Jaw opening forces in subjects diagnosed with Temporomandibular disorder

Study Protocol

Research Personnel

Primary Investigator: Professor Paul Brunton

Co Investigators:

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2. **Dr. Carolina Loch**
3. **Dr Ajith Polonowita**
4. **Assoc. Prof. Neil Waddell**

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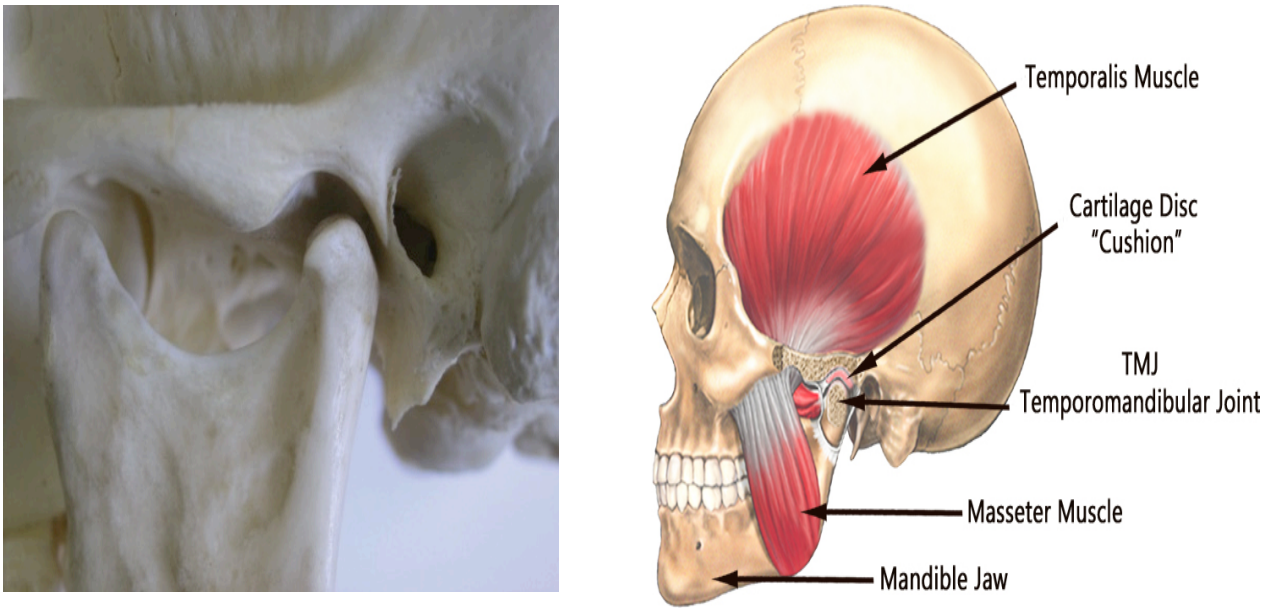
1. Introduction

The muscles of the masticatory system control jaw opening and closing movements, with the assistance of ligaments and the guidance of joint surfaces. Consequently, jaw movements and the dynamics of the masticatory muscles are closely interconnected. Jaw movements are controlled by muscle forces and muscle forces are modulated through changes in their biodynamics by jaw movements (1).

To date, most studies have focused on jaw closing movements and bite force estimates (2, 3). In comparison, little is known about the properties of the jaw depressor muscles, namely the digastric, geniohyoid and mylohyoid. These muscles act against the hyoid bone to pull the mandible downwards (4). In this process, these muscles are also assisted by the stylohyoid, infrahyoid and lateral pterygoid muscles, which assist in stabilising the hyoid bone and promoting the anterior sliding movement of the mandibular condyle (4). A small number of previous studies have provided estimates of average muscle forces required for jaw opening and their association with gender, biological parameters (facial size) and anthropometric parameters (height and weight) (1, 4, 5). However, these studies used measuring devices which were quite variable, ranging from rigid metal frame systems mounted on tables (4, 5) to flexible head devices composed of adjustable velcro belts (6). In addition, these studies focused on biomechanical analysis which included not only muscle and joint forces but also the torques generated by these forces (1).

