T.C.
FATIH UNIVERSITY
INSTITUTE OF BIOMEDICAL ENGINEERING

Comparison of Duration Effect of K2 Trainer on Jaw Muscle

SERKAN ARİ

MSc THESIS
BIOMEDICAL ENGINEERING PROGRAMME

İSTANBUL, JUNE / 2014

T.C.
FATIH UNIVERSITY
INSTITUTE OF BIOMEDICAL ENGINEERING

Comparison of Duration Effect of K2 Trainer on Jaw Muscle

SERKAN ARİ

MSc THESIS
BIOMEDICAL ENGINEERING PROGRAMME

THESIS ADVISOR
ASSIST. PROF. DR. ŞÜKRÜ OKKESİM

İSTANBUL, JUNE / 2014

T.C.
FATİH ÜNİVESİTESİ
BİYOMEDİKAL MÜHENDİSLİK ENSTİTÜSÜ

Çene Kaslarında K2 Aparesinin Tedavi Süresi Boyunca Karşılaştırılması

SERKAN ARİ

YÜKSEK LİSANS TEZİ
BİYOMEDİKAL MÜHENDİSLİĞİ PROGRAMI

DANIŞMAN
YRD. DOÇ. DR. ŞÜKRÜ OKKESİM

İSTANBUL, TEMMUZ/ 2014

T.C.

FATIH UNIVERSITY

INSTITUTE OF BIOMEDICAL ENGINEERING

Serkan ARİ, a MSc student of **Fatih University** Institute of Biomedical Engineering student ID **52011104**, successfully defended the thesis/dissertation entitled **"Comparison of Duration effect of K2 Trainer on Jaw Muscle**", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor : Assist. Prof. Dr. Şükrü OKKESİM.....
Fatih University

Prof. Dr. Sadık KARA .....
Fatih University

Assoc. Prof. Dr. Serdar YILMAZ……..
Fatih University

It is approved that this thesis has been written in compliance with the formatting rules laid down by the Institute of Biomedical Engineering.

Prof. Dr. Sadık KARA
Director

Committee Members

Date of Submission : 07 May 2014

Date of Defense : 07 Jully June 2014

To my wife Ayşe ARİ, who believed in me when no one else did?

Special thanks to İsa ARSLAN, Bunyamin PINAR,
Duran Sakallı and Huseyin CIFTCI
for making everything easier

ACKNOWLEDGEMENTS

First, I would like to thank Assist. Prof. Dr. Şükrü OKKESİM, my thesis supervisor, for his inspiration, guidance, motivation and friendly tolerance during my thesis work. I always felt lucky to have been worked with him. would like to thank my family and friends who supported me all the time.

I especially thank to Abdullah al kafee who are the research assistants of the Biomedical Engineering Institute, for their help in Matlab routines, creative solutions and technical support.

Furthermore I would also like to thank to capa haspital and there doktor to help me to collect my data for this research.

Jully 2014 **SERKAN ARİ**

TABLE OF CONTENTS

Page

ABBREVIATIONS

EMG :Electromyography

PSD : Power Spectral Density

RMS : Root Mean Square

SNR : Signal to Noise Ratio

STFT : Short Time Fourier Transform

TB : Triceps Brachii

WT : Wavelet Transform

MF : Muscle Fatigue

MNF : Mean Frequency

MPF : Mean Power Frequency

WT : Wavelet Transform

FT : Fourier Transform

LIST OF FIGURES

Page

LIST OF TABLES

SUMMARY

Comparison of Duration Effect of K2 Trainer on Jaw Muscle

Serkan ARİ

Biomedical Engineering Programme

MSc Thesis

Advisor: Assist. Prof. Dr. Şükrü OKKESİM

Electromyography (EMG) is a method for investigating the functional state of neuromuscular system. EMG based on a motor unit with its innervated myofibers .Surface EMG main system is used in biomedical research and nevre and muscle contraction or physical change, and diagnosis the neural or muscle malfuncton. . In the Orthodontics department, the name of the treatment is abnormalities of the teeth and jaw in the layout or position located differently. In Orhodontist department such abnormalities are called malocclusion. This type of patient are called the visual inspection and cephalometry those obtained by imaging technique which is provided result by analysis of the image and treatment. In cephalometry evaluated with images of the jaw bones and muscle any condition of abnormalities treatment is needed.

Aim of the thesis is 15 patients ages 8 and 14, ranging K2 called the apparatus's or trainer Antemia the mesatal, orbicularis oris and mentalis muscles suction, jaw clenching and swallowing activity during the EMG signals parameters are evaluate the result, before starting the treatment and after 3 months later of the treatment recorted are analyzed. in the literature EMG signals recorded were analyzed by the method of Wavelet Theorem. Re-Power Spectral Density of this EMG signal obtained by calculating the maximum PSD values are used as feature value

Keywords: Electromyogram, Power spectral density, Isometric Contraction, Isotonic Contraction.

ÖZET

Çene Kaslarında K2 Aparesinin Tedavi Süresi Boyunca Karşılaştırılması

Serkan ARİ

Biyomedikal Mühendisliği Programı

Yüksek Lisans Tezi

Danışman: Yrd. Doç. Dr. Şükrü OKKESİM

Orthodonti, diş ve çene düzeninde/pozisyonunda bulunan anormallikleri tedave eden anabilimdalının adıdır.Orhodontistler bu tür anormallikleri malokluzyon olarak adlandırmaktadırlar. Hastanın tanısı görsel muayene ve cephalometry isimli görüntüleme tekniği ile elde edilen görüntünün analizi ile konulmakta ve tedavi süreci başlamaktadır. Her nekadar tedavi sürecinde anormalliklerin durumu cephalometry görüntüleri ile değerlendirilsede uygulanan tedavinin çene kemikleri ve kasları üzerindeki etkisinin değerlendirilebileceği quantitative bir yöntem bulunmamaktadır.Tez çalışmasının amacı K2 olarak adlandırılan apareyin/trainer antemior, mesatal, orbıcularis oris ve mentalis kaslarında oluşturduğu etkiyi elektromyogram sinyallerinden hesaplanacak parametrelerle değerlendirmektir Bu amaçla yaşları 8 ile 14 arasında değişen 15 hastadan, emme, çene sıkma ve yutkunma aktiviteleri esnasında EMG sinyalleri tedavi başlamadan hemen önce ve 3 ay sonra kaydedilerek analiz edilmiştir.

Kaydedilen EMG sinyalleri literatürde yer alan çalışmalarda başarısı kanıtlanmış olan Dİscreate Wavelet Theorem yöntemi ile analiz edilmiştir. Daubechies dalgacığı/wavelet 3.seviyede kullanılarak yaklaşım/approximation ve detay/detail katsayılarına ayrılmış ve her bir detay ile son yaklaşım katsayı kullanılarak sinyal yeniden reconstruct edilmiştir. Yeniden elde edilen bu sinyalin Power Spectral Density değerleri hesaplanarak maksimum PSD değeri feature olarak kullanılmıştır

Anahtar kelimeler Electromyogram, Mechanomyogram, Isometric Contraction, Isotonic Contraction.

CHAPTER 1

INTRODUCTION

1.1 **Purpose of the Thesis**

The influence of myofunctional habits like abnormal lip and tongue function on craniofacial development and orthodontic problems has been regularly reported in publications. Various appliances have been used for the treatment of this problem. The human body consists of different system which include the nervous system, the cardiovascular system, the musculoskeletal system etc. In our body physiological processes Each system perform some important task. The primary function like body moving substance with movement most of them generating heat and physical change that reflects makes some signal those signal provide there nature and activities. Electromyography (EMG) is a method for investigating the functional state of neuromuscular system. EMG based on a motor unit with its innervated myofibers [1]. Surface EMG main system is used in biomedical research and nevre and muscle contraction or physical change, and diagnosis the neural or muscle malfuncton. [2–5]. In the Orthodontics department literature, the name of this treatment is abnormalities of the teeth and jaw in the layout position located differently. Irregular manner that affected the alignment of the teeth development jaws like soft healthy tissue and speaking skills in badly [1].This Class is divided into three malocclusion. Class II upper and lower jaws in the normal position is, but the teeth are normally a lot of and abnormal alignment, which is Class II mandibular upper jaw than be left behind and Class III upper jaw, lower jaw than behind the discomfort represents. Orthodontik Class II malocclusion is seen in 49% of patients with disease [2,3].

Faculty of dentistry orthodontics departments, patients who head bulge seen in the upper and lower jaw opening is characterized by disorders of the mouth [4]. Therefore,

orthodontic literature, teething period during the abnormal lips and tongue function (lip biting, thumb sucking, tongue teeth with application of force, etc.) caused by normal growth initiative, which control problems on a large interest has been. Many methods was presented for this solution [5-6]. Mouth or channel protection method called dysfunction to eliminate mouth its main purpose is to force exerted by the muscles stabilized. Another important objective is to prevent and mitigate the incisors in the upper jaw protrusion formed.

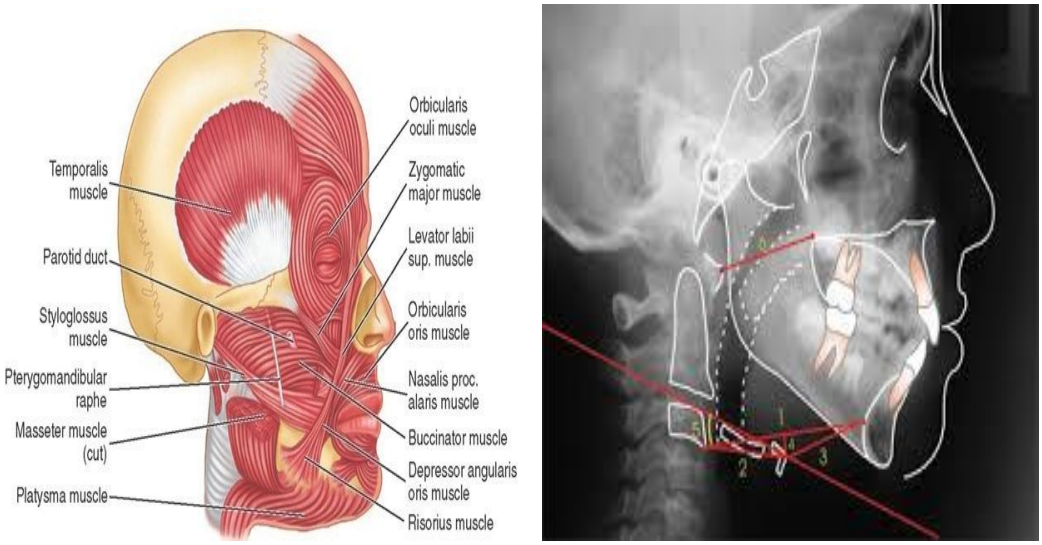

Figure1.1 :Cephalometry image and some points of measurement [****].

