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Detection of Temporomandibular Muscle Disorders in Children. Development of Android-Based Electromyography Tools (EMG Dentosmart)

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ABSTRACT

Introduction: The jaw joint or the Temporo Mandibular Joint (TMJ) is the most complex joint, this joint opens and closes like a hinge and shifts forward, back and from side to side. The jaw joint has a very important role in the function of mastication, swallowing and speech. During the chewing process, this joint supports a large amount of pressure from the jaw joint muscles. One way to detect temporomandibular muscle abnormalities is to determine the strength of contractions in the muscles involved when performing masticatory functions.

Objective: The aim of this study is to develop an innovative android-based portable tool for early detection of Temporomandibular disorders (TMD) in Masseter and Temporalis muscles based on Android as a early detection with a short time analysis thereby reducing the severity of the child's jaw joint disorders.

Methods: In mastication muscle, thirty 7.2 ± 1.3 years old pediatric patients were 30 people, assessed using a dentosmart EMG detection device and the results compared muscle strength in pediatric patients with class I malocclusions with mesioocclusion and distoocclusion malocclusions.

Results: In the application, the diagnosis will be displayed in 2 conditions, namely "Normal" or "Temporomandibular disorders". For class I malocclusion is a normal condition, but for class II (mesioocclusion) and III (distoocclusion) malocclusion is a condition called abnormal "Temporomandibular disorders".

Conclusion: Early detection of jaw joint muscle disorders based on an android smartphone. Jaw joint disorders are identified based on electrical activity in the masseter and temporalis muscles and process the data obtained as a result of a temporary diagnosis to see the strength of normal or abnormal muscle contractions.

Keywords: Electromyogrphy, Muscle Disorders, Temporomandibular Joint

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INTRODUCTION

Temporomandibular disorder (TMD) or jaw joints are joints connecting the temporal and mandible and consisting of mandibular bone with the condyle (rounded tip). TMD is controlled by the *musculus* or muscles that known as mastication muscles. These muscles regulate TMD and consist of *m. masseter, m. temporalis, m. medial pterygoid,* and *m. lateral pterigoideus*, which surround the jaw and the TMD.[1,2] The muscles have a variety of purposes, especially *m. masseter* and *m. temporalis* which control the mouth closing movement. This movement cannot work effectively if the teeth condition is abnormal due to bad habits that can cause jaw joint disorders.[2,3] TMJ dysfunction can occur in adults or children. Bad habits in children such as tongue thrust, nail bites or pencils, finger sucking and chewing on one side, and poor oral hygiene conditions that cause premature loss of posterior teeth are factors that can trigger TMJ dysfunction. In children, this dysfunction rarely causes pain, but if left feared will cause further dysfunction, causing complaints such as pain when opening the mouth, headaches, or pain in the ear. TMJ dysfunction can affect the joints and muscles around it. The accompanying symptoms can include joint sounds described as clicking or crepitus, asymmetrical or limited movement of the mandible, and sometimes accompanied by pain in the jaw, ear, head and face.[1,2,3]

Basic Health Research data in 2018 shows the prevalence for teeth and mouth problems in Indonesia increased to 57.6%, from 25.9% in 2013[2]. The data shows that dental and oral health in Indonesia must be given more attention. One of the dental and oral health problems in Indonesia is interference jaw joint disorder or also known as Temporomandibular Disorder (TMD). There are many factors that cause jaw joint disorder, one of which are bad habits like bruxism, chewing on one side and resting chin on hand. It causes limitations in functional jaw movements, for example difficulty in opening and closing the mouth as well swallowing food.[3,4]

Efforts to detect early abnormalities in jaw joint disorders on *m. Masseter* and *m. Temporalis* has been actively researched, one of which is by using electromyography (EMG). EMG is an evaluation tool for assessing masticatory muscle function in TMD patients. EMG uses surface electrodes to determine electrical activity in the position of mandibular rest (lower jaw) and hyper or hypoactivity of these muscles during rest, and to check para-functionality and muscle balance during chewing and clenching activities.[4,5]

