Measuring Sensibility of the Trigeminal Nerve

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The form and function of the face have always been a central focus for plastic surgeons. As approaches to facial rejuvenation and craniomaxillofacial surgery become increasingly sophisticated, measurement techniques have become more crucial. Appropriately, it is being recognized that the trigeminal nerve, responsible for facial sensibility, plays an essential role in evaluating outcomes and complications in craniomaxillofacial surgery. Investigations so far have considered the sensory changes associated with orofacial pain,[1] facial trauma,[2] facial palsy,[3] cleft lip repair,[4] flap reconstruction of the face,[5,6] complications of intracranial surgery,[7] headache,[8,9] and complications of Le Fort and mandibular osteotomies.[10–14] Normative data using traditional neurologic techniques for the trigeminal nerve have been reported,[2,15,16] such as the Semmes-Weinstein nylon monofilaments, two-point discrimination, and vibration thresholds.

Traditional techniques for evaluating sensibility have important limitations. The Semmes-Weinstein nylon monofilaments, for example, do not make a true measurement, but rather give an estimate of the one-point static pressure threshold that in reality lies between two of the filaments. Vibration uses a waveform stimulus that travels across the skin for a considerable distance, and therefore is not valid for defining the threshold for a given nerve to a restricted region of skin. Two-point discrimination records only the distance component of the cutaneous pressure threshold, whereas the true cutaneous pressure threshold requires the pressure at which the two points can be distinguished also to be specified.[17] Not only has application of the concept of applying measurement of force to distance discrimination been considered before,[18,19] but the Pressure-Specified Sensory Device also has been reported for evaluation of lip[20–22] and cheek sensibility.[23] Because these latter clinical studies have not included normative data, the present study was undertaken to provide this requisite information.

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PATIENTS AND METHODS

The population tested to obtain normative data for the trigeminal nerve included 27 women and 15 men, with an age range of 14 to 69 years. Exclusion criteria were history of facial injury; history of facial pain; history of facial surgery; history of headaches; history of central nervous system problems, including stroke, seizure, or loss of consciousness; and history of taking any narcotic or neuropathic pain medication within the previous 2 weeks. Subjects were recruited from employees, friends, relatives, and coworkers. Total time for enrollment and neurosensory testing was 2 hours.

Evaluation of trigeminal sensibility was performed with the Pressure-Specified Sensory Device (Sensory Management Services, LLC, Baltimore, Md.). This device is a computer-linked, hand-held instrument that uses a force-transducer attached to two independently mounted metal prongs. Each prong has a rounded end. As the prong or prongs are pressed against the skin surface to be tested with slowly increasing force by the examiner (E.A.), the subject is asked to answer a question related to what sensation is perceived. The subject is asked to discriminate either one-point static or one-point moving touch stimulus on the skin surface, or two-point static or two-point moving touch on the skin surface. The subject responds by pressing a hand-held button, the message from which signals the computer to stop acquiring the increasing pressure stimulus data input. The force measured divided by the hemispherical surface area of the prong is recorded as the pressure at which the individual stimulus was perceived. Five such perceptions are recorded. The highest and lowest are discarded by the computer, which averages the remaining three and reports the result as the cutaneous pressure threshold for either one-point static, one-point moving, two-point static, or two-point moving touch stimulus. The unit of measurement for these pressure thresholds is grams per millimeter squared. The distance at which one from two points can be distinguished is varied throughout the test to determine the smallest distance at which the discrimination can be determined. The unit of measurement for this distance is millimeters. The cutaneous pressure two-point threshold for a given piece of skin is defined by both the pressure and distance measurement. Normative data for the Pressure-Specified Sensory Device have been reported already for the upper extremity (index and little finger pulp, dorsal ulnar and radial hand, and thenar eminence)[24,25] and for the lower extremity (deep and superficial peroneal nerves, hallux pulp, and medial calcaneal surface of the heel).[26]

Statistical analysis compared the normally distributed data for each test site for differences related to the two age brackets younger than 45 years and 45 years or older, as this cutoff has been demonstrated previously to have physiologic significance.[24,26] Statistical description of the data demonstrated them to be normally distributed, and therefore a parametric test, the *t* test, was used to compare differences in mean sensibility between facial regions related to different branches of the trigeminal nerve, V1 (forehead), V2 (midface), and V3 (mandible) (Fig. 1).

