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LARYNGEAL EMG *

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Introduction

Electromyography (EMG) is a technique for providing graphic information about the time course of the electrical activity of the muscle fibers which accompanies muscle contraction and subsequent effects such as tension development. Since Faaborg-Anderson reported his extensive study on human laryngeal EMG in 1957, a good number of reports have been advanced relating to both clinical and research applications. As the muscle fibers are innervated by the pertinent motor nerves, EMG can reflect, to some extent, the function of the nervous system itself, particularly that of the lower motor neurons. The practical aspects of laryngeal EMG are discussed relating to both clinical and research applications in this presentation.

Clinical use of EMG in laryngology

Clinical EMG developed initially in the fields of neurology and physical medicine from the requirements for improved diagnostic and prognostic methods. In particular, a major application of EMG examination has been in the differential diagnosis between neurogenic and myogenic causes of muscular weakness. In the field of laryngology, the clinical use of EMG is considered to aim at the following; (1) the differential diagnosis of immobile vocal cords, (2) the prognostic evaluation of laryngeal paralysis, (3) the diagnosis of laryngeal involvement in motor neuron diseases, and (4) the examination of abnormal laryngeal kinesiology.

Recently, laryngeal EMG has been widely accepted as a routine procedure for the assessment of laryngeal pathology with special reference to the status of immoblie vocal cords. In the author's research laboratory, a percutaneous approach using a bipolar concentric needle electrode has been used, in which the two innervation territories, (i. e., the cricothyroid and the thyroarytenoid), are examined bilaterally.

The percutaneous insertions are preceded by the intradermal administration of a small amount of 0.5% Xylocaine solution through a Panjet at the site of needle insertion (Fig. 1).

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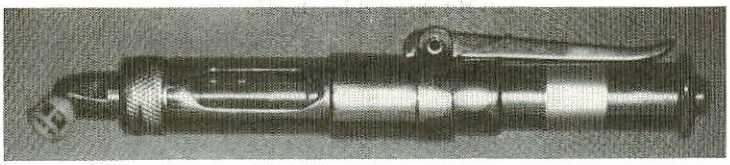
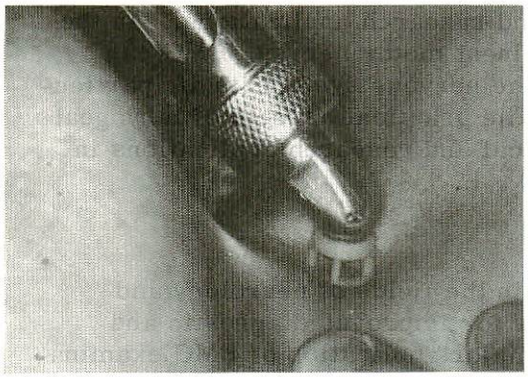


(a)

5 cm



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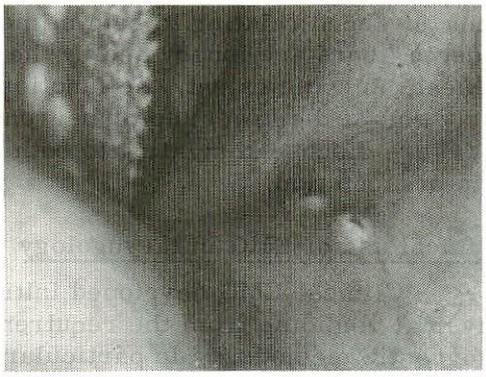

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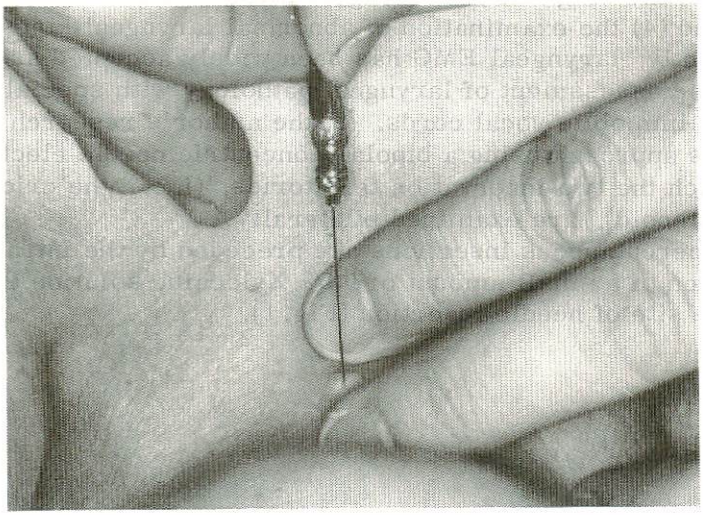


