主　論　文

# STUDY ON DERMATOMES BY MEANS OF SELECTIVE LUMBAR SPINAL NERVE BLOCK

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選択的腰部神経根ブロックによるデルマトームの検討

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Abstract

Regions of sensory impairment of 71 patients in 86 lumbar spinal nerve blocks (L4 19 cases, L5 41 cases, S1 26 cases) were determined by the writing brush method. Distinctive regions included the medial side of the lower leg, the side of the first dorsal digit, and the side of the fifth digit respectively of the L4 (88%), L5 (82%) and S1 (83%) spinal nerves without 100% matching because of displacement of one spinal segment by the furcal nerve. A band-like impaired zone from the proximal to the periphery appeared in 42%, 44%, and 92% respectively of the L4, L5, and S1 blocks. The marked difference between L4, 5 and S1 may be caused by the diversity of the dorsal rami of the spinal nerves and double control by the lateral cutaneous nerve of the thigh.

Key words: SELECTIVE LUMBAR SPINAL NERVE BLOCK, DERMATOME

In patients suffering lumbosacral radicular symptoms, dermatomal sensory changes are important signs by which the segmental location of the affected nerve can be determined clinically, but clinical diagnosis is often difficult because the pattern of sensory loss does not necessarily match the classical patterns of dermatomes.

Research on dermatomes began in the latter half of the nineteenth century, and various methods have been used. Bolk dissected the cutaneous nerves[1] and Head studied the hypersensitive regions in patients suffering herpes zoster and organic diseses.[3] Kocher focused his attention on sensory loss in cases of spinal injuries, and Foerster and Nozaki studied the regions of sensory impairment occurring after rhizotomies.[2,7] Keegan et al studied cases of sensory impairment in patients suffering herniated intervertebral disks,[4] and Wakasugi studied the regions of sensory impairment occurring after subarachnoidal phenol blocks.[10]

The patterns of dermatomes determined by these methods, however, do not necessarily match. Consequently, a study was undertaken using modern techniques to establish the pattern of the lumbosacral dermatomes. The patterns were determined by ascertaining the regions of sensory impairment caused by spinal nerve blocks, and the clinically useful distinctive regions of spinal segments were deter-

mined.

Materials and Methods

The subjects were 71 patients suffering lumbosacral radicular symptoms and having 86 lumbar spinal nerve blocks, including 19 at L4, 41 at L5, and 26 at S1. Since the number of cervical vertebrae was normal, the levels of each nerve root corresponded to the vertebrae counting from the first thoracic vertebra. Cases where the number of spinal vertebrae were abnormal and cases of lumbosacral transitional vertebrae were not included.

After radiculography was performed under fluoroscopy and the nerve root was identified, about 1.5 cc of 2% Xylocain was injected. In cases where no adjacent nerve root was imaged in the radiculogram, the regions of sensory impairment which appeared soon after were identified and the boundaries were designated by the writing brush (tactile) method. The writing brush method was chosen because it is widely used clinically, and the sense of touch causes the patient less discomfort than the sense of pain, enabling a detailed study. The boundaries recorded were the lines where there was a shift from the normal to the impaired areas, then from the impaired to the normal areas. These were decided after testing by the writing

brush method at least twice. After the boundaries were determined and traced with magic ink, they were photographed with a Polaroid camera. (Figure 1.) The photographs were used to determine the dermatomes of each of the nerve roots by superimposing them on figures of the lower limbs in four directions drawn on graph paper (anterior, lateral, medial, and posterior side, and the optional division of each side is shown by [X,Y] on the coordinates consisting of the horizontal axis = X and vertical axis = Y). (Figure 2.)

## Results

### Regions of sensory impairment caused by nerve root blocks

The region of sensory impairment caused by L4 blocks extended from the midline of the trunk posteriorly, across the buttock, through the lateral and anterior side of the thigh and the medial side of the leg to the first digit of the foot. The region of at least 75% ($N \geq 15$) superimposition was found on the medial side of the lower leg. (Figure 3.)

