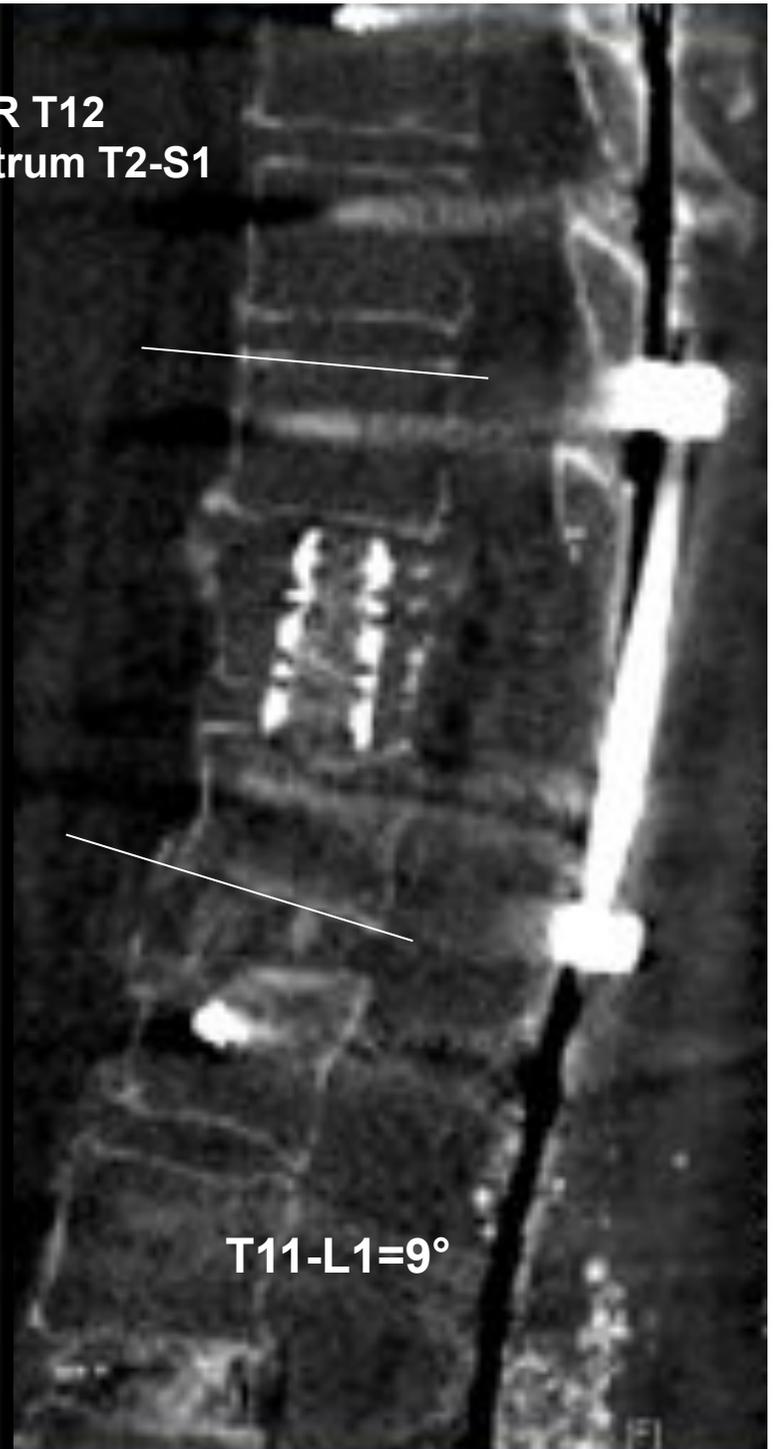
Female, 62 y-old, post-traumatic kyphosis

