**RESEARCH ARTICLE**

# Electromyography (EMG) Assessment of Masticactory Muscles in evaluation of Splinting and exercise of Temporomandibular Disorders (TMD)

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**ABSTRACT**

This study assed activity of masticatory muscles by electromyography with comparing the efficacy of exercise program and different splinting methods of anterior disc dislocation. Twenty patients with anterior disc dislocation without reduction divided into two groups; one for centric splint(n=10)& the other one for the anterior repositioning splint(n=10). It was found that, there was a statistically significant decrease in mean joint pain scores through all periods in the both treatment and statistically significant difference between duration and amplitude of motor unit of anterior temporal and Masseter muscles of the two groups. There was no a significant difference between duration and amplitude of motor unit of anterior temporal and Masseter muscles of the two groups before and after treatment at three months with highly significant difference of the two groups before and after treatment at six months, on MRI, there was marked reduction of joint effusion of temporomandibular joint in both groups.

**Keywords:** Temporomandibular joint, exercise program, splint, electromyography, magnetic resonance image (MRI).

## INTRODUCTION

Anterior disc displacement is a common subtype seen in temporo-mandibular disorders (TMD) patients. It may cause mandibular movement disorders, such as clicking of joint, intermittent closed lock, limitation of mouth opening. These disorders may affect the life qualities of patients (Guo *et al*., 2016). Internal derangement (ID) of the TMJ may be defined as a disturbance in normal anatomic relationship between disc and condyle that interferes with the smooth movement of the joint and causes momentary catching, clicking, popping or locking (Tanaka et al., 2002). Temporomandibular joint (TMJ) dislocation is an

uncommon but debilitating condition of the facial skeleton. The condition may be acute or chronic. Acute TMJ dislocation is common in clinical practice and can be managed easily with manual reduction. Chronic recurrent TMJ dislocation is a challenging situation to manage. Treatment is usually done by injecting sclerosing agent into the joint capsule to produce scarring and contracture of the ligaments. A capsulorrhaphy may be performed, whereby the ligaments are shortened surgically. If the cause of the chronic dislocation is an abnormally tense or shortened lateral pterygoid muscle, a myotomy is performed (Nareh *et al*., 2015).

EMG evaluations of the masticatory muscles constitute important resource to help the differential diagnosis and supply substantial surveying and management of suggested therapy (kawazoe *et al*., 1980).Muscle fatigue thought to be the important factor causing pain in patient with TMD. It is attributed to chronic hyperactivities or chronic disuse of the masticatory muscles **(**Dimitrova and Dimitrov,2003). The aim of this study was to assess function of masticatory muscle by using electromyography and compare the final outcome of treatment of anterior disc displacement by using centric and anterior repositioning splint and exercise program.

## MATERIAL AND METHODS

### Patients and Methods

This study was done at Alazhar University hospitals from February 2015 to February 2016 in cooperation of rheumatology, physical medicine department & maxillofacial surgery department, Dental medicine.

**Inclusion criteria:**

Only subjects presenting a clear-cut clinical diagnosis of ADDWoR were included:

1-A complaint of pain with mouth opening and /or with chewing difficulty.

2-Pain and tenderness of the TMJ and the masticatory muscles on the affected side.

3-Limitation of mouth opening with deflection and limited lateral movement of the incisors

4-Patients had to present at least one antagonistic molar contact on each side.This to ensure support of the splint by natural teeth.

5-Age of the patients ranged between 20-35 years of age.

6-Confirmation of clinical examination on MRI.

**Exclusion criteria:**

Patients were excluded from the study if they had congenital malformation in TMJ region, had previous surgical treatment in TMJ or had any current systemic disease.

**Group (1):** Ten patients were treated by centric splint.
**Group (2):** Ten patients were treated by anterior repositioning splint (ARS).
All patients were submitted to the following procedures:

**I-Clinical examination**

*1- Visual analogue scaling for pain:* Patient was asked to mark their pain (during chewing, mandible movement, and rest position) level on a visual analogue scale (VAS) (0 - 100 mm VAS).

*2*-They were given an exercise program consisting of slow active and passive mouth opening and closing exercises, isometric mouth exercises, mouth stretching exercises, and resistive mouth exercises, with each exercise to be performed for 6 seconds with 10 repetitions. The exercises were performed twice a day. Clinical examination was done before treatment (splint therapy) and at 15, 30, 90, and 180 days post treatment.

**II-Radiographic evaluation:** Orthopantogram was performed for all patients before the treatment to exclude any patient with osseous pathosis

**III-Electromyography evaluation:** The electromyography unit used in this study present in rheumatology, Physical Medicine and rehabilitation Department, Sayed Galal Univerity Hospital .

Registrations were obtained from right and left masseter and anterior temporalis muscles. Recordings were performed before treatment, at 3 months and 6 months post treatment.

**Electrodes position**: Bipolar surface electrodes with 14mm inter-electrode distance were used for the registrations. Each subject held the ground electrode in the neck. In all subjects the electrodes were placed in a standardized position on the most active part of the jaw muscles as the subject clenched. In themasseter muscle the electrodes were placed 1 cm behind the palpated anterior border in the area of greatest distension, parallel to the main direction of the fibers.In the anterior temporalis muscle the upper

electrode was placed just in front of the anterior border of the hairline in the area of greatest lateral distension . The lower electrode was placed caudal to the first electrode, parallel to the main direction of the fibers.

**Technique of electromyography:** EMG was done by (Nihon Kohden, made in Japan2006, model JB-942BK).Penetration of the muscle being tested with bipolar electrode to depth of 0.5-1cm was done. The patient asked to clench with the teeth in centric occlusion. MU discharge roughly 10 times each second during muscle contraction, this give one MUAP waveform during each 100 msec sweep interval 