Mobile phones are increasingly used in health systems in both developing and developed countries and more innovative applications are produced as supportive tools. Current mHealth apps mostly focus on individual prevention disease, personal health safety, improving health,

improving well-being, and giving advice on response to treatment.[5,6] For example, the non-prescription drugs mobile health application (NMMHA) has been developed to support users with safe and effective medicines that can be accessed legally without seeking treatment by a health professional.[7,8] Another work tried to improve the quality of prehospital emergency healthcare services by developing and implementing a mobile based emergency system. The pro-posed application served as a communication tool for the ambulance staff and the hospital paramedics, hence allowed them to reduce the diagnostic time.[7] In dental field, an android application was developed to help detect teeth and mouth disease suffered by the user using Dempster-Shafer method.[8,9,10]

Therefore, the electromyography tool is designed to facilitate the interpretation of the TMJ abnormalities using an Android-based tool for detecting jaw joint muscle disorders in Masseter and Temporalis muscles. This work also performed some testing on the application to measure the accuracy rate.

MATERIALS AND METHODS

The electromyography tool has several components, which are surface electrodes, batteries, raspberry pi, android smartphones, electromyography, IC (integrated circuit) MCP3008, and 5 inch LCD. The sensor surface electrodes are attached to the *Massester* and *Temporalis* muscle to detect the electrical activity of the muscle, and determine whether the muscle is contracting or not. All stimulations received by the sensor will be recorded by the EMG that will interpretation them into signals. These signals are received by IC MCP3008 to perform signal conversion from analog to digital. This is necessary because the Raspberry Pi device or component can only receive digital signals. The calculation is performed on the Raspberry pi through the encoding process to determine the level of abnormalities or problems experienced by the Masseter and Temporalis muscles, and the result is automatically sent to an Android application that has been programmed in such way to connect the EMG and the Android smartphones.

Raspberry pi used to control and receive signals from the electrode and electromyographic surface sensors. Raspberry pi also served as an intermediary for the tool and the application in Android smartphones. The application is built using MIT App Inventor, an open-source website-based plat-form that used to design, add features, and create functions to build an Android application.The illustration of the proposed system is shown in Figure 1. Intraoral photographs of one of the pediatric patients participating in this study shown in Figure 2.

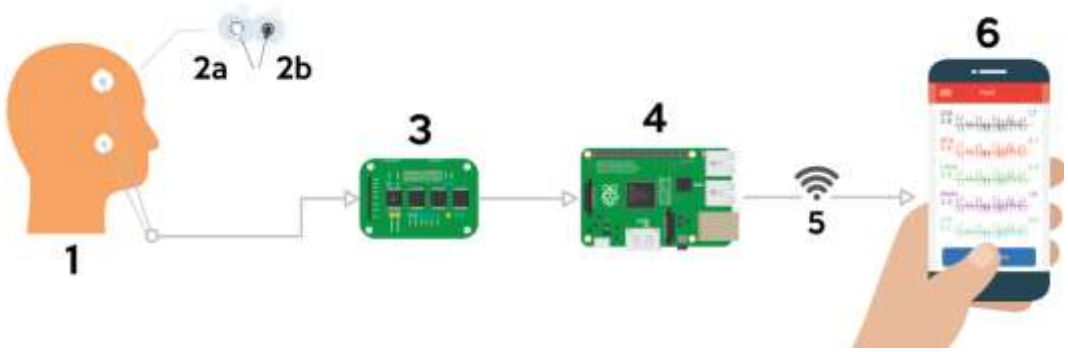


Figure 1: The illustration of the proposed system :(1) Patients; (2a) Sensor in muscle Masseter; (2b)Sensor in muscle Temporalis; (3) Electromyography (EMG); (4) Raspberry Pi; (5) *Wireless Fidelity* (Wi-Fi); (6) *Smartphone* Android

Figure 2: Intraoral photos of one of the pediatric patients participating in this study (A) Display of the dentosmart EMG device installation; anterior, (B) Lateral taking

