Review Article

Rehabilitation of impaired speech function (dysarthria, dysglossia)

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Abstract

Speech disorders can result (1) from sensorimotor impairments of articulatory movements = dysarthria, or (2) from structural changes of the speech organs, in adults particularly after surgical and radiochemical treatment of tumors = dysglossia. The decrease of intelligibility, a reduced vocal stamina, the stigmatization of a conspicuous voice and manner of speech, the reduction of emotional expressivity all mean greatly diminished quality of life, restricted career opportunities and diminished social contacts. Intensive therapy based on the pathophysiological facts is absolutely essential: Functional exercise therapy plays a central role; according to symptoms and their progression it can be complemented with prosthetic and surgical approaches. In severe cases communicational aids have to be used. All rehabilitation measures have to take account of frequently associated disorders of body motor control and/or impairment of cognition and behaviour.

Keywords: speech disorders, dysarthria, dysglossia, functional therapy, prosthetics

1. Definition and introduction

Oral or spoken communication belongs to the elemental functions of human existence. It is made possible by the ability to produce differentiated sounds, an acoustically perceptible way of conveying information. The function of the organs participating in speech can be compared with the construction of an organ pipe: respiration corresponds to the bellows, the larynx to the pipe itself and the articulatory organs of the vocal tract (lips, jaw, tongue, pharynx and velum) modify the air flow and the sound produced in the larynx by narrowing or closing the passage and by modifying the resonance cavities. The fast sequence of sounds during speaking requires a highly complex pattern of movement of all active muscles which has to be timed with the utmost accuracy. Speech disorders caused by sensorimotor impairments of the articulatory movements are called dysarthria. The articulatory movements of patients suffering from dysarthria are characterized by weakness, reduction in speed, malcoordination, altered muscle tone or by dyskinetic symptoms. Speech disorders caused by structural changes of the speech organs - in adults mostly after surgical and radiochemical treatment

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of tumors - are called dysglossia. The decrease of intelligibility, a reduced vocal stamina, the stigmatization of a conspicuous voice and manner of speech, the reduction of emotional expressivity have grave consequences: greatly diminished quality of life, restricted career opportunities and diminished social contacts.

2. Dysarthria

2.1. Aetiology and pathogenesis of dysarthric disorders

Among the causes that lead to disorders of the dysarthric type are all neurological diseases of the muscular-skeletal system; here either the motor structures of the CNS or the lower motoneuron can be affected. CNS structures in which damage is relevant are areas of the sensorimotor cortex, the cortico-nuclear tracts descending from these areas to the brain stem, the reticular formation, the polysynaptic segmental motor tracts including thalamus and basal ganglia, and the cerebellum. Dysarthria also occurs when the lower motoneuron is damaged (the nuclei of the cranial nerves V, VII, IX, X and XII or these cranial nerves themselves; the cervical nerves C1 to C8, the thoracical nerves T1 to T12 and the structures of the neuromuscular junction) or when the muscular system is injured. Speech disorders connected with isolated peripheral paresis are classified by some authors as dysglossia; for further differentiation within the terminology which is not standardized please refer to the relevant specialist literature [1], [2].

Depending on its location central damage leads to disorders analogous to motor disorders of the extremities: paresis (flaccid or spastic), akinesia and rigidity, ataxia, tremor and myoclonus, as well as different types of dyskinesia [1]. *Disorders caused by central damage are very often characterized by the fact that several functions of speech production are affected: respiration, phonation, articulation and prosody (rhythm of speech, intonation and accentuation)*, hence the termini "dysarthrophonia" or "dysarthrophonopneumia". If the damage is so severe that no articulatory movements are possible at all, the term used is anarthria. The most common diseases accompanied by dysarthria are listed in Table 1 (Tab. 1).

2.2. Classification and symptomatology

Dysarthric disorders are classified either according to the location of the damage (cortical, subcortical - extrapyramidal, cerebellar, bulbar) or according to the symptoms. A classification following the symptoms seems to be of greater use for the planning of therapy. Descriptive criteria are strength of muscle, tone of muscle (hypertonic, hypotonic) and the kinematics of the movements (range, speed and accuracy).

