

**POSSIBILITIES OF DEVELOPMENT IN THE REHABILITATION OF PHONATION
AND SWALLOWING FUNCTION**

Ph.D.Thesis

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Possibilities of development in the rehabilitation of phonation and swallowing function

(Possibilities of development in the rehabilitation of phonation and swallowing function as way of improving quality of life following laryngeal surgery and in other laryngo-pharyngeal dysfunctions)

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INTRODUCTION

As the possibilities of medicine improve and change and society's expectations rise, improving quality of life is gaining more and more consequences. This is a motivation to strive to improve different functions. On the field of ENT, radical operations, causing deficits in vital (swallowing function) and human functions (phonation, articulation, verbal communication in short) are becoming more frequent. These lead to a substantial decrease in quality of life. Diagnosing and treating the impairment of function (both phonation and swallowing) requires systematic and objective action. I learned about analysis and treatment methods above during my studies abroad (Benjamin Franklin University in Berlin, directed by Prof. Dr. Manfred Gross, Regensburg University, directed by Prof. Dr. Tamás Hacki, Graz Klinik der Phoniatrie, directed by Prof. Dr. Gerhard Friedrich). These procedures are essential to quality phoniatric care, studies and patient care. Instead of using subjective methods to describe phonation i.e. breathy, veiled (41, 42, 115) methods that describe voice quality with numeric values have been gaining ground (39, 54, 86, 87, 114). More and more calculations take into account the patient's own opinion on the state of their voice (37, 52). In the field of phoniatry, as in other professions, it is important to introduce standardized diagnostic and therapeutic methods in order to improve the quality of patient care. The leading symptom in phoniatric disorders is a change of the timbre, and the appearance of hoarseness. Hoarseness is subjective, and hard to define, and instead of a long description, the goal is to introduce a quick, short, simple, easy-to-follow numeric scale that may be used to categorize hoarseness (37).

Systematic diagnostics of, and therapy for swallowing are integral parts of rehabilitation. Research and development is necessary in this field due to the large number of patients: over 15 million patients effected in the United States of America (American Speech-Language-Hearing Association 1992.). As a result, the field of phoniatry has changed as well. Beside diagnostics of phonation, speech and pediatric hearing disorders, diagnostics and therapy of swallowing are now integral components of phoniatry. As the treated patients number of head and neck surgeries rise, the frequency of oropharyngeal dysphagia cases rises also, because modern tumor surgery now includes further regions, some of them involved in swallowing. Post-operative dysfunction (articulation, phonation, swallowing disorders) following surgical treatment of head and neck tumors make treatment of these states necessary, even though both the surgical and the non-invasive oncotherapy aim to retain function, and spare the larynx (7, 26, 27, 28, 29, 30, 31, 57, 58).

In the rehabilitation of swallowing, the task of the phoniatrist is to perform the appropriate examinations, and determine therapy based on the results.

Dysfunctions occurring after the surgical treatment of head and neck tumors lead to a substantial decrease in life quality. Communication remains intact, while swallowing is difficult after supraglottal laryngectomy, as protective laryngeal function is impaired due to structural and sensory deficits. This may be transient, but if left untreated, it is a permanent condition. *The incidence of aspiration pneumonia in patients 7-29% (31, ASHA, 2005) and 1,5-9% in patients died from aspiration pneumonia (31, 90). Treatment of the developed oropharyngeal dysphagia is necessary ((9, 19, 20, 48, 66, 67, 68, 69, 76, 77, 80, 90, 95, 111).*

Treatment of postoperative dysfunctions requires complex team effort, and an integral part of this is phoniatric rehabilitation. The goal is to restore function as similar to physiological as possible, and to decrease dysphagia of different locations and severity, and to correct phonation, which is often impaired as well.

Diet is an essential part of treatment, especially in the period of dysphagia treatment when we analyze the characteristics of foods, as we try to find foods that ensure appropriate energy, nutrient and fluid intake, while still remaining easy-to-swallow without aspiration, when aiming for continuous oral feeding in patients.

Determining the rheological characteristics, temperature, taste and energy content of foods that may be swallowed safely is a very important task, in order to further decrease the risk of pneumonia. The challenge for now is to combine rheological studies with the complex imaging techniques used to monitor pathological swallowing states. Rheology is a branch of physics that determines the deformations of solid and semisolid materials and fluids under the effects of exterior forces. This science deals with the flow of materials (rheo=to flow, logos=science). This science helps fine-tune dysphagia diagnostics and therapy (59, 75 ,92). The peripheral sensory input going to the centrally located swallowing center depends on the viscosity, consistency, volume, temperature and taste of the bolus. Volume and consistency of the bolus depends on viscosity. The higher the viscosity of the food, the smaller the swallowed quantity. In comparison the average volume of one sip of water is about 20 ml, while the amount of mashed potatoes swallowed at once is only 5-7 ml. Clinical studies have shown, that the consistency of food influences swallowing function. Increasing bolus consistency decreases aspiration when oral control is impaired (3). Depending on the pathomechanism of the dysphagia, it is appropriate to compose a trial bolus or trial food that is diluted or thick, may have a slippery surface, may fall apart easily, or may have stronger cohesion, have higher or lower temperatures, or a distinctive taste (Germain, 45). To perform this task, it is absolutely

necessary that the phoniatrist/ENT specialist in charge of diagnostics and swallow therapy work together closely with the dietician.

Composing of the dysphagia diet is a task that must take into account the individual state and rehabilitation capability of the patient (49). Objective measures must be found to quantify data in swallowing treatment (74). Many attempts have been made to standardize diet. *Martin* (73) and *Pardoe* (94) published a multi-level diet with subjective, qualitative descriptions. *L. Mann* (72) standardized foods with an objective method. Several scientific publications deal with determining the viscosity of fluids and semi fluids (25, 35, 96, 97, 98). Due to all of the reasons above, I concluded that it is essential to introduce these methods in Hungary and develop them, instead of continuing with earlier treatment methods that were based on empirical evidence, and were mainly trusted to the patients. While conducting our work, our aim was to find a quantitative method to determine the viscosity of food/trial food, which would complement current existing results and help unify standardizing trial boluses and foods, so based on the results of the trial swallow test, we may compose and offer patients a variety of foods of a certain viscosity, that may be taken safely in their condition.

AIMS OF THESE THESIS

- was to individualize rehabilitation methods, should be able to compare the results among the rehabilitation methods, and having quick numeric measurement.
- following surgical and non-surgical (radiochemotherapy) organ sparing therapy,
- during voice reeducation made necessary by dysfunctions of different varieties
- during the application of conservative methods of swallowing rehabilitation.

The aims in detail are as follows:

1. 1.-To introduce numeric methods instead of the currently used subjective vocal descriptions.
- 1.2.-Analyzing and categorizing the subcomponents of hoarseness
- 1.3.-Applying the above in the rehabilitation of phonation.
- Application of objective methods of improving voice function:
- 1.4.-Measuring voice range profile (Hacki's voice range profile measuring device).
- 1.5.- Application of a numeric patient satisfactory scale, that takes patients' opinion into account (sec. Friedrich).

1.6. -Calculating and applying dysphonia-index based on all of the above, not only in functional dysphonia, but in rare cases also, like modern Botox treatment of spasmodic dysphonia, improving voice quality of transsexuals, which have not received attention in the literature.

-The method appears to be applicable in objectifying surgical results, and also in objectifying the effects following phonosurgical treatment in unilateral vocal cord paralysis following.

-To be able to compare results, in addition to the known standard values, we measured the voice parameters of individuals with healthy voices, no voice complaints or symptoms suffering from thyroid disease, and analyzed results according to these voice parameters.

2. Instead of relying on spontaneous learning, random swallowing, and empirical therapy,

2.1. we introduced evidence-based systematic swallowing tests and

2.2. therapy, the distribution of this new information, the classification of oropharyngeal dysphagia, application, development of systematic diagnostics and therapy.

2.3. Based on the comparative viscosity studies, we determined with rheologic methods boluses given during swallow tests, with everyday cold and hot dishes. We thereby composed dishes, with known viscosity, calorie, nutrient and fluid content, and we hope that this will be the basis for switching to per os oral feeding.

MATERIALS AND METHODS SUMMARY

Patients

The data from 207 voice disorders (1) and 168 dysphagia patients (2) we analyzed.

1. Voice disorders included:
 - 1.1. Functional dysphonia (non-organic dysphonia)
 - 1.2. Spasmodic dysphonia
 - 1.3. Transsexual voice changes
 - 1.4. Unilateral vocal cord paralysis (organic dysphonia)
2. Post-therapeutic oropharyngeal dysphagia: dysphagia following partial laryngeal, pharyngeal and oral surgery, radiochemotherapy or combined therapy

METHODS

1. Application of numeric voice analysis (voice quality and voice function) methods

1.1. RBH-system : The RBH scale is a 4 level auditive scale to describe hoarseness. This is an auditive hoarseness scale (scale of severity: 0-3), where 0 = normal, 3 = severe hoarseness. The “R” (Roughness) is characterized by the roughness resulting from the irregularity in the vibration of the vocal cords; the “B” (Breathiness) is characterized by the air-turbulence resulting from the inappropriate closure of the vocal cords; and “H” represents (Hoarseness .) /sec. Wendler/. This scale may be applied well, in comparison to lengthily subjective voice descriptions (i.e. severely hoarse voice -H3).

