SPINAL INSTABILITY PREDICTING SCORE (SIPS) FOR SUBSEQUENT FRACTURES AFTER VERTEBROPLASTY IN PATIENTS WITH OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES

Hyeun Sung Kim, MD, PhD,

Hyung Jun Ahn, , MD, Ki Hyun Jeon , MD, Woo Jin Choi , MD, PhD, Kwan Tae Kim , MD, PhD, Seok Won Kim , MD, PhD [1], Chang Il Ju , MD[1], Seung Myung Lee , MD, PhD [1], Ho Shin , MD, PhD [1]

Department of Neurosurgery, Hurisarang Spine Hospital, Daejeon city, Republic of Korea

Department of Neurosurgery, College of Medicine, Chosun University, Gwangju city, Republic of Korea[1]

The Incidence of Subsequent Fracture

- **Syed et al.:** New fracture, 1 year after VP; 22% of individuals
- **Hyde et al.:** New fracture, 9 month after KP ; 30% (20 / 66 patients)
- **Tanigawa et al.:** New compression fractures, after VP; 37% (28 / 76 patients)
- **Grados et al.: 4 years after VP; 52% (13 / 25 patients)**
- **Chiang CK et al.:** *Subsequent fractures post-vertebroplasty within 1 year:*

  => 12% to 24% of patients
- **Han IH, Chin DK et al.:** *The incidence of subsequent fractures after PVP;*

  => ranges from 8% to 52%

< The occurrence rate of adjacent facture >

=> *42%~67%* of subsequent vertebral fractures

Materials

- ***659 patients*** underwent vertebral augmentation procedures
  - ❖ Between May 2003 and November 2007
- ***285 patients (VPs, n=231; KPs, n=54)*** with *X-ray follow-up > 6 months.*

[Classification of the subsequent fractures]
Based on the subsequent fracture pattern

1) No subsequent Fractures (NSFs): No subsequent fractures.

2) Neo-Fractures (NFs): New vertebral fractures involving another vertebrae after a new history of trauma.

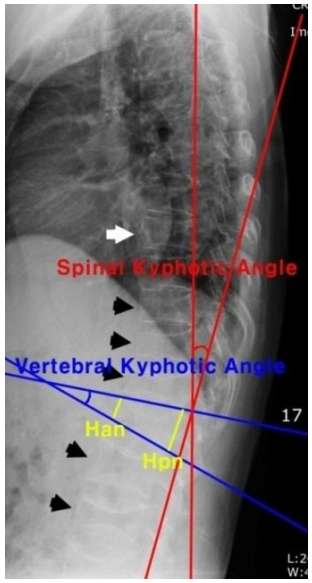
3) Hammer Fractures (HFs): New vertebral fractures involving another vertebrae without a definite history of trauma.

4) Kyphotic compression fractures (KCFs): Progressive collapse & kyphotic changes of augmented vertebrae after vertebral augmentation procedures.

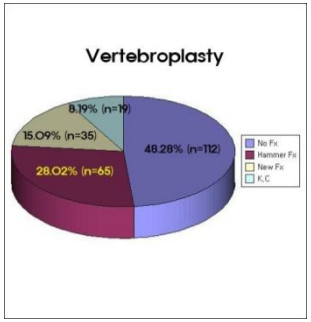
Analysis

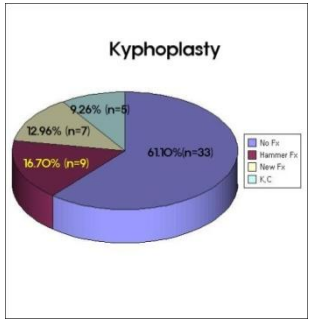
- **We compared subsequent fx patterns between patients who underwent VPs or KPs**
  - ⇒ Analysis of the subsequent fracture patterns revealed that only VPs had statistical significance

- **Each occurrence rate was studied for factors induce subsequent fractures**
  - ⇒ Scoring was performed ***related to the hammer fracture occurrence rate only***
  - ⇒ By summation of those scores, we obtained predicting scores for following fractures
  - ⇒ ***SIPS for subsequent fractures:*** after correcting the SIPS by factors that may prevent ***hammer fx***



