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The Spine Journal 6 (2006) 185–189

THE SPINE JOURNAL

Changes in the iliac crest–lumbar relationship from standing to prone

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Received 11 March 2005; accepted 14 July 2005

Abstract

BACKGROUND CONTEXT: It is known that positioning patients on the Jackson and Andrews operative tables causes changes in lumbar lordosis and pelvic rotation. However, it is unknown if the relationship between the iliac crest and underlying lumbar levels, in particular the L4–L5 interspace, changes from standing to prone on these tables.

PURPOSE: To assess the changes in the relationship between the iliac crests and lumbar spinal levels from standing to prone on two different operative positions using the Jackson and Andrews frames.

STUDY DESIGN/SETTING: Comparative analysis of iliac crest position relative to spinal levels in the preoperative standing position and while positioned on the Jackson and Andrews frames.

PATIENT SAMPLE: 48 randomly selected patients who underwent spinal surgery on either the Jackson or Andrews frame.

OUTCOME MEASURES: Imaging.

METHOD: Comparative measurements were made of the preoperative and intraoperative plain lateral lumbar radiographs. The location of the superior border of the iliac crest relative to the L4 lumbar spine level was compared between radiographs.

RESULTS: Preoperatively, the iliac crest aligned with L4/L4–L5 spinal level in 79.2% of the 48 patients compared with 85.5% of intraoperative cases ($p=.59$). Intraoperative iliac crest level aligned with the L4/L4–L5 level in 80.8% and 90.9% of the patients on the Andrews and Jackson tables respectively ($p=.43$). Thirty-four patients (70.8%) demonstrated no change in iliac crest alignment between intraoperative and preoperative radiographs. There was a trend for the iliac crest to shift cephalad with operative positioning.

CONCLUSION: Approximately 30% of patients demonstrated changes in the relationship between the iliac crest and lumbar levels between standing and positioning prone. The intraoperative position of the iliac crest aligned more accurately with the L4/L4–L5 spine level on the Jackson and Andrews frame compared with preoperative standing radiographs respectively. Further biomechanical studies should investigate the implication for lumbopelvic fixation.

Keywords: Iliac crest; Lumbar spine; Operative position; Radiograph; Jackson frame; Andrews frame

Introduction

For spine surgeons, anesthesiologists, physiatrists, and general practitioners among others, the use of the iliac crests has been used as a marker of the L4–L5 interspace. This practice assumed a fixed relationship between the iliac crest and lumbar levels. However, if changes occur in the

FDA device/drug status: not applicable.

Nothing of value received from a commercial entity related to this manuscript.

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1529-9430/06/$ – see front matter
doi:10.1016/j.spinee.2005.07.002

relationship with operative positioning, this implies that the preoperative plain radiograph may be misleading as a template for the L4–L5 location relative to the iliac crest, and lumbopelvic fixation in the operative prone position may have biomechanical implications not yet investigated.

Review of the literature revealed interest in this topic but limited focused investigation of this issue [1–6]. Early on, Render confirmed the practice of using the iliac crests as an approximation of L4/L4–L5 spinal level to be reasonably acceptable, but noted that relying solely on the iliac crests could result in erroneous placement of epidural or spinal needles [1]. In an attempt to find another, perhaps more reliable landmark, Jung et al. proposed the use of the tenth rib line in combination with the iliac crests [2]. Others have investigated the effects of anatomic position on the reliability of the surface landmarks. Kim et al. [3] demonstrated little change in intercrestal line position with full lumbar flexion, and Fisher et al. [4] found hip flexion to produce up to a 21% widening of the interspinous space but did not correlate their findings with changes in the iliac crest position. Stephens et al. [5] and Guanciale et al. [6] established variations in lumbar sagittal alignment between standing and prone position on different operative tables but did not investigate changes in alignment between the iliac crest and lumbar levels. The purpose of this study was to investigate the relationship between the iliac crests and lumbar spinal levels in the standing versus prone position in two common operative positions.

Materials and methods

Forty-eight randomly selected patients, 18 males and 30 females with an average age of 58 years (range, 33–82 years) who underwent spinal surgery from January 1999 through June 2003 by two surgeons (HHB and SEE) were included in this study. Inclusion criteria were history of lumbar surgery, intraoperative placement on either an Andrews (Orthopaedic Systems, Inc., Hayword, CA) table or Jackson (Orthopaedic Systems, Inc.) spine table and availability of preoperative and intraoperative radiographs. Twenty-six patients, 13 males and 13 females with an average age of 58.4 years (range, 33–82 years) met inclusion criteria for the Andrews table group. Twenty-two patients, 5 males and 17 females with an average age of 56.6 years (range, 36–80 years) were included in the Jackson table group. Age difference was not significant between groups ($p=.66$).

