An anatomic study of the interspinous space of the lumbosacral spine

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Abstract

Purpose The purpose of this study is to quantify the interspinous anatomy at the L4/5 and L5/S1 levels.

Methods One hundred reconstructed computer tomography scans of the lumbosacral spine were reviewed by two separate surgeons. Data were collected from the midline sagittal reconstructed image at the L4–5 and L5–S1 levels. Measurements obtained included the disc angle, anterior and posterior disc height, and maximum interspinous space in both the anterior–posterior and cephalad–caudal directions. The disc height and disc angle were correlated with the interspinous height.

Results The mean age of the patients reviewed was 47 years (range: 16–91; standard deviation: 20). According to our data population, the average length of the interspinous space was larger at the L4–5 level (13 mm) than the L5–S1 level (9 mm). The interspinous height was similar between the two levels. A poor correlation existed between the disc height or disc angle and the interspinous height. There was no correlation between measurements and age.

Conclusions The interspinous space available, as defined by computer tomography, at the L5/S1 level, is less able to accommodate current interspinous devices compared to the adjacent L4/5 level. The limiting factor is the length of the sacral part of the L5–S1 interspinous space.

Keywords Interspinous space · Lumbosacral spine · Interspinous spacers

Introduction

Spine surgery continues to advance toward less invasive techniques to address a multitude of problems. Lumbar interspinous spacers, although not a new concept [14], is such an alternative for use in the degenerative conditions such as spinal canal and foraminal stenosis [5, 12, 16], segmental instability [1], and back pain [7, 9]. Theoretically the implants are designed to unload the facet joints, and indirectly decompress the spinal canal or intervertebral foramen by providing distraction through the spinous processes and limiting extension at the implanted segment.

To our knowledge, the anatomic space available for these implants in the lower lumbar and lumbosacral spine has not been reported. Variability in both soft tissue and osseous posterior spinal anatomy is reflected by the range in size available for these devices [2]. Clearly, if the space is too large in a cephalad–caudal direction (interspinous height) then an implant will fit loosely and not obtain the required distraction between spinous processes. If the space is too small, then the implant will not fit without producing excessive kyphosis or requiring the removal of bone, potentially increasing the risk of spinous process fracture. Likewise, if the anterior–posterior dimension (interspinous length) of the interspinous space is too small then the interspinous device will not be implantable. This is a particular clinical concern at the lumbosacral junction.

Not only is little known about the defining dimensions of this anatomic space, but it is unclear whether this dimension varies with severity of degenerative disc disease. We hypothesized that the interspinous height might

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decrease with advancing age and resulting degenerative disease. Furthermore, it is not known whether the dimensions of the intervertebral disc, characterized by the disc height and disc angle, correlate with the potential interspinous space and in particular the interspinous height. Knowledge of such a correlation could assist in the pre-operative planning process as these dimensions can be more easily retrieved from a standard lateral projection radiograph than can the dimensions of the interspinous space.

The purpose of this study was to define the interspinous space available in the lower lumbar and lumbosacral spine measured with computer tomography. As well as determining if a correlation exists between the interspinous height and the corresponding disc height or disc angle, and if a correlation exists between the interspinous height and age.

Materials and methods

We retrospectively reviewed 100 reconstructed computer tomography scans of the lumbosacral spine taken at the London Health Science Centre, Canada, between 2004 and 2006. The scans were randomly selected from all available scans performed at our institution during that time. Scans were not included in this review if the image quality was poor, the entire lumbar spine and lumbosacral junction was not in view, surgery had been performed on the spinal column, or the spine had evidence of any other pathologic process other than degenerative spondylosis. The indication for the radiological investigation was blinded from the study assessors; these CT scans were “negative trauma screening scans” and were not performed to diagnose specific lumbar pathology. Scans were also selected to encompass a large range in subject age so that the description of the interspinous space reflected potential age-related changes.

The computer tomography scanner (VCT, GE Medical Systems) provided a slice size (2.5 mm × 1.25 mm) reconstructed for PACS viewing to 5 mm cuts. All scans were performed with the patient in the supine position. CT analysis was performed independently by a spinal fellow and spinal surgeon using the midline sagittal reconstructed image at the L4/5 and L5/S1 levels. Confirmation of the slice position was obtained by cross-referencing the sagittal image to the axial cut. All digital images were measured with the computer program Centricity 2.1 (GE Medical Systems) using the calibrated guide.

Measurements obtained at each level included a disc angle, anterior disc height, posterior disc height, the interspinous height (maximum cephalad-caudal measurement) and interspinous length (maximum anterior-posterior measurement) (Fig. 1). The interspinous length was

Fig. 1 Measurements obtained at each level including: disc angle, anterior disc height, posterior disc height, the interspinous height and interspinous length

defined anteriorly by either the lamina or ligamentum flavum depending on where a spacer most likely would fit, and the most posterior insertion of the interspinous ligament to the spinous processes (which also represented the most anterior insertion of the supraspinous ligament to the spinous process). The interspinous height was defined by maximum distance between the spinous processes superiorly and inferiorly.

Inter-observer reliability was determined for all measurements using the interclass correlation coefficients (ICC). Degree of agreement was determined based on criteria published by Landis and Koch [6]. The reported measurements are the average between the two assessors. The interspinous height and length were compared between levels using student *t* test (*p* value ≤ 0.05 is significant). The degree of correlation between maximum interspinous height and disc height, disc angle, and age was assessed using the Pearson *R* correlation.

Results

The mean patient age was 47 years (range: 16–91 years). Assessors obtained all measurements for each of the 100 patients. The average result of each measurement is reported in Table 1. Acceptable agreement was achieved between the two observers. Intra-class correlation coefficient ranged between moderate and near perfect (Table 2).

