THE CONTRIBUTION OF PERIODONTAL MECHANORECEPTORS TO PHYSIOLOGICAL TREMOR IN THE HUMAN JAW

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by

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Author's Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any other university or other tertiary institution, and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Paul F. Sowman

November, 2007

Abstract

The human jaw, like all other articulated body parts, exhibits small oscillatory movements during isometric holding tasks. These movements, known as physiological tremor, arise as a consequence of the interaction of various factors. One of these factors is reflex feedback from peripheral receptors. In the human jaw, receptors that innervate the periodontium are able to transduce minute changes in force. This thesis examines the contribution of these periodontal mechanoreceptors (PMRs) to the genesis of physiological tremor of the human jaw.

By using frequency domain analysis of time series recorded during isometric biting tasks, the character of physiological jaw tremor can be revealed. Physiological jaw tremor was observed in force recorded from between the teeth as well as from electromyograms recorded from the principal muscles of mastication. These recordings have shown us that jaw physiological tremor consists of a frequency invariant component between 6 and 10Hz. This frequency remains unaltered under various load conditions where the mechanical resonance of the jaw would be expected to vary greatly (Chapter 2). Such findings indicate a 'neurogenic' origin for this tremor. A possible candidate for this neurogenic component of physiological tremor in the jaw is the reflex feedback arising from the PMRs.

Using local anaesthetisation, it has been shown in this thesis, that by blocking outflow from the PMRs, the amplitude of neurogenic physiological jaw tremor can be reduced dramatically. This procedure caused a dramatic reduction in not only the mechanical recordings of tremor but also in the coupling between masseteric muscles bilaterally (Chapter 3) and between single motor units recorded from within a homonymous muscle (Chapter 4).

The obvious mechanism by which periodontal mechanoreceptor anaesthetisation could reduce the amplitude of physiological tremor in the jaw would be by reducing the amplitude of the oscillatory input to the motoneurones driving the tremor. This interpretation remains controversial however as physiological tremor in the jaw can be observed at force levels above which the PMRs are supposedly saturated in their response. In light of this knowledge, the saturating characteristics of these receptors in terms of reflex output were examined. To do this, a novel stimulation paradigm was devised whereby the incisal teeth were mechanically stimulated with identical stimulus waveforms superimposed upon increasing tooth preloads. This necessitated the use of a frequency response method to quantify the reflexes. An optimal frequency for stimulation was identified and used to confirm that the hyperbolic saturating response of PMRs observed previously, translated to a similar phenomenon in masticatory reflexes (Chapter 5).

These data reinforced the idea that physiological tremor in the jaw was not just a consequence of rhythmic reflex input from PMRs, as the dynamic reflex response uncoupled from the input as the receptor-mediated reflex response saturated. An alternative hypothesis was then developed that suggested the effect of PMR suppression in physiological tremor was via tonic rather than rhythmic effects on the masseteric motoneurone pool.

By utilising a novel contraction strategy to manipulate the mean firing rate of the motor neuron pool at a given level of force production, data contained in Chapter 6 shows that population motor unit firing statistics influence the expression of physiological tremor, and such manipulations mimic, to an extent, the changes in firing statistics and tremor amplitude seen during anaesthetisation of the PMRs. This thesis therefore posits a mechanism whereby periodontal input influences the firing rate of motoneurones in such a way as to promote tremulous activity (Chapter 5). However, as this proposed mechanism did not explain the full extent of tremor suppression seen during PMR anaesthetisation it can therefore only be considered a contributing factor in a multifactor process.

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Dedication

I’d like to dedicate this thesis to my Mum and Dad.

To Mary-Anne and Fred, who nurtured my interest in learning from the beginning.

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