Relief of facial pain after combined removal of precentral and postcentral cortex

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Cortical removals which included precentral and postcentral facial representations resulted in relief of facial pain in two patients. Because of known failures following only postcentral (SmI) ablations, these operations were designed to eliminate also the cutaneous afferent projection to the precentral gyrus (MsI) and the second somatic sensory area (SmII). In one case burning pain developed after a stroke involving the brain stem and was not improved by total fifth nerve section; prompt relief followed corticectomy and lasted until death from heart disease 20 months later. In the other case persistent steady pain that developed after fifth rhizotomy for trigeminal neuralgia proved refractory to frontal lobotomy; relief after corticectomy was immediate and has lasted 14 months. Cortical localization was established by stimulation under local anesthesia. Each removal extended up to the border of the arm representation and down to the upper border of the insula. Such a resection necessarily included SmII, and in one case responses presumably from SmII were obtained before removal. The suggestions of Biemond (1956) and Poggio and Mountcastle (1960) that SmII might be concerned with pain sensibility may be pertinent in these cases.

Key Words: intractable facial pain • corticectomy • precentral gyrus • postcentral gyrus

The removal of the somatic sensory cortex for relief of pain has not resulted in consistent success. The results reported in 38 cases of "central" pain treated by postcentral gyrus removals were recently reviewed by White and Sweet. Although 30 were initially relieved, only nine were free of pain for over 5 mos, and only five had relief of pain a year or more after operation.

Because of the known failures following postcentral removals alone, we elected in two cases of intractable facial pain to remove both precentral and postcentral areas of facial representation. These removals included also the entire second somatic sensory area. With this procedure we hoped to eliminate not only the facial afferents that project to the postcentral cortex, but also those that project to the precentral cortex and to the second somatic sensory area. Both cases were followed by long-term relief.

Case Reports

Case 1

A 61-year-old man was briefly hospitalized in 1958 following a sudden attack of vomiting, numbness of the left side of the face, and a tendency to fall to the left. These complaints persisted and during succeeding months the patient gradually developed con-
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Continuous burning left facial pain for which he was hospitalized. Neurological examination in 1959 by Dr. James Stephens showed decreased sensation to pain in the left first and second trigeminal divisions, a decreased left corneal response, and slight left hemiataxia with minimal weakness of the proximal muscles of the left arm and leg. It was Dr. Stephens' opinion that the patient had a left pontine lesion and suffered from true central pain. The pain continued and in 1961 a total trigeminal nerve section was performed by a neurosurgeon. A facial nerve paralysis resulted as a complication. The facial pain was neither relieved nor modified by this operation. During the next year a variety of medications was tried without success. He was hospitalized once with salicylate intoxication following an overdose of aspirin for pain.

Examination. The patient was admitted under our care in 1962 for continuous burning facial pain with recent related weight loss of 25 lbs. Examination showed anesthesia in the left trigeminal distribution, a moderate left facial nerve paresis, and bilateral ataxia worse in the left extremities. The patient was seen by neurologists, neurosurgeons, and psychiatrists. It was the general opinion that his pain was real and that he was desperate.

Operation. On November 1, 1962, the areas of facial representation in the right precentral and postcentral gyri were removed under local anesthesia. Results of stimulation and recording are shown in Fig. 1. The cortical removal extended superiorly to the border of hand representation and inferiorly to the Sylvian fissure with excision of the opercula of the pre- and postcentral gyri so that the insular gyri were exposed after the removal.

Postoperative Course. The patient had some dysarthria and weakness of the left hand, but these disabilities gradually improved so that he later had only slight weakness of the left grip. No epileptic seizures occurred. His facial pain was completely relieved after operation. He was seen periodically and remained free of facial pain until his death July 10, 1964, 20 months after cortical surgery, from coronary thrombosis which was shown at autopsy.

Case 2

A 41-year-old woman was treated by a neurosurgeon in August, 1957 for trigeminal
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neuralgia with extracranial alcohol injections of the left second and third divisions. Relief was insufficient, and in January, 1958, the left trigeminal sensory root was sectioned via the temporal route. This was followed by the complication of facial palsy and later by a corneal ulcer. There was some residual trigeminal sensation. In November, 1958, the patient developed continuous left facial painful dysesthesia which became a major complaint. The pain was aggravated by the slightest touch and was not relieved by medication. Because of continuing pain, a frontal lobotomy was performed in January, 1965, by electrocoagulation of the anteromedial quadrants of both frontal lobes. She was relieved for a short period but the pain recurred and was even more troublesome. She consulted many physicians and tried a variety of medications, including carbamazepine (Tegretol, Geigy) without relief.