Espically at a young age persons behavior such as thumb sucking tonge thrust which is caused by teeth abnormalities in order to prevent the formation of Myofonksiyonel APARs are still referred to as a developed method [7,8]. In this thesis, the main functions by stimulating the trains is used fort the front teeth in the upper jaw in a position to take much more suitable and balance out to force the tongue against the teeth ,lips and facial muscles. Myofonksiyonel appliances, are used for many years. Because they are simple and affordable orthodontic appliances in this particular space, but they must be carefully chosen cases [9].

At an early age orthodontic treatment start, lips, cheeks sucking, mouth breathing, tongue and teeth like pushing functional problems in order to fix 4 to 12 year-olds

frequently used myofonksiyonel apparatus which is one, Pre Orthodontic Trainer apparatus patients in the study used by the apare has been. In general, tissue growth, development and diversity occurs with jaw and tooth structure around the mouth. Abnormalities in the teeth structure are resolve by the force therapy applied balanced and stable making it to sink in the ideal teeth alignment to create oral dysfunction[10].

In children jaw development soft tissue and speaking negetively affect the health orthodontic alignment of the teeth that gives a results in an irregular manner called malocclusion mouth disorders arise. orthodontic treatment is applied using various functional appliances with a better way to provide dental and oral dysfunction ranking is intended to resolve [4]. This apparatus being used in the orthodontic treatment induced changes myofonksiyonel not been studied sufficiently. However, for patients it is very impotant to orthodontic treatment begin to give accurate and sufficient information. Orthodontists patients with different treatment plans like tratment total duraation of time, possible risks, total sucess treatment should be give to the patient. For this reason patient medical history and x-ray report of the images of teeth and with jaw despite using fot the treatment protocol. what is the expected success and apparatus are unable to estimate the total usage time [5]. Therefore, when it should be start and when it should be finished the main correction can be seen in the result. During the treatment making more accurate decisions or total duration of the treatment we can make a table for decision error and good result.

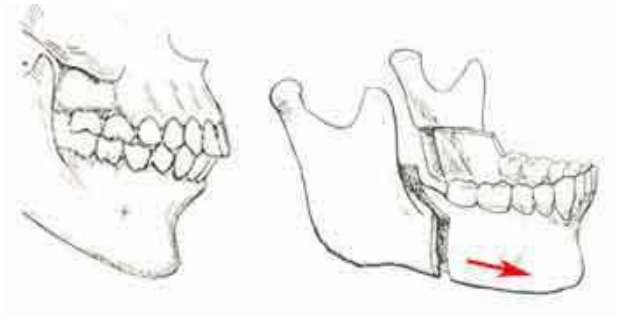

Figure 1.2: Cephalometry image [***]

1.2 Arrangement of the Thesis

In this thesis mainly focused the ortodonst treatment related masseters, anterior temporal, mentalis and orbicularis oris muscles caused in active competence and failure, how often it change at what time and at what period is used more effective detection treatment for both patient and doctor. Also examine the effect of twin block appliance on jawclosing muscles.

For this reason diagnosis using the electromyogram (EMG) examination. EMG testing is applicable in the clinical delay [6]. The main challenge in analyzing these signals, EMG signals are weak, noisy and non-stationary signals is deterministic. Furthermore, EMG signals of trained technicians EMG muscle activity can not distinguish the true genius that contains noise [7].

After getting the EMG signal recording we calculating the value of the right masseters APARs twin block, the right anterior temporal, created in the mentalis and orbicularis oris muscle is to evaluate the effect. Class II malocclusion, EMG signals from the 15 children have been taken separately. At the time of initiation of treatment (0 months), respectively, and then 3 monthswere also recorded. If 0 months and after 3 months record obtained the values in this Pre-Orthodontik Trainer as a result of orthodontic treatment with apparatus of muscle fibers will result stems from changes in the characteristics. The EMG signal are obtained by the power spectral (PSD) and shannon energy of the EMG signals to compare. Results showed that the effect of the TWİN block appliance on jaw closing muscles activity can be evaluated from EMG recording.

The aim of this follow-up study was to evaluate the effects of Pre-Orthodontic Trainer (POT) appliance on the anterior temporal, mental, orbicularis oris, and masseter muscles through electromyography (EMG) evaluations in subjects with Class II division 1 malocclusion and incompetent lips

CHAPTER 2

Background of skeletal muscle tissue

2.1 Masseter

The masseter muscle is a facial muscle that plays a important roles in the chewing of food. The muscle shaped same to a parallelogram, joining to the mandible and the cheekbone. The masseter muscle itself is divided into two part:

1. superficial
2. deep

There is enougf portion in the masseter It is very thick also tendon-same like portion of the muscle which joints to the cheekbone. Inside of the portion is smaller and more muscular portion of the muscle that connects to the mandible. The masseter is organised by total three muscles: first one is the temporalis, second one is medial pterygoid and last one is lateral pterygoid. This all muscles work together to pull the jaw down and back up again. The masseter is the main muscle which pulls the mandible upward. All four muscles are connected to a single division of the trigeminal nerve. Because of the bulk of the masseter muscle, portions of it are sometimes removed by plastic surgeons performing jaw reduction surgery. Individuals who grind their teeth while sleeping may develop squared jaws as a result of the masseter growing due to the additional exercise it receives over time.

The masseter is a muscle running between the cheekbone, or zygomatic arch, and lower jawbone, or mandible. It has a large superficial portion and a smaller deep portion, both of which are situated close to the parotid salivary gland. In fact the duct which carries saliva from the gland crosses the masseter muscle on its way into the mouth. There are

two masseter muscles, one on each side of the skull, and they are very strong — among the most powerful in the human body. A branch of the trigeminal nerve, known as the mandibular nerve, supplies the muscle with nerve impulses which cause it to contract, raising the lower jaw when chewing or speaking.

Figure 2.1: Masseter muscle [****]

Clenching the jaw and feeling above the angle of the lower jawbone allows the masseter muscle to be felt. Masseters are involved in lift up the lower jaw so that the upper and lower sets of teeth can meet when chewing food, a process known as mastication. As the body is normally held upright, the muscle is typically working entirely against gravity. The masseter is one of the group known as the muscles of mastication, which also includes the temporalismuscle and the medial and lateral pterygoids. Together, the muscles of mastication work to grind food substances between the teeth, but only the lateral pterygoid acts to open the mouth while the others close it.

2.2 Orbicularis Oris

the orbicularis oris located in the face muscle inserts directly into the lips, it controls the main part of the mouth movement like encircles the mouth, originating in the maxilla and mandible bones. this muscle relies on the seventh cranial nerve, like the buccal branch of the facial nerve. In very simply says that the orbicluarlis oris is often referred to as "the kissing muscle. Our facia expression and puckering the lips this muscle is responsible for those movement. When facial movement like kissing action the lips

must be contract into a pucker to forcefully exhale, which is necessary for playing certain music instruments such as trumpets and other horns. The obicularis oris muscle is also main action is for closing and opening the mouth. In the past, the muscle was thought to be a sphincter. But now a days it has been found to not exactly meet that definition, even though it does perform sphincter-like opening and closing actions.

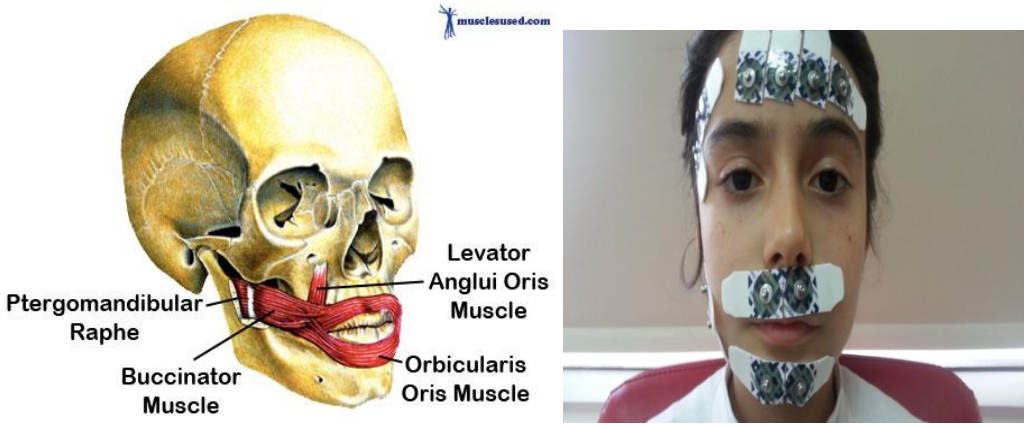

Figure 2.2: orbicularis oris muscle [*****]

2.3 Mentalis

The mentalis is a muscle located directly below the lower lip, near the chin tip. It is mainly for raising the lower lip movement. it movement mainly to wrinkle the chin and push the lower lip out, sometimes it's another name is pouting muscle. People when try to show there expression like sadnes or displeasure they used this muscle. people go all there lifetime without showing a thought to their mentalis, sometimes people are plagued with medically movement also disorders that greatly affect this muscle. Normally mentalis doesn't used pose for all people but offcourse there are a few order differance and condition may be required medical advance. Like geniospasms, a rare genetic disorder, may affect the mentalis muscle. With geniospasms, the chin and lower lip quiver involuntarily and repeatedly. Geniospasms come normaly life tension or too much stress, normally it start in childhood. Also It maybe happen due to genetical

problem. This can be a socially excluding condition for the patient, By proper early madical care it may be possible to care.

