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Is the Electrical Threshold of Sensation on the Soft Palate Indicative of the Recovery Process of the Swallowing Reflex Based on Functional Assessment?

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<http://dx.doi.org/10.5772/60771>

1. Introduction

Patients with dysphasia have a variety of motor deficits in orofacial and pharyngeal movements. Disorders in the orofacial region, such as dysphasia developed, may be induced by cerebral vessel disease, cancer in the orofacial and neck region, and other conditions. Functional assessment of mastication and the deglutition is most likely to be performed using videoendoscopy (VE) and videofluoroscopy (VF), although electromyography (EMG), ultrasonography (US), and other modalities are also used. Although VE is the primary method for examination of swallowing, projection of VE during instantaneous variations in swallowing cannot be observed because of whiteout. On the other hand, although VF is the best choice for functional assessment of eating and swallowing, we cannot avoid a bombing experience. Therefore, we devised a new method to reduce the reliance on VF examination.

Electrical thresholds of the sensation of structures with primary disease in the orofacial region of patients with stroke, head and neck tumor, external injuries, and other conditions following orofacial treatments were examined. The results suggested a close relationship between the electrical threshold of sensation and the recovery process, because patients with various orofacial and neck diseases showed a lower threshold of electrical sensation associated with treatment. Thus, changes in the oral and pharyngeal phases using VF in patients with brain tumors, stroke, external injuries, amyotrophic lateral sclerosis and myasthenia gravis were investigated.

Many researchers have evaluated VF results based on the Videofluorographic Examination of Swallowing Worksheet developed by Logemann [8]. However, because the inspection items on this worksheet comprise many measurement items, numerous hospitals conduct their own modified VF assessments [2, 3, 5-7, 14]. Based on experiences in other hospitals, 11 key events were identified for the assessment of VF: bolus formation, tongue-to-palate contact, premature bolus loss, residue in the oral cavity, and oral transit time in the oral phase; and lift in the soft palate, triggering of the pharyngeal swallow, vallecula residue, pyriform sinus residue, pharyngeal transit time, and aspiration in the pharyngeal phase. Furthermore, these items were classified into three levels: grade 0 as normal, grade 1 as inadequate, and grade 2 as a true abnormality. The total scores for all items in the oral and pharyngeal phases separately are calculated and a higher sum in each phase represented a more serious condition is presumed. Electrical thresholds of sensation on the soft palate during the hospital visit were measured, too. Guidance regarding an accepted way of stretch training fitting various disorder parts, such as gum rubbing, the Mendelsohn maneuver, thermal tactile stimulation, the head lift exercise (Shaler exercise), the tongue holding maneuver and Sylvester maneuver. Trainings involved procedures suitable for each patient after obtaining first-person informed consent. For example, patients with the deglutition disorder were performed by thermal tactile stimulation during the hospital visit and Shaker exercise in the residence. Patients performed the training method best suited to their disease twice daily.

Finally, we examined the relationship between the total scores for all items in the oral and pharyngeal phases and the threshold of electrical sensation on the soft palate. We hypothesized that if electrical threshold measurement can be substituted for VF assessments, radiation exposure to patients can be reduced. Furthermore, electrical threshold stimuli on the soft palate and other areas are produced by an appeal of a loose press feeling in the stimulus area of subjects, not painful sensation.

2. Material and method

We aimed to elucidate the relationship between changes in the electrical threshold of sensations associated with various orofacial symptoms and the recovery processes of areas affected by orofacial disorders depending on the oral rehabilitation technique. Thus, we investigated the relationship between modified VF assessments and sensory electrical threshold evoked on the soft palate. In particular, electrical stimuli are appealed by a loose press feeling in the stimulus area of subjects, not painful sensation.

2.1. Subjects

First experiment: We examined 11 patients (8 males, 3 females; age range, 30-66 years) with various disorders in orofacial regions (facial muscles, n=4; lingual muscles, n=5; hypoesthesia of the soft palate, n=2) (Table 1). All medical treatments were performed over a long time period (range, 10-80 months). We compared the relationship between the degree of recovery following oral rehabilitation and the electrical threshold of sensation in the deficient orofacial regions.