1.2. Measuring voice range profile (sec. Hacki).This is a method that measures the boundaries of vocal production by measuring the lowest and the highest sound frequency (Hz) and the lowest and the loudest sound pressure (dB).

1.3. Calculating dysphonia-index (sec. Friedrich). This is a numeric method based on the above and complimented with patient satisfaction.

2. Examining and treating oropharyngeal dysphagia:

2.1. Systematic examination of posttherapeutic oropharyngeal dysphagia (following treatment of head and neck tumors) with endoscopic swallow testing and swallow X-rays.

2.2. Treatment of posttherapeutic oropharyngeal dysphagia: with causal, compensatory and dietetic methods.

2.3. The dysphagia patients diet combined with rheological methods.

1. Voice disorders and 2. swallowing disorders

1. Voice disorders

1.1.Functional dysphonia

Functional dysphonia is a condition characterized by changes in the timbre of voice (usually hoarseness, or a change in pitch), voice dynamics and pitch range decreased, and the loadability of the larynx, to. No organic alteration may be found in the larynx primarily (non-organic dysphonia). Accompanying paraesthesia complaints (urge to clear the throat or swallow, having a lump in one's throat, dryness in the pharynx, coughing, tightness in the neck) are almost always present (71, *Friedrich*).

This condition may be treated by phoniatrics-logopedics, so-called voice therapy. The goal of voice therapy is to stop aphisiological phonation, and develop physiological phonation techniques (voice reeducation). *Voice therapy is done according to the following guidelines sec.*

Frint: the goal is to develop costo-abdominal breathing, and to prolong expirations period; to decrease laryngeal muscle tone. After this we perform nasalization and vocalization exercises. The techniques learned during the exercises should be adopted in everyday speech. Finally, increasing the intensity of phonation was also practiced. (41,42,79). We performed voice therapy once a week for an average of 19 weeks (43-3weeks).

The leading symptom of this condition is hoarseness (Heiserkeit), which is a type of change in the timbre of voice, described as an auditive pathological noise element. Hoarseness may be caused by inadequate closing of the vocal cords, which leads to turbulent airflow and breathiness (Behauchtheit), or by irregular vibration of the vocal cords: roughness (Rauhigkeit). *Nawka T., Anders J., Wendler J.*(86,87,114) based their hoarseness scale on the above (RBH-system), and it has been well known in phoniatrics literature ever since (82,84,119), and it is useful in monitoring therapeutic success (89).

1.2 .*Spasmodic dysphonia*

Spasmodic dysphonia –described as spastic dysphonia by Traube in 1871 – is a voice impairment originating in the nervous system (20). This condition used to be categorized as a functional phonation disorder, but is now clearly listed among neurological disorders. *Bloch* raised this question in 1965 (18). Neurologically this condition is an extrapyramidal disorder, - *Aronson* drew attention to this in 1968 (5) – and we categorize it as a craniocervical dystonia, together with for example blepharospasm, oromandibular dystonia and torticollis. All these conditions are characterized by spastic muscle activity, which cannot be overruled voluntarily (according to *Böhme*, 20)- involuntary spasms of the laryngeal muscles.

This is a rare condition, 3,5 cases occur in 1 million people (Nutt, 1988. cit in *Böhme*,20). Etiology is unknown, anamnesis data may include trauma, anoxia, laryngitis. We differentiate between two basic types *Aronson*,1973 (5), *Wolfe and Bacon*,1976 (117), *Wieser and Schlorhauser* (116): adductor-type and abductor type. Certain authors mention the extremely rare combined type. Reaching a diagnosis is simple. Diagnosis is definite based on auditive analysis and larynx examination. In the most common adductor type, because of the extreme spasm of the phonation apparatus, a sound reminiscent of grunting is formed, which is characterized by voice breaks, and aphonic periods with press. *Wendler* (114) compares patient's vocal production to an electronic speaker with contact problems –“Wackekontaktphänomen”. The patient feels like he/she is being suffocated. Larynx examination shows overadduction of the vocal cords. The rare abductor type is characterized by breathy sounds interrupted by aphonic periods. The vocal cords

are in abduction during phonation, so the vocal cords do not close. During auditive analysis speech is mostly characterized by interruptions in all cases. Whispering, laughter, and so-called non-communicative phonation remain symptom-free. Singing voice is intact in mild to moderate cases, but in severe cases singing voice may be impaired or rendered impossible. Range is decreased, and volume changes from quiet to loud involuntarily.

Concerning therapy: Logopedics and voice coaching are usually unsuccessful. This is because this is not a functional, but a neurological disorder, so voice therapy is ineffective. Because of this other methods have been experimented with to improve phonation. *Dedo*, 1976 (33) produced temporary improvements by cutting through the *n. recurrens* on one side. *Biller* tried crushing the nerve (15). It was partly based on this, that in 1992 *Blitzer* (16, 17) experimented with temporary chemical denervation of the thyroarytaenoidalis muscle complex with Botulin-Toxin-A injections (Botox), which lead to good voice results for about 3-6 months. This treatment may be repeated after elimination of the effect. In the adductor type the toxin should be injected into the *m. thyroarytenoidus lateralis*, and in abductor type into the *m. cricoarytenoideus posterior*. The injection starts taking effect after a few-day latency period. According to *Laskawi* (62) the voice-improving efficacy of this procedure is 90% in adductor and 57 % in abductor type. Side effects include pain 10%, hoarseness 10-22%, dysphagia with aspiration, which occurs because the paralyzing effect spreads to the surrounding muscles (108). Injection the toxin is of course symptomatic treatment only, but patients become symptom-free as the spasms subside.

In terms of treatment for spasmodic dysphonia the literature ranks Botox injections in both adductor and abductor cases as the treatment of choice (1, 55, 85, 88, 44, 11). In Hungary Lichtenberger was among the first to inject transcutaneous Botox under laryngomicroscopic and EMG control, and he also performed this procedure on our study patients.

1.3. Transsexuality and voice

The effects of hormones on voice are well known (*Heinemann*, 53).

Transsexuality is the permanent and complete transposition of the gender, in the course of which there is a contradiction between somatic gender and the mental sexual identity (*Böhme*, 20). In short, a transsexual is a person, who wishes to belong to the other gender. In contrast to the female voice, which is lower after administration of testosterone and becomes similar to that of boys at the age of puberty, male voice does not change to a female pitch following castration

or estrogen therapy (2, 6, 34, 100, 118). The wish of male- to- female transsexuals to change their voice to have a female pitch poses a special problem (22, 46,109). The consequences of transsexuality include lifelong hormone treatment, a series of transformation surgeries, voice treatment and if required, phonosurgery as well. *Gross* (47) and *Donald* (34), *Mounth* (81) suggest surgery as the method of choice for changing the voice of the male-to-female transsexuals, aiming to decrease the vibrating mass of the vocal fold. Surgical treatment may include cricothyroid approximation, scarification, injection of tramcinolone into the vocal folds and endolaryngeal shortening of the vocal fold (*Gross*, 47). Surgical complications are: granulation, fistula and level differences between the two vocal folds (*Mahlsedt*,70). These may be avoided if voice coaching is used to achieve a higher pitch. If this method proved to be unsuccessful, surgery may be performed at any time.

Three male to female transsexuals were treated with voice therapy. 2 male-to-female transsexuals were analyzed as controls. The average age of patients was 23 years (20-26 years). Voice therapy was performed once a week through an average period of 9.6 months. Parallel to the voice therapy estrogen administration was also started (2 mg followed by 4 mg daily dose of oestradiol). Since according to data obtained from the literature estrogen therapy only has a minimal effect to elevate voice pitch (107), the expected improvement was related to voice treatment alone. *We devised a new, formerly unknown method of conservative voice therapy. Voice function and the results of voice treatment were assessed by the following methods:* The goal of voice treatment was to develop a female pitch, high-pitch vocalization by using the first articulation zone, costo-abdominal breathing technique to lengthen the time of expiration, to decrease laryngeal muscle tension, and to increase head resonance compared to chest resonance. The exercises performed were primarily nasalization and vocalization. Attention was given to the formation of soft tones, precise articulation, and female intonation. Finally, increasing intensity of phonation was also practiced. We also supported the patient's *auditive discrimination by using audio-visual feedback*. The practicing person could observe the achieved speaking frequency on the screen of the voice range profile measuring device.

We have measured voice parameters of treated and untreated transsexuals and calculated by Fiedrich dysphonia index.

1.4. *Unilateral vocal cord paralysis*

The impairment of the motor and sensory innervations of the larynx (n.lar.inf. et sup.) may be polietiological. Symptoms, that differ from the symptoms of bilateral vocal cord

paralysis, are (56,102,104,105): hoarseness of different severity and type, voice fatigue, and maybe even aphonia. Patients are unable to sing. The the vocal pitch range and the vocal intensity range are severely impaired. When measurements were made decreased phonation time values were found. Voice complaints were caused by the irregular vibrations of the vocal cords due to impaired innervation, or beceasue vocal cords failed to close, which led the air to „escape”, causing turbulent air flow. This is supported be acoustic and aerodynamic analysis (83).

