

The Facial Nerve and Gustatory Function*

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ABSTRACT

Electrogustometry has become one of the most important and useful diagnostic methods as has audiometry and vestibular function tests in the otolaryngological field. Although much literature, concerning the facial nerve and gustatory function have appeared, still problems remain to be solved in future research.

To these points of view, the anatomical relationships of the nerves associated with gustatory function were reviewed and discussed. And also the clinical importance and usability of electrogustometry is emphasized.

INTRODUCTION

Since the clinical application of electrogustometry in otolaryngology was introduced in the past decade, there have been many interesting articles concerning the facial nerve's association with gustatory function.

Today, electrogustometry, as coordinated with audiometry and vestibular function tests, has become one of the important methods of otolaryngologic examination and diagnosis.

The facial nerve is a mixed nerve giving general and special visceral efferent fibers to the submaxillary and sublingual salivary glands, as well as afferent fibers to the tympanic cavity, the external auditory meatus, part of the tympanic membrane, and to the anterior two thirds of the tongue, and general and special sensory impulses such as taste.

The chorda tympani's special afferent fibers are responsible for gustatory sensation in the anterior two thirds of the tongue.

Gustatory sensation is one of the most important daily sensations. We often see changes in taste sensation following stretching or damage (cut or injury) of the chorda tympani due to tympanoplasty, middle ear and stapes surgery, or tympanomastoidectomy. Other causes for changes in sensation include acoustic neuromas, cerebellopontine angle lesions, Bell's palsy, and other nerve injuries. There are still many interesting but unknown factors related to or affecting gustatory function.

Of the three nerves affecting taste sensation, the glossopharyngeal, the lingual, and the facial nerve, the latter nerve and lesions of it is emphasized in this paper, particularly, its effect on changes in gustatory function.

The importance of the use of electrogustometry will be emphasized.

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Reviewing the literature I have noticed that clinical use of electrogustometry has long been advised by such as A. Volta (1792), A. P. Skouby, Zilstorff-Pedersen. K. (1955), and I. C. K. Mackenzie (1955) who are all associated with research in this area.

Until the present time we have mainly relied upon the use of a chemical method which is a semiquantitative measurement. This involves the use of four basic flavors: saltiness, sweetness, acidity and bitterness. The chemicals used are quinine, hydrochloric or citric acid, sodium chloride, and sugar or saccharin solutions. These substances are applied to the lingual to determine whether or not these particular taste sensations are present.

Research by B. Krarup, C. H. Best, N. B. Taylor and L. M. Beidler suggests that this chemical method is not the best for localizing taste examination because the solution rapidly diffuses throughout the mouth. This method also requires a great deal of time and causes inconvenience and is not precise. These investigators used a galvanic current to test response.

In 1958, B. Krarup first used electric taste testing in the clinic. Krarup, beside being the first to use this method clinically, systematized the test by creating an electrogustometer which enabled a precise, quantitative determination of the taste threshold. Also he was able to convince others of the clinical practicability of the electrogustometer. Salute his pioneering spirit and praise his contributions to otolaryngology.

Since Krarup began his research, others have been quick to institute the use of electrogustometry. Among others these include H. Feldmann, E. Maier (1959), H. Herbert, S. Wagner, I. M. Young (1962), W. Pascher, H. Tomita (1964), J. L. Pulec, W. F. House

(1964), T. R. Bull, O. Jepsen, D. Taverner (1965), M. Fons, P. A. Osterhammel (1966), H. J. Gerhardt, H. Berndt (1967). These have built upon the work of Krarup by simplifying and modernizing his electrogustometer. Today, electrogustometry is being used widely. It aids in the correct diagnosis of lesions of the facial nerve.

The taste buds on the tongue, which are supplied by the lingual and chorda tympani nerves on the anterior two thirds and glossopharyngeal nerve on the posterior one third, are capable of differentiating four basic flavors: saltiness, sweetness, acidity and bitterness. Sweet material and salt are tasted best at the tip of the tongue, acid along the sides of the middle of the tongue and bitter things on the posterior part of the tongue.

A detailed knowledge of the anatomic physiology of the facial nerve is necessary to understand the various problems related to differential topographic diagnosis of facial nerve lesions.