In L5 blocks, the region extended from the midline of the trunk posteriorly, across the buttock, through the lateral side of the thigh, the lateral side of the

leg, and the medial side of the dorsum of the foot to the first digit. The region of at least 75% (N≥31) superimposition was found on the lateral side of the lower leg, the medial side of the dorsum of the foot, and the first digit of the foot. (Figure 4.)

In S1 blocks, the region of at least 75% (N≥20) superimposition extended from the midine of the trunk posteriorly, across the buttock, through the posterior, lateral aspect of the thigh and leg to the fifth digit of the foot. (Figure 5.)

Distinctive regions of spinal segments (Figure 6)

The distinctive region of a spinal nerve is defined as the region having the most superimposition of regions of sensory impairment occurring after blockade of that nerve, and which is least involved following blockade of adjacent nerve roots.

Distinctive region of L4 spinal nerve root:

Seventeen cases had sensory impairment on the medial side of the lower leg: 15 of these were caused by L4 blocks and the other 2 were caused by L5 blocks. In other words, when sensory impairment was found on the medial side of the lower leg, this region was subserved by the L4 spinal segment in 15 of 17 cases (88%).

Distinctive region of L5 spinal nerve root:

Forty-nine cases had sensory impairment on the side of the first digit on the dorsum of the foot: 40 of these were caused by L5 blocks, 7 by L4 blocks, and 2 by S1 blocks. In other words, when sensory impairment was found on the side of the first digit on the dorsum of the foot, this region was subserved by the L5 spinal segment in 40 of 49 cases (82%).

Distinctive region of S1 spinal nerve root:

Thirty cases had sensory impairment on the side of the fifth digit on the foot: 25 of these were caused by S1 blocks and the other 5 were caused by L5 blocks. In other words, when sensory impairment was found on the side of the fifth digit of the foot, this region was subserved by the S1 spinal segment in 25 of 30 cases (83%).

<u>Cases with a continuous band-like zone of sensory impaired area from the proximal to the periphery due to nerve root blocks</u>

Careful study of the regions of sensory impairment due to spinal nerve blocks revealed that the regions of sensory impairment formed a continuous band-like zone from the posterior midline of the trunk to the periphery in 8 of 19 cases (42%) of L4 blocks, 18 of 41 cases (44%)

of L5 blocks, and 24 of 26 cases (92%) of S1 blocks. (Figure 7.)

Discussion

The cardinal result of the present study was defining the distinctive distributions of the lumbosacral nerve roots and the reliability of this pattern.

The L4 nerve root innervates the medial side of the lower leg in 88% of individuals. The L5 nerve root innervates the side of the first digit on the dorsum of the foot in 82% of individuals. The S1 nerve root innervates the side of the fifth digit of the foot in 83% of individuals.

Reasons for the lack of 100% matching of the distinctive regions of spinal segments may include the furcal nerve,[5] overlapping of spinal segments, intersegmental anastomosis between spinal nerve roots,[6] and nerve root anomaly. Of these causes, displacements in the spinal segments due to diversity of the furcal nerve is a major consideration.

In the subjects used in this study, displacement of one spinal segment at the L4, L5, and S1 levels was found in five cases and six spinal nerve roots.

The following is a typical example: this was a case of sensory impairment occurring in the L5 region due to L4 block. On X-ray, the number of vertebrae was normal and no lumbosacral transitional vertebrae were observed. (Figure 8.) According to the Kudo classification of the furcal nerve, even if the furcal nerve is L4, when it has a thick branch to the lumbosacral trunk, many afferent nerve fibers go to the usual L5 region. This suggests the possibility of sensory impairment occurring in the L5 region due to L4 block.[5]