Treatment of unilateral vocal cord paralysis is a voice therapy (32, 41), or surgery. Surgical treatment is endoscopic injection or implants to augment the volume of the affected vocal cord (24, *Brünnings, 1911*, 4, *Arnold 1962*). The first thyraoplasty medializing the paralyzed vocal cord was reported by Payr (93) in 1915. In 1996 *Brandenburg* (21) used autologous fat for endoscopic injections. *Friedrich* (38, 40) developed a titanium implant for medialising the vocal cord. The results of surgery prove the significance of these procedures, and they are supported by the international literature (*Friedrich 38, 40, Lichtenberger et al. 64, 14, Rovó,Czigner 103, Bigenzahn 13*).

We calculated patients' Friedrich dysphonia-indexes before and after therapy, according to the scheme described above. In Hungary t hyreoplasty and laryngomicroscopic procedures were performed on our study patients by Lichtenberger.

Application of numeric voice analysis methods (voice quality, voice function, objective and perceptual voice measurements)

Voice quality is determined by frequency, the possible presence of noise elements (hoarseness, air-flow (volume, and air-flow possibly becoming turbulent) continuity (possible interruptions).

The voices of the study individuals were studied as follows:

a.,Voice was categorized according to the so-called RBH-system. This is an auditive hoarseness scale (scale of severity: 0-3), where 0 = normal, 3 = severe hoarseness. The “R” (Roughness) is characterized by the roughness resulting from the irregularity in the vibration of the vocal cords; the “B” (Breathiness) is characterized by the air-turbulence resulting from the inappropriate closure of the vocal cords; and “H” represents Hoarseness.

b) Phonation time was measured how long the patient could sustain of the sound “o” after inspiration (normally 18-20 seconds).



c) With the aid of Voice range profile measurement (sec. Hacki-Taba, Homoth, Hamburg, Germany) the following were measured: 1) minimum and maximum values of habitual speaking pitch (while reading a standard text), 2) physiological voice range profile, 3) voice frequency (Fo in semitones, ST) and 4) vocal intensity (SPL in dB) (i.e. vocal pitch range and vocal intensity range). (The microphone was placed at a distance of 30 cm, and it had an "A" filter.) Voice pitch range was measured by half tones, vocal intensity range was measured in decibels (*Hacki*, 51).

e) Communicative impairment was determined by the patient. We graded the degree to which the person's voice could be used for communication. This was determined on a subjective 0-3 scale, where: 0 = no limitations, 1 = limited communication only in the case of voice load, 2 = a small degree of constant limitation, 3 = constant strong limitation in everyday communication.

Based on the obtained data (points a-e) we calculated the Friedrich dysphonia-index, which shows the improvement of voice quality numerically. Calculations are shown in Table 1.

Table 1.
Calculation of Friedrich dysphonia index

Points for calculation	0	1	2	3
Hoarseness (RBH-graduation 0-3)	H0	H1	H2	H3
Pitch range (ST=semitones)	>24	24-18	17-12	<12
Intensity range (dB)	>45	45-35	34-25	<25
Phonation time (s)	>15	15-11	10-7	<7
Impairment of communication	0	1	2	3
Dysphonia Index:	0	1	2	3

Calculating Dysphonia Index as seen in the table above: adding up values within the appropriate range, and dividing it by 5. (Normally: 0).

2.1 .Swallow disorders (dysphagia)

Definition of oropharyngeal dysphagia:

We define dysphagia as a disorder of the oral preparation, or the disorder of oral, pharyngeal or esophageal transport. Depending on the location of the lesion we differentiate between

oropharyngeal and esophageal dysphagia. Swallowing disorders may have very severe, even lethal consequences: aspiration pneumonia, dehydration, malnutrition, and social isolation.

Symptoms:

The most conspicuous sign of the nourishment disorder is aspiration, which may have serious clinical repercussions, such as pneumonia. This may even be caused by regular saliva aspiration. Aspiration may occur pre-, intra- and postdeglutitively, meaning before, during or after the swallowing reflex is activated. So-called silent aspiration is characteristic of neurogenic dysphagia, and post pharyngeal-laryngeal operations, and post radiotherapy states.

Prevalence of this disorder: The number of patients suffering from dysphagia has been on the rise, due to the rise in average life expectancy, accidents, intracranial lesions, and increase in the number of head and neck tumors and the fact that surgical treatment is now available for tumors that were deemed inoperable before. According to the statistics of *Böhme* (19) 12% of acute patients, and 40-50% of elderly patients in need of care suffer from swallowing disorders. Dysphagia is present following 25-32% of cerebrovascular insults and 55% lead to aspiration. According to the correlation between the size of the cerebral lesion and the swallowing disorder aspiration occurs in 21% of the cases, where the lesion is smaller than 2 cm, and 75% when it exceeds 2cm.

According to the data of *Bigenzahn* (12) in 2001: 13-15% of hospitalized patients, 50-60% of patients in need of chronic care suffer from swallowing disorders. According to *Finestone* (36) dysphagia occurs in 29-64% of the cases following a stroke.

As it is well established we differentiate between 4 phases of swallowing.

1. Biting and chewing are part of the oral preparation phase. Time period may vary individually.

In this phase food is cut into pieces, mixed with saliva, and an appropriate bolus is formed, of suitable size for swallowing, and mixed with saliva. Lips close after biting, the buccal, and cheek muscles become appropriately toned. The mandible rotates with the teeth, and shoveling tongue movements mix the cut-up food with saliva.

2. Oral transport phase takes about 1-1,5 seconds.

In this phase the bolus is moved to the base of the oral cavity, until swallow reflex is activated. The bolus is moved to the back of the tongue, and from here it is moved back to the pharynx by the backward strokes of the tongue, and by being pressed to the palate. Meanwhile the pressure

in the pharynx turns negative, which helps backward transport. When the bolus reaches the anterior fauceal pillar, the swallow reflex is activated.

3. The time period of the pharyngeal phase is 1 second.

This phase starts once the swallowing reflex is activated, and it is an automatic after that.

Once the swallowing reflex is activated, the airways are protected in multiple ways. The upper esophageal orifice opens up, and the bolus slips into the esophagus.

4. Esophageal phase: average duration: 4-20 seconds.

Peristaltic waves pass through the esophagus, and the bolus finally slips into the stomach.

Dysphagia diagnostics

The basic element of swallow testing is giving foods of different viscosity and monitoring swallowing with multi-colored staining and videoendoscopy. The goal is to find a food bolus, that may be swallowed without danger of aspiration, and is of suitable temperature and size, and is in accordance with anatomical features, and also to find *a swallowing technique* appropriate for given sensory and motor functions (Hacki,48, Langmore 60,61). This test – which has vital consequences –may be performed by systematically altering the color of trial foods of different viscosity (and perhaps temperature). The test may be performed transnasally with flexible optics, or transorally by rigid laryngoscopy. After swallowing, it may be observed, which structures have been colored by the trial bolus, and if there is any sign of retention, penetration or aspiration. The endoscopic diagnostic may be complimented *with swallow X-rays done with absorbable contrast if necessary*, which provides information on the regions inaccessible for the endoscope, function of the upper esophageal sphincter and the esophagus (8). We may determine quantity of aspiration, but saliva aspiration, and stasis of saliva may not be analyzed with this method. *These test may determine, whither aspiration occurs in the pre,-intra-or postdeglutitive phase, meaning before, during or after the activation of the swallow reflex.* The above test may determine whether the patient' nourishment may be managed orally, and therapy may be determined as well.

Methods used in treating dysphagia

Categorization of methods according to Bartolome (9.):

1. causal therapy
2. compensatory therapy
3. adaptational methods.

1. Causal therapy

Serves to correct function directly or indirectly. Some of these are: thermal-tactile stimulation, and exercises of the lips, the tongue and the larynx (91,110).

2. Compensatory methods (67.)

To correct impaired function, head and body postures unusual for physiological swallowing may be adopted, so the patient may swallow without aspirating. Different swallow techniques protect the airways by blocking them at different levels (glottic, supraglottic), and they also help the transport of the bolus into the esophagus.

The following swallowing maneuvers are recognized:

a. *Voluntary swallowing*: by voluntary exertion the basis of the tongue is pressed against the pharynx when swallowing.

b. *Supraglottal swallowing*: first step is to hold one's breath in after inspiration, followed by forceful swallowing, and later by croaking and coughing, and finally after swallowing, followed by exspiration and inspiration. Closure of supraglottal structures and coughing protect the airways.

c. *Super-supraglottal swallowing*: after holding one's breath strong pressing is performed (maybe even voluntary increase of abdominal pressure), which closes glottal-supraglottal structures, and helps guide the bolus while swallowing.

d. *Mendelsohn-manouver*: the point of this maneuver is to keep the larynx in an elevated position, thereby opening the upper esophageal sphincter, and strengthening muscles that lift the larynx.

Regular, frequent croaking and swallowing: voluntary increase of swallowing frequency, and „clearing” of the larynx (clearence) to prevent saliva overflow, and saliva aspiration.

3. By adaptational procedures we mean application of devices, i.e. oral prosthesis.

Dietetics also falls under this category.

It is also important to inform caring staff and relatives: whether patient may eat, and if so what and how. During therapy patient must be nourished through a feeding tube, or through a percutaneous endoscopic gastrostomy (PEG) until appropriate fluid and calorie intake can be secured safely per os.

Consequences of surgical procedures, and different resections:

1. Following (partial) resection of the lips, the tongue, floor of mouth, and the mandible, oral bolus control, preparation of the bolus, retaining it in the oral cavity, formation, transport and clearance of food remnants are affected. Impairment of bolus control may lead to pre-deglutitive aspiration. Bilabial (p, b), alveolar (t,d,l), fricatives (z,c,s,sz, cs, zs), lateral (-l) and tremulant (r) may be effected.