The course of the fibers carrying taste impulses from the anterior two thirds of the tongue to the central nervous system has long been discussed. The literature shows contradictory statements as to the course of taste fibers from the geniculate ganglion to the nucleus of the solitary tract of the medulla oblongata.

The generally accepted pathway for the central branches of the taste fibers is one which passes from the geniculate ganglion via the nervus intermedius to the solitary nucleus.

However K. Ranner (1956) have developed a "direct pathway" theory which states that the taste fibers from the lingual nerve connect directly to the solitary nucleus via the trigeminal nerve, thus bypassing the

chorda tympani. Clinically, in acoustic tumor cases we have frequently seen early taste impairment even before the trigeminal and facial nerve impairment was diagnosed. For this reason, Ranner's direct pathway theory was not believed to be correct. This led to further study.

As postulated by V. M. von Bechterew's theory, it is generally felt that afferent fibers of the vagus, glossopharyngeal and facial nerves travel to the solitary nucleus which is the primary taste center. From the solitary nucleus these afferent fibers cross to the opposite side and travel along the lateral cerebral (Sylvius) fissure terminating in a center at the inferior portion of the postcentral gyrus.

Taste sensation of the posterior one third of the tongue is not only a single, simple function of the glossopharyngeal nerve but also it coordinates general sensory and taste sensations. When we block the trigeminal nerve, the sensation of touch, pain and taste are lost. This proves the function of coordination mentioned above. Thus, along with further study of the lingual nerve pathway previously mentioned, we must also study the coordinated functions of the glossopharyngeal nerve.

Normally, the chorda tympani arises from the facial nerve in the third segment of the facial canal, some five mm. above the stylomastoid foramen. It passes upwards and forwards through the tympanic cavity to reach the lingual nerve in the parapharyngeal space. The chorda tympani may be regarded as an anastomosis between the facial and lingual nerves, and it mainly carries taste fibers from the anterior two thirds of the tongue. When the chorda tympani is in a state of neuropraxia it can not send taste impulses from the tongue to the

facial nerve via the lingual nerve. Therefore, this kind of case shows a loss of taste sensation.

Statistically, among the twelve cranial nerves, the facial nerve and the trigeminal nerve are the two nerves most involved in taste sensation. Clinically, when a facial nerve is paralyzed, the patient will certainly have abnormal taste sensations.

In the above kind of cases, we must use electrogustometry to determine and differentiate the precise localization of a lesion. In addition, we must also use the tests for lacrimation, nerve excitability, stapedius reflexes and other examinations as needed.

Today, electrogustometry has shown itself to be one of the most important methods of diagnosis and evaluation of facial nerve lesions. This test should be routinely used in every clinic.

I would like to review the relationship between a lesion of the facial nerve and taste sensation.

When the loss of taste is noticed on the posterior one third of the tongue, a glossopharyngeal paralysis is suggested as the cause. When the loss of taste is on the anterior two thirds of the tongue, a trigeminal nerve paralysis is the usual cause. If the lesion is seated between the geniculate ganglion and the chorda tympani, there is a loss of taste, not only on the anterior two thirds of the tongue, but also on the palate. However, if the lesion is seated on the side of the facial nerve peripheral to the junction of the chorda tympani and the facial nerve to the stylomastoid foramen, then taste impairment does not occur.

In some cases, in spite of loss of the chorda tympani nerve, taste impairment does not exist. This seems to be due to a reinnervation of the opposite, healthy side of

the tongue, or to a process of anastomosis originating in the healthy side of the tongue. Thus, this indicates that just as in the apex of the tongue, this process of anastomosis also exists in the anterior two thirds of the tongue.

Because the location of the junction of the chorda tympani and the facial nerve sometimes exists anywhere between the level of the horizontal semicircular canal and a few mm. above the stylomastoid foramen, we must recognize that it is not always easy to make a correct diagnosis of the lesion of the facial nerve.

In cases where there is a lesion between the internal acoustic meatus and the geniculate ganglion there is no taste impairment. Also, as previously stated, when there is an acoustic tumor, taste impairment occurs early even before the trigeminal and facial nerve lesion is diagnosed. In addition, sometimes lesions involving the eighth nerve exist, there is strong evidence for pathologic changes when they are located within the internal acoustic meatus. Therefore, the author, along with others, believe that the direct taste pathway does not lie via the trigeminal nerve.

