CT scan assessment of the pathway of the true lateral approach for transforaminal endoscopic lumbar discectomy

IS IT POSSIBLE?

We performed a prospective study to examine the influence of the patient’s position on the location of the abdominal organs, to investigate the possibility of a true lateral approach for transforaminal endoscopic lumbar discectomy. Pre-operative abdominal CT scans were taken in 20 patients who underwent endoscopic lumbar discectomy. Axial images in parallel planes of each intervertebral disc from L1 to L5 were achieved in both supine and prone positions. The most horizontal approach angles possible to avoid injury to the abdominal organs were measured. The results demonstrated that the safe approach angles were significantly less (i.e., more horizontal) in the prone than in the supine position. Obstacles to a more lateral approach were mainly the liver, the spleen and the kidneys at L1/2 (39 of 40, 97.5%) and L2/3 (28 of 40, 70.0%), and the intestines at L3/4 (33 of 40, 82.5%) and L4/5 (30 of 30, 100%). A true lateral approach from each side was possible for 30 of the 40 discs at L3/4 (75%) and 23 of the 30 discs at L4/5 (76.7%). We concluded that a more horizontal approach for transforaminal endoscopic lumbar discectomy is possible in the prone position but not in the supine. Prone abdominal CT is more helpful in determining the trajectory of the endoscope. While a true lateral approach is feasible in many patients, our study shows it is not universally applicable.

Initially endoscopic surgery for lumbar disc herniation was performed by a posterolateral approach.1-4 Kambin and Zhou5 introduced the concept of the ‘triangular working zone’ on the posterolateral corner of the intervertebral disc between the exiting root and the dural sac, enabling transforaminal endoscopic disc surgery to be performed through this area. As access to the ventral epidural space under direct vision is frequently needed to achieve an adequate decompression, more horizontal access routes have been developed by various authors.6-9 However, these inevitably increase the risk of penetrating the abdominal cavity. Accordingly, truly tangential insertion of the endoscope by a ‘true lateral approach’ has been avoided because of its greater risk.8

Some authors have recommended a pre-operative abdominal CT scan to show all the abdominal structures if a more lateral approach is being considered.8,9 Preferably the scan is performed with the patient prone because most transforaminal endoscopic discectomies are performed in this way.8 A safe endoscopic trajectory will not injure the abdominal organs, and its associated skin entry point, can also be determined from these images. Logically, the prone position with the abdominal muscles relaxed on an operating frame should allow the abdominal contents to move ventrally, allowing a wider window for a true lateral approach but we are unaware if this assumption has been demonstrated.

In this study we compared CT images taken in both the supine and the prone position to determine whether position affects the location of the abdominal organs and any possible trajectory of an endoscope. Based on these results, we also determined the proportion of patients in whom a true lateral approach is feasible.

Patients and Methods

The study included 20 consecutive patients (12 men and eight women) with a lumbar disc herniation who underwent a transforaminal endoscopic discectomy through an extreme lateral approach.10 Their mean age at the time of surgery was 37 years (24 to 68) and their mean body mass index (BMI) was 23.2 kg/m² (18.4 to 29.6). Patients with a history of intra-or retroperitoneal surgery were excluded. Each patient underwent an abdominal CT scan before surgery in both the supine and the prone position, which included the lumbar spine, intra-abdominal organs and skin. Conventional abdominal CT scans were first taken in the supine position. The patient was then turned prone on an operating frame with their
abdomen relaxed, and the scans were repeated. CT images were reconstructed parallel to each disc space from L1 to L5, at 2 mm intervals (Fig. 1).