Treatment: Exercises mobilizing the mandible, and the anterior articulation region (bilabial-p,b-alveolar-t,d, fricatives -z,c,s,sz,cs,zs- lateral-l, tremulant-r). Chewing bags may be used to improve chewing motions. Compensatory methods such as head-positions change and supraglottal swallow techniques should be practiced and may be used to prevent aspiration.

2. Total resection of the tongue effects swallowing function and speech equally severely. Beside impairing bolus formation and transport, elevation of the larynx, opening of the esophageal orifice is also adversely effected, causing pre- and post-deglutitive aspiration.

Treatment: head-positions change, the head to the healthy side to improve bolus passage. Swallow maneuvers such as the Mendelsohn-manouver and super-supraglottic swallowing may help prevent aspiration. Food may be placed „back” while eating, a syringe may be used as an aid. Small volume pureed boluses are recommended. Regular articulation exercises improve speech.

3. Aspiration may occur following surgical treatment of pharyngeal and radix lingue tumors (pre-deglutitive aspiration). Pharyngeal contraction, bolus transport are damaged due to resection of the pharynx, and if the trigger zones of the swallowing reflex are affected, delayed reflex activation may result.

Recommended treatment includes reflex stimulation, and adopting voluntary swallowing.

The absence of contact between the radix lingue and the pharynx may be observed after radix lingue resection. It consequently leads to aspiration, especially when consistency is difficult to control. Bolus propulsion is damaged, and larynx protection is impaired.

Treatment:

Improving tongue motility, altering head position, and applying super-supraglottal swallowing and Mendelsohn-manouver. Consistency should be increased, and thickening additives may be useful. Recommended articulation exercises include practicing k and g sounds.

4. After resection of soft palate tumors there isn't any proper contact between the soft palate and the tongue, and food regurgitates through the nose. Speech becomes nasal.

It may be necessary to do certain exercises in velopharyngeal insufficiency (blowing, suction, soft palate massage, k, g, articulation exercises) and to wear a palate prosthesis also.

5. Consequences of hypopharynx resection: Retention in the lower part of the pharynx, with consequential post-deglutitive aspiration.

Treatment: head-postures change the head to the healthy side, and performing voluntary increased clearance (croaking).

6. Consequences of supraglottic laryngectomy:

less airway protection (aspiration), impaired pharynx peristaltics. Decreased larynx elevation, which leads to cricopharyngeal dysfunction, which in turn results in post-deglutitive aspiration. Due to damage to the n. lar.sup., sensory dysfunction and decreased coughing reflex may result.

Tasks: Respiratory coordination exercises, practicing voluntary croaking, coughing.

Practicing laryngeal elevation (Mendelsohn-manouver), super-supraglottic swallowing, and altered compensatory head position (80). Some of the important dietary measures include increasing consistency, and thickening fluids. Symptoms combine when supraglottic laryngectomy and radix lingueresection are both performed.

7. Insufficient vocal cord closure following hemilaryngectomy (due to the resection of the ary-region, and one side of the larynx). Because opening of the esophageal orifice is restricted due to asymmetrical larynx elevation, intra- and post- deglutitive aspiration occurs.

Therapy: Respiratory coordination, Mendelsohn-manouver, super-supraglottic swallowing, altered head position, afterswallowing, practicing voluntary croaking, coughing.

Surgery effects phonation. Phonation exercises (aiming to improve vocal cord closure) may be performed to improve phonation and vocal quality.

8. Consequences of subtotal laryngectomy:

Intra-deglutitive aspiration occurs due to incomplete closure. Reduced larynx elevation leads to restricted opening of the esophageal orifice, which leads to post-deglutitive aspiration.

Performing super-supraglottic swallowing, combined with Mendelsohn-manouever is recommended. It is also recommended to move the ary-region closer to the scar fold (vocal cord closing exercises) to improve phonation.

9. Dysphagia is rare following total laryngectomy. The most severe consequence in these cases is loss of speech.

Should dysphagia occur, it is due to the limited opening of the esophageal orifice, which is caused by the lack of larynx elevation, and this process may be enhanced by scarring. Passage may be restricted by scarring at the radix lingue, and pharynx peristaltics may also be limited.

Treatment aims to increase tongue motility, pumping tongue motions, and practicing voluntary swallowing. Masako-maneuver: the patients hold the tip of their tongues with their front teeth while swallowing, thereby aiding the opening of the esophageal orifice.

10. Consequences of pharyngo-laryngo-esophagectomy:

Limited tongue motility, and passage in the junction, limited peristaltics in the transplant.

Treatment: exercises to improve tongue motility, forceful swallowing, afterswallowing, choosing foods of slippery consistency, and sitting upright for 1 hour after eating!

Most patients after partial resectionen are tracheotomised after radical surgery.

The effects of tracheotomy (wearing a cannula) on swallowing (*Bartolome*, 9):

1. As it partially fixates the trachea, laryngeal elevation is restricted.

Insufficient vocal cord closure, insufficient opening of the esophageal orifice.

2. The esophagus is under pressure:

difficult passage, food „overflows”, and causes post-deglutitive aspiration.

3. Swallowing reflex, vocal cord closure, and coordination of swallow apnea may be restricted.

Recommended treatments: manually closing the cannula while swallowing, and altering head position, and practicing the Mendelsohn-manouever.

Dysphagia caused by radiotherapy

Radiotherapy may cause mucositis, xerostomia, oedema, mycosis, fibrosis. This causes damage to fine motor function, and insufficient pharynx peristaltics lead to retention. Impaired sensory

function leads to impaired swallow reflex, and scaring on the neck limits laryngeal elevation, which in this causes limited opening of the esophageal orifice. Uncoordinated swallowing inhibits airway protection.

Therapy recommended in radiotherapy:

In case of dryness in the mouth, it is recommended to use artificial saliva. In case mycosis develops on the mucous membranes oral antimycotic treatment is recommended. If swallowing is painful, patients are right to take analgetics before meals. If mucous membranes are dry, or covered with thick mucus, it is recommended to inhale with salts. Exercises aiming to improve swallowing: tongue motility exercises, thermo-tactile stimulation, laryngeal elevation, forceful swallowing, afterswallowing, croaking, anteflexion of the head, supraglottic swallowing should be practiced.

The literature states, that performing swallow exercises may prevent or delay the necessity to use a feeding tube, or insert a PEG (Rosenthal, 101).

We would like to add everyday experience to this, which was that composing the right diet was in vain if the hospital kitchen did not meet specifications, and this lead to the development of the following method. The patient may aspirate, or might not be able to swallow if the consistency of the food does not meet the specifications set by swallow tests. It is very important to determine rheological properties, temperature, taste and energy content of food, to further decrease risk of aspiration pneumonia.

It is not easy to compose a trial bolus, or an everyday diet. Several factors must be taken into consideration when composing a diet: rheological properties, consistency, physical state, malleability, and plasticity are all important. Sometimes a patient may not be able to swallow fluids, but may be able to swallow purees nevertheless.

Swallow smooth surface foods, but not slightly coarse ones. Swallow thinner pudding, but not thicker ones, or the other way around. If the oral preparatory phase is impaired, than purees, if transport is impaired, then foods with slippery surfaces, that do not fall apart are recommended.

Nutritional content is equally important. Especially in the early stages of the diet, when swallowing functions are just returning, aspiration risk may be higher. Using a feeding tube may be indicated in this phase, to be able to secure the appropriate amount of fluids, energy and nutrients. Under favorable circumstances function returns and feeding tube may not be necessary afterwards.



Food temperature influences the mechanism of swallowing. Cold stimulates the muscles, and helps activate the swallow reflex. Food on body temperature, like saliva, is less stimulating as warm or cold food. Taste has a similar stimulatory effect on the swallow reflex. Sour tastes especially, and well chosen spicing also are beneficiary. These measures may only be applied if the patient's condition permits. Mucous membrane injury may be a contraindication, which may be quite common in patients following surgery and radiotherapy.

In the United States of America and Western Europe, where there is a stronger tradition of treating dysphagia than here, diets were composed for patients. Textbooks differentiate between three or four levels of thickness. This however did not prove sufficient in practice, because several other factors beside thickness influence whether a patient can swallow a bite or not. Some of these are coarseness, slipperiness, stickiness of the surface, plasticity, pliability and lumpiness etc.

After taking all of this into consideration the Phoniatry and Pediatric Audiology Department of the ENT Clinic of Regensburg University, lead by prof. Dr. Tamás Hacki, constructed seven types of foods, including the consistency of foods, that may be used in composing a dysphagia diet (49). This diet wasn't based on objective measurements either. The importance of composing a diet (normal diet, restricted diet, artificial nutrition) is supported by the literature (65). Attempts had been made previously to standardize diet. It is necessary to introduce a well-calibrated food to the patient given (Masako, 74). Martin (73.) and Pardoe (94) published a multi-level diet with a qualitative description. Later Mann (72) standardized foods with an objective rheological method. Several Food Science articles (Gasztónyi 43, Ramesway 96, 97, 98) dealt with measuring the viscosity of semi-fluids, fluids, and rheology found its way to dietetics and dysphagia treatment (Felt 35, Germain 45). Bolus viscosity effects pharyngeal peristaltics. Greater viscosity results in stronger peristaltic contractions (Raut, 99). Bolus temperature is also important, that is why we studied foods on room temperature, and on higher temperatures as well. The cold bolus could heighten sensory input (74).

