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An Analysis of the Lumbosacral Dermatomes in Man

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The localization of nerve root pathology is determined by a number of means. The mapping of sensory alterations of the skin area is one of the important tools for clinical evaluation. Using this technic, the clinician is able to pinpoint nerve root pathology. Nerve root pressure, such as occurs following a ruptured intervertebral disk or other stress phenomena, is reflected by abnormal sensory changes of the skin of the lower extremities. Merritt[15] estimated that, in 50% of such lesions, confirmation of single nerve root pressure can be diagnosed by cutaneous sensory changes of the skin.

The examiner attempts to map cutaneous areas of sensory changes according to skin dermatomes. A dermatome is defined as that area of skin subserved by a single dorsal nerve root. There does not appear to be any conflict in the charting of these dermatomes and their serial banding in the trunk. We have observed considerable variance of dermatome charts of the lower extremity as illustrated in modern textbooks of anatomy and neuroanatomy. In addition, there has been much confusion and divided opinion regarding the degree of co-innervation of dermatomes.

The purpose of this article is an attempt to clarify for the clinician the exact clinical dermatomes subserved by the lumbosacral nerve roots in man.

HISTORICAL DATA

Two methods have been employed in the determination of the area of skin subserved by a specific posterior nerve root—the anatomic method and the physiologic method.

The anatomic approach was applied by Herrington[9] and by Bolk.[2] They attempted by anatomic dissection to follow the fibers of a nerve root to its destination. Bolk postulated that there was no overlap of cutaneous sensory fibers. He also believed in the wandering of metameres into the limb bud.

Sir Charles Sherrington,[17] again using anatomic dissections in frogs and Macaca monkeys, came to the conclusion that the overlap of sensory endings in the skin was considerable. Fig. 1 is a copy of Sherrington's drawing, showing the sensory nerve overlap in the region of the nipple. It can be seen that co-innervation is rather marked, according to his drawing.

Sir Henry Head,[7] using the physiologic method of approach to the placement of

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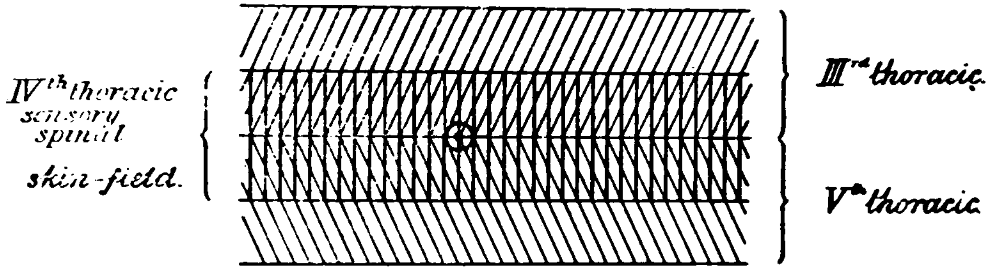

Diagram of the position of the nipple in the sensory skin-fields of the IVth, IIIrd and Vth thoracic spinal roots.

FIG. 1. Sherrington's[17] drawing, illustrating co-innervation of the skin.

dermatomes, collected a large number of patients with herpetic eruptions as a result of Herpes zoster. The dermatome chart prepared by him is shown in Fig. 2. The trunk dermatomes are segmental bands and in harmony; however, in the lower extremity, there is no banding. Specific nerve roots subserved the proximal or the distal portion of the lower limb. Head concluded that there was very little co-innervation of dermatomes.

Foerster,[5] by the anatomic method, mapped the dermatomes in man. His chart is illustrated in Fig. 3. His work consisted in severing several nerve roots above and below a specific nerve. The remaining sensibility of the skin represented the dermatome for the specific isolated nerve root. The serial banding of the trunk dermatomes can be seen. In the lower extremity, sacral 2 presents some orderly segmentation, and is shown as supplying both the proximal and distal limb. The remaining nerve roots supply either the proximal or the distal portion of the limb. The dermatomes of the lower limb are quite similar to those of Head. Foerster concluded that resection of a single nerve root in man was not followed by loss of cutaneous sensibility.

