DISTRIBUTION OF HUMAN PACINIAN CORPUSCLES IN THE HAND

A cadaver study

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The subcutaneous distribution and number of Pacinian corpuscles were studied in ten fresh cadaver hands. They were found to cluster close to nerves and vessels at the metacarpophalangeal joints and the proximal phalanx. The total mean number in the hand was 300 (192–424). The percentage of the total was 44 to 60% in the fingers, 23 to 48% in the metacarpophalangeal area and 8 to 18% in the thenar and hypothenar regions. Corpuscles in palmar skin overlying the distal phalanx were smaller than receptors in the metacarpophalangeal area. The lowest density of corpuscles was along the nerves and vessels of the middle phalanx.

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The main receptors for the perception of swiftly moving skin stimuli or vibration are the Meissner and Pacinian corpuscles (PC) (Bruce, 1980; Junqueira and Carneiro, 1984). In particular, the PC is believed to be a quickly adapting receptor with pronounced sensitivity to vibration (Wiesenfeld-Hallin and Hallin, 1984). A single axon terminal supplies the elongated corpuscle which is built up by numerous cells originating from the peripheral nervous system. The multilayered connective tissue covering the nerve ending acts as a transducer which converts mechanical energy delivered during skin stimulation to neural activity (Koshima et al, 1992). Pacinian corpuscles are the largest encapsulated sensory receptors with diameters amounting to 1–2 mm (Miller and Rusenas, 1976). PCs are widely spread in the body, both in mammals and in man. Their anatomical distribution has been investigated in the cat forefoot (Kumamoto et al, 1993a), the hand of the monkey (Kumamoto et al, 1993b), the fetal human finger (Sathian and Devanandan, 1983) and the human adult hand (Roset-Llobet and Domenech-Mateu, 1991). The numbers of Pacinian corpuscles in different tissues vary according to reports from 667 in the cat forefoot to 416 to 458 in the monkey hand (Kumamoto et al, 1993a; 1993b). In the hand of fresh human cadavers a number of 266 has been reported (Roset-Llobet and Domenech-Mateu, 1991) The aim of the present study was to investigate the distribution, number and sizes of Pacinian corpuscles in a larger group of fresh cadaver hands. In particular, the relationship of the Pacinian corpuscles to nerves and vessels has been studied.

MATERIAL AND METHODS

The present study was based on ten fresh cadaver hands. Six specimens came from women with a mean age of 83 (range, 74–89) years and four from men, mean age 71.5 (range, 69–75) years. The left hand was dissected in four cases and the right hand in six. The tissue of the hand superficial to the flexor tendons was carefully dissected using magnifying loupes. Only subcutaneous Pacinian corpuscles, often localized close to nerve structures, were noted. Deeply situated receptors and corpuscles close to superficial flexor tendons or joints as described by Zimny et al (1989) were not included in this study. The distribution of PCs was investigated in the thenar, hypothenar and the three phalanges of the fingers. Each finger was subdivided in an ulnar and radial side and the number of Pacinian corpuscles was separately recorded for each phalanx.

We had noted previously that corpuscles harvested from the flexor aspect of the distal phalanx were smaller than receptors harvested from the metacarpophalangeal region. In four specimens 50 corpuscles were dissected out from the metacarpophalangeal region of the index finger and ten corpuscles were removed from palmar skin covering the distal phalanx of the index finger. After dissection the corpuscles were fixed in glutaraldehyde for 24 hours and subsequently immersed in phosphate-buffered saline 0.1 M (PBS) for 36 hours. They were embedded in the centre of a cat liver specimen to facilitate cutting thin 14 µm cross sections with a cryostat. The sections were stained with toluidine blue. The size of the corpuscles was assessed using a Leica DMRBE microscope (Leica Microsystems AB, Sollentuna, Sweden), and digitized using a Kappa CF 8/1 FMCC CCD camera (Kappa Mikroskop-System AB, Hålsjö, Sweden) and a Perceptics Pixel Buffer image grabber card (Parameter AB, Stockholm, Sweden) mounted in a Macintosh Quadra 800 computer (Apple Computers AB, Kista, Sweden). The greyscale of the image was adjusted and segmented using the density slicing feature of the NIH Image software (version 1.55 NIH, USA) so that the outline of the Pacinian corpuscles was assessed automatically. The greatest vertical diameter of each corpuscle was measured as well as the transverse diameter perpendicular to the long axis. The surface of each corpuscle was recorded.

