The Termination Level of the Dural Sac Relevant to Caudal Epidural Block in Lumbosacral Transitional Vertebrae: A Comparison between Sacralization and Lumbarization Groups

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Background: Lumbosacral transitional vertebrae (LSTV) are a relatively common variant and have been considered as one of the reasons for back pain. It is not unusual for clinicians to encounter patients with LSTV who require caudal epidural block (CEB) for pain management.

Objective: We investigated the termination level of the dural sac (DS) and anatomical features of the lumbosacral region relevant to CEB in patients with LSTV and compared these findings between sacralization and lumbarization groups.

Study Design: A retrospective evaluation.

Setting: A university hospital with inpatient and outpatient LSTV cases presenting low back pain.

Methods: Four hundred ninety-four LSTV patients were included and categorized into sacralization (n = 201) or lumbarization groups (n = 293). Magnetic resonance imaging (MRI) of all of the LSTV patients were reviewed to determine the level of DS termination, the shortest distance between the apex of the sacral hiatus and DS, and the presence and the caudal level of sacral perineural cysts. Each lumbosacral vertebra column was divided into 3 equal portions (upper, middle, and lower thirds). The MRI findings in both of the groups were compared and analyzed.

Results: The distribution frequency of the levels of DS termination demonstrated a significant difference between the 2 groups. The mean caudal DS level in the lumbarization group was significantly lower than the sacralization group (lower third of the S2 [131 (44.7%) of 293 patients] vs. lower third of the S1 [78 (38.8%) of 201 patients]). The DS terminated at the S3 in more than 19% of the lumbarization group, whereas in only one case of the sacralization group. Although the incidence of perineural cysts was not significantly different between the 2 groups, the mean level of caudal margin of perineural cysts in the lumbarization group was significantly lower than the sacralization group (middle third of the S3 [10 (35.7%) of 28 cases] vs. middle third of the S2 [11 (44%) of 25 cases]).

Limitations: This study reveals several limitations including the practical challenge of accurate enumeration of the transitional segment and the constraints on generalizability posed by the single-country study.

Conclusion: When planning CEB for patients with LSTV, pre-procedural MRI to check the anatomical structures, including the level of DS termination and caudal margin of perineural cysts, would be of great use for lowering the risk of unexpected dural puncture during the procedure, especially in the lumbarization cases.

Key words: Termination of the dural sac, dural sac termination, lumbosacral transitional vertebrae, transitional vertebra, caudal epidural block

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umbosacral transitional vertebrae (LSTV) are a relatively common variant and can be seen in 25% (range 15–35%) of the general population (1–3). Morphologically, LSTV have intermediate characteristics between the sacral and the lumbar vertebrae, and the transitional segment shows an elongation of its transverse process, with varying degrees of fusion. LSTV can be defined as either sacralized L5, which means “sacralization” of the lowest lumbar segment, or lumbarized S1, which means “lumbarization” of the most superior sacral segment of the spine (2,4). Back and buttock pain can be associated with LSTV, as shown by Lorenzo et al (2). Appreciation of anatomical variations due to LSTV may impact safe performance of caudal epidural steroid injection.

Caudal epidural block (CEB) is a relatively safe procedure which is used in a wide range of clinical settings (5–8). It is used for intra and postoperative analgesia in a variety of operations and has become one of the most commonly performed interventions in pain practice for those with low back pain and radiculopathy. Although it is rare, the potential complication of dural puncture during CEB could occur. Therefore, determining the anatomical location of the sacral hiatus, the sacrococcygeal ligament, and the level of termination of the dural sac (DS) are essential before performing CEB, to prevent dural puncture (7-9). In this context, the questions could arise whether the termination level of the DS of LSTV patients would be significantly different from that of others with similar clinical symptoms and furthermore, within the LSTV group, the caudal level of the DS would be different based on the type of transitional segment—sacralization and lumbarization.

Although there have been many studies regarding the mean level of termination of the DS in patients with low back pain and/or sciatica, there is a lack of publication that evaluated the DS termination separately for LSTV patients. Therefore, the purpose of the present study was to investigate the level of DS termination in relation to the spine in patients with LSTV, by using magnetic resonance imaging (MRI), and to compare this position between the sacralization and lumbarization groups. In addition, the distance between the apex of the sacral hiatus and the DS and the presence and caudal level of sacral perineural cysts were also evaluated in our LSTV patients.