Research methods

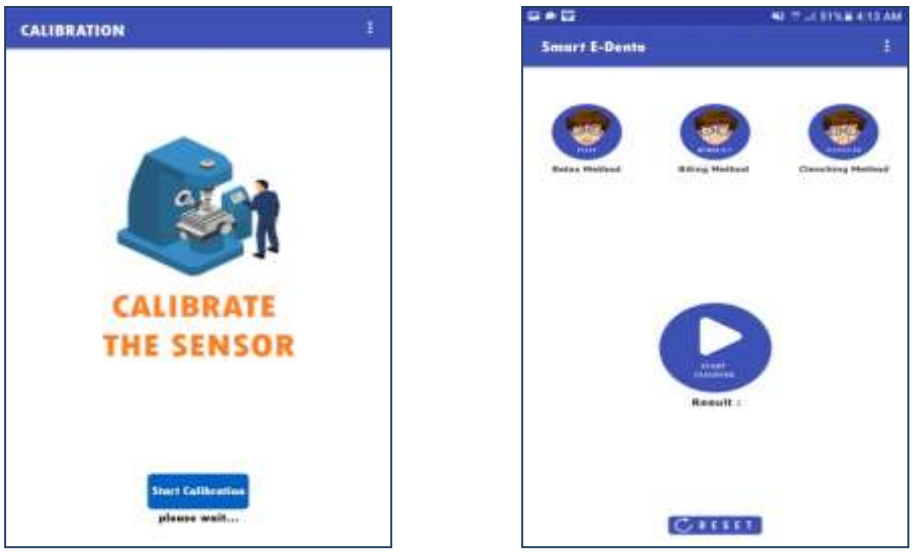
A number of pediatric patients with an average age of 7.2 ± 1.3 years totaling 30 people came to dental hospital of Hasanuddin University and have been recorded with their parents. A number of these pediatric patients will follow the study by examining the muscles of the jaw joint area (masseter) using certified dentosmart electromyography.

Patients are classified into 3 (three) groups with classification of the jaw relationships between class I (normal), class II with mandibular protrusion, and class III with mandibular retrusion. Patients who entered the inclusion criteria were invited to participate in this study. Informed consent followed the Research Ethics of the Faculty of Dentistry of Hasanuddin University and was registered (Ethical Approval Recommendation No. 0144 / PL.09 / KEPK FKG-RSGM UNHAS / 2019). Exclusion criteria are the patient is not cooperative and is not willing to follow the examination procedure. The inclusion criteria are: Pediatric patients who are cooperative and can work together, are healthy as evidenced by a certificate by a doctor. There is no history of sleep problems (snoring, apnoea, and restless sleep), pediatric patients without prior orthodontic treatment, no respiratory distress, and no systemic disease.

The test results obtained sampling rate in units of ksps (kilo samples per second) for both diagnoses as shown in Table 1.

Table 1: Sampling rate results in ksps

	Diagnosis	
	Normal	TM Disorder
Relax position	0.04 – 0.08	0.11 -0.21
Biting	0.07 – 0.013	0.17 – 0.29
Clenching	0.10 – 0.0.15	0.20 -0.29