Using an axial cut, including the lowermost disc level among the CT images reconstructed parallel to each disc space from L1 to L5, we determined the most ventral transforaminal approach from both right and left sides that would avoid injury to any abdominal organ, and would not be obstructed by the facet joints. The target point was the junction of the posterior border of the caudal vertebral body and the medial border of the pedicle, and the reference line was a horizontal line extending from the posterior border of the caudal vertebral body. The approach angle between the determined route and the reference line was measured, and anterior and posterior deviation from the target point designated as negative and positive values, respectively (Fig. 2). The L5/S1 discs were excluded because transforaminal access is frequently difficult, and variations in the height of the iliac crest can cause measurement errors. We also excluded the L4/5 discs when the iliac crest was 10 mm higher than the inferior margin of the corresponding disc, because of the expected difficulty of a transforaminal approach. The abdominal organ that first interrupted the approach route as it moved from the posterior to the anterior aspect of the patient’s trunk was designated as the obstacle preventing a more lateral approach. A true lateral approach was defined as feasible when the access angle was < 0° at each disc level.

Statistical analysis. We compared access angles between the prone and supine positions on both right and left sides, and at all levels between L1 and L5, using Wilcoxon’s signed ranks test. A p-value < 0.05 was considered statistically significant.

Results
We found that the iliac crest was 10 mm or more higher than the inferior disc margin for three L4/5 discs in the supine position and five L4/5 discs in the prone position; these data were therefore excluded from our analysis. The mean access angles in the supine position were approximately 20° at L1/2, and 10° at L2/3 on each side, decreasing to < 5° at L3/4 and L4/5. In the prone position, the mean access angles were < 10° even at L1/2, and had negative angles at L2/3, L3/4, and L4/5. There was no statistically significant difference in access angles between
the right and left sides at any level in the supine position (p³0.055; Table I). However, in the prone position the mean angle was significantly greater (less horizontal) from the right at L2/3 and L3/4 than from the left. At each level, the mean access angle was significantly smaller in the prone position than in the supine position (Table I).

The obstacles to a more lateral approach at L1/2 (39 of 40, 97.5%) and L2/3 (28 of 40, 70.0%) were mainly the liver, the spleen and the kidneys. In contrast the lateral approach was obstructed by the intestines in 33 of 40 cases at L3/4 (33 of 40, 82.5%) and in all 30 at L4/5 (30 of 30, 100%) (Fig. 3).

In the prone position, a true lateral approach was possible in 24 of 40 cases at L2/3 (60.0%), for 30 of 40 at L3/4 (75.0%) and for 23 of 30 at L4/5 (76.7%). By contrast, only ten of 40 access routes had safe trajectories at 0° at L1/2 (Fig. 4).

**Discussion**

Modern endoscopic surgery for lumbar disc herniation was developed in the early 1990s and used a posterolateral approach aiming towards the centre of the disc.1-4 It also depended on the spontaneous regression of the protruded annulus or nucleus after decompression of the central portion. Kambin and Zhou5 first demonstrated the radiological landmarks of a safe zone for the insertion of instruments on the dorsolateral corner of the intervertebral disc. The use of small-calibre endoscopes through this space allowed the peri-annular and neural structures to be seen and herniated disc fragments to be removed under direct vision.11,12 When the conventional posterolateral approach was used, the approach angle was 45°. As transforaminal techniques developed, the approach angle moved closer to the horizontal plane: from 35° to 45° from the horizontal as described by Kambin et al,6 to 25° to 30° by Yeung and Tsou,7 and 20° to 25° by Yeung and Yeung.8 Recently, Ruetten, Komp and Godolias9 introduced the extreme lateral approach in which, for levels L3/4 and L4/5, skin entry was made as close to the dorsal edge of the inferior articular process as possible. The advantages of a more horizontal approach angle and a more lateral skin entry point are an easier approach to the ‘triangular working zone’,12 greater direct visualisation of the protruded disc and epidural space, and more convenient manipulation of the instruments. However, this approach poses the risks of injury to intra- and retroperitoneal abdominal organs. For this reason, some reports have recommended a pre-operative CT scan of the abdomen if the extreme lateral approach is being considered.8,9 In order to define a safe approach route, the scan window should be wide enough to include all the intra-abdominal structures and the abdominal wall.9 The patient should also be scanned in the prone position.8 These suggestions were presumably made on the assumption that the location of various abdominal organs differs

