INFLUENTIAL FACTORS ON CLINICAL ACCURACY OF CT-BASED ACTIVE INFRARED NAVIGATION SYSTEM.

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INTRODUCTION

Computer assisted navigation technology has been widely applied to spine surgeries. Compared with traditional method, navigation guided surgery has shown greater advantage, especially in the aspect of accuracy (Gelais 2012, Shin 2012). Navigation accuracy plays important role especially in challenging regions such as cervical and thoracic vertebrae (Liu 2010, Tian 2013).

However, as our clinical experience, ideal accuracy could not be easily obtained and sustained. Clinical factors, such as light, movement of camera and bed, distance between camera and patient tracer, were supposed to influence clinical accuracy. As we know, there is no study reporting the issues. Our goal is to determine if and how those factors affect the accuracy of CT (computerised tomography) -based active infrared navigation system.

MATERIALS AND METHODS

A Sawbone® model with pre-placed titanium marker points was taken to mimic human lumbar bone (figure 1). The CT-based active infrared navigation system (from Stryker®) was used. Four to six titanium marker points on L2 were selected to accomplish the manual point to point registration process. The positions and postures of model, bed, camera, and tracer were finely controlled.

After registration, clinical accuracy was measured using three titanium marker points from spinous process and facet on each vertebra. In the ‘design interface’ of navigation software, the coordinates of target marker points were recorded, which we describe as ‘image coordinate’ in this paper. Then in ‘navigation interface’, we use a pre-registered pointer to measure coordinates of each marker point (figure 1), which we describe as ‘navigation coordinate’ in this paper. The distance between image coordinate and navigation coordinate is defined as clinical accuracy.

We investigated several clinical factors including shadowless lamps, movement of bed, and distance between camera and patient tracer.