1. VCR T12:

Intra-operative monitoring

2. Posterior instrumentation T9-L3

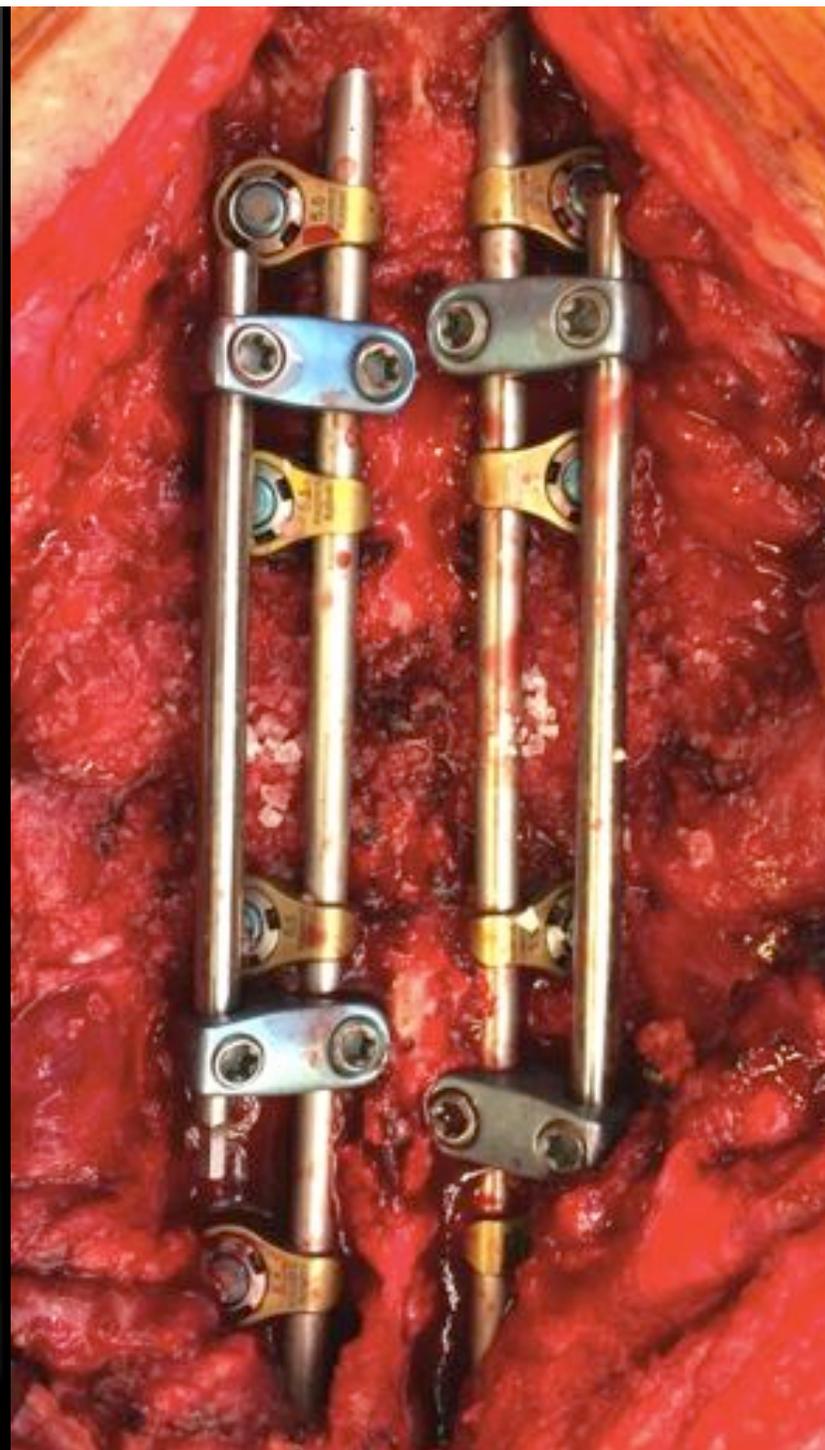






Prévenir la fracture de fatigue :

- Tiges + rigides (Cr-Co, Ø 6 mm)
- Tiges supplémentaires « montage 4 tiges »
- Greffe osseuse de qualité