Authenticity of many dermatomes

Dermatomes can be classified into two major types: Haymaker type originating from Foerster, and Keegan type. The major difference between the two is that the regions of spinal segments are present in an insular form in the Haymaker type, whereas the regions form a continuous band-like zone from the proximal to the periphery in the Keegan type. This difference is closely related to a difference of opinions on the embryology of dermatomes in the extremities, i.e., the difference between Bolk's theory that dermatomes shift in an insular form to the periphery as the extremities grow and Keegan's theory that they expand in the form of a band-like zone from the proximal to the periphery.[4]

Careful study of the regions of sensory impairment due to spinal nerve blocks revealed that the regions of sensory impairment formed a continuous band-like zone from the proximal to the periphery in 42% of L4 blocks, 44% of L5 blocks, and 92% of S1 blocks.

These differences in the incidence of band-like dermatomes might be explained either by differences in the incidence of cutaneous branches of the lumbosacral dorsal rami, or by variable density of overlapping innervation by the lateral cutaneous nerve of the thigh.

Gray's Anatomy[9] denies the presence of cutaneous branches of the dorsal rami of the L4 and L5 spinal nerves. However, Pearson's study of human embryos[8] reveals that this is not strictly the case. He found that a cutaneous branch of L4 occurred in 4 out of ten specimens. The L5 and S1 dorsal rami lacked direct cutaneous branches but joined the posterior sacral plexus from which secondary cutaneous branches arose that were believed to stem primarily from S1 and S2 with a possible contribution from L5[8].

Variations in the presence of anaesthesia over the posterior trunk might therefore correlate with the presence of a cutaneous branch of the dorsal ramus of the spinal nerve anaesthetised. Clearly the 40% incidence of a cutane-

ous branch from L4 is consonant with the 42% incidence of numbness over the trunk recorded in this study. Similarly, the seemingly regular presence of an S1-derived cutaneous branch is concordant with the high incidence of a band-like distribution of numbness following S1 blocks. In this regard, the 44% incidence of numbness over the trunk and buttock possibly reflects how often the L5 dorsal ramus furnishes a cutaneous contribution to the posterior sacral plexus.

Alternatively or additionally, it needs to be recognised that the lateral thigh is innervated by the lateral cutaneous nerve of the thigh (L2,3). Its territory borders on and may overlap the territory over the posterior, lateral thigh sometimes embraced by the L4 and L5 dermatomes. One could imagine that in individuals where this overlap is dense, the individual might not report anaesthesia over the thigh upon clinical testing following an L4 or L5 nerve block. In such cases a fundamental band-like distribution of anaesthesia would be lacking resulting only in an insular dermatome for the segment. More precise clinical testing, grading for thresholds of perception, might vindicate this conjecture, but the resources of time and effort for such a demanding study outweigh the additional benefits that might be derived, and the cardinal

findings of the present study would not be affected.

NOTE:

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Fig. 2 Anterior, lateral, medial, and posterior side, and optional division of each side is shown by (X,Y) on the coordinates consisting of horizontal axis = X and vertical axis = Y

Fig. 3 Extending from the midline of the trunk posteriorly, across the buttock, through the lateral and anterior side of the thigh and the medial side of the leg to the first digit of the foot.

Fig. 4 Extending from the midline of the trunk posteriorly, across the buttock, through the lateral side of the thigh, the lateral side of the leg and the medial side of the dorsum of the foot to the first digit

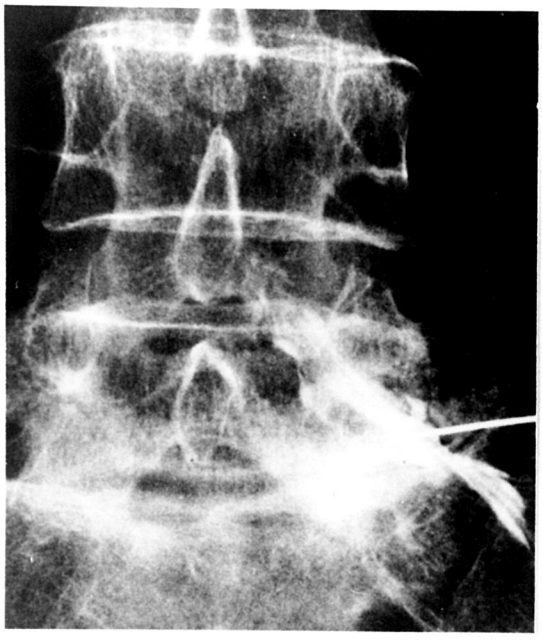
Fig. 5 Extending from the midline of the trunk posteriorly, across the buttock, through the posterior, lateral aspect of the thigh and leg to the fifth digit of the foot.