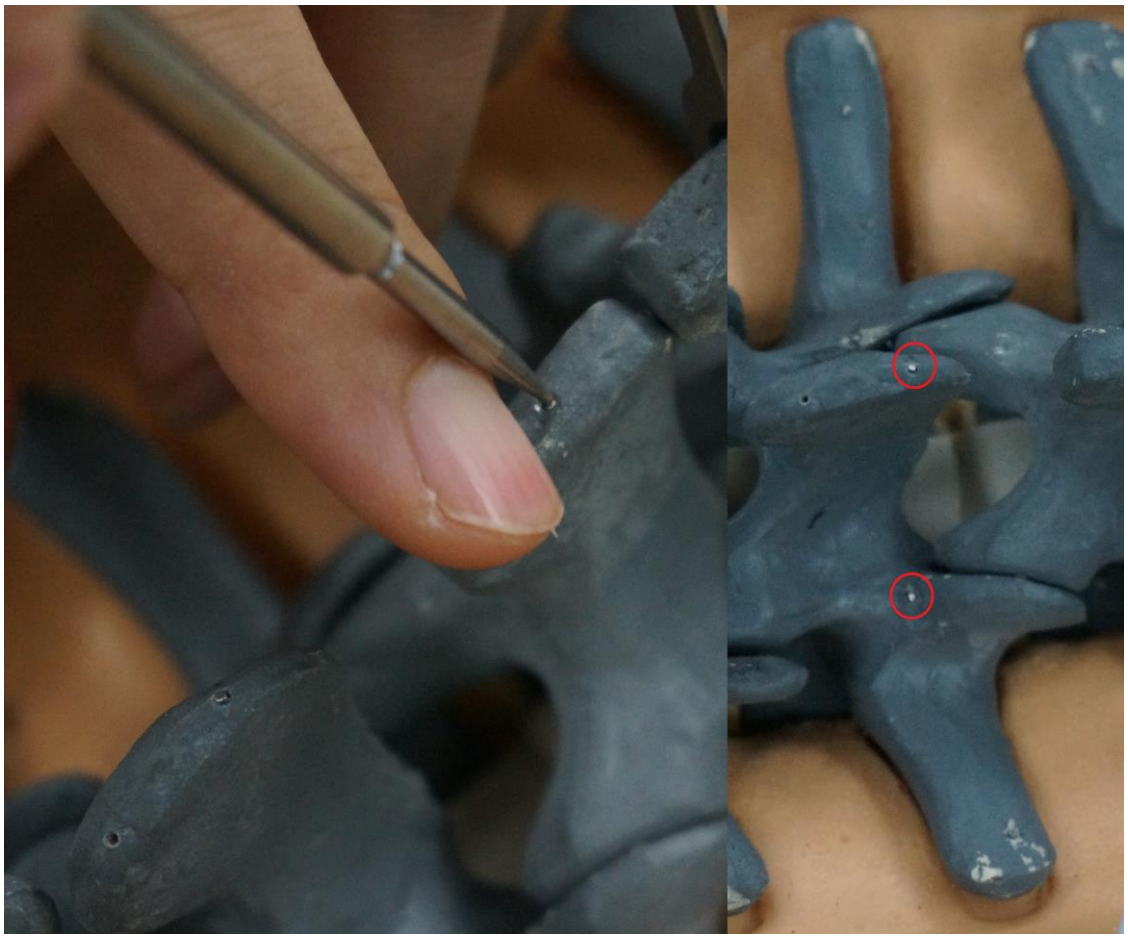


Figure 1: Navigation coordinates measurement using a pointer and Sawbone model with titanium marker points (red circles)

RESULTS

Movement of operation bed

After manual registration process, clinical accuracy was recorded. Then after changing of the height or angle of the bed, clinical accuracy was recorded again without re-registration. The navigation system was not able to sustain its clinical accuracy when bed was moved (Table 1).

	Initial registration		After bed move		Pared t test
	Mean	SD	Mean	SD	*P*
Up	3.01	1.62	3.79	2.32	0.004
Down	3.01	1.62	5.66	2.22	0.000
Head up	3.01	1.62	3.49	2.19	0.016
Head down	3.01	1.62	3.28	1.58	0.083
Left up	3.01	1.62	3.08	1.14	0.762
Left down	3.01	1.62	3.41	1.69	0.038
Restore to initial status	3.01	1.62	2.66	1.48	0.066

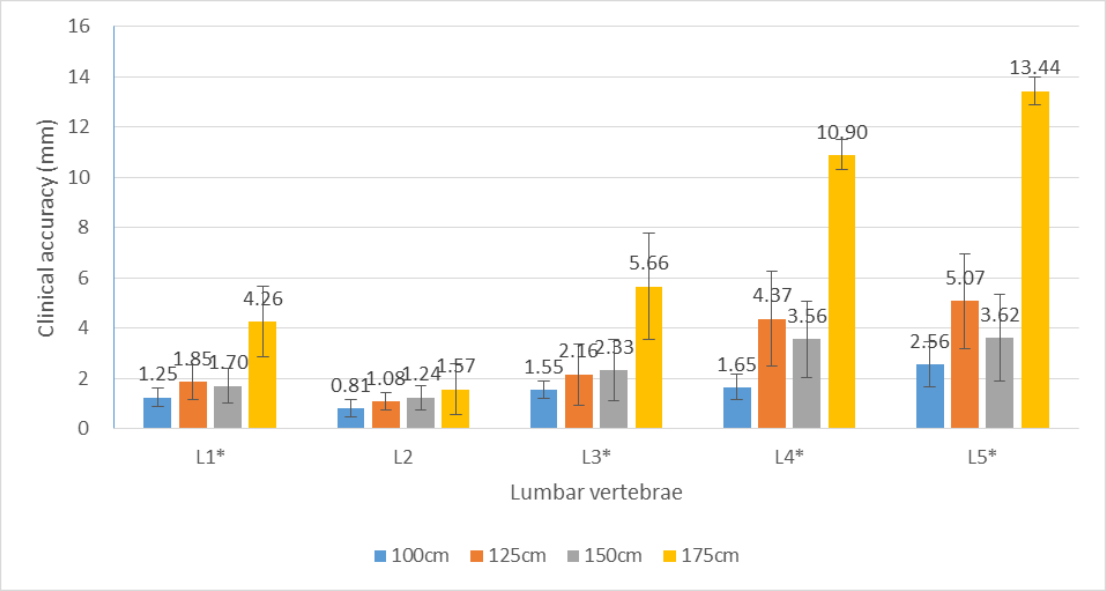
Up/down: Bed was 10 cm higher or lower than initial position; Head up: The head side was elevated and the foot side was degraded. The angle between bed and initial level was 5 degrees; Head down: Like 'head up' but the bed was moved the opposite way; Left up/down: Bed was