The various disorders among the 11 patients were as follows: acoustic nerve tumor (n=1), diabetes (n=1), cerebral infarct (n=4), neck tumor (n=4), and facial nerve palsy (n=1) (Table 1). Guidance regarding an accepted way of stretch training fitting various disorder pats, such as gum rubbing, the Mendelsohn maneuver, thermal tactile stimulation, the head lift exercise (Shaker exercise), and the tongue holding maneuver were provided. Training involved procedures suitable for each patient after obtaining first-person informed consent. Patients performed the training method best suited to their disease twice daily. The thermal tactile stimulation was performed when the patients visited the hospital, and the relationships between the electrical threshold of sensation from one month to the next as well as the degree of recovery according to the training condition, including hearing investigation were examined.

Patient No.	Etiology	Location of disorder	Age	Sex	Time after onset
1	Accostic nerve tumor	unilateral tongue	55	F	60 months
2	Diabetes	unilateral tongue	59	F	120 months
3	Cerebral infarct	unilateral tongue	62	M	30 months
4	Neck tumor	unilateral tongue	30	M	48 months
5	Neck tumor	unilateral neck region	30	M	60 months
6	Neck tumor	unilateral mandibular part	43	F	36 months
7	Cerebral infarct	unilateral upper lip part	62	M	6 months
8	Neck tumor	unilateral neck region	30	M	50 months
9	Facial nerve palsy	unilateral tongue	35	M	3 months
10	Cerebral infarct	bilateral soft palate	66	M	36 months
11	Cerebral infarct	bilateral soft palate	62	M	6 months

Table 1. Patient characteristics in the first experiment. F: female, M: male.

Second experiment: Eight patients (six males, two females were evaluated; age range, 24-67 years) with glossopharyngeal nerve paralysis of the soft palatal lift. The duration of the patients' dysphasia symptoms ranged from 7 to 39 months before the investigation (Table 2). The eight patients exhibited various symptoms as follows: brain tumor (n=2), cerebral hemorrhage (n=2), cerebral contusion (n=2), amyotrophic lateral sclerosis (n=1), and myasthenia gravis (n=1) (Table 2). The degree of dysphagia was classified based on many VF assessments as described by Logemann [8] (underside of Modified VF worksheet, Table 3). The bolus formation, tongue-to-palate contact, premature bolus loss, and oral transit time were measured in the oral phase, while lift in the soft palate, triggering of pharyngeal swallow, epiglottic vallecula residue, pyriform sinus residue, pharyngeal transit time, and aspiration were measured in the pharyngeal phase. Thus, the analysis comprised the total assessments in the oral and pharyngeal phases. These items were divided into three levels: grade 0 as normal, grade 1 as inadequate, and grade 2 as a true abnormality.

Patient No.	Etiology	Location	Age	Sex	Time after onset	Status
1	Brain tumor	Brain stem	48	M	7 months	full oral
2	Brain tumor	Brain stem	54	M	9 months	NG
3	Cerebral hemorrhage	Multiple	67	M	7 months	NG
4	Cerebral hemorrhage	Middle cerebral artery territory	58	M	1 year 3 months	full oral
5	Cerebral contusion	Multiple	19	M	10 months	NG
6	Cerebral contusion	Multiple	25	F	2 years 1 months	PEG
7	Amyotrophic lateral sclerosis	-	60	M	3 year 3 months	full oral
8	Myasthenia gravis	-	24	F	2 years 1 months	full oral

Table 2. Patient characteristics in the second experiment. NG: no symptoms, PEG: gastrostomy.

We utilized the total scores for all items in the oral and pharyngeal phases separately. In particular, we considered that a higher sum in each phase might indicate a more serious condition. All procedures were approved by the ethic committee at Nihon University School of Dentistry.

2.2. Threshold of electrical sensations

First experiment: A special electrode was designed for electrical stimulation of the tongue dorsum. This electrode consists of a button-like electrode with a central part (cathode, 0.5 mm across) and round wire (anode, 1.0 mm across) (Figure 1A). This electrode performed the local electrical stimulation. An electrode was applied to the facial skin as a skin patch (one side was the cathode and the other side was the anode) with a 25-mm distance between commercial electrodes (Figure 1B). The electrode applied to the soft palate was a circular disc cathode with a 1.0-cm diameter and circular disc anode with a 1.0-cm diameter made of stainless steel (Figures 1C and 1D). We categorized as “C” or “D” according to various oral conditions. The electrodes were separated according to their use in patients with natural teeth (Figure 1C) versus complete dentures (Figure 1D). The low electrode impedances were approximately 6.5-7.5 k Ω at 20 Hz as measured by Neuropack- μ , Nihon Kodan Co.) and the stimulations were 0.2 msec in duration and 5 Hz in frequency.