**Table I.** Comparison of the mean (sd) access angles (°) at each level (Wilcoxon’s signed ranks test)

<table>
<thead>
<tr>
<th>Level</th>
<th>Supine Right</th>
<th>Supine Left</th>
<th>Prone Right</th>
<th>Prone Left</th>
<th>Supine vs prone</th>
<th>Prone vs prone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(°)</td>
<td>(°)</td>
<td>(°)</td>
<td>(°)</td>
<td>p-value</td>
<td>p-value</td>
</tr>
<tr>
<td>L1/2</td>
<td>18.6 (10.4)</td>
<td>21.8 (9.2)</td>
<td>7.9 (12.8)</td>
<td>5.8 (2.8)</td>
<td>0.055</td>
<td>0.147</td>
</tr>
<tr>
<td>L2/3</td>
<td>12.8 (10.7)</td>
<td>10.8 (10.4)</td>
<td>-3.1 (12.1)</td>
<td>-5.6 (1.0)</td>
<td>0.121</td>
<td>0.034</td>
</tr>
<tr>
<td>L3/4</td>
<td>3.5 (9.6)</td>
<td>1.4 (11.9)</td>
<td>-7.6 (11.4)</td>
<td>-12.5 (0.1)</td>
<td>0.489</td>
<td>0.005</td>
</tr>
<tr>
<td>L4/5</td>
<td>-1.8 (8.1)</td>
<td>-0.9 (11.4)</td>
<td>-8.3 (6.4)</td>
<td>-9.8 (2.2)</td>
<td>0.864</td>
<td>0.220</td>
</tr>
</tbody>
</table>

| L1-2   | 10            | 7            | 32           | 30          |
| L2-3   | 40            | 0            | 26           | 24          |
| L3-4   | 40            | 0            | 33           | 30          |
| L4-5   | 30            | 0            | 23           | 23          |

**Fig. 3**

Histogram showing the obstacles to the lateral approach at each intervertebral level. The main obstacles to the lateral approach are the liver, spleen and kidneys at L1/2 and L2/3, and the intestines at L3/4 and L4/5.

**Fig. 4**

Chart showing the possibility of a true lateral approach at each level. In the prone position, a true lateral approach was possible for 24 of 40 access routes at L2/3, for 30 of 40 access routes at L3/4 and for 23 of 30 access routes at L4/5. By contrast, only ten of 40 access routes had safe trajectories at 0° at L1/2.
between individuals and may change with position. Placing patients in the prone position with a relaxed abdominal wall allows the abdominal contents to move ventrally under the influence of gravity, thereby allowing a more lateral skin entry point with less risk of injury to the abdominal organs. However, we have been unable to find any evidence to support these assumptions.

We found that the mean approach angles in the prone position were significantly smaller than those in the supine position at each level. This suggested that a more horizontal approach was possible in the prone than in the supine position, even in the same patient. It appears that the internal organs, whether they are solid or soft, can migrate ventrally with gravity, which allows more space for safe placement of the endoscope. As most transforaminal endoscopic lumbar discectomies are performed with the patient in the prone position, an abdominal CT scan in the supine position is less helpful in assessing safe trajectory for the instruments. Ideally patients should be placed prone for their CT scan as if on an operating frame.

The obstacles to a more lateral approach were mainly the solid organs such as liver, spleen and kidneys at L1/2 and L2/3, and the soft organs such as intestine at L3/4 and L4/5. Unlike the solid organs, the intestines can also change their shape, location and volume with time, owing to peristalsis or the intraluminal accumulation of gas or faeces. Although the appropriate approach may be decided on the basis of a pre-operative CT scan, surgeons should keep this in mind during surgery, particularly at the lower lumbar levels. In our practice we usually recommend that patients with constipation or gaseous abdominal distension take laxatives per rectum on the morning of surgery to diminish such risks.

