PROJECTION OF DENTAL RECEPTORS IN THE RABBIT SENSOMOTOR CORTEX

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In experiments on rabbits the topical organization of dental representation in the cortex was studied by the evoked potentials method. Each tooth was shown to be locally represented in the sensomotor cortex. During stimulation of threshold strength these zones do not overlap one another. Topographically the dental projection region occupies a territory including areas ParI, Praecag, Preacgr, and PC.

KEY WORDS: cortical dental projection region; pain.

The conduction, analysis, and integration of afferent excitation in brain structures have now been studied for many years in the course of physiological, morphological, and clinical investigations. This has been due to the insistent demands of clinicians for an explanation of the mechanisms of formation of integral adaptive responses to lesions arising in various peripheral structures.

Dental pain is a highly subjective psychophysiological state which is accompanied by severe emotional, autonomic, motor, and other manifestations [1-3, 8]. Different levels of analysis, including the cortical, are concerned in their integration.

Several workers have studied the pathways and mechanisms of conduction and processing of pain afferentation arising during stimulation of the teeth [7, 9]. They have shown that excitation arising during stimulation of dental receptors reaches particular zones of the cortex. However, the topical organization of dental projections still remains largely unexplained. This is particularly true of the projection of the dental receptors in rabbits. The topical organization of the cortical representation of receptors of the incisors and crown teeth of rabbits was studied in the investigation described below.

EXPERIMENTAL METHOD

Experiments were carried out on 24 rabbits anesthetized with pentobarbital (40 mg/kg). The dental pulp was stimulated by single square electric pulses of threshold intensity (1-5 V, 1 msec) by means of steel bipolar electrodes. The electrodes were inserted into holes previously drilled with a dental drill on the anterior surface of the superior and inferior incisors and crown teeth. The stimulating electrodes were fixed in the pulp by a special device, and at the same time the animal's teeth and head were secured in the SÉZh-2 stereotaxic apparatus. The pulses were generated by an ÉSL-2 stimulator. For monopolar recording of evoked potentials (EP) arising in the brain during electrical stimulation of the superior and inferior incisors and the superior and inferior crown teeth by a current of threshold strength at 48 points of the skull the electrode was moved successively over the surface of the skull (Fig. 1). It will be clear from Fig. 1 that the whole of the upper surface of the skull, including the sensomotor, parietal, and visual regions on the right and left sides, was investigated.

EXPERIMENTAL RESULTS

The experiments showed that in response to single electrical stimulation of threshold intensity of each tooth, a primary EP (a characteristic positive-negative wave) appeared locally in the cortex. Its parameters

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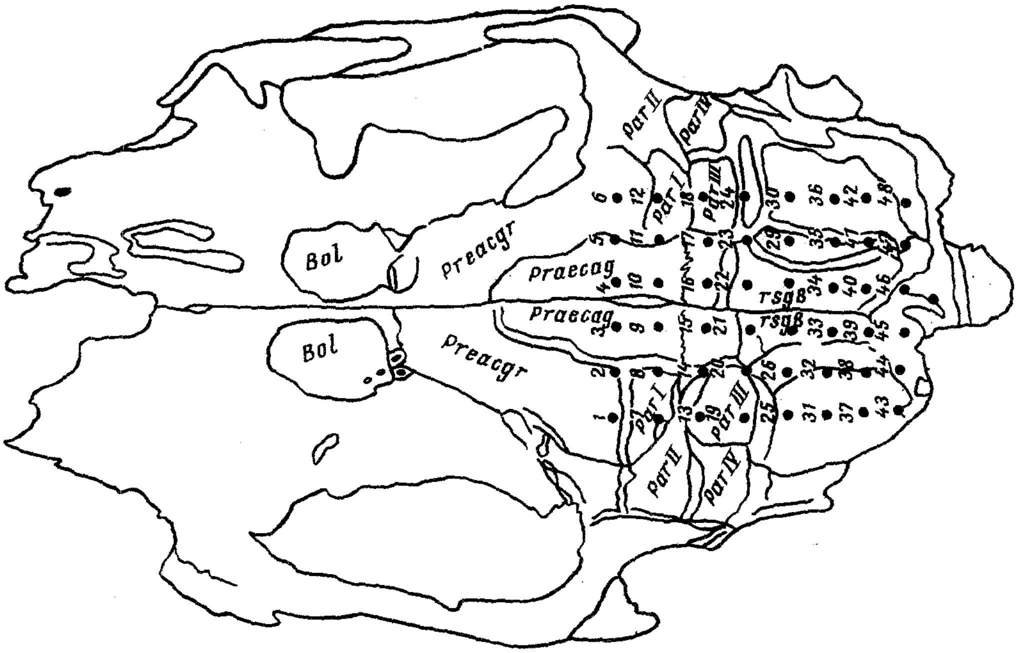

Fig. 1. Map showing positions of recording electrode at 48 points of rabbit's skull, on which is projected a cytoarchitectonic map of the cortex [7].