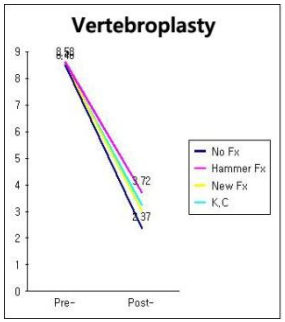
The Rate of Subsequent Fractures

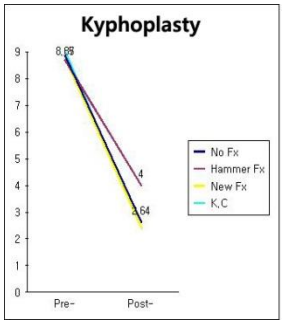




Changes in the VAS after Treatment

Final Follow-up





Related Factors to the Items of the SIPS (Spinal Instability Predicting Score) for subsequent Fx

Categories	Grade	Score
Spinal Kyphotic Angle	~ 14	1
	15 ~ 24	4
	25 ~	6
Vertebral Kyphotic Angle	0 ~ 14	1.5
	15 ~ 19	4
	20 ~	6
Vertebral Height	100% ~ 76%	1.5
	75% ~ 51%	3
	50% ~ 26%	5
	25% ~	10
Augmentation Level	1 level	2
	2 level	4
	3 level	6
BMD	~(-2.49)	1
	(-2.5) ~ (-2.99)	2
	(-3.0) ~ (-3.49)	3
	(-4.0) ~	4
	(-3.5) ~ (-3.99)	5
Site	T12, L1	2
	~T9, L5	3
	T11, L3	4
	L2, L4, T10	5
Total Score		9 ~ 38

Total Corrected SIPS

3~38

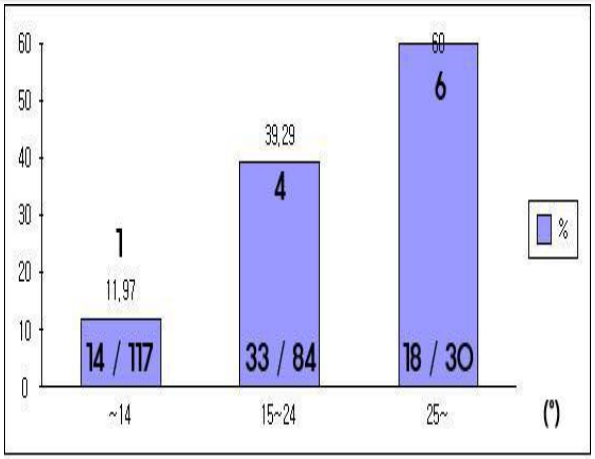
Preventing Factors for Hammer Fracture after Vertebral Augmentation Procedures

Group	Grade	Detail
A	0	● No previous fracture.
B	-2	● Previous single or two-level thoracic, thoracolumbar junction or lumbar fracture that is already fused.
C	-8	● Previous multiple fractures that are already fused (above 3 levels). ● Fracture vertebrae's unstable side adjacent to old fracture located at the thoracolumbar junction (it does not include the stable side). ● Unstable side adjacent to the booster augmentation (including VP, KP and previous fusion) ● Bed rest condition.

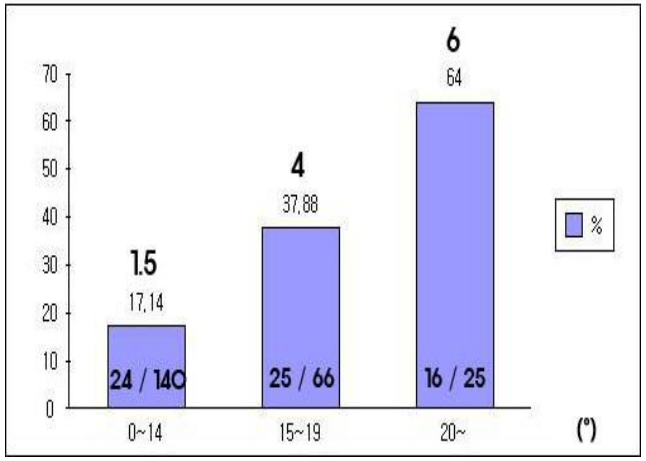
Adjacent Previous fx **Booster (Prophylactic) augmentation**