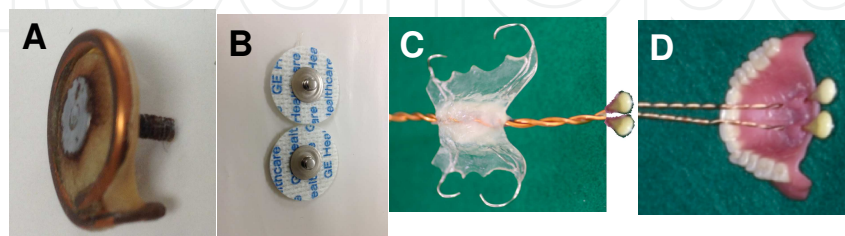


Figure 1. The electrode was used in various regions: (A) tongue dorsum, (B) facial skin, and (C,D) soft palate. (A) The special button-like electrode consists of a central part (cathode, 0.5 mm across); this electrode is suitable for local stimulation. (B) Commercial-release electrodes were used for facial skin stimulation. (C, D) The electrodes were separated according to their use in patients with (C) natural teeth versus (D) complete dentures.

Second experiment: The electrodes for electrical stimulation were connected to thin acrylic maxillary splints or full dentures depending on their fit in the paralytic regions of each patient. The stimulus part for electrical stimulation were determined depending on exploration of the hypoesthesia on the soft plate. The electrode comprises a circular disc cathode and anode, both 1.0 cm in diameter, and is made of stainless steel. The electrode mounted at the top of the shielded elastic wire (braided wires) ensured good electrical contact with the moist nature of this part of the mouth. A silicon impression material (GC Co.) was used to cover the surfaces of the stimulating electrodes at low electrode impedances (approximately 6.5-7.5 k Ω at 20 Hz as measured by Neuropack- μ , Nihon Kodan Co.). Stöhr and Petruch [12] and Stöhr et al. [13] reported that electrical stimulation in lips or gingival mucosa was appropriate in 0.1-0.2msec (duration) and 1-20 Hz (frequency). On the basis of these data, we decided to stimulate with 0.2msec in duration and 5 Hz in frequency. We employed the first sensation at the increased value with serial access from 0.2 mA. (depending on the mechanical mature).Measurements were performed three times, and the threshold value was averaged. We expected to determine the degree of recovery by the changes in the threshold of electrical sensations. We measured the threshold of electrical sensation in the soft palate with the use of Neuropack- μ every arrival at the hospital. The electrode was jointed with the dental resin on a palatal plate denture or full denture made from each patient, were always stimulated on the same point in every checks. We defined the electrical threshold as the patients were firstly sensed minimum values.

2.3. Modified VF worksheet

Although the VF worksheet proposed in Logemann's study [8] is used by many dentists and otolaryngologists, many medical institutions use a more concise version. We divided the dysphasia scale into the oral phase and pharyngeal phase. In the oral phase, we examined the bolus formation, tongue-to palate contact, premature bolus loss, residue in the oral cavity, and oral transit time. In the pharyngeal phase, we examined the lift in the soft palate, triggering of pharyngeal swallow, epiglottic vallecula, pyriform sinus residue, pharyngeal transit time, and aspiration.

For both the oral and pharyngeal phases, the bolus formation, tongue-to-palate contact, premature bolus loss, residue in the oral cavity, oral transit time, lift in the soft palate, and triggering of the pharyngeal swallow were categorized into three levels: grade 0 as normal, grade 1 as inadequate, and grade 2 as a true abnormality (Table 3). In particular, the amount of premature bolus loss, residue in the oral cavity, and epiglottic vallecula and pyriform sinus residue were divided into three levels: grade 0 indicated no residue, grade 1 indicated residue in <50% of the bolus, and grade 2 indicated residue in >50% of the bolus. Furthermore, aspiration was divided into three levels: grade 0 indicated no aspiration, grade 1 indicated supraglottic penetration and grade 2 indicated subglottic aspiration.

All oral and pharyngeal phase criteria were categorized into three levels, 0, 1 and 2. Based on the assortment of the three levels according to the standardized definition, wthat a more serious condition in the oral or pharyngeal phase would be indicated by a higher total for each criterion, as shown in the totals for the oral and pharyngeal phases in Table 3. We considered that assessments performed using these three simplified levels would provide consistency

with respect to the criteria used during long-term evaluation (>2 months after symptom onset). The criterion for each phase (oral and pharyngeal) was employed by the total.

