THE ACCURACY OF SURFACE MEASUREMENT FOR OSTEOPOROTIC SPINE MOTION ANALYSIS

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INTRODUCTION

The surface method of measuring lower thoracic and lumbar spine motion with Fastrak® was examined for validity. There is an increasing awareness of the health risks of exposure to radiation associated with repeated radiographic assessment of spinal curvature and spinal movements. As a skin-surface measurement device, Fastrak® was employed to study the effect of low bone mineral density on spine motion. However, the reliability and validity of data recorded has not been established. The purpose of this study was to develop a methodology to determine the accuracy of the surface measurement device when it is applied on osteoporotic spine motion analysis.

METHODS

The Fastrak® system consists of a source of pulsed electromagnetic waves and four sensors of signals. The source was placed in fixed positions close to the subject. The sensors of signals were attached to the skin overlying spinous processes. The angle and distance between each sensor and the source were then sampled at 30 Hz and input to computers for calculation.

Nine volunteers (3 men, 6 women, 73±4 yrs old) with different level of bone mineral density (2 normal, 5 osteopenia, 2 osteoporosis) agreed to participate. In this study, the region of interest is lower thoracic spine and lumbar spine. The tips of the spinous processes of the seventh thoracic (T7), the first lumbar (L1), and first sacral (S1) vertebrae were identified by palpation and three sensors were placed over them. Three more sensors were evenly distributed on the spine between T7 and L1 and two more between L1 and S1 to reconstruct the spine curvature. Two sets of Fastrak® systems were used in this study.

With sensors attached, the subjects were requested to take lateral radiographs in three postures: neutral upright, full flexion, and full extension. In order to facilitate the image processing, two radiopaque lead markers were fixed on each sensor as shown in Figure 1.

The sagittal rotation and translation of vertebrae and sensors were then calculated from the radiographs. The vertebral body corners of T7, L1, and S1 were marked out on the three radiographs using the method presented by Frobin [1]. The translation and rotation of the overall lower thoracic spine and lumbar spine were calculated from the corners points of T7, L1 and that of L1, S1, respectively. As for the sensors, the lead markers were easily identified on the radiographs and two lead markers on one sensor could determine the orientation and location of that sensor. Therefore, the movement of sensors on T7, L1, and S1 could be calculated.
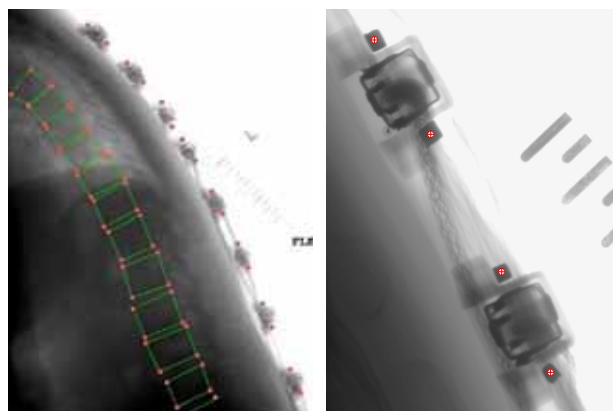
Figure 1: Manual 4 points quadrangles and sensors with radiopaque markers mounted on skin.

RESULTS AND DISCUSSION

Table 1 shows the differences of rotation angle and translation distances in two orthogonal directions calculated from vertebrae corners and lead markers on the sensors. The differences are relative differences in percentage, i.e., the calculated differences are divided by the motion range calculated from vertebrae corners. These differences were regarded as the error of the surface measures with respect to radiographic measures. It can be observed the accuracy is poor. It might be caused by the fatty bagged back of the aged subjects and the inaccurate palpation of osteoporotic spines.

	T7-L1		L1-S1	
	F / N	**E / N**	**F / N**	**E / N**
Rotation Angle	5.62%	12.3%	8.31%	10.85%
Translation X	16.30%	8.56.3%	9.47%	4.59%
Translation Y	9.34%	11.40%	2.41%	7.83%

Table 1: The accuracy of surface measures and radiographic measures. (F/N: Flexion-Neutral, E/N: Extension-Neutral)

CONCLUSIONS

Radiographs taken with 3D sensors are demonstrated as a method of accuracy estimation of surface measurement. It is expected that the relationship between the measured data obtained with the two methods can be established when sufficient subjects are examined and the surface measured data can be compensated. Therefore, more accurate data could be collected and radiographic risk eliminated. Although the accuracy calculation method is applied on elderly people with osteoporotic spine in this study, it is obvious that the method is applicable to normal healthy person as well.

REFERENCES

1. Frobin W, Brinckmann P, Leivseth G, Biggemann M, Reikeras O. Precision measurement of segmental motion from flexion-extension radiographs of the lumbar spine. *Clin Biomech* **11**(**8**), 457-465, 1996.