RESULTATS de la CHIRURGIE

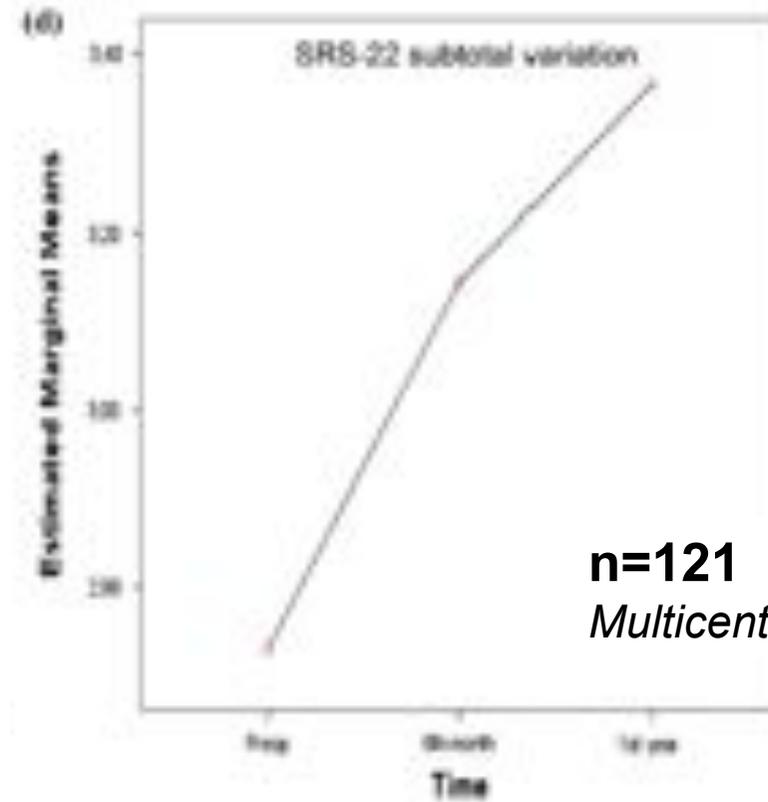
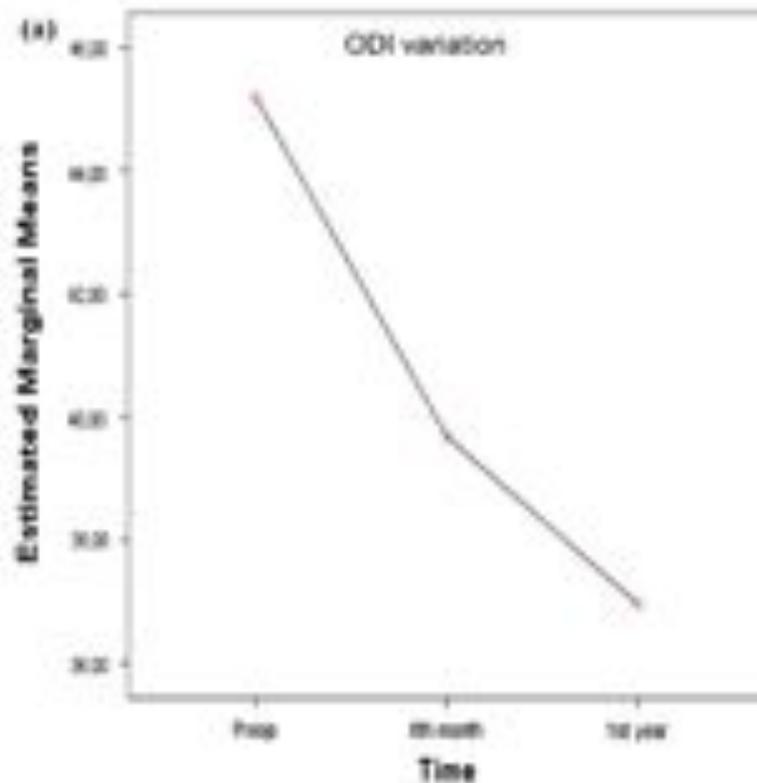
Safety and efficacy of osteotomies in adult spinal deformity: what happens in the first year?

Selim Ayhan¹ · Bilal Aykac¹ · Selcen Yuksel² · Umit Ozgur Guler¹ · Ferran Pellise³ · Ahmet Alanay⁴ · Francisco Javier Sanchez Perez-Gruoso⁵ · Emre Acaroglu¹ · ESSG European Spine Study Group

Eur Spine J
DOI 10.1007/s00586-015-3981-3

ESJ, 2015

ORIGINAL ARTICLE



n=121
Multicentrique

RESULTATS de la CHIRURGIE

Spine

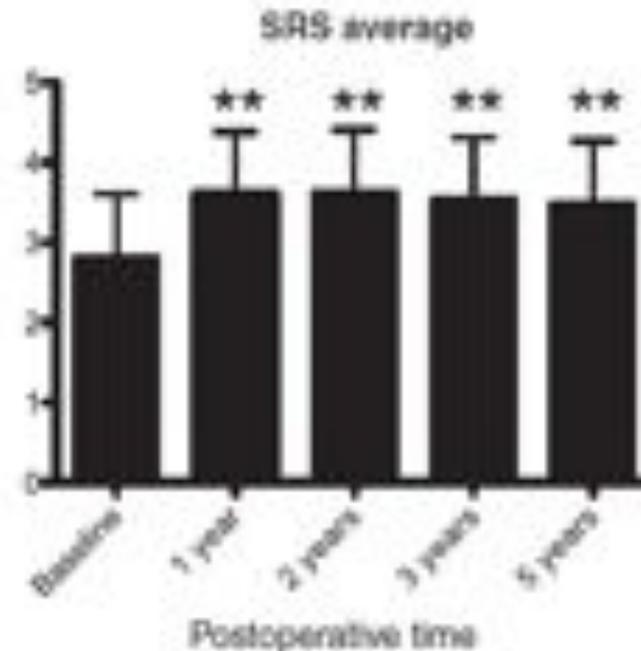
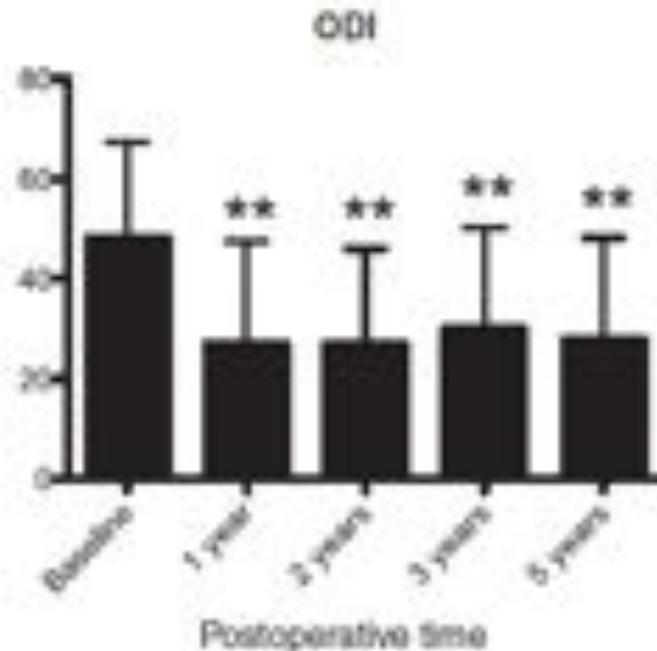
SPINE Volume 39, Number 5, pp 424-432
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OUTCOMES

