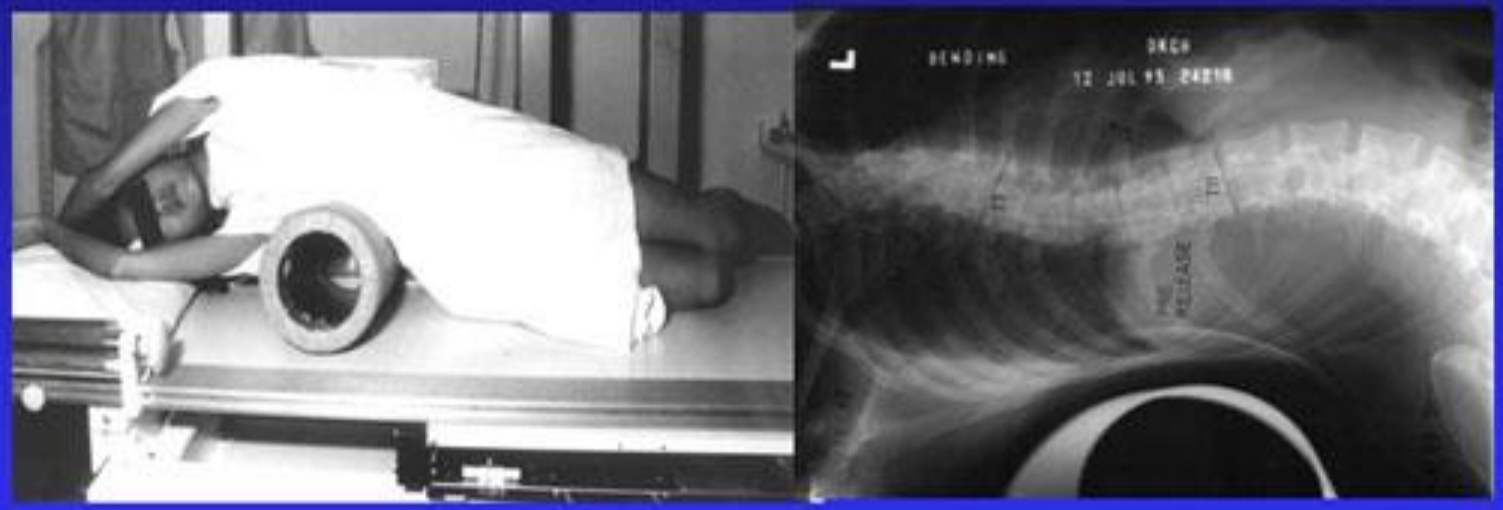
Hong Kong

Strategy for Fusion Level Determination



Professor Kenneth Cheung
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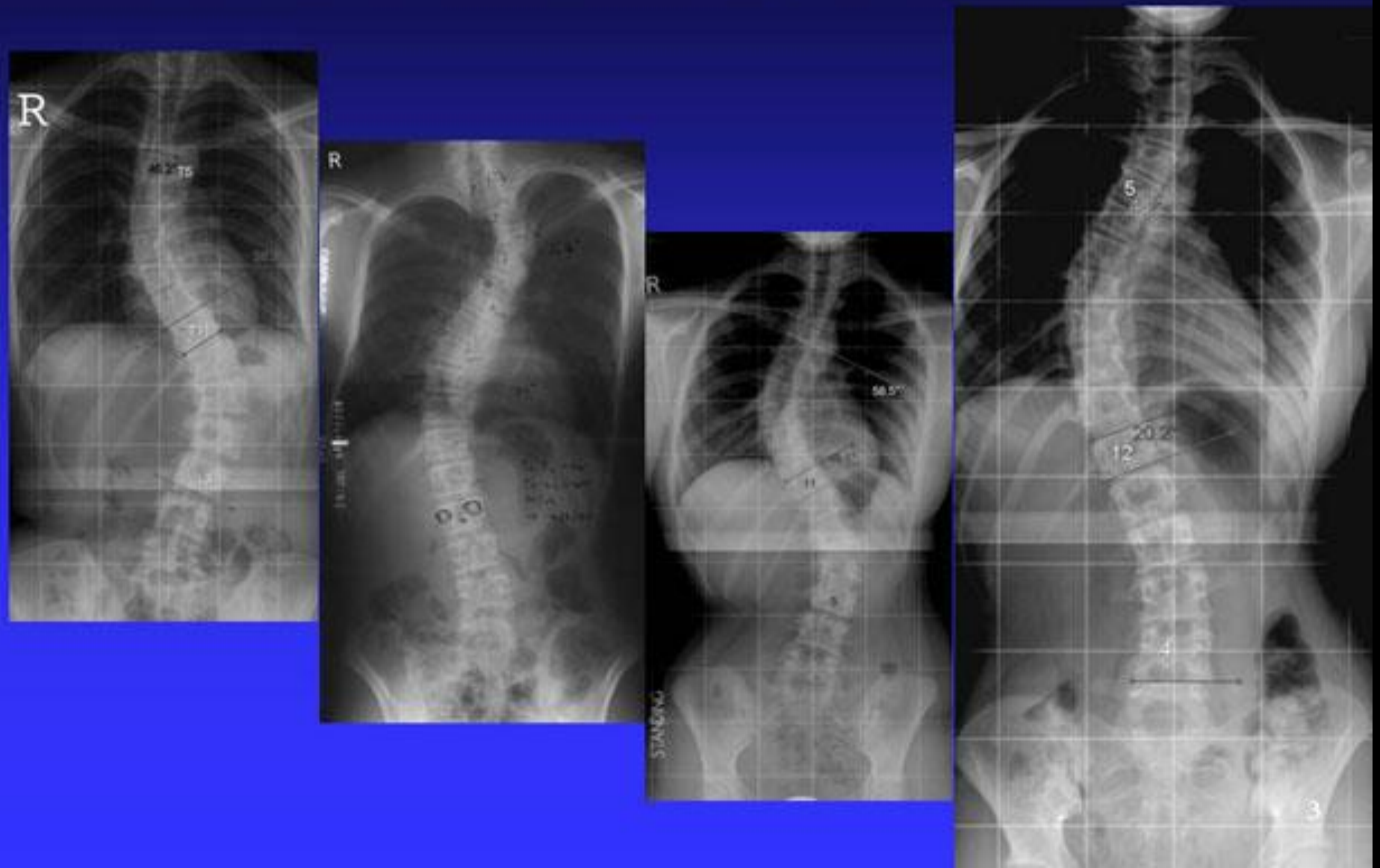
Fusion levels versus curve patterns



Fusion levels versus curve patterns

Lumbar major
Anterior correction and fusion
End vertebra to end vertebra

Fusion levels versus curve patterns

Double major curves
Risk of decompensation
Aim: balance
Stable to stable

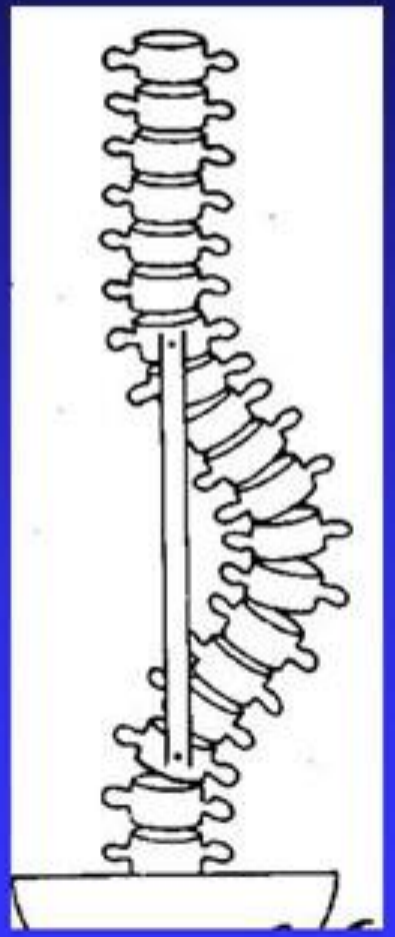
Fusion levels versus curve patterns

- Thoracic major
- Lenke 1 and 3
- King's Type II/III

- Guidelines on fusion levels?
  - Harrington's stable zone
  - Bending films
  - Truncal shift *(add levels)*
  - Experience

Requirements of scoliosis fusion surgery

- Straight spine…*or*…Balance
- Fusion block
  - End-plates as parallel as possible
  - No relative shift
- Is there a way that we can predict what the shortest fusion block that predicts the above?

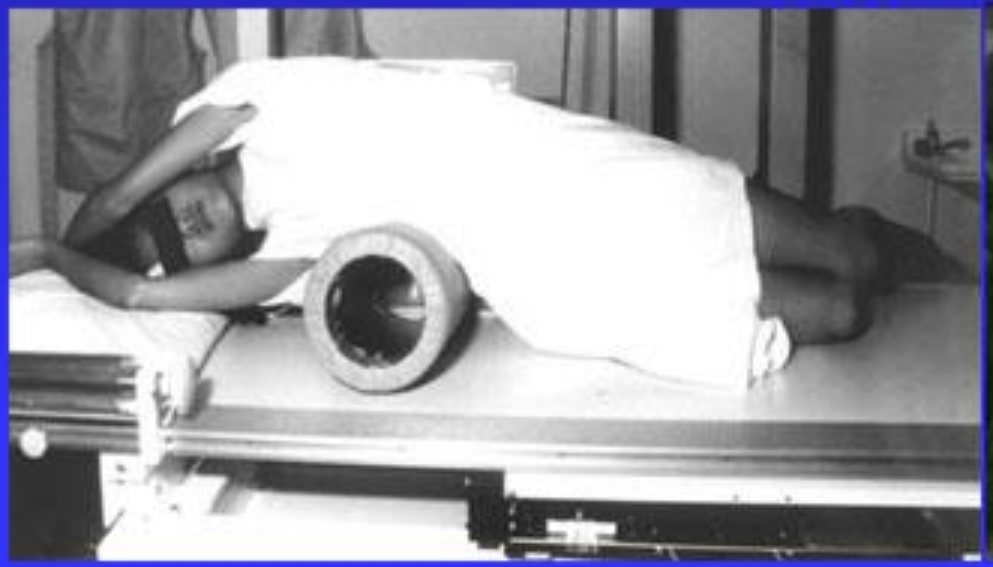


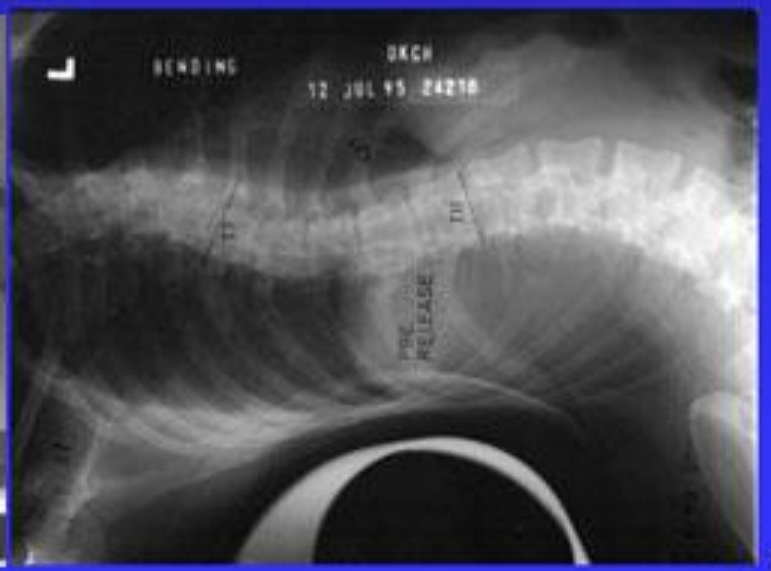
Prediction of Correction of Scoliosis with Use of the Fulcrum Bending Radiograph*

BY K. M. C. CHEUNG, F.R.C.S., F.H.K.A.M.(ORTH SURG)†, AND
K. D. K. LUK, M.CH.(ORTH), F.R.C.S.(ED), F.R.C.S.(GLAS), F.R.A.C.S., F.H.K.A.M.(ORTH SURG)†, HONG KONG

Investigation performed at The Duchess of Kent Children's Hospital, Hong Kong

JBJS-A 79 (8), August 1997





Comparison of Supine Bending vs. Fulcrum Bending

	Mean angle	SD
Preop standing	58	9
Supine bending	31	10
Fulcrum bending	24	9
Postop standing	25	9


65°
T11
Standing AP
T4
42°
T11
C Y K
SUPINE
LATERAL BENDING
Supine bending
30°
T11
C Y K
Fulcrum Bending
27°
Postop

Conclusions

- The fulcrum bending radiograph is a reproducible method of determining spinal flexibility.
- Predicted well the correction obtained with the segmental spinal instrumentation used.