Spastic dysarthria: This is caused by spastic paresis due to lesions of the upper motoneuron and accompanied by muscular hypertonia as well as by a deterioration of strength and precision. Reflectory movements associated with coughing, choking and swallowing are usually unaffected (dissociated paresis, also see Table 3, as well as movements associated with emotional expression like laughing and crying. Auditory characteristics include a strained, harsh voice quality, a shift of the tongue's articulation zones backwards leading to an imprecise production of consonants, hypernasality (caused by spasticity of the palatine arches or by a weakness of the velum's elevators) as well as slow and monotonous speech. *Spastic dysarthria is the most common type of dysarthria resulting from severe closed head trauma.*

Rigid hypokinetic dysarthria: Damage is localized mainly in the basal ganglia. In the presence of an increased background activity the muscle resistance to passive stretch is increased; akinesia and bradykinesia are to be found. The voice is weak and breathy, the articulation imprecise, the rate of speech may be increased, sounds and syllables iterated. *The most common cause is Parkinson's disease of which this speech disorder counts among the early symptoms. It can also be accompanied by a tremor of the voice, in consequence of a tremor of the vocal folds.*

Ataxic dysarthria: Typically, muscular movements are characterized by overshoot or undershoot

(dysmetria); motor efforts cannot be stably maintained. This disorder is caused by damage to the cerebellum and connected areas. As to articulation, there is a tendency toward lenisation and fortisation, the phonation is hoarse and strained, with devoicing, pitch breaks and an instability of pitch as well as loudness. Speech is produced in a syllabic way and at a lower speed. *The most common causes are inflammatory and degenerative diseases of the cerebellum, but also cerebrovascular damage and trauma in this area*.

Dyskinetic and dystonic types of dysarthria: Inappropriate muscle activation patterns with hypertonic contractions and uncontrolled movements can also affect the muscles involved in speech production. This can lead to varying impairments of voice quality, to interruptions in speech flow or to involuntary vocal output as observed in Huntington's disease or in athetosis. Spasmodic dysphonias (where the larynx muscles are affected) and oromandibular dystonia result from focal dystonia. Tremor and myoclonus, which can cause phonatory as well as articulatory disorders, belong to the group of repetitive hyperkinesias with a variety of frequency, amplitude and acceleration patterns [3].

Flaccid dysarthria: *This is caused by a flaccid paresis following damage to the lower motoneuron (nuclei of the cranial nerve in the brain stem, peripheral nerves),* but can also be observed after suprabulbar lesions. Symptoms are reduced muscle tone, loss of voluntary and reflectory functions, muscular atrophy and possibly fasciculations often concerning single muscles only. The damage results, depending on its localization, in a weak, breathy voice, hypernasality, imprecise consonants and a decrease in speech rate. *The most frequent cause of flaccid dysarthria is damage in the brain stem (bulbar symptoms), e.g. in cases of amyotrophic lateral sclerosis. But also peripheral nerve damage as occurs in polyneuropathy or tumors or damage of the neuromuscular junction as occurs in myasthenia or muscular diseases can lead to the symptoms of flaccid dysarthria.*

Mixed types: As a consequence of extended damage, e.g. in the case of encephalitis disseminata, after closed head trauma or cerebrovascular diseases frequently there can be seen a combination of several types of dysarthric disorder.

3. Dysglossia

3.1. Aetiology and pathogenesis of dysglossia

Speech disorders which arise from damage to the peripheral structures involved in speaking are called dysglossias. They can be caused by many factors: by congenital malformations (in particular craniofacial malformations including clefts of the palate, jaw and lips and oro-mandibulo-facial malformations accompanying various syndromes [4]), by acquired dental defects and trauma, but above all by the defects and tissue alterations caused by surgical and radio-chemotherapeutic treatment in the head and neck region. As opposed to dysarthrias often only specific areas of phonation and articulation are concerned. Depending on the damage the results can range from incomplete realizations of sounds to total failure of functions. Congenital malformations most frequently lead to characteristic adaptations.