Clinical and Radiographic Outcomes After 3-Column Osteotomies With 5-Year Follow-up

Kevin R. O'Neill, MD, MS, Lawrence G. Lenke, MD, Keith H. Bridwell, MD, Seung-Jae Hyun, MD, Brian Neuman, MD, Ian Dorward, MD, and Linda Koester, BS

n=126
Monocentrique



COMPLICATIONS

Spine

SPINE Volume 37, Number 8, pp 693-700
©2012, Lippincott Williams & Wilkins

DEFORMITY

Complications and Risk Factors of Primary Adult Scoliosis Surgery

A Multicenter Study of 306 Patients

Sebastien Charosky, MD,* Pierre Guigui, MD,† Arnaud Blamoutier, MD,‡ Pierre Roussouly, MD,§ and Daniel Chopin, MD,|| Study Group on Scoliosis

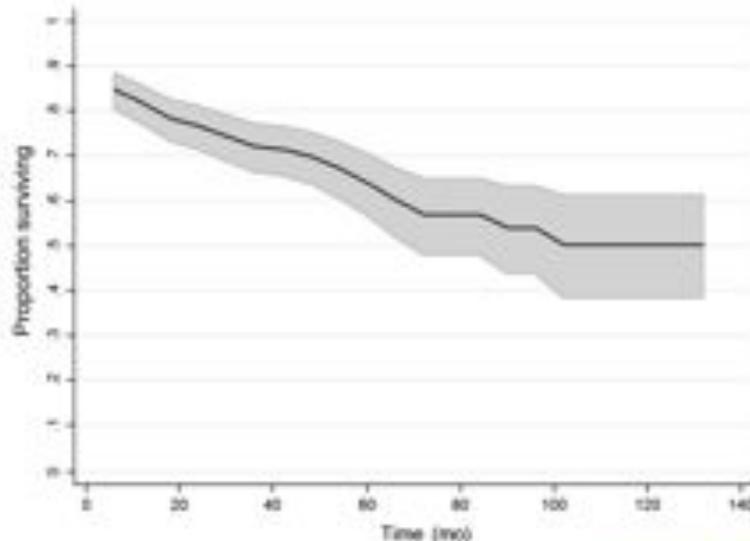


Figure 1. Global survival curve shows a survival rate of 74% at 2 years and 56% at 5 years.

➤ Complications

- Infectieuses : **5.2%** (4% < 3mois)
- Neuro. : **7,5%** (4% reprise)
- Mécaniques : **24%** (19% reprise)

➤ Facteurs de risques :

- Nbre de Nx instrum. (**5-10**)
- Extension au sacrum : **OR 3,6**
- PSO : **OR 2,8**
- PT : > **26°** (vs 23°)