G. Hafner (50), Smith Hammond (112) stress the importance of diet and compensatory processes and we have found the same in our work on systematic swallow therapy (78.). Lazarus (63) proved the efficacy of swallow exercises. Schindler (113) stressed the necessity of applying phoniatric intervention (altering food consistency, compensatory head posture, oropharyngeal muscle strengthening). We elaborated on this method.

We developed the following method to diet (Rheologic measurements):

Steps of the procedure measurements in swallowing:

1. Measuring of the test food series according to their viscosity.
2. Assigning commonly consumed foods to these standard test food series based on matching viscosities.
3. Determining nutrient, energy, and fluid content of foods of which we specified viscosity, and including this data in food formulas to allow their preparation to specific standards either at the hospital or at home.

From the list of rheological parameters of foods we chose the determination of viscosity since it best describes the properties of materials (45). Viscosity, or internal friction, describes an internal movement in flowing bodies (media), effected by the shear force (parallel to the direction of movement), and is a material constant depending on temperature and pressure. Its units are described as Pa.s. [1 centiPoise (1 cP)=1mPas] and it can be measured by a viscometer.

Among fluids and semi-fluids, Newtonian and non-Newtonian fluids can be differentiated. A Newtonian fluid is one for which the shear stress, that is the parallel force per unit area required to sustain a constant rate of fluid movement between two fluid layers in a unit distance, is linearly proportional to the rate of deformation. A piston moving in a cylinder filled with fluid and gas may serve as an example of this. Any fluid that does not exhibit a linear relationship between the shear stress and the rate of deformation is a so-called non-Newtonian fluid (45, 43). For Newtonian liquids, viscosity is not influenced by time or by shear rate.

Non-Newtonian products are described by an apparent viscosity, which implies that a particular textural characteristic is affecting the overall such as mass density, shear rate, time or yield stress. (Shear rate, a gradient of velocity in a flowing material.)

The shear forces waking while swallowing have the same effect when giving trial bolus and real food to patients.

The materials used in our study had non-Newtonian fluid characteristics. The measurements were performed using a rotational viscometer, a UDS200 air-bearing supported rotational rheometer, and a PP50 plate/plate measurement system (Physica / Anton Paar GmbH., Graz, Austria). We considered it important to determine the viscosity of foods served both warm and cold, thus measurements were taken at 40°C and at 20°C or room temperature. During the

studies, 30 values were obtained for each material. Measurements were repeated three times (90 values). The duration of each measurement was the same (10 sec). The viscosity was plotted against the shear rate (flow curve).

For the test food used in video-endoscopic swallowing studies, we prepared a series with increasing viscosity (gel, pudding, puree, mush) by adding thickening agent (Resource Thicken Up[®]) a commercially available thickening agent made of cornstarch, and water.

Table 2

Test food concentration (%)	3.3	5	6.6	7.5	10	15	20
Resource Thicken Up [®] Thickening agent (g)	1	1	1	1.5	2	3	4
Water (cm ³)	30	20	15	20	20	20	20

Table 2: describes the measured concentrations of the test food series

The concentration series of the test food prepared by combining Resource Thicken Up[®] thickening agent and water.

Corresponding to everyday foods, we chose foods of gel, pudding, puree and mush consistency from hospital menus. Viscosities of a total of 18 foods were measured. The foods were prepared by qualified dieticians according to accurately specified (g, mL) food formulas, in several variations of consistency (formulas available upon request).

Flow curves (rheograms) were prepared from the viscosity readings of the test foods and the real foods. The viscosity was plotted against the shear rate on a decimal logarithmic graph. We matched the rheograms of the test food of various consistencies with the rheogram of the food with the closest values. As a result, we obtained the corresponding test food - food pairs (see Table 3). Analysis and matching of the rheograms were performed by determining the minimal distance of each plot of the graphs to those of the other graphs using the comprehensive R Archive Network statistical software version 2.4.0.

On the graphs, the shear rate (X-axis) was plotted against the viscosity of the test foods and real foods of different thickness values (Y-axis). We assigned a real food with a matching consistency to each test food. Some of the rheograms obtained from the measurements are represented in Figures 1-7 according to the increasing viscosity series (from 3.3% to 20%). In all graphs are X-axis: Pa.s log10, Y-axis: 1/s. The following figures include those trial and real foods on the same graph that were most similar in terms of viscosity, and properties of the curve. We determined these similarities mathematically (R-trial). We marked the name of the real food and the concentration of the trial food at the bottom of every figure.

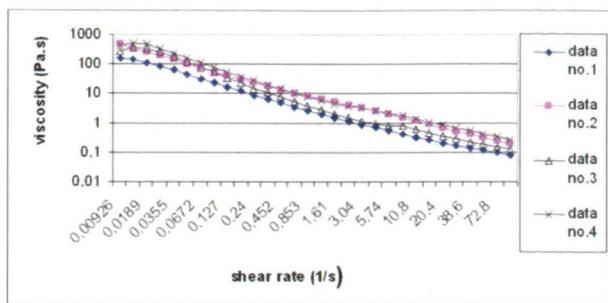


Figure 1.

Figure 1: Test food of 3.3 % (1g Thickening agent and 30 cm³ water) (data series no. 1) and the foods with an approximate viscosity: peach puree (data series no. 2), viscosity graph of kefir served warm (data series no. 3) and cold (data series no. 4).

1. Test food of 3.3% (1g Thickening agent and 30 cm³ water)
2. Peach puree
3. Kefir served warm
4. Kefir served cold

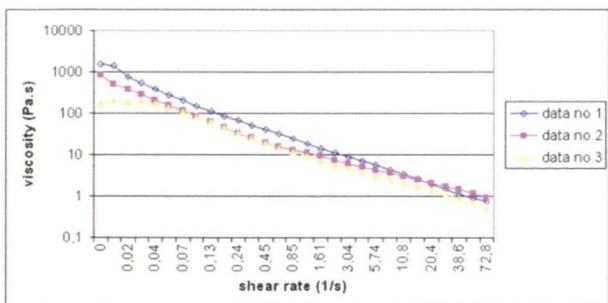


Figure 2.

Figure 2: Test food of 5 % (1g Thickening agent and 20 cm³ water) (data series no. 1)

and the foods with an approximate viscosity: broccoli puree (data series no. 2), warm fruit jelly (data series no. 3).

1. Test food of 5% (1g Thickening agent and 20 cm³ water)
2. Broccoli puree
3. Warm Dini® standard fruit jelly

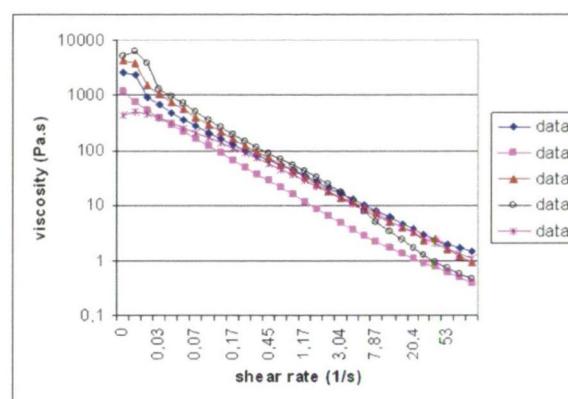


Figure 3.

Figure 3: Test food of 6.6 % (1 g Thickening agent and 15 cm³ water) (data series no. 1) and the foods with an approximate viscosity: vegetable soup puree (data series no. 2), peach jelly (data series no. 3), green pea puree (data series no. 4) and cold pudding instant (data series no. 5).

1. Test food of 6.6% (1 g Thickening agent and 15 cm³ water)
2. Vegetable soup puree
3. Peach jelly
4. Green pea puree
5. Cold pudding instant

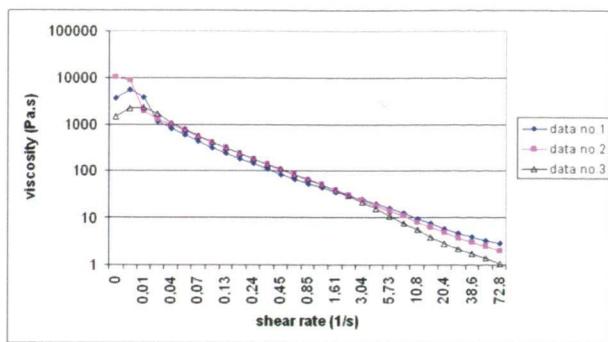


Figure 4.

Figure 4: Test food of 7.5 % (1.5g Thickening agent and 20 cm³ water) (data series no. 1) and the foods with an approximate viscosity: carrot puree (data series no. 2) and cold vanilla pudding (data series no. 3).

1. Test food of 7.5% (1.5g Thickening agent and 20 cm³ water)
2. Carrot puree
3. Cold vanilla pudding

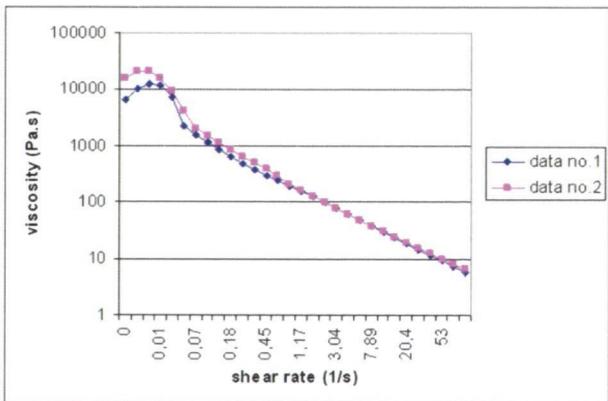


Figure 5.