In the supine position there was no significant difference in the approach angle from either side; however, in the prone position the approach angle from the right at L2/3 and L3/4 was significantly greater (less horizontal) than from the left. In seven of the 20 approaches from the right the kidney posed an obstruction, especially at L3/4. As the right kidney is located lower than the left in the abdominal cavity owing to the presence of the liver, it is more likely to hamper the more horizontal introduction of the endoscope. Therefore, when approaching L2/3 or L3/4 from the right side, the risk of injury to the kidney should be considered.

A true lateral endoscopic approach to the intervertebral disc has been described but not recommended for fear of injury to the abdominal contents. Yeung and Yeung warned that the trajectory should not reach 0° from the horizontal plane or the abdominal cavity would be at risk. Even when an extreme lateral approach to the L3/4 and L4/5 levels was introduced, the dorsal edge of the inferior articular process was the ventral limit of entry. In our study, the ventral shift of the abdominal organs in the prone position permitted a more lateral approach. A transforaminal approach parallel to the coronal plane was possible in 30 of 40 cases (75.0%) at L3/4 and in 23 of 30 (76.7%) at L4/5. These findings show that, in contrast to previous reports, a true lateral or tangential approach, rather than an extreme lateral approach, is possible at L3/4 and L4/5 in a considerable number of patients. Although a conventional transforaminal approach may be effective for most patients with a prolapsed disc, a true lateral approach could be more helpful under certain circumstances, for example in those with a large central disc protrusion or a sequestered nucleus, especially at distal levels with narrow neural foramina. The 20° to 30° viewing angle of contemporary endoscopes theoretically allows horizontal viewing of the posterior annulus even with a 20° to 30° approach angle. However, because most endoscopic instruments are straight as well as rigid, it is not easy to manipulate them towards.

Diagrams showing the advantages of a true lateral access (solid line) over an extreme lateral approach (dotted line). In cases of a) a large centrally herniated disc or sequestrated fragment and b) a hypertrophied facet joint (black arrow), the true lateral access allows better visualisation of protruded or sequestrated disc material and easier manipulation of straight instruments.
posteriorly displaced disc material with the same working angle. True lateral access can provide better visualisation of protruded or sequestered disc material and easier manipulation of straight instruments to remove it (Fig. 5a). It is also helpful in patients with a hypertrophied facet joint, which encroaches on the neural foramen and frequently prevents a straight instrument from entering the triangular working zone, directing it instead towards the exiting nerve root. A more horizontal approach would both be safer and would not require the additional excision of the inferior articular process for access (Fig. 5b). Using this technique, the somewhat complicated calculations of trajectory could be avoided. The appropriate skin entry point is obtained by simply checking the target point on posteroanterior and lateral views. Nevertheless, the application of this approach to the L1/2 and L2/3 discs is still challenging. At the upper lumbar levels, the possible approach angle is relatively steep. In addition, because the surface of the upper lumbar disc is more concave and has a more acute angle in the axial plane, a horizontal approach carries a greater risk of damage to the dura.13

A limitation of this study is that it was based on CT images obtained pre-operatively, which may not perfectly mimic the conditions present at the time of surgery. Intraoperative CT scanning may be helpful in this respect but was not evaluated in this study. We originally planned to investigate the feasibility of pre-operative CT in the prone position. In the process of data analysis, we found that many patients had enough space for a true lateral approach to the region of the protruded disc, particularly at the lower lumbar levels. We are now trying to apply this approach to selected patients with large prolapsed discs or hypertrophied facet joints, as well as using approach angles of 0° or less. Another weakness is that we did not stratify the body mass index. Unintentionally, our series did not include any severely underweight or obese patients. Some obese patients have large amounts of intra-abdominal fat, which may surround the abdominal organs and prevent them from moving ventrally even in the prone position.

In conclusion, a more horizontal approach for transforaminal endoscopic lumbar discectomy may be possible in the prone position as a result of ventral shift of the abdominal organs. A prone CT scan should be obtained pre-operatively with the patient on an operating frame to determine the appropriate angle at which to introduce the endoscope. The organs most vulnerable to injury from a lateral approach are the liver, spleen and kidneys at L1/2 and L2/3, and the intestines at L3/4 and L4/5.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References