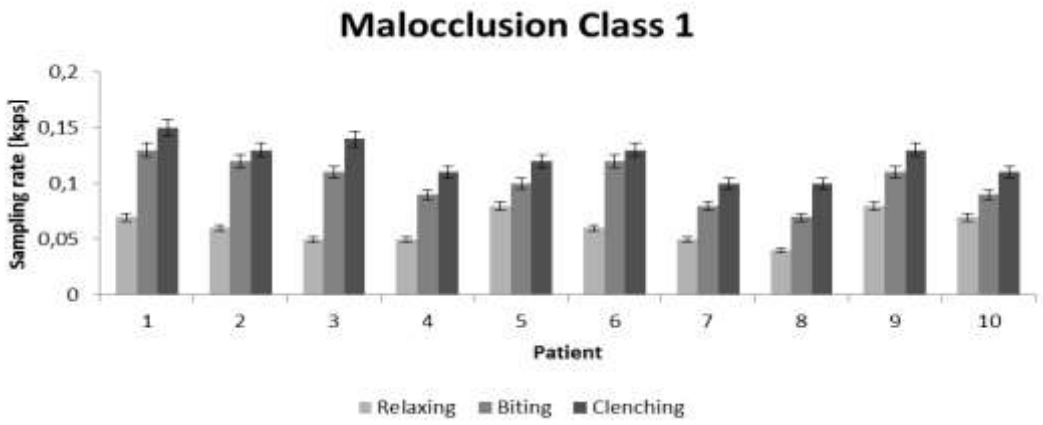


A B

Figure 3: The apllication image of (A) homepage and (B) main page

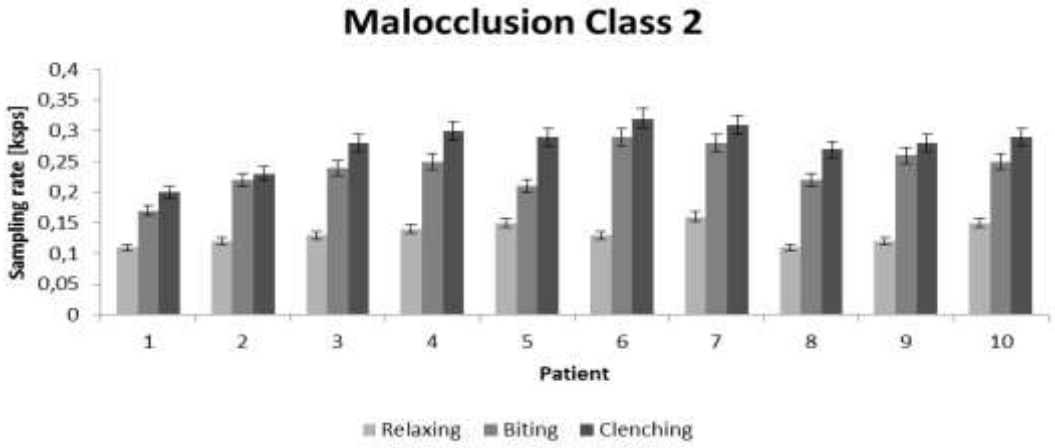
RESULTS

The proposed tool performance test was carried out on 30 patients for class 1, class 2, and class 3 malocclusions. The total sample of patients was 18 in boys and 12 girls. Interpretation of jaw joint disorders/abnormalities with the proposed application is done in three conditions, namely relaxing position, biting, and clenching teeth. In the application, the diagnosis will be displayed in 2 conditions, namely "Normal" or "Temporomandibular Disorder". For class I malocclusion is a normal condition, whereas for class II and III malocclusion is a condition called abnormal "There are temporomandibular abnormalities". Based on graphs 1,2 and 3, it appears that class I (normal) malocclusions show lower muscle activity values than class II and II malocclusions recorded with EMG amplitude values when relaxed, mild biting (centric occlusion), and hard biting (maximal intercuspal). Clinching activity in class II malocclusions showed the highest EMG values compared with class I and II malocclusions.[11,12,13]



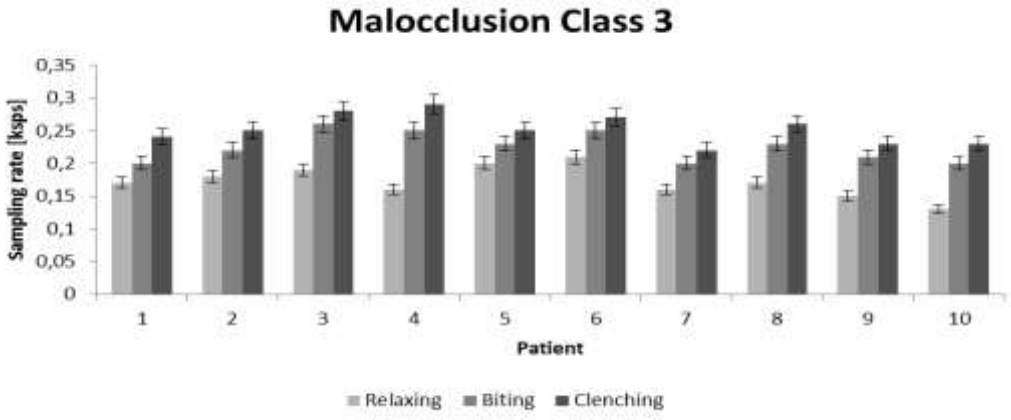
Graph 1: Results of EMG Recording in Class I Malocclusion Patients