Hammer Fracture Occurrence Rate

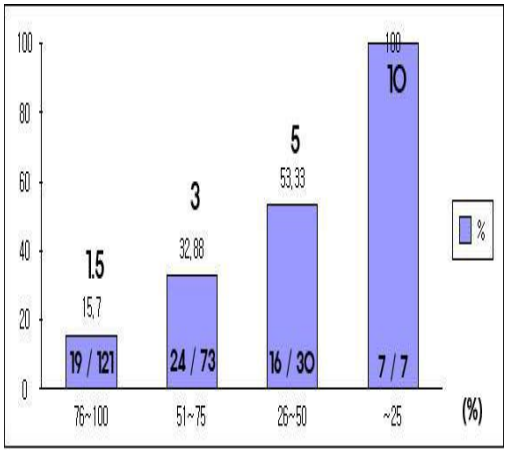
Spinal Kyphotic Angle Factors



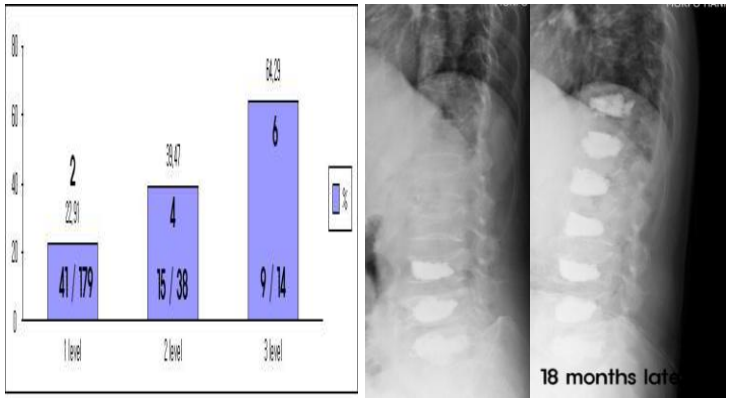
Vertebral Kyphotic Angle Factors



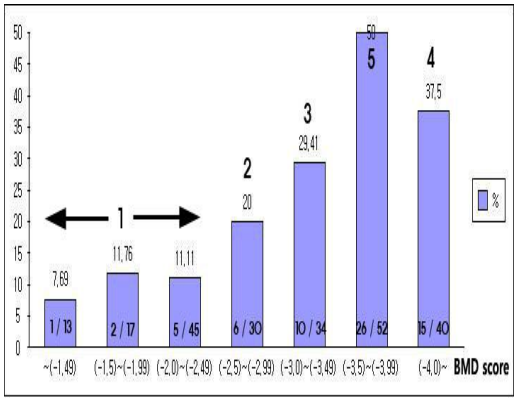
Vertebral Height Factor



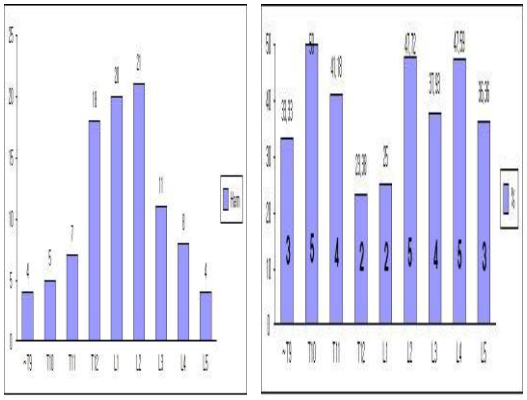
Augmented Level Factors



Osteoporosis (BMD) Factors

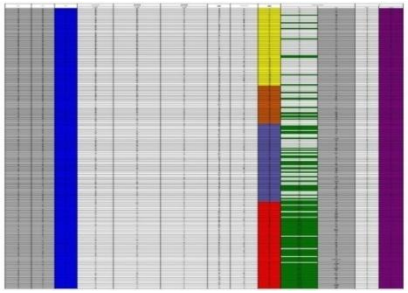


Fracture Site Factors



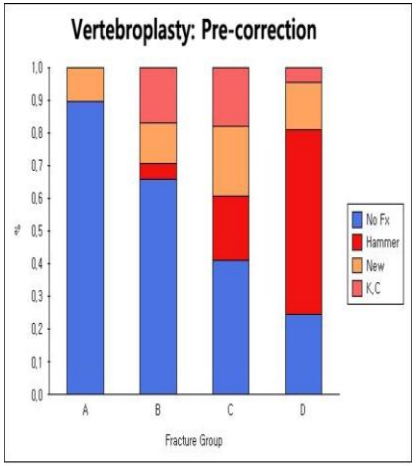
Evaluation : DEXA method

Spinal Instability Predicting Score (SIPS)



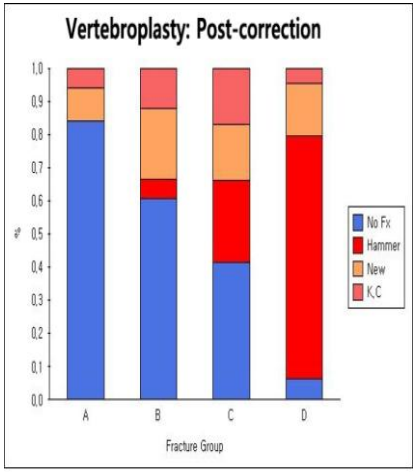
Subsequent Fracture Risk Group
: based on the Corrected SIPS in VPs

Group		Score
Group A	No risk group	~11.5
Group B	Low risk group	12~13.5
Group C	Moderate Risk group	14~18.5
Group D	High risk group	19~



Results

Group	No Fractures	Subsequent Fractures [HFs, NFs, KCFs]
Group A (n=69)	{ 84.06% (58) }	**{ 15.9% (11) }** [0.00% (0), 10.1% (7), 5.8% (4)]
Group B (n=33)	{ 60.61% (20) }	**{ 39.4% (13) }** [6.1% (2), 21.2% (7), 12.1% (4)]
Group C (n=65)	{ 41.54% (27) }	**{ 58.5% (38) }** [24.6% (16), 16.9% (11), 16.9% (11)]
Group D (n=64)	{ 6.24% (4) }	**{ 93.8% (60) }** [73.4% (47), 15.6% (10), 4.7% (3)]



Explication

- **Corrected SIPS:** High predictive rate for subsequent fractures
- **Group A:** No chance for subsequent fractures after VP in activities of daily living
- **Group D:** High chance for subsequent fractures in any activities of daily living