Fig. 6 The probability that the medial side of the lower leg is subserved by the L4 nerve root is 88%. The probability that the side of the first dorsal digit is subserved by the L5 nerve root is 82%. The probability that the side of the fifth digit is subserved by the S1 nerve root is 83%.

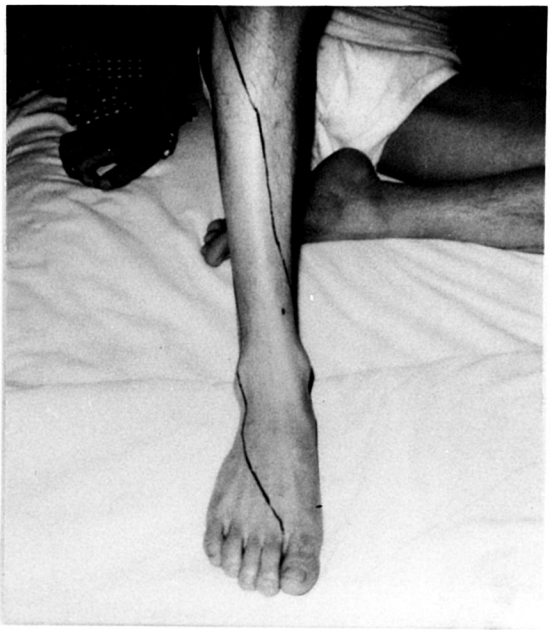
Fig. 7 It was found that the regions of sensory impairment formed a continuous band-like zone from the post-

erior midline of the trunk to the periphery in 42% of L4 blocks, 44% of L5 blocks, and 92% of S1 blocks.