3.2. Classification and symptomatology

According to the localization of the damage dysglossias can be classified as labial, dental, lingual, palatal, velopharyngeal and nasal, with impairments of sound production at all places of articulation, but also with impairments of phonation. According to Leonard et al. [5] anterior tongue resections are accompanied mainly by defective consonants, posterior resections mainly by defective vowels. The probability of articulatory deterioration caused by resections of tumors from the oral cavity or from the oropharynx varies a lot [6]: base of tongue 100 %, mandible 87,5 %, floor of mouth 81 %, tongue 72,7 %, lips 28,6 %, tonsils 27,3 %. To what degree the functions are impaired also depends on the techniques of reconstruction. With local flaps the speech intelligibility is least impaired, with transplants from the small intestine, myocutaneous or fasciocutaneous transplants the degree of impairment is higher [7]. Koppetsch and Dahlmeier have shown in a study in 2004 [8] that patients with tumors of the tongue or of the floor of the mouth suffered from a deterioration of all oral functions like chewing,

swallowing and speaking as well as impairment of tactile and gustatory sensitivity after tumor resection and reconstruction, but particularly after the start of radio-chemotherapy. Defects of the palate and the maxilla very often create connections between nasal cavities, paranasal sinuses and oral cavity which leads to a strong open nasalization as well as to severe swallowing disorders. It should also not be forgotten that tumor resection and radiation can cause secondary damage of lower cranial nerves with corresponding impairments of speech, which may appear immediately after the treatment, but possibly only years or even decades later [9].

4. Diagnosis of speech disorders

Two aspects have to be considered: (1) The registration of physiological parameters (movement, strength, EMG) may give information about the disorder's underlying mechanisms and so may lead to conclusions about type, degree and localization of the disease. (2) Measuring auditory and acoustic characteristics enables us to define the functional effects of deficiencies in speech motor control and so to describe the impairment of communication. Both components are essential for differential diagnosis and for establishing guidelines for therapy [10].

The clinical examination of speech disorders should include the following steps [11]:

• Anamnesis

• Auditory examination including intelligibility test

• Inspection and palpation of speech organs including endoscopic examination of velopharynx and larynx

• Acoustic analysis of speech sound

• Aerodynamic methods of measurement

• Registration of further physiological parameters

• If appropriate examination with imaging techniques

Anamnesis should establish:

• Primary disease, former treatment, medication

• In cases of cerebral damage: Degree, localization

• Date of damage, improvement/deterioration since

• Effects of the speech disorder on daily life (social contacts, work, leisure)

• Speech disorders before the actual disease; abnormalities in speech development

• Possibly associated symptoms: Malsensations, pain, urge to clear throat, chewing and swallowing disorders, impairment of gustatory sensitivity

• For treating dysarthria it is absolutely necessary to find out about possibly associated neurological and neuropsychological disorders (Table 2 (Tab. 2))

Disorders of this kind can influence the ability for oral communication and have to be taken into consideration in therapy. In cases of acute cerebral damage vital functions like respiration, circulation and ingestion are often initially impaired, which requires long-term intubation, tracheotomy and gavage. These often lead to mechanical damage to the voice and speech organs; this has to be distinguished from the symptoms caused by cerebral damage.

Auditory examination

Auditory examinations register the effects resulting from impairment of speech respiration, phonation, articulation and prosody. These examinations serve as a basis (1) for systematic phonetic analysis and (2) for identifying the aspects of the speech disorder which are relevant for communication. The symptoms are tested in a variety of tasks and classified with the help of evaluation scales [12]. The

German version of the "Frenchay Dysarthria Test" [13] offers a standardized procedure which combines visual and auditory observation of dysarthric symptoms, although the patho-physiological causes and the functionally relevant symptoms are not sufficiently taken into account.

One of the decisive parameters for the ability to communicate is intelligibility. A reliable and valid procedure to measure intelligibility is the computer-based "Münchner Verständlichkeitsprofil (MPV, Munich intelligibility profile)", which provides an overall value for intelligibility as well as specific information relevant for therapy [14].

Inspection and palpation of the speech organs as part of a neurologically oriented phoniatric examination

Inspection and palpation are central elements in the examination of speech disorders. They allow a qualitative evaluation of the laryngeal and articulatory motor control disorders. Examination includes the following points [15]:

• Structural changes (inflammation, defects, scars, changes in the mucosa)

• Characterization of the sensorimotor disorder according to changes in muscle tone, reduction in amplitude and speed of movement, signs of hyperkinesia and apraxia; examinations are carried out during rest as well as during voluntary and reflectory action. The most important criteria for the distinction between central and peripheral paresis are listed in Table 3 (Tab. 3).