Examination. In 1967, the patient came under our care with the complaint of unremitting left facial pain which was exacerbated by touch to the face. The pain centered about the left eye and was described as "hooks pulling my face and eye." She had a neuroparalytic keratitis and a left facial paresis.

First Operation. Because of slight residual sensation in all three divisions, an attempt was made in June, 1967, to complete the section of the trigeminal sensory root via the posterior fossa. However, adhesions and severe bleeding from near the root precluded its section, and the pain continued to be refractory.

Second Operation. In August, 1967, a cortical resection was performed. The right Rolandic areas were identified by cortical stimulation under local anesthesia. The areas of facial representation in the precentral and postcentral gyri were removed. The excision extended inferiorly to include the opercula comprising the upper bank of the Sylvian fissure so that, after the removal, the insular gyri lay exposed. Superiorly the excision extended to the area for arm representation.

Postoperative Course. There was initial transient dysarthria and dysphagia, which cleared completely. Weakness of the left arm also ensued but this improved so that the patient had a good grip at the time of discharge. Sensation in the trigeminal distribution was markedly impaired. Pinprick could be perceived following repetitive or prolonged stimulation, but pain could not be elicited from the left side of the face. A mild left facial paresis was present, but a fairly symmetrical smile could be produced. She was slightly less dextrous with the left hand. There was transient slight impairment of two-point discrimination in the left fingers. No epileptic seizures occurred. During the 2½ years since corticectomy the patient has remained completely free of facial pain as documented by periodic examination.

Results of Cortical Stimulation and Recording

The observations made on the exposed cortex in Case 1 were significant (see "Discussion") and are, therefore, reported in detail.

Cortical stimulation was carried out with a single monopolar electrode held by hand. Threshold responses were sought. Stimuli of 60 cycle ac calibrated in milliamperes were delivered for 3 sec. An attempt was made to allow 1 min between successive stimuli in order to avoid facilitation. Responses in the form of evoked potentials about 100 μV in size were recorded in the postcentral hand area at Point 2 upon electrical stimulation of the left median nerve at the wrist. Peripheral stimulation with a 1 msec pulse at 1-sec intervals was adjusted in voltage until sufficient to elicit slight adduction of the thumb. Evoked potentials have been recorded with similar techniques in both precentral and postcentral gyri. The results below concern the left side of the body unless otherwise noted. Quotations have been taken verbatim from tape recording. Letters A through Z and numbers 1 and 2 below refer to the points stimulated; stimulus strength in milliamperes is noted after the response for each point (Fig. 1).

A. Sensation. Drawing inside "left side of my mouth." Stimulation repeated later gave the sensation "right at the corner of my mouth on the lower lip" and in "the middle of the left side of my tongue" (1.0 mA).

B. Sensation. Left side of face, poorly described (0.8 mA).

C. Sensation, Movement. "Kind of a burning feeling" in left index finger and thumb, with flexion of those digits (0.8 mA).
D. Sensation. Left upper lip near nose (1.0 mA).
E. Sensation. "The left side of my tongue... right in the middle" (1.0 mA).
F. Vocalization. "EEEEE, I couldn't talk"; facial movement poorly described (1.0 mA).
G. Sensation. "Right in the corner of my mouth and in lower lip a little bit" (1.3 mA).
H. Sensation, Movement. Upper lip near corner of mouth, slight twitching upper lip (2.2 mA).
I. Movement. Tongue movement and inability to speak; "moved right there in the tongue, and just put me so I couldn't talk" (2.2 mA).
J. Movement. "My left hand kind of felt like it moved a little"; flexion of digits and wrist seen, elbow flexed slightly (2.2 mA).
K. Movement. "Something moving in there, clear inside my mouth on the left, kind of under my cheek bone" (2.8 mA).
L. Sensation. "A little funny feeling there in my hand... it don't hurt"; about at junction of palm and fingers (2.8 mA).
M. Movement. "Seemed like it moved that arm from the elbow back"; slight extension of elbow seen (2.8 mA).
N. Movement, Sensation. Flexion of fingers and radial deviation of wrist; sensation, base of palm, from thenar to hypothenar eminences (2.8 mA).
O. Sensation. "Some kind of a light flapping... it was something I could see, never had that before, I could just feel it ashivering, seemed like it was a light... I believe it was more to the right" (2.8 mA).
P. Movement. "My thumb just wanted to clench right down," flexion of thumb, lesser flexion of other digits (2.8 mA).
Q. Movement. "Seemed like my chin just moved up and down, more on the left side of my chin"; chewing movements seen (2.8 mA).
R. Movement. "Right in my mouth (extending) down to the chin, and the tongue," on the left, and then "went clear down to my stomach," inability to speak, clonic movement of head and neck seen (2.8 mA).
S. Movement. "Something hit me in the left eye... mostly movement"; eye seen to close tightly, some retraction of left side of mouth (2.8 mA).
T. Movement. Left side of both lips, left side of neck, probably platysma (2.8 mA).
U. Movement. "Oh boy!" Strong flexion seen of left elbow, lesser of wrist (2.8 mA).
V. Movement, Vocalization, Sensation. Initial vocalization then inability to speak; feeling of movement and/or sensation "right in my mouth... face and then neck... mostly on the left side, and it went down to my stomach there again"; jerking of head and movement of left neck seen (2.2 mA).
W. Movement, Sensation. "My left hand, all the fingers" (but not the thumb) (2.2 mA).
X. Sensation. "Just a different feeling there," about left eye and left side of face (2.8 mA).
Y. Movement. Quivering in left corner of mouth, more upper lip than lower, and "my tongue, too," on left; presence of sensation not established (2.8 mA).
Z. Movement, Sensation. "Little feeling inside my mouth, left side of tongue too"; movement seen of lower lip (3.3 mA).
I. Sensation. "Inside of my left face, up in my mouth and it seemed like in my head partly, above my lip but inside" (pointed to cheek) (3.3 mA).
2. Evoked Potentials. Obtained on electrical stimulation of the median nerve at the wrist.