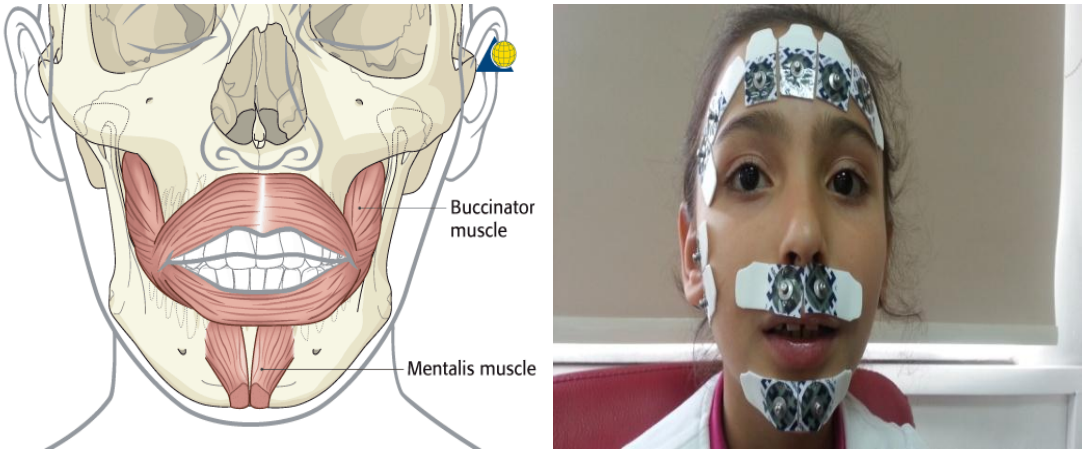

Figure 2.3: Mentalis muscle

when the mentalis is affected by geniospasms, there are medical treatment it can be work to control the spasms. Specifically, injections of botulinum toxin A, known by the brand name Botox, work well. As a result of the injections, the muscle is paralyzed, but the facial expressions are not impaired and the speech is not impeded. Botox is one of the most cost effective, least painful, and quickest methods to treat the problem. However, all options should be considered because there are side effects to Botox, as well, including pain, headache or upset stomach.

2.4 Temporalis and TMJ

The temporalis muscle is a broad, radiating muscle, its located at the side of the head which arises from the whole of the temporal fossa and from the deep surface of the temporal fascia. As we can see in the figure, temporalis is a quite large muscle. its main connection to the top of the mandible both side of the head along to the side skull. If cleanches of the teeth. if the temporalis muscle one cleanches the teeth is activated its involved all parts of the muscle. The grinding teeth causes increased muscle stain to the temporalis, as does anxiety or stres induced muscle tension. It Works in conjucation

with and is affected by other muscles of mastication, its called the chewing muscles. Very common symptoms temporalis are head pain behind the eyes.

Poor posture, clenching the teeth, and stres this all can perpetuate trigger points in the temporalis which is the primary cause of tension type headaches. Also there is strong relation between the neck and shoulder muscles with the temporails.

Figure 2.4: Temporalis muscle

2.5 Electromyography and its application in orthodontics

The clinical use of electromyography (EMG) for orthodontic diagnosis and for treatment planning has been suggested. The EMG was used to evaluate masticatory movements in children, with special reference to occlusion and the actions of masticator muscles and association with facial morphology were investigated Electromyography is an electrical system which defined recording also study electrical properties of skeletal muscle. November fibers, by means of electrical signals transmitted over the central nervous system that are stimulated by motoneurons. And consisting of a group of muscle fibers that motoneuron, contractile to the smallest unit of structure is called the motor unit [9]. Voluntary muscle movements, various chemical reactions occurring in the body resulting in the motor unit action potential related muscles caused by introducing said [10]. Maximum value of GDP will be held over the analysis of motor

unit activity during the task area provides information on the temporal and spatial situations [11]. EMG signals GDP values motor unit action potential develops as a result of the sum of spectral characteristics. Thus each case be said to be a characteristic of the power spectrum [12]. For these reasons the apparatus is used as a criterion to evaluate the effects of GDP

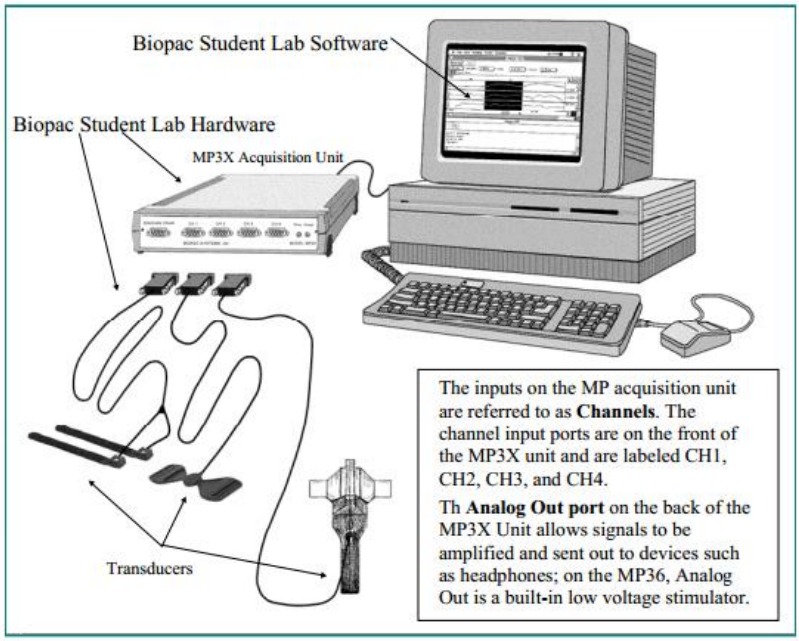

Figure 2.5: EMG signal conducted by Biopac

Galvani's biological electrical activity in animals in the 18th century reveal the presence of electrophysiology to the present day scientific journey began. In the early 19th century, opened an era of Galvani and Volta friends walked the path of the invention. The second half of the 19th century by the stimulation of a motor nerve and muscle contraction that occurs with increasing stimulus intensity increased the amplitude of the action potential was an exciting development. Science placed on the brick wall, constitutes the beginning of the clinical or diagnostic electrophysiology. And the first electrophysiological tests as a measure of muscle contraction with electrical stimulation began.

EMG second important issue in the development of the brick wall, and that the presence of the oscilloscope in 1922, a few years after the discovery of the needle electrode has been konstrantrik. This technique has become widespread clinical use of

electromyography. Repetitive nerve stimulation and stimulation with the nerve conduction studies was thereafter to be activated. Then reflexes, late potentials, somatosensory and motor evoked potentials and single fiber EMG developed in electrophysiology has been involved in major investigations.

Electromyography devices in recent years with the transition from analog technology to digital technology began to be seen important innovations are not drastic. With digital technology, statistical and mathematical operations-intensive application on the electromyographic activities of the motor unit discharge characteristics, the frequency of motor units on various electrical configurations to quantify the effect as it has been possible to achieve. Linear Fourier spectral analysis known as frequency analysis, turn / amplitude, discharge frequency, such as nonlinear chaotic advanced mathematical analysis.

The muscle is contracting or not that is determined by the surface electrode.: by insertion of a surface electrode into the muscle and observing by cathode-ray oscilloscope the action potentials spontaneously present in a muscle or induced by voluntary contractions, as a means of detecting the nature and location of motor unit lesions; recording the muscle nevre function by electrical simulation .EMG is the main device which used in this test. EMG is the record which measured by EMG device. EMG structure mainly worked in motor unit. Usually muscle skeletal fiber are contacted by nevre. many of them connected at same place all branches are suplied of the axon of one spinal motor neuron.

2.5.1 Electromyography in orthodontics

The first effort to apply electromyography to dentistry was made by Robert E. Moyers4. He observed that the normal relations of teeth to each other in the same jaw and with those of the opposite jaw were influenced by muscular balance. With relevance to orthodontics, the muscles of importance are the mandibular elevators, namely: masseter muscle, temporalis muscle, and the medial pterygoid muscle; and the mandibular depressor, i.e. the lateral pterygoid muscle. The genioglossus muscle also plays an important role in determining facial morphology. This muscle is responsible for the

protraction of the tongue. Mentalis muscle and orbicularis oris muscle are also important.

Figure 2.6: EMG signal conducted by Biopac sys, MP 150 unit

The physiologic information primary to understanding the recording and following study of the electrical activity of muscle using EMG techniques. Electromyography (EMG) is an experimental procedure involved with the development, recording and evaluating of electrical activity produced through muscular contractions. EMG signals are complex, non-stationary and noisy signals. A raw EMG signal taken during our experiments is shown in figure2.7. If it is used correctly, EMG allows to directly looking into the muscle, measurement of muscular performance, analysis to progress sports activities and detects muscle response in ergonomic studies such as; motor control, neuromuscular physiology, postural control and movement disorders.

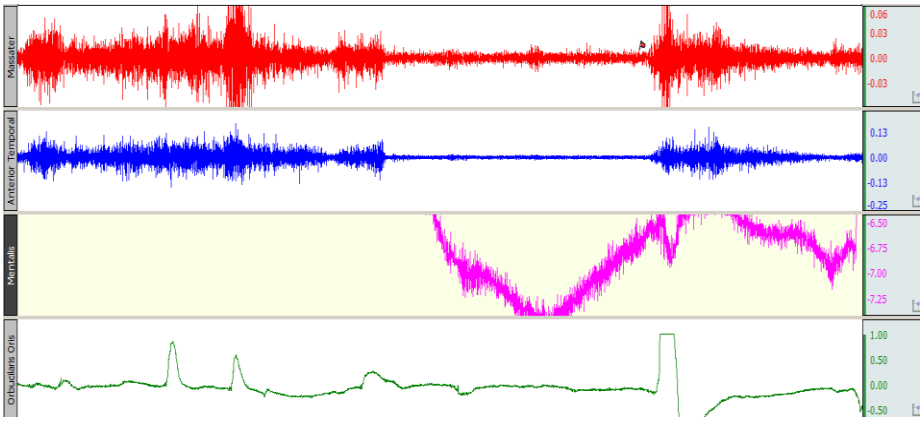

Figure 2.7: A typical EMG Signal

If it is used correctly, EMG allows to directly looking into the muscle, measurement of muscular performance, analysis to progress sports activities and detects muscle response in ergonomic studies such as; motor control, neuromuscular physiology, and postural control and movement disorders.