**Methods**

This retrospective study was approved by the institutional review board and the requirement for informed consent was waived.

**Population**

We electronically searched the radiologic reports for MRIs of the lumbar-sacral spine that were performed from January 2000 to December 2016. The 3 keywords for the computer search were “transitional vertebra,” “lumbarization,” and “sacralization.” This initial search selected 665 images for assessment of possible causes of lower back pain and radiculopathy. Among them, 84 images were excluded from our study owing to postoperative spine (n = 33), presence of severe degenerative changes (n = 31), such as severe scoliosis or central canal stenosis, metastasis in the lumbosacral area (n = 2), and in patents where identification of the DS was difficult (n = 18). Patients under the age of 16 years (n = 12) or those that did not get lumbar radiographic series—anteroposterior (AP) and lateral and with or without oblique views (n = 39) were excluded. Patients who did not have available plain radiographs or computed tomography (CT) images, such as radiographs of the entire spine, rib series, thoracic radiographs, or chest CT image, that enabled counting of the number of thoracic vertebrae and correct identification of the L1 vertebral body, were further filtered (n = 36) to determine the correct numeric assignment of the LSTV. Finally, a total of 494 LSTV patients (mean age of 55.05 years, range of 17–89 years; 236 men and 258 women), composed of sacralization (n = 201) and lumbarization (n = 293) groups, were included in the study (Fig. 1).

**Image Analysis**

All images were reviewed on picture archiving and communication system workstations (G3, Infinitt, Korea). All of the 494 lumbar radiographic series were independently read by 2 radiologists (J.Y.J., 5 years of experience and Y.M.J, 8 years of experience). All LSTV patients were categorized into sacralization or lumbarization groups. Since depending on the number of thoracic vertebrae, the transitional vertebra can be interpreted as a sacralized L5 segment (sacralization) or a lumbarized S1 segment (lumbarization); we assume the number of thoracic vertebrae to be 12 in all of the patients, to gain consistency and reliability in determining the level of lumbar or sacral segment which locates the caudal tip of the DS. This would be especially helpful in confusing situations when hypoplastic ribs from transverse processes at the thoracolumbar junction or 11 and 13 pairs of ribs are seen.

Then, LSTV patients were classified according to Castellvi et al (10) (Fig. 2) into one of 4 types. Type I...
Termination Level of Dural Sac Relevant to CEB in LSTV

Fig. 1. *A flow chart of the patient selection.*

**MRI of lumbo-sacral spine including “transitional vertebra” or “lumbarization” or “sacralization” in the radiologic reports from 2000 to 2016 (n=665)**

Excluded (n=135):
- Postoperative spine
- Severe scoliosis or central canal stenosis
- Metastasis in the lumbosacral area
- Difficulty in identifying the dural sac
- Patients under age 16 years
- No lumbar radiographic series

Limitation in correct numeric assignment of the transitional segment (n=36)

LSTV patients (n=494)

Sacralization group (n=201)  Lumbarization group (n=293)

Fig. 2. *A schematic illustration of the Castellvi classification (10).*
exhibits dysplastic transverse processes, measuring at least 19 mm in height (craniocaudal dimension). Type II includes incomplete lumbarization or sacralization with the enlarged transverse process(es) that has pseudoarthrosis with the adjacent sacral ala. Type III describes complete lumbarization or sacralization with the enlarged transverse process(es), which has complete fusion with the adjacent sacral ala. Type IV involves type II on one side and type III on the other side. To minimize the number of categories, we classified the cases into 4 basic types regardless of unilateral or bilateral findings (2). Any discrepancies were settled by mutual consensus between the authors. If there were additional available CT scans covering the entire lumbosacral junction and sacrum, the CT images were used to arbitrate a disagreement between the readers (Fig. 3).

Fig. 3. Appearances of LSTV based on the Castellvi classification (10). The white asterisks show enlarged transverse processes in type I LSTV. The black asterisks show pseudoarthrosis, whereas the black stars show osseous fusion. As shown in types III and IV, additional CT images could be used for confirmation of the classification of LSTV.

