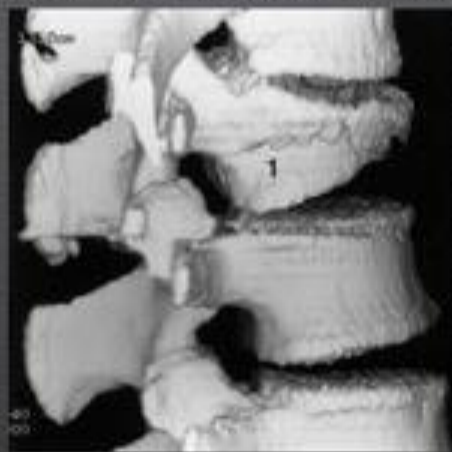


**THE ROLL OF BALLOON KYPHOPLASTY IN
THE MANAGEMENT OF TRAUMATIC
THORACOLUMBAR FRACTURES**



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ORLANDO, FL**



THORACO-LUMBAR FRACTURES

- Epidemiology
 - USA 160,000 per year
 - 10-30% SCI
 - 15-20% T11-L1
 - High speed

THORACO-LUMBAR FRACTURES

- Epidemiology
- ORMC
 - Lumbar: total 165 32% sx
 - Thoracic: total 144 33% sx
- posterior approach with short segment instrumentation
- Percutaneous pedicle screws **Longitude®** or **Sextant®** (Medtronic)
- Non-operative management with TLSO brace
- Significant economic impact

THORACO-LUMBAR FRACTURES

- AO
- 1445 cases (Magerl, Gertzbein 94)
- 3 categories with associated SCI
- Type A 14%
- Type B 32%
- Type C 55%

THORACO-LUMBAR FRACTURES

- Type A (66%)
- Axial compression
 - Compression fracture
 - Burst fractures
 - A1 , A2 , A3

THORACO-LUMBAR FRACTURES

- Type B
- Flexion Distraction
 - Chance fractures
 - Comminuted burst

THORACO-LUMBAR FRACTURES

- Type C
- rotation circumferential
 - fracture + dislocation
 - friction
- anterior , media y posterior column damage

TREATMENT OPTIONS

- Posterior segmental fusion
 - Long segment
 - Short segment
- Anterior corpectomy fusion
- 360 degrees

ANTERIOR APPROACH

- Advantages :
 - excellent decompression
 - correction of kyphosis is optimal
 - posterior tension band supplementation provides 360 degrees correction
- Long term correction

ANTERIOR APPROACH

- Disadvantages
 - Significant soft tissue invasion
 - Blood loss
 - Increased length of stay
 - Morbidity

POSTERIOR APPROACH

- Advantages
 - allows transpedicular decompression of the segment
 - Short segment instrumentation
 - Minimally invasive techniques

ANTERIOR APPROACH

- Disadvantages
 - Progressive Kyphosis
 - Failure of instrumentation
 - Chronic back pain

THORACO-LUMBAR FRACTURES

- Indications for surgery
 - $> 20^\circ$ kyphotic deformity
 - $> 50\%$ loss of VB height
 - 50% canal compromise
 - Posterior elements fracture with severe instability with or without SCI

BALLOON KYPHOPLASTY

- The needs
 - minimally invasive technique that allows correction of the anterior column
 - biocompatible cement with biomechanical strength for the loads
 - control pain acutely and in the long term
 - decreased wound morbidity
 - Decreased length of stay

THE CONS

- Bone density
- cement
- risk of cement migration
- Correction of kyphosis
- Long term results