Preoperative diagnoses included herniated nucleus pulposus, spinal stenosis, and two grade I degenerative spondylolistheses. Discectomy and laminectomy with or without posterior fusion comprised the procedures performed. Fusion procedures were done on the Jackson table, whereas non-fusion procedures were done on the Andrews table. Patients on the Andrews table were positioned prone with the hips and knees flexed 90°; those on the Jackson spinal table were in a nearly anatomic prone position with the hips and knees extended [5] (Figs. 1 and 2).

Fig. 1. Patient on an Andrews frame with the hips and knees flexed 90°.

Fig. 2. Patient on a Jackson table with the hips and knees extended.

Preoperative lateral plain radiographs of each patient in the standing position were obtained as part of the routine preoperative evaluation for spinal surgery. A line was drawn parallel to the superior edge of the iliac crest through the vertebral column in order to determine the associated lumbar spinal level (eg, L4 spinous process or L4–L5 interspinous space) (Fig. 3).

In addition to investigating the iliac crest to lumbar spine level relationship, attempts were made to quantify the changes. The distance between the line drawn and the caudad surface of the L4 spinous process was determined. When the line extended from the iliac crest intersected the spine cephalad to the caudad surface of the L4 spinous process, the distance measured was designated a negative number. When the line fell caudad to the caudad surface of the L4 spinous process, the distance was recorded as a positive number. The cephalo-caudal height of the L4 spinous process was also measured to provide baseline measurements of the different sizes of the L4 spinous process. Intraoperative radiographs were obtained with the 7patients positioned on the operating table and the above measurements repeated. L4 cephalo-caudal height was only recorded from the preoperative radiographs because there was no change noted between preoperative and intraoperative radiographs after the first 15 measurements owing to similarity in magnification. Intraobserver accuracy of the measurements was established with the first 15 radiographs. Preoperative and intraoperative measurements were compared and the statistical significance of the results determined using either an unpaired *t* test or Fisher exact test.

Lateral radiographs were selected for analysis because of the common use of the lateral view intraoperatively to localize spinal levels. In cases where right and left iliac crest levels differed on the lateral radiograph, the more superior iliac crest was used for measurement because it represented the shadow that was between the X-ray source and the spine. This choice provided a consistent measuring point between groups and accounted for approximately similar magnification of the vertebrae and ilium nearest the X-ray source.

Results

Andrews table group

Overall 21 patients (80.8%) had the iliac crest level aligned with the L4 spinous process or the L4–L5 interspace both preoperatively and intraoperatively (Table 1). However, all patients showed measurable variations between the preoperative and intraoperative position, and nine patients (35%) in the operative position also demonstrated greater than 1 cm of movement in either direction of the iliac crest relative to L4. Additionally, nine patients (35%) demonstrated a change in iliac crest level from preoperative to intraoperative position. The average cephalo-caudad height of the L4 spinous process in this group was 28 mm (SD 4 mm).

Jackson spine table group

In this group, 17 patients (77.3%) had preoperative radiographs revealing alignment of the iliac crests with the L4/L4–L5 spine level. Intraoperatively, the iliac crest line intersected the L4 spinous process or the L4–L5 interspace in 20 patients (90.9%) (Table 2). All patients showed measurable variations between the preoperative and intraoperative position, and five patients (23%) in the operative

Fig. 3. Lateral plain radiograph demonstrating the measuring technique.

position demonstrated greater than 1 cm of movement in either direction of the iliac crest line relative to lumbar spine level. Additionally, five patients (23%) in this group demonstrated a change in iliac crest level from preoperative to intraoperative position. Average L4 spinous process cephalo-caudal height was 25 mm (SD 4 mm).

There was no correlation between mean cephalo-caudad L4 spinous process height and iliac crest to lumbar spine alignment changes. The mean L4 spinous process height among the 34 patients with no change in iliac crest alignment was 27 mm (SD 5 mm). The mean among the 14 patients who did demonstrate a change in iliac crest alignment from preoperative to intraoperative position was 25 mm (SD 3 mm) (p=.37).

The analysis of groupings based on patient gender revealed no significant differences. Specifically, the percentage of male and female patients demonstrating no change in iliac crest alignment was similar. Twenty-one females (70%) and 13 males (72.2%) had no change in iliac crest to lumbar spine level alignment observed on preoperative and intraoperative radiographs (p=1.0). The change in distance from the iliac crest line to the caudad surface of the L4 spinous process with operative positioning was also similar for males and females.