Parameter	Patient No.																										
	1			2			3			4			5			6			7			8					
	1st.	1M	2M	1st.	1M	2M	1st.	1M	2M	1st.	1M	2M	1st.	1M	2M	1st.	1M	2M	1st.	1M	2M	1st.	1M	2M			
Oral phase																											
Bolus formation	0	0	0	2	2	2	1	1	1	1	1	1	2	1	1	2	2	2	1	1	2	1	1	1	1	1	1
Tongue-to-plate contact	0	0	0	1	1	1	0	0	0	0	0	0	2	1	1	2	2	2	2	2	2	0	0	0	0	0	0
Premature bolus loss	1	1	1	3	3	3	3	3	1	0	0	0	3	1	1	3	3	3	3	3	3	3	3	3	3	3	3
Residue in oral cavity	1	1	1	3	0	0	3	2	1	2	2	2	3	1	1	3	3	3	2	2	2	3	3	3	3	3	3
Oral transit time	1	0	0	1	1	1	1	0	0	0	0	0	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Total in the Oral phase	3	2	2	10	7	7	8	6	3	3	3	3	11	6	5	11	11	11	9	9	10	8	8	8	8	8	8
Pharyngeal phase																											
Lift in the soft palate	2	2	2	2	0	0	2	2	1	2	2	2	2	1	1	2	1	1	2	2	2	2	2	2	2	2	2
Triggering of pharyngeal swallow	1	1	0	1	0	0	1	1	1	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1
Vallecular residue	2	1	0	2	2	2	3	1	1	1	1	1	3	1	1	3	3	0	3	3	3	2	2	2	2	2	2
Pyriform sinus residue	2	2	1	3	2	2	3	1	1	1	1	1	3	1	1	3	2	1	1	2	2	0	0	0	0	0	0
Pharyngeal transit time	1	1	0	1	0	0	1	1	1	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1
Aspiration	1	1	0	2	0	0	2	0	0	1	0	0	2	0	0	2	1	0	0	0	1	1	1	1	1	1	1
Total in the Pharyngeal phase	9	8	3	11	4	4	12	6	5	5	4	4	12	5	3	12	9	2	8	9	10	7	7	7	7	7	7
Threshold of sensation in a soft palate (mA)	8.6	5.6	2.2	8.0	2.2	1.6	7.3	3.4	2.9	5.6	2.2	2.1	6.8	5.5	2.1	7.0	6.1	3.1	2.8	3.3	2.8	3.3	3.0	3.2	3.3	3.0	3.2
1 st.: the first medical examination 1 M: the examination after one month 2 M: the examination after two month																											

Table 3. Measurements of videofluoroscopic dysphagia scale (VF assessments) and threshold of electrical sensation during the patients’ hospital visits. Patients 1-6 had brain disease, and patients 7 and 8 had spinal cord disease and a muscular disorder, respectively..

3. Results

First experiment: We evaluated the recovery process of each patient as they performed routine exercises and gave an oral assessment of how they felt at each monthly hospital visit. The relationships between the recovery process and the electrical threshold of sensations are indicated by regression curves for each patient (Figures 1A, tongue dorsum; 1B, facial skin; and 1C, soft palate). The regression curves of the electrical threshold and time course showed ① $y=-0.0442X+3.1564$, $r^2=0.58404$ (acoustic nerve tumor), ② $y=-0.0105X+2.425$, $r^2=0.0363$ (diabetes), ③ $y=-0.0269X+2.4865$, $r^2=0.6517$ (cerebral infarct) and ④ $y=-0.0177X+4.2982$, $r^2=0.02184$ (neck tumor) on tongue dorsum stimulation, ⑤ $y=-0.1669X+6.2984$, $r^2=0.22006$ (neck tumor), ⑥ $y=-0.1605X+3.0904$, $r^2=0.45346$ (neck tumor), ⑦ $y=-0.0159X+1.3826$, $r^2=0.43144$ (cerebral infarct), ⑧ $y=-0.0237X+4.4219$, $r^2=0.08506$ (neck tumor), ⑨ $y=0.0984X+4.1664$, $r^2=0.5461$ (facial nerve palsy) on facial skin stimulation, and ⑩ $y=-0.0448X+12.404$, $r^2=0.00864$ (cerebral infarct), and ⑪ $y=-0.0022X+3.5931$, $r^2=3E-05$ (cerebral infarct) on soft palate stimulation. These findings suggested that the electrical threshold stimulation decreased with the time course of the recovery process, because all “gradients” of these data were observed as negative values (Figure 2), although each r^2 value (regression estimate of approximate curve) was

indicated by divergence or convergence. In particular, although each disease showed a different slope, the recovery trend appeared to be unrelated to the onset of treatment.