Table 1 Result of each measurement obtained at both L4–5 and L5–S1 levels

Data value	Mean	Median	Range	Standard dev.	<i>p</i> value
Anterior disc height (mm)					
L4–5	11	11	5–16	2.2	
L5–S1	11	11	6–17	2.2	
Posterior disc height (mm)					
L4–5	6	6	2–10	1.8	
L5–S1	5	5	1–10	1.6	
Disc angle (degrees)					
L4–5	10	9.5	2–18	3.2	
L5–S1	14	14	5–23	4.6	
Interspinous height caudal-cephalad (mm)					
L4–5	6	6.5	1–14	3.0	0.17
L5–S1	7	6.5	2–18	3.2	
Interspinous length anterior-posterior (mm)					
L4–5	13	13	3–22	3.2	<0.001
L5–S1	9	9	1–20	3.4	

The average interspinous length was larger at the L4–5 level (13 mm) than the L5–S1 level (9 mm; $p < 0.001$; Table 1). At L4–5 the interspinous length was ≤ 10 mm in 18% of subjects, while at L5–S1 it was ≤ 10 mm in 63% of patients (Fig. 2). The interspinous height was similar between the two levels (mean of 6 mm at L4–5 and 7 mm L5–S1; Table 1), although L5–S1 had a broader range (Fig. 3).

We found no correlation between age and any of our measured values (Pearson R range: -0.29 to 0.04). Poor correlation existed between Cobb angle or disc height and the maximum interspinous height (Pearson R range: -0.28 to 0.29).

Discussion

Clinical reports have provided promising early data for a number of different interspinous implants including the

Fig. 2 Interspinous length for the L4–5 and L5–S1 levels for the 100 study patients **Fig. 3** Interspinous height for the L4–5 and L5–S1 levels for the 100 study patients

X-stop [12, 16], DIAM [7], and Wallis [9] for degenerative spinal conditions. Four-year results were obtained for the longest followed of these implants [5] and demonstrated an improved quality of life versus non-operative management [3]. The results of longer term follow-up studies are needed [4]. Basic science has provided some insights into the treatment mechanism of these implants. Lumbar cadaveric studies have shown that at the implanted level the disc and facet joints are unloaded [13] [15], and narrowing of the spinal canal and intervertebral foramen is prevented in extension [8]. Position magnetic resonance imaging of the lumbar spine pre- and post-in vivo implantation has shown

Table 2 Moderate to high inter-rater reliability was established for each measure with an ICC ranging from 0.5 to 0.9 using a two-way random effect model with agreement and single-rater reliability

Measurement	Intraclass correlation coefficient	95% confidence interval	<i>p</i> value two-tailed	Agreement
5/1 disc angle	0.87	0.79–0.91	<0.0001	Near perfect
4/5 disc angle	0.78	0.68–0.85	<0.0001	Near perfect
Interspinous space L4–5 superior–inferior	0.731	0.63–0.81	<0.0001	Substantial
Interspinous space L4–5 anterior–posterior	0.5	0.25–0.62	<0.0001	Moderate
Interspinous space L5–S1 superior–inferior	0.62	0.49–0.73	<0.0001	Substantial
Interspinous space L5–S1 anterior–posterior	0.63	0.4–0.77	<0.0001	Substantial

significantly improved spinal vertebral canal and intervertebral foramen spaces at the implanted level [10, 11]. However, despite the fact that these described biomechanical and radiographic effects are dependent on changes to the interspinous space, to our knowledge there is no description of the morphology of the space into which these implants are placed.

In the lumbar spine, degenerative central and/or foraminal spinal stenosis most commonly affects the L4/5 followed by the L5/S1 level. There are few reports of implantation of this type of device at the L5/S1 level. This may in part be due to concerns regarding the anatomic constraints at this level. Indeed, the common perception that the interspinous length at L5–S1 is smaller than that found in the lumbar spine was confirmed by this study. The L5–S1 interspinous length was found to be significantly less than L4–5 ($p < 0.001$). This was generally due to an insufficiency on the sacral side of the space as opposed to the lumbar side. At L5–S1 the interspinous height exceeded the largest sized Diam implant (14 mm) in 2% of patients in this cohort, and accommodated an implant in all subjects at the L4/5 level. The goal of our study was to define the interspinous space available at this level and its relationship, if any, to other anatomic dimensions. However, we found no correlation between the interspinous height with disc angle, anterior disc height or posterior disc height.

We appreciate the limitations of this study. The posterior boundary we used in determining interspinous length can be difficult to define which could potentially lead to under measurement. One would ideally prefer the implant not to sit on a diverging spinous process posteriorly and therefore we defined this as the posterior limit for an implant. We believe that because our intraclass correlation coefficient was substantial, and we averaged the two assessors' measurements, any significant discrepancy in determining the interspinous length was minimized. Our data has also been taken from static supine imaging that do not give a representation of the interspinous space through a full range of motion or more importantly in the upright position when a interspinous spacer would most likely function. However, for most spinal surgeons, clinical decision making is made from CT's or MRI's in which the patient is placed in a supine position. We also appreciate that the anterior–posterior space could be enlarged during surgical implantation, although this would detract somewhat from the ideal implantation technique and weaken the spinous processes. Our patient population represents a large age range and does not specifically represent the cohort diagnosed spinal stenosis for which the implants are commonly utilized. However, our intent was to determine if a relationship existed between age and interspinous space so we purposefully chose a wide age range of patients.

The data from this paper is an important step in quantifying the interspinous height and length in the lower lumbar and lumbosacral spine. It provides an insight into the anatomic boundaries of the lower lumbar and lumbosacral interspinous space. Careful pre-operative evaluation should occur before implanting an interspinous device, particularly at L5–S1.

Conflict of interest None.

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