• Impairment of sensibility and reflectory reaction

• Signs of functional maladaptation (e.g. hyperadduction of the larynx)

Visual and palpatory examination applies to the muscles of the neck and the floor of the mouth, the lips, jaw, tongue and velum. Among the methods to investigate the velopharynx and larynx are laryngoscopy, stroboscopy, and fiberendoscopy for the endonasal examination of velum, pharynx and larynx. Video recording permits the analysis of movement in slow motion, serves to document the examinations as well as to evaluate therapy and can be used for biofeedback therapy [16].

Examinations with high speed cameras, 3D-endoscopy, kymography, ultrasound and electroglottography can be very useful to judge disorders of motor control and to achieve differential diagnosis of structural impairments, peripheral nerve lesions and central disorders of voice function.

Measurement of acoustic parameters

The analysis of the speech signal resulting from the articulatory movements allows objective description of qualitative changes in the realization of sounds as well as a quantification of symptoms relevant for communication, like reduction in movement speed, changes in pitch or impaired fluency.

Aerodynamic methods of measurement register pressure and air flow during speaking. Separate measurements of oral and nasal air flow allow classification of impairments in velar function [17].

Registration of further physiological parameters

Measuring electrical muscle activity (EMG) is of particular importance for distinguishing peripheral paresis (with pathological spontaneous activity) from central paresis.

Gröne 2002 [18] describes in detail several methods which are also used clinically for examining specific articulatory movements: Palatography allows the contact between tongue and palate to be assessed. Electropalatography describes moreover in detail the temporal and spatial aspects of the contacts between tongue and hard palate during speaking. Electromagnetic articulography allows analysis of the movements of tongue, pharynx and velum.

Imaging techniques

By means of *ultrasound* structural changes can be detected and individual movement patterns can be documented. *Cineradiography or videofluoroscopy* of the speech process allow a differentiated evaluation of motion patterns, particularly of their coordination, but because of the exposure to radiation there must be a clear indication justifying its use. *Nuclear magnetic resonance imaging (NMRI)* is also suitable for showing structural changes and analyzing movements, although the temporal resolution in the latter case is still unsatisfactory.

5. Therapy

The main goals in treating speech disorders are an improvement of the speech motor output and an improvement of the communicative abilities in order to reduce the effects of the disablement on everyday life. When judging the potential for rehabilitation and establishing an attainable goal of therapy, the following prognostic factors have to be taken into account:

(1) Kind and degree of damage to the brain, period of time passed since the beginning of the disease and the development of the disease, progression or stability. In cases of tumor disease further structural changes have to be considered: scars or tissue changes after radiation and chemotherapy.

(2) Multimorbidity and unfavorable psychosocial conditions frequently reduce the therapeutic chances for older patients.

(3) It must be guaranteed that qualified therapists are accessible to the patient.

(4) Personality and psychosocial surroundings can have decisive influence on the course of the therapy.

(5) Associated neuropsychological disorders like impairment of cognition, language and perception as well as changes in behaviour, e.g. subdued incentive, influence course and result of therapy.

The principles of treating speech disorders have been already formulated by Darley et al 1975 [19]:

(1) An early start of treatment aims to avoid maladaptation, e.g. hyperactivity of remaining muscle functions; in case of progressive diseases the intelligibility is to be maintained as long as possible.

(2) By acquiring compensatory strategies, e.g. a reduced speech rate, it should be possible to optimize the use of remaining functions.

(3) The patient should aim to acquire voluntary control of speech in different situations of daily life, at work and in private life.

(4) Necessary modifications of speech behaviour cannot be attained without adequate self-perception; this forms an essential part of therapy.

(5) The speech motor systems respiration - phonation - articulation influence one another. For this reason it is essential to find out in diagnosis which system is most affected; this should be the initial focus of treatment.

(6) The compensatory techniques of speech and communication to be acquired have to be acceptable for the patient and his surroundings.

(7) The patient's motivation has to be aroused and kept up by making him understand the nature of his disorder and the principles of its treatment.

The therapeutic methods follow the general principles of rehabilitation, restitution - compensation - adaptation:

Restitution means restoring impaired functions, e.g. strengthening paralyzed muscles or re-achieving tongue motility impaired by scar tissue. *Compensation* means improving functions by substitution strategies or by the use of remaining abilities, while the disorder continues. *Adaptation* means adjusting to the disorder mainly by a change of communicative behaviour, e.g. avoiding background noise in conversations; in severe cases alternative means of communication have to be used.