(d)

Fig. 1 (a) Panjet (b) Use of Panjet before electrode insertion (c) Circumscribed swellings following intradermal administration of Xylocaine solution (d) Insertion of a needle electrode

Directions of needle insertion are schematically shown in Figure 2. For reaching the thyroarytenoid, the needle is passed through the cricothyroid space near the midline and advanced cranially and slightly laterally in the submucous tissues near the anterior commisure. In order to avoid bringing the needle too close to the mucosal surface the subject is asked to phonate during insertion so as to bring the vocal cords to the midline. For the cricothyroid, insertion is made at the level of the lower edge of the cricoid ring and 5 mm lateral to the midline. The needle is advanced postero-laterally and slightly upward aiming toward the inferior tuberculum of the thyroid cartilage. Penetration of the fascia is often felt when the tip of the needle reaches the muscle.

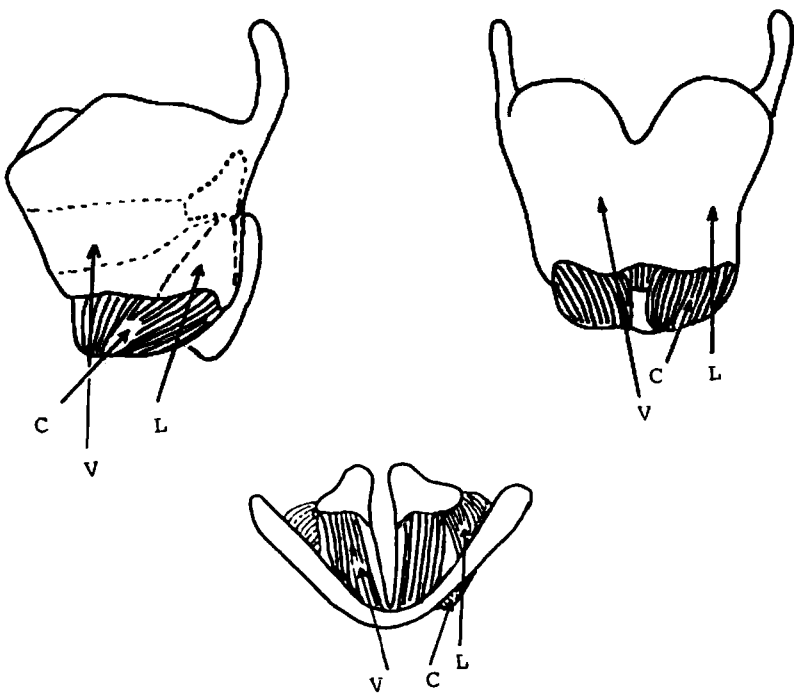


Fig. 2 Directions of insertion of the needle electrode into the thyroarytenoid (V), cricothyroid (C) and lateral cricoarytenoid (L).

Several hundred cases have been examined following this method in the last twenty years at the University of Tokyo Hospital. The following table summarizes a part of our experience with respect to the incidence of pathological conditions over three years, from January 1976 to December 1978.

laryngeal paralysis	83	
motor neuron diseases	18	
other CNS disorders	8	
"functional" dysphonia	11	
(spastic dysphonia		5)
miscellaneous	5	
	125	

Table I.

Of the 125 cases, the most common condition was laryngeal paralysis. EMG is considered to be useful in differentiating laryngeal paralysis from mechanical fixation of the cricoarytenoid joint, and to estimate the extent, degree and prognosis of paralysis. Examples of laryngeal EMG patterns are shown in Figure 3. Normal volitional activity obtained from the thyroarytenoid during phonation is characterized by interference voltage (top). An example of the sign of complete dennervation is shown in the middle of the figure where no volitional activity is seen, but some