Keegan[10-13] and Keegan and Garrett[14] have presented a dermatome chart, illustrated in Fig. 4. It is quite similar to the one prepared by Edinger.[3] Their chart was prepared by the anatomic method of mapping sensory changes in patients with proven ruptured disks pressing on a specific nerve root, or indication of specific root pathology by myelographic studies. In a few instances, rhizotomy of a single nerve was carried out to relieve painful stimulii. These authors maintain that there is co-innervation of dermatomes. They also believed that, despite this nerve overlap, there is a hyposensitive area, or true primary dermatome, which extends into the lower extremity from the dorsal midline to its termination. They also believed the harmony of banding for the

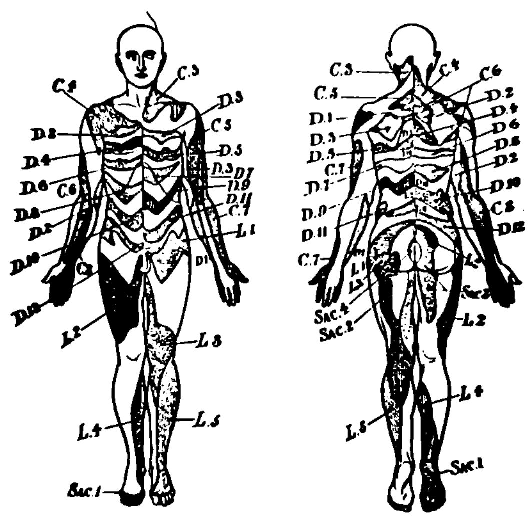

FIG. 2. Head's[7] chart of the human dermatomes.

lower extremities was the same as for the trunk. These spiral arrangements of the dermatomes of the lower extremities were explained on limb rotation from the fetal to the adult position.

DEVELOPMENT OF THE PERIPHERAL SENSORY NERVES

A great mass of data has been written relative to this problem. Noback and Schriver[16] have summarized many of these data on nerve invasion into the limb bud. Once a nerve fiber innervates the ectoderm of a given segment, this original nerve supply is retained throughout ontology. Each dermatome of a somite is thought to develop into the skin dermatome of the adult.

The work of Elftman and Detwiler,[4] using embryos of amblystoma, clearly shows that the skin of the limb is derived almost exclusively from the skin which covers the limb bud at its first appearance. As the limb grows in length, the quadrants of ectoderm elongate with it, retaining their relationship with respect to each other. They also proved that cutaneous areas supplied by successive segmental nerve roots are displaced on the appendage in a pattern which is distinct in spite of the overlap of adjacent areas. Harrison[8] has shown that there is relative migration of the skin with respect to the underlying muscles and that this may be responsible for some of the details of the pattern of nerve distribution.

The sensory fibers of the spinal nerves are distributed to the skin of the body in a segmental manner. The skin of the limb bud is also supplied by peripheral nerves, derived in a segmental manner. Fig. 5, taken from Hamilton et al.,[6] illustrates the segmental banding.

It has been pointed out by Arey[1] and Streeter[18] that the limb buds, which are flattened and paddle-shaped and project at right angles to the body, undergo several changes in position during growth. At first, they point caudad, then at right angles to the