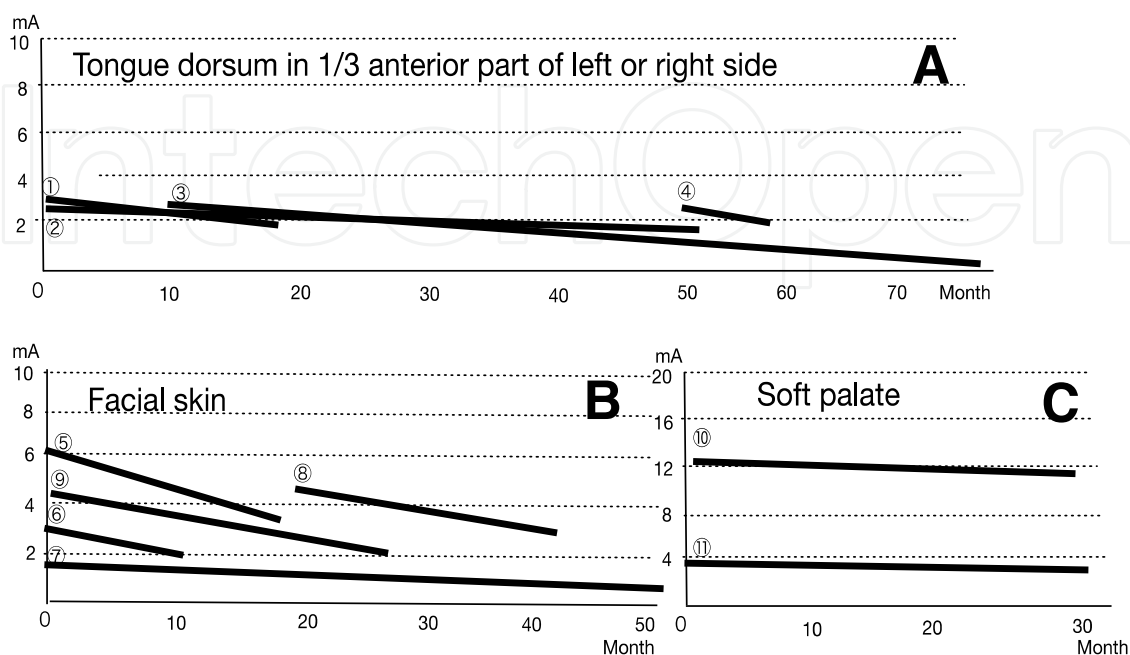


Figure 2. Changes in the recovery process of threshold electrical stimulation. Each start point indicated the start of treatment after onset of the disease.

Second experiment: All patients in the present study had severe swallowing dysfunctions as shown in Table 1. These disorders, which share characteristics in common with dysphasia, were divided into two types depending on the underlying cause. The location of the underlying cause was classified as either the brain (patients 1-6) or spinal cord (patients 7 and 8) (Table 2).

All criteria of the oral and pharyngeal phases were categorized into three levels: 0, 1 and 2 (Table 2). We investigated the relationship between the threshold of sensation and each value in the VF assessment of each patient's disease condition. These values were grouped into classes according to the data shown in Table 3. The total score of the VF assessments in the oral and pharyngeal phases and the threshold of sensation in each patient are shown in Figures 3Aa, 3Ab and 3B; the averages and standard deviations in each figure are indicated in Figures 3C and 3D. Almost all data showed a recovery trend (negative "gradient" of the regression curve) with the exception of amyotrophy lateral sclerosis and myasthenia gravis. Thus, amyotrophic lateral sclerosis and myasthenia gravis did not exert a curative influence on our treatment, because suggesting based on the VF and threshold that sensation did not recover (Figure 3: black lines, amyotrophic lateral sclerosis; red lines, myasthenia gravis). These results may suggest that such muscle diseases do not recovery with the type of training performed in this study. Although the average scores of the VF assessments and threshold electrical

stimulation indicated a recovery trend for all diseases, separate analysis for each disease was importance to obtain more detailed data. Based on these findings, we believe that the electrical threshold of sensation on the soft plate may reflect the recovery process of swallowing reflex disorders.