The anatomic level of the DS tip was determined by using conventional lumbar MR images. Lumbar MR images were acquired with 3.0 Tesla (T) MRI machines (Skyra and Verio, Siemens Healthcare, Erlangen, Germany) or 1.5-T scanners (Avanto, Siemens Healthcare, Erlangen, Germany) using phased array spine coils in a supine position. Sagittal images were acquired using a slice thickness of 3.0 mm and a 0.3 mm interslice gap. Routine scans consisted of T1-weighted sagittal and axial images (TE range 3 – 13ms, TR range 450 – 704ms) and T2-weighted sagittal and axial images (TE range 91 – 95ms, TR range 3200 – 5910ms). In some MRI studies, sagittal short-tau inversion recovery (STIR) sequence (TE range 55 – 81ms, TR range 2500 – 4310ms) of the whole spine was available. The midsagittal sections for each subject were used when possible to improve the reliability for the measurement of the caudal end of DS.

Two radiologists independently reviewed the MR images. To establish the caudal tip of the DS in relation to the lumbosacral spine, the L5 and each sacral vertebra column was divided into 3 equal portions (upper, middle, and lower thirds [u, m, and l, respectively]) in considering the method of Saifuddin et al (11) (Fig. 4). By extending a line perpendicular to the long axis of the dura at the most inferior convergence point of the DS, the point where the perpendicular line crosses the adjacent vertebrae was determined to be the most caudal level of the DS. For statistical evaluation, each lumbosacral vertebral regional level of the caudal DS tip was assigned as numbers from one (lower third of the L5) to 10 (lower third of the S3). The shortest distance between the upper margin of the sacrococcygeal membrane and the DS was measured to estimate the safe length of advancing the needle for CEB (Fig. 5). The presence of a perineural cyst (Tarlov cyst) and its caudal level were also investigated (8). The level of caudal margin of perineural cysts were assigned as numbers in the same manner as described above. In cases where there was a disagreement between the readers, further discussion had been made to achieve consensus.

**Statistical Analysis**

All statistical analysis was performed using commercial software SPSS Version 20.0 (IBM Corporation, Armonk, NY). Descriptive statistics for baseline demographic data were calculated. Continuous variables are presented as mean ± standard deviation and categorical variables as frequency (percentages). For quantitative and qualitative comparisons between the 2 LSTV groups with lumbarization and sacralization, continu-
ous variables were compared by using the analysis of an independent samples t-test, and categorical variables were compared by using a chi-square test. For all tests, $P < 0.05$ was considered to be indicative of a statistically significant difference.

**Results**

Demographic data and cross-tabulation of imaging findings, other than the level of DS termination of all LSTV patients ($n = 494$), sacralization group ($n = 201$), and lumbarization group ($n = 293$), are outlined in Table 1.

No significant difference was found in age between the sacralization and lumbarization groups ($P = .364$). There were significantly more women (133 of 201) than men (68 of 201) in the sacralization group, whereas there were more men (168 of 293) than women (125 of 293) in the lumbarization group ($P < .001$). The 494 patients with LSTV were placed into 4 Castellvi classification subgroups: 101 patients (20.4%) had LSTV type I, 194 patients (39.3%) had LSTV type II, 141 patients (28.5%) had LSTV type III, and 58 patients (11.7%) had LSTV type IV. LSTV type I was significantly more common in the lumbarization group than in the sacralization group (92 [31.4%] of 293 patients vs. 9 [4.5%] of 201 patients, $P < .001$), whereas LSTV type III and IV were significantly more common in the sacralization group (84 [41.8%] of 201 patients for type III and 36 [17.9%] of 201 for type IV) than in the lumbarization group (57 [19.5%] of 293 patients for type III and 22 [7.5%] of 293 for type IV) ($P \leq .001$).

In our study population, 53 cases (25 [12.4%] of the sacralization group and 28 [9.6%] of the lumbarization group) of sacral perineural cysts were seen. The incidence of perineural cysts was not significantly different between the 2 groups ($P = .375$) (Table 1).

The mean shortest linear distance between the upper margin of the sacrococcygeal membrane (SCM) and the DS showed no significant difference between the sacralization (31.1 mm) and lumbarization groups (27.9 mm) ($P = .232$) (Table 1).