Figure 5: Test food of 10.0 % (2g Thickening agent and 20 cm³ of water) (data series no. 1) and the foods with an

approximate viscosity: potato flakes - water - broccoli puree - Nutritive (data series no. 1).

1. Test food of 10% (2g Thickening agent and 20 cm³ of water)
2. Potato flakes - water - broccoli puree - Nutritive

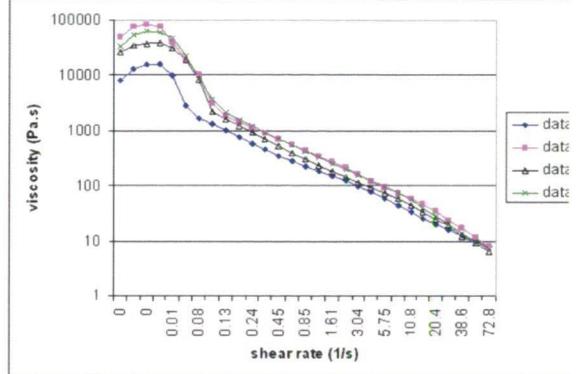


Figure 6.

Figure 6: Test food of 15.0 % (3g Thickening agent and 20 cm³ water) (data series no. 1) and foods with an approximate viscosity: potato flakes with water (data series no. 2), potato flakes - water - Nutritive (data series no. 3), potato flakes with milk (data series no. 4).

1. Test food of 15% (3g Thickening agent and 20 cm³ water)
2. Potato flakes with water
3. Potato flakes - water - Nutritive
4. Potato flakes with milk

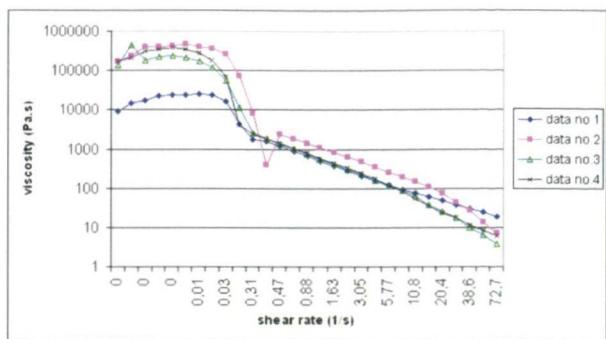


Figure 7.

Figure 7: Test food of 20.0 % (4g Thickening agent and 20 cm³ water) (data series no. 1) and the foods with an approximate viscosity: corn mush (data series no. 2), potato flakes with water (data series no. 3), and potato puree with milk (data series no. 4).

1. Test food of 20% (4g Thickening agent and 20 cm³ water)
2. Corn mush
3. Potato flakes with water
4. Potato flakes with milk

Table 3 contains food groups which were matched to one of the test foods on the basis of similar viscosity.

Table 3

In the left column the test foods are indicated, and in the right column the foods of matching viscosity are specified. The viscosity of fluid (water 1mPa.s) is known, thus fluid was not measured.

Test food % Test food g/cm ³ 1.water	Foods
3.3% 1g powder - 30cm ³ water (see Fig. 1) 2.	peach puree (40°C) Danone® kefir warm(40°C) Danone® kefir cold(20°C)
5% 1g powder - 20cm ³ water (see Fig. 2) 3.	broccoli puree, warm and cold fruit jelly(40°C)
6.6% 1g powder - 15cm ³ water (see Fig. 3) 4.	vegetable soup(40°C) green pea puree(40°C) peach jelly(20°C) Danette® pudding cold instant(20°C)
7.5% 1.5g powder - 20cm ³ water (see Fig. 4) 5.	carrot puree(40°C)
10% 2g powder - 20cm ³ water (see Fig. 5) 6.	potato flakes+water+Nutritivedrink®+broccoli (40°C)
15% 3g powder - 20cm ³ water (see Fig. 6) 7.	potato flakes+water(40°C) potato flakes+water+NutritiveNutridrink®(40°C) potato flakes+milk(40°C)
20% 4g powder - 20cm ³ water (see Fig. 7) 8.	corn mush(40°C) potato puree+water(40°C) potato puree+milk (40°C)

Table 3: The test foods (3a) and real foods (3b) matched based on viscosity.

We marked trial foods and real foods within a category with numbers 1-8, so they may be marked clearly in the recipies.

We considered it unreasonable to measure viscosities above mush thickness (Figure 7), since the rotational cone-plate measurement technique is not appropriate for a low viscous material, and such measurements are of no practical importance from a dietary standpoint. This is because patients able to swallow foods of mush thickness are also able to consume thicker foods (light, mixed diet), provided the masticatory function is intact, since during mastication the consistency of a solid food becomes semi-solid.

RESULTS

1. Functional rehabilitation of patients with voice dirorders, and registering, RESULTS

1.1. The voice of 95 functional dysphonia patients was analyzed according to the RBH-system before and after voice therapy. 74 of the 95 patients were female, and 21 were male, with an average age of 42 (between 8-76 years).

RBH-values were the following before therapy:

ROB0H0 (patients)	R1B0H1 (patients)	R2B0H2 (patients)	R2B1H2 (patients)	R3B0H3 (patients)	R3B1H3 (patients)	R3B3H3 (patients)
0	40	26	7	14	4	4

Table 4.
RBH values before therapy

Before treatment most patients complained of mild to moderate hoarseness.

RBH-values were the following after therapy:

ROB0H0 (patients)	R1B0H1 (patients)	R2B0H2 (patients)	R2B1H2 (patients)	R3B0H3 (patients)	R3B1H3 (patients)	R3B3H3 (patients)
73	19	3	0	0	0	0

Table 5.
RBH values after therapy

73, that means 76,8% of patients left with a normal voice following therapy. The voice of 14 patients improved (14,7%), and there was no change in 8 cases (8,42%). We received the following results in the patients where we did not achieve R0B0H0 (normal voice).

Proportions turned out as follows broken down to voice qualities.

R3B1H3: the voice of 1 patient improved to R2B0H2,

R3B0H3: in 7 out of 14 patients R1B0H1,

R2B0H2: changed to R1B0H1 in 5 cases, and 2 did not change

R2B1H2: became R1B0H1 in 1 out of 1,

R1B0H1: hoarseness did not change in 6 patients.

Summary: The majority of patients, 73 (76,8%) left with a normal voice after therapy, the voice of 14 patients improved (14,7%), and there was no alteration in 8 cases (8,42%). Results clearly show improvement. The RBH-system is a quick, clear, numeric method to show the difference between states before and after therapy. It clearly shows how hoarseness components change, as R measures the irregularity of vocal cord vibrations, B demonstrates breathiness, which is a sign of airflow becoming turbulent. So improved parameters not only indicate healing, but also show how pathological components disappear.

1.2. In 3 spasmodic dysphonia patients we calculated so-called Friedrich dysphonia index before and following Botox injections.

Before we started testing, we examined the voice field of 15 professional singers, and 13 young adults attending the University of Theatre, Film and Television, who didn't have voice disorders, and the voice of 51 patients suffering from thyroid conditions, but without voice symptoms.

Data from the professional singers was as follows:

Average vocal dynamics of professional singers was 58,1 dB, and average range was 33,2 ST (semitones). Table 6.

	Singers
Vocal intensity range(dB) average	58.11 (0 score)
Pitch range in semitones (ST) average	33.22 (0 score)

Table 6. Data from professional singers



Results of individuals attending the University of Theatre, Film and Television were as follows: Hoarseness was not observed (R0B0H0), average phonation time: 21,38 sec. (0 points), vocal intensity range(dB) average: 61dB (0 points), pitch range average in semitones : 34 ST (0 points), suitability for communication 0 points, so Friedrich-D-I.:0.

Table 7.

Phonation time (s) average	Pitch range in semitones (ST) average	Vocal intensity range(dB) average
Professionals 21,38 (0 score)	34 (0 score)	61 (0 score)

Table 7. Average scores of students (healthy, professional)

Values of patient suffering from thyroid disorders were the following:

Score Voice	0 51 patients	1	2	3
Hoarseness (RBH-system) 0points	H0 51 patients	H1 0 patients	H2 0 patients	H3 0 patients
Pitchrange (ST) 1,39points	>24 11 patients	24-18 15 patients	17-12 19 patients	<12 6 patients
Intensity range(dB) 0,9points	>45 21 patients	45-35 18 patients	34-25 12 patients	<25 0patients
Phonation time(s) 0,58points	>15 31 patients	15-11 12 patients	10-7 6 patients	<7 2 patients
Impairment for communication 0	0 51patients	1 0 patients	2 0 patients	3 0patients
Friedrich Dysphonia Index=[Σ:5] 0,57	Score/ 5			

Table 8. Results of voice symptom-free thyroid disorders patients

(35 female and 16 male between ages 28-85, average age 51,3 years, average Dysphonbia Index 0,57)

We made separate calculations for patients suffering from 9 malignant thyroid diseases:

Table 9.

