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Effect of experimental jaw muscle pain on dynamic bite force during mastication

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ABSTRACT

Knowledge about how Temporomandibular Disorder (TMD) pain patients regulate masticatory function is still unclear. To investigate the effect of experimental jaw muscle pain as well as texture and size of food on mastication, twelve healthy participants (30.6 ± 7.5 years old) participated in this study. Experimental pain was induced by an infusion of 0.5 M monosodium glutamate (MSG) with isotonic saline (IS) serving as a control. After the infusions, the Jaw Functional Limitation Scale (JFLS) and Pain Catastrophizing Scale (PCS) were filled out. Electromyographic (EMG) activity in the masseter and temporalis muscles, jaw movements and bite force, which was measured by a customized intra-oral device, were recorded simultaneously during mastication of three different types of food. Pain was scored continuously on a visual analog scale. The results demonstrated a trend towards a decrease in the impulse of the bite force, as well as a significant decrease in EMG activity of the masseter muscle during the first five masticatory cycles, in the MSG session. Also, MSG induced increased JFLS and PCS scores compared with IS. On the other hand, the results suggested that the applied levels of pain may not change habitual masticatory movements. This study has revealed that a clinically relevant level of pain in the masseter muscle has only minor impact on the performance of mastication, probably due to a lack of exacerbation of pain during function. In future studies of jaw muscle function during painful conditions, it is important to include patient-based reports of functional limitation and emotional distress.

1. Introduction

Temporomandibular disorders (TMDs) are chronic pain conditions in the musculoskeletal structures in the craniofacial region with a higher prevalence in women (6.3–15%) than men (3.2–10%).[1] Patients with myofascial TMD pain may have impaired masticatory function due to limited jaw movements and the awareness of muscle pain may also impede and perturb mastication.[2] Though the effect of experimental muscle pain or fatigue on static bite force, like maximum voluntary contraction, is well studied,[3,4] the relationship between pain and the control of dynamic bite force during mastication still remains unclear. In experimental studies, it has been reported that intense pain induced by injection of hypertonic saline into the masseter muscle causes a decrease of the electromyographic (EMG) activity of the masseter muscle during the closing phase (agonist phase) with an EMG increase during the opening phase

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(antagonist phase) compared with a non-painful condition.[5] This indicates that the pain hampers masticatory smoothness and efficiency, in accordance with the Pain Adaptation Model.[6] Bite force, EMG activity and jaw movements are important parameters in the analysis of mastication.[7–12] Bite force can be considered the parameter, which best indicates the final output of the other masticatory components.[13] However, the mechanism of bite force generation and control during mastication of different types of food is unclear. It is important to observe the characteristics of bite force during mastication and how bite force is influenced by experimental muscle pain. To experimentally mimic clinical myofascial TMD pain, injections of monosodium glutamate (MSG) have been used in several studies.[14,15] Since pain induced by a bolus injection of MSG is short-lasting and quite intense compared with clinical TMD pain,[15] a prolonged infusion of MSG can be an alternative option. Also, the prolonged infusion of MSG at a lower rate can extend the duration of the experimental pain.[16]

One of the reasons why it is difficult to analyse the mechanism of bite force control during dynamic jaw movement is the challenge to fabricate a measuring device, which can be used in an experimental condition and does not interfere with normal mastication. Recently, we have introduced an intraoral bite force detector,[17] which allows detection of dynamic bite force during mastication together with a recording of EMG activity and jaw tracking.

Besides jaw motor function, psychological factors are important risk factors for the development of TMD.[18] The Integrated Pain Adaptation Model (IPAM) was proposed as the most suitable explanation of motor control under painful conditions.[19] The strategy to recruit motor units may be modified in order to maintain homeostasis, namely completion of the mastication task. When pain is experienced in the masticatory muscles, the strategy to carry out mastication may differ between individuals, depending on psychological status or emotions.[20] Therefore, to clarify the possible association between motor function and psychological status during mastication, it is necessary to analyse both physical parameters such as force and EMG activity and factors indicating the subjective limitations in function and psychological conditions with the use of questionnaires such as the Jaw Functional Limitation Scale (JFLS)[21] and the Pain Catastrophizing Scale (PCS).[22] For example, a relationship between catastrophizing scores under a mild pain condition and activity in cortical regions involved in motor response has been demonstrated.[23]

Clarification of the effect of pain on dynamic jaw movement is important for the understanding of impaired masticatory function in patients with TMD. Therefore, the aims of this study were to investigate the influence of experimental muscle pain induced by infusion of MSG as well as texture and size of food on bite force, jaw movements and EMG activity during mastication and to relate such findings to the JFLS and PCS scores.

2. Materials and methods

2.1. Participants

Twelve healthy adults (six men, six women, age: 30.6 ± 7.5 [average ± s.d.] years) with natural normal dentition (at least 28 teeth) and no signs or symptoms from the stomatognathic system participated in this study. Both verbal and written informed consent was obtained from all participants and the experimental protocol was approved by the local Ethics Committee (Central Denmark Region No. 20100101). This study was conducted in accordance with the Declaration of Helsinki II. The number of participants in this within-subject study was determined by an estimate of changes in bite force/EMG corresponding to 15%, and intra-individual variation of 18% and risk of type I error of 5%. Furthermore, the technical circumstances with customized fabrication of the bite force transducers limited the number of participants.[17]

2.2. Study design

This study consisted of the following two sessions: one with an injection of MSG and a control session with injection of isotonic saline (IS) in randomized order. Baseline and follow-up recordings were obtained in both sessions. The interval between sessions was 5 min.

In each session, the participants were asked to chew three different types of food. Pieces of carrot (brittle),[24] were cut in a shape of 20 mm diameter and 10 mm thickness (Regular sized carrot, RC) and 23 mm diameter and 13 mm thickness (Large sized carrot, LC). The other test food (unbreakable) was disk-shaped jelly (HARIBO Syrlinger [HARIBO, Bonn, Germany], HA, 20 mm diameter and 5 mm thickness).[24–26]

During each recording, the participants were asked to sit upright in a comfortable and natural position in a chair. They were also asked to fix their eyes on a point on the wall and to avoid movements of the head during mastication.

2.3. Experimental muscle pain

To elicit the experimental muscle pain, sterile 0.5 M MSG was infused into the mid-portion of the masseter muscle on the side ipsilateral to the bite force measurement device in each participant. IS (0.9% NaCl) was infused as a control.[6,27] Each infusion was applied with the use of a syringe pump (B. Braun® Perfusor Space, B. Braun Melsungen AG, Melsungen, Germany) though a disposable syringe and a 27-gauge hypodermic needle. To fix the position of the needle, a tube (Small bore connection tubing, 50 cm, B. Braun Melsungen AG, Melsungen, Germany) connected to the needle was attached on a frame of a Sirognathograph (SGG, Siemens, Munich, Germany)[28] with tape (3M™ Micropore™ Medical Tape, 3 M ESPE, MN, USA). To maintain a moderate intensity of pain during recordings in the infusion sessions, a bolus of 0.14 ml MSG, infusion rate 51.42 ml/h, was infused to first evoke pain. This was followed by a continuous infusion at a rate of 6.00 ml/h to maintain the pain intensity for 8 min of each infusion session.[16]

An electronic visual analog scale (VAS) was used to score the intensity of induced pain continuously during the infusions.[29] The lower endpoint on the VAS was 'no pain at all' and the upper one was 'the worst imaginable pain'. The sampling rate of VAS was 0.5 Hz, and the VAS ratings were stored electronically for later analysis.