The level of DS termination was extending from the lower third of the L5 to the lower third of the S3. The level of termination of the DS in all of the LSTV patients was most commonly the lower one-third of the S2 (in 26.9% of the total population). In comparing by groups, however, the distribution frequency of the levels of DS termination on MR images demonstrated a significant difference between the sacralization and lumbarization groups. The mean caudal DS level in the
Table 1. Demographic data and results of cross-tabulation of findings

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 494)</th>
<th>Sacralization Group (n = 201)</th>
<th>Lumbarization Group (n = 293)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)*</td>
<td>55 ± 17.8</td>
<td>53.7 ± 18.2</td>
<td>55.9 ± 17.6</td>
<td>0.364</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Male</td>
<td>236</td>
<td>68</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>258</td>
<td>133</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>Subtype</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSTV type I</td>
<td>101 (20.4)</td>
<td>9 (4.5)</td>
<td>92 (31.4)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>LSTV type II</td>
<td>194 (39.3)</td>
<td>72 (35.8)</td>
<td>122 (41.6)</td>
<td>0.223</td>
</tr>
<tr>
<td>LSTV type III</td>
<td>141 (28.5)</td>
<td>84 (41.8)</td>
<td>57 (19.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>LSTV type IV</td>
<td>58 (11.7)</td>
<td>36 (17.9)</td>
<td>22 (7.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>Perineural Cyst</td>
<td></td>
<td></td>
<td></td>
<td>0.375</td>
</tr>
<tr>
<td>Presence</td>
<td>53</td>
<td>25</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Absence</td>
<td>441</td>
<td>176</td>
<td>265</td>
<td></td>
</tr>
<tr>
<td>Shortest Distance Between SCM and DS (mm) *</td>
<td>29.1 ± 24.5</td>
<td>31.1 ± 24.5</td>
<td>27.9 ± 24.4</td>
<td>0.232</td>
</tr>
</tbody>
</table>

LSTV = lumbosacral transitional vertebrae, SCM = sacrococcygeal membrane, DS = dural sac

*Data are the mean ± standard deviation

Table 2. Incidence of caudal level of the DS in LSTV patients and comparison between the sacralization and lumbarization groups

<table>
<thead>
<tr>
<th>Caudal Level of DS</th>
<th>Total (n = 494)</th>
<th>Number of LSTV Patients (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sacralization Group (n = 201)</td>
<td>Lumbarization Group (n = 293)</td>
<td></td>
</tr>
<tr>
<td>Lower third of L5</td>
<td>5 (1)</td>
<td>5 (2.5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Upper third of S1</td>
<td>22 (4.5)</td>
<td>22 (10.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Middle third of S1</td>
<td>48 (9.7)</td>
<td>47 (23.4)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Lower third of S1</td>
<td>83 (16.8)</td>
<td>78 (38.8)</td>
<td>5 (1.7)</td>
</tr>
<tr>
<td>Upper third of S2</td>
<td>75 (15.2)</td>
<td>38 (18.9)</td>
<td>37 (12.6)</td>
</tr>
<tr>
<td>Middle third of S2</td>
<td>71 (14.4)</td>
<td>8 (4.0)</td>
<td>63 (21.5)</td>
</tr>
<tr>
<td>Lower third of S2</td>
<td>133 (26.9)</td>
<td>2 (1.0)</td>
<td>131 (44.7)</td>
</tr>
<tr>
<td>Upper third of S3</td>
<td>43 (8.7)</td>
<td>1 (0.5)</td>
<td>42 (14.3)</td>
</tr>
<tr>
<td>Middle third of S3</td>
<td>12 (2.4)</td>
<td>0 (0)</td>
<td>12 (4.1)</td>
</tr>
<tr>
<td>Lower third of S3</td>
<td>2 (0.4)</td>
<td>0 (0)</td>
<td>2 (0.7)</td>
</tr>
</tbody>
</table>

LSTV = lumbosacral transitional vertebrae, DS = dural sac

The mean level of caudal margin of perineural cysts in the lumbarization group was significantly lower than in the sacralization group (middle third of the S3 [10 (35.7%) of 28 cases] vs. middle third of the S2 [11 (44%) of 25 cases], P ≤ .001) (Table 3).