Phonation time (s)	Vocal intensity (dB)	Pitch range (ST)	Friedrich Dysphonbia Index
25	55	22	0,2
14	48	15	0,6
26	32	16	0,8
18	35	25	0,2
17	39	15	0,6
7	35	18	0,8
20	44	15	0,6
26	29	11	1
34	45	24	0,4
0,58 score average			

Table 9.

Data from 9 patients with thyroid tumors

Friedrich Dysphonbia Index= 0,58

The table shows, that the main differences between professionals and non-professionals are in pitch range and vocal intensity range. So in the future, we will be comparing results to the 0,57 Friedrich Dysphonbia Index.

Table 10. shows the results of 3 spasmodic dysphonia patients before and after treatment

Patients	pretreatment examination	Pre treatment examination (point value)	post treatment examination	post treatment examination (point value)
Voice quality (RBH-graduation 0-3)				
persons				
1.	H3	3	H1	1
2.	H1	1	H0	0
3.	H3	3	H1	1
Pitch range in semitones (ST)				
persons				
1.	20	1	20	1
2	13	2	18	1
3.	13	2	20	1
Vocal intensity range(dB)				
persons				
1.	31	2	50	0
2.	48	0	49	0
3.	46	0	43	1
Phonation time (s)				
persons				
1.	8	2	15	1
2.	12	1	14	1
3.	1	3	5	3
Suitability for communication				
persons				
1.	2	2	0	0
2.	1	1	0	0
3.	2	2	0	0
Dysphonia index				
persons				
1.		2		0,6
2.		1		0,4
3.		2		1,2

We calculated so-called Friedrich Dysphonia Index for **3 spasmodic dysphonia patients** before and following injection of Botox.

In summary: The calculated dysphonia-index values show the efficacy of treatment. The beneficial effects of intralaryngeal BOTOX to alleviate symptoms in adductor type spasmodic dysphonia are supported by the fact that all three patients became symptom free, and both voice status analysis and Friedrich dysphonia index values improved (in patient 1 from 2 to 0,6, from 1 to 0,4 in the second patient and from 2 to 1,2 in the third patient). (*The number of patients is so low, because this is a rare condition*).

1.3. 5 transsexual patients

We measured values before and after treatment, and compared the results to that of transsexuals not receiving therapy

Table 11.
Voice parameters of the transsexuals studied

Patients	1 st examination	1 st examination (point value)	2 nd examination	2 nd examination (point value)
Voice quality (RBH-graduation 0-3)				
Treated persons				
1.	H0	0	H0	0
2.	H0	0	H0	0
3.	H0	0	H0	0
Controls				
4.	H0	0	H2	2
5.	H0	0	H0	0
Pitch range in semitones (ST)				
Treated persons				
1.	15	2	14	2
2	22	1	23	1
3.	18	1	16	2
Controls				
4.	18	1	22	1
5.	23	1	27	0
Vocal intensity range(dB)				
Treated persons				
1.	31	2	57	0
2.	46	0	61	0
3.	32	2	53	0
Controls				
4.	31	2	44	1
5.	34	2	31	2
Phonation time (s)				
Treated persons				
1.	12	1	22	0
2.	24	0	22	0
3.	30	0	28	0
Controls				
4.	18	0	12	1
5.	15	1	10	2
Suitability for communication				
Treated persons				
1.	3	3	0	0
2.	3	3	0	0
3.	3	3	0	0
Controls				
4.	3	3	3	3
5.	3	3	3	3
Dysphonia index				
Treated persons				
1.		1,6		0,4
2.		0,8		0,2
3.		1,2		0,4
Controls				
4.		1,2		1,6
5.		1,4		1,4

Results clearly support the efficacy of treatment. *De Bruin et al.*(23) report a positive effect of conservative voice treatment, although without quantitatively describing the improvement. We paid special attention to this during voice treatment of our patients. We compared the voice parameters of treated and nontreated patients. The nontreated patients used hyperfunctional phonation. The non-physiological techniques became functional dysphonia (*Gross*, 47). That show pathological dysphonia index.

In summary: The improvement of Friedrich Dysphonia Index values was clear at the end of treatment (in the first patient from 1,6 to 0,4, from 0,8 to 0,2 in the second patient, and from 1,2 to 0,24 in the third patient), this improvement could not be observed in the untreated individuals. We were able to support the efficacy of the voice therapy we developed and applied to our patients, and we also observed the development of functional dysphonia in non-treated cases.

1.4. Unilateral vocal cord paralysis

The pre-and postoperative data were evaluated and compared 25 patients- There were 15 lipo-augmentation and 10 thyroplastics performed according to the methods of Friedrich. (The average age was 54,9 years, 22-79 years).

The voice quality improvement after management of unilateral vocal cord paralysis with lipoaugmentation and Titanium implant Table 12. (sec. parameters Table 1.)

	No.	Mean	Difference of mean
Hoerseness lipoaugmentation	pre 15	2,733	
	post 15	0,667	2,067
Titan implant	pre10	2,8	
	post10	1,1	1,7
Pich range lipoaugmentation	pre 15	2,067	0,267
	post 15	1,8	
Titan implant	pre10	2,3	
	post10	2,2	0,1
Intensiy range lipoaugmentation	pre 15	2,133	
	post 15	1,267	0,867
Titan implant	pre10	1,9	
	post10	0,9	1,0

Phonation time	pre 15	2,8	
lipoaugmentation	post 15	1,2	1,6
Titan implant	pre10	2,9	
	post10	1,7	1,2
Communicative impairment lipoaugmentation	pre 15	2,8	
	post 15	0,6	2,2
Titan imlant	pre10	2,2	
	post10	0,5	1,7
Dysphonia-index lipoaugmentation	pre 15	2,507	
	post 15	1,107	1,4
Titan implant	pre10	2,42	
	post10	1,28	1,14

Table 12.

Comparing the dysphonia-index results (0,57) of voice symptom- and complaint-free thyroid patients with the values of 1, 10 and 1,28 (not with 0), the result is close to the result expected before the thyroid surgery, and proves the efficacy of augmentation and implants (values were 2,5 and 2,4 before) . We compare these results based on the fact, that the most common cause of unilateral vocal cord paresis is strumectomy (10). And also according to certain authors (106) signs of phonation hyperfunction may be observed in healthy individuals.

We also examined the cases, where histology proved malignancy in the thyroid (9 out of all cases). We found no significant difference from the data we acquired in the voice symptom- and complaint-free thyroid cases (Table 9.).

In summary: Improvements following treatment of vocal cord paralysis may be monitored with the improvement of Friedrich dysphonia index values (table 12.). When comparing calculated Friedrich dysphonia index values of vocally symptom-free thyroid patients with that found in professionals, we found the result to be off by 0,57 in the non-professional group. When comparing patients' result to these values, improvement is evident.

2.2. Our efforts to improve rehabilitation of oropharyngeal dysphagia, RESULTS

We examined treated and controlled 168 dysphagia patients.

We would like to demonstrate the examination of dysphagia patients based on the testing we did (National Oncology Institute, Department of Head and Neck Surgery) on 168 patients, suffering from different types of head and neck tumors (according to localization 10 nasopharyngeal, 92 oropharyngeal/floor of mouth, 32 laryngeal, 32 hypopharyngeal, 2 metastasis). The average age of patients was 57 (from 33 to 80 years), male to female ratio: 132:36. Tumor treatment was surgical in 56, chemotherapy in 69 and the combination of the two in 43 cases.

137 patients underwent swallow therapy (81,54%), the average duration of therapy was 7 days (ranging from 1-31 days), with exercises done daily.

31 patients did not need swallow therapy (18,4%). 56 treated patients received rheological and dietetic counseling (40,87%), which is 33,33% of all patients. 6 patients received dietetic counseling.

According to the calculations of Table 3.: 10 patients were able to eat foods with viscosity values between 1 and 7, 19 of them from 1 to 2, 1 from 1 to 6, 13 from 1 to 4, 2 from 1 to 8 and 5 from 1 to 5 (50 patients).

Altering posture: 80 patients, swallow maneuver: 19 patients, articulation exercises: 8 patients, clearance, purposeful clearing, croaking: 8 patients, Masako maneuver 1 patient, 6 patients received dietetic counseling.

12 patients (6,5%) received permanent PEG-s due to the failure of swallow therapy.

We had 12 unsuccessful cases. They are as follows:

-2 patients *showed up for therapy only 1 time* (1 patient underwent resection of radix lingue, and 1 supraglottic resection)

-2 patients underwent so-called dry-training only, due to their *severe lung condition*, swallowing examinations were contraindicated, and PEG was created (1 patient hypopharynx tumor, 1 elderly patient left side radical block dissection with the resection of the external carotid artery, nerves X,XI, and XII , the muscles of the floor of mouth, and tangential mandible- floor of mouth removal)

-1 patients underwent surgery *following a stroke* (resection of radix lingue)

-5 patients did not learn to swallow despite regular treatment:

- in 1 case the patient suffered from silent aspiration , unilateral laryngeal paresis and hypopharyngeal cicatrix, increased tone of the esophageal orifice following supraglottic resection and pharynx resection. In patient developed aspiration pneumonia, because of saliva aspiration without oral feeding.

-in 1 case the post-operative dermal dehiscence healed secondarily following radiotherapy and right-side I-V level dissection on the neck, resection of radix lingue, mandible segment resection.