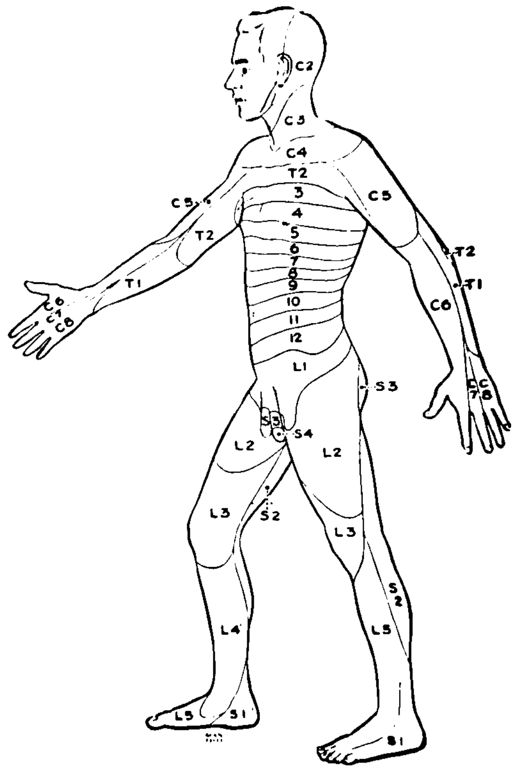

FIG. 3. Foerster's chart of the human dermatomes (after Foerster, from Haymaker and Woodall). From Peripheral Nerve Injuries, Philadelphia, W. B. Saunders Company, 1953.

body wall. The next change is ventrad at the knee, which points outward and laterally; the sole faces the trunk. At this stage, the great toe and tibial side of the leg constitute the cephalic border of the limb. Finally, the lower limb undergoes a torsion of 90° through its long axis; the knee then points cephalic. It is only natural that the medial tibial surface is innervated by the lumbar nerves and the lateral and posterior surfaces by the sacral nerves.

Therefore, the serial banding of the dermatomes of the trunk in man is agreed on by all. In the extremities, there is a divergence of opinion. Keegan[10–13] and Keegan and Garrett[14] are in favor of the continuation of this serial banding as far as the lower extremities are concerned, except for the spiralling secondary to limb rotation. They believe this banding for the limbs is preserved in the adult structure, despite the joining of anterior primary rami by connecting loops to form the cervicobrachial and lumbosacral plexuses.

MATERIAL AND METHODS

The material forming the basis of our study of the lumbosacral dermatomes in man is an analysis made on a number of separate evaluations of the sensory changes on patients on whom a specific nerve was totally interrupted by operative means. The nerve root was sectioned to relieve pain. Complete neurectomy was done on nearly all patients as a salvage procedure when decompression of the nerve root failed to relieve painful stimulii. The entire root was sectioned. Complete section eliminates any argument as to whether afferent impulses are transmitted by efferent pathways, as suggested by Foerster.[5] The abnormal sensory areas were determined in 26 patients following lumbar 5 root section, and in 51 patients with sacral 1 section. Lumbar 4 nerve root was sectioned in one patient.

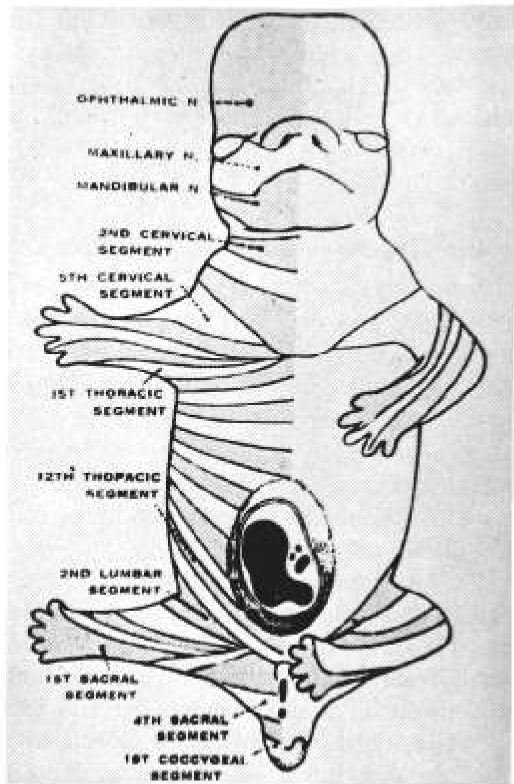

FIG. 5. The segmental skin banding as illustrated by Hamilton, Boyd and Mossman.[6]