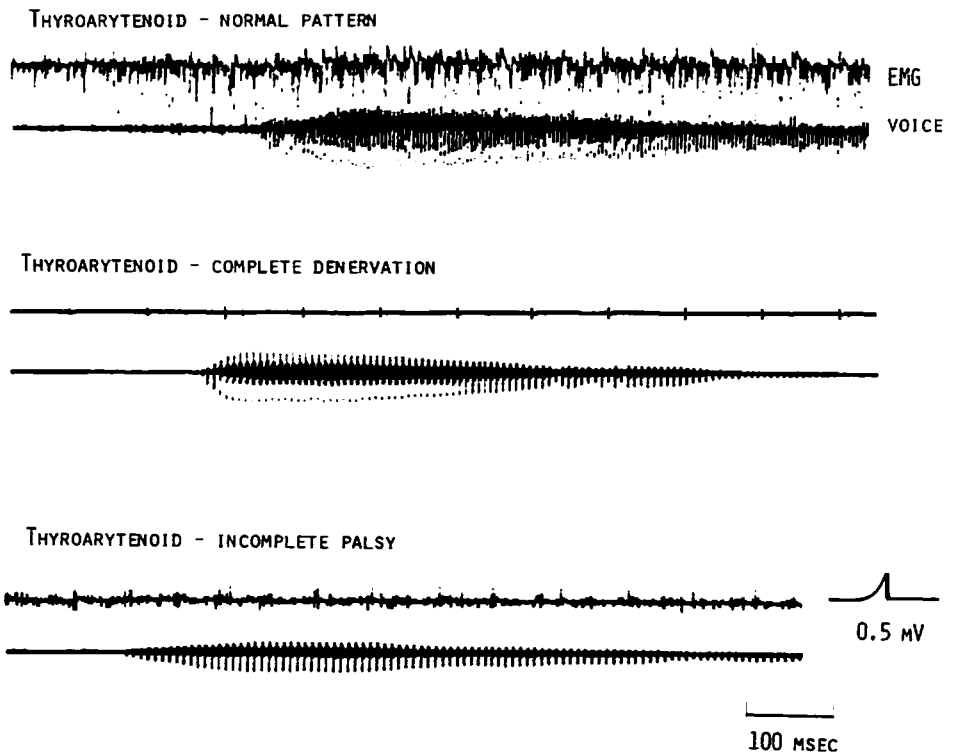


Fig. 3 Examples of EMG patterns recorded from the thyroarytenoid muscle.

slight involuntary fibrillation voltage is recorded. This finding always indicates poor prognosis. An example of electromyographically incomplete paralysis is illustrated at the bottom where the volitional activity is partially preserved. According to our experiences, the only significant relationship between EMG findings and the prognosis in terms of the recovery of vocal cord mobility is that recovery should be expected if remaining volitional EMG activities in the territory of the recurrent laryngeal nerve are confirmed in the early period of the development of paralysis.

It is not unusual to observe volitional EMG activities months to years after the onset of paralysis without any evidence of improvement in vocal cord mobility. It has been claimed that the apparent immobility of the vocal cords is due to the so-called mechanism of misdirected regeneration in which confusion occurs in the differentiated innervation between the abductor and adductor muscles in the course of the regeneration of the injured nerve fibers. A similar phenomenon is observed in the case of facial nerve paralysis. Other possibilities have also been cited in that an increase in the amount of intramuscular connective tissues which accompanies atrophy of the muscle fibers may result in an abnormality in the contractile mechanism of the reinnervated muscle fibers.

Motor neuron diseases involving the cranial nerve region such as the bulbar form of amyotrophic lateral sclerosis (bulbar palsy) also requires EMG evaluation for the purpose of definitive diagnosis. Usually, gross movements of the vocal cords are not affected in such cases but EMG examination often reveals abnormal wave forms such as high amplitude voltage (Fig. 4). This pattern is considered to be indicative of the possibility of the involvement of the motor nuclei in the brain stem.

Pathological kinesiology of the larynx can also be described in EMG terms. Figure 5 exemplifies the EMG pattern of the thyroiarytenoid obtained in a case of spatic dysphonia. The pattern of grouping voltage in the adductors seems compatible with the glottal behavior of intermittent overconstriction and can be taken as a peripheral manifestation of abnormal laryngeal control in this disorder.