Following Duffy 1995 [20] therapeutic approaches to speech disorders can be classified into (1) behaviour-modifying methods, (2) prosthetic intervention and (3) medical procedures.

5.1. Functional therapy: Behaviour-modifying methods and instrumental aids

Modification of behaviour means in this context influencing one or several speech motor functions, as well as linguistic or communicative behaviour. In the specific treatment of speech motor control there are direct and indirect methods [21]:

Indirect methods of treatment: Indirect approaches mainly aim at a restoration of the impaired function and correspond to the principle of *restitution*. The training tasks have no phonetic content, but rather are located "outside" the speech process and are based on the principles of physiotherapy, adapted to the specific conditions of the speech muscle system. Among those methods are relaxation techniques, correction of posture, reversal of pathological reflexes, stimulation (sensory stimulation, passive and active movement) and specific exercises aiming at an influence on muscle tone, as well as on the strength, amplitude, accuracy and smoothness, selectivity and symmetry of movement, and also aiming at voluntary efforts. Indirect methods are used in all speech motor systems (respiratory movements - laryngeal function - articulatory movements) and can be effectively supported by instrumental aids and feedback procedures: control of expiratory volume velocity can be trained by visual feedback with pneumotachometric parameters, abdominal and thoracic respiratory movement can be trained by feedback with kinematic parameters. The phonation can be visualized by the registration of loudness and pitch (visipitch), also the coordination between expiration and voice can be visualized, so the patient can recognize and influence it. As to the speech musculature EMG-feedback devices have proved very helpful for the reduction of muscle tone as well as for the improvement of selective motility of those muscles accessible from outside. The improvements attained by indirect methods of therapy are not automatically transferred onto speech behaviour. Special transfer exercises are necessary.

Direct methods of treatment: Here the speech motor system itself is modified; this includes all exercises with phonetic and linguistic content. This mainly leads to behaviour modifications following the principle of *compensation*, which means that a continuing disorder is improved by substitution strategies. An example is the treatment of patients with Parkinson's disease who suffer from a weak voice caused by laryngeal hypoadduction; there are attempts to increase the sound volume of their voice by means of specific exercises aiming at variation of respiratory depth and of subglottal pressure, combined with tension in the whole body as well as with exercises for pressing and pushing (*Lee Silverman Voice Treatment* [22]). Direct therapeutic methods can also include instrumental aids and biofeedback techniques like speech delayer or tactile board for support of rhythmization. By means of video-endoscopy with fiberoptics the articulatory movements of the velum or larynx can be visualized [16], [23].

Indirect and direct approaches complement each other and are therefore usually applied side by side. Attention should always be paid to the hierarchy of the main disorders in each motor sub-system as well as to a reduction of compensatory maladaptations (e.g. laryngeal hyperadduction, overarticulation, exaggerated speech rate). A detailed discussion of specific methods of treatment for each speech motor system can be found in Vogel 2002 [21].

In therapy, besides the treatment of speech disorders the patient should also acquire communicative strategies adapted to his intelligibility and stamina (e.g. short sentences, accurate planning, precise content). Another important part of therapy consists in working out together with the patient and his family suitable correction techniques.

Alternative means of communication have to be used when sufficient ability for oral communication cannot be attained. There are a great variety of devices from simple letter boards to writing computers and complicated multimedia systems; they all have to be adapted individually and require specific training to be used efficiently.

5.2. Prosthetic intervention

A simple prosthetic device that is helpful for mandibular instability consists of a small plastic block (bite block) which is wedged between the teeth and so inhibits undesired movements of the lower jaw and

helps to keep the opening angle of the jaws small.

Prostheses are applied particularly in cases of extensive defects of the tongue, the floor of the mouth, upper and lower jaw and velopharynx or in cases of severe functional disorders of the tongue and velopharynx caused by paralysis. The so-called obturator prosthesis allows contact between tongue and palate even in cases of tongue atrophy or missing substance in tongue and palate; sound production is thus made possible or easier. Moreover any opening between oral and nasal cavitiy can be closed, so no air is lost and oral pressure can be adequately built up (Figure 1 (Fig. 1)).