**CORRECTION OF DEFORMITY IS THE RESULT OF THE
BALLOON INFLATION BEYOND THE RESISTANCE OF THE
CANCELLOUS BONE**



$$F = P \times A$$

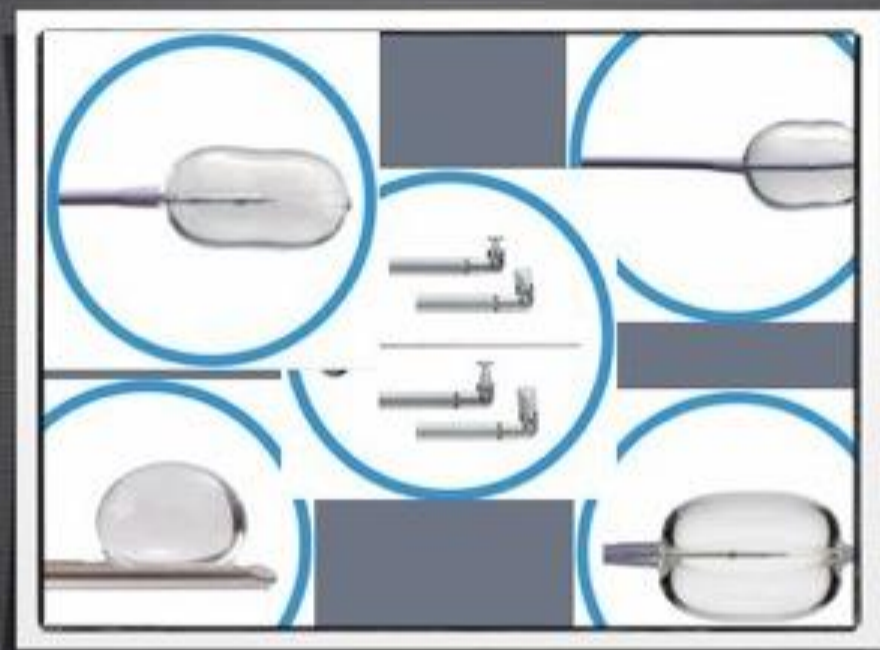
PSI MAX 300



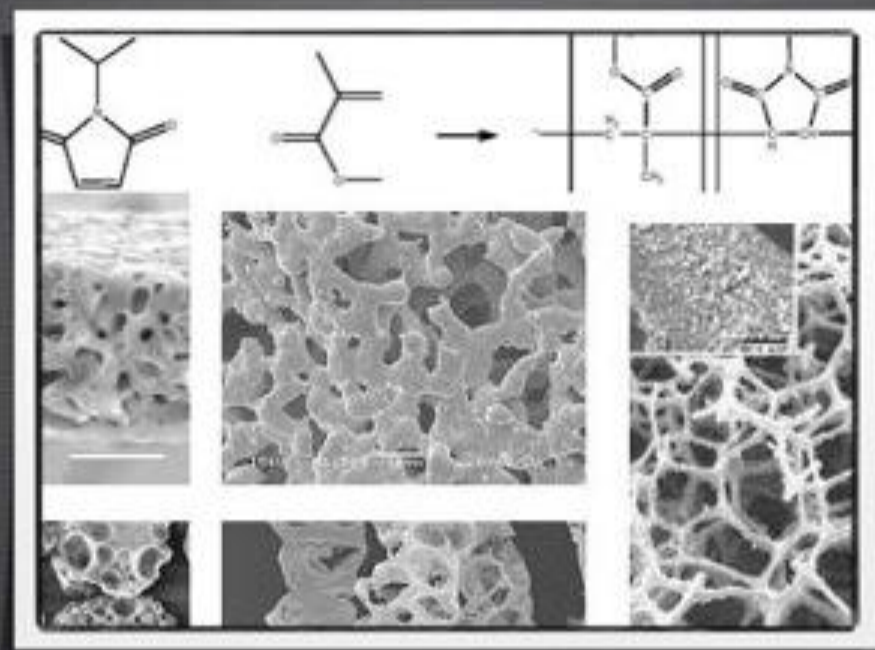
**BALLOON EXPANSION IS DIRECTLY PROPORTIONAL TO
TISSUE RESISTANCE. IN AIR 50-70 PSI IN CANCELLOUS
BONE 70 A 300 PSI.**



BONE DENSITY



BONE DENSITY



**CEMENT
PMMA VS CAP**

CEMENT PMMA VS CAP

- Setting Behavior
 - PMMA polymerization exothermic can reach 60 degrees
 - PMMA risk of monomers embolization
 - CaP crystallization isothermal
 - CaP hydrophilic more likely to washout by blood

Calcium Phosphate

Advantages

- Potential to gradually resorb and remodel into new host bone
- Potential use to treat traumatic fractures of non-osteoporotic bone in younger patients
- Low exotherm
- Non-toxic

Concerns

- Higher Cost
- Handling and Setting Characteristics Different from PMMA
- **Biomechanical Properties in A Load-bearing Situation**

Verlaan JJ, et al. J Bone Joint Surg Am 2004;86-A:1230-8.

Constantz BR, et al. Science 1995;267:1796-9.

Larsson S, et al. Clin Orthop Relat Res 2002;23:32.

Frankenburg EP, et al. J Bone Joint Surg Am 1998;80:1112-24.

Goodman SB, et al. Clin Orthop Relat Res 1998;42:50.

Lieberman IH, Togawa D and Kavanja MM. Spine J 2005;5:305S-16S.

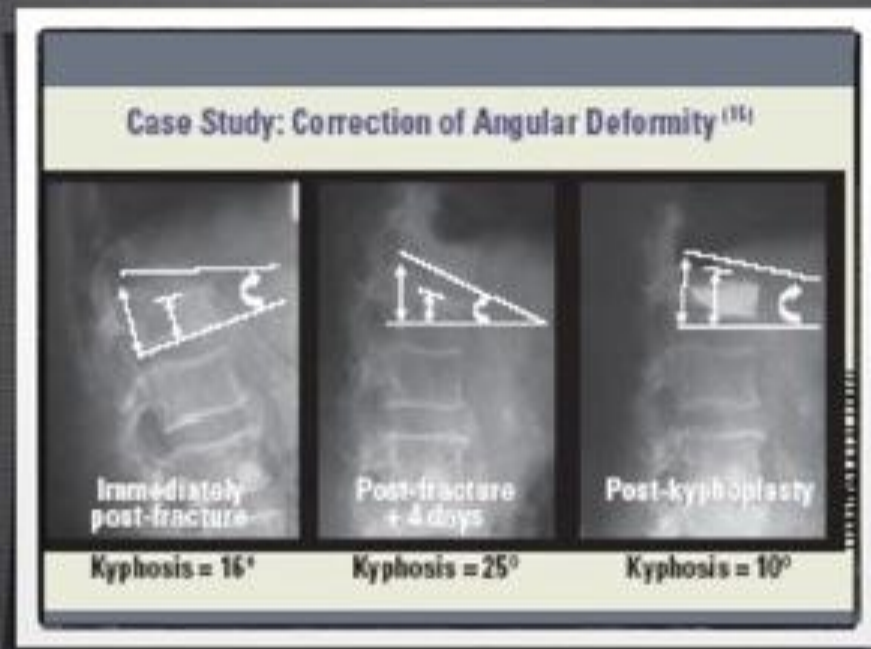
Chow LC, et al. J Biomed Mater Res 2000;53:511-7.

Friedman CD, et al. J Biomed Mater Res 1998;43:428-32.

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Lee DD, et al. Clin Orthop Relat Res 1999;S396-405.

Schildhauer TA, et al. J Orthop Trauma 2000;14:309-17



CORRECTION OF KYPHOSIS

FAILURE OF POSTERIOR INSTRUMENTATION WITH PROGRESSIVE KYPHOSIS

- Traditional pedicle screw instrumentation allows indirect reduction and kyphosis correction of thoracolumbar burst by distraction and ligamentotaxis, but because of frequent failure to support the anterior spinal column, loss of correction associated with high rate of failure is not rare.
- Kramer DL, Rodgers WB, Mansfield FL. Transpedicular instrumentation and short-segment fusion of thoracolumbar fractures: A prospective study using a single instrumentation system. *J Orthop Trauma* 1995;9:499-506.
- Parker JW, Lane JR, Karaikovic EE, Gaines RW. Successful short-segment instrumentation and fusion for thoracolumbar spine fractures. *Spine* 2000;25:1157-70.
- Speth MJ, Oner FC, Kadic MA, de Klerk LW, Verbout AJ. Recurrent kyphosis after posterior stabilization of thoracolumbar fractures: 24 cases treated with a Dick internal fixator followed for 1.5-4 years. *Acta Orthop Scand* 1995;66:406-10.
- Benson DR, Burkus JK, Montesano PX, Sutherland TB, McLain RE. Unstable thoracolumbar and lumbar burst fractures treated with the AO fixateur interne. *J Spinal Disord* 1992;5:335-43.
- Müller U, Berlemann U, Sledge J, Schwarzenbach O. Treatment of thoracolumbar burst fractures without neurologic deficit by indirect reduction and posterior instrumentation: Bisegmental stabilization with mono-segmental fusion. *Eur Spine J* 1999;8:284-9.