The Temporomandibular joint (TMJ) is a complex structure containing muscles (masticatory muscles), tendons and bones, which articulates the jawbone to the skull. The TMJ is a synovial diarthrodial joint where the joint surface and the joint space is divided into two separate compartments by means of an intra-articular disc (7). Temporomandibular disorders (TMDs) affect the articulatory system, consisting of the temporomandibular joints, mandibular muscles and occlusion. TMDs can result in pain and disability and can affect daily activities, quality of life and psychological well-being (8). In the United States, it is estimated that for every 100 million working adults, TMD contributes to 17.8 million lost workdays annually (9). The prevalence of TMD is between 5% and 12% of the population; however, up to 70% of the population will experience signs or symptoms of TMD at some point in their life (10). The prevalence rates of TMDs are higher among younger persons (age 18 – 44) and are about 1.5 times higher in women than in men (11, 12). In the USA, it is estimated that $4 billion is spent every year on the diagnosis and treatment of temporomandibular disorders.



(a) (b)

Figure 1. The Temporomandibular joint (a) and associated muscles (b) (13)

Patients presenting with TMD may have symptoms, which include restriction or alteration of the range of mandibular movement, localised pain and tenderness in the masticatory muscles, jaw joint pain, jaw joint sounds such as clicking or crepitation, unexplained tooth sensitivity, tooth or restoration fracture and chronic daily headache (14). The causes of conditions affecting the TMJ are not completely understood. Several studies have shown that multiple factors such as trauma to the teeth or jaw, stress and anxiety contribute towards TMD. However, it is not clear, whether some of these causes directly lead to TMD or if they are a result of the disorder. Recent studies have shown that a central sensitization component and genetic risk factors are associated with TMD (15) . At present, assessment of the TMD is based on questionnaires (diagnostic criteria for TMD (DC/TMD)), dental X-rays, CT scans and TMJ arthroscopy where a small thin tube (cannula) along with a camera (arthroscope) are inserted to view the area and help determine the diagnosis (16, 17).

In a previous study, the maximum jaw opening forces in healthy subjects were measured to test differences between the sexes, and to investigate any association with age and anthropometric parameters such as height and weight. However, so far no studies have used jaw-opening forces as a screening tool to diagnose Temporomandibular disorders (TMDs).

2. Current study

This is a pilot/feasibility study which focuses on the maximum jaw opening forces in subjects diagnosed with a TMD. Diagnosis will be carried out by (Dr Ajith Polonowita, the TMD specialist) careful evaluation of the history and detailed examination of the masticatory apparatus according to the TMD diagnostic questionnaire used in the TMJ clinic at the Faculty of Dentistry, University of Otago (Questionnaire attached) (8, 18). Patients will be divided into three categories based on the TMD diagnosis (Table 1). Patients who are diagnosed with osteoarthritis and sleep bruxism will be excluded from the study since both osteoarthritis and sleep bruxism has no correlation with TMDs.

Table 1. Different categories based on TMD symptoms (Inclusion criteria)

Category	Symptoms
1	Patients diagnosed with myofascial pain
2	Patients diagnosed with disc dislocation
3	Patients diagnosed with both of the above conditions

3. Aims and objectives

The main aim of this study is to investigate the maximum jaw opening forces in patients diagnosed with certain temporomandibular disorders and to evaluate whether the jaw opening forces differ or correlate according to the different types of TMDs investigated (Table 1). Secondly, this research also aims to investigate the maximum jaw opening forces before and after treatment of patients diagnosed with certain TMDs. A statistical analysis (one-way ANOVA) will be conducted to assess whether there is a statistically significant difference in the maximum jaw opening forces following treatment. A statistical analysis of $p < 0.05$ would consider significant.

4. Research Questions

The main research questions of this project are:

- What is the maximum jaw opening force in subjects diagnosed with the TMDs being investigated? Do the maximum jaw opening forces differ according to the different types of TMDs investigated?

- Do the subjects diagnosed with the TMDs investigated and healthy subjects differ in regards to the forces required to open the mouth?
- Is there a significant difference in the jaw opening forces before and after treatment in TMD patients at each time period investigated?

5. Study design

This is a pilot study which will recruit approximately 40 both male and female patients ranging from 18 – 60 years from all ethnicities who attend the TMJ clinic at the Faculty of Dentistry, University of Otago. On average 10 patients attend the TMD clinic on a weekly basis. Jaw opening forces of controls were already obtained from volunteers at the Faculty of Dentistry. Inclusion criteria for the current study will be based age (20-60 years) and patients who visit the TMJ clinic with myofascial pain and disc displacement with and without reduction.