SPINE Volume 26, Number 5, pp E74–E79

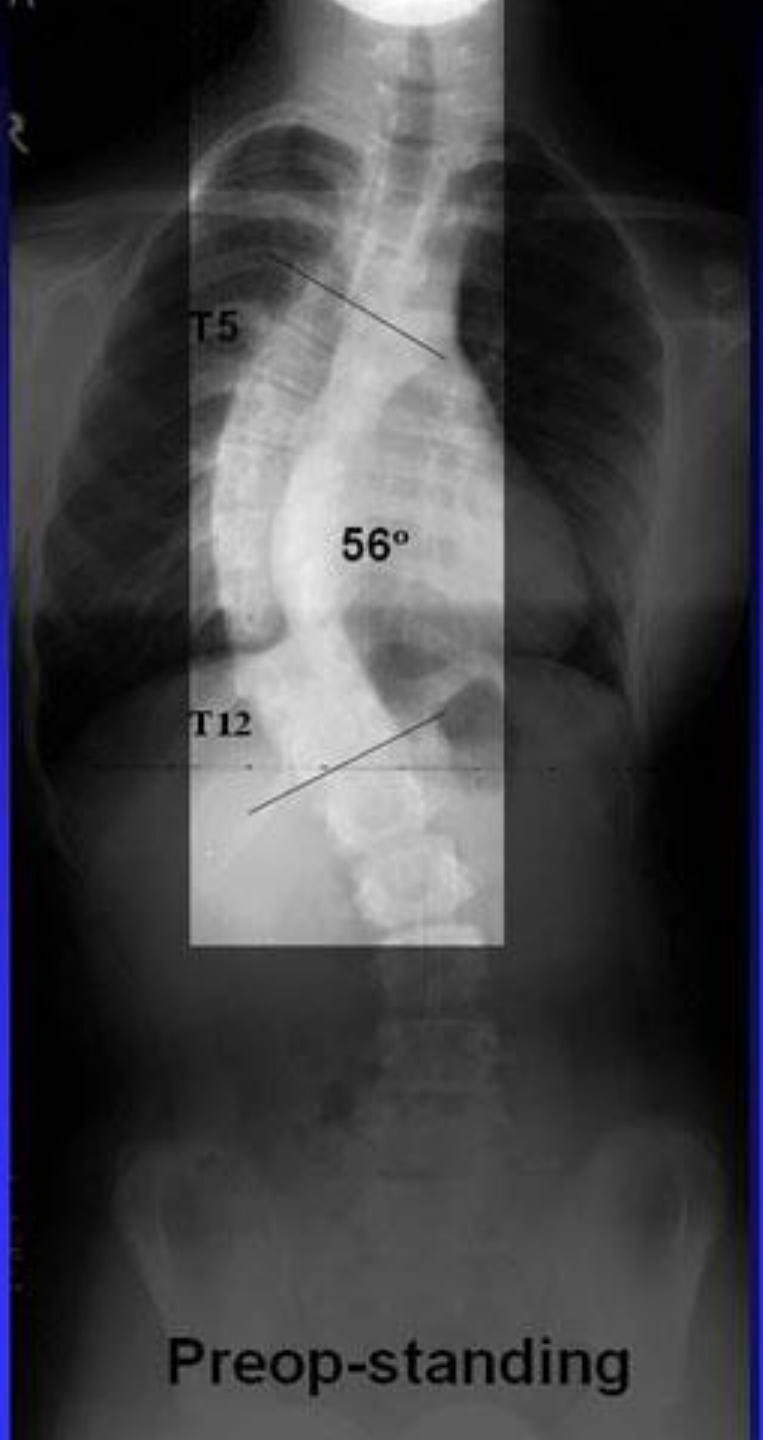
Prospective Comparison of Flexibility Radiographs in Adolescent Idiopathic Scoliosis

Steven J. Klepps, MD,* Lawrence G. Lenke, MD,* Keith H. Bridwell, MD,*
George S. Bassett, MD,† and J. Whorton, RN‡

Conclusion. To achieve maximal preoperative correction, thoracic fulcrum-bending radiographs should be obtained for evaluating main thoracic curves, whereas side-bending radiographs should continue to be used for evaluating both upper thoracic and thoracolumbar/lumbar curves. [Key words: scoliosis, spinal fusion, radio-

Selection of fusion levels

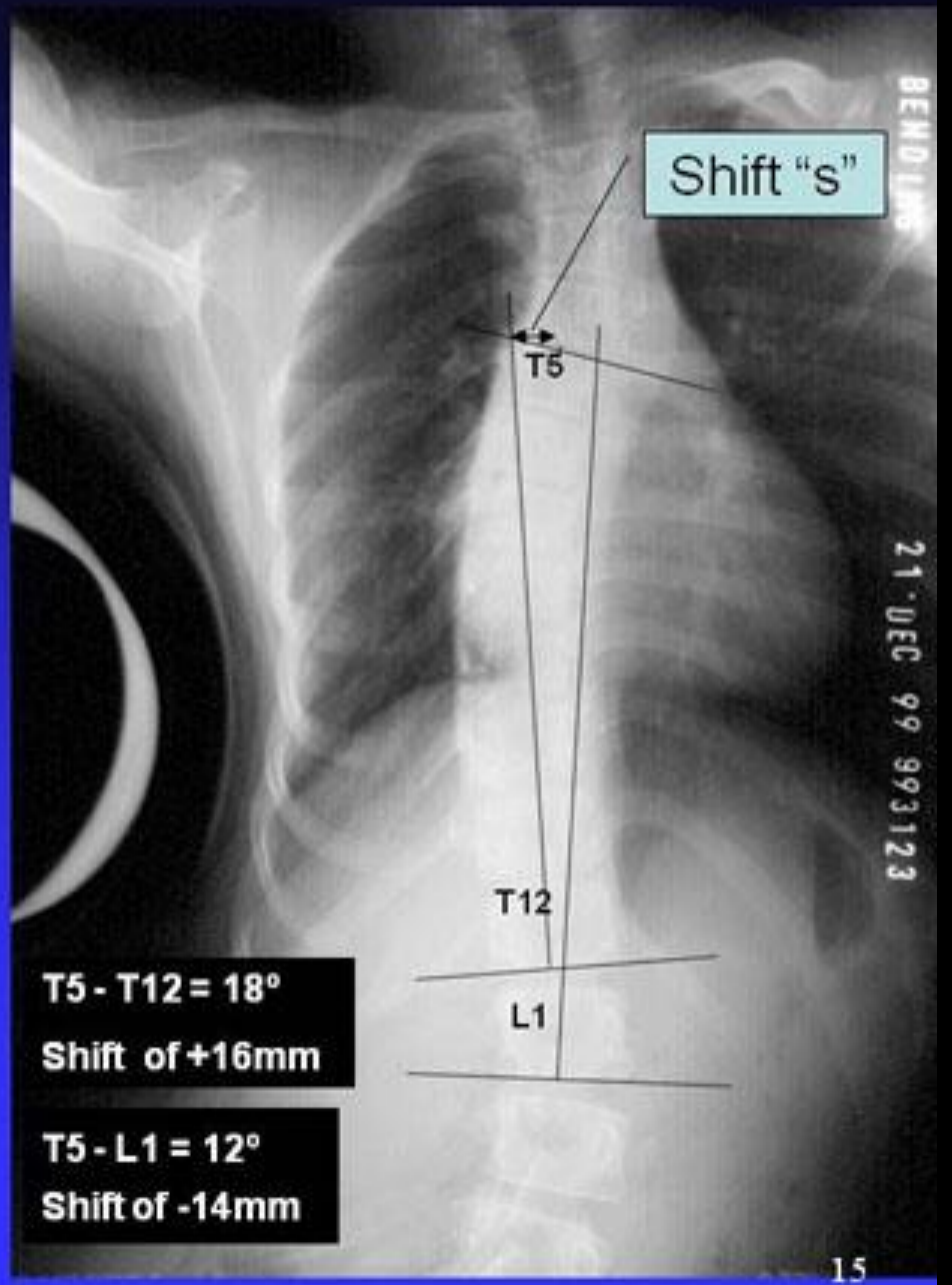
- Preoperative fulcrum bending can predict postoperative correction
- Preoperative prediction of the shortest fusion block that would allow the spine to be "balanced"
  - cranial and caudal vertebra to be near parallel and with minimal shift



Preop-standing

Preop Ful Bend

- **Acceptable balance =** *predicted* **fusion block**
  - **angle < 20°**
  - **shift of < 20mm**
- **Principles**
  - **Select the shortest fusion that can achieve this**
  - **Sacrifice thoracic for lumbar segments**
  - **Avoid stopping at junctional kyphosis**
  - **No shorter than end to end vertebra**



Prospective study on fusion level selection

- Outcome
  - Curve correction
  - Balance
  - Behavior of unfused segments
- Compare the difference in lower fusion level using the stable zone concept.