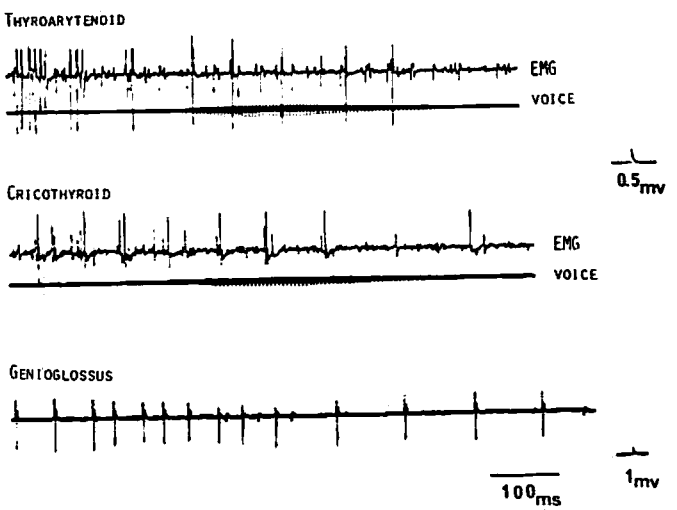


Fig. 4 EMG patterns of three different muscles in a case of bulbar palsy.

Fig. 5 EMG pattern of thyroarytenoid obtained from a case of spastic dysphonia.

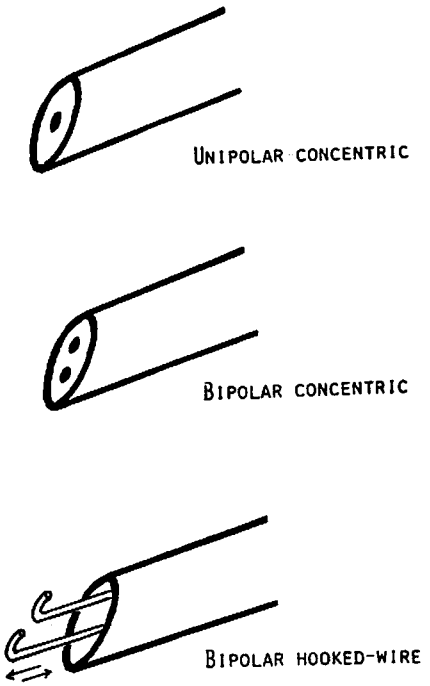
Research potentials of laryngeal EMG

From the early era of EMG investigations of the larynx, the research potential of this technique has been widely recognized. Above all, application of EMG to research on sustained phonation and singing has attracted the interests of many investigators. In recent years the extensive use of laryngeal EMG in the field of experimental phonetics has opened a new dimension in elucidating the nature of laryngeal adjustment in human speech production. The introduction of more appropriate types of electrodes, hooked-wire electrodes for example, and the use of computer averaging techniques have accelerated progress in the field of laryngeal research. In this type of research, multichannel recordings are most advantageous and, for this purpose, the technique of peroral insertion of wire electrodes to the posterior cricoarytenoid (PCA) and the interarytenoid (INT) muscles under indirect laryngoscopy has been developed to be used in addition to the conventional percutaneous approach.

Figure 6-a illustrates different types of electrode tips. For the hooked-wire electrodes, Isonel-coated platinum-irridium alloy wire with a diameter of 0.002', has been in use. For peroral insertion, wire electrodes are directed to the insertion points as illustrated in Fig. 6-b, using a specially designed probe (Fig. 6-c).

By means of the above technique, reciprocal activity patterns between PCA and INT have been observed in many different languages. For example, a reciprocal relationship was even found to exist for a five way distinction produced at the same point of articulation. Figure 7 shows examples of computer-averaged EMG curves of PCA and INT for test utterances comparing five types of labial stops embedded word-medially.

Simultaneous recordings of the laryngeal EMGs and visual observation of glottal activity are now possible by combining EMG and fiberoptic cinematography. Figure 8 shows a blockdiagram of the system for combined study. This technique can provide significant information on the temporal patterns of muscle activity related to corresponding glottal movements and speech sounds. Figure 9 shows an example of the comparison between EMGs of PCA and INT and the time course of glottal opening for the production of a Japanese word containing a voiceless consonant /s/. The EMG curves are obtained by integrating a single token by means of computer processing. It is always necessary to simultaneously record acoustic signals for later analysis of the combined data.