RESULTATS de la CHIRURGIE

Spine

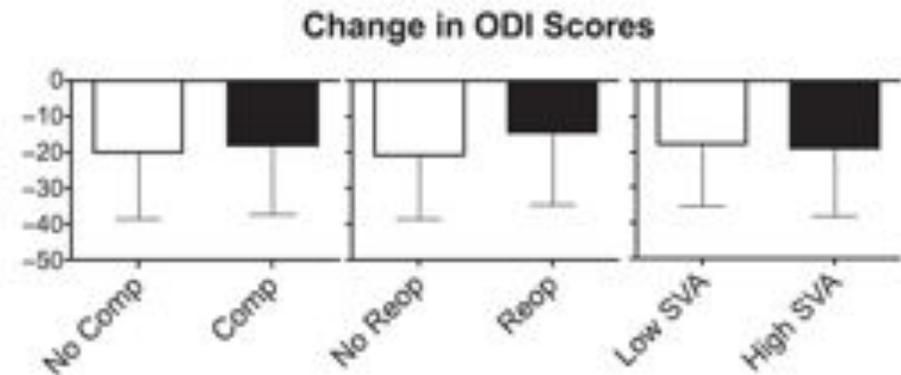
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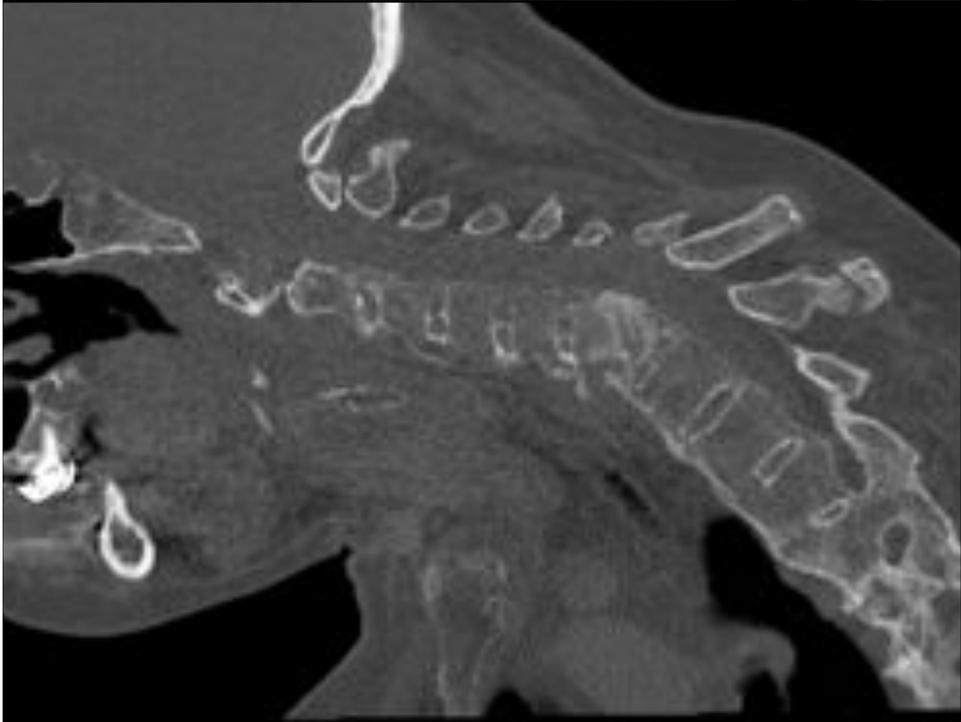
n=126
Monocentrique



**Patients avec / sans complication:
Pas de différence statistique à 5 ans**

- Man, **54 y-old**
- Medical history of **ankylosing spondylitis**
- History of neck injury (fall during biking) 11 mths ago
- Progressive and painful deformity of the cervical spine
- Major disability: wheeling chair...
- Physical examination:
 - Major cervico-thoracic kyphosis
 - no motor deficit