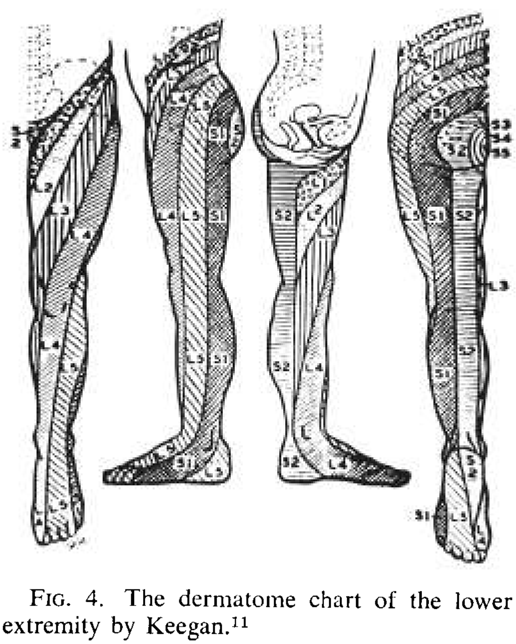

FIG. 4. The dermatome chart of the lower extremity by Keegan.[11]

We used the tactile sensation method. A sharp pointed pencil or pen was used, stroking from the involved zone to the normal, and from the normal to the abnormal. The skin area with abnormal sensation was considered the dermatome subserved either by lumbar 5 or sacral 1 nerve roots. In a few patients, thermal changes were recorded; however, this modality was discarded, for in all patients so tested tactile sensation produced a more vivid response. Sensibility of pain was assessed in nearly all patients, using the prick of a pin.

RESULTS

The patients experienced either complete or markedly reduced sensation when tactile means were employed. Using the prick of a pin, anesthesia was present in many and decreased in some. The anesthetic area was narrower than with tactile sensation.

Utilizing tactile changes, hypesthesia of the skin is quite specific in the distal portion of the limb. The constant area subserved by sacral 1 nerve started with the plantar and dorsal surfaces of the fourth and fifth toes. It then extended in a band-like segmental manner to include the anteriolateral and posteriolateral surfaces of the foot.

Proceeding upward from the ankle to the knee, the sensory banding varied in width and length. Hypesthesia and a narrower band of anesthesia covered the lateral and posteriolateral surfaces of the skin. The sensory changes in some patients extended above the knee, into the thigh, but usually terminated in the region of the knee. In no case did the sensory alterations extend to the mid-dorsal region of the body.

The area of skin subserved by the fifth lumbar nerve was also mapped. Distally, in the region of the foot, there was a constant, nearly clear-cut, band of hypesthesia. The sensory changes were of the anterior and tips of the first, second and third toes. The sensory band then extended upward onto the anterior surface of the ankle. The lateral margin of the sensory band coincided with the medial border of sacral 1 band. The segmental banding then proceeded upward to the region of the knee, occupying the anteriolateral skin area. The width and length of changes varied from one patient to another, as was also found in sacral 1 determinations. As has been pointed out by others, these variable changes in the width and length of segmental banding could be explained by individual psychologic interpretations. In no case did the sensory deficit go to the mid-body line. There were no sensory changes on the plantar surfaces of the foot.

The sensory changes following interruption of the fourth lumbar nerve root were mapped in one patient. Beginning on the foot, there was a striplike band of decreased sensation, occupying the anteriomedial surface of the foot. The band then extended upward, occupying the anteriomedial surface of the lower leg, and extended into the lower anterior thigh region. The lateral boundary of this band abutted upon the medial margin