2.6 Biopac Student Lab MP36 system

The heart of every Biopac Student Lab system is the data acquisition unit, which converts incoming signals into digital signals that can be processed by a computer. MP36/35 units have four input channels and the MP45 unit has two input channels. Electrodes, transducers, and/or input/output devices connect to the MP data acquisition unit so students can record data from their own heart signals (ECG), brain waves (EEG), muscle activity (EMG), eye movement (EOG), and more or from animal or tissue preps.

The MP data acquisition unit is the heart of all Core Packages. The MP Unit has an internal microprocessor to control data acquisition and communication with the computer. The MP Unit takes incoming signals and converts them into digital signals that can be processed with the computer. There are analog input channels (four on

MP36/35 units, two on MP45), one of which can be used as a trigger input. The MP Unit must be connected to the computer and electrodes, transducers, and/or I/O devices must be connected to the MP Unit. Users are suggested to take a few minutes to become familiar with the MP Unit prior to making any connections. The MP36 has a built-in stimulator and is not compatible with/does not require the SS58L; order OUT3 for low voltage stimulus capability with the MP36.

MP36 data acquisition unit:

- Increased performance (24-bit A/D converter)
- Expanded amplifier settings
- Built-in stimulator
- New stimulator and output control features
- Improved Electrode Check for electrode impedance
- New digital input & output capabilities

❖ Increased triggering options

Figure 2.8 : EMG signal conducted by Biopac sys. MP 36 unit

2.7 Micro-electrode interface cable for MP36/36R

His fully-shielded, unity gain, high-impedance, differential input, electrode interface cable permits high resolution recording of biopotential signals. This interface cable incorporates dual ultra-high impedance buffer amplifiers (one for Vin+ and one for Vin-) to allow for connections to needle electrodes, wire electrodes, or very small surface electrodes (~1 mm diameter). The adapter terminates with standard 1.5 mm male Touchproof electrode connectors [30]. Typically, this electrode interface cable is used with needle, wire, pellet, or glass micro-electrodes for use in animal or organ studies. Interface with EL450 series needle electrodes, LEAD140 clip adapters (to connect to wire or Ag/AgCl pellets in glass electrodes), or LEAD110 unshielded electrode leads. If a single-ended configuration is required, use one JUMP100C to connect Vin- to GND to establish the reference electro

- **Vin+** Red
- **Ground** Black
- **Vin-** White

Figure 2.9 Electrode cable

2.8 Disposable electrode

Surface EMG is a non-invasive technique which detect the signals that contain timely characteristics and is really useful to understand the answers from the muscles to the impulses (3. 7) . Surface electrodes are placed on the skin which covers the target muscle and can detect the activity which is gathered from lots of motor units [24]. Thanks to the production of the electrodes which are designed as parallel to the developing technology, surface EMG is used in the studies of human anatomy and mechanism, medical area of sports and in the cliniques. Surface EMG is really a useful method for analyzing the combined muscle groups recorded by means of sticking the electrodes outside on the skin.

The mesatal, orbicularis oris and mentalis muscles are the muscles that work antagonist to each other is very different. For example; in the flexion movement done by eating or laugf. This four muscles places in a body were shown in figure 2.11. Also before each recording section skin muscles are cleaning by alcohol. Electrodes are feel with electrode gel. Its very important to attached the electrode in the skin so EMG signal can take much more beter. The electrodes are 4mm recording diameter and total is 20 mm. Electrode alignments were assisted by platform during the voluntary cleaching and relaxation in the position. The common ground electrodes are put into the forehead of the sunject and active electrodes are placed on the right position. As you can see in the Picture.

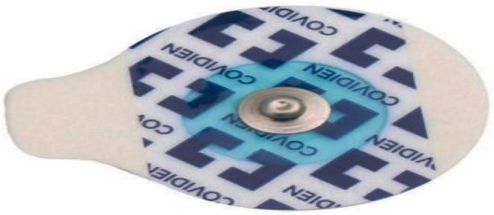

Figure 2.10 Disposable electrode

2.9 EMG Signal

In every human body there are two type movements;

1. voluntary movement and
2. involuntary movement.

Involuntary movements are generated by smooth and cardiac muscles which are under the control of the autonomic nervous system. This muscles works without nervous input. In contrast to voluntary movements are initiated by action potentials from motor neurons. Each motor neuron branches and synapses with up to a hundred muscle fibers. These fibers constitute a motor unit[16].Process of muscle contraction occurs 3 steps; excitation (stimulation), contraction and relaxation. The number of fibers contracting will determine the force of the contraction of the whole muscle.

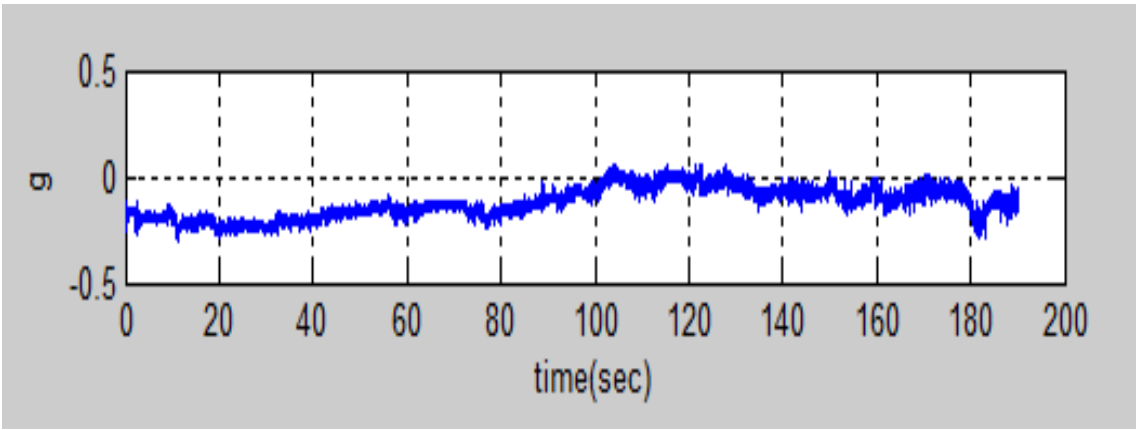

Figure 2.11 EMG signal

2.10 The Motor Unit

A cell contain different structures inside and the outside. This motor unit is provided with the difference between cell and electrochemical potentials is the difference between the two sides of the cell membrane [17]. In the muscle cells which belong to the skeleton, this potential difference is -90mV. The basic ions which make the resting potentials are Na^{++}, K^{+} and C^{-} [15]. When the depolarize current impulses of enough quantity are applied, an action potential starts. But this potential is only activated, when the depolarization exceeds the threshold. After the threshold is passed, the action potential performs a fast change in the cell potential and then turns back to the resting potential [19]. This action potential goes further by spreading with the same number and the same shape throughout the muscle and the nerve cells. When the cell is excited, the membrane potential increases towards the positive. This increasing potential, immediately after passing the threshold of -60mV, continues to increasing to 20 mV which is the repolarization threshold even if the impulse is deactivated. The membrane potentials which cannot pass the threshold, turn to their resting states when the impulse disappears. This is called "All-or-None Law. " Muscle fibers are excited by the central neurosystem by motoneurons which help to transmit the electrical signals. One motoneuron has neural connections to several muscle fibers [20]. The smallest functional unit of this muscle which contains motoneurons and muscle fibers is called motor unit (figure 2.13).

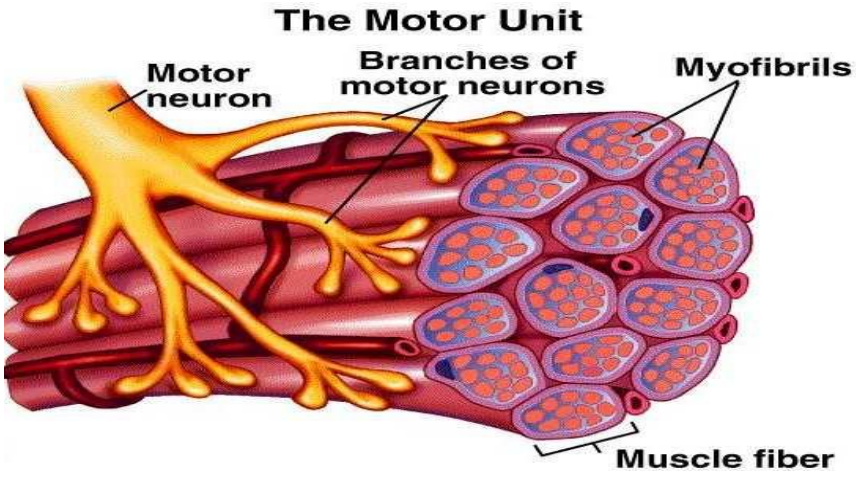

Figure 2.12 Motor unit

The environmental factors and our bodies central nervous system controls the motor units in order to optimize the interaction. Muscles strength are evaluated by two options as a result of the activation of the motor units, the number of excited motor units and the frequency of impulse. They can change according to the different types of muscle.

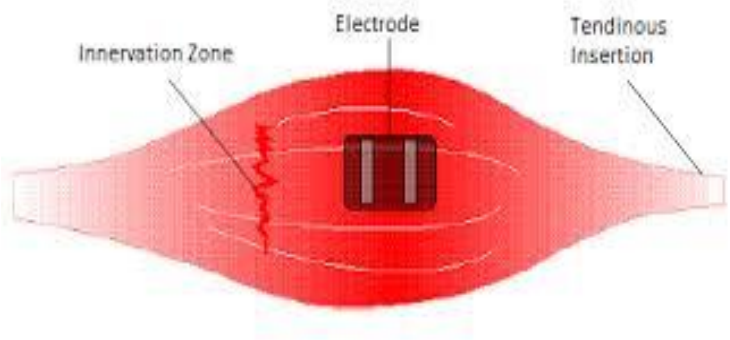

Figure 2.13 Motor unit action potential with EMG signal.

Action potential is activated as a result of the impulse coming from the central nervous system by means of motoneuron, potential acetylcoline is created at the end of the neuromuscular connection. Acetylcoline impulses muscle fibers and the membrane of sarcolemma. This impulse starts the fast depolarization and repolarization of muscle fibers. This action potential goes further throughout sarcolemma by passing the muscle fibers [29]. The action potential happens in all of the muscle fibers which locate at the motor unit, and immediately after, all muscle cells are excited at the same time in this motor unit [28]. Depolarization which occurs in all of the muscle fibers creates and electrical field around the muscle fibers. This field can be detected by electrodes which are put on the muscle bundles on which this field is created. The result is called the muscle fibers potential. All the muscle fibers potentials combine the Motor Unit Action Potential. This is the main job of motor unit.