ANTERIOR CORPECTOMY

CORRECTION OF THE

ANTERIOR COLUMN

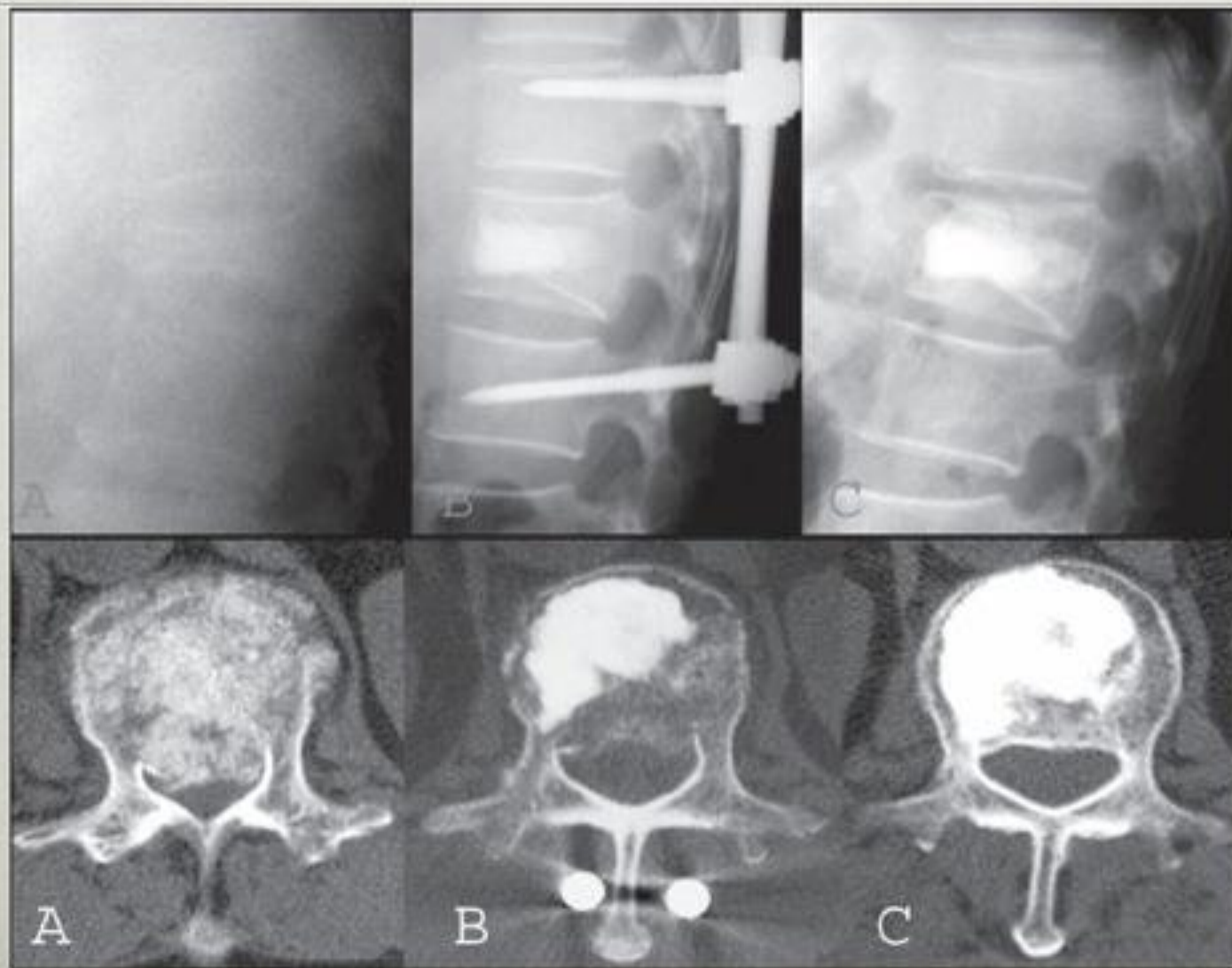
- Consequently, anterior instrumentation with strut grafting, mesh cage and plates have been introduced to augment the anterior vertebral column and have proved to be effective. However, an anterior approach is more invasive and is associated with prolonged operation and hospitalization time, blood loss, donor site complaints and increased morbidity.
- Arrington ED, Smith WJ, Chambers HG, Bucknell AL, Davino NA. **Complications of iliac crest bone graft harvesting.** Clin Orthop Relat Res 1996;329:300-9.
- 9 Kaneda K, Taneichi H, Abumi K, Hashimoto T, Satoh S, Fujiya M. **Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurological deficits.** J Bone Joint Surg Am 1997;79:69-83

**TRANSPEDICULAR INSERTION OF HYDROXYAPATITE
GRAFT INDIRECT REDUCTION OF THORACOLUMBAR
BURST FRACTURES WITH NEUROLOGICAL DEFICIT: A
RETROSPECTIVE STUDY**

EUR SPINE J 1994;3:184-201

- Tomoaki Toyone et al
- 18 patients , prospective study. Posterior short segment instrumentation + Hydroxyapatite. 2 years follow up. Japan
- Results: All patients improved at least one ASIA point
- Kyphosis reduced from mean 17 degrees preoperatively to 2 degrees post operatively , at the end of 2 years 1 degree.
- Mean canal compromise preoperatively, post-operatively and at two years was 60%, 22% y 11%.

