Statistical Methods and Artificial Neural Networks Techniques in Electromyography

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ABSTRACT

This work represents a comparative study for the activity of the masseter muscle for patients before trial base denture insertion and the activity of the same muscle after trial denture base insertion for both right and left masseter muscles. The study tried to find if there were significant differences in the activity of the masseter muscle before and after patients wearing their trial denture base using two approaches: parametric statistical methods and a Neural Network Classifier. Statistical analysis was performed on three feature vectors extracted from autoregressive (AR) modeling, Discrete Wavelet Transform (WT), and from Wavelet Packet Transform (WP). The least significant difference test and the student t-test have not proved significant differences in the masseter muscle activity before and after wearing denture. However, using the same feature vectors, a neural network classifier has proved that there are significant differences in the masseter muscle activity before and after patients wearing trial denture base.

Keywords: *Dentistry, Discrete Wavelet Transform (DWT), Electrmyography EMG, Feature Extraction, Neural Network Classification, Wavelet Packet Transform (WP)*

1. INTRODUCTION

Structural reorganization of the motoer unit, the smallest functional unit of muscle, takes place because of disorders affecting peripheral nerve and muscle. Motor unit morphology can be studied by recording its electrical activity. The procedure is known as clinical electrmyography (EMG). In clinical EMG motor unit action potentials (MUAP's) are recorded using a needle electrode at mild voluntary contraction. The MUAP reflects the electrical activity of a single anatomical motor unit. It represents the compound action potential of those muscle fibers within the recording range of the electrode (Kallenberg & Hermens, 2006). Features of MUAP's extracted in the time domain such as duration, amplitude, and phases proved to be very valuable in differentiating between muscle and nerve diseases with the duration measure being the key parameter used in clinical practice. However, the measurement of the duration parameter is a difficult task depending on the neurophysiologist and/or the computer aided method used. The definitions of widely accepted criteria that will allow the

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computer-aided measurement of this parameter are still lacking (Calder et al., 2008; Dimitrova & Dimitrov, 2003).

On the other hand, frequency domain features of MUAP's like mean, or median frequency, bandwidth, and quality factor provide additional information in the assessment of neuromuscular disorders and it has recently been shown that the discriminative power of the MUAP mean or median frequency is comparable to the duration measure or spike duration measure (Pfeiffer & Kunze, 1993). However, it will be possible to rely on the evaluation of a spectral parameter only if each power spectrum estimate does not suffer from large mean square error (MSE), otherwise, the estimates may mislead us in our understanding of the physiology.

1.1. Problem Definition

Clinical measurements of the vertical dimension of occlusion often rely on the determination of mandibular rest position. Recent research efforts have shown that the postural position is a range of positions rather than a single and absolute one (Michelloti et al., 1997). Some authors insist that interocclusal vertical dimension is highly variable throughout life (Amorim et al., 2010). It is therefore not surprising that many procedures for its assessment have been the subject of many investigations (Krivickas et al., 1998). In general interocclusal distance at the clinical rest position is less than introcclusal distance at the electromyographically silent (physiologic) rest position of the mandible. Variations in the interocclosal distance at the physiological rest position of the mandible determined by masticatory electromyographic silency are apparently due to emotional stress during clinical trials and/or the biologic incompatibility of the instrumentation used to measure mandibular movement. The question remaining is-do the jaw muscle plays any part either continuously or intermittently, in determining mandibular rest position? Numerous attempts have been made to record activity from the jaw muscles of relaxed human subjects, the majority using surface electromyographic electrodes (Wang et al., 2007). Some reports claim to demonstrate continuous activity, particularly of the temporal muscle, others report intermittent activity or no activity.

However, in general the methods employed provided an inadequate basis for objective conclusion. A methodical approach of study of intra-muscular activation patterns is provided by the spectral analysis EMG (Zuccolotto et al., 2007). However, the Fourier methods often used in the analysis of EMG usually suffer from several limitations. One of these is the underlying assumption that the original signal is stationary (Karlsson et al., 1999). As a result Fourier Methods are not generally appropriate for the analysis of EMG signals. Kihwan and Minamitani (Barisci, 2008) reported the validity of the autoregressive (AR) model for surface EMG. However, the main problem with the parametric modeling methods is the selection of the model order (Karlsson et al., 1999). Recently, time-scale methods (wavelet transforms) were proposed in an effort to overcome the limitations of the traditional time-frequency methods (Goswami & Chan, 1999). The time-scale methods act as a mathematical microscope in which one can observe different parts of the signal by just adjusting the focus. This allows the detection of short-lived time components of signals. As a generalization of the wavelet transform (WT), the wavelet packet has been recently introduced and developed, which allows a best adapted analysis of the signal.

Wavelets were introduced as a signal representation in which an analysis window, whose size is chosen to be short at high frequencies and long at low frequencies (to pick up all the abrupt changes), is passed through the signal. This corresponds to having the frequency response logarithmically scaled along the frequency axis, as opposed to the short–time Fourier transform (STFT) or Gabor representation (Feichtinger & Strohmer, 1997). Many researchers have reported the application of wavelets to the surface EMG (Salvador & de Bruin, 2006; Berger et al., 2006). In this paper, we propose a new approach for determining the physiologic rest position of the mandible. The