2.11 EMG Signal Measurement Methods

Generally, EMG signals are evaluated by 2 methods. One is applied by using needle electrodes which are really sensitive to deep muscles, invasive method. The other one is used for detecting the movements of exhaustive muscle groups, non-invasive method.

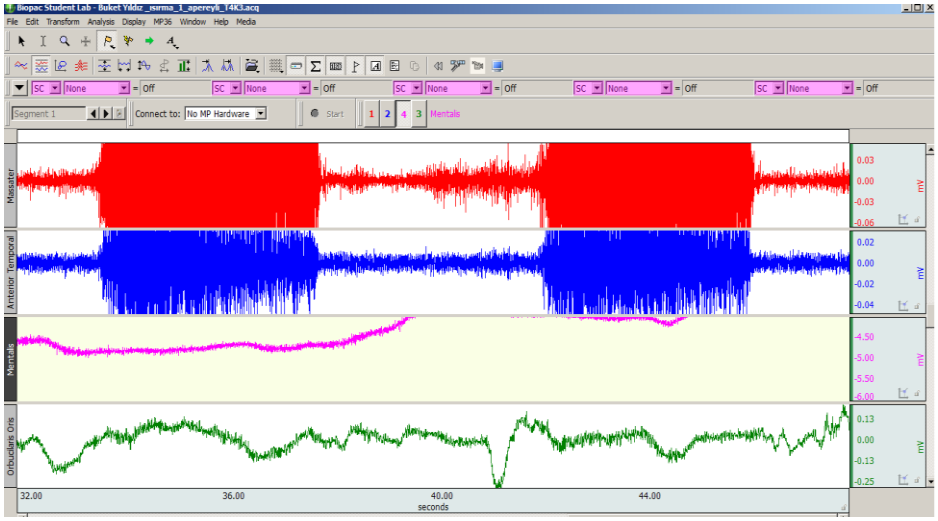

Figure 2.14 Jaw closing muscle EMG signal.

2.12 EMG Signal Processing

EMG signals aren't periodical and deterministic signals. In other words EMG signals' selected in any time period statistical behaviours are not same exactly. Because these signals don't repeat themselves and they cannot represent EMG signals obtained from all of a single mathematical expression recording time [45]. Some information can be gained from time domain in signal processing but it will be need frequency analysis for more information. For that reason the Fourier analysis can be exemplified to the used method. Fast Fourier Transform (FFT) is a frequently used method to indentify saved signals' frequency spectrum during the contraction performed at certain times [16]. But EMG signals are non-stationary signals in terms of frequency, amplitude and wave form [15]. So it's certain that using classic methods as the Fourier Transformation (FT) isn't appropriate to process these signals. Short Time Fourier Transform (STFT) was developed in order to be applicable FT to the non-stationary signals. In STFT the signal is divided into small windows and each of the dived windows are accepted as stationary. The only problem in STFT is to perform a good dissolvability in time-scale, in frequency scales the dissolvability is at poor levels at the end of the STFT realized with time-scale and narrow windows. On the other hand when the window is expanded it is observed improvement in frequency dissolvability, in time-scale the dissolvability decreases. For that reasons the Wavelet Transform (WT) was implemented to obtain

feature from the EMG signals in order to make real the most efficient analysis. WT, which includes scale concept providing the time-frequency determination, is quite appropriate for non-stationary signals [24].

CHAPTER 3

MATERIAL AND METHOD

(3.6)

Aim of the thesis is apparatus's Antemia the mesatal, orbicularis oris and mentalis muscles movement analysis which is caused in effect of electromyogram signals will be calculated parameters. To evaluate this purpose we collect 15 children EMG record. Those children age was 8-14. EMG signals were recorded from mesatal, orbicularis oris and mentalis muscles. The most common features to evaluate the muscle fatigue in literature are increasing of amplitude in time domain and transition from high frequency to low frequency in frequency domain. MF was evaluated with these features which can compute from EMG signals. The EMG recording are made of maximal voluntary cleanching, with the subjects sitting upright and dental relax chair. In order to obtain features power spectral density (PSD), which provides analyzing of non-stationary signals like EMG was used to compute the features scientifically statistical analysis was done.

3.1 Recording Procedure for Electromyogram Signals

After ethical approval was received from Istanbul çapa hospital, 4 subjects that 15 of the them to be children are recruited. These patients have teeth jaw problem. The age range is between the 8 – 14. During the EMG signals were recorded simultaneously from the mesatal, orbicularis oris and mentalis muscles. The demographic information about the patient and experimental details are given in Table 3.1.

Table 3.1 Demographic information and experimental details

Hospital	Istanbul Capa hospital
Muscles	1. masseter 2. temporalis 3. orbicularis oris and 4. mentalis
EMG signal device	Biopac system ,MP36R
Contraction types	1. Suction 2. Swallowing 3. Squeezing
The number of patient	15
Age	Children (8 ± 14)

Figure 3.1 The mesatal, orbicularis oris and mentalis electrode connectin.

In our experiments three type contractions were analyzed, they are Suction, swallowing, squeezing. During the mouth muscle contraction the length of contraction or muscle remains stable but the muscle shape has changed. On the other hand during the Suction,

swallowing, squeezing contraction the length of contraction has changed but the muscle remains stable.

Before the experiment and its reasons were told clearly to the patient. In the experiment time the Suction, swallowing, squeezing muscle, keeping body stable as possible as was asked. First of all the relevant regions were cleaned off with biomedical materials in order to remove sediment and the layer of skin. Then EMG electrodes and canbles were placed on the muscle right place. mesatal, orbicularis oris and mentalis muscles surface electrodes have been placed on the muscles which were located by examining manually. And amidst them. The reference electrode has been positioned on the temporalis bone of the skeleton muscle.

In order to record EMG signals the biopac device (figure 3.2), which can record all four signal simultaneously was used.

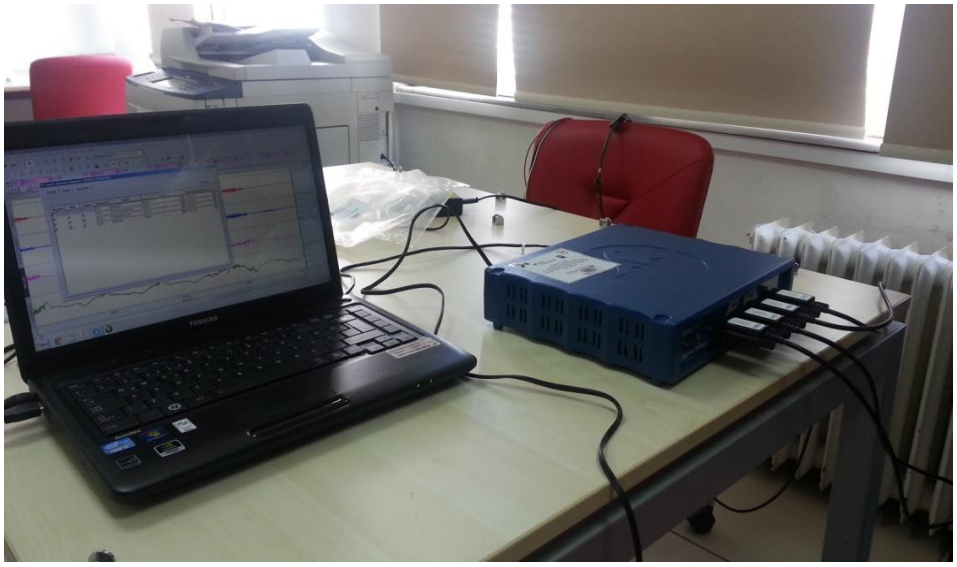

Figure 3.2 Biopac device setting.

For the Suction experiment, it was asked from children suction four times. Sample photos from Suction, contraction experiments are shown in figure (3.3).

Figure 3.3 Suction contraction experiment

For the, swallowing, contraction experiment it was asked from children swallowing three times. During the exercises EMG signals were recorded simultaneously. Sample photos from swallowing contraction experiments are shown in figure (3.4).

Figure 3.4 Swallowing contraction experiment

3.2 Treatment for children from 8 to 14 years with a developing malocclusion

Melocclusions is a trabel that refrs to the incorrect relation between the teeth of the two dental arches and misaligment of teeth. Most orthodontic techniques treat only the dental component. Some treat Tooth and Jaw. The Myofunctional component is most often ignored. This can slow treatment and be the cause of relapse. The Pre-Orthodontic TRAINER¨ allows treatment of the 3 components of a malocclusion. The pre-Orthodontic TRAINER¨ is a Combined Functional and Tooth Guidance Appliance developed from the need for a more comprehensive early treatment. In many Orthodontic cases, tongue position and incorrect swallow is a major cause. The Trainer has a tongue tag for proprioceptive location of the tongue tip into its correct resting position. The child learns where this position is with the Trainer in place and this acts as a "reminder" where this "spot" is. The Tongue guard prevents a tongue thrust swallow when in place, which is a position "training" process for the tongue.

Melocclusions can be divided into Three types called

- Class I
- Class II
- Class III

Class I: It refers to cases where teeth are to crowded and unattractive.

Class II: It Refers to cases where the lower jow is placed behind the upper jaw.

Class III: It refers to cases where to the upper jaw is placed behind the lower jaw.

Figure 3.5 K2 appliance

In this thesis work fort the class II we used the appliances. The aim of this functional appliances are early treatment of malocclusion, orthopaedic effects on the bone allowing for the correction of skeletal malocclusions not possible with dentally fixed appliances. General disadvantages are lack of ability to align the teeth, plus complex and expensive construction. The more the appliances are developed to improve their performance, the more prone they are to breakage and poor compliance. Furthermore, despite their name, few functional appliances do not have significant effects on the soft tissue. Correction of tongue thrusting, reverse swallowing, oral habits and mouth breathing, all of which have been shown to greatly influence growth and dental alignment

Figure 3.6 Pre-Orthodontic with appliance ÇIKAR

From this need the pre-Orthodontic TRAINER¨ was developed as a definitive early treatment for the child 8-14 years - the ages when traditionally functional appliances work best. The intention was to produce an easy to use prefabricated device with the orthopaedic effects of a functional appliance, combined with a tooth guidance system, plus an unique myofunctional training feature. The product does not require manufacture in the laboratory and is made in a universal size for all children 6-14 years (mixed dentition stage), allowing orthodontic treatment to be implemented earlier and at lower cost. The application of a tooth guidance into a functional appliance overcomes one of the major disadvantages of other functional appliances.