The Pathogenesis of Subsequent Fractures

◆ **Ahn Y et al. Predictive factors for subsequent vertebral fracture after percutaneous vertebroplasty. J Neurosurg Spine 2008**

The mechanisms of subsequent fracture at adjacent and nonadjacent vertebrae are different

- **A direct pillar effect:**
  - **Adjacent-level fractures;** The difference in strength caused by cement augmentation.
- **A dynamic hammer effect:**
  - **A non-adjacent fractures;** The difference in segmental mobility.

◆ **Han IH, Chin DK et al. Magnetic resonance imaging findings of subsequent fractures after vertebroplasty. Neurosurgery. 2009**

- BME of AVFs appeared significantly toward previous injected cement.
- This phenomenon supports the idea that the **biomechanical effect of injected cement is one of the causative factors that affect the occurrence of AVF after PVP.**

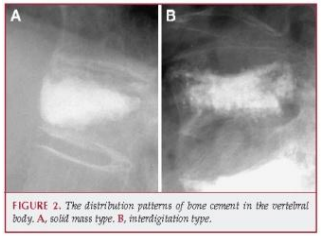


FIGURE 2. The distribution patterns of bone cement in the vertebral body. A, solid mass type. B, interdigitation type.

Risk Factors for Subsequent Fractures

Preoperative Vertebral Condition

- **Prior vertebral fracture:** Syed et al., Lee et al., Voormolen et al.
- **Proximity to the initial fracture site:** Tanigawa et al., Uppin et al., etc.
- **Higher initial wedge angle or wedge angle change:** Lin et al., Kim et al.
- **Severity of the vertebral fractures**
- **Vacuum clefts within the compression fracture:** Lin et al.