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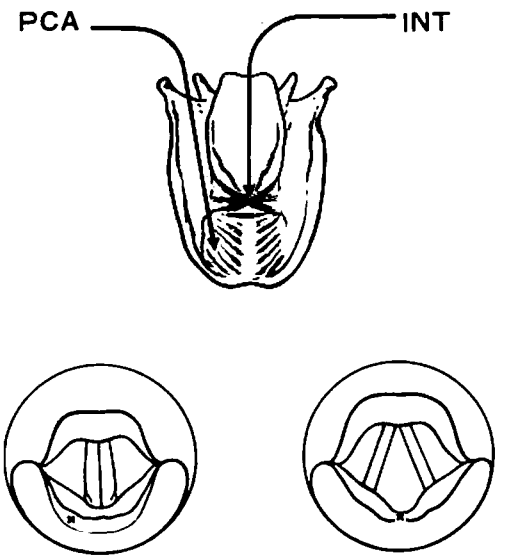

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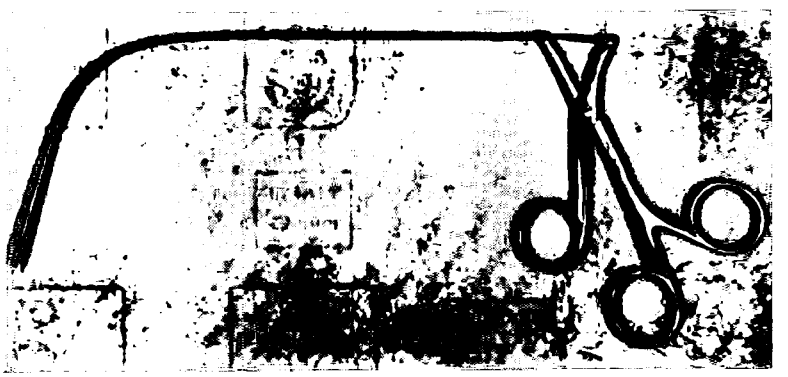

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Fig. 6 (a) Different types of electrode tips (b) Insertion of wire electrodes to PCA and INT (c) A curved probe for peroral electrode insertion

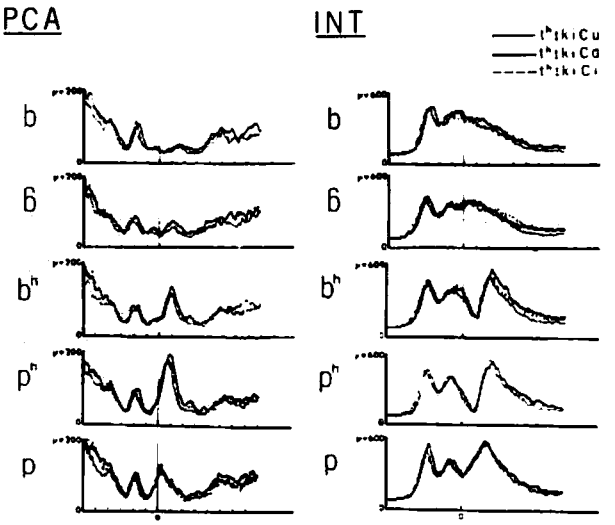

Fig. 7 Averaged EMG curves of PCA and INT for test utterances containing five phonetically different types of labial stops embedded word-medially. For each type, three curves are superimposed, each of which represents a different vowel carrier following the stop consonant (Hirose, 1977).

