

Mapping of dermatomes of the lower extremities based on an animal model

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Previous dermatome drawings have been developed on the basis of investigations in humans and thus differ among investigators. The authors recently reported detailed dermatomes of the rat hindlimb that were mapped by electrical stimulation of spinal nerves and observation of plasma extravasation in the corresponding skin. In this paper a new human dermatome chart is proposed that has been reconstructed from rat dermatomes; the accuracy of previously reported dermatomes is also discussed. These newly defined dermatomes are arranged as serial semicircles, not as bands extending spirally from the low back down to the lower extremity as shown by Keegan. The posterior pattern differs markedly from that of any previously described charts in that the S-2 dermatome is "interposed" within the S-1 dermatome. This study clarifies the basic arrangement of lower-extremity dermatomes. Based on the present chart, it is concluded that Bonica's dermatomes are the most accurate among those previously reported.

KEY WORDS • dermatome • spinal nerve root • rat

MAPS of dermatomes have been created based on investigations of patients or healthy volunteers.^{2,5,7,8,10,11} Head and Campbell⁸ described dermatomes found by observing the distribution of eruption areas in patients with herpes zoster. Foerster⁵ noted dermatomes that overlapped considerably, which he observed by cutting nerve roots above and below the identified nerve root and examining "remaining sensibility" in patients. Keegan¹⁰ described well-delineated dermatomes consisting of serial bands of dermatomal zone segments that were found by observing hypalgesic and painful areas in patients with an intervertebral disc herniation (Fig. 1). Hansen and Schliack⁷ mapped dermatomes by observing hypalgesic patterns arising from disc herniation and eruption areas in herpes zoster. After considering Hansen and Schliack's chart, Bonica² based his description of dermatomes on spinal nerve block findings (Fig. 1).

These dermatomes, however, differ considerably from each other. The variation is probably because of the following problems, which are inevitable in human investigations: 1) in herpes zoster, a skin eruption area is not always located entirely within a single dermatome because several ganglia can be involved;²³ 2) discrimination of the affected nerve root from the intact roots is difficult even with contemporary morphological and functional diagnostic tools. To collect a sufficient number of patients for each segment who have a surgically confirmed lesioned root is even more difficult and time consuming; 3) considerable anatomical variation in nerve roots,¹³ spinal nerves,²⁴ peripheral nerves, and spinal

segmentation may confuse the results. In addition, it is unclear whether the boundary lines were determined blindly in the previous investigations; an examiner with knowledge of previous dermatome charts may have been influenced by these earlier charts in determining the boundaries.

Dermatomal somatosensory evoked potentials recorded at nerve roots or spinal nerves after electrical stimulation of the skin can be applied to map dermatomes; in this technique, subjective sensory examination is avoided. Although dermatome mapping using this method has been used in dogs⁴ and cats,¹⁸ it has not been used for human subjects.

The low back and lower extremities are basically homologous between humans and other mammals; therefore, we assumed that the dermatomes, too, should be arranged identically and that human dermatomes could be reconstructed from experimentally determined animal dermatomes. Animal dermatomes have been described using remaining sensibility in monkeys^{15,22} and sheep,¹⁴ and by electrophysiological recordings at nerve roots in monkeys¹⁷ and cats.^{17,18} However, these charts only exhibit a rough distribution and configuration of dermatomes and the details are insufficient to reconstruct a human chart.

It is known that electrical stimulation of peripheral nerves activates afferent C-fibers, causing plasma extravasation in the corresponding skin by releasing neurotransmitters from the terminals.^{3,9} In rats, intravenously applied Evans blue dye solution enables such plasma