# Fig. 1



Radiculography



Polaroid photography

Fig. 2

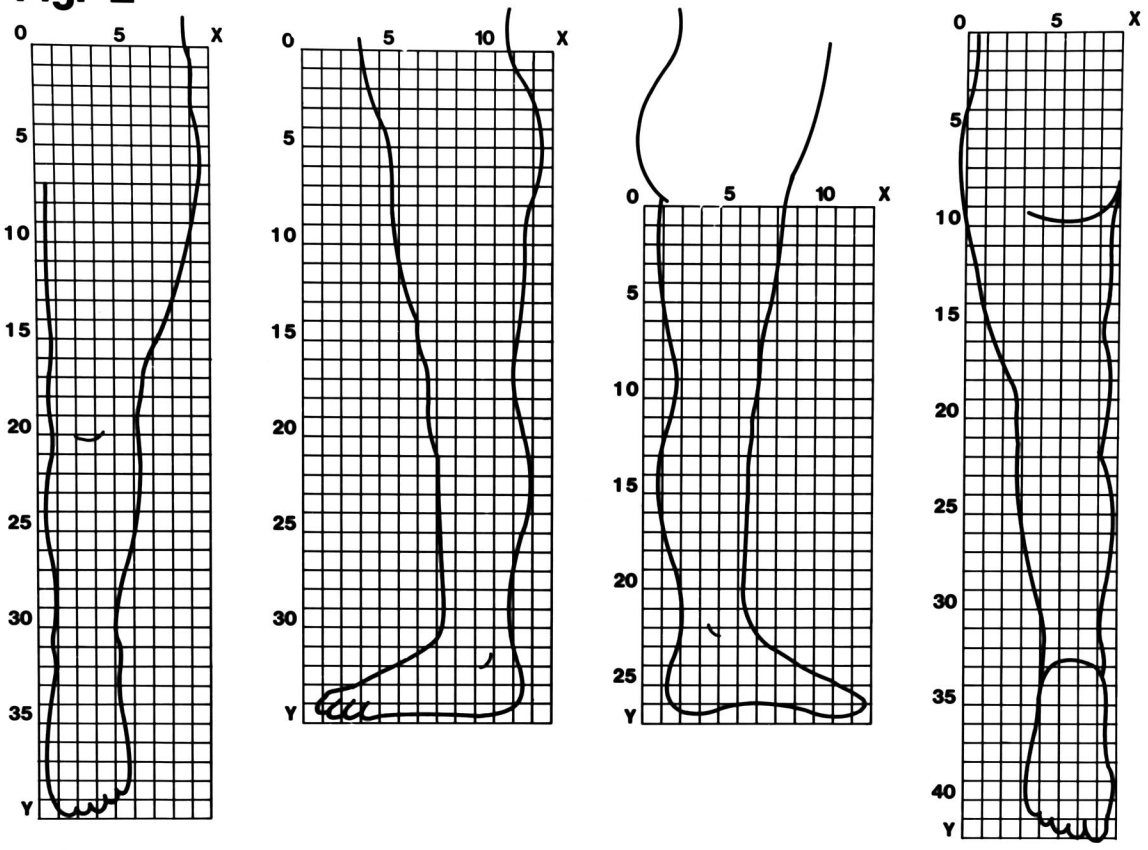

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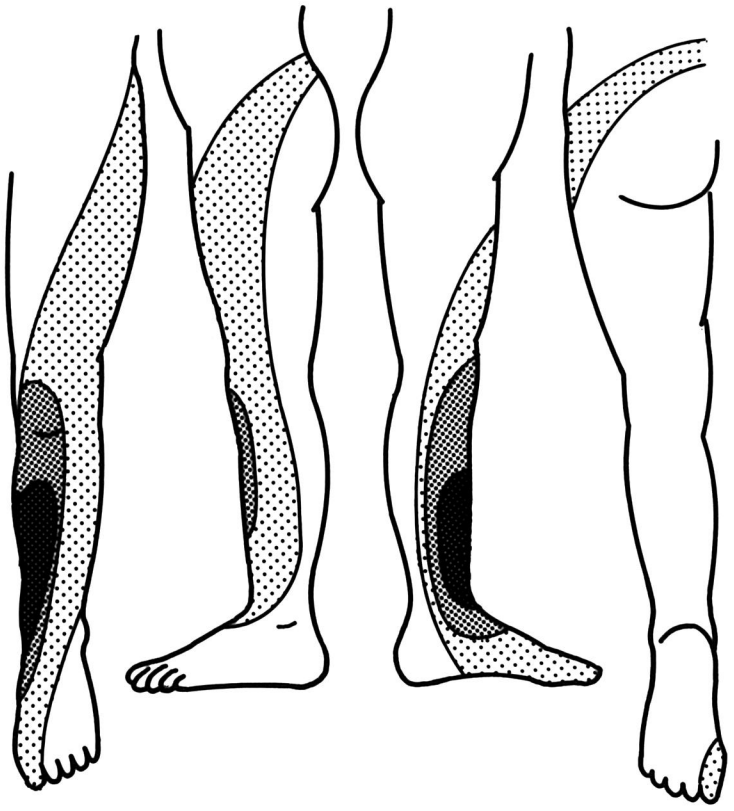
**Fig. 3 Regions of sensory impairment caused by $L_4$ nerve root block**