Fig. 1. Neurosensory testing of the trigeminal nerve being performed with the Pressure-Specified Sensory Device. The patient reclines comfortably. The examiner applies the rounded metal prongs of the sensory testing device to the skin surface being tested (zygoma), and slowly increases the pressure of application of either one or two prongs, as either a static or a moving touch. When the nonpainful stimulus is perceived, the patient pushes a button, communicating to the computer to stop acquiring data.

RESULTS

Table 1 lists the age-related normative data for the eight sites tested. The cutaneous pressure thresholds for static and moving two-point discrimination were significantly higher (less sensitive) for the group 45 years or older in the regions of the medial and lateral forehead, zygoma, nasolabial fold, and mentum ($p < 0.001$) but not significantly different for the upper lip (white) or for the upper or lower vermilion. There was no significant difference in sensibility for any site related to age for either one-point static or one-point moving touch stimulus (Fig. 2).

Comparison of cutaneous pressure thresholds between sites demonstrated the vermilion to be significantly more sensitive (lower thresholds) than the zygoma, cheek, mentum, or medial or lateral forehead ($p < 0.001$) and the zygoma and the cheek regions each to be significantly more sensitive (lower thresholds) than the forehead regions ($p < 0.001$). The medial forehead region was significantly more sensitive (lower thresholds) than the lateral forehead ($p < 0.001$). There was no significant difference between the cheek and the zygoma or between the upper and lower vermilion.

DISCUSSION

It is perhaps not surprising that the most prominent part of the face, the nose, has received the most study in terms of sensibility. In the blind burrowing animal, the mole, its nasal sensory organ, described first by Eimer, has the analogues of the quickly and slowly adapting nerve fibers and receptors of the human fingertips.[27] In the bill of the duck, required for "seeing" underwater in the silt to select appropriate food items from small stones, Boecke, from Utrecht, Holland, demonstrated the same types of sensory end-organs.[27] Thirty years ago, in a comparative study of mammals, Montagna and colleagues observed that the hair follicles (vibrissae) around the nose, lips, and mouth were the most innervated parts of the body, except for the hairless face of humans.[28] It would appear to be the appropriate time, now, to document the sensibility of hairless human facial skin.

Documenting sensibility has been a continuing struggle. The perception of pain, a small (diameter) nerve fiber function, remains without a physiologic instrument with which to measure its threshold, and so a psychological instrument, the visual analogue scale, or the Likert scale, has been validated for that purpose.[29,30] For the perception of touch, a large (diameter) nerve fiber function,

Table 1. Mean Normative Facial Sensibility Data

	1PS (g/mm)	2PS (g/mm)	2PS (mm)	1PM (g/mm)	2PM (g/mm)	2PM (mm)
Lateral forehead						
<45 yr	0.88	31.11	10.6	0.58	10.16	8.2
≥45 yr	1.16	39.42	14.9	0.71	11.78	12.5
Medial forehead						
<45 yr	0.88	22.94	8.4	0.56	5.27	6.4
≥45 yr	0.95	33.38	11.2	0.88	8.23	9.1
Zygoma						
<45 yr	0.71	23.10	6.5	0.54	5.47	4.7
≥45 yr	0.78	20.58	9.4	0.58	5.20	7.4
Nasolabial fold						
<45 yr	0.76	13.39	5.1	0.54	3.45	3.8
≥45 yr	0.80	13.53	7.6	0.55	3.72	5.9
Upper lip (white)						
<45 yr	0.77	11.08	4.5	0.51	2.66	3.4
≥45 yr	0.82	13.07	6.0	0.57	4.68	4.4
Upper vermilion						
<45 yr	0.77	3.98	3.1	0.49	1.10	2.8
≥45 yr	0.73	3.80	3.8	0.52	1.15	3.0
Lower vermilion						
<45 yr	0.69	3.57	3.0	0.47	1.13	2.8
≥45 yr	0.78	3.27	3.6	0.54	1.31	3.0
Mentum						
<45 yr	0.82	16.88	5.0	0.52	2.52	3.70
≥45 yr	0.64	17.18	7.1	0.62	4.28	5.30

1PS, one-point static; 2PS, two-point static; 1PM, one-point moving; 2PM, two-point moving.