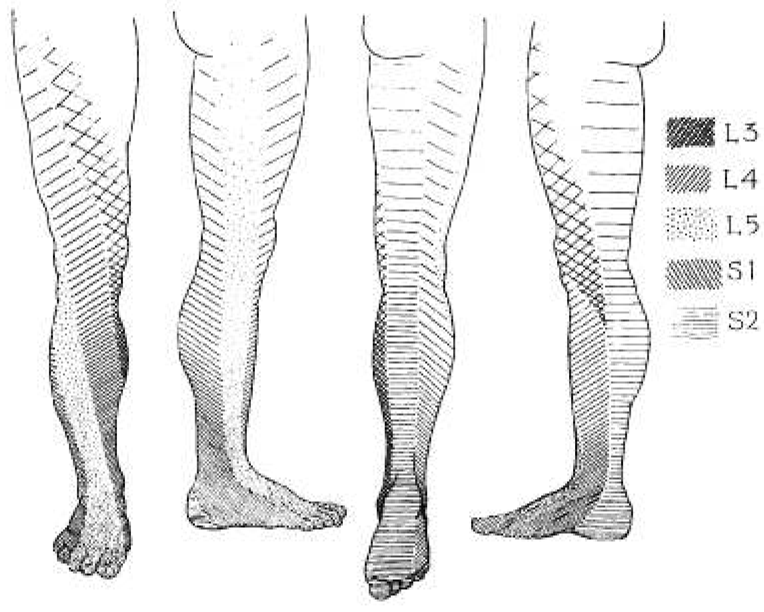

FIG. 6. The clinical lumbosacral dermatome chart as prepared by the authors.

of the fifth lumbar nerve changes. There was no disturbance of sensation of the medial surface of the heel. Again, the band did not extend to the mid-line of the body.

DISCUSSION

The question of dermatome overlap, or co-innervation of the skin, has been discussed in the literature. There are a number of divergent expressions. It has been our observation that for a few weeks following nerve root interruption, sensory changes of the skin are more extensive in width and in length than one finds following the passage of time. During the early period of interruption, the patient experiences a greater degree of dysesthesia. The shrinkage of the dermatome zone is never complete. In the region of the foot and ankle there remains a band of decreased sensation, and usually a loss of sensibility to all cutaneous modalities, indicating autonomy for each nerve root of the lumbosacral region. The dictum of Foerster is erroneous, for there is a loss of cutaneous sensibility with the division of a single nerve root. The loss of sensation for the lumbosacral nerve roots is in the region of the foot and ankle.

The usual dermatome charts in the literature have been illustrated in this article. We do not believe these charts are accurate for the lower limb in man.

For the clinical evaluation of specific nerve root pathology, we have prepared a dermatome chart (Fig. 6). We believe this chart to be a reliable one for the determination of the dermatomes subserved by lumbar 4, lumbar 5, and sacral 1 nerve roots. In the chart, S2 area has been added, as has been L3 nerve root, by the constructive method. In the distal portion of the limb, in the region of the foot and ankle, this chart is nearly exact when compared to that of Edinger,[3] Keegan,[10-13] and Keegan and Garrett.[14] The only major disagreement is the lack of the wedge-shaped area on the plantar surface of the foot, shown for lumbar 5 dermatome in their charts. It is embryologically impossible for the metameres to have wandered to such an extent that both the anterior as well as the posterior surfaces of the foot are subserved by lumbar 5 nerve root.

Each lumbosacral nerve root has an area of skin belonging exclusively to it. Despite this autonomy of each nerve root for the distal portion of the limb in man, our conclusions indicate considerable co-innervation or overlap for the proximal portion of the lower limb, in agreement with Sherrington[17] and Foerster,[5] and acknowledged to some degree by Keegan,[10-13] Keegan and Garrett.[14] We do not disagree with the latter authors, who have postulated a primitive or primary embryologic dermatome extending from the mid-line of the body to the distal portion of the limbs. However, we do believe that it is clinically impossible to verify this segmental banding, except in the region of the foot and ankle. As is shown in Fig. 6, the sensory changes became less and less as the examiner proceeded proximally, and fade out completely in most cases in the region of the knee or the lower thigh region.

SUMMARY

The literature has been reviewed concerning dermatome charts. An analysis of the skin sensory deficit on many patients following complete neurectomy of the lumbosacral nerves has been done. From these data, we have prepared a clinical dermatome chart, which is a useful and accurate adjunct in determining the pathology of a specific lumbosacral nerve root.

This chart and our findings confirm Keegan,[10-13] and Keegan and Garrett's[14] analysis of an orderly segmental dermatome banding for the distal portion of the lower extremities. We do not believe that sensory changes can be accurately determined in the proximal lower limb. Also, our data show the skin of the plantar surface of the foot to be innervated by S1 and S2 nerves, not by L5 nerve root.

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