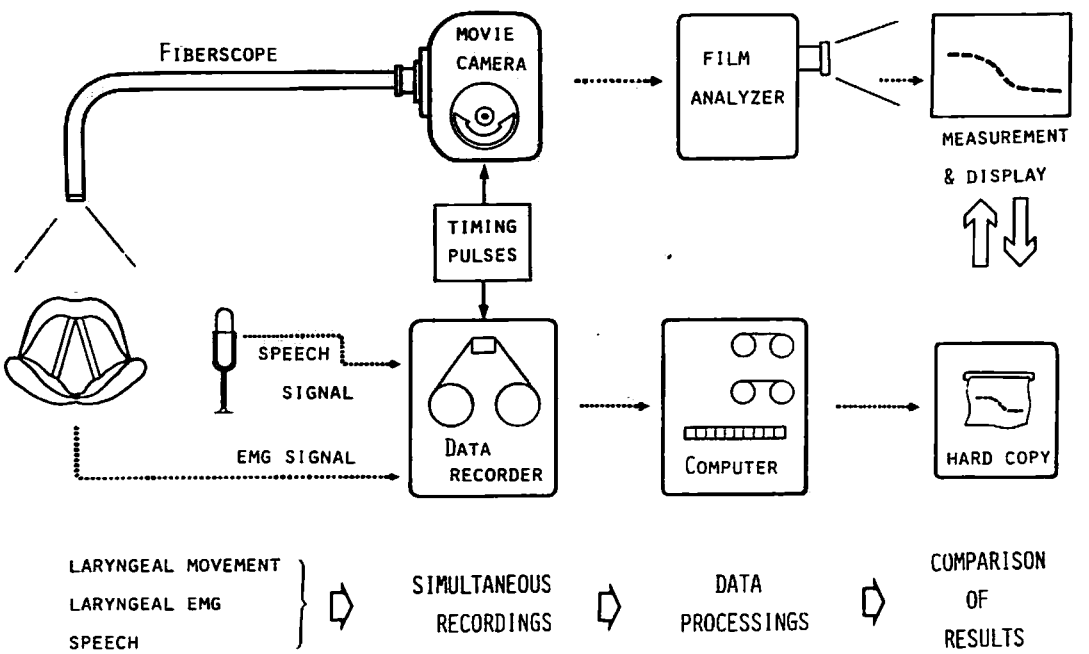

Fig. 8 Simultaneous recording system for laryngeal EMG and fiberoptic cinematography of the larynx.

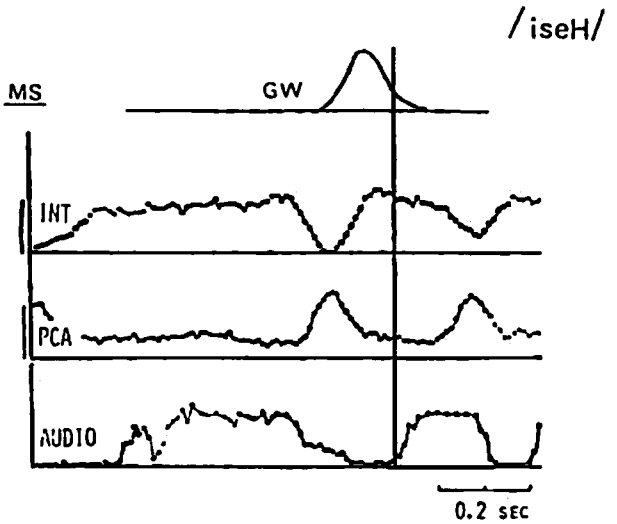

Fig. 9 Time curve of the glottal width (G.W.), smoothed and integrated EMG curves of INT and PCA, and speech envelope (AUDIO) for /iseH/. The curves are aligned on the same time axis. The vertical line indicates the voice onset for the vowel [e] (Sawashima et al., 1978)

Limitations of laryngeal EMG

It can be said that the limitations of EMG assessment of laryngeal function partly lie in the technical difficulty of its application. For example, although electrode insertion techniques are well-documented in the existing literature, the proper placement of electrodes in each individual case is not always easy and a certain amount of practice is needed in addition to a good knowledge of the pertinent topographic anatomy and physiology of the larynx. In multichannel recordings in particular the difficulty increases in proportion to the number of electrode pairs required. It should also be mentioned that in the case of paralysis, verification of the proper placement of electrodes is inherently difficult.

As for data interpretation on paralytic cases, there are certain limitations in the prognostic evaluation of long-standing paralysis, as has been mentioned. From the physiological viewpoint it can be argued that the sampling size of active motor units is often too small to represent a given muscle, and there may be random fluctuations in the firing pattern even for the same volitional action. Computer-processing has been introduced to overcome these problems by obtaining the averaged indication of muscle activity through repetitive recordings of the same utterance type. Another problem is that the relationship between measured EMG activity and its mechanical effect is not necessarily linear and purely quantitative descriptions of the results obtained are sometimes obscure.

If these limitations are taken into consideration, the use of EMG can provide valuable information for clinical practice as well as for speech communcation research. Since this technique seems to provide some insight

into the nature of motor commands from the central nervous system, the significance of EMG should not be underestimated.

Acknowledgement

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