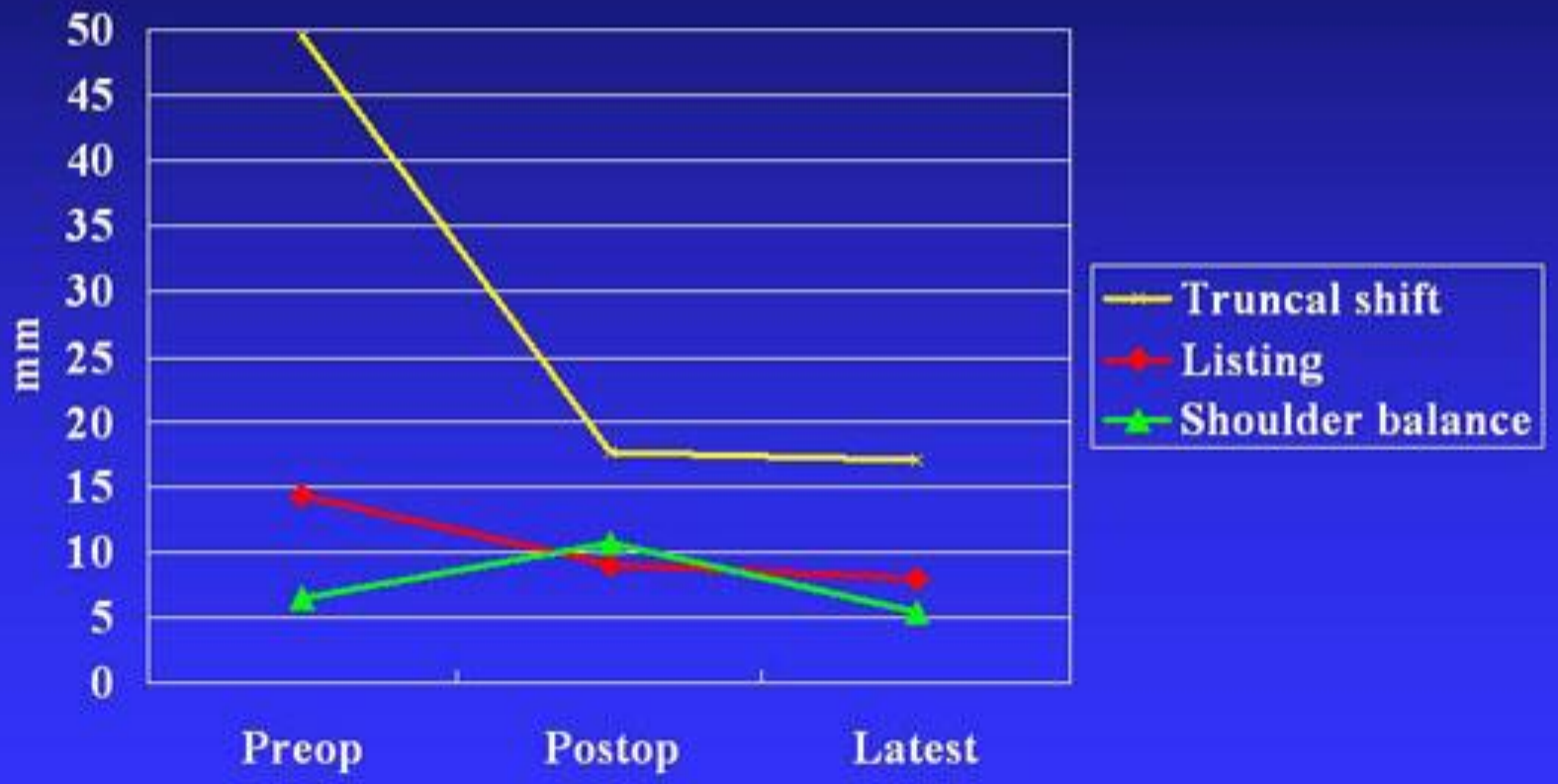
Results

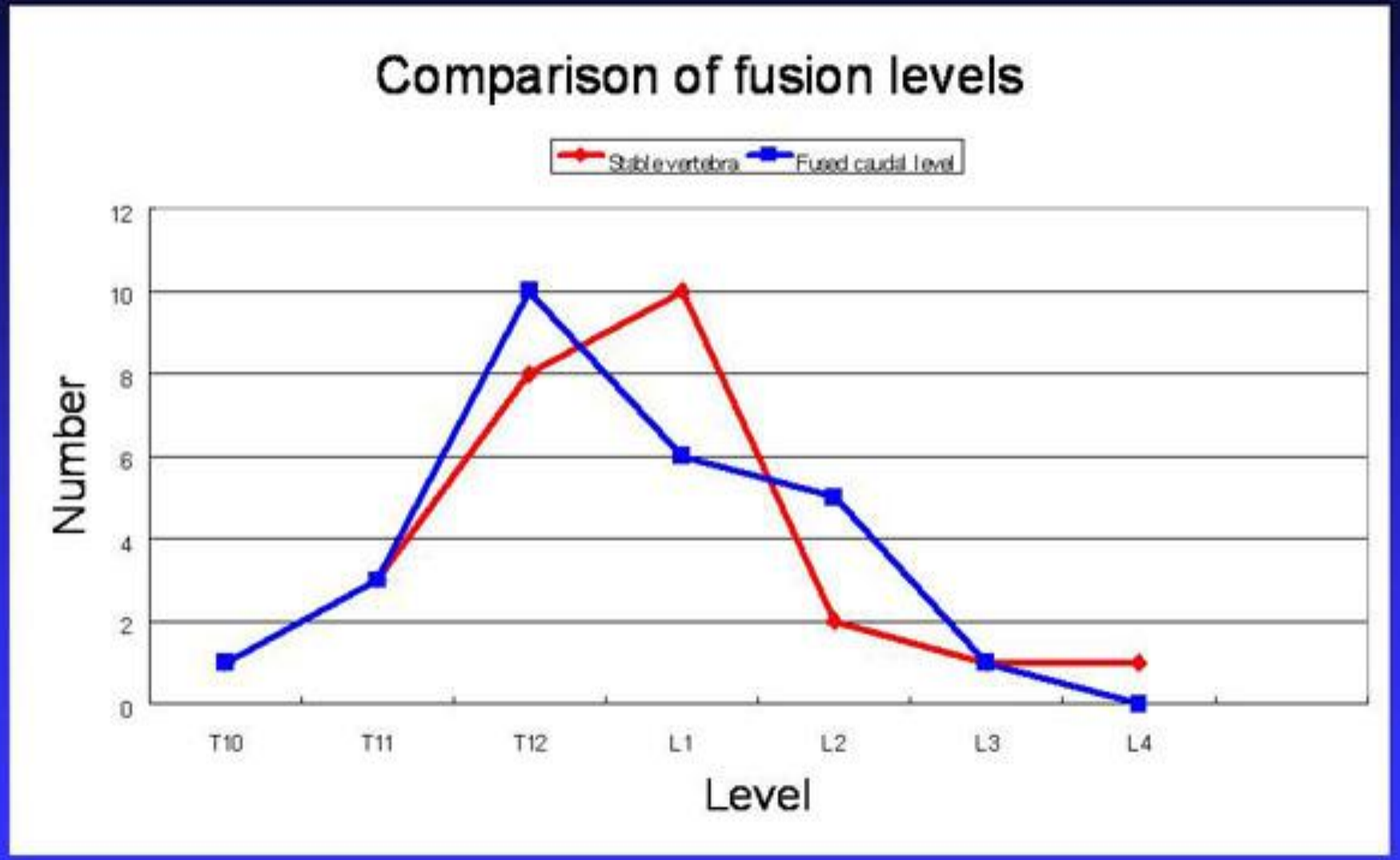
- 44 patients recruited
- 26 followed to maturity
  - 23 female, 3 male
  - Mean age at surgery 14.8 yrs (11 to 26)
  - Mean FU 25.6 months (12.7 to 46.8)

Correction was well predicted by fulcrum bending XR

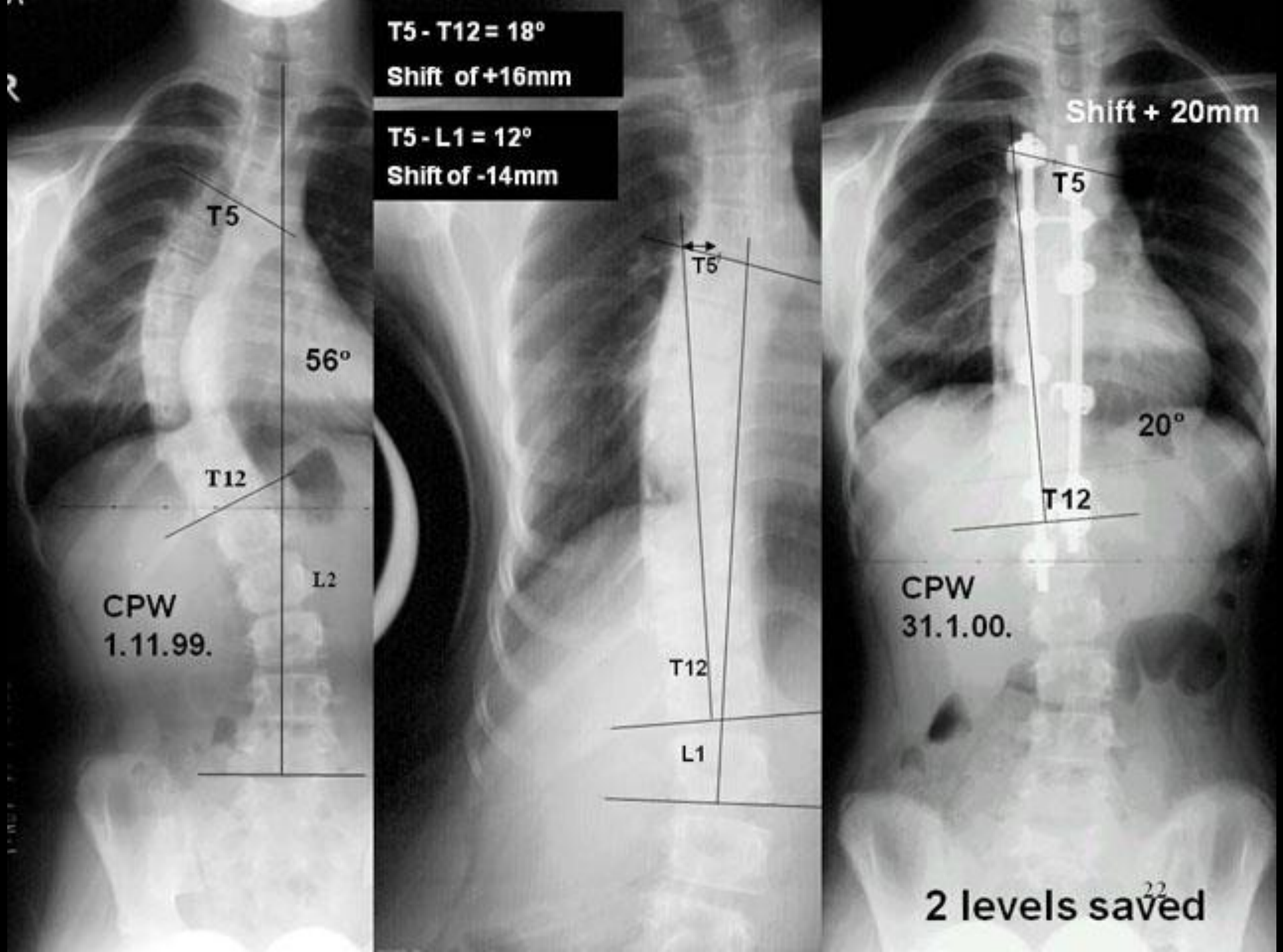
	Primary curve	Fusion block
Preop	57° (44-82)	------
Fulcrum bend	20° (0-36)	13.4° (0-20)
Postop	21° (6-37)	18.2° (2-31)
Latest follow-up	25° (7-44)	23.1° (7-39)

Balance is significantly improved after surgery and is maintained at the latest follow up




Comparison of fusion levels
Stable vertebra
Fused caudal level
Number
12
10
8
6
4
2
0
T10
T11
T12
L1
L2
L3
L4
Level

- Number of caudal levels short of stable vertebra?
  - 0 in 9 patients
  - 1 level in 11 patients
  - 2 levels in 4 patients
  - 3 levels in 2 patients
- Mean 0.96 levels shorter


T5 - T12 = 18°
Shift of +16mm
T5 - L1 = 12°
Shift of -14mm
T5
56°
T12
L2
CPW
1.11.99.
T5
T12
L1
Shift + 20mm
T5
20°
T12
CPW
31.1.00.
2 levels saved

Case 15

T5–T11 = 46°
Stable vert L1

FB
T5-T11 = 19° / 28mm
T5-T12 = 15° / 16mm

Postop
T5-T12 = 17°
1 level saved

Case 10

T2-T11 = 46°
Stable vert L2
Listing 30mm
Truncal shift 93mm

FB
T2-T11=10° / 2mm

Immed postop
T2-T11=7°/10mm
3 levels saved
Truncal shift 19mm

30m postop
Listing 11mm
Truncal shift 5mm

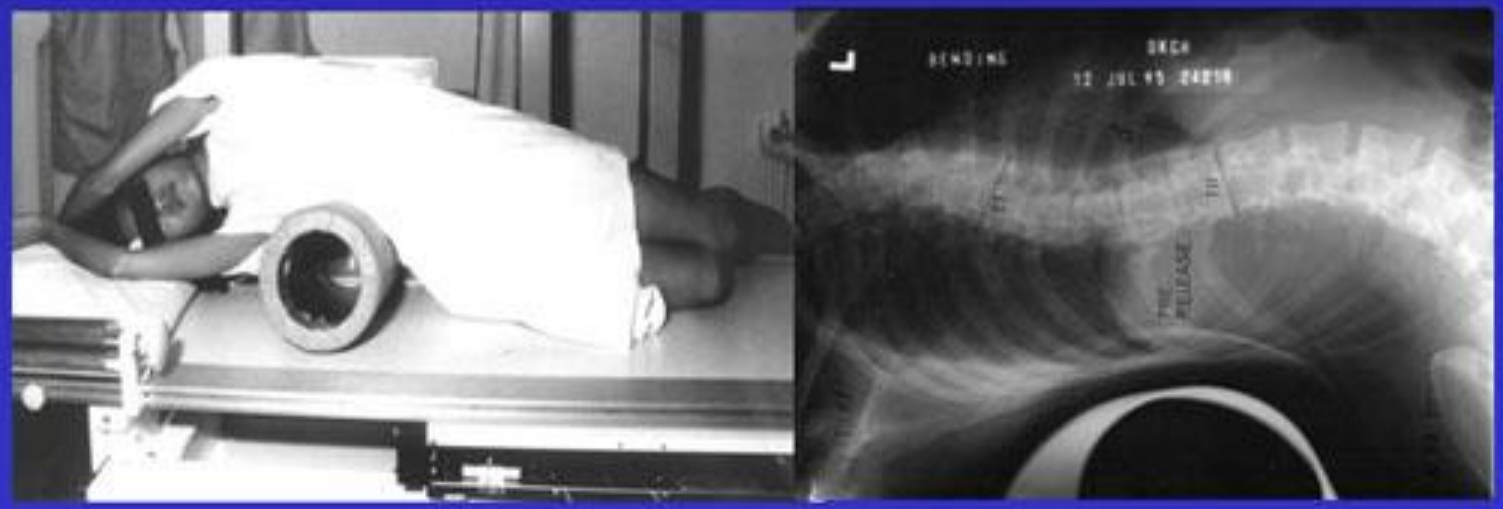
3 levels saved

SPINE Volume 33, Number 20, pp 2192–2198

Selection of Fusion Levels in Adolescent Idiopathic Scoliosis Using Fulcrum Bending Prediction