4.1 RESULTS AND DISCUSSION

When we look at the EMG results there are a diffrance between with appliances and without appliances.The power spectral density (PSD) is commonly used for frequency domain analysis of the surface EMG.when the herbest is placed in with appliances, the maxımum PSD value is getting by MATLAB EMG recorded during suction, swallowing, squeezing from 3 subject the treatment, activity of anterior temporal, mental, and masseter muscles was decreased and orbicularis oris activity was increased

The total variation is calculated using a simple formula which is given by as follow:

$$= \frac{result\ for\ with\ appliances - result\ for\ without\ appliances}{result\ for\ with\ appliances} \times 100$$

When we looked to the both result, the most common thing is energy of the PSD signals, between the appliances and without appliances. The maximum PSD value and the area under power spectral density signals exibit same variation. SO this result it can be seened that the massater, anterior temporal, mental, and masseter muscles are less tightened from the jaw closing activity when the herbast appliance is used. The present study of a sample of 15 children is designed to gain some information on the effect of treatment with a functional massater. This 15 children results show that the tightening ability of the massater, anterior temporal, mentalis and orbulical oris muscles is reduced by the herbast appliances. As a same time scientific solutions to the problems about usage time of apparatus such herbst and develop an asusual program to find out the time duration of the treatment.the total size of the muscle that the main activity is recorded it should be increased. This kind of therapy must be longitudinal thus the recording result of the EMG signal maybe periodical.