TOMOAKI TOYONE ET AL



**KYPHOPLASTY-AUGMENTED SHORT-SEGMENT PEDICLE SCREW
FIXATION OF TRAUMATIC LUMBAR BURST FRACTURES: INITIAL
CLINICAL EXPERIENCE AND LITERATURE REVIEW.
NEUROSURG FOCUS . 18(3) 2005**

ACOSTA ET AL

- UCSF 2005
- 5 patients
- retrospective
- 53 mean age
- indications: reduction of the vertebral height > 50%, canal compromise > 50%, Kyphosis > 20°
- Kyphosis pre-operative mean 36 , post-operative 5
- PMMA

**KYPHOPLASTY-AUGMENTED SHORT-SEGMENT PEDICLE SCREW
FIXATION OF TRAUMATIC LUMBAR BURST FRACTURES: INITIAL
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NEUROSURG FOCUS . 18(3) 2005

ACOSTA ET AL

TABLE 2

Radiographic results in five patients with burst fractures

Case No.	Kyphosis (°)				Anterior VB Height (%)			
	Preop	Postop	FU	% Correction Loss	Preop	Postop	FU	Height Loss
1	30	5	10	5	60	90	80	10
2	40	15	15	0	50	75	75	0
3	40	0	10	10	50	80	75	5
4	35	5	5	0	55	90	80	10
5	35	0	5	5	55	95	90	5
mean	36	5	9	4	54	86	80	6