A Prospective Study

Keith D. K. Luk, MChOrth, FRCS, FHKAM, FHKCOS, Angus S. Don, FRACS, Chee S. Chong, MBBS, MS(Orth), Yat W. Wong, FRCS, FHKAM, FHKCOS, and Kenneth M. Cheung, FRCS, FHKAM, FHKCOS



Discussion

- Key is curve flexibility
  - Why you can fuse shorter anteriorly
- Curves have different flexibilities / correctability
  - Big curves are not necessarily stiff and vice versa
- Stable zone principle addresses
  - Curve magnitude
  - Truncal compensation
  - But not flexibility

Fusion level determination using the fulcrum bending XR

- Fulcrum bending can predict curve flexibility
- Reproducible
- Principle of fusion level selection easily taught
- Does not compromise outcomes
- Fusions can be shorter in:
  - More flexible curves
  - No significant preop truncal decompensation

Instrumentation strategy in scoliosis correction

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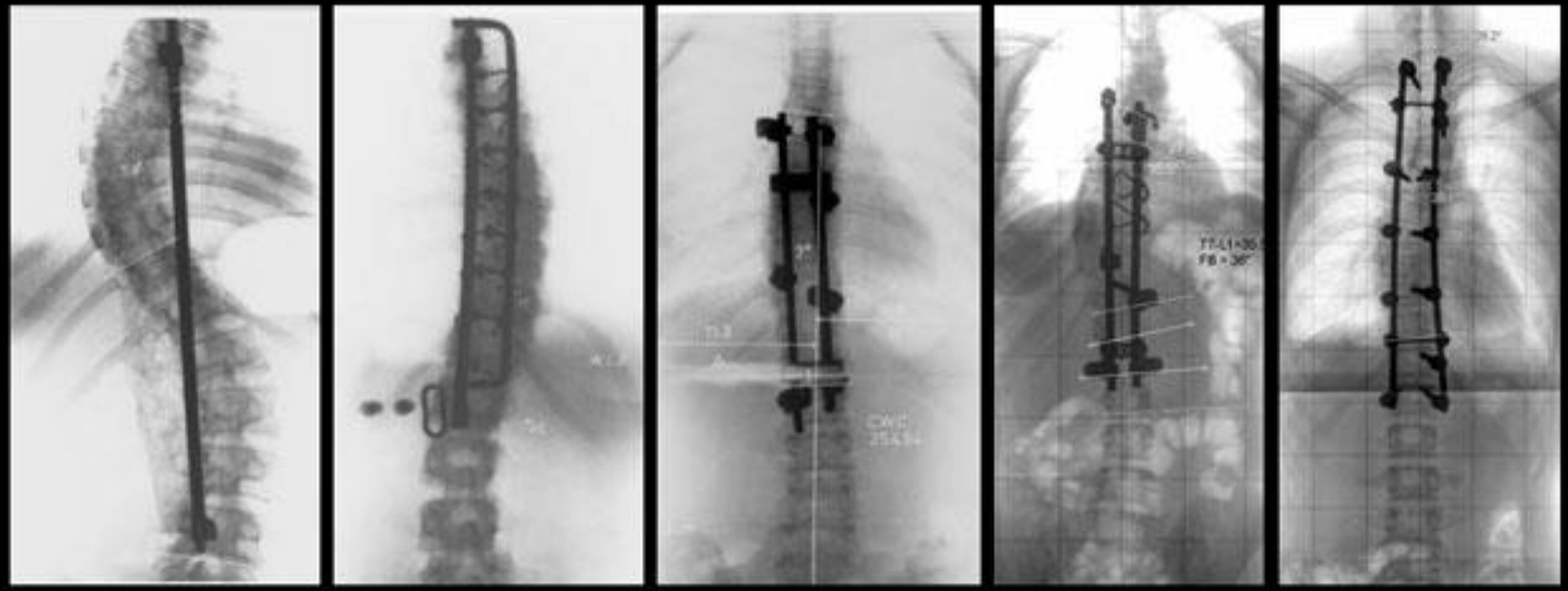
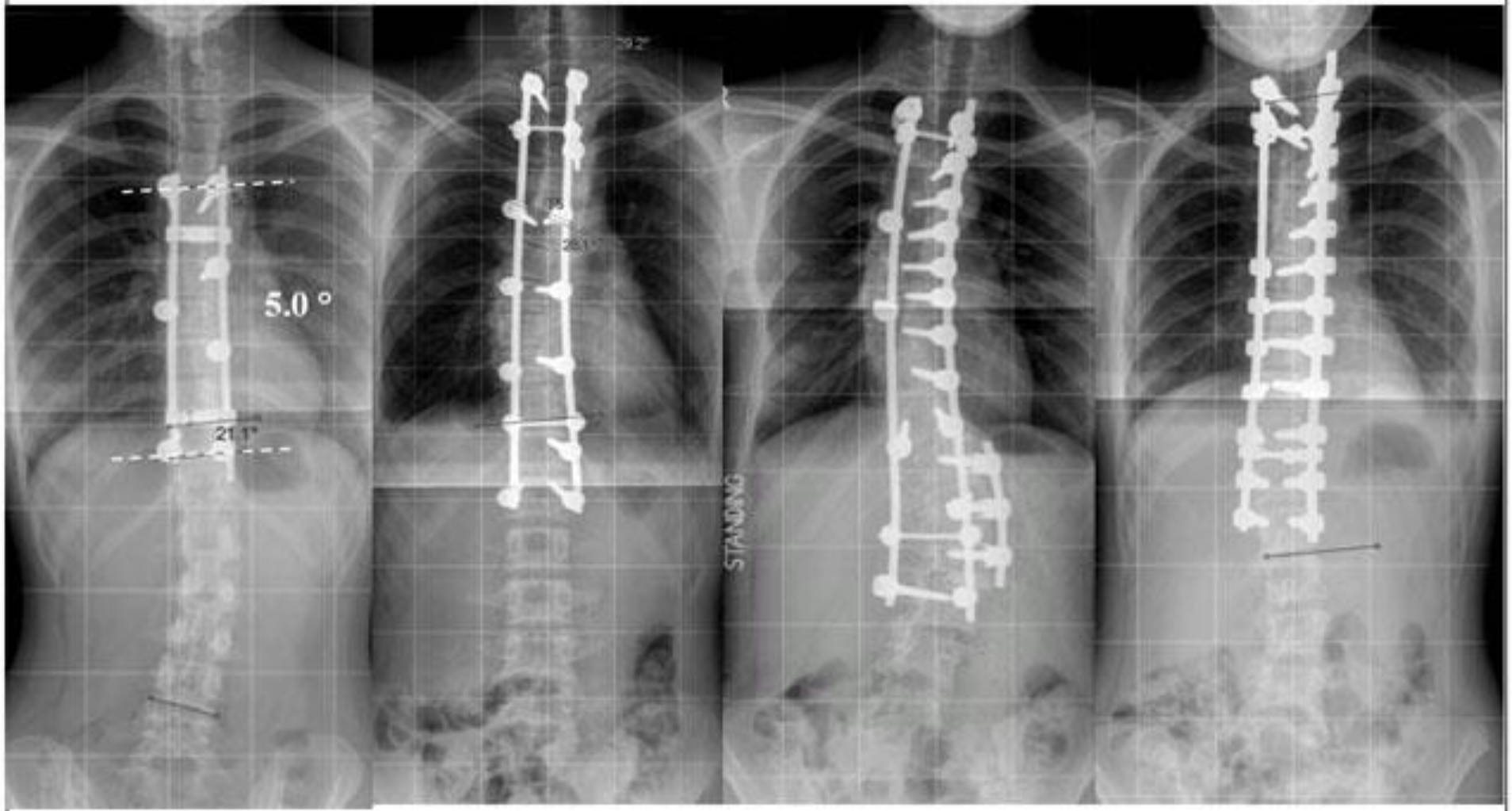
Clinical Professor
Division of Spine Surgery
The University of Hong Kong



Pedicle screws – how many are needed?



Reprinted from SPINE, Vol. 23, No. 21, November 1, 1998

Printed in the U.S.A.

Assessment of Scoliosis Correction in Relation to Flexibility Using the Fulcrum Bending Correction Index (FBCI)

Keith D. K. Luk, MCh (Orth), FRCSE, FRCSG, FRACS, FHKAM (ORTH),
Kenneth M. C. Cheung, FRCS, FHKAM (ORTH), D. S. Lu, MD, PhD,
and John C. Y. Leong, OBE, FRCS, FRCSE, FRACS, FHKAM (ORTH), JP

"Correction rate" (%)

$$= \frac{\text{Preop Cobb angle} - \text{postop Cobb angle}}{\text{Preop Cobb angle}} \times 100$$

Actual correction

Fulcrum flexibility (%))

$$= \frac{\text{Preop Cobb angle} - \text{FB Cobb angle}}{\text{Preop Cobb angle}} \times 100$$

Predicted correction

FBCI (%) = correction rate/fulcrum flexibility

Correction rate expressed as a function of flexibility

SPINE Volume 29, Number 5, pp 560–563

A Prospective Comparison of the Coronal Deformity Correction in Thoracic Scoliosis Using Four Different Instrumentations and the Fulcrum-Bending Radiograph

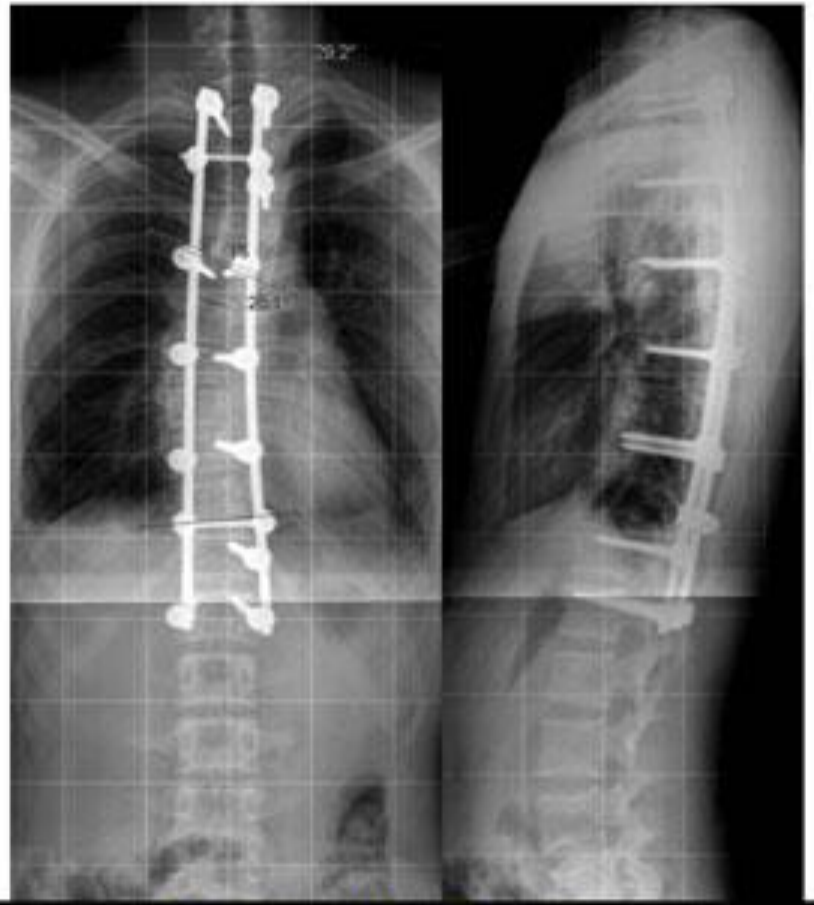
K. D. K. Luk, FRCS, FHKAM (Orth), D. S. Lu, MD, PhD, K. M. C. Cheung, FRCS, FHKAM (Orth), and Y. W. Wong, FRCS, FHKAM (Orth)

- Consecutive series of 127 patients treated by
  - CD-Horizon
  - Moss-Miami
  - TSRH
  - ISOLA
- When curve flexibility is taken into account, their ability to correct thoracic scoliosis is the same.