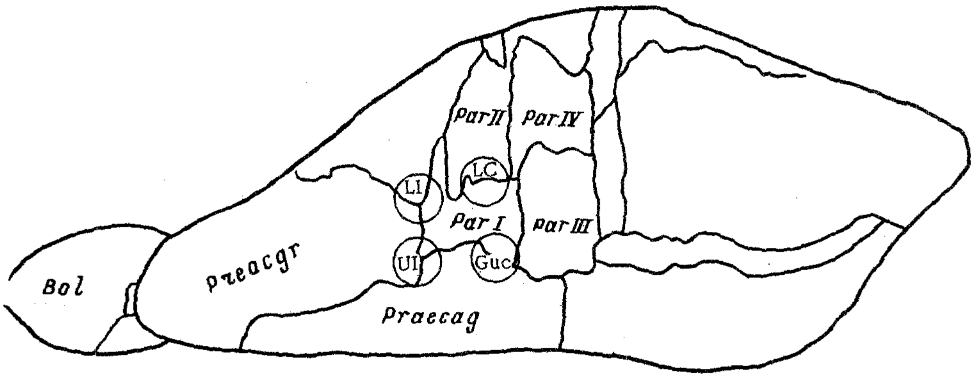

Fig. 2. Projection zones of dental receptors of incisors and crown teeth in rabbit cerebral cortex. UI) Upper incisor; LI) lower incisor; UC) upper crown tooth; LC) lower crown tooth.

were identical for stimulation of the incisors and crown teeth, but they depended on the intensity of stimulation. The positive wave in response to electrical stimulation of threshold strength had an amplitude of 50-75 μV. The amplitude of the negative wave reached 25-40 μV. The point at which this wave was recorded locally with a minimal latent period of 10-12 msec and with an amplitude of 75-100 μV was the focus of maximal activity (FMA) during stimulation of the pain receptors of that particular tooth. During threshold stimulation of the upper crown tooth of the rabbit, the point at which the FMA was found was located in the anterior portion of the sensomotor cortex of the contralateral hemisphere relative to the stimulated tooth, 1.5 mm anteriorly to the coronal and 3-4.5 mm laterally to the sagittal suture (Fig. 1, point 11).

FMA to stimulation of the inferior crown tooth was 6-7.5 mm laterally to the sagittal and 1-1.5 mm anteriorly to the coronal suture (Fig. 1, point 12). The point where FMA of the primary response to threshold stimulation of the upper incisor was identified was 4-4.5 mm laterally to the sagittal and 3-4.5 mm anteriorly to the coronal suture (Fig. 1, point 5). Finally, FMA of the dental projection of the lower incisor was located 6-7.5 mm laterally to the sagittal and 3-4.5 mm anteriorly to the coronal suture (Fig. 1, point 6). All these points were projected on a cytoarchitectonic map of the rabbit cerebral cortex [6] (Fig. 2).

FMA in the dental projection of the upper crown tooth was found to lie on the boundary between ParI and Praecag, whereas FMA of the lower crown tooth lay on the boundary between ParI and ParII. The local dental projection of receptors of the upper incisor occupied an area on the boundary between ParI, Praecag and Preacgr, and finally, the local dental projection of receptors of the lower incisor lay in area ParI, on the boundary with Preacgr and PC.

An increase in the intensity of stimulation of the pulp of any of the teeth caused widening of the zone of dental projection. EP in response to stimulation of the tooth was no longer quite so strictly localized, but spread also to neighboring points of the cortex, initially in the projection zones of the other teeth and in symmetrical zones of the ipsilateral hemisphere (an increase in the strength of stimulation by 15-30% over threshold), and later not only in the sensomotor areas, but also in the parietal and occipital regions of the cortex (stimulation at 50% over threshold strength). An increase in the intensity of stimulation by 75-100% or more above the threshold caused the appearance of EP in virtually all cortical regions.

If the pulp of a tooth was stimulated by an electric current of twice the threshold strength, a primary response whose positive phase, with high amplitude (not less than 75 μV) and short duration (8-10 msec) appeared after a latent period of 10 msec in the cortical dental projection zone of the rabbit sensomotor cortex. The negative phase of the primary response appeared after a latent period of 18-20 msec, its duration 14-16 msec, and its amplitude 100 μV. With increasing distance from FMA of dental projection the latent period of the EP increased, the amplitudes of both the positive and the negative phases of the EP decreased, and their duration and configuration changed.

As the investigations showed, each tooth thus has its appropriate local dental projection in the cortex. Zones of dental projection can be clearly revealed only by electrical stimulation of the teeth with threshold intensity, at which the zones do not overlap each other. Foci of maximal activity occur in the cortical dental projection region and can be detected by threshold stimulation of pain receptors of the upper and lower crown teeth and incisors of the rabbit. They are situated in zones of the cortex contralateral relative to the stimulated teeth and they occupy a territory which, according to the coordinates of a cytoarchitectonic map [6], includes area ParI, Preacgr, Praecag, and PC. These findings agree with the results of investigations showing that in response to electrical stimulation of the teeth of other experimental animals (cats and dogs) projection regions of the dental receptors are found in the cortex [4, 5, 9]. However, as the present experiments showed, dental projections of the teeth in the cortex can be demonstrated only by the use of electrical stimulation of the dental pulp of threshold strength. Any increase in the intensity of stimulation leads to regular spreading of excitation in the cortex.

The latent period of the primary responses in the dental projection zone, in the FMA of dental receptors of rabbits anesthetized with pentobarbital, was found to be 10-12 msec. This figure differs somewhat from those obtained in other investigations [5] in which primary EP in the cortical projection zone of the canine teeth of cats were recorded 3-5 msec after electrical stimulation of the tooth. The reason for the short latent period may be that not only afferents from the pulp of the tooth were stimulated electrically, but also fast-conducting fibers from surrounding tissues [9].

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