RESULTS

Macroscopic findings

The total number of subcutaneous Pacinian corpuscles in the ten dissected hands is shown in Table 1. The mechanoreceptors occurred in clusters in subcutaneous tissue close to the common digital nerve and digital nerve branches and vessels in the fingers (Fig 1). The clusters were randomly orientated with respect to the nerves and the skin surface. The corpuscles were most numerous in the metacarpophalangeal and proximal phalangeal regions (Table 2). In these areas they were located in subcutaneous tissue in close contact with adjacent nerve structures. The number of corpuscles in the fingers varied between 44 and 60% of the total amount in the hand. The percentage of Pacinian corpuscles found at the MP level ranged from 23 to 48% of the total number, and at the thenar and hypothenar regions from 8 to 18%. The total number of corpuscles in the middle phalanges of all the fingers varied between 11 and 40 (mean 23) whereas the number in the palmar skin of the distal phalanx ranged from 29 to 76 (mean 48) (Table 2). Generally, the mechanoreceptors were more abundant in the distal phalanx than in the middle phalanx. In the digits the greatest concentration of corpuscles was detected in the index (mean 62), middle (mean 63) and ring finger (mean 60) (Table 2). The largest range of Pacinian corpuscles (35–124) was found in the middle finger (Table 2). The number of corpuscles in the thenar area was a mean of 16 (range, 7–25) and in the hypothenar area was 18 (range, 10–36).

The mean surface area of ten Pacinian corpuscles in the distal palmar skin of the index finger was 0.77 mm^2 (0.28–1.24 mm^2), whereas the surface of 50 receptors in the index metacarpophalangeal region had a mean of 3.5 mm^2 (range, 0.85–14.53 mm^2). The greatest long axis was 3.5 mm and the smallest was 0.66 mm. The largest transverse diameter perpendicular to the long axis was 4.84 mm and the smallest was 0.30 mm.

Light microscope findings

No histological variations of the corpuscles were noted irrespective of differences in size and localization. Larger corpuscles had more numerous layers of the outer core.

Table 1—The total number of PCs

Area	*Mean (Range)*
Thumb	38 (29–50)
Index	63 (48–89)
Long	63 (35–124)
Ring	60 (34–96)
Little	41 (21–59)
Thenar+hypothenar	31 (25–61)
Total number in the hand	300 (192–375)

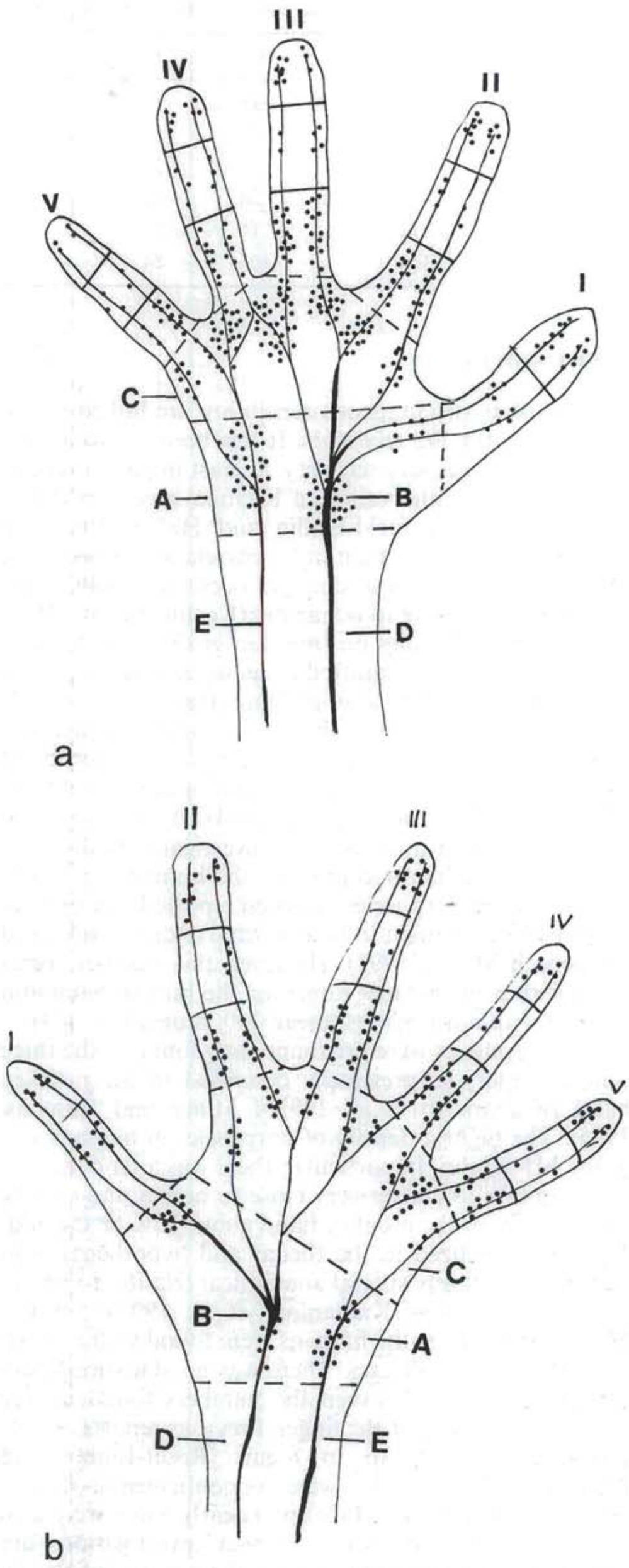

Fig 1 Distribution of Pacinian corpuscles in cadaver hands. (a) right hand of a 89-year-old female specimen. (b) left hand of a 76-year-old female specimen. A = hypothenar. B = thenar. C = metacarpus. D = median nerve. E = ulnar nerve.