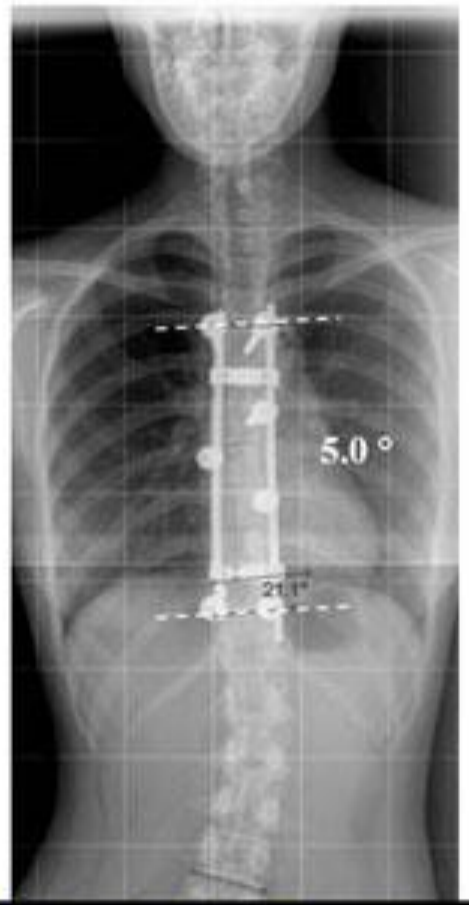
A comparison of 3 pedicle screw strategies taking into account curve flexibility

Fulcrum bending correction index (FBCI)

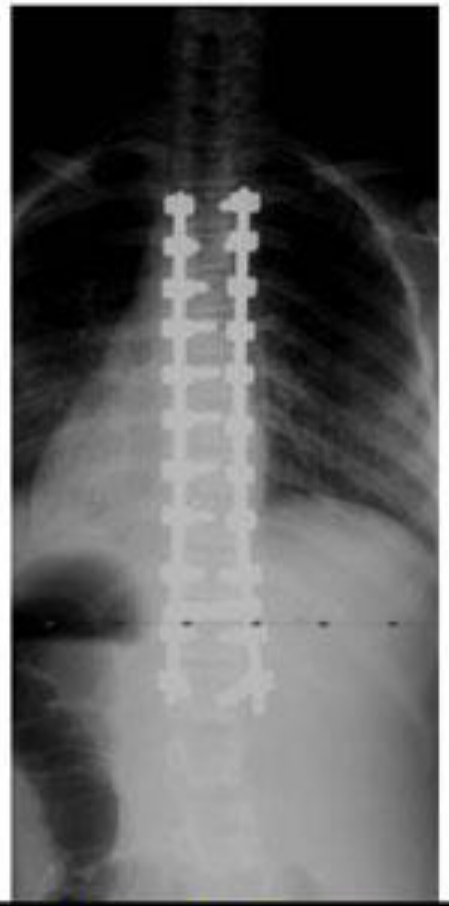
Pedicle screw strategies



Alternate level screws
Titanium



Key vertebral screws
Titanium



Every level screws
Stainless steel

Cheung, Lenke et al.

Methodology

- Consecutive series of AIS with thoracic curves requiring surgery
  - Alternate level pedicle screw strategy
  - Key vertebral screw strategy
  - Every level screw strategy

  (provided by Cheung, Lenke et al.)
- Radiographs
  - Preop standing PA and lateral
  - Fulcrum bending
  - Postop standing PA and lateral 3 days after surgery and at latest follow-up

Results

Alternate levels

- 42 patients (7 males: 35 females)
- Mean age = 14.6 years
  (11 to 21 years)
- Mean no. of levels = 9.4 (6-13)
- Lenke's classification
  - Type 1 (main thoracic) = 31
  - Type 2 (double thoracic) = 4
  - Type 3 (double major) = 3
  - Type 6 (TL/lumbar) = 4

Key vertebral screw

- 17 patients
- Mean age = 15.6 years
  (10 to 26 years)
- Mean no. of levels = 8.9 (4-12)
- Lenke's classification
  - Type I curves = 9
  - Type II curves = 3
  - Type III curves = 5

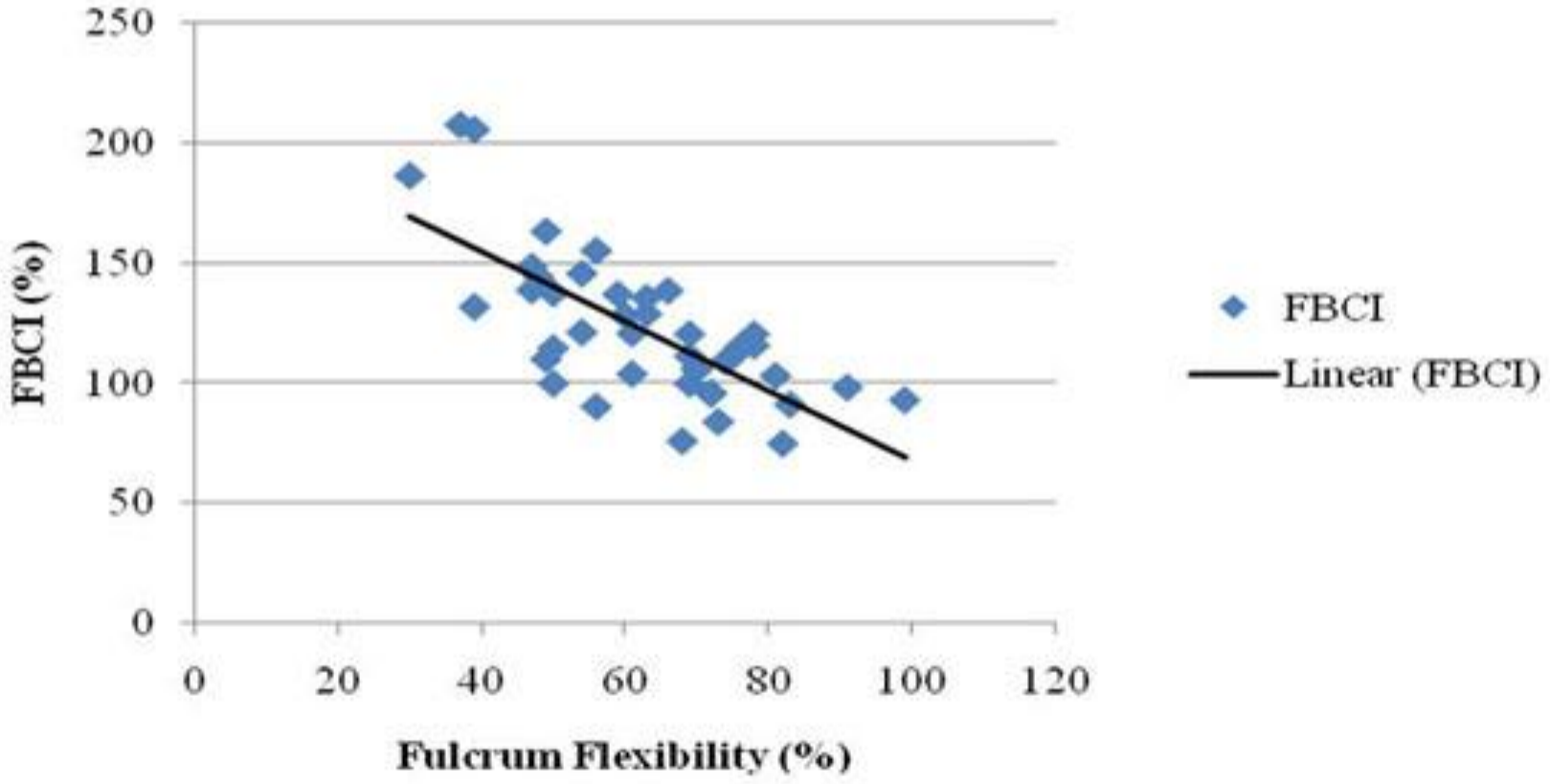
Radiographic result

	Alternate level	Key vertebral	Every level
	Mean angle (±SD)		
Preop standing PA	58°(±10)	56.6° (±5.2)	58°(±8)
Preop fulcrum bend	22°(±10)	22° (±9)	28°(±9)
Postop standing PA	15° (±7)	16° (±6.0)	15° (±6)
Fulcrum Flexibility	63% (±15)	62%(±14)	52%(±14)
Curve Correction	73% (±12)	71%(±11)	74%(±11)
FBCI	122% (±31)	119%(±33)	152% (±47)

Pedicle screws correct better than FBR suggests

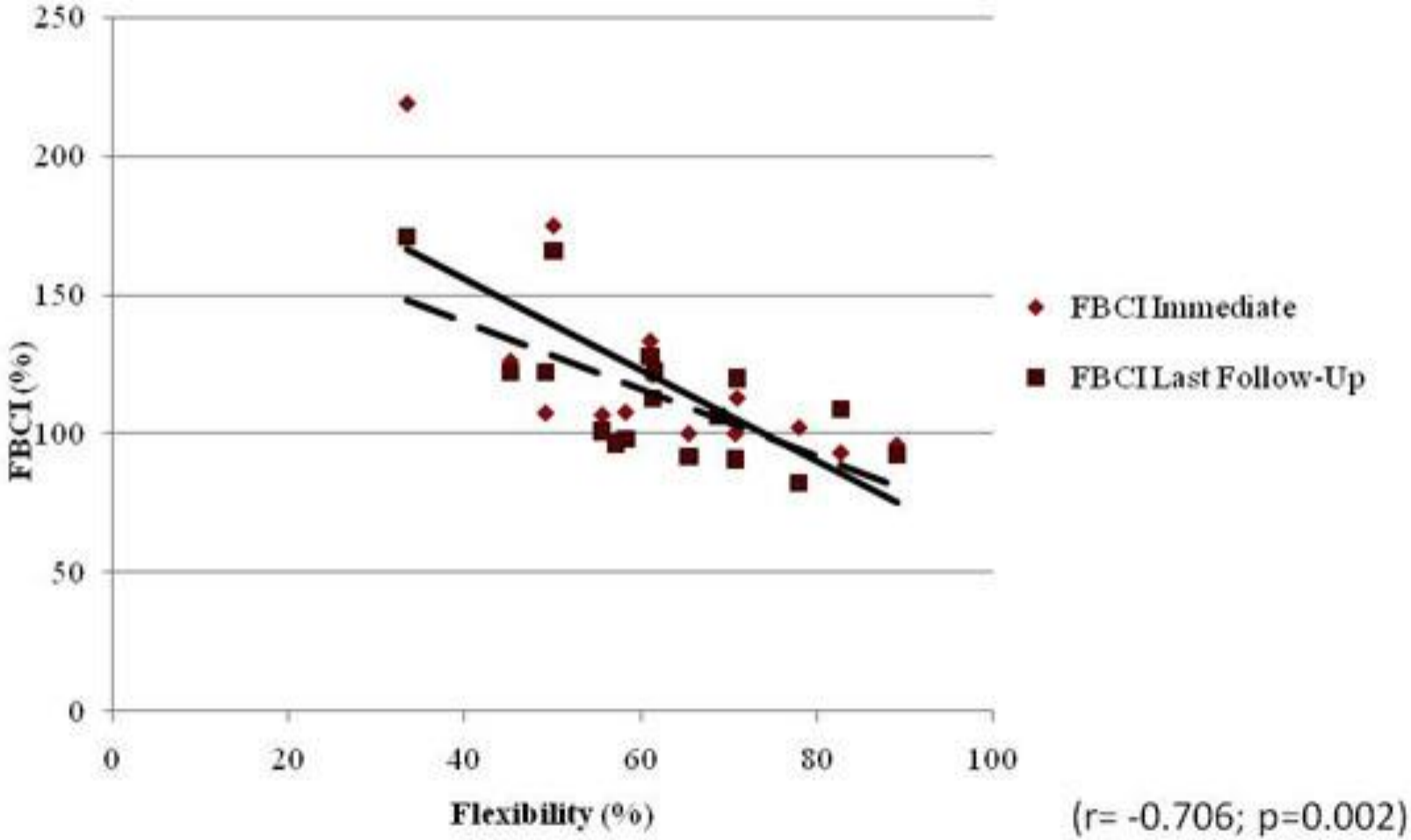
FBCI is correlated with flexibility

Alternate level screws (titanium)