-1 patient underwent laryngectomy and bilateral selective neck block dissection after developing a secondary laryngeal tumor 12 years after tumor of the floor of mouth, which was successfully treated with radiotherapy (m. latissimus dorsi free flap was implanted three years after radiotherapy due to the osteoradionecrosis of the mandible). Post-operative scarring, and facial, labial, and tongue oedema was more substantial than usual.

- in 1 case the recidive tongue tumor, primarily treated with chemo-radiotherapy was treated with glossectomy, and a thyroid flap, and skin necrosis occurred in patches on the skin of the submandibular region, damaged by radiotherapy.

-1 patient had to have the feeding tube reinserted, due to temporary difficulties swallowing, but it could be removed again in a couple of days (hemiglossectomy and left-side radical neck block dissection). In patient developed aspiration pneumonia.

-for 2 patients per os intake was complimented via PEG (temporarily for 6 months following 1 buccal resection, 1 patient following haemiglossect. et mRND l.s., thyroid flap reconstruction, who underwent radiotherapy earlier due to a laryngeal tumor).

The incidence of aspiration pneumonia in our patients 1% (one patient because of saliva aspiration without oral feeding). No lethal complications occurred.

We performed swallow X-rays in 45 of our cases. 20 underwent supraglottic laryngeal, 21 of the radix lingue resection, and we proved, that 11 patients with mesopharyngeal tumors were able to swallow without aspiration. In 2 cases the decrease in the speed of motion of the pharynx, and retention could be observed.

CONCLUSIONS

Concerning phonation analysis: phoniatry, similar to audiology strives to describe voice characteristics numerically. This is why certain auditive numeric methods must be adopted in Hungary. We use this to monitor other voice dysfunctions, not functional dysphonia only with the RBH-scale, measuring voice range profile and Friedrich dysphonia index. The result support the efficacy of applying these methods to monitor voice dysfunctions and it is comparable, correctly documentation.

According to our aims, substituting current subjective voice descriptions with numerical methods – *applying the RBH-scale*. This way voice status becomes comparable, and thus we may assess therapeutic success quickly and easily. We were the first to publish our results with these methods in Hungary, together with the *ELTE Faculty of Logopedics (Fül-orr-gégegyógyászat 2005.)*. By introducing and applying these methods, we ensured that results in Hungary will be comparable in the future.

-Analyzing and categorizing subcomponents of hoarseness *by applying the RBH-scale, as this hoarseness scale analyses the presence of hoarseness components in the voice.* Utilizing all of the above in the rehabilitation process of phonation, in functional dysphonia, spasmodic dysphonia, transsexual phonation, and unilateral vocal cord paralysis.

-Applying *objective methods* of voice function analysis:

-Measuring voice range profile (with Hacki's *voice range profile* analysis device). The results of this informative method, compared to values obtained from healthy individuals indicate laryngeal voice function, quality of voice function (normal or decreased) and the potential of the vocal apparatus. *By introducing voice range profile analysis in Hungary, we have widened the arsenal of phoniatry, and we have also used this method outside the above for voice analysis of patients dependant on their voices, for example students of the University of Theater, Film and Television.*

- Applying a numeric satisfactory index that takes the opinion of the patient into consideration (sec. Friedrich). Calculating dysphonia-index, which we introduced and published in Hungary (*Fül-orr-gégegyógyászat*, 2001), objectifies results from the patients' point of view.

-Calculating dysphonia-index from all of the above, in not only functional dysphonia, but in rare conditions, such as modern Botox treatment of spasmodic dysphonia, improving voice quality in transsexual individuals, which have not been analyzed in the literature.

-We devised a new, formerly unknown method of conservative voice therapy in transsexual individuals (*Folia Phoniatrica et Logopedica*, 2005).

-This method proved to be appropriate to objectively monitor surgical results, and objectify effects of phonosurgery in unilateral vocal cord paralysis.

-In order to be able to compare results we measured voice parameters of healthy professionals, and patients suffering from thyroid conditions without voice symptoms or complaints, and we analyzed our results based on these voice parameters.

Concerning swallow tests:

Our aim, to be able to compose and offer patients a diet that includes foods with viscosity values measured during trial swallow testing, and are safe to swallow, has been met, as our results prove. Applying systematic diagnostics and therapy, categorizing treatment, and

devising and applying treatment plans for different kinds of procedures, and further developing these treatments with rheological methods helps to compose a diet more suited for the patients' individual state, and rehabilitation capacities.

Dysphagia following head and neck tumor therapy may be temporary or permanent, treatment is obligatory if the patient has symptoms, but based on accumulating evidence, it should be done preventively as well.

Experience shows, that it is hard to find the appropriate choice from a variety of foods, if this is not done based on quantitative criteria. Repeated attempts try the patience of both patient and therapist. The materials used in the clinic and the home kitchen may differ also, which makes it hard to reproduce estimated consistency, that is why it is necessary to compose a diet based on rheological methods. Our own measurements have proven, that foods within the same consistency group, such as purees, may fall into different viscosity categories. This proves, that if patients are given instructions containing qualitative instructions, it may mean different consistencies, and may be a source of danger.

Using this method, our study group was able to determine, based on the results of trial swallow tests, which foods the patient would be able to eat safely both in the hospital, and at home. After the trial food is consumed safely, without aspiration, per os nourishment may be permitted. Thus aspiration may be reduced. Swallow exercises may prevent or delay the necessity of having a feeding tube or a creating a PEG. Determining objective viscosity helps minimize the "nothing by mouth" period.

Our measurements proved, that qualitative consistency descriptions aren't always enough. After all, different viscosity values were measured within a consistency group – for example puree-, and we differentiated diets accordingly. Based on this we defined 5 varieties of mashed potatoes. The energy- nutrient- and fluid- content of the food we made and determined were constant, and determinant data was included in the recepies. Patient calorie and fluid intake may be calculated accordingly. If supplementation is necessary according to calculations, the supplement should be set at the same level of thickness. The devised method made the difficult clinical part of transition to per os nourishment easier. The foods prepared this way, beside being easy to prepare at home, and increasing swallowing safety, also contribute to rehabilitation and developing conscious nourishment habits. Standardizing foods not only increases efficacy of swallow therapy, but makes it possible to compare rehabilitation results from different centers, and further develop swallow therapy.



Determining objective viscosity helps minimize the "nothing by mouth" period. In our experience, applying this method led to successful swallow rehabilitation of over 74,4% of our patients, for whom the swallow therapy used abroad, and adapted in Hungary would not have been enough. *We developed this method further.* We published the methods in both Hungarian and international literature, and have presented them at congresses on several occasions (*J of Food Phisic*, 2008, European Radiology 2000, *Fül-orr-gégegyógyászat* 2000, *Fül-orr-gégegyógyászat* 2009, EUFOS Kongress, 2000, IFOS, 2009), we have published in related fields (*European Radiology* 2000, *Rehabilitáció*, 2002, *Rehabilitációs orvoslás* (in press), *Új diéta*, 2004, *Vasculáris neurológia – book section*, 2006, university lecture notes, invited by ELTE: Mészáros K., Hacki T.: *Oropharyngealis dysphagia vizsgálata és kezelése* - in press-), and applied them for years when rehabilitating swallow disorders of post cerebral vascular attack patients at the Swallow Clinic at National Institute of Psychiatric and Neurology.

(Authors will make the recipes available.)

NEW CONCLUSIONS

According to our work, in relevance to Hungary

1. *we were the first to use numeric voice descriptions (RBH-system),*
2. *voice range profile analysis,*
3. *applying dysphonia-index, in not only to describe voice quality in functional dysphonia, but in other conditions as well,*

which we learned while studying abroad (Benjamin Franklin Univ. in Berlin, Regensburg Univ., Graz Klinik der Phoniatrie).

We adapted these methods in Hungary, and integrated it into the *logopedic training program of Bárczi Guszav Faculty of Special Education at Eötvös Lóránd University (ELTE)*.

2. *We applied a new teratment method in treating the voices of male-to-female transsexuals.*
3. *We applied the RBH-system not only for the examination of functional dysphonia, but to monitor the efficacy of phoniatric treatment (operative and non-operative).*

4. We supported the efficacy of modern procedures (Botox injections, lipoaugmentation, Titanium implants) by calculating dysphonia-index.

5. Not only did we compare results to average, but to our own measurements as well. We found these measurements to support that as for example one of the most common causes of n. recurrens paresis is strumectomy, the results of therapy for nervus recurrens paresis should be compared with the results of these patients. We also examined the voices of patients suffering from malignant thyroid conditions separately, in cases where the tumor did not infiltrate the nerve. We found no differences in patients' voices. We calculated dysphonia-index in both vocally symptom-free thyroid patients and professionals as well, so we had a realistic basis for monitoring patients' voices.

These methods, similar to numeric methods used routinely, and compulsory in audiology, and contribute to the quality phoniatry care.

6. Application of systemic swallowing diagnostics and therapy in Hungary – we adapted and integrated it into the advanced logopedic training program of Bárczi Guszav Faculty of Special Education at Eötvös Lornd University (ELTE) and integrated it into the dietetic training program of Semmelweis University.

7. and complementing it with objective, rheological measurements to determine foods that are safest for patients to swallow without aspiration. Successful rehabilitation of patients who underwent organ sparing surgery supports the need for these types of procedures, the functional rehabilitation of the organ, and avoiding total laryngectomy.

All of the above helps patients avoid communication disorders, and they improve quality of life as well (life threatening dysphagia), which we proved in 375 patients.

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