The maximum jaw opening forces in patients diagnosed with the TMDs included in the study (table 1) will be measured during their initial visit to the clinic. During this visit, the patient would normally receive treatment depending on the severity of the TMD. Treatment includes TMD self-management instructions such as routinely encouraging patients to rest their masticatory muscles by voluntarily limiting their use (avoiding hard or chewy foods and restraining from activities that overuse the masticatory system), physiotherapy and the use of stabilisation splints (7). Following treatment, the maximum jaw opening forces for each patient will be measured during their review appointments at 1, 3 and 6 months. The maximum jaw opening forces in healthy subjects (exclusion criteria included patients with myofascial pain, temporomandibular joint disorders, undergoing orthodontic treatment or edentulous patients) obtained in a previous study will be used as a control (Estimation of jaw opening forces in adults, 2015). Participants in the proposed study will be matched with the gender of the control participants. A portable, compact and rigid jaw opening measuring system, validated in a previous study (need ref here) (fig. 2) will be used to collect jaw-opening force measurements without compromising the safety and comfort of the patients.

6. Data Collection

Participants will receive a "Participant Information Sheet" during a meeting with the assistant research fellow who will provide a thorough explanation about the research aims and will give the opportunity to ask questions. Participants will then be asked to sign a consent form and to complete a simple form with information such as their age, contact information, date of birth,

gender and ethnicity. Participants who have given informed consent to be involved in the study will be asked to attend a 15min session where they will wear a head device designed to measure jaw opening forces (Fig. 2). The device is connected to a data-capture system manufactured by Biotronics Ltd (Fig. 3). After device placement, participants will be asked to open their jaw a few times so they get used to the equipment. With their jaws held together in centric position, participants will then be asked to attempt to open their jaws as forcefully as possible for 2 seconds 7 times, pausing for a 10 second interval between each attempt. The jaw opening forces will then be recorded in the data capture system. Participants will also have their height and weight measured in calibrated scales and stadiometers. All data collected will be stored preserving confidentiality and anonymity. Participants will be assigned a number code and data will be stored in a password-secure computer.

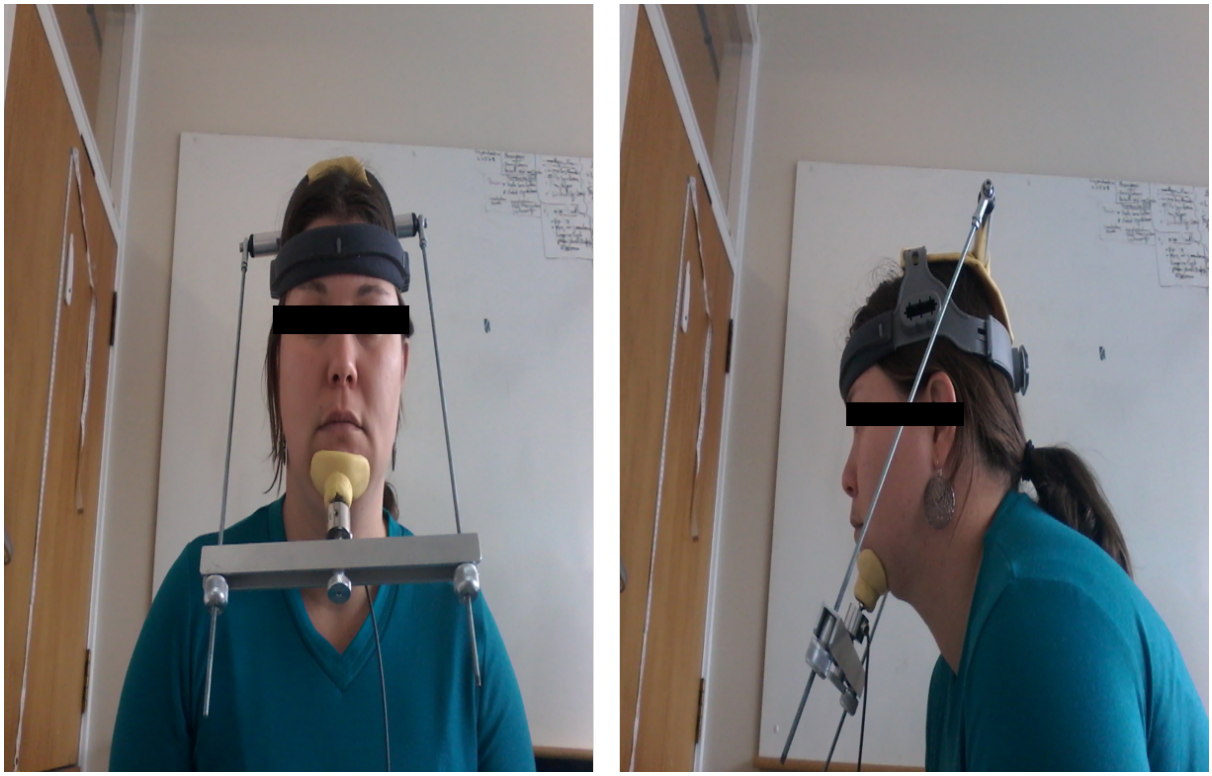


Figure 2: Head device coupled to a loading cell in order to measure jaw-opening forces.