FBCI is correlated with flexibility

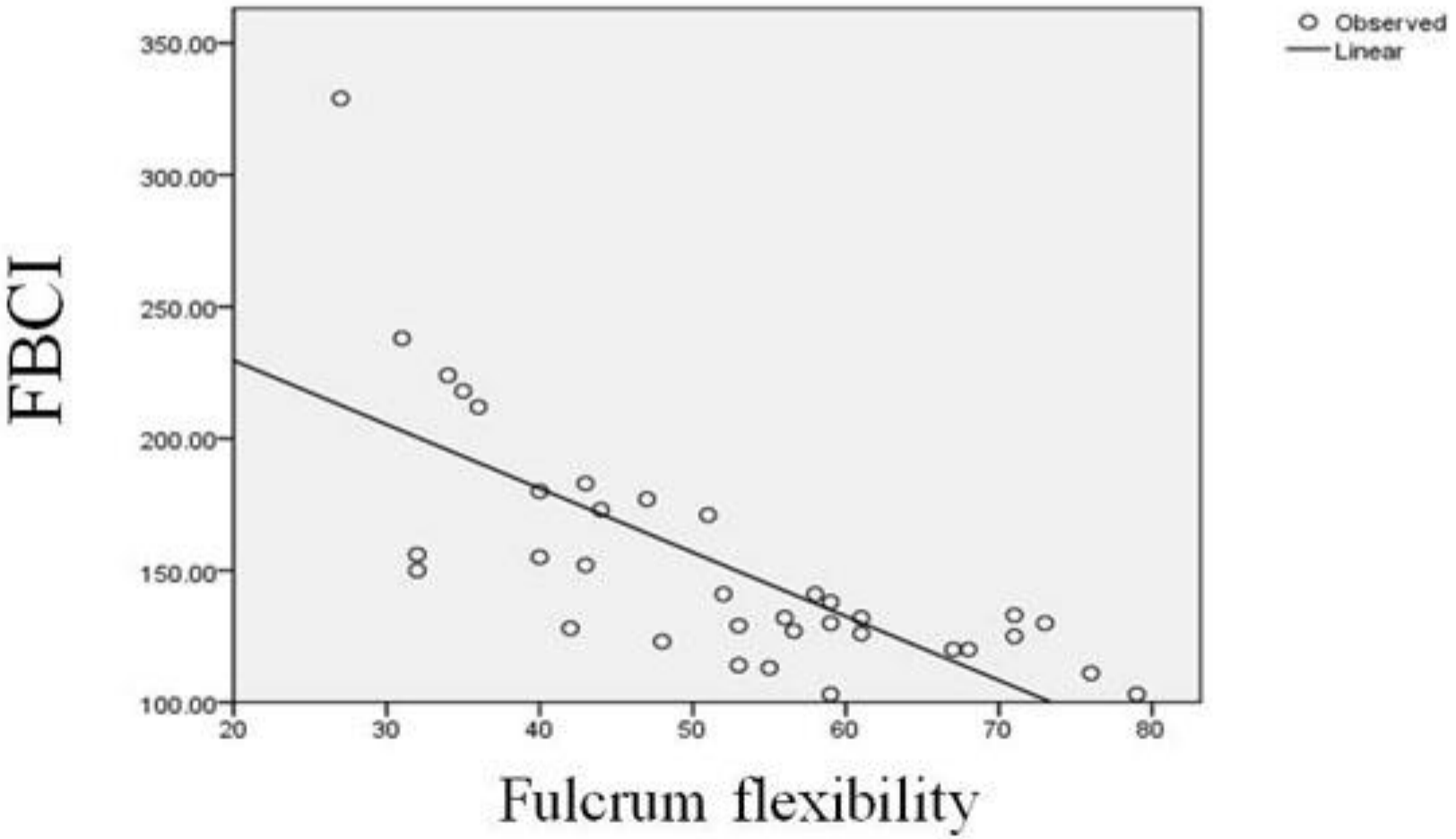
Key Vertebral Screws (titanium)



(r= -0.706; p=0.002)

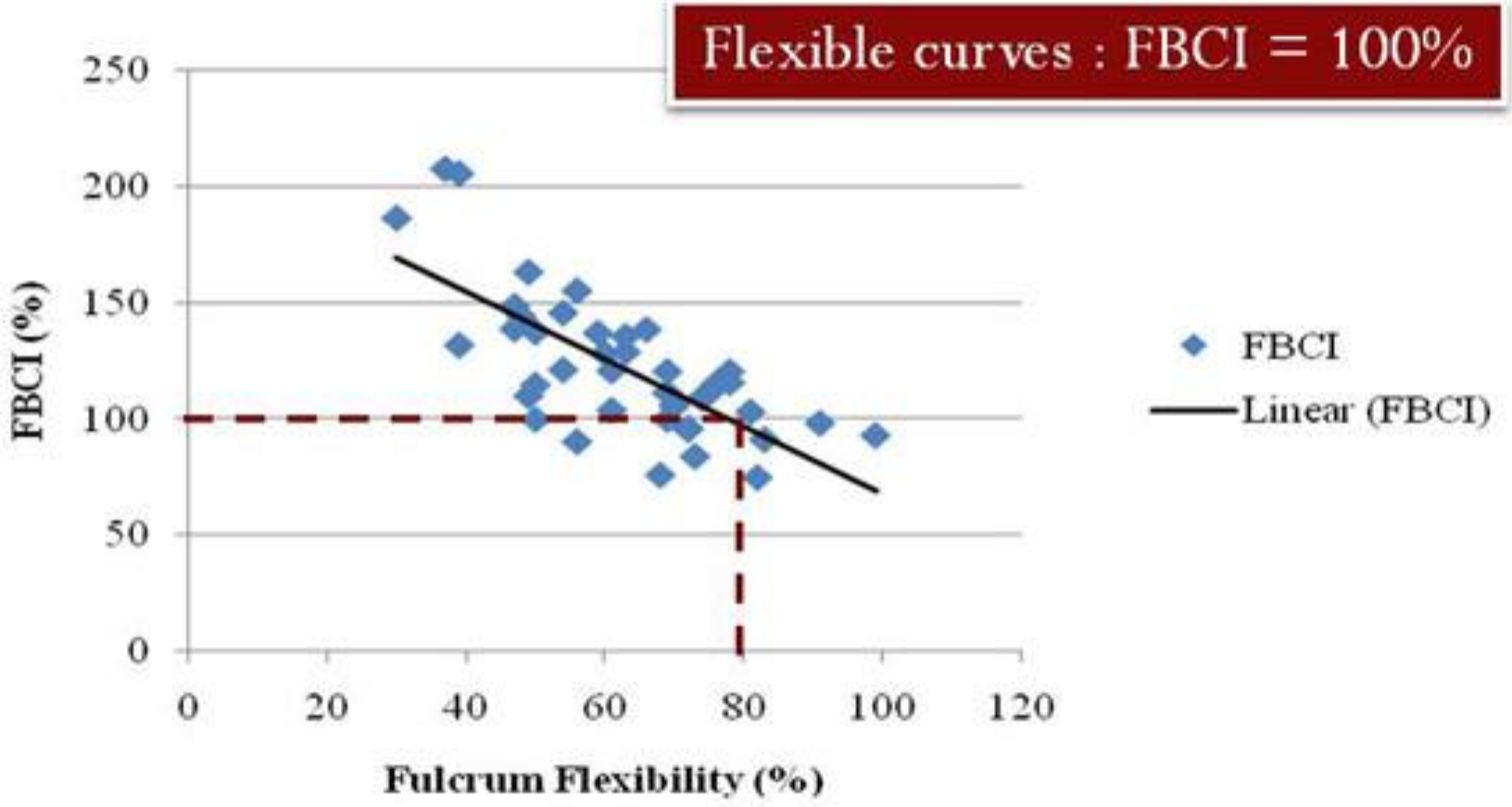
FBCI is correlated with flexibility

Every Level Screws (stainless steel)

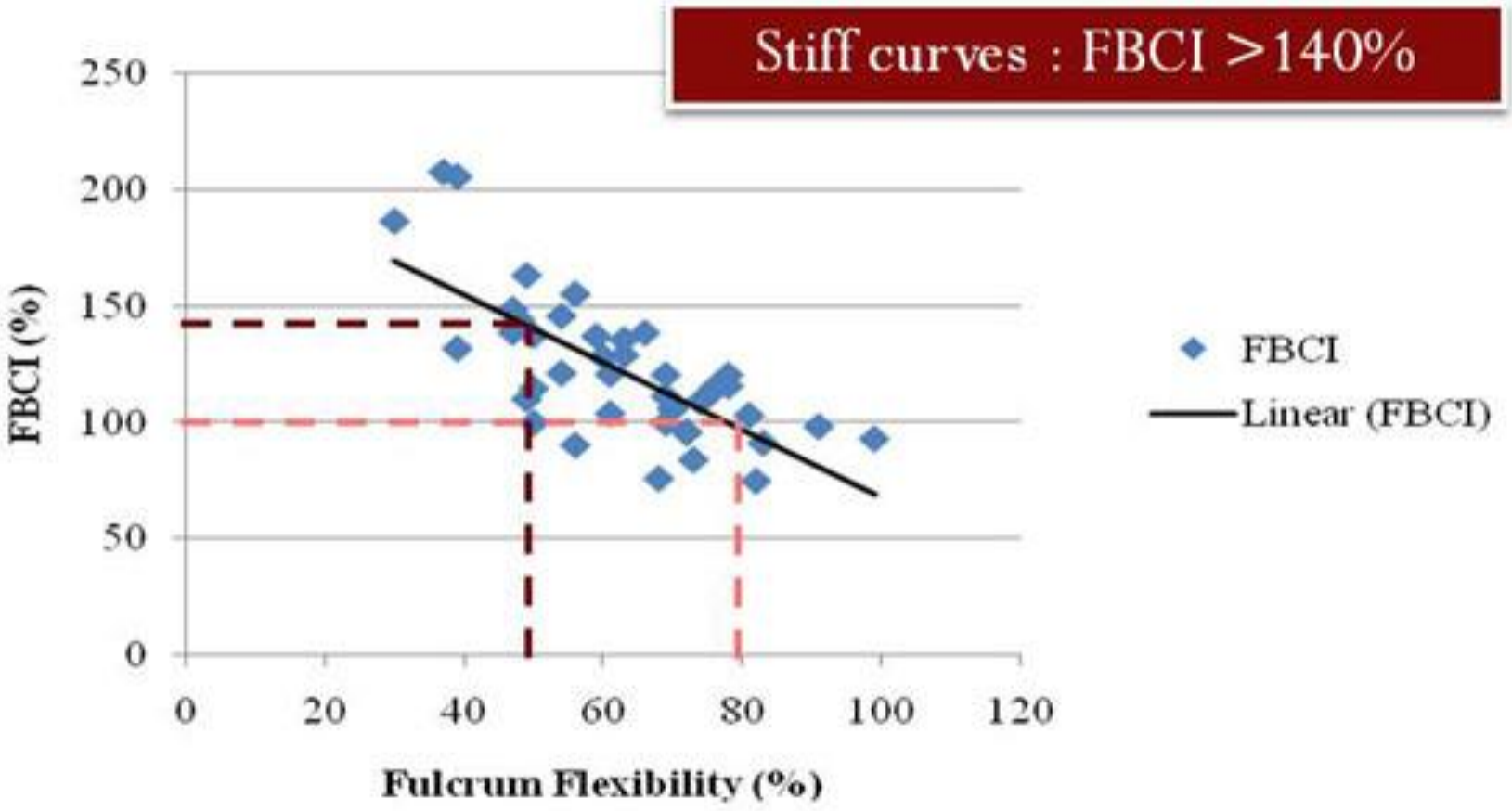


Cheung, Lenke et al.