**Discussion**

It has been known that back pain correlates with LSTV (2,12-15). Therefore, it is not uncommon to encounter patients with LSTV in the process of back and buttock pain management such as epidural steroid injection or epidural adhesiolysis. Although the cau-
The vertebral level of caudal margin of perineural cysts, seen in 53 of 494 LSTV patients

<table>
<thead>
<tr>
<th>Caudal Margin of Perineural Cysts</th>
<th>Number of Patients with Perineural Cysts (%)</th>
<th>LSTV Group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sacralization Group (n = 25)</td>
<td>Lumbarization Group (n = 28)</td>
</tr>
<tr>
<td>Lower third of S1</td>
<td>1 (4.0)</td>
<td>0 (0)</td>
<td>0.285</td>
</tr>
<tr>
<td>Upper third of S2</td>
<td>9 (36.0)</td>
<td>2 (7.1)</td>
<td>0.016</td>
</tr>
<tr>
<td>Middle third of S2</td>
<td>11 (44.0)</td>
<td>0 (0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lower third of S2</td>
<td>3 (12.0)</td>
<td>4 (14.3)</td>
<td>1.000</td>
</tr>
<tr>
<td>Upper third of S3</td>
<td>1 (4.0)</td>
<td>6 (21.4)</td>
<td>0.104</td>
</tr>
<tr>
<td>Middle third of S3</td>
<td>0 (0)</td>
<td>10 (35.7)</td>
<td>0.001</td>
</tr>
<tr>
<td>Lower third of S3</td>
<td>0 (0)</td>
<td>6 (21.4)</td>
<td>0.016</td>
</tr>
</tbody>
</table>

LSTV = lumbosacral transitional vertebrae

The lumbarization group was significantly lower than in the sacralization group, since the DS terminal was located more distally in the former group. However, unlike previous reports, perineural cysts below the S3 were not found in any group of LSTV patients (6,8).

With regards to the type of LSTV, the incidence of each subtype of LSTV was significantly different between groups. In particular, the majority of type 1 LSTV patients was found in the lumbarization group, therefore we could assume that sacralization of transitional vertebra is more inclined to form pseudoarthrosis or complete osseous fusion with the sacral ala.

During the caudal approach, it is also necessary to know the distance between the apex of the hiatus and the end of the DS for deter-
mining the length of the needle to be introduced into the canal (5,7,8). Aggarwal et al (9) found the mean distance between the apex of the hiatus and the end of the DS to be 31.6 ± 12 mm (range 5.76 – 60.0 mm). We found a similar mean distance of 29.1 mm, considering measurement error, with a similarly large range of distances 3.7 – 85 mm. Since the minimum value was less than 5 mm, the needle should be advanced carefully from the sacroccocygeal ligament during a caudal approach to prevent dural puncture in patients with LSTV, as applied to other patients.

However, there are several limitations to the current study. First, it is possible that some cases of LSTV could be missed because we had performed text searches of radiologic reports of lumbosacral MRI for the initial patient selection. These missing data might have influenced the results. Second, for accurate numbering of a transitional segment, we selected all LSTV cases that were possible to identify the entire thoracic segments and to correctly assign the L1 vertebral body—for example, patients who had radiographs of the whole spine or thoracic spine. However, in local clinics, as it is more common to have lumbar spine radiographs alone without other available imaging, accurate enumeration of the transitional segments could not always be possible. Third, since this was a single-center, single-country study, it may have limited the generalizability. Multi-center, multi-country studies with a larger number of LSTV cases are warranted to consolidate our findings. Fourth, in the subtype classifications, we did not make a distinction between unilateral and bilateral pseudoarthrosis and fusion. Since it is beyond our scope to compare the difference of LSTV subtypes seen in the sacralization and lumbarization groups, it was unnecessary to make the model complicated by increasing the 4-level outcome to an 8-level outcome. Finally, measures of interrater agreement were not obtained about imaging data; however, analysis of the raw data did not reveal a big difference between the readers.

**Conclusion**

Consequently, as the main result, our study demonstrated a difference in the DS termination level between groups of transitional vertebra with lumbarization and sacralization, which means that the position of the DS tip in the lumbarization group was significantly lower than in the sacralization group, and in the lumbarization group, the proportion of cases that the DS tip was located at the S3 was greater than that in the previously reported general population studies. Therefore, when planning caudal procedures for pain management in patients with LSTV, especially in the lumbarization cases, pre-procedural MR imaging to check the termination level of the DS, the distance between the upper margin of the SC and the end of the DS, and the presence of incidental cystic structures would be of great use for lowering the risk of unexpected dural puncture during the procedure.

**References**


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