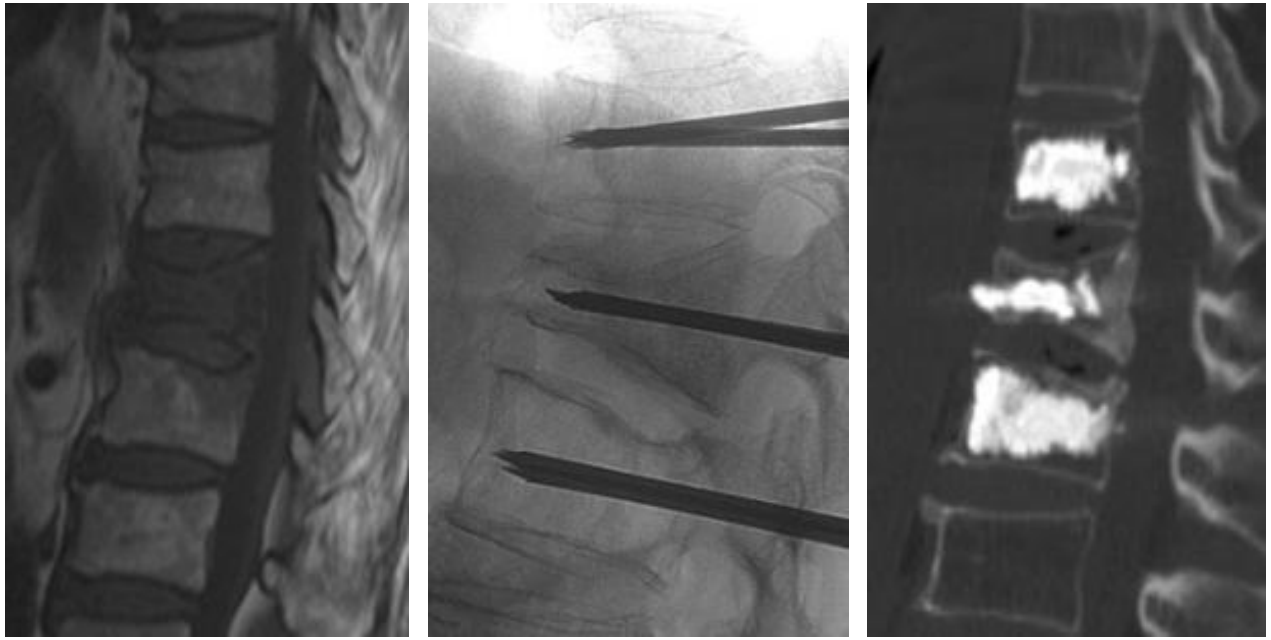
Intra-operative Condition

- **Cement leakage into the disk after Tx:** Lin et al., Komemushi et al.
- **Maximum filling with bone cement:** Berlemann et al.
- **Treatment of Multiple vertebrae:** Lee et al.
- **Great degree of height restoration of the cemented vertebra:** Mermelstein et al.
- **Treatment of vertebrae at the thoracolumbar junction:** Kim et al.

Prophylactive vertebral reinforcement : Clinical

- **Kobayashi et al. Prophylactic VP: cement injection into non-fractured vertebral bodies during percutaneous VP. Acad Radiol.**

Prophylactic cement injection into non-fractured vertebrae adjacent to fractured vertebrae may prevent new compression fractures after VP.



CONCLUSION

Biomechanical instability accompanied by compression fractures may play an important role in subsequent fractures after vertebroplasty for osteoporotic vertebral compression fractures.

According to the corrected SIPS, group D had a high predictive score.

If the corrected SIPS is high, the patients have a greater chance for subsequent fractures.

Therefore, we must give more attention to such patients; Indeed, education for strict bed rest, spinal bracing, kyphoplasty, booster vertebral augmentation, or transpedicular screw stabilization may increase spinal stability and decrease subsequent fractures.

Disclosure

- **Apollon® Co-designer**
- **An Advisory Doctor of the 365 Homecare**