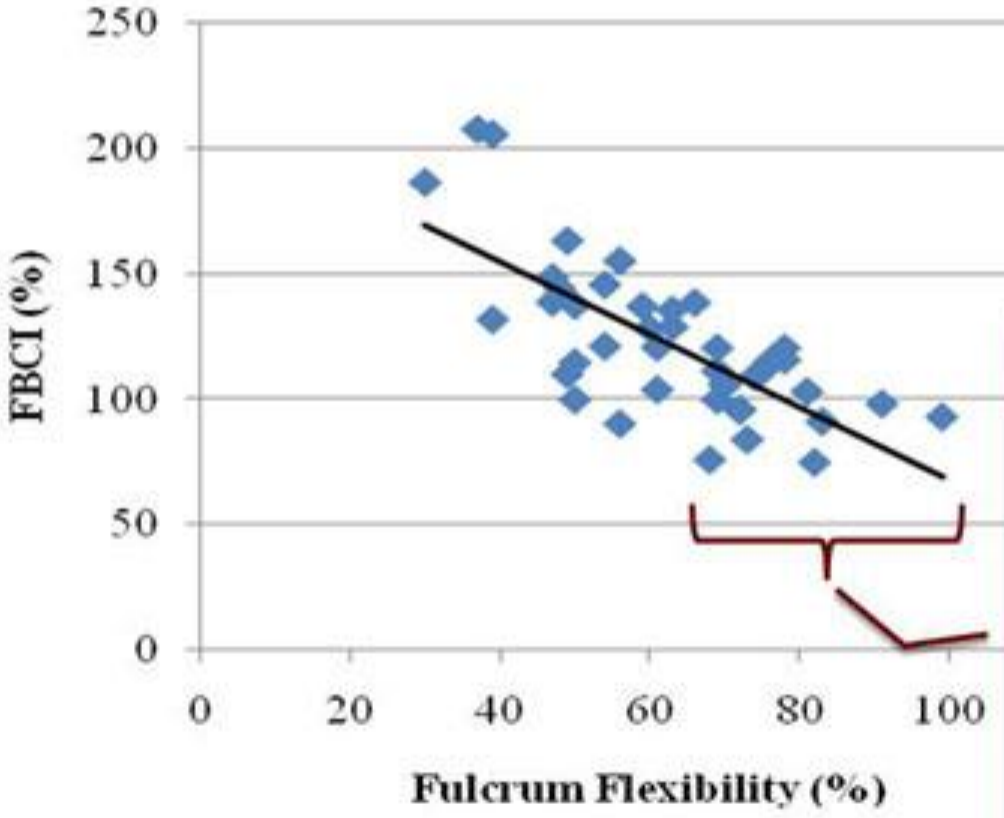
FBCI is correlated with flexibility



FBCI is correlated with flexibility



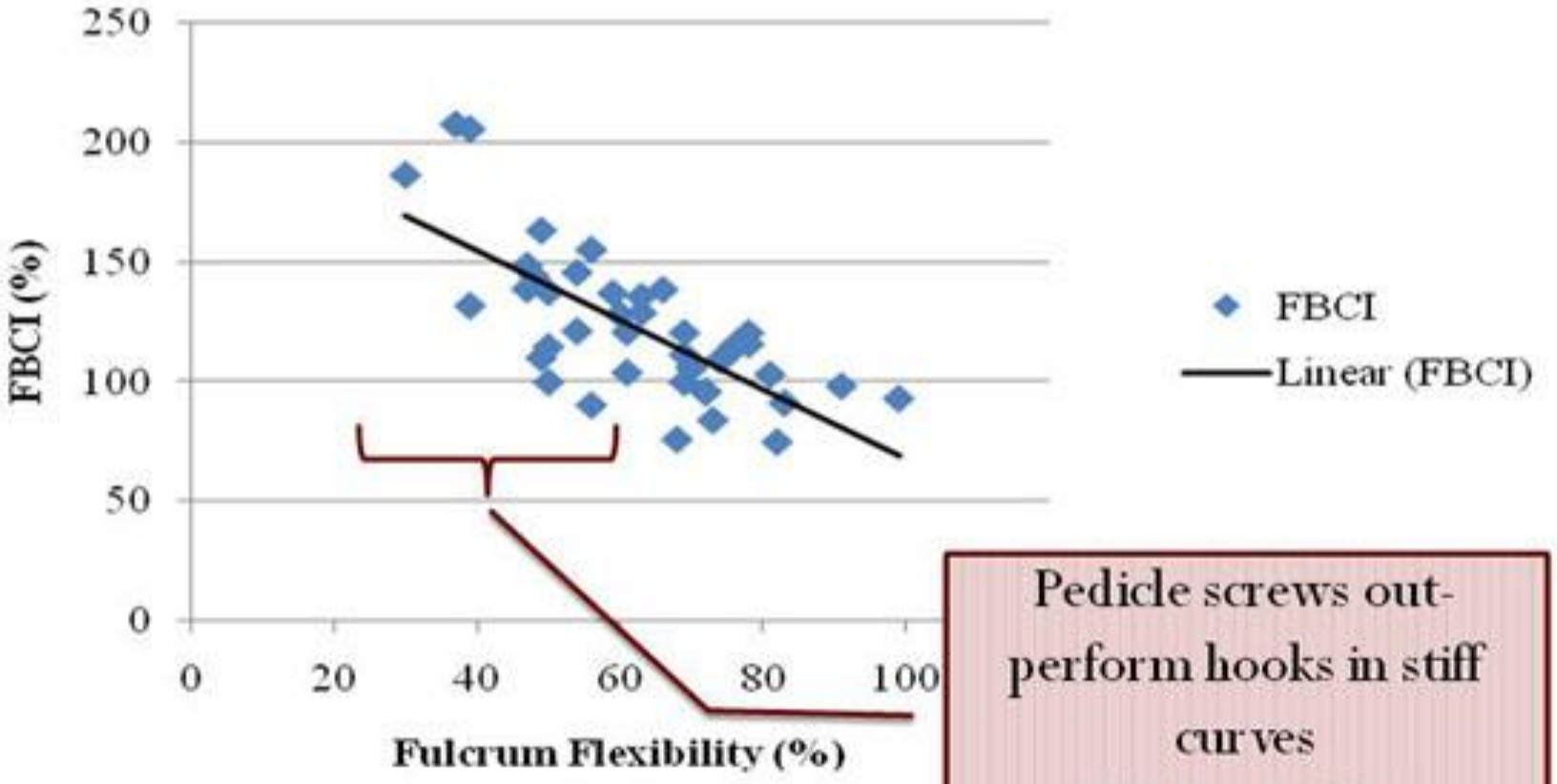
FBCI is correlated with flexibility



Pedicle screws are no better than hooks in flexible curves (FBCI = 100%)

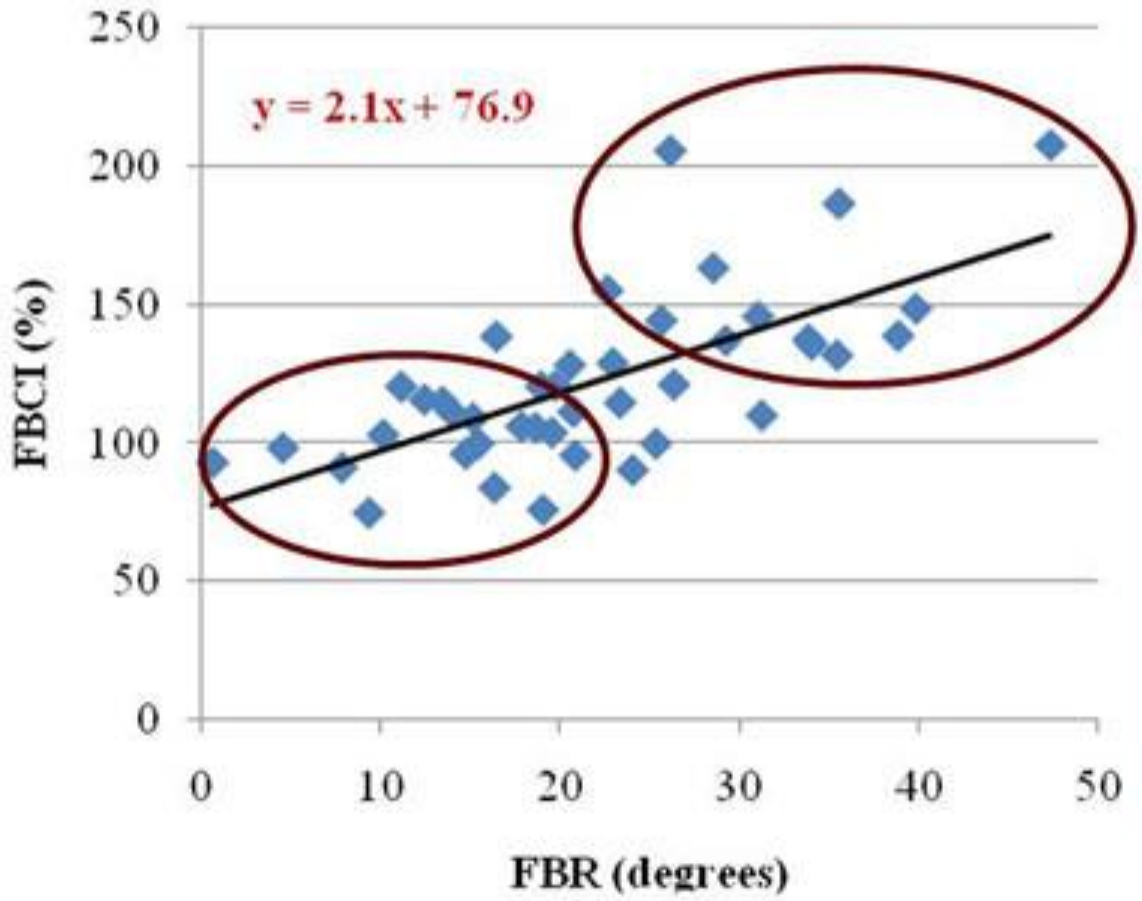
No difference between 3 screw strategies

FBCI is correlated with flexibility



Pedicle screws out-perform hooks in stiff curves
(FBCI > 100%)

