Peripheral projections of sensory fascicles in the human superficial radial nerve

M. Campero, J. Serra and J. L. Ochoa

1Department of Neurological Sciences, Universidad de Chile, Santiago, Chile, 2Neuropathic Pain Unit, Hospital General de Catalunya, Barcelona, Spain and 3Oregon Nerve Center, Good Samaritan Hospital, Portland, OR, USA

Correspondence to: Dr M. Campero, Departamento de Ciencias Neurologicas, Universidad de Chile, J. M. Infante 553, Providencia, Santiago, Chile
E-mail: mcampero@med.uchile.cl

Summary
The sensory territories of different cutaneous fascicles of the superficial radial nerve were delineated by microneurography at the level of the distal forearm in humans. Three fascicular patterns were found at this level: one supplying the dorsum of the radial aspect of the dorsum of the hand over the first dorsal interosseous space; another supplying the lateral aspect of the first metacarpal extending to the lateral aspect of the thumb; and a third innervating the second interosseous space and the proximal phalanx of the index and middle fingers. The compound fascicular territory is comparable to the classical territory described for the superficial radial nerve. Intraneural microstimulation of individual fascicles did not evoke paraesthesiae or pain beyond their fascicular territory, regardless of the stimulus intensity. We conclude that the superficial radial nerve at the forearm in man is composed of only three fascicles, as shown by the present study and from previous anatomical work. Referred pain seems related to nerve activity in afferent fibres from fascicles supplying deep tissues and muscles, not from cutaneous afferents.

Keywords: nerve; fascicle; microneurography; intraneural stimulation; receptive field


Introduction
Anatomical studies have shown that nerve fibres within a nerve trunk are subdivided into well defined fascicles, ‘which by repeatedly uniting and dividing, engage in a plexus formation along the full length of a nerve’ (Sunderland, 1945). The expected result would be that the more distal the fascicle the less likely it would be that the common topographic arrangement would be found. However, the fascicular receptive fields of individual fascicles in the human median nerve, recorded both at wrist and arm level, do not exceed the area of one or two digital nerves (Schady et al., 1983; Moore and Schady, 2000). Eleven cutaneous fascicular patterns have been described in the ulnar nerve in humans (Marchettini et al., 1990), all of which cover a continuous area of skin. The sum of the different fascicular receptive fields makes up the cutaneous territory of the median and ulnar nerves. In the present paper, we describe the fascicular cutaneous territory of the superficial radial nerve in humans. These results complement previous studies on the fascicular cutaneous innervation of the hand. In contrast to the referred pain evoked by intraneural stimulation of mixed motor and sensory fascicles in the median (Schady et al., 1983; Torebjörk et al., 1984) and ulnar (Marchettini et al., 1990) nerves, intraneural microstimulation of sensory fascicles of the superficial radial nerve, at painful levels, elicits sensations projected only to the cutaneous territory of that nerve.

Methods
Twenty-two experiments were performed on eight healthy volunteers (one female, seven males) and six patients (four females, two males) affected by neurological disorders not involving the radial nerves and without CNS disorders affecting sensory discrimination. All volunteers and patients gave informed consent and the local ethics committee approved the study. All experiments were performed at distal forearm level where the superficial radial nerve turns posteriorly beneath the tendon of the brachioradialis muscle appearing on the dorsum of the forearm, superficial to the abductor pollicis longus muscle (Sunderland, 1978). Microneurographic recordings were obtained from the superficial radial nerve at the distal forearm, as described in detail elsewhere (Vallbo and...
Fascicular territories of the radial nerve

Results

Twenty-three sensory fascicles were identified by microneurography, all of which could be grouped in three different anatomical patterns. One fascicular pattern \( (n = 8) \) covered the radial aspect of the dorsum of the hand over the first dorsal interosseous space (Fig. 1, top). Among these fascicles, one (number 6 from right to left, top to bottom) covered, to some extent, the second dorsal interosseous space, but the main area covered the first dorsal interosseous space. These fascicles extended up to the proximal interphalangeal joint of the index finger. A second pattern \( (n = 8) \) covered the dorsal aspect of the hairy (and to a lesser extent glabrous) skin of the first metacarpal extending to the lateral or medial dorsal aspect of the hairy (and to a lesser extent glabrous) skin. The borders of the cutaneous receptive fields were then delineated with coloured ink, photographed and copied to a template. The compound receptive field was obtained by superimposing each single fascicular receptive field.