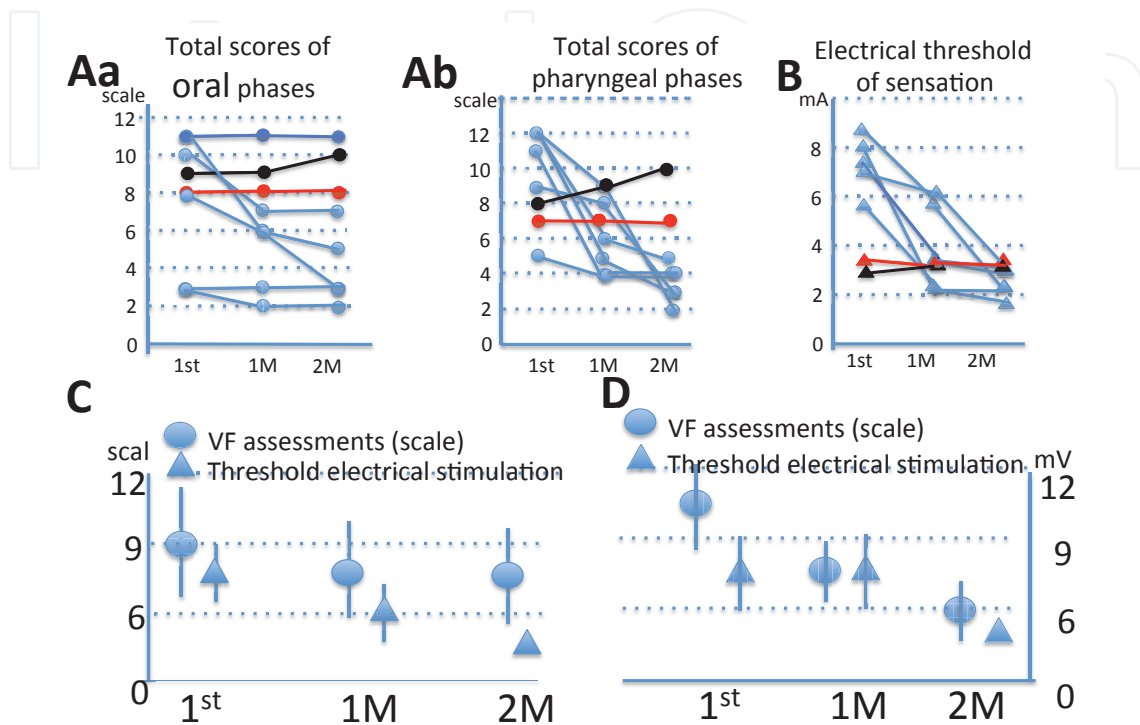


Figure 3. Relationship between total scores of VF assessments in (A) the oral phase and (D) the pharyngeal phase and the threshold of electrical sensation. (Aa) VF assessments in the oral phase. (Ab) VF assessments in the pharyngeal phase. (B) Electrical threshold of sensation. Black lines: amyotrophic lateral sclerosis. Red lines: myasthenia gravis. (C, D) Averages and standard deviations of VF assessments and electrical threshold of sensation.

4. Discussion

4.1. Total of VF assessments in the oral and pharyngeal phases and the threshold of electrical sensation

It was investigated that the relationship between the threshold of sensation and each value in the disease history of each patient. The relationship between the total in the oral phase and the threshold of sensation differed significantly (paired t-test, $P < 0.05$). Furthermore, the relationship between the total in the pharyngeal phase and the threshold of sensation were statistically significant at $P < 0.01$. The regression curves of each relationship were examined, too. The total scores of the VF assessments in the pharyngeal phase and the threshold of electrical sensation were strongly associated ($r^2 = 0.75$). However, the total score of the VF assessments in the oral

phase and the threshold of electrical sensation were not strongly associated ($r^2=0.13$) (Figures 4A and 4B).

Because the total scores in the pharyngeal phase and the threshold of sensation showed a strong correlation, the decrease in electrical sensation might be related to recovery of the pharyngeal phase.