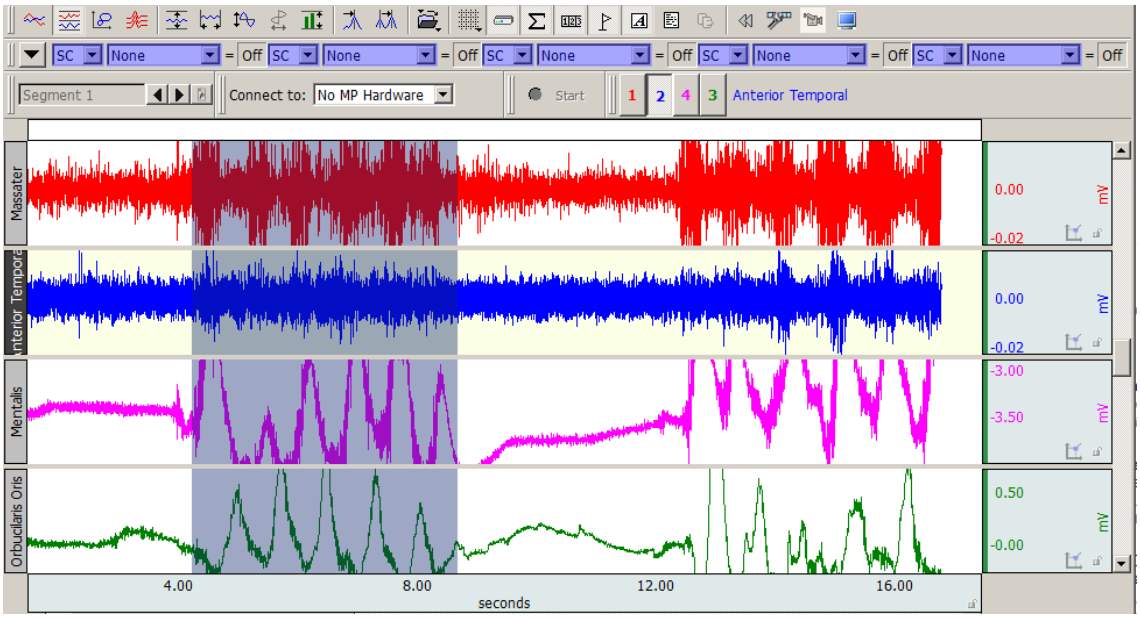

Figure 4.1 A sample graph and its slope for EMG

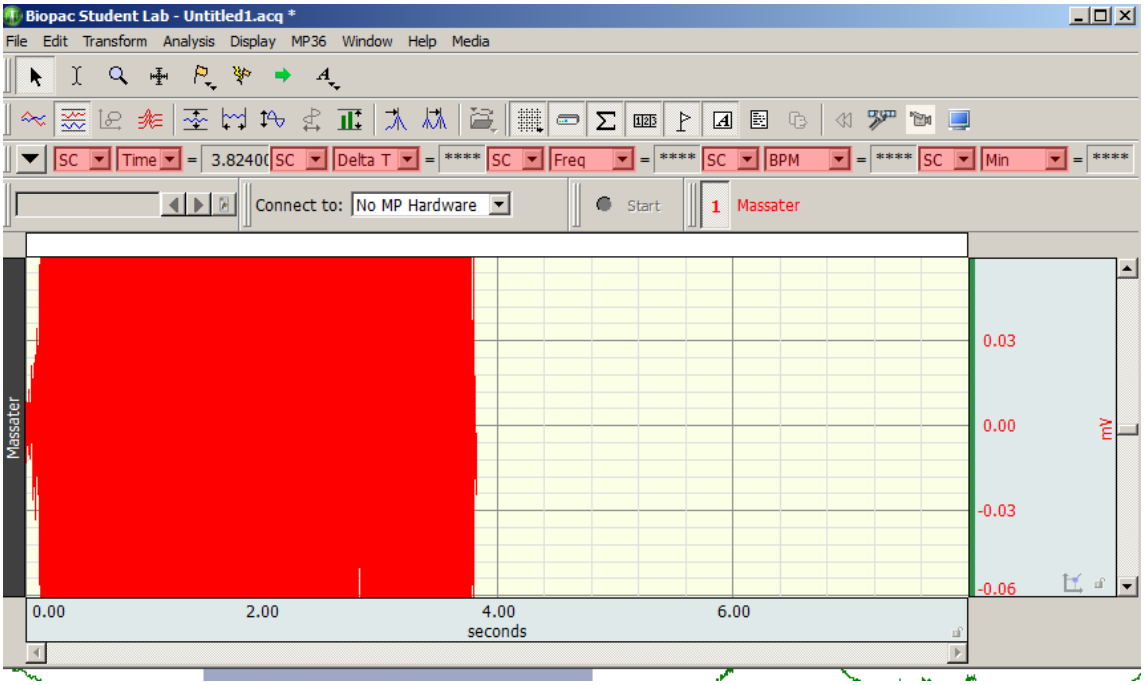

Figure 4.2 A sample MASSATER graph and its slope for EMG2

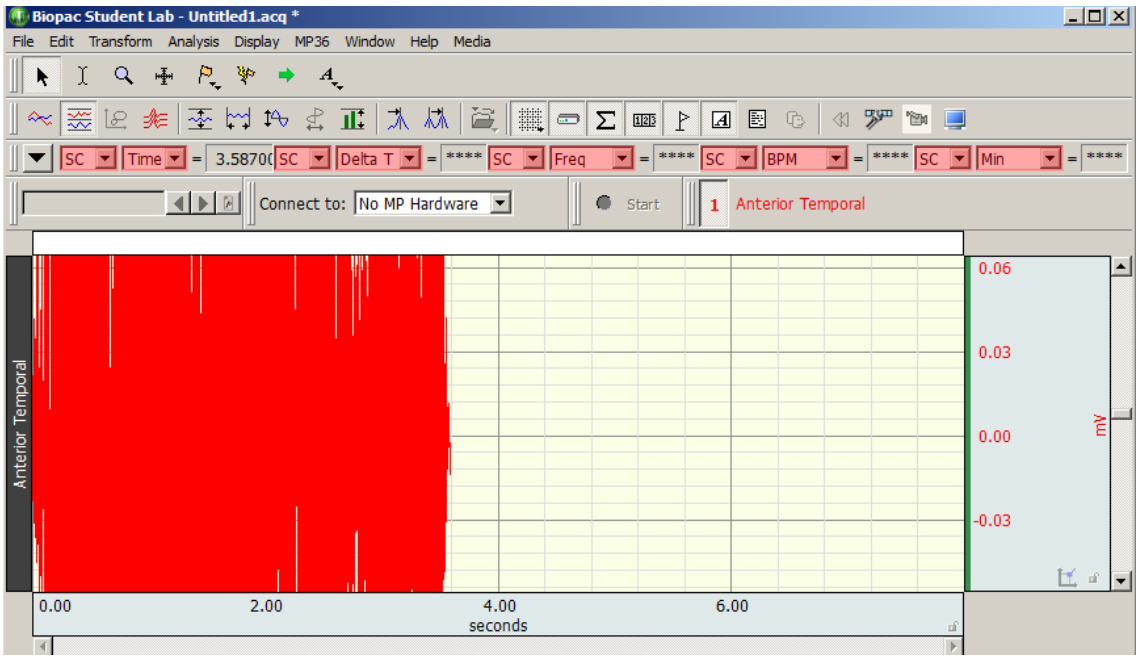

Figure 4.3 A sample ANTERİOR TEMPEROLİS graph and its slope for EMG1

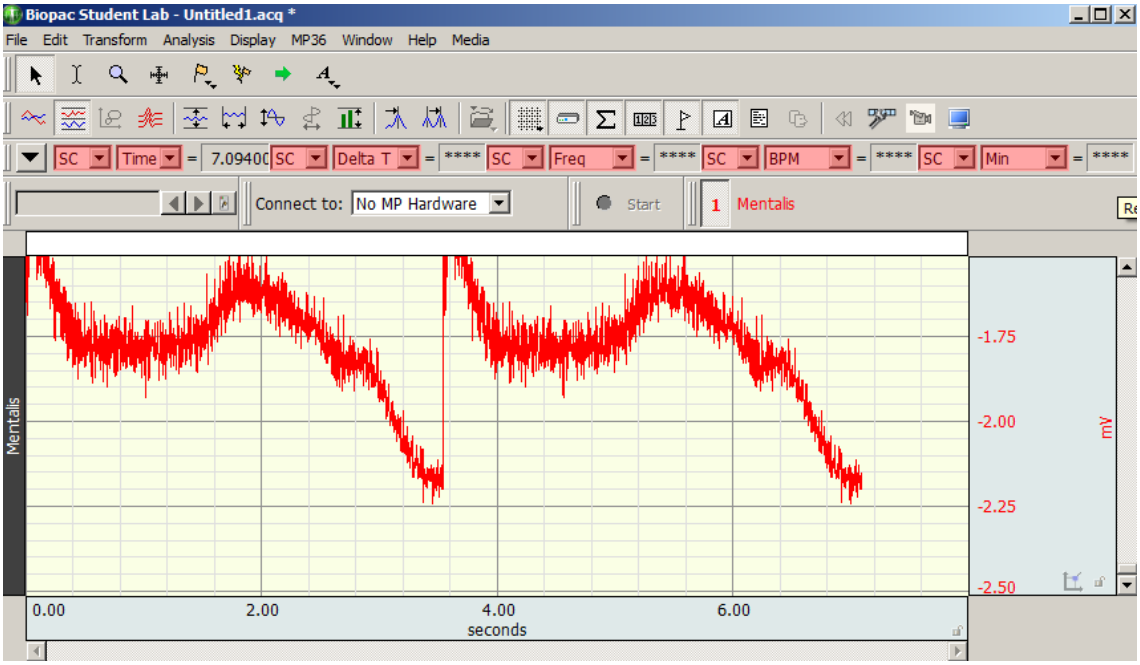

Figure 4.4 A sample MENTALİSH graph and its slope for EMG4

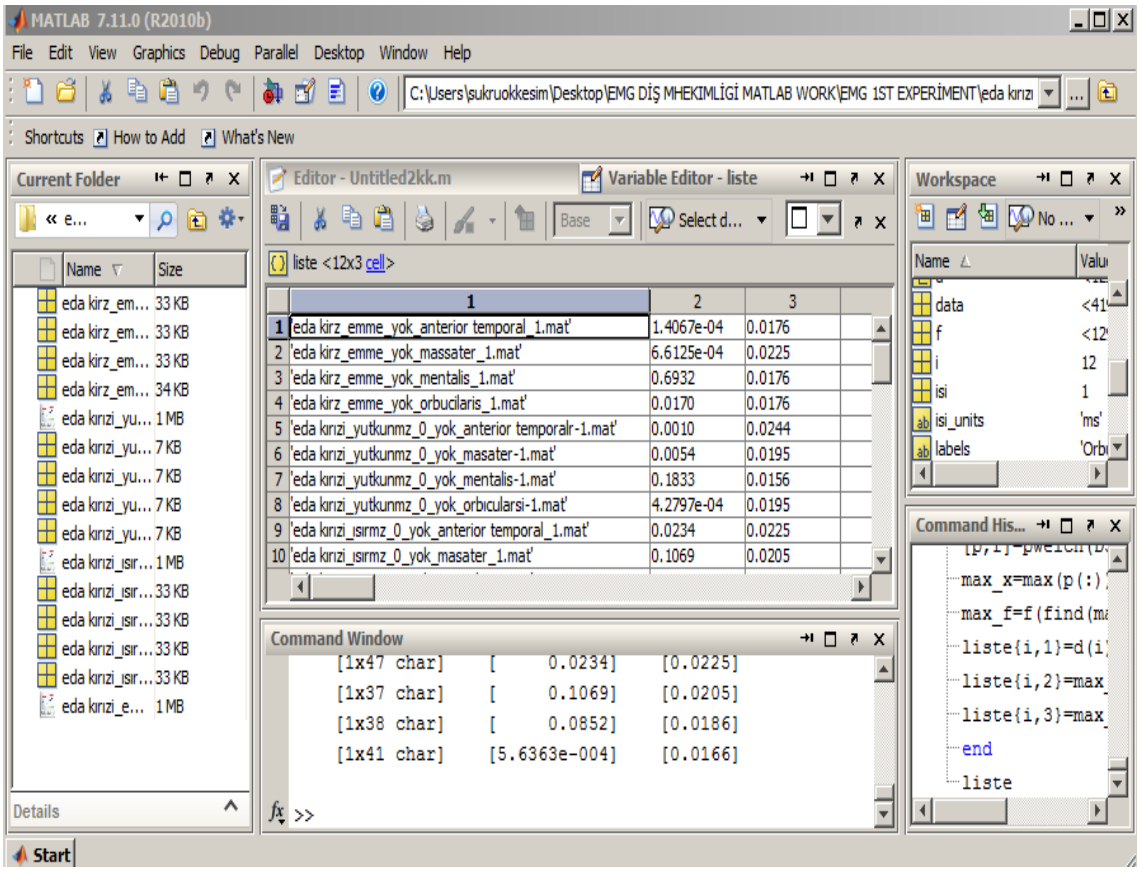

Figure 4.5 A sample MATLAB PROGRAM for EMG signals

Table 4.1

Value of the Max PSD feature of 10 patient for **Suction** activity.

Patient	Without appliance (Pre-treatment) Trainer group			
	Suction Max PSD Signals			
	Masseter	Anterior temporalis	Orbicularis oris	mentalis
1	0.01900	0.01620	0.01950	0.01460
2	0.09500	0.03000	0.01200	0.06450
3	0.08300	0.00343	0.00490	0.09930
4	0.08850	0.09300	0.01620	0.01560
5	0.01440	0.01850	0.00370	0.00121
6	0.08100	0.00410	0.00218	0.03470
7	0.00309	0.00307	0.00200	0.00950
8	0.00900	0.00200	0.00673	0.02300
9	0.01920	0.00153	0.01200	0.00203
10	0.01200	0.02230	0.04180	0.00827
Mean ± Std				

Table 4.2

Value of the Max PSD feature of 10 patient for **Suction** activity.

Patient	With appliance At the end of 3 months(Post-treatment) **Trainer group**			
	Suction Max PSD Signals			
	Masseter	Anterior temporalis	Orbicularis oris	mentalis
1	0.00720	0.00104	0.00010	0.00120
2	0.00770	0.00530	0.00090	0.00340
3	0.00560	0.01500	0.00020	0.00360
4	0.00430	0.00440	0.00010	0.00010
5	0.00760	0.00390	0.00120	0.00400
6	0.00380	0.00274	0.00270	0.00110
7	0.000320	0.00810	0.00200	0.00040
8	0.01080	0.00712	0.00610	0.00160
9	0.00520	0.00630	0.00100	0.00041
10	0.00110	0.00430	0.00140	0.00050

Table 4.3

Value of the Max PSD feature of 10 patient for **Swallowing** activity.

Patient	Without appliance (Pre-treatment) **Trainer group**			
	Swallowing Max PSD			
	Masseter	Anterior temporalis	Orbicularis oris	mentalis
1	0.00411	0.00275	0.00543	0.00052
2	0.00590	0.03100	0.00380	0.00043
3	0.00960	0.00024	0.00030	0.00059
4	0.00885	0.00930	0.00016	0.00015
5	0.00758	0.00727	0.00319	0.00420
6	0.00020	0.00368	0.00202	0.00021
7	0.00349	0.00266	0.00012	0.00620
8	0.00011	0.00060	0.00023	0.00010
9	0.00156	0.00245	0.00220	0.00105
10	0.00200	0.00012	0.00107	0.00640

Table 4.4

Value of the Max PSD feature of 10 patient for **Swallowing** activity.

Patient	With appliance At the end of 3 months(Post-treatment) **Trainer group**			
	Swallowing Max PSD			
	Masseter	Anterior temporalis	Orbicularis oris	Mentalis
1	0.00031	0.00013	0.00015	0.00056
2	0.00074	0.00056	0.00030	0.00068
3	0.00045	0.00091	0.00090	0.00059
4	0.00030	0.00051	0.00015	0.00080
5	0.00017	0.00040	0.00014	0.00010
6	0.00030	0.00023	0.00015	0.00040
7	0.00067	0.00090	0.00040	0.00015
8	0.00073	0.00012	0.00010	0.00022
9	0.00018	0.00030	0.00012	0.00033
10	0.00230	0.00028	0.00017	0.00030

Table 4.5

Value of the Max PSD feature of 10 patient for **Squeezing** activity.

Patient	Without appliance (Pre-treatment) Trainer group			
	squeezing Max PSD			
	Masseter	Anterior temporalis	Orbicularis oris	mentalis
1	0.00310	0.07800	0.00174	0.00028
2	0.00043	0.02300	0.00019	0.07640
3	0.00343	0.07900	0.00032	0.09600
4	0.00565	0.00060	0.00320	0.07560
5	0.00890	0.00020	0.00019	0.00023
6	0.00030	0.00560	0.00140	0.00010
7	0.00021	0.00120	0.00115	0.00420
8	0.00068	0.00023	0.00018	0.00763
9	0.00012	0.00780	0.00662	0.00042
10	0.00107	0.00010	0.00034	0.00025

Table 4.6

Value of the Max PSD feature of 10 patient for **Squeezing** activity.

Patient	With appliance At the end of 3 months(Post-treatment) Trainer group			
	squeezing Max PSD			
	Masseter	Anterior temporalis	Orbicularis oris	mentalis
1	0.00063	0.00115	0.00224	0.00036
2	0.00089	0.00530	0.00012	0.00067
3	0.00010	0.00043	0.00050	0.00812
4	0.00020	0.00020	0.00062	0.00160
5	0.00016	0.00011	0.00025	0.00093
6	0.00015	0.00070	0.00060	0.00036
7	0.00090	0.00051	0.00045	0.00052
8	0.00071	0.00056	0.00067	0.00016
9	0.00030	0.00380	0.00041	0.00072
10	0.00140	0.00042	0.00085	0.00043

4.2. CONCLUTION

Orthodontists need to inform patient of different appliance alternatives, extent of expected success during the consultation stages .however they still couldn't predict the degree of the treatment success. Power spectral density (PSD), energy of the power spectral density and area under the power signal maybe an index to evaluate of the effect of these appliances. There are many papaers proved that Jaw closing in children with class malocclusion can be evaluated by EMG signals. However there are no standardized criteria or scoring system for quantitative evaluation. That's why researchers still go on to analyze the orthodontic muscle system. In our study, Jaw closing muscle fatigue is happened during contractions is evaluated by parameters calculated from surface EMG signals quantitively, in this fatigue types. For this aims, EMG recorded during suction, swallowing, squeezing from 3 subjects. The obtained results show that fatigue that happened from withour treatment and 3 months later treatment recording contractions can be evaluated by EMG signals.