Discussion

According to this investigation, preoperative standing radiographs of 48 patients demonstrated alignment of the iliac crest with the L4 spinous process or L4–L5 interspace in 79% of patients (Table 3). This finding was consistent with a previous study of 163 patients demonstrating the similar alignment 78.5% of the time [1].

In addition to investigating iliac crest alignment in the standing position, the effects of operative positioning were also studied. The data demonstrated a trend towards a higher likelihood of alignment of the L4/L4–L5 level with the iliac crest after intraoperative prone positioning compared with the standing preoperative position (p=.59) and more so on the Jackson versus the Andrews table (p=.43). All patients shifted the iliac crest relative to the L4 spinal level between the standing and prone position, and 23% to 35% shifted greater than 1 cm and across spinal levels. According to previous studies [5,6], this change likely occurred from changes in pelvic rotation and lordosis with positioning on the Jackson and Andrews tables. Lumbopelvic fixation in the operative position may therefore produce unwarranted biomechanical implications for individual patients that are outside the scope of this study. Similarly, Stephens et al. [5] and Guanciale et al. [6] expressed concerns that lumbar fixation on the Andrews table may not re-create physiologic lordosis for the individual patient.

Despite this important insight, there are limitations to this study worth noting. Statistically significant differences cited as trends between patient groups may become significant with greater statistical power. The authors tried to minimize this likelihood in the measurements by analyzing movements of greater than 1 cm, although all patients demonstrated a measurable shift in the iliac crest to the L4 level alignment from standing to prone.

This research has important implications for the spine surgeon. First, patient placement in the two operative

Table 1
Distribution of spine level correlating with preoperative and intraoperative iliac crest level in the Andrews table group

	Preoperative		Intraoperative	
Level	No.	%	No.	%
L3	1	3.8	2	7.7
L3–4	2	7.7	2	7.7
L4	18	69.2	17	65.4
L4–5	3	11.5	4	15.4
L5	2	7.7	1	3.8

Table 2
Distribution of spine level correlating with preoperative and intraoperative iliac crest level in the Jackson spine table group

	Preoperative		Intraoperative	
Level	No.	%	No.	%
L3	0	0.0	0	0.0
L3–4	2	9.1	1	4.5
L4	13	59.1	15	68.2
L4–5	4	18.2	5	22.7
L5	3	13.6	1	4.5

Table 3
Distribution of spine level correlating with preoperative and intraoperative iliac crest level in the entire population

	Preoperative		Intraoperative	
Level	No.	%	No.	%
L3	1	2.1	2	4.2
L3–4	4	8.3	3	6.3
L4	31	64.6	32	66.7
L4–5	7	14.6	9	18.8
L5	5	10.4	2	4.2

positions investigated may result in shifts in the iliac crest level relative to the L4/L4–L5 location greater than 1 cm or across levels. There was a slight trend for the L4/L4–L5 location to shift cephalad relative to the iliac crest. Therefore, neither preoperative radiographs nor palpation of the iliac crests with the patient positioned for surgery will result in accurate identification of underlying lumbar spinal level in 100% of cases. The shift in the relationship between the iliac crest and spinal levels in the standing versus prone positions may have biomechanical implications for lumbopelvic fixation in individual patients and should be investigated further.

This research also has important implications for the fields of anesthesiology and physiatry as well. Patient placement on the Andrews table with the hips flexed to 90° is analogous to the knee chest and lateral decubitus positions commonly used in these fields of medicine for accessing the spinal canal. For this reason, the reliability of the iliac crests as an indicator of spinal level in these positions should only be considered as accurate as previously discussed.

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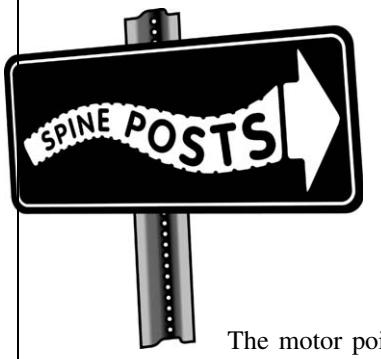

One Hundred Fifty Years Ago in Spine

The motor points, which define the interface between nerves and muscles, were first described by Robert Remak [1] in 1855. Remak had been an assistant of Johann Lucas Schönlein, who in his clinic at the Charité in Berlin had been the first to teach medicine in German instead of Latin.

Reference

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