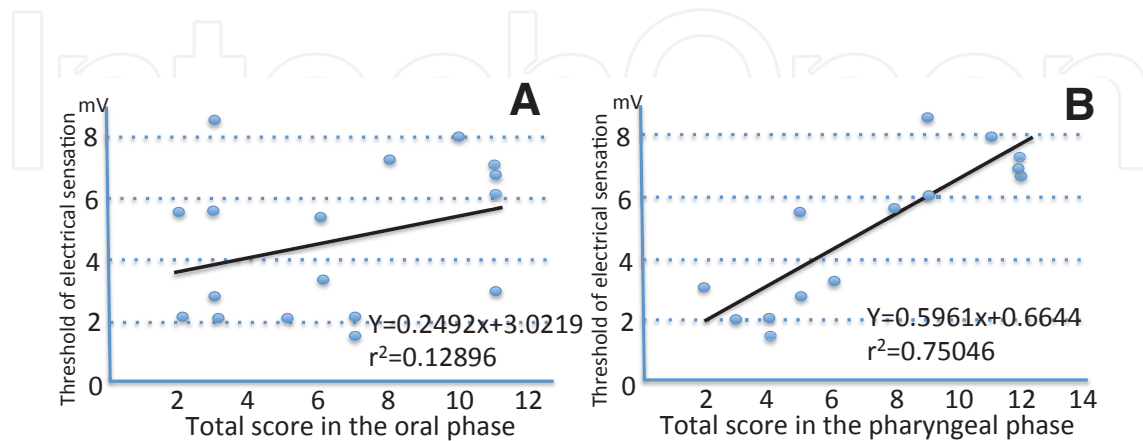


Figure 4. Relationship between (A) total score in the oral phase and threshold of sensation and (B) total score in the pharyngeal phase and threshold of sensation.

4.2. Relationship between VF assessments and electrical stimulations on the soft palate

We considered the presence of a relationship between the recovery process and electrical threshold of sensation, as shown in the first experiment. The results were assumed by a close relationship between the two. Why is there a relationship between a decrease in the threshold of electrical sensation and the recovery process? The well-known phenomenon of “active touch” or “haptic perception” is characterized by object perception through touch. It has been believed that sensory organs function by passive touch. However, Asanuma and Arissian [1] reported the functional role of peripheral input to the motor cortex during voluntary movements in the monkey. Specifically, they proposed that voluntary movements are induced by peripheral sensory inputs. Thus, we believe that measurements of the threshold of electrical sensation are necessary to measure recovery of voluntary movements.

Furthermore, our hypothesis involves the relationship between VF assessment parameters and electrical stimulation in patients with various disorders. VF assessments were divided into the oral and pharyngeal phases because the former is controlled by the first motor cortex of cerebral cortex (M1) and the latter is controlled by the brain stem. In particular, VF assessments of the oral phase are related to voluntary masticatory movements, while VF assessments of the pharyngeal phase are related to the swallowing reflex. We evaluated the relationship between VF assessment parameters and electrical stimulation in patients with various disorders using the swallowing worksheet proposed by Longemann [8], because we utilized measurements in the oral phase (related to masticatory processes) and pharyngeal phase (related to the swallowing reflex). In oral phase, we measured (1) bolus formation, (2) tongue-to-palate contact,

(3) premature bolus loss, (4) residue in oral cavity, and (5) oral transit time. On the other hand, measurements in the pharyngeal phase included (1) lift in the soft palate, (2) triggering of pharyngeal swallow, (3) epiglottic vallecula residue, (4) pyriform sinus residue, (5) pharyngeal transit time, and (6) aspiration. The relationship between total VF assessments in the oral phase and the threshold of electrical sensation showed a weak association with cerebral hemorrhage, cerebral contusion, amyotrophic lateral sclerosis and myasthenia gravis (Figure 4A). However, the relationship between total VF assessments in the pharyngeal phase and the threshold of electrical sensation had a strong association with these disorders (Figure 3B). On the other hand, a decrease in the electrical threshold of sensations following the treatment process was not observed in patients with amyotrophic lateral sclerosis or myasthenia gravis (black and red lines of Figures Aa, Ab and B).

In summary, the criteria for evaluating recovery of the swallowing reflex may be covered by the electrical threshold of sensation on the soft palate, and acceptance of the electrical stimulation will produce a reduction in the bombing experience. Why does the threshold of electrical sensation reflect recovery of the swallowing reflex? The reflex arc progresses as follows: receptor organ, afferent fiber, central nerve for the reflex, efferent fiber and effector organ. In particular, initiation of the swallowing reflex starts from the regions that induce swallowing (primarily the soft palate, posterior part of tongue, and posterior wall of the pharynx). VF assessments of the pharyngeal phase exhibited the swallowing reflex, and this reflex was initiated by stimulation of the regions that induce swallowing. We consider that the stimulation of these regions involves perception by sensory organs, and the swallowing reflex is then evoked by the sensory stimulation.