In our study, there is a movement that has negative effects on the received signals; EMG signal to noise ratio (SNR) value which is smaller than the noise has been spawned. This can be analyzed by EMG signals but the analysis of isometric contraction is easier. In literature, there are a lot of studies about EMG. In our study we try to decrese to the noice ratio during the EMG recording. The results from the present EMG follow-up study of a sample with Class II division 1 malocclusion with incompetent lips indicated that treatment with appliance showed a positive influence. Also, our further aim was the evaluation of quantitative data of the more the appliances are developed to improve their performance. (3.9)

CONCLUSIONS AND DISCUSSION

Orthodontists need to inform patient of different appliance alternatives, extent of expected success during the consultation stages .however they still couldn't predict the degree of the treatment success. Power spectral density (PSD), energy of the power spectral density and area under the power signal maybe an index to evaluate of the effect of these appliances. There are many papaers proved that Jaw closing in children with class malocclusion can be evaluated by EMG signals. However there are no standardized criteria or scoring system for quantitative evaluation. That's why researchers still go on to analyze the orthodontic muscle system. In our study, Jaw closing muscle fatigue is happened during contractions is evaluated by parameters calculated from surface EMG signals quantitively, in this fatigue types. For this aims, EMG recorded during suction, swallowing, squeezing from 3 subjects. The obtained results show that fatigue that happened from withour treatment and 3 months later treatment recording contractions can be evaluated by EMG signals.

In our study, there is a movement that has negative effects on the received signals; EMG signal to noise ratio (SNR) value which is smaller than the noise has been spawned. This can be analyzed by EMG signals but the analysis of isometric contraction is easier. In literature, there are a lot of studies about EMG. In our study we try to decrese to the noice ratio during the EMG recording. The results from the present EMG follow-up study of a sample with Class II division 1 malocclusion with incompetent lips indicated that treatment with appliance showed a positive influence. Also, our further aim was the evaluation of quantitative data of the more the appliances are developed to improve their performance.

REFERENCES

1. *Deluca, C., Towards understanding the EMG signal ch 3 of muscles alive. Williams & Wilkonson, Baltimore, 1978.*
2. *Tarata, M.T., Mechanomyography versus electromyography, in monitoring the muscular fatigue. Biomed Eng Online, 2003. 2(3).*
3. *Öberg, T., L. SANDSJö, and R. KADEFORS, Subjective and objective evaluation of shoulder muscle fatigue. Ergonomics, 1994. 37(8): p. 1323-1333.*
4. *Soo, Y., et al. Quantitative estimation of muscle fatigue using surface electromyography during static muscle contraction. in Engineering in Medicine and Biology Society, 2009. EMBC 2009. Annual International Conference of the IEEE. 2009. IEEE.*
5. *Van De Graaff, K.M., Human anatomy. 2002: McGraw-Hill New York.*
6. *http://education-portal.com/academy/lesson/what-are-tissues-types-lesson-quiz.html#lesson.*
7. *Kadefors, R., E. Kaiser, and I. Petersen, Dynamic spectrum analysis of myo-potentials and with special reference to muscle fatigue. Electromyography,*
8. *Kimura, J., Electrodiagnosis in diseases of nerve and muscle: principles and practice. 2013: Oxford university press.*
9. *Guyton, A.C., Textbook of medical physiology. Vol. 762. 1971: Saunders Philadelphia.*
10. *Iaizzo, P. and R. Pozos, Analysis of multiple EMG and acceleration signals of various record lengths as a means to study pathological and physiological oscillations. Electromyography and clinical neurophysiology, 1991. 32(7-8): p. 359-367.*
11. *Oka, H. Estimation of muscle fatigue by using EMG and muscle stiffness. in Engineering in Medicine and Biology Society, 1996. Bridging Disciplines for Biomedicine. Proceedings of the 18th Annual International Conference of the IEEE. 1996. IEEE.*
12. *lation of baseline-fluctuation in needle EMG recordings. Computer methods and programs in biomedicine, 2006. 81(1): p. 79-93.*
13. *Reaz, M., M. Hussain, and F. Mohd-Yasin, Techniques of EMG signal analysis: detection, processing, classification and applications. Biological procedures online, 2006. 8(1): p. 11-35.*
14. *Usumez S, Uysal T, Sari S, Basciftci F, Karaman A, Guray E "The Effects of Early Preorthodontic Trainer Treatment on Class II, Division 1 Patients" Angle Orthod., 74, No. 5, pp. 605–609, 2003*

15 *D. O. Tosello, M. Vitti, F. Berzin, "EMG activity of the orbicularis oris and mentalis muscles in children with malocclusion, incompetent lips and atypical swallowing—Part II" J. Oral. Rehab. 26; 644–649, 1999*

16 *J. Kimura, "Electrodiagnosis in disease of nevre and muscle: principles and practice", Philadelphia, F. A. Davis, 1983*

17. *Kim, R. B. Hanson, T. L. Abell, and J. R. Malagelada. "Effect of inhibition of prostaglandin synthesis on epinephrine-induced gastroduodenal electromechanical changes in humans". Mayo Clinic Proc. 64:149–157, 1989.*

18 *Rodriguez I., Malanda A., Gila L., Navallas J., Rodriguez J. "Filter design for cancellation of baseline – fluctuation in needle EMG recordings", Comput. Meth. and Prog. in Biomed. 81: 79-93, 2006.*

19. *Zhang Y., Wang Y., Wang W., Liu B., "Doppler ultrasound signal denoising based on wavelet frames", IEEE Trans. Ultrason. Ferroelectr. Frequency Control, 48, 709–716, 2001.*

20. *Girault J. M., Kouame D., Ouahabi A., Patat F., "Micro-emboli detection: an ultrasound Doppler signal processing view point", IEEE Trans. Biomed. Eng., 47, 1431–1439, 2000.*

21. *Hu, G., "Digital Signal Process—Theory, Algorithm and Actualization", Qinghua Univr. Press, China, 1998.*

22. *Cheng, J., Lan C., "Experimental studies on sound and vibration of a two-tone" Chinese Peace Bell, Journal of Sound and Vibration, 261, 351–358, 2003.*

23. *Alves, N. and T. Chau, Stationarity distributions of mechanomyogram signals from isometric contractions of extrinsic hand muscles during functional grasping. Journal of electromyography and kinesiology, 2008. 18(3): p. 509-515.*

24. *Barry, D., Vibrations and sounds from evoked muscle twitches. Electromyography and clinical neurophysiology, 1992. 32(1-2): p. 35.*

25. *Iaizzo, P. and R. Pozos, Analysis of multiple EMG and acceleration signals of various record lengths as a means to study pathological and physiological oscillations. Electromyography and clinical neurophysiology, 1991. 32(7-8): p. 359-367.*

26. *Oster, G. and J.S. Jaffe, Low frequency sounds from sustained contraction of human skeletal muscle. Biophysical journal, 1980. 30(1): p. 119-127.*

27. *Akataki, K., et al., Age-related change in motor unit activation strategy in force production: A mechanomyographic investigation. Muscle & nerve, 2002. 25(4): p. 505-512.*

28. *Enoka, R.M. and J. Duchateau, Muscle fatigue: what, why and how it influences muscle function. The Journal of physiology, 2008. 586(1): p. 11-23.*

29. *K.C. Disselhorst, J. Silny, G. Rau, "Estimation of the relationship between the non-invasively detected activity of single motor units and their characteristic*

pathological changes by modeling", J. Electromyogr. Kinesiol. v. 8, p. 323–335, 1998.

30. *C. Frigo, M. Ferrarin, W. Frasson, E. Pavan, R. Thorsen, "EMG signals detection and processing for online control of functional electrical stimulation", J. Electromyogr. Kinesiol. v. 10, p. 351–360, 2000.*

31. *R.F. Kleissen, J.H. Buurke, J. Harlaar, G. Zilvold, "Electromyography in the biomechanical analysis of human movement and it clinical application", Gait Posture, v. 8, p. 143–158, 1998.*

32. *M.J. Zwarts, G. Drost, D. Stegeman, "Recent progress in the diagnostic use of surface EMG for neurological diseases", J. Electromyogr. Kinesiol., v. 10 p. 287–291, 2000.*

33. *Rodríguez-Carreño, I., et al., Filter design for cancellation of baseline-fluctuation in needle EMG recordings. Computer methods and programs in biomedicine, 2006. 81(1): p. 79-93.*

34. *Lindstrom, L.H. and R.I. Magnusson, Interpretation of myoelectric power spectra: a model and its applications. Proceedings of the IEEE, 1977. 65(5): p. 653-662.*

35. *Reaz, M., M. Hussain, and F. Mohd-Yasin, Techniques of EMG signal analysis: detection, processing, classification and applications. Biological procedures online, 2006. 8(1): p. 11-35.*

36. *C S Sherrington, "Remarks on some aspects of reflex inhibition" Proc. R. Soc. Lond. B, p. 97 519, 1925.*

37. *M., Massler "The oral screen". J Dent Child, v. 19, p. 100-106, 1952.*

38. *F. Kraus "Vestibular and oral screens", Trans Eur Orthod Soc, v. 32, p. 217-224, 1956.*

39. *E. A. Cheney, "Treatment planning and theraphy in the mixed dentition", Am, J. Orthod., v. 49, p. 568- 580, 1963.*

40. *uf S, Baltromejus S, Pancherz H. Effective condylar growth and chin position changes in activator treatment: a cephalometric roentgenographic study. Angle Orthod. 2001;71:4–11.*

41. *Basciftci FA, Uysal T, Bu¨yu¨kerkmen A, Sarı Z. The effects of activator treatment on the craniofacial structure of Class II division 1 patients. Eur J Orthod. 2003;25:87–93.*

CURRICULUM VITAE

Name Surname:	**Serkan ARI**
Place and Date of Birth:	**1988**
Address:	**Fatih University, 34500 Büyükçekmece, İstanbul**
E-Mail:	**serkan.ari@hotmail.com**