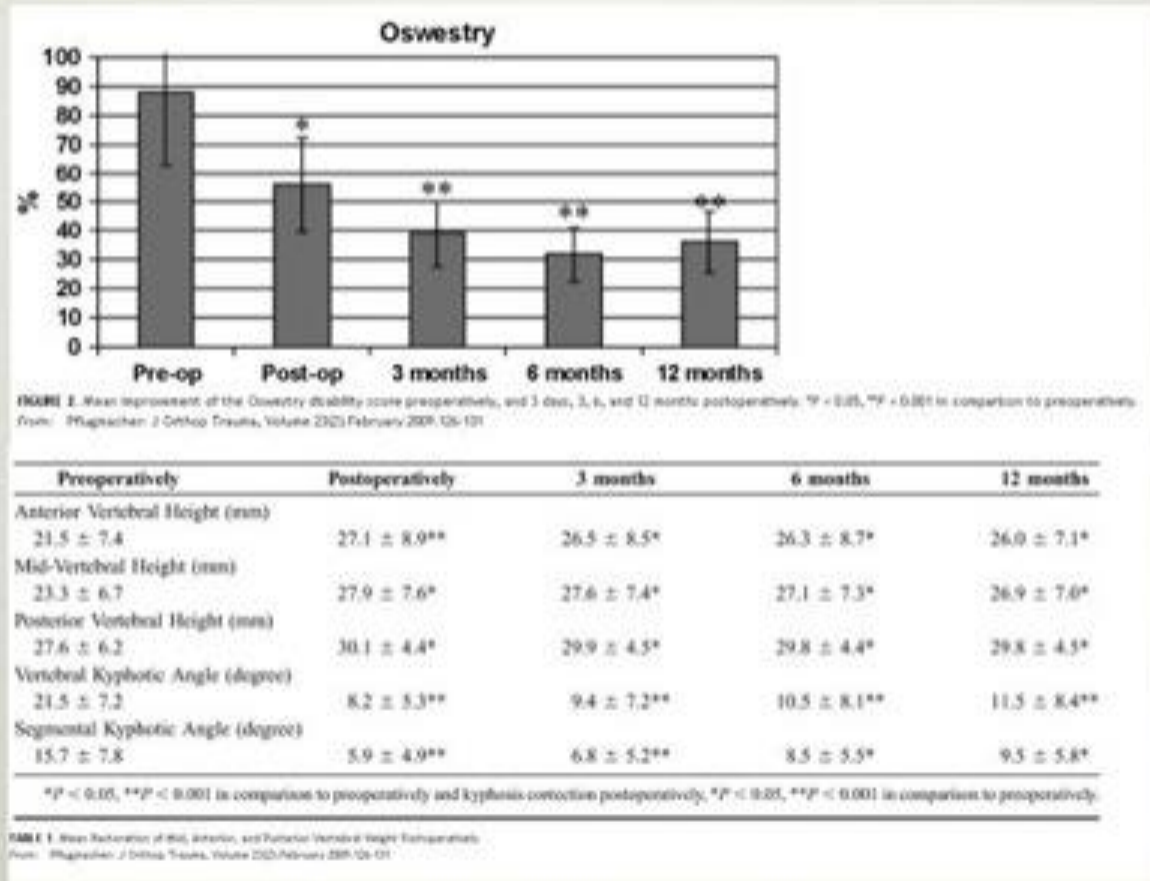




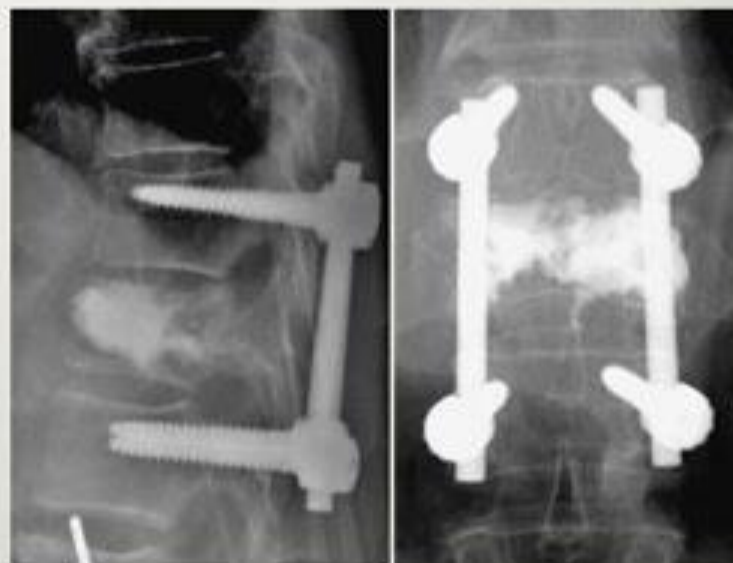
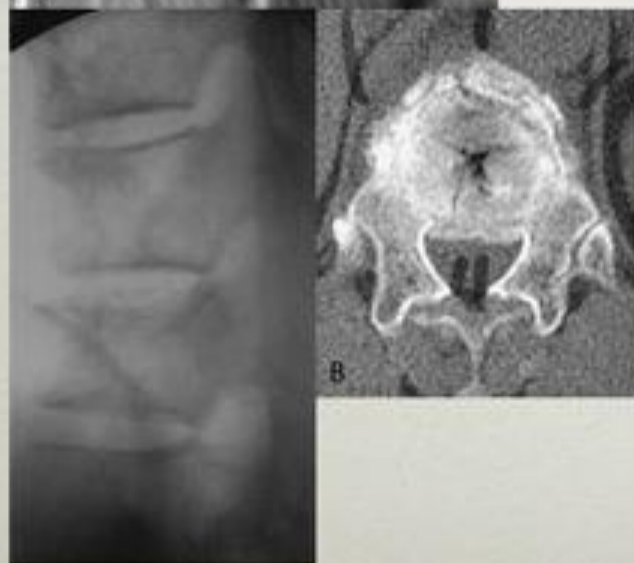
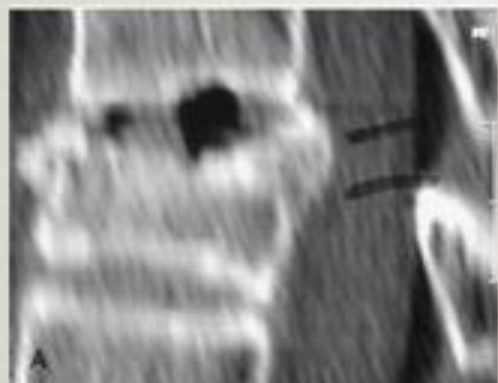
BALLOON KYPHOPLASTY COMBINED WITH POSTERIOR INSTRUMENTATION FOR THE TREATMENT OF THORACOLUMBAR FRACTURES

- Pflugmacher et al. J orthop Trauma. 23, 2, feb. 2009
- PMMA
- 25 patients A3 fractures + osteoporosis
- Mean age 59 (52-72)
- Kyphosis angle was followed as well as the score Oswestry (ODI) for disability
- Results:
 - Pain (VAS) 7.8 a 4.9 ($p < 0.001$)
 - Incapacity to perform daily activities (ODI) 88% a 35% (3 months) 36.5% (1 year) ($P < .05$).
 - Correction of kyphosis was maintained one year post operatively.

PFLUGMACHER ET AL. J ORTHOP TRAUMA. 23, 2, FEB. 2009



**PFLUGMACHER ET AL. J ORTHOP
TRAUMA. 23, 2, FEB. 2009**



**DIRECT REDUCTION OF THORACOLUMBAR BURST
FRACTURES BY MEANS OF BALLOON KYPHOPLASTY WITH
CALCIUM PHOSPHATE AND STABILIZATION WITH
PEDICLE-SCREW INSTRUMENTATION AND FUSION.
KOVORESSIS ET AL . SPINE VOL 33(4), FEB 2008**

- Prospective study
- 23 patients , mean age 48 yo
- A3 fractures
- Follow up 24 months
- operative time 23 min
- Kyphosis correction : preop mean 16° to postop mean 1 °
- 4 cases cement extravasation: 3 para-vertebral y 1 intra-discal
- Sagittal correction maintained at 24 months

**DIRECT REDUCTION OF THORACOLUMBAR BURST
FRACTURES BY MEANS OF BALLOON KYPHOPLASTY WITH
CALCIUM PHOSPHATE AND STABILIZATION WITH
PEDICLE-SCREW INSTRUMENTATION AND FUSION.
KOVORESSIS ET AL . SPINE VOL 33(4), FEB 2008**

Table 1. Roentgenographic Changes* in Short Versus Long Instrumentation Combined With Kyphoplasty

	Gardner Angle (°)			Spinal Canal Encroachment (%)			Anterior Vertebral Body Height			Posterior Vertebral Body Height		
	Preop	Postop	% Changes	Preop	Postop	% Changes	Preop	Postop	% Changes	Preop	Postop	% Changes
Short†	12 ± 13	-2 ± 4	70 ± 48	31 ± 22	23 ± 25	14 ± 39	0.66 ± 0.14	0.92 ± 0.07	44 ± 28	0.96 ± 0.05	0.98 ± 0.04	2.5 ± 4
Range	(-5 to 24)	(0 to -8)		(12 to 53)	(0 to 50)		(0.51 to 0.88)	(0.77 to 1)		(0.88 to 1)	(0.88 to 1)	
Long†	16 ± 10	2 ± 4	88 ± 19	33 ± 25	25 ± 18	16 ± 15	0.67 ± 0.09	0.91 ± 0.06	38 ± 19	0.94 ± 0.08	0.95 ± 0.12	0.8 ± 7
Range	(0 to 35)	(0 to 10)		(10 to 75)	(0 to 50)		(0.62 to 0.86)	(0.8 to 1)		(0.77 to 1)	(0.77 to 1)	

All values are shown as average ± standard deviation.

*No statistical significant changes were shown in the preoperative values and amount of postoperative changes of all radiographic parameters between the two groups.

†Short and long instrumentations.