Practical implications



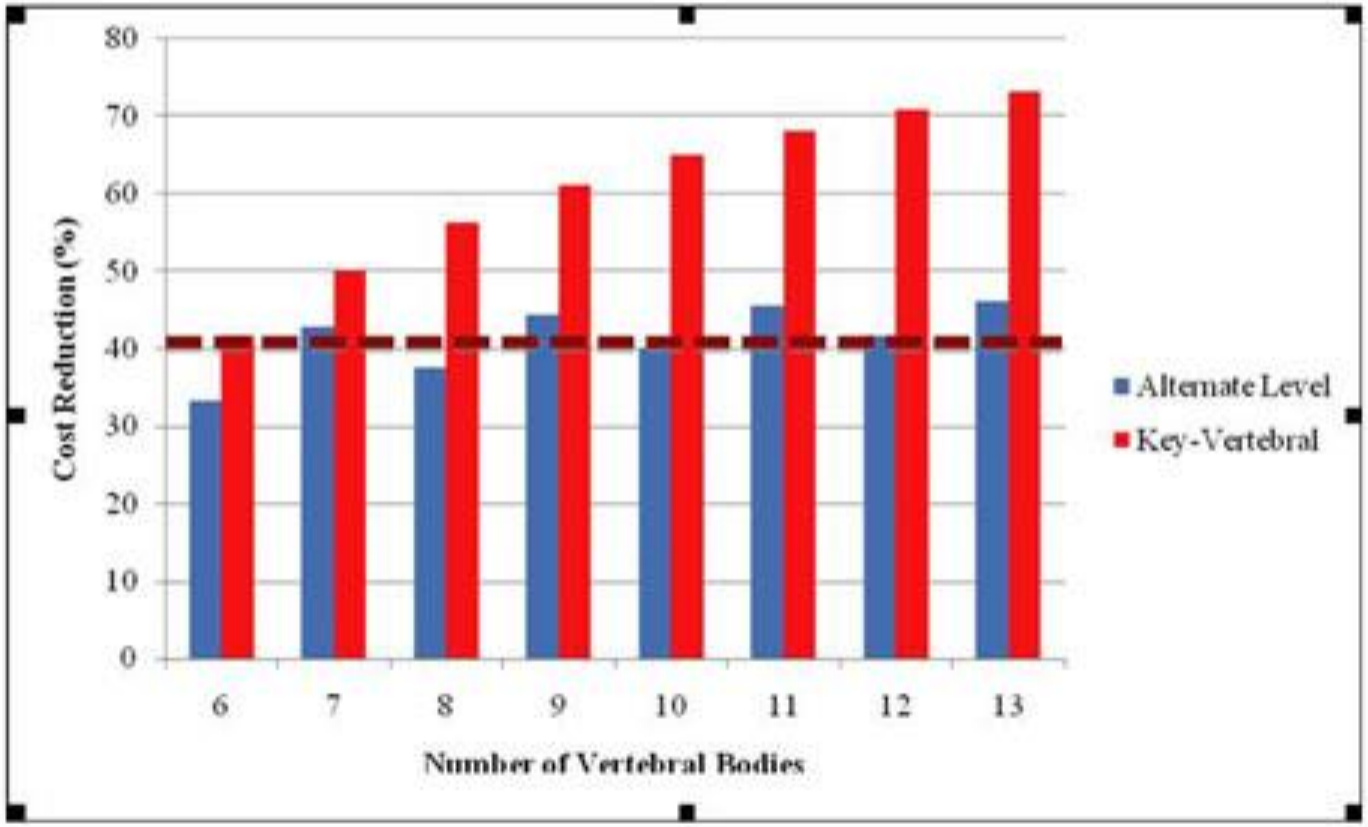
Flexible curves:
Instrumentation strategy with hooks, hybrid or screws

Stiff curves:
Pedicle screws recommended

No difference between alternate level or key vertebral screw strategies:
Mean FBCI – 170%

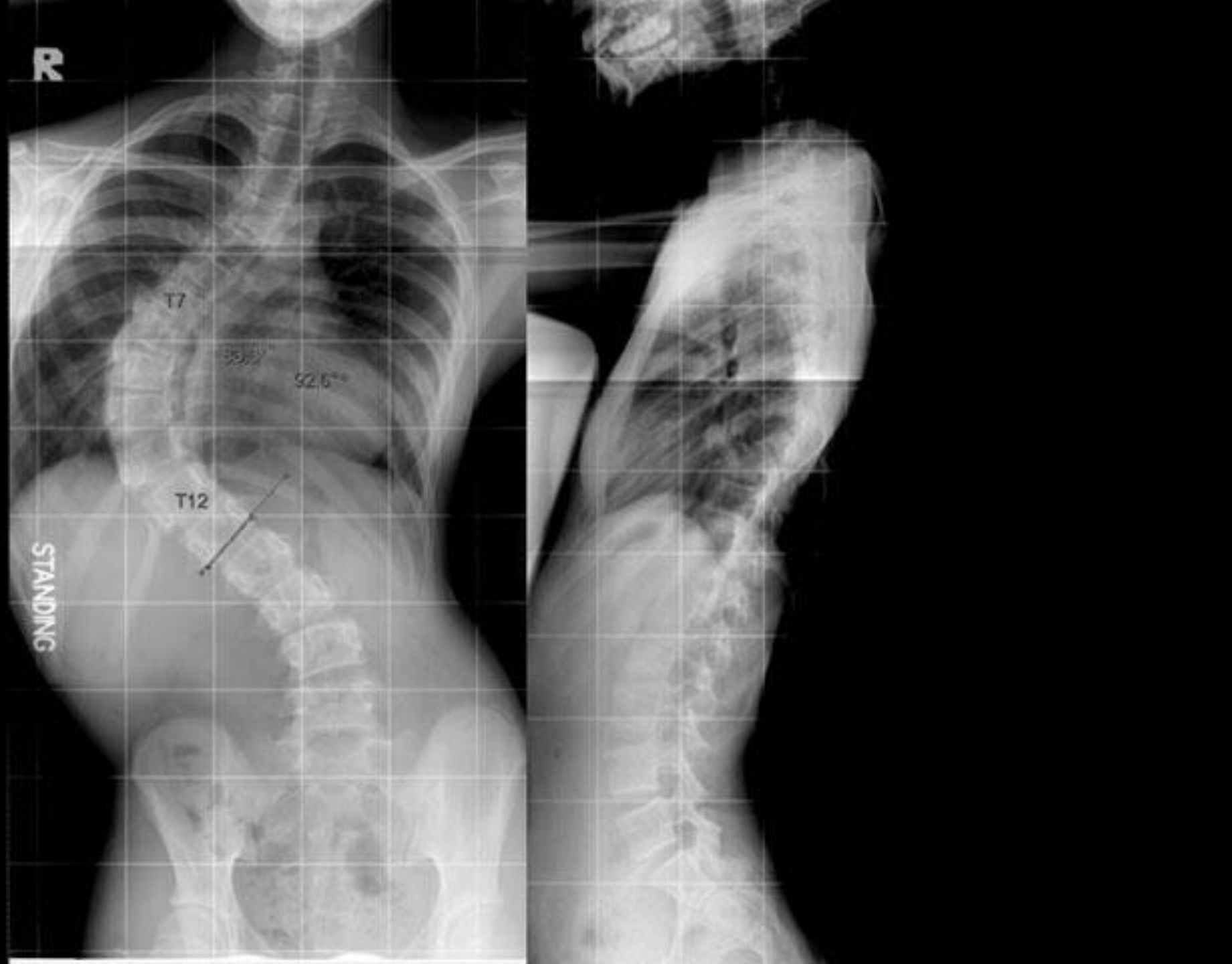
Every level screw and stainless steel implants: mean FBCI – 200%

Cost savings
alternate level and key vertebral level screws
vs every level pedicle screws



Key is Curve Flexibility

example……



T6-L1=93°

Risser = 2

Oct 2006

Fulcrum bending XR

T6 to L1=34°

T6 to L2=28°

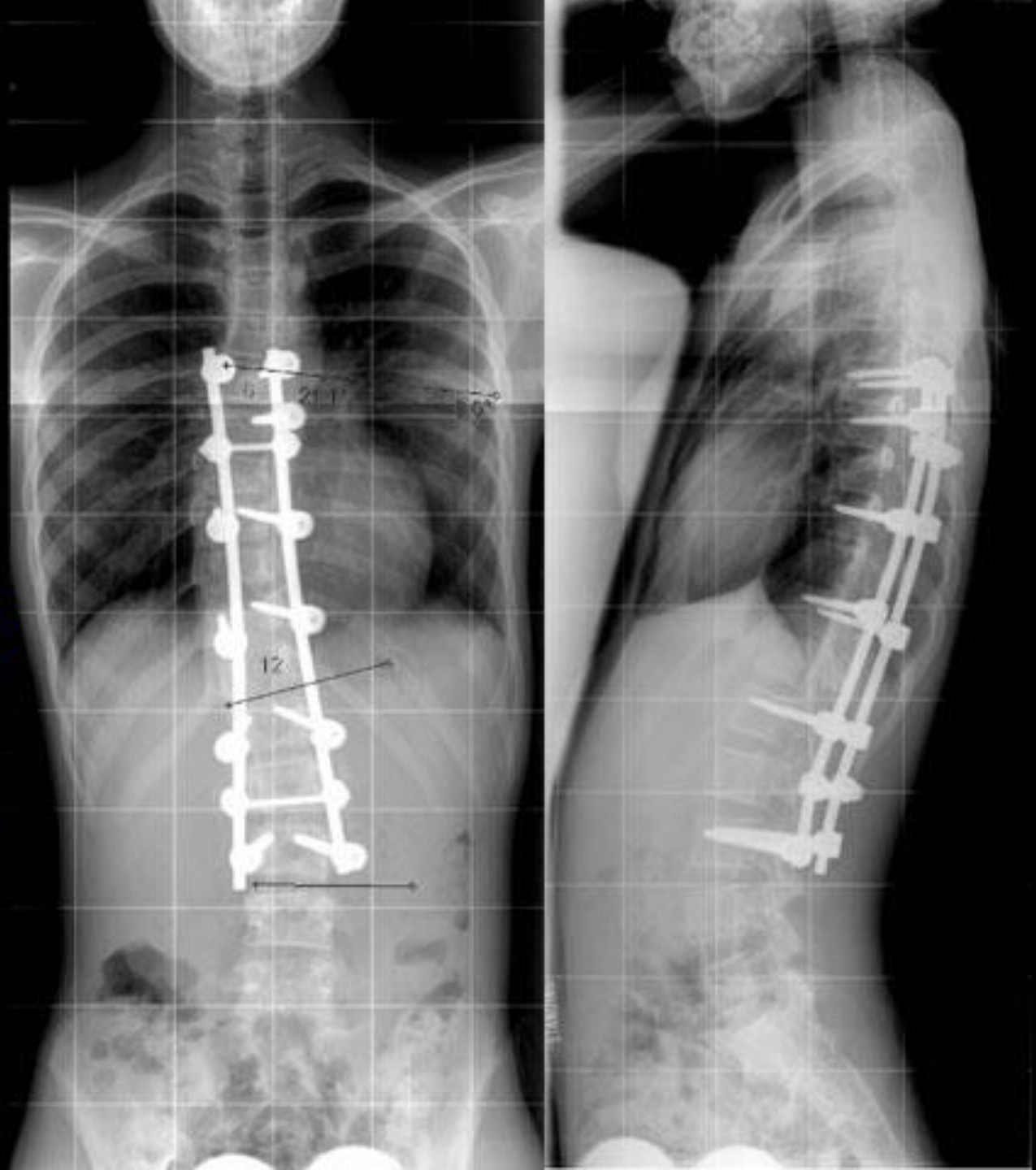
T6 to L3=16°

6 days
postop

Standing XR

T6-L3 = 6°

T6-L1 = 20°



Conclusion

- Pedicle screws are more powerful than hooks at correcting coronal curvatures (FBCI>100%)
- No difference between screw strategies for flexible curves
- More correction can be achieved in stiff curves with screws at every level and stainless steel implants
- Multiple level screws do not offer additional benefits to hook or hybrid systems in flexible curves (FBR <20 deg)

Acknowledgement

Alternate level screw	Key vertebral screw	Every level screw
Ken Cheung	Jingfeng Li	WY Cheung
Deepa Natarajan	Ken Cheung	Larry Lenke
Dino Samartzis	Dino Samartzis	Keith DK Luk
YW Wong	Xiaodong Zhu	
WY Cheung	Ming Li	
Keith Luk	Keith Luk	

The University of Hong Kong