Discussion

A greater cortical area receiving facial afferents was eliminated by a combined precentral and postcentral ablation than by removal of the latter area alone. The cutaneous afferents to the precentral cortex have been studied by various workers. Somatic sensory input to the precentral gyrus does not appear to depend on the integrity of the postcentral cortex. Penfield and Jasper elicited sensory responses on stimulation of the precentral gyrus after removal of the corresponding portion of the adjacent postcentral gyrus. A study by one of us showed an...
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intimacy of sensory and motor function in a single area of somatic representation in marsupials. These observations formed part of the theoretical basis for the performance of the present operations. It has been emphasized by Woolsey that each of the four cortical areas of somatic representation contains both sensory and motor function. On this basis he has proposed the following designations: 1) postcentral or somatic sensory-motor area I (SmI); 2) second sensory or somatic sensory-motor area II (SmII); 3) precentral or somatic motor-sensory area I (MsI); 4) supplementary motor or somatic motor-sensory area II (MsII). Our removals have included the regions of facial representation in three of the four areas noted above: SmI, MsI, and SmII.

Our initial intent in combining the precentral and postcentral removals was to eliminate the sensory functions of both MsI and SmI, but it may be that the additional removal of SmII was of greatest significance in the relief of pain. The localization of arm responses in SmII served only to identify that area; SmII was undoubtedly totally removed in both cases, including subdivisions of face and leg as well as arm. Biemond proposed, on the basis of three cases with opercular lesions, that consciousness of pain sensation is established in the second sensory area rather than in the postcentral area. Talairach, et al., reported that interruption of thalamocortical fibers beneath this area may result in relief of pain. Other clinical cases that bear on the possible relationship of the second sensory area to pain were recently reviewed by White and Sweet and Cassinari and Pagni. Poggio and Mountcastle showed that many neurons in the posterior (PO) nuclear complex of the thalamus were activated by noxious stimuli. The PO complex includes the second somatic sensory area in its field of projection, and the possibility that this cortical area may play an especially important role in pain mechanisms was considered by Mountcastle.

The reasons for reduction of painful states following cortical ablations are unclear. It is possible that subcortical neurons that bear a relation to central pain have an ongoing activity that may be reduced by removal of appropriate cortex. Waller and Feldman showed in cats that a corticothalamic dis-charge was necessary for sustaining the ongoing activity of deafferented somatosensory thalamic neurons. There was deafferentation of the area of skin to which pain was referred in both cases: the first patient had trigeminal sensory loss and a decreased corneal reflex, presumably due to a small pontine infarct; the second had a nearly total surgical section of the trigeminal sensory root.

Penfield and Welch and Penfield and Jasper reported a case (B.L.) of probable stroke followed by development of burning pain in the left side of the body. This pain was relieved after removal of the right postcentral gyrus but recurred 18 months later. The right precentral gyrus was removed 3 years after the initial corticectomy. It is noteworthy that immediately after precentral gyrectomy under local anesthesia on the operating table it was no longer possible to produce pain by rubbing the left side of the body. Unfortunately, the pain eventually recurred. These observations provide evidence that in this case the precentral gyrus as well as the postcentral gyrus bore a relation to the painful state. Neither the supplementary motor area nor the second sensory area appeared to be molested during this operation.