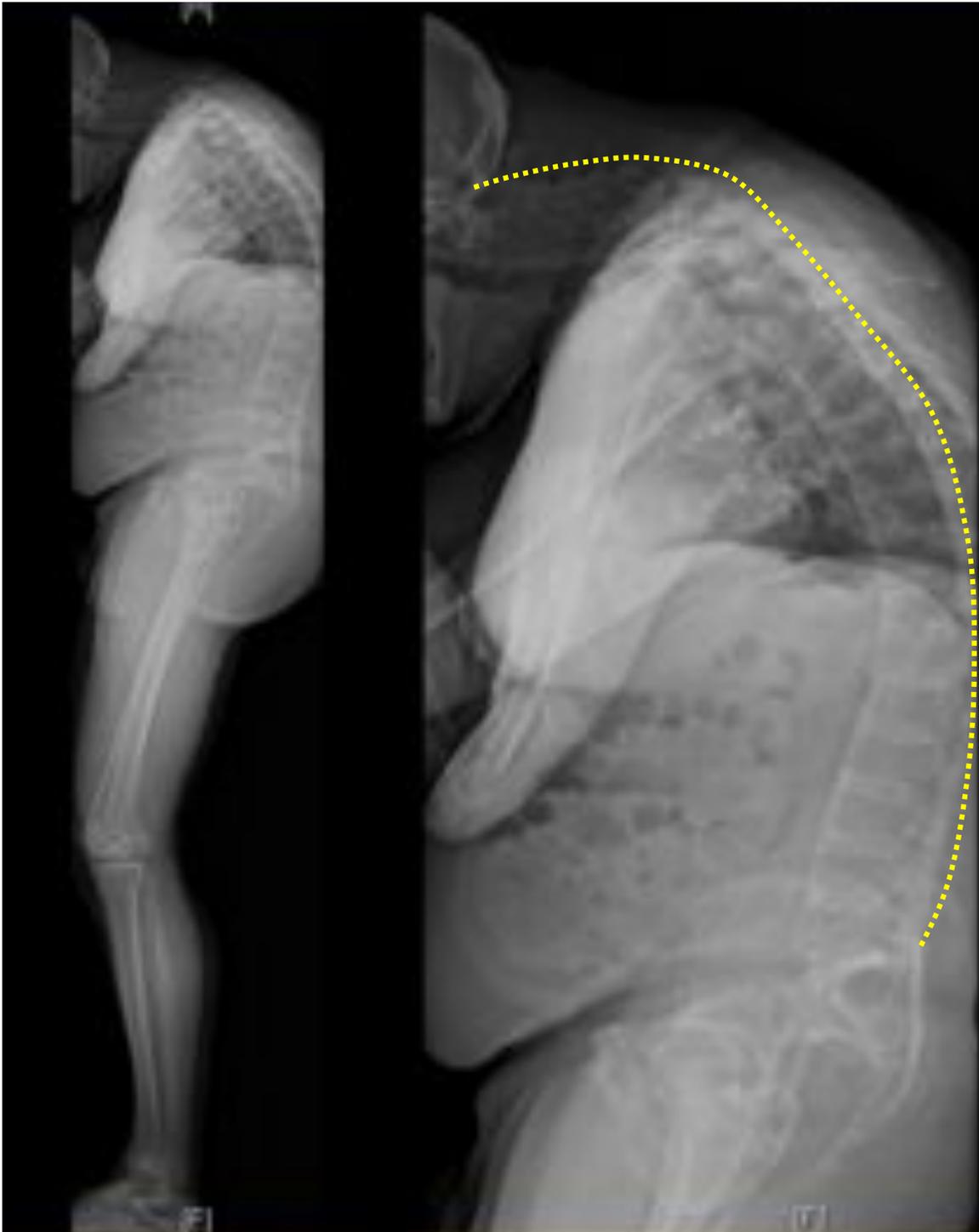
C6-T1: +50°

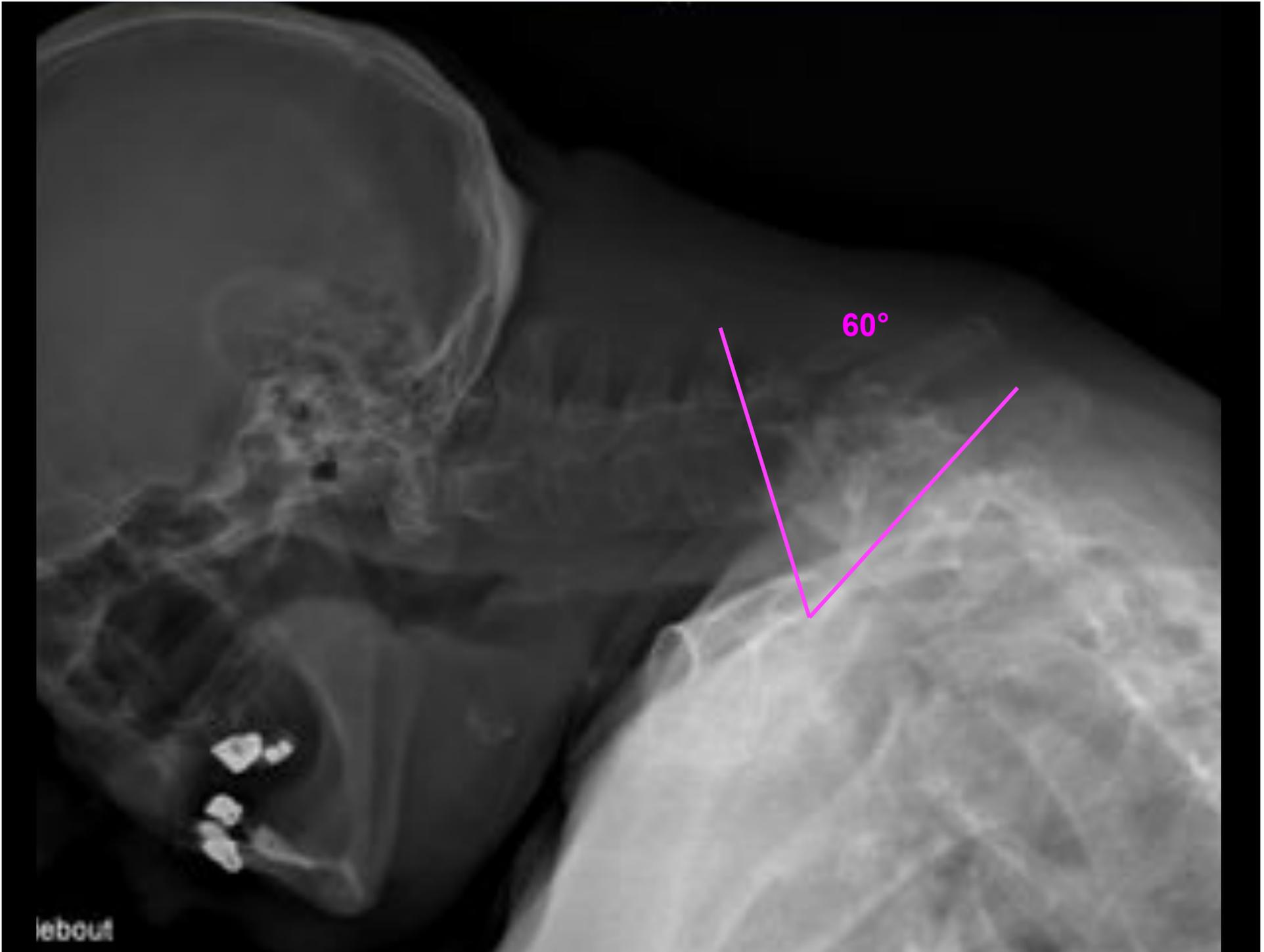
C6

T1









lebout



MRN: 1027694
DOB: 08/04/196
Sex: F

debout