A prosthetic enlargement of the alveolar ridge is also a measure that can improve function after partial resection of the tongue. Of particular significance are prostheses of the velum; velar function in regulating air flow plays a central role in connection with the rest of the articulatory functions. An impaired closure of the velopharynx not only has severe effects on resonance including hypernasality, but may also affect the kinematics and coordination of other articulators, of phonation and respiration and may lead to pronounced functional maladaptations. Thus the treatment of velopharyngeal closure defects is of great importance. The results of behaviour-modifying therapeutic approaches are often unsatisfactory, particularly in the treatment of bilateral paresis of the velum, a frequent symptom after severe closed head trauma. But also defects of the velopharynx after tumor resection and radiotherapy lead to severe impairments affecting the motor function systems mentioned above. The velar prosthesis ("palatal lift") therefore belongs to the most successful and effective methods of treating dysarthria [20]. Vogel and Sauermann [24] made decisive advances in the further development of its technical construction, adaptation to the patient's palate and subsequent therapy. In order to lift and possibly extend the velum a covered metal plate shaped like the soft palate is fixed to the teeth like a brace; towards the back the plastic covering widens into a thin elastic blade. This lifts the velum and closes most of the velopharyngeal passage (Figure 2 (Fig. 2)).

The aerodynamic conditions during speaking are immediately improved (less air is lost, intraoral pressure can be built up again); this frequently contributes to normalizing the other speech motor abilities often making effective training possible for the first time. Disadvantages and risks (sensation of foreign body, gag reflex, impairment of nasal respiration, increased salivation, swallowing difficulties) have to be met by patient adaptation. An intensive accompanying exercise therapy of sufficient duration (at least 6 weeks) is obligatory. Early intervention is desirable, but even in cases of velopharyngeal insufficiency having persisted for years success can be excellent. For many patients the prosthesis could be shown to have a stimulating effect, facilitating active raising of the velum so that in the end the prosthesis did not have to be worn any more.

5.3. Surgical procedures

In cases of dysarthria surgical methods for voice improvement are rarely indicated. They are appropriate though in cases of peripheral paresis of the vocal fold caused by lesion of the nucleus of the vagal nerve with excavation of the vocal fold and loss of glottal closure. Above the glottis there are a number of surgical procedures that can improve sound production depending on the localization and centre of the disorder; e.g. velopharyngeal insufficiency can be improved by plastic surgery of velopharynx or pharynx. Velopharyngoplasty (connection between velum and back wall of the pharynx in the shape of cranially or caudally pedunculated flaps) can be successful if residual contraction of the lateral and posterior muscles of the pharynx is still present. But these are affected by central lesions just as often as the velum itself. Because of shrinking of the flaps and formation of scar tissue the success of an operation often does not last. If the velum still has a residual but insufficient lifting function, attempts can be made to create velopharyngeal contact by augmenting the back wall of the pharynx with body tissue or artificial material. In cases of oropharyngeal defects after tumor treatment a surgical reconstruction of areas relevant for articulation (lower jaw, floor of the mouth, tongue, palate, pharynx) can lead to an improvement of speech ability. Surgical loosening of scar structures can be considered when motility is impaired by them.

Currently, the only medication of any significance is injection of botulinum-toxin in cases of severe spasticity of the orofacial muscles or in cases of focal dystonia, in particular spasmodic dysphonia.

All prosthetic and surgical measures require close cooperation between speech therapist, phoniatrician, dentist/maxillofacial surgeon and ENT specialist.

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Figure 1: Obturator prosthesis applied to 54 year old patient, female, after tongue resection

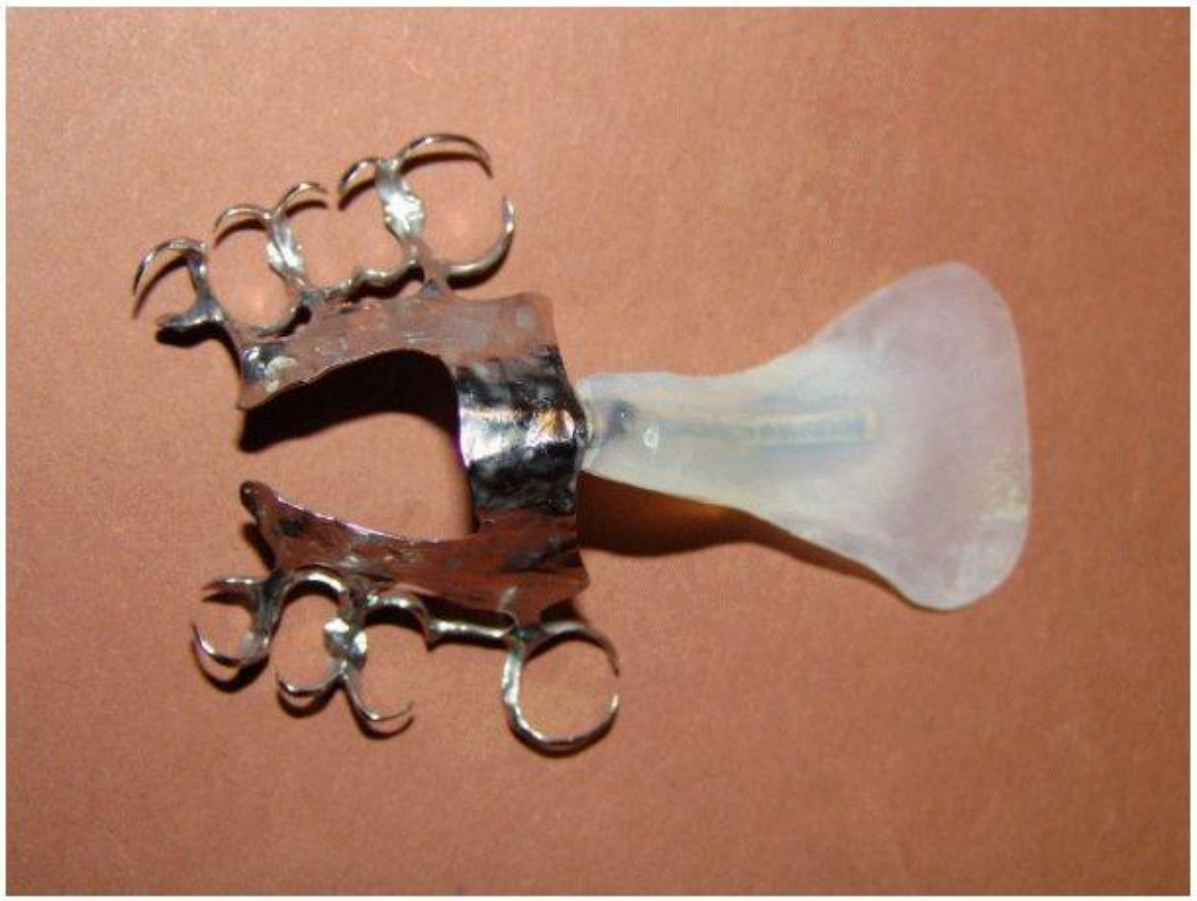

Figure 2: Velar prosthesis (palatal lift)

Cerebrovascular diseases
Cerebral ischemia
Intracerebral hemorrhage
Closed head trauma
Degenerative diseases of basal ganglia
Parkinson's disease
Huntington's disease
Degenerative diseases of cerebellum
Cerebellar atrophy
Spinocerebellar diseases
Olivo-ponto-cerebellar atrophy
Infectious and inflammatory diseases
Multiple sclerosis
Encephalitis
Tumors
Intoxications
Severe hypoxia
Side effects of medication

Table 1: Most common diseases accompanied by dysarthria

- Sensorimotor disorders (disorders of posture and movement, frequently impaired head control)
- Impairment of perception
- Impairment of cognition (attention, concentration, memory, planning)
- Linguistic disorders
- Personality changes

Table 2: Neurological and neuropsychological disorders frequently associated with dysarthria (Schröter-Morasch, v. Deuster 1998 [11])

Criteria	Peripheral paresis	Central paresis
Voluntary movements	lost	lost or impaired (fine motor functions, coordination)
Reflectory movements, emotional movements	lost	present
Muscle tone	decreased	decreased initially, later increased
Muscular atrophy	present if persistent, possibly formation of a lateral sulcus on the tongue	absent
Fasciculations	present (not always seen)	absent
Hyperkinesia	absent	possibly present

Table 3: Criteria for distinguishing peripheral and central paresis of speech organs (Schröter-Morasch 2002 [25])