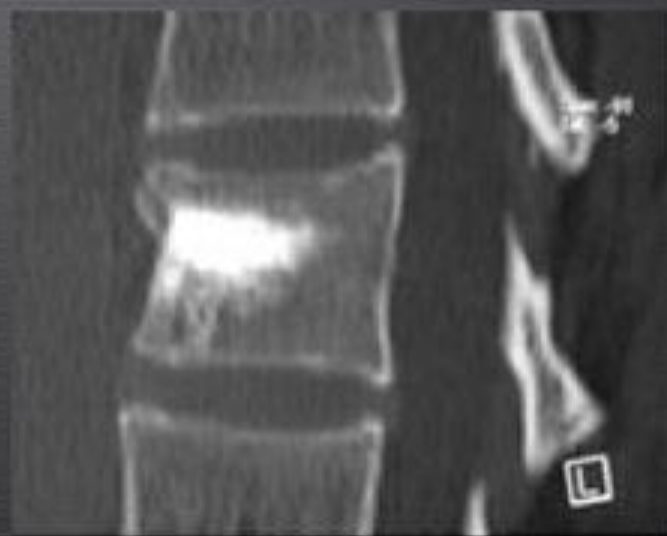
Table 1. Roentgenographic Changes in Short Versus Long Instrumentation Combined With Kyphoplasty

From: *Kovoressis: Spine, Volume 33(4), February 11, 2008, E110-E108*



C A P

PRE-OP



POST-
OP

35 YO TRAUMATIC FRACTURE (L1, TYPE A1.1)

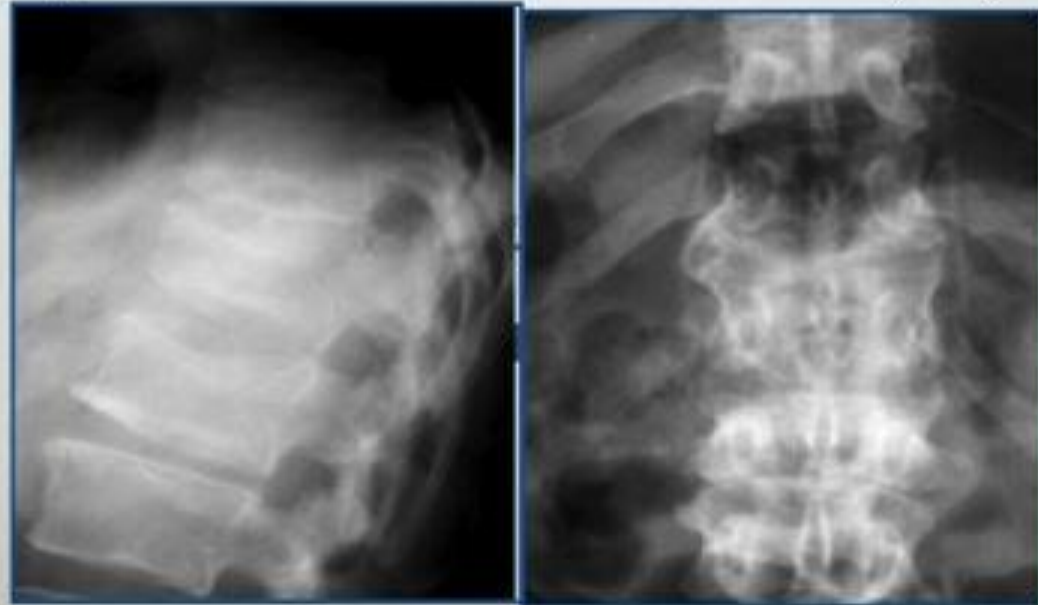
A1.1 – Impaction Fracture (A1) with Endplate Infracture



Patient: 40-year-old woman

Cause of trauma: Fall

Diagnosis: T12 and L1 - Recent A1.1 fractures (9 days old)



Pre-Op:

X-ray

LAT



AP



MRI

T12



CT-scan

L1



Treatment:

- Pain medication
- **Balloon Kyphoplasty with KyphOs FS**
- ~~2 levels treated with 3 cc (T12) and 4.4 cc (L1) of KyphOs FSTM.~~
- 1h15 min procedure time under general anaesthesia.
- Bed rest for 24 hours

Result:

- No cement extravasations
- **Post-Op:** No per-operative adverse events
- Fracture reduction



Outcomes:

Patient experienced pain relief right after surgery
and returned to work 4 weeks post surgery.

FRACTURE REDUCTION MAINTAINED AT 1- AND 4-MONTH

X-ray

1 M

LAT



A1.2 - Impaction Fracture (A1) – Wedge Fracture



- 33-year-old man
- Fall during paragliding
- Reported heavy back pain, localized at thoraco lumbar junction

Diagnosis:

- L1 - Fresh A1.2 fracture (2 hours old)

X-ray

Pre-Op:



AP



LAT

CT-scan



Sagittal



Coronal



Axial

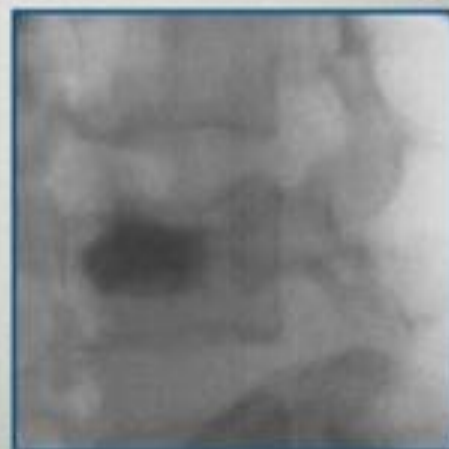
Balloon Kyphoplasty with KyphOs FS™

- “Kissing balloons” approach was chosen for this particular fracture.
- KyphOs FS™ volume injected: 4.7 cc left and 4.5 cc right.

Inflation of Balloons



Injection of KyphOs FS™



Result:

- No cement extravasations

Post-Op:

X-ray



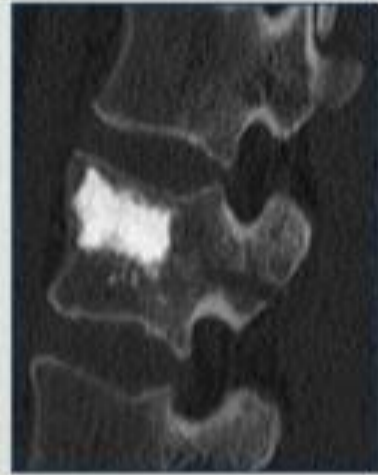
LAT



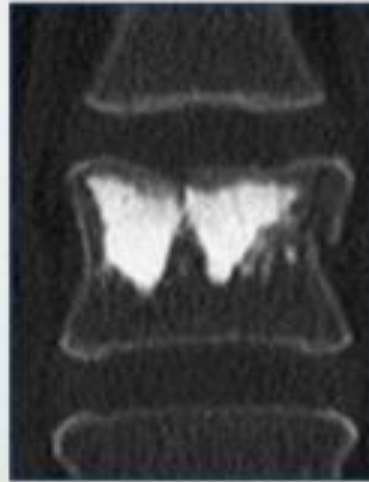
AP

Post-Op:

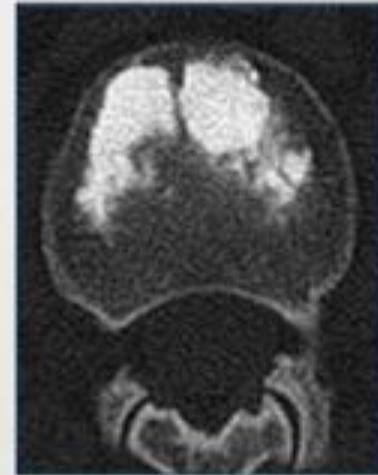
CT-scan



Sagittal



Coronal



Axial

Outcomes:

24 hours post-op: Patient almost pain free.

4 days post-op: Patient was discharged from hospital pain free.

A3.1 – Incomplete Burst Fracture (A3) with Single Burst



Patient:

- 37-year-old man
- Cause of trauma: Fall

Examination:

- Physical / neurological exam: No SCI
- Reported back pain at thoracic-lumbar junction, pain localized at pressure & palpation of L1
- VAS-score 6

Diagnosis:

- L1 - A3.1 fracture (8 days old)

Pre-Op:

X-ray



LAT

CT-
scan



Coronal



Sagittal



Axial

• **Balloon Kyphoplasty with KyphOs FSTM**

- on 8 days old fracture
- 45 min procedure time under general anaesthesia.
- KyphOs FS™ volume injected: 4.5 cc left and 4.2 cc right.

Intra-Op:



Latitude™ Curvite



Balloon insertion



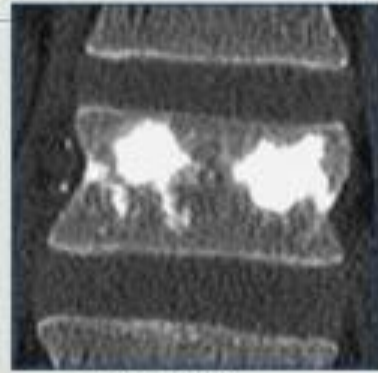
Balloon inflation



Injection of Kyphos FS

< 48 hours after treatment

Post-Op:



Coronal



Sagittal



Axial

Follow-up:

X-ray

< 48 Hours



3 Months



6 Months



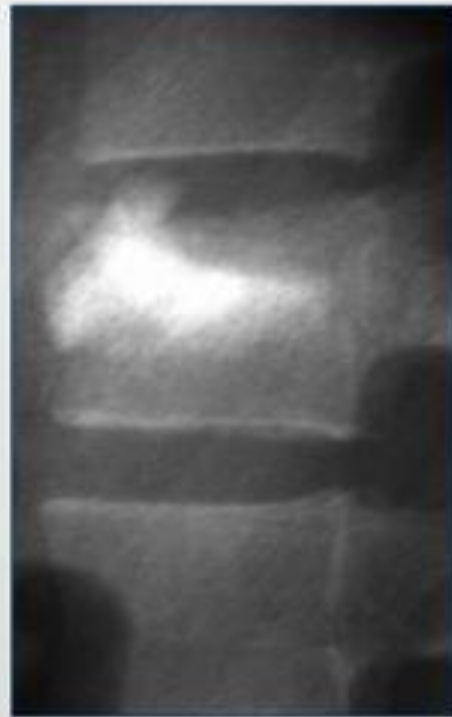
Outcomes:

- Pain Reduction:
 - Immediately post-op: VAS = 1
 - 3 months follow-up: VAS = 0
- Functions: Patient able to perform all functions without any limitation at 3-month follow-up.

Post-traumatic fracture T 12 (Kyphos FS)