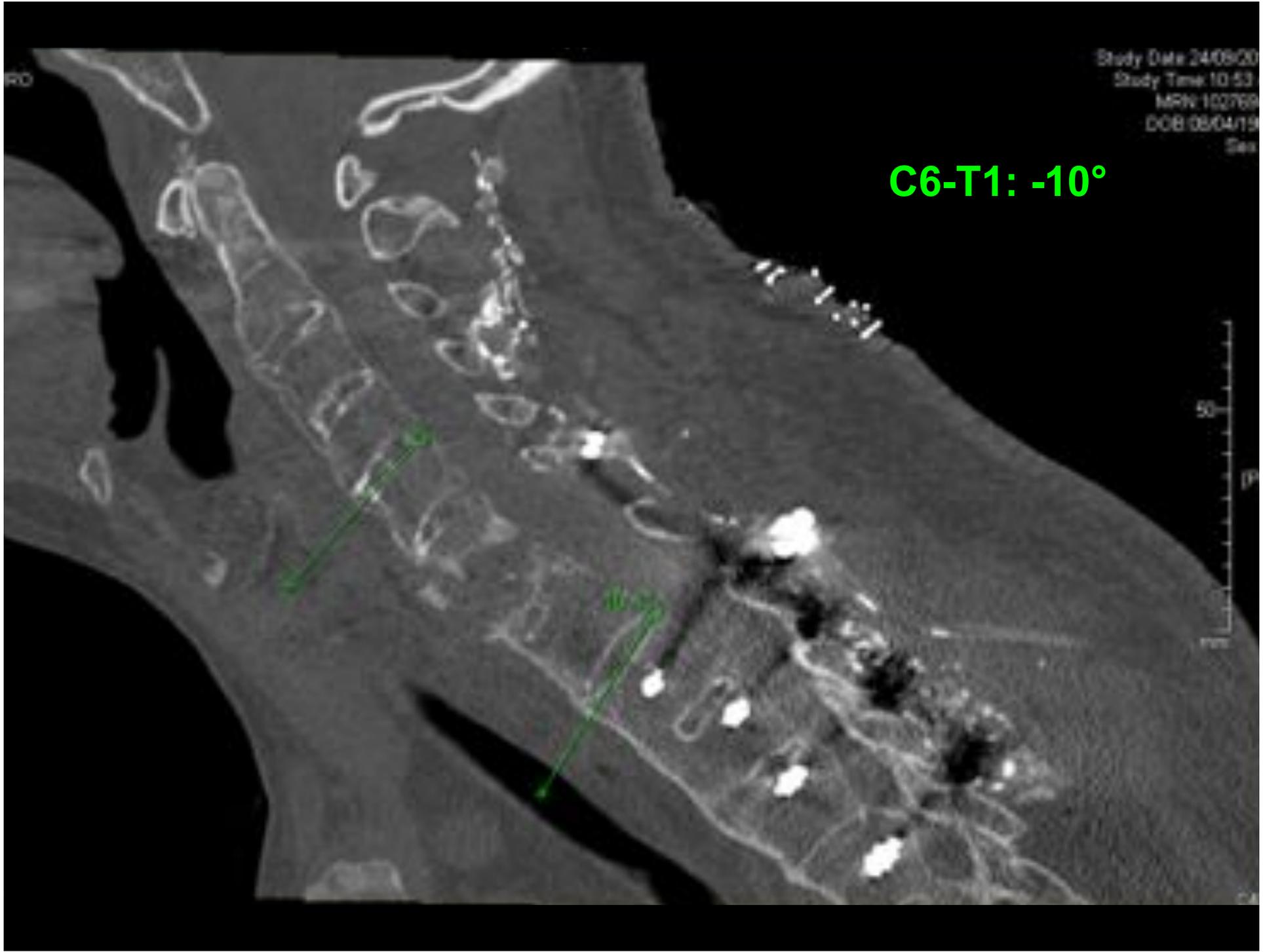


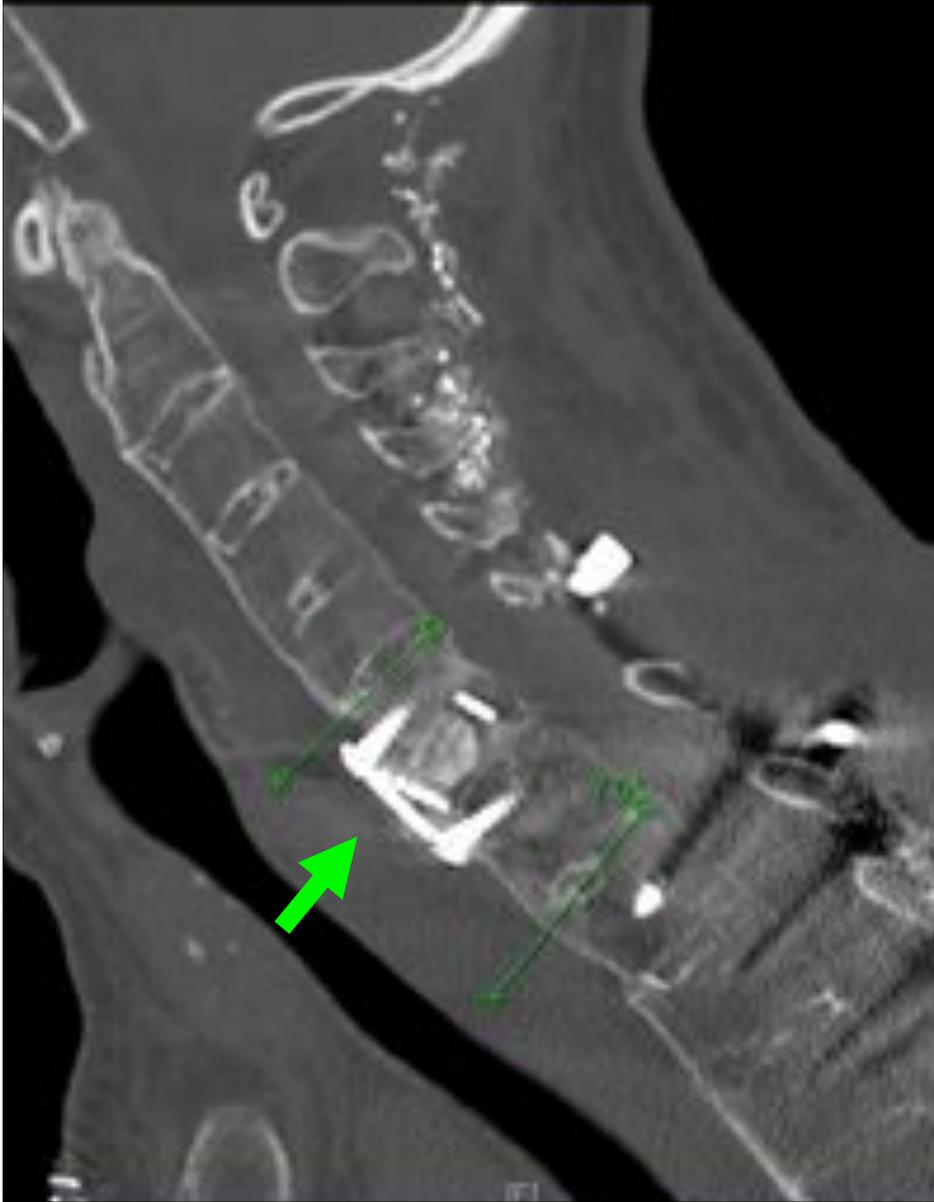
C333
W5436

C2-T5 posterior instrumentation

Study Date: 24/06/20
Study Time: 10:53
MRN: 102769
DOB: 08/04/19
Sex:

C6-T1: -10°





Preop



**M6
postop**





Hôpitaux de Lyon



Merci pour votre attention



cedric.barrey@chu-lyon.fr