4.3. Relationship between electrical sensation and voluntary movement or reflex

When we execute hand movements (especially during search behavior), we take notice of a keen sense in the fingers. Namely, our cutaneous sensation is excited before the execution of movements. This helps us to understand the inaccuracy and inadequacy of movements in patients with sensation disorders. In particular, when the patients with unilateral lingual nerve disease (e.g., secondary to sensory nerve damage during wisdom teeth extraction) are promoted to perform tongue protrusion, the tongue bends toward the diseased side. Furthermore, monkeys with tactile agnosia after blocking of the first somatosensory cortex (SI) exhibit poor performance in gripping an object (Hikosaka et al.) [4]. Nelson [9] reported somatosensory neuronal activity in the SI prior to movement. These results indicate that sensory information in the SI is necessary for the initiation and preparatory of the start of movements. Based on these findings, it is understandable that the somatosensory information obtained prior to movement excites the facial, intraoral, and pharyngeal regions. Sessle et al. [10]. Sessle [11], Stohr and Petruch [12] and Stohr et al. [13] reported that a close relationship between the facial motor and sensory cortices is needed during facial and tongue movements. We assumed the presence of a relationship between electrical sensation and the recovery process based on our findings in the orofacial region. However, two patients in the present study (nos. 7 and 8, Table 2) exhibited no change with electrical stimulation treatment. Both of these patients had muscular atrophy, a degenerative disease. These results may suggest that progressive deterioration of the muscle and spinal cord make reconstruction difficult. On the other hand, although a close relationship between VF assessment of the pharyngeal phase and electrical

stimulation on the soft palate was observed (cumulating tendency), there was a weak relationship between VF assessment of the oral phase and electrical stimulation on the soft palate (scattering tendency) (Figures 4A and 4B). VF assessments of the oral phase involved stimulation of various regions of masticatory movements controlled by the M1. Because disorders of these regions become diffuse around the orofacial region, the electrical sensation of the soft palate cannot cover the entire disease region. However, VF assessments of the pharyngeal phase showed that the swallowing reflex was initiated by stimulation of the regions involved in induction of swallowing (primarily the soft palate, root of tongue, and posterior portion of wall of pharynx). We believe that this conclusion can be drawn from our experimental data: measurement of the electrical threshold can be performed as a substitute for VF assessment in the pharyngeal phase, and patients can undergo less radiation. Namely, the swallowing reflex, nasopharyngeal closure, elevation of hyoid bone and pharynx (laryngeal elevation), laryngeal closure (downward movement of the epiglottis), and esophageal sphincter relaxation are accomplished by serial processing after the initiation of sensory stimulation in the induced regions. We arrived at this conclusion from our experimental data.

Measurement of the electrical threshold can be performed as a substitute for VF assessment in the pharyngeal phase, and patients can undergo less radiation as a consequence.

5. Conclusion

Although VF (videofluoroscopic examination of swallowing) is the best choice for the functional assessment of eating (mastication) and swallowing, we cannot avoid a bombing experience. Therefore, we devised a new method to reduce the need for VF examination. The electrical threshold of sensation in centrally diseased sites of the orofacial region has long been examined in patients with stroke, head and neck tumor, external injury and other disorders following on the orofacial treatments. The results suggest a close relationship between the electrical threshold of sensation and the recovery process. Many researchers have evaluated the results of VF assessments based on the Videofluorographic Examination of Swallowing Worksheet developed by Logemann (1993). We selected 11 applicable items used by many hospitals: bolus formation, tongue-to-palate contact, premature bolus loss, residue in oral cavity, and oral transit time in the oral phase; and lift in the soft palate, triggering of pharyngeal swallow, vallecular residue, pyriform sinus residue, pharyngeal transit time, and aspiration in pharyngeal phase. In particular, we considered that a higher sum in each phase might indicate a more serious condition. We also measured the electrical threshold of sensation on the soft palate when patients visited the hospital. Why is the threshold of electrical sensation reflected by recovery of the swallowing reflex?

In particular, VF assessments in the oral phase are related to voluntary masticatory movement, while those in the pharyngeal phase are related to the swallowing reflex. Initiation of swallowing reflex starts from the regions that induce swallowing (primarily the soft palate, posterior part of tongue, and posterior wall of the pharynx). We propose that electrical thresholds in the soft plate can be assessable as the function of swallowing reflex.

Nomenclature

VE: videoendoscopic evaluation of swallowing. VF: videofluoroscopic examination of swallowing. SI: first somatosensory cortex. M1: first motor cortex.

Acknowledgements

This work was supported by Sato research grand and Sogoshigaku research grant of Nihon University School of Dentistry, by Grants-in-Aid for Scientific Research (21592539) and by a grant from the Ministry of Education, Culture, Sports, Science, and Technology to promote multi-disciplinary research projects.

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