rotated 15 degrees along head-foot axis from initial position so that the left side of model was higher/lower.

Table 1: Clinical accuracy of CT-based navigation system under different bed movement（N=42）

Distance between camera and patient tracer

We tested four different distances between camera and patient tracer. At each distance, we did registration process separately and recorded the clinical accuracy. In general, the shorter the distance, the better the clinical accuracy (Figure 2).



* P<0.001 by analysis of variance.

For L2, which was the registration lumbar, no significant difference of clinical accuracy was found between different distances. However, the clinical accuracy was numerically larger under larger distance. For the other vertebrae, significant difference of clinical accuracy was found between different distances according to the analysis of variance.

Figure 2: Clinical accuracy of CT-based navigation system under different distance between camera and patient tracer

Shadowless lamps

The exposure of shadowless lamps may alter the clinical accuracy of CT-based active infrared navigation system (Table 2). The clinical accuracy of L1 and L5 became worse after shadowless lamps were turned on.

	Lamp off			Lamp on			Student t test
Lumbar	N	Mean	SD	N	Mean	SD	*P*
1	18	1.62	0.61	9	2.19	0.84	0.040
2	12	1.22	0.40	6	1.40	0.58	0.470
3	18	2.35	1.06	9	2.00	0.50	0.434
4	18	3.60	1.63	9	4.21	0.82	0.198
5	18	3.57	1.64	9	5.09	1.15	0.020

Table 2: Clinical accuracy of CT-based navigation system when shadowless lamps were on or off

DISCUSSION

There are two major methods to assess the accuracy of navigation assisted surgery. One way is to measure the accuracy of navigation system under ideal experimental condition (Koivukangas 2011), which is quite different from clinical condition. Thus, this method reveals the accuracy mostly like nominal accuracy. The navigation accuracy of clinical operation could be significantly different from that of ideal experiment (van de Kraats 2006). Another way, which has been practiced in many studies (Gelalis 2012, Shin 2012, Tian 2011, Liu 2010, Tian 2013), is to classify different relationship between pedicle screws and pedicles using post-operative CT scan after navigation assisted pedicle screw placement surgery. However, under varied clinical factors, this method is not suitable for comparison between different equipment. This method is not able to provide accuracy numerically.

In this study, we define clinical accuracy as the distance between 'image coordinate' and 'navigation coordinate'.

The accuracy of CT-based navigation may be affected by the position alteration between pre-operative CT scan and operative position of spine sequence. However, there are many other factors affecting the accuracy of navigation system in clinical practice.

This study showed that the clinical accuracy became better when the distance between camera and patient tracer decreased. The ideal camera-tracer distance was 1 meter, which should be achieved before surgery. However, under this distance, the visible area of the camera is relatively limited, which may influence the convenience of operation.

The clinical accuracy of the navigation system in this study may become worse because of exposure to lamps, movement of camera or bed. Therefore, when the point to point registration is done, the camera and bed should not be moved. Otherwise, surgeon should recheck the accuracy or re-register to assure clinical accuracy.

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