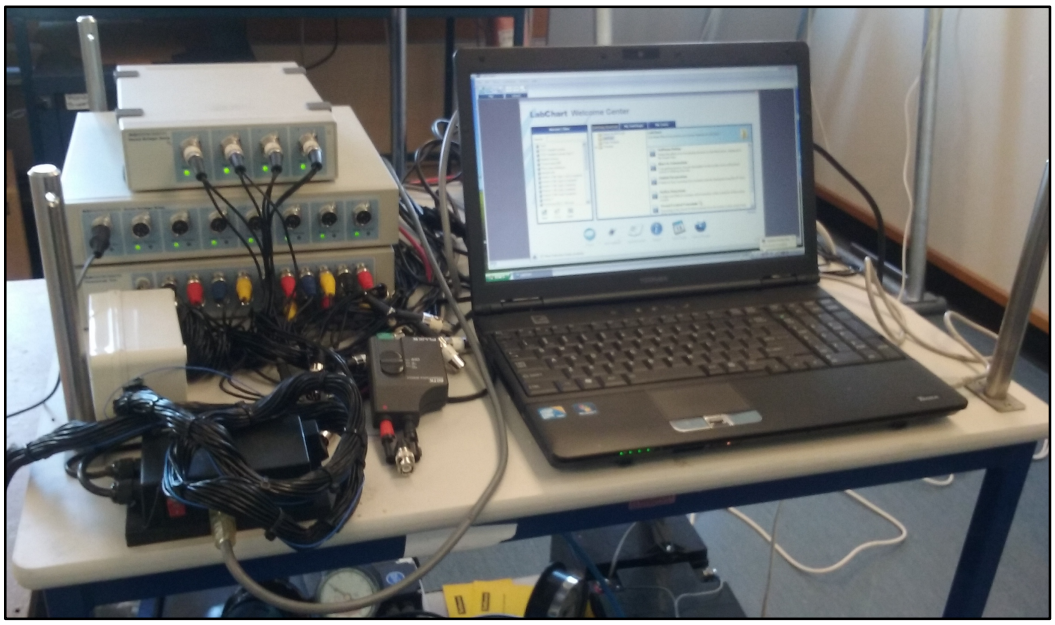


Figure 3: Data capture system.

7. Significance of this project

Jaw movements are the only parameters that can be objectively recorded and measured. Jaw opening is important not only as a record of the severity of the TMD symptoms but also as an indication of rate and degree of improvement. Until now, the screening of TMDs has been based on indirect and subjective measures (Manfredini Chiappe et al. 2006). This project will be a major driving force in providing a quantitative diagnostic tool for TMJ disorders and would potentially have an international impact.

8. Personnel

Key personnel directly involved in this research include **Prof Paul Brunton**, Principal Investigator (PI). Prof. Brunton is a leading scholar in Restorative Dentistry with research interests in operative dentistry, tooth preparation and tooth whitening, and the early diagnosis and treatment of tooth wear. Associate investigators include **Dr Carolina Loch, Dr Ajith Polonowita, Jithendra Ratnayake,** and **Assoc Prof Neil Waddell**. Dr Loch is a Lecturer at the Department of Oral Sciences, with experience in evolutionary oral biology including functional morphology and dental morphology of humans and other mammals. Dr Polonowita is a registered specialist in Oral Medicine with research interests in TMD and its management. Jithendra Ratnayake is an Assistant Research Fellow at the Faculty of Dentistry, with experience in Biomaterials. Assoc. Prof Waddell research expertise is in the field of dental materials and craniofacial biomechanics.

9. Budget

The study will be funded through internal funds from the Office of the Dean, Faculty of Dentistry.

Item/Activity	**Cost**
Manufacturing of the Jaw opening measuring device by EmTech	$1500
Calibration and maintenance of data-capturing system	$2626
Printing Participant Information Sheets and Consent Forms	$200
TOTAL	**$4326**

10.Research schedule

Tasks	Jul-Sep 17	Oct-Dec 17	Jan-Mar 18	Apr-Jun 18	July – Sep 18
Ethics Application					
Remanufacturing/redesign data capturing system					
Participant Recruitment					
Data collection					
Data analysis and manuscript drafting					

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