Because of the above information, electrogustometry, when applied clinically, is useful to determinate the precise location of the lesion in middle ear disease, facial paralysis and facial weakness. It is also very useful in the differential diagnosis of acoustic neuroma, cerebellopontine angle lesions, and other organic and central disorders of the lingual and glossopharyngeal nerves.

One important fact is that the taste threshold varies according to age, health, physical and mental condition, racial strain, and life style of the patient. It also varies in cases of congenital taste blindness and tho-

se with taste abnormalities as recruitment phenomena. Certain diseases also influence our taste sense such as: ageusia, hypogeusia, hypergeusia, parageusia, heterogeusia and cacogeusia. The patient may also display a subjective abnormal acuteness of the taste sense such as a gustatory hallucination. Therefore, the correct evaluation of lesions of the facial nerve is extremely difficult. We always need a detailed history and care must be taken to consider all the possibilities before a diagnosis is made.

In summary, the author has reviewed the anatomical relationships between the nerves associated with the taste function, and the changes in gustatory function related to lesions of the facial nerve. The usability of electrogustometry in the clinical diagnosis of facial nerve paralysis is emphasized. The author wholeheartedly advocates the use of this method for diagnosis.

This is not to say that the chemical method is not clinically useful. This chemical method, which is less quantitative than electrogustometry (which has an electric taste) can be used for analysis in parageusia cases in which qualitative values are needed. I have found that, instead of Krarup's pipet-method and Maier and Feldmann's cotton applicator-method, it is better to use the glass stick method which controls the amount of solution better and thereby avoids any added stimulation to the surface of the tongue.

In conclusion, I feel that we must concentrate on further studies concerning 1) the direct pathway of the lingual nerve, 2) the possibilities of the reinnervation special pathway of the lingual nerve between the healthy and pathologic sides of the tongue, and 3) whether or not any coordinative relationship between the glossopharyngeal and trigeminal nerve for taste reception

exists on the posterior one third of the tongue.

DISCUSSION

Dr. Tomita, H. (Tokyo, Japan) - comment

I have studied whether the taste goes through the internal auditory canal or not, and found that the taste in the area innervated by the chorda tympani was completely lost after a surgical section of the total facial nerve fiber in the internal auditory canal. The section of chorda tympani due to tympanoplasty resulted in the extension of the contralateral chorda tympani by about 2 cm. There is always a limited area where the taste sensation is lost after the section of the chorda tympani. This result confirms that the taste does not go through the trigeminal nerve. The electrogustometric test revealed that there was no taste sensation in the area of circumvallate papillae after the block of the glossopharyngeal nerve. These facts should be taken into consideration when we carry out the electrogustometry.

Dr. Saito, H. (Kyoto, Japan) - question and comment

Histologically the chorda tympani nerve has a great capacity to regenerate. Seven cases out of 10 in which the chorda was cut during operation, regenerated fibers can be found in the iter chordae anterioris. I would like to ask both of Drs. Tomita and Pulec how many days after surgery you tested the taste sensation.

Dr. Pulec, J. L. (Los Angeles, USA) - answer to Dr. Saito

The taste was tested many times after surgery from 1 week to several months.

The test remained the same.

Dr. Pulec, J. L. (Los Angeles, USA) - question to discussion of Dr. Tomita

Dr. Tomita brought up a new but interesting subject. The anatomy of the taste and sensory fibers of the facial nerve. In two cases of rare geniculate ganglion neuralgia, the nervous intermedius was sectioned by the middle cranial fossa approach. One patient lost all taste to the anterior 2/3 of the tongue on the operated side as well as the disturbing pain. The other patient obtained only partial loss of taste function and only improvement but not relief of pain. Adequate section of the nervous intermedius was confirmed by review of movies taken at surgery. Taste and pain were finally removed following excision of the geniculate indicating that not all sensory fibers are in the nervous intermedius but that some pass through the trunk of the facial nerve in the internal auditory canal.