Pre-op
22 mm
17°



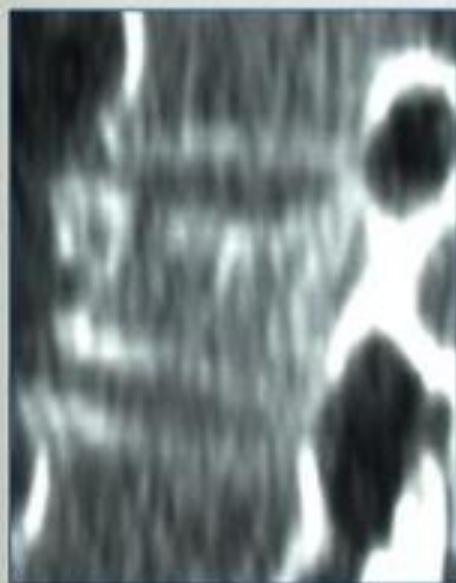
Post-op
25 mm
7°

9 months VAS 0



9 months later
22 mm
12°

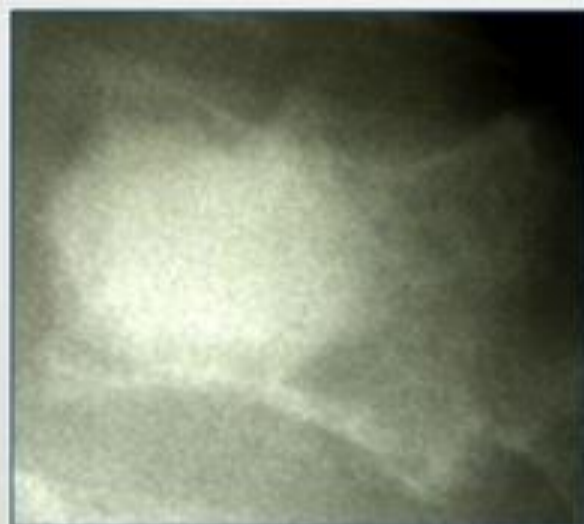
POST-TRAUMATIC FRACTURE T12



Pre-op

12 mm

13°



Post-op

20 mm

10°



1 month later

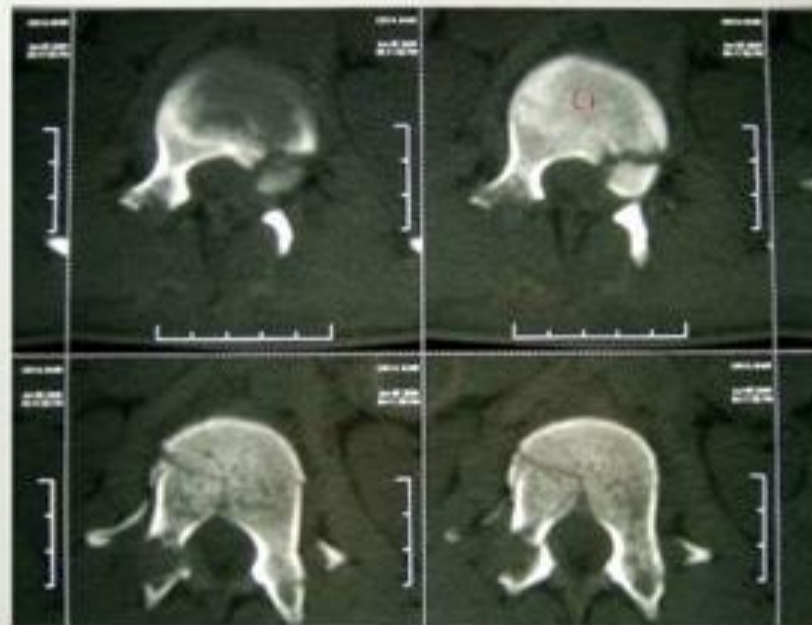
16 mm

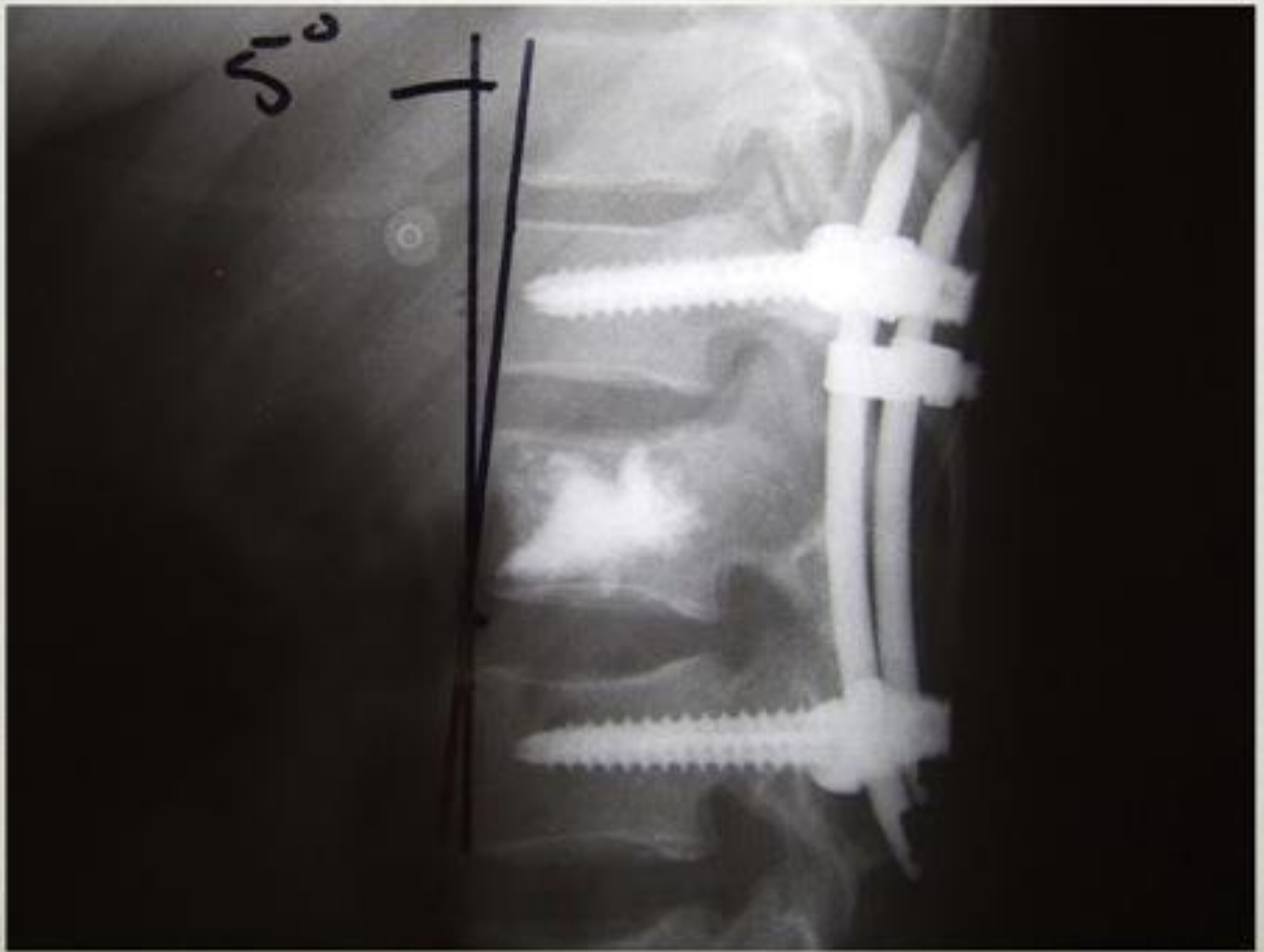
23°

VAS 9 months: 3/10

L1 BURST FRACTURE

26 YO





CONCLUSIONS

- The use of percutaneous or open kyphoplasty in traumatic thoracolumbar fractures is safe
- There is significant potential pitfalls related to the configuration of the fractures, the bony density and the type of cement
- Calcium Phosphate cement is actively studied in order to provide a safer more reliable tool
- The use of supplementary posterior instrumentation increases the tension band biomechanical support and improves long term results
- Additional studies are needed to determine clear limits of indications and contra-indications



GRACIAS
THANK YOU
OBRIGADO