Then, intraneural microstimulation was given at threshold level with square-wave electrical pulses at 3–5 Hz delivered through the recording electrode in the same infrasacular position. The stimulus intensity was increased in steps until detection threshold was reached (usually around 0.3 V). It was then further increased to clearly suprathreshold pain levels. The subject was asked to describe the characteristics and distribution of the projected sensation. Finally, the intrafascicular position of the electrode was reconfirmed by switching to recording mode from the same sensory fascicle.

Discussion

The fascicular arrangement of sensory fibres in the median and ulnar nerves in humans demonstrates that nerve fibres grouped in one single fascicle supply a continuous area of skin, and not separate cutaneous territories, as might be expected by anatomical studies (Sunderland, 1945). Although the total number of fascicles determined by intraneural microstimulation for the human median nerve has not been directly measured, the sensory fascicular territory resembles the innervation area of a single palmar digital nerve or a digital interspace (Schady et al., 1983). For the human ulnar nerve (Marchettini et al., 1990) it was possible to identify by microneurography 11 sensory fascicular patterns covering the skin of the hand. ‘Several’ small fascicles are described in the cutaneous division of the ulnar nerve at the wrist in anatomical studies (Sunderland, 1978).

Sunderland (1978) described a constant pattern of three ‘funiculi’ in the proximal 1.5 cm of the separate superficial radial nerve, while in proximal segments the bundles containing fibres of this branch occupied the anterior pole of the radial nerve. Although the number of fascicles in distal segments of the superficial radial nerve is not specified, the present results indicate that the nerve at the level of the distal forearm contains only three sensory fascicles.

The most distal branches of the superficial radial nerve in one anatomical study (Bas and Kleinert, 1999) have been described to extend up to the nail bed of the thumb in every case; in nearly a third of the cases the branches extended to the nail bed of the index finger and in a very few they reached this level in the middle finger. In the present work, fascicles covering the distal phalanx of the index finger were
Fig. 1 (Left) Area of 23 individual cutaneous fascicles delineated using microneurography in 14 subjects. These fascicles covered the first interosseous space and, to some extent, the base of the thumb (top), the thumb alone (middle) and the second interosseous space and the base of the index and middle fingers (bottom). (Right) Composite of the sum of all fascicular territories of each of the three pattern distributions.
not found, although, considering our small sample number, fascicles extending further distally may exist.

The compound cutaneous receptive field of the superficial radial nerve as delineated by the present method is equivalent to the known anatomical territory of the human superficial radial nerve (Haymaker and Woodhall, 1953). It was found that the cutaneous territory never extended to the ulnar aspect of the dorsum of the hand or to the median innervated distal dorsum of the fingers. One narrow area in the hand dorsum between the ulnar and superficial radial territory might still be supplied by a distal branch of the posterior antebrachial nerve, as suggested by Pollock and Davis (1933).

Fascicular microstimulation of either the median or the ulnar nerve is able to evoke pain referred to remote areas, provided that the fascicle innervates muscle and deep structures. It has been proposed that convergence of group III and IV afferents in second-order neurons in the spinal cord is one of the mechanisms underlying this referred pain (Torebjörk et al., 1984). Pain induced by microstimulation of cutaneous afferents has not been described to evoke referred pain, but a distorted sensation may occur under experimental conditions (Torebjörk et al., 1992). In line with previous findings (Schady et al., 1983), intraneural microstimulation of afferent fibres in different fascicles in the superficial radial nerve did not evoke pain beyond the anatomical territory of the nerve.

References