It remains possible in this case that long-term relief of pain might have been achieved if the second sensory area had been removed additionally. Török reported that removal of the arm representation of the precentral and postcentral cortex relieved phantom arm pain in a patient followed 6 mos. The evidence for the extent of Török's removal is not complete since he obtained no responses in the awake patient on stimulation of the gyrus which he termed postcentral, but obtained 12 positive responses from the gyrus next rostral, and one positive response of vocalization from the gyrus rostral to that. It is possible that he removed the cortex from the gyri on either side of the postcentral sulcus rather than the Rolandic fissure.

Cortical Localization. The responses obtained on cortical stimulation were of importance in establishing the nature and extent of the cortex resected. They also provided valuable information, incidentally gained, on the normal pattern of cortical localization in man.

In the precentral gyrus in Case 1, two areas were found representing the upper ex-
tremity (Fig. 1). An upper region (Point U) was in the expected location of the precentral "arm area"; a lower region (Points J, L, M, N, P) bordering on the Sylvian fissure also yielded responses from the upper extremity. Between these two regions was an area devoted to the head (Points F, I, Q, R, S, T, V). The lower area of arm representation was found at the foot of the precentral gyrus and was undoubtedly a portion of the "second sensory" area. Penfield and coworkers\textsuperscript{8,9} localized the second sensory area in man in the "suprasylvian zone" on either side of the lower end of the fissure of Rolando extending on to the opercular cortex within the Sylvian fissure. They found this region more frequently at the foot of the precentral gyrus rather than the postcentral gyrus. This area in man is presumed to correspond with somatic sensory-motor area II established by Woolsey and co-workers\textsuperscript{17} in other mammals. One might expect to find SmII at the lower end of the postcentral gyrus since it has been found in other mammals at the lower or lateralmost end of SmI. Its extension to the foot of the precentral gyrus in man represents an apparent dislocation from that locus. Perhaps in man there has occurred a migration of this area due to an elaboration of the face representation in the postcentral gyrus. Somatic sensory-motor area II contains contralateral and, to a lesser extent, ipsilateral sensory and motor representation of the entire body, but its function remains obscure.

We identified the SmII area in Case 1 by establishing responses from the arm representation within it. Stimulation of available suprasylvian cortex about this island of arm representation yielded facial responses. In all mammals in which the relatively small SmII area has been established, it has been found immediately subjacent to and contiguous with the facial representation of the primary sensory-motor areas. From our limited observations the pattern was not clear enough to show which, if any, facial responses came from SmII. This would have been of interest, since the complaint of these patients was facial pain. Much of the representation of SmII probably lies inaccessible to a surface electrode within the Sylvian fissure or within the Rolandic fissure. Nonetheless, it appears rather certain in our cases that the face, arm, and leg representations within SmII were ablated in their entirety since all the Rolandic cortex below the arm representations of SmI and MsI was removed down to the upper border of the insula.

The sensory responses (Points H, X) in SmI from the upper lip and face obtained on stimulation at the foot of the postcentral gyrus do not agree with Penfield's sensory sequence,\textsuperscript{8} but do correspond with the pattern of sensory localization found by Woolsey\textsuperscript{9} in the chimpanzee. Both of these responses were elicited behind and below points yielding responses from the tongue. Point X, which yielded a response about the left eye and side of face, indicated that a proximal portion of the face (as compared with the lips and tip of tongue, which are distal or apical portions) was represented more caudally on the postcentral gyrus. Such a pattern accords with Woolsey's schema and suggests that the somatic sensory representation in man may follow the pattern found in other mammals more closely than previous evidence has indicated.

The visual sensation produced at Point O, near the foot of the precentral gyrus just rostral to points from which somatic responses were obtained, may be best categorized as a visual hallucination. Its significance is unclear. It is possible that this sensation was an illusion produced by eye movement induced by the stimulation. It is doubtful that the spread of the current accounted for excitation of remote areas.

Speech effects including vocalization and inhibition of speech were obtained widely from within the precentral representation for the head. These effects have been observed by many investigators. The patient in Case 1 agreed that cortical stimulation provided the first "sensations" in the left side of his face since his fifth nerve was sectioned, but he was unsure whether these sensations felt normal.

**Summary**

Cortical removal, which included facial representations in the precentral motor area, the postcentral sensory area, and the second sensory area, resulted in long-term relief of facial pain in two patients.

**References**

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