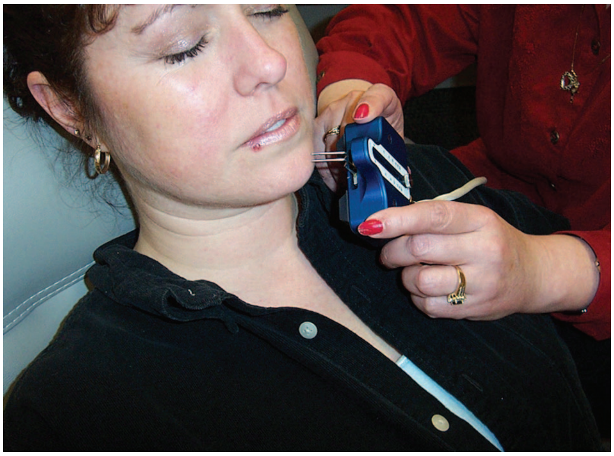

Fig. 2. Close-up of application of the Pressure-Specified Sensory Device to the mentum.

there are two subgroups physiologically: slowly and quickly adapting fibers. Vibratory threshold testing can measure the threshold for the quickly adapting subgroup but, as the stimulus is a wave form, the stimulus spreads for a considerable distance, depending on its intensity, to adjacent skin surfaces, stimulating overlapping nerve territories (i.e., both the radial and median nerves for the index finger pulp). In contrast, the cutaneous pressure threshold can uniquely define a small area of skin surface. Static and moving touch stimuli can measure, respectively, both the slowly and quickly adapting subpopulations of the large-diameter myelinated fingers unambiguously. By measuring both the force and the distance at which one from two either static or moving points can be distinguished, the Pressure-Specified Sensory Device has been proven to be the instrument most appropriate for recording the human cutaneous pressure threshold.[31] In this report, normative data for the facial skin innervated by the trigeminal nerve are reported.

For the lips, especially the vermilion, the level of two-point discrimination, on the order of 3 mm, is the same as these thresholds in the fingers for people younger than 45 years. This implies that the innervation density of nerve fibers and receptors in the vermilion and the fingertips is the same. The lips, however, do not have either Meissner, Pacinian, or Merkel cell receptors. Rather, they have a mucocutaneous end organ, which appears to be a form of the Meissner corpuscle adapted for epithelium in transition from glabrous to mucous membrane.[27] The results of the present study demonstrate that most regions of the face, with the exception of the lip regions, have a significant increase in the cutaneous pressure threshold for static and moving two-point discrimination (are less sensitive) after the age of 45 years. This has not been demonstrated previously.

Comparison of the data in this study with those previously published using Semmes-Weinstein nylon monofilaments, vibration, and traditional two-point discrimination[2,15,16] qualitatively similar judgment that the vermilion is the most sensitive area and the forehead the least sensitive. For some regions of the face, there is a qualitative difference, for example, the study by Kesarwani et al.[2] demonstrates the cheek and the chin to be of equal sensitivity, whereas the study by Posnick et al.[15] and the present study (Table 1) demonstrate the chin to be more sensitive than the cheek. In quantitative terms, the previous studies that used the Semmes-Weinstein nylon monofilaments to characterize the value for one-point static touch are reported as the marking on the nylon monofilament, representing a logarithmic value of *force* (not even the force in milligrams) and therefore cannot be compared directly to the actual measurement of the one-point static *pressure* reported in this present study. In quantitative terms, the previous studies that reported moving and static two-point discrimination values (two-point moving and two-point static) did so just in the distance between the prongs (in millimeters), but without stratifying for age. The values for two-point moving and two-point static discrimination given in previous studies correspond to those reported in the present study for the age group older than 45 years. The increasing threshold with increasing age identified in the present study confirms similar findings for the upper and lower extremities[24,26] and is most likely related to the previously documented decrease in sensory receptor density that occurs with age and which has been reviewed.[27] These results seem especially timely as plastic surgeons contemplate their involvement with diseases as common as the headache and as rare as transplanting (and reinnervating) the human face.[32]

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DISCLOSURE

A. Lee Dellon, M.D., has a proprietary interest in the Pressure-Specified Sensory Device.

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