N=19



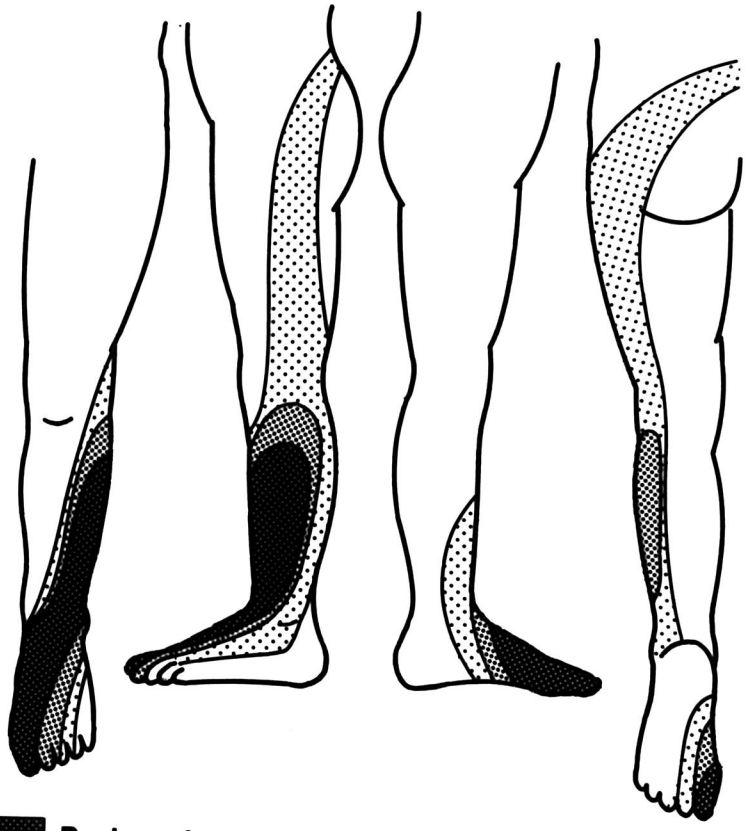
Region of more than 75% (N≧15) seperimposition

Region of 50~75% (N=10~15) superimposition

Region of 25~50% (N= 5~10) superimposition

**Fig. 4 Regions of sensory impairment caused by $L_5$ nerve root block**

N=41



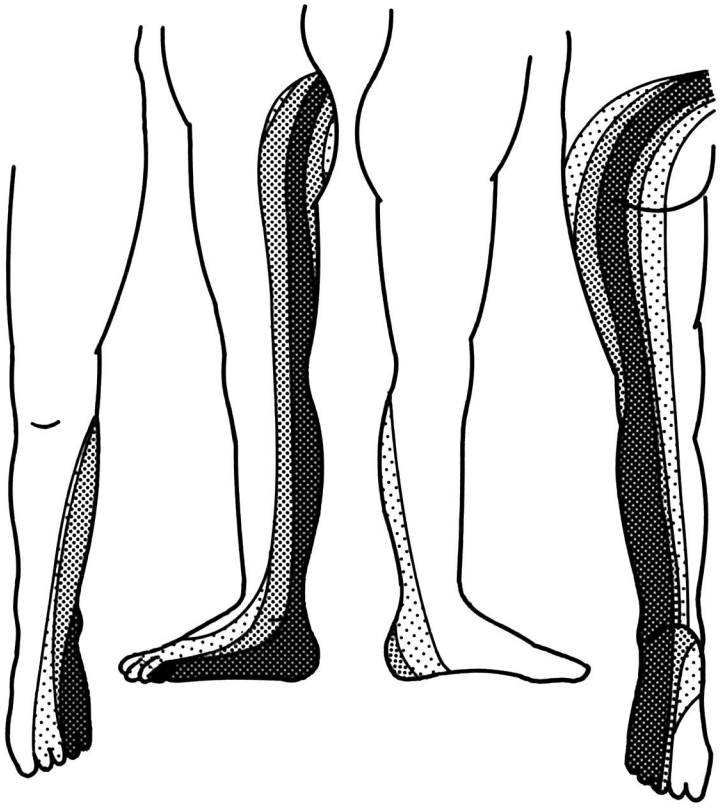
Region of more than 75% (N≧31) superimposition