Table 2—Mean number of PCs according to the finger area

	MP	*Proximal*	*Middle*	*Distal*	*Total*	*Range*
Thumb	14	12		12	38	28–50
Index	24	21	7	10	62	44–89
Middle	25	23	6	9	63	35–124
Ring	28	18	5	9	60	34–96
Little	16	10	5	8	39	25–59
Total	107	84	23	48	262	

DISCUSSION

Some aspects of cutaneous sensibility are linked to the function of the PC receptors. It has been reported that the quality of sensory recovery, at least in part, is correlated with the reinnervation of Pacinian receptors (Haro et al, 1994; Wiesenfeld-Hallin and Hallin, 1984). In experimental studies there was a correlation between the observed morphological changes occurring in PCs and the time of exposure to ischaemia (Koshima et al, 1992). Morphological studies on free skin grafts have revealed absence of PCs in the grafted areas suggesting an incomplete sensory recovery after grafting (Haro et al, 1994). It has also been suggested that the sympathetic nervous system in some way may play a role in mechanoreception both normally and under pathological conditions (Wiesenfeld-Hallin and Hallin, 1984). In view of these studies it seemed interesting to investigate the distribution of PC mechanoreceptors in the human hand. The number of 266 corpuscles has been reported in a cadaver hand and was thought to be abnormal (Roset-Llobet and Domenech-Mateu, 1991). However, this number seems to be within the normal range for the human hand and fits well with our findings (mean 300, range: 192–424).

The corpuscles were predominantly found in the three central fingers as previously described in the monkey hand (Kumamoto et al, 1993b; Miller and Rusenas, 1976). The highest density of corpuscles in humans was in the MP region. In particular, there was a tendency for the receptors to cluster very close to nerves and vessels. By contrast, in the monkey hand about 75% of the endings were localized in the thenar and hypothenar eminences without any special anatomical relation to nerves or nerve branches (Kumamoto et al, 1993a; 1993b). Most corpuscles in the humans were found in the proximal and distal phalanges. There was no statistically significant difference between the numbers found on the radial or ulnar side of the finger. Previous reports of corpuscle lengths of up to 8 mm (Roset-Llobet and Domemech-Mateu, 1991) were not confirmed in our dissections, although large PCs up to nearly 5 mm were seen in three of 50 corpuscles. Further investigations are needed to analyse whether or not there is a relationship between size and function.

In conclusion it can be said that in the human hand the number of Pacinian corpuscles varies among individuals. The total number of mechanoreceptors in the palmar regions of the hand seems to be fairly constant. Most corpuscles cluster close to nerves and vessels in the MP area and proximal phalanges of the three central digits. The middle phalanges contain fewer corpuscles than the distal phalanges. The sizes of the corpuscles in the palm and MP region are larger than those found in the distal phalanx. The histological feature of PCs is the same irrespective of their anatomical site and size.

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References

Bruce MF (1980). The relation of tactile thresholds to histology in the fingers of elderly people. Journal of Neurology, Neurosurgery, and Psychiatry 43: 730–734.

Haro JJ, del Valle ME, Calzada B, Pérez A, Pérez JL, Vega JA (1994). Human glabrous skin autografts partially reinnervated without sensory corpuscles. Scandinavian Journal of Plastic, Reconstructive and Hand Surgery, 28: 25–31.

Junqueira LC, Carneiro J. The sense organ. In: *Basic histology*, Maruzen Asia, Singapore, 1984: 196–225.

Koshima I, Moriguchi T, Soeda S (1992). Electron microscopic observations of degeneration of human pacinian corpuscles in amputated fingers. Journal of Plastic and Reconstructive Surgery, 89: 243–248.

Kumamoto K, Takei M, Kinoshita M, Ebara S, Matsuura T (1993a). Distribution of pacinian corpuscles in the cat forefoot. Journal of Anatomy, 182: 23–28.

Kumamoto K, Senuma H, Ebara S, Matsuura T (1993b). Distribution of pacinian corpuscles in the hand of the monkey. *Macaca fuscata*. Journal of Anatomy, 183: 149–154.

Miller SH, Rusenas I (1976). Changes in primate pacinian corpuscles following volar pad excision and skin grafting. A preliminary report. Journal of Plastic and Reconstructive Surgery, 57: 627–636.

Roset-Llobet J, Domenech-Mateu JM (1991). Uncommon number and distribution of the pacinian corpuscles in a human hand. Journal of Hand Surgery, 16B: 89–91.

Sathian K, Devanandan MS (1983). Receptors of the metacarpophalangeal joints: a histological study in the bonnet monkey and man. Journal of Anatomy, 137: 601–613.

Wiesenfeld-Hallin Z, Hallin RG (1984). The influence of the sympathetic system on mechanoreception and nociception. Human Neurobiology, 3: 41–46.

Zimny ML, DePaolo C, Dabezies E (1989). Mechano-receptors in the flexor tendons of the hand. Journal of Hand Surgery, 14B: 229–231.

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