Based on graph 1, in class I malocclusion (normal conditions), masseter and temporalis muscle activity recorded by the largest EMG when the patient is clenching. Then followed by chewing activity, and the lowest masseter and temporalis muscle activity when in a state of rest (relaxing).[14]



Graph 2: Results of EMG Recording in Class II Malocclusion Patients

On graph 2, class II malocclusion shows the highest masseter and temporalis muscle activity when in a state of clenching compared to when chewing or even resting.[15]



Graph 3: Results of EMG Recording in Class III Malocclusion Patients

Based on graph 3, in class III malocclusions, masseter and temporalis muscle activity recorded by the largest EMG

when the patient is clenching. Then followed by chewing activity, and the lowest masseter and temporalis muscle activity when in a state of rest (relaxing).[16]

From the three graphs it can be concluded that the high activity of masseter and temporalis muscles in class II malocclusions during clenching (clenching) than in class I and III malocclusions. This is because the retrognatic face has the highest authoritative activity in the posterior temporalis and the prognathic face has high activity in the anteriortemporalis when clenching in the intercuspal position. Malocclusion has a close relationship with the occurrence of Temporomandibular Disorder. This is due to the entire body posture and functional abnormalities such as swallowing and chewing are affected by dental occlusions that can be transmitted to the masticatory muscles including those that play a role in the jaw joints. This condition is likely to cause changes in discus and condyle relations, which are responsible for disc displacement and TMJ clicking.[17,18,19]

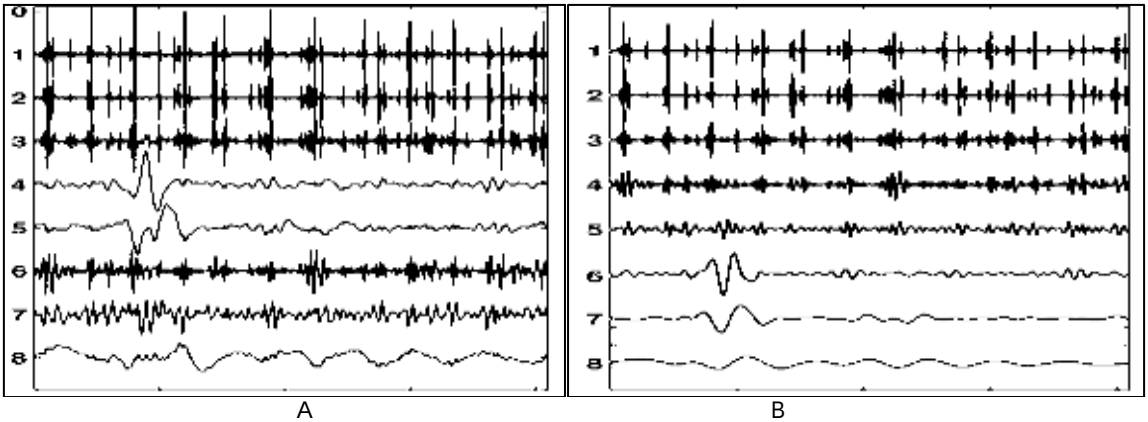


Figure 4: EMG records in muscles in normal relationship to class I malocclusion, (A) resting position, (B) clench position.