Dr. Wigand, M. E. (Würzburg, W. Germany) - comment to Drs. Kim and Pulec

Short comment on Dr. Pulec's most interesting remark: There is an old controversial discussion concerning the intermediate nerve. Early neuroanatomists have stated (according to Sheller) that part of the gustatory fibers run along the great superficial petrosal nerve and run back to the brain stem joining the fibers of the trigeminal nerve. So your observation would beautifully fit into their concept.

Dr. Diamant, H. (Umea, Sweden) - comment to Drs. Kim and Tomita

Even if the discussion has come a little bit aside, it is extremely important to discuss what happens to the out or damaged

chorda tympani. We have found in material of nearly 90 cases that once cut the chorda tympani rarely gets its function back. Even patients with damaged chorda tympani will have impaired function in a fairly high percentage.

REFERENCES

- Beider, L. M.: *Dynamics of Taste Cells, in the Text of Zotterman, Y.: Olfaction and Taste*, 133, Pergamon Press, London, 1963.
- Best, C. H.: *The Physiological Basis of Medical Practice, in the Text of Taylor, N.B.: Applied physiology*, The Williams & Wilkins Co., Baltimore, 1961.
- Bull, T. R.: *Taste and the Chorda Tympani*, J. Laryng. & Otol. (London) 79: 479, 1965.
- Chusid, J. G., and McDonald, J.J.: *Correlative Neuroanatomy and Functional Neurology* 91, Lange Medical Publications, Los Altos, 1964.
- Feldmann, H. u. Maier, E.: *Neue methodische und differentialdiagnostische Gesichtspunkte zur Funktionsprüfung der Chorda Tympani*, Archiv Ohren-usw. Heilk. u. Z. Hals-usw. Heilk. 174: 423, 1959.
- Fons, M., and Osterhammel, P. A.: *Electrogustometry*, A.M.A. Arch. Otolaryng. 83: 538, 1966.
- Gerhardt, H. J., u. Berndt, H.: *Zur Schädigung des Geschmackssinnes durch die Stapesoperation*, Z.Laryng. Rhinolog. 46: 520, 1967.
- Herbert, H., Wagner, S., and Young, I. M.: *Quantitative Measurement of Taste Function*, A. M. A. Arch. Otolaryng. 75: 138, 1962.
- Jepsen, O.: *Topognosis (Topographic Diagnosis) of Facial Nerve Lesions*, A.M.A. Arch. Otolaryng. 81: 446, 1965.
- Krarup, B.: *Electro-Gustometry; A Method for Clinical Taste Examinations*, Acta Otolaryng. 49: 294, 1958.
- Krarup, B.: *Taste Reactions of Patients with Bell's Palsy*, Acta Otolaryng. 49: 389, 1958.
- Krarup, B.: *On the Technique of Gustatory Examinations*, Acta Otolaryng. Suppl. 140: 195, 1958.
- Krarup, B.: *Taste Fibers and the Chorda Tympani*, Acta Otolaryng. Suppl. 140: 201, 1958.
- Krarup, B.: *Electrogustometric Examination in Cerebellopontine Tumors and on Taste Pathways*, Neurology 9: 53, 1959.
- Mackenzie, I. C. K.: *A Simple Method of Testing Taste*, Lancet 268: 377, 1955.
- Pascher, W., and Tomita, H.: *Otoneurologische Befunde nach Entfernung von Kleinhirnbrückenwinkeltumoren*, Archiv Ohren-usw. Heilk. u. Z. Hals-usw. Heilk. 183: 217, 1964.
- Pulec, J. L., and House, W. F.: *Facial Nerve Involvement and Testing in Acoustic Neuromas*, A.M.A. Arch. Otolaryng. 80: 685, 1964.
- Ranner, K.: *Zur sensorischen u. sensiblen Innervation der Zunge*, Wien. klin. Wschr. 68: 245, 1956.
- Skouby, A.P., and Zilstorff-Pedersen, K.: *The Influence of Acetylcholine, Menthol and Strychnine on Taste Receptors in Man*, Acta Physiolog. Scand. 84: 250, 1955.
- Taverner, D.: *Electrodiagnosis in Facial Palsy*, A.M.A. Arch. Otolaryng. 81: 470, 1965.
- Tomita, H.: *Facial Nerve Paralysis and Electrogustometry*, Practica Otologica Kyoto 61: 419, 1968.