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This article describes the poster presentation made about Shimadzu tomosynthesis.

Evaluation of thoracolumbar vertebral fractures using tomosynthesis

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1. Introduction

Tomosynthesis, a contraction of the words "tomography" and "synthesis," is an X-ray tomographic imaging method. Conventional film-based tomography has disappeared along with the widespread feasibility of computed tomography (CT), but the advent of flat panel X-ray detectors (FPDs) and digital image processing technologies has triggered a resurgence of interest in tomosynthesis. Key characteristics of the X-ray system we use are to have the ability to perform both radiography and tomosynthesis examinations **(Fig. 1)**, and it allows us to perform 2.5 to 5-second short tomosynthesis scanning. Also, the X-ray dose for tomosynthesis is about the same or up to around double the level of radiography, which is approximately 1/10 the dose of CT **(Fig. 2)**.
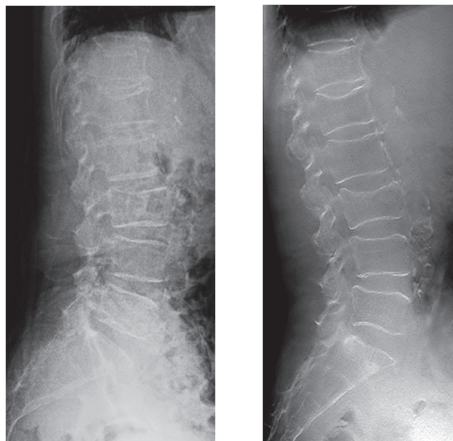

Fig.1 Radiography (Left) and Tomosynthesis (Right) Images of Lumbar Vertebrae

Characteristics of Tomosynthesis

R/F System	Scanning Time	X-ray Dose Ratio	
			Tomosynthesis /Radiography
Also enables Radiography	Normally 2.5 to 5-second	Frontal Head	1.1
		Lateral Cervical Spine	2.2
		Knee Joint	2.0
		Hip Joint	1.1
		Approximately 1/10 of CT	

Fig.2 Characteristics of Tomosynthesis

2. Purpose

The objective of this study was to evaluate the effectiveness of tomosynthesis for diagnosing thoracolumbar vertebral fractures.

3. Materials

Both radiography and tomosynthesis examinations were performed to diagnose 34 cases of suspected thoracolumbar vertebral fractures within the same day. 12 of the cases were male and 22 were female. The average age was 75.5 (range: 19 to 95 years). The equipment used in this study was a Shimadzu SONIALVISION G4 Digital Radiography/Fluoroscopy system.

4. Methods

A) The presence of vertebral fractures in each imaging method was evaluated ranging from 7th thoracic vertebra to 5th lumbar vertebra (total: 408 vertebrae).

B) In this study, fresh vertebral fracture (FVF) diagnostic protocol was newly defined by using tomosynthesis, and those FVF cases were compared with plain MRI for further investigations. Because the standard diagnostic criteria for fresh vertebral fracture determined by tomosynthesis is not established, we defined the following vertebrae as FVF. When tomosynthesis shows cortical discontinuity of vertebral endplate or anterior wall, or when tomosynthesis shows intravertebral trabecular bone fracture (low absorption band), or both **(Fig. 3)**.
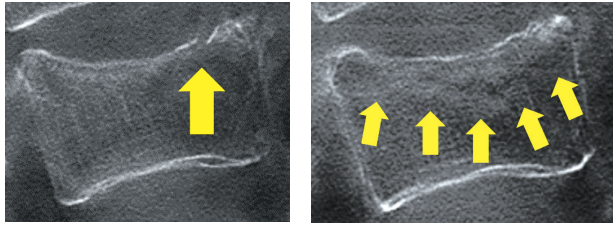
Fig.3 The tomosynthesis image showing cortical discontinuity of vertebral endplate or anterior wall (Left), and the tomosynthesis image showing intravertebral trabecular bone fracture (low absorption band) (Right).

5. Results

A) The number of vertebral fractures identified by each imaging method in each region (thoracic and lumbar vertebrae) are shown in **Table 1**.
Tomosynthesis detected all 43 vertebral fractures which were identified by radiography. Furthermore, for more than half of the all 34 cases, tomosynthesis also identified additional vertebral fractures that could not be identified by radiography.

Table 1 The Number of Vertebral Fractures Identified by Radiography and Tomosynthesis

	Radiography	Tomosynthesis
		(n = number of vertebrae)
Thoracic vertebrae	21	37
Lumbar vertebrae	22	38
Total	43	75

Findings about Vertebral Fractures Identified by Radiography

Detection rate by tomosynthesis	43 of 43 vertebrae (100 %)
Fractures identified by tomosynthesis in other vertebrae	18 of 34 cases (53 %)

B) The proper diagnosis rate of tomosynthesis for FVF was 67% in comparison with MRI **(Table 2)**. This proper diagnosis rate was same for both in the detection of cortical discontinuity of vertebral endplate or anterior wall, and in the detection of intravertebral trabecular bone fractures (low absorption band).
MRI confirmed 73 % (16 vertebrae) of FVFs for 22 FVFs diagnosed by tomosynthesis.

Table 2 Detection of cortical discontinuities of vertebral endplate or anterior wall, and intravertebral trabecular bone fractures (low absorption band), by MRI and tomosynthesis.

1. Cortical discontinuities of vertebral endplate or anterior wall

MRI / Tomosynthesis	Fracture: positive	Fracture: negative
Fracture: positive	10	5
Fracture: negative	5	77

Sensitivity: 67 %　Specificity: 94 %　Positive predictive value (proper diagnosis rate): 67 %

2. Intravertebral trabecular bone fractures (low absorption band)

MRI / Tomosynthesis	Fracture: positive	Fracture: negative
Fracture: positive	12	6
Fracture: negative	4	75

Sensitivity: 75 %　Specificity: 92 %　Positive predictive value (proper diagnosis rate): 67 %

6. Discussion

Nakano and Takahashi et al previously reported separately that the proper diagnosis rates of vertebral fracture were 35 to 59 % by radiography [1,2], and indicated that accurate diagnoses were difficult based on radiography alone. In over half of the cases of lower thoracic and lumbar vertebral fractures in our study as well, fine fractures were overlooked from not being identifiable by radiography alone, but successfully identified by tomosynthesis. Consequently, due to the extremely low proper diagnosis rate of detecting vertebral fractures by radiography, tomosynthesis provides a useful examination method.

Furthermore, to the best of our knowledge, no reports have been published about diagnostic utility in comparison between tomosynthesis and MRI. Based on our new definition for FVF evaluation by tomosynthesis, tomosynthesis achieved 73 % of proper diagnosis rate in comparison with MRI, tomosynthesis is considered as a useful diagnostic method for the evaluation of FVF as well.

7. Conclusion

Presumably, tomosynthesis could serve as a useful radiographic imaging method for diagnosing thoracolumbar vertebral fractures.

References
1) Tetsuo Nakano, et al.: Rate of correct diagnosis for vertebral fracture by plain roentogenograms., Journal of Japanese Society for Fracture Repair, Vol. 21, Issue 2: 586-588, 1999
2) Toshiyuki Takahashi, et al.: Diagnosis and Treatment of Osteoporotic Thoracolumbar Vertebral Fracture, Neurological Surgery, Vol. 44, Issue 8: 637-650, 2016