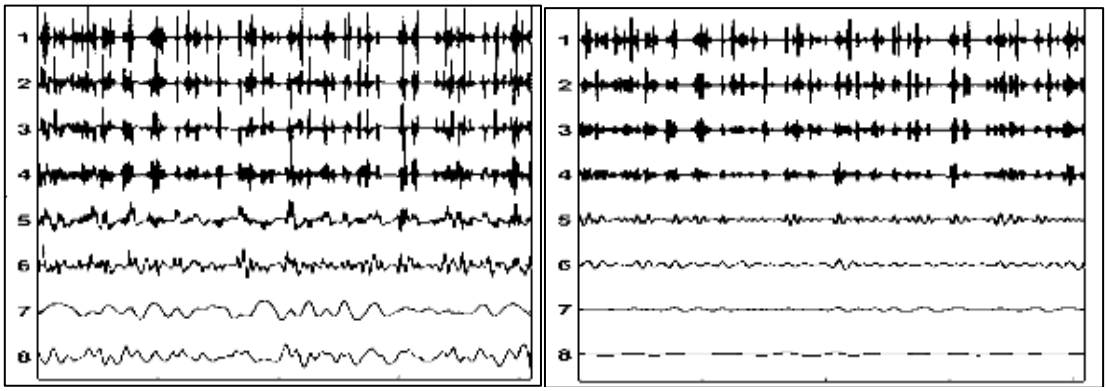


Figure 5: EMG records in muscles in normal class II and class III malocclusion relationships, (A) resting position, (B) clench position.

The results of jaw joint muscle recording (Figure. 4 and 5) using electromyography can be seen that there are amplitude waves that show different wave results due to the level of muscle activity and jaw joint abnormalities (TMD) associated with class I, II malocclusions and III The results of jaw joint muscle recording (Figure 4 and 5) using electromyography can be seen that there are amplitude waves that show different wave results due to the level of muscle activity and jaw joint abnormalities (TMD) associated with class I, II malocclusions and III.[20,21,22]

DISCUSSION

The main cause of non-dental pain in the orofacial region in children and adolescents is temporomandibular disorders (TMD), which are disorders involving masticatory muscles, temporomandibular muscles, and related structures. The prevalence of TMJ disorders in children and adolescents ranges from 9.8% to 80%. Previous research suggested that the signs and symptoms of temporomandibular disorders (TMD), such as headaches, joint sounds, pain in the TMJ area, limited mouth opening, deviation deflection, tenderness in TMJ, painful muscle mastication.[23,24,25,26,27]

Jaw joint abnormalities can occur in adults or children. Bad habits in children such as tongue thrust, nail biting or pencils, finger sucking and chewing on one side, and poor oral hygiene conditions that cause premature loss of posterior teeth are factors that can trigger jaw joint abnormalities. In children, abnormalities of the jaw joints rarely cause pain, but if left unchecked it will cause further dysfunction, causing complaints such as pain when opening the mouth, headaches, or pain in the ear. Jaw joint abnormalities can affect the joints as well as the surrounding muscles. The accompanying symptoms can include joint

sounds that are described as clicking or crepitus, asymmetrical or limited movement of the mandible, and sometimes accompanied by pain in the jaw, ear, head and face.[28,29,30,31]

The home page of the Android Smart E-Dento application (Figure 3A, 3B) is used to calibrate the surface electrode sensor so that the tool can work properly and accurately. The button on the home page is used to start calibration by instructing the raspberry pi to run the calibration program on the surface electrode sensor. If the calibration fails, a notification will appear in the form of text asking to repeat the calibration. However, if the calibration is successful, it will proceed to the main main where the test was carried out.[32,33,34,35]

On the main display, there are four buttons where the three buttons at the top are used to retrieve diagnostic data via a surface electrode sensor that is connected to a raspberry pi. The start diagnosis button is used to start the diagnosis of jaw joint abnormalities in patients based on the data obtained. After the data is processed, the diagnosis results will be displayed on the Android application. The reset button functions as a button to restart the diagnosis process.[28,29]

The data collection process carried out in the main view must be carried out according to the method chosen in the application because the data will be compared with the data source obtained from the study. The data collection process will affect the accuracy of detection.[1,2]

CONCLUSION

Smart E-Dento is a tool used to conduct early detection of jaw joint disorders based on an Android smartphone. Smart E-Dento can identify jaw joint disorders based on electrical activity in the masseter muscle and temporalis muscle and process the data obtained as a result of a temporary diagnosis for normal or abnormal muscle contraction strength, so that it can be detected early and produce an appropriate diagnosis in order to perform treatment earlier there is a disruption of the function of mastication in the growth and development of children.

CONFLICT OF INTEREST STATEMENT

No potential conflicts of interest relevant to this article were reported.

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