Region of 50~75% (N=21~31) superimposition

Region of 25~50% (N=11~21) superimposition

## Fig. 5 Regions of sensory impairment caused by $S_1$ nerve root block

N=26



Region of more than 75% (N≧21) superimposition

Region of 50～75% (N=13～20) superimposition

Region of 25～50% (N=7～13) superimposition

## Fig. 6 Distinctive regions of spinal segments

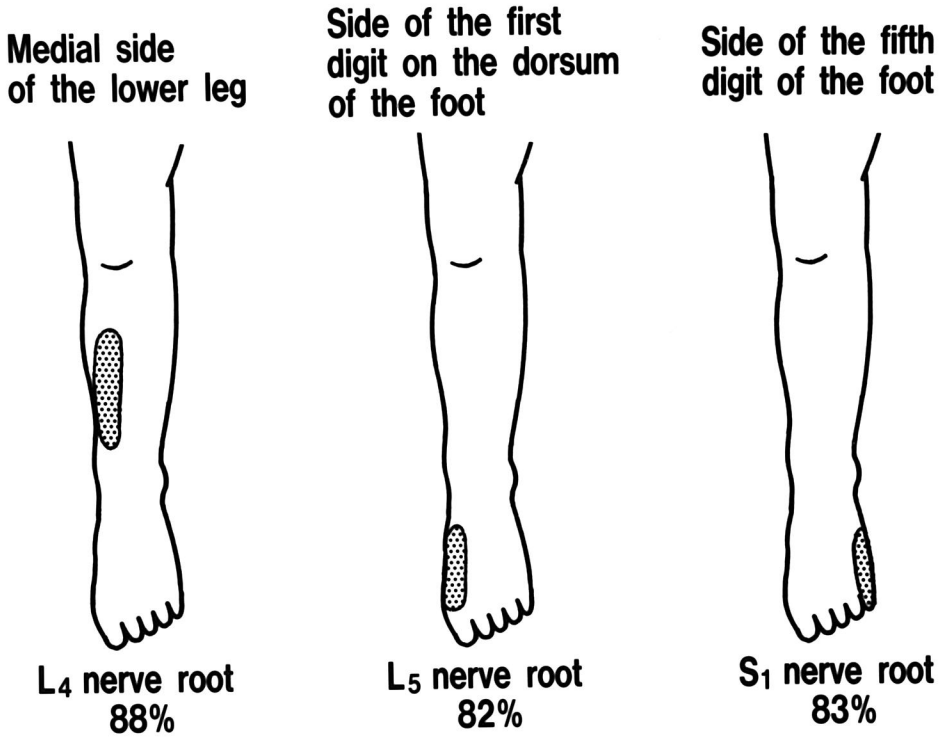
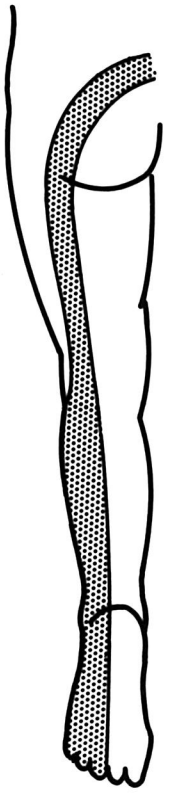


**Fig. 7**

**Cases with a continuous band-like zone of sensory impairment area from the proximal to the periphery due to nerve root blocks**



**(Example)**
**$S_1$ nerve root**

| | | |
|---|---|---|
| **$L_4$ nerve root** | **42%** | **( 8/19)** |
| **$L_5$ nerve root** | **44%** | **(18/41)** |
| **$S_1$ nerve root** | **92%** | **(24/26)** |

Fig. 8 Case with so-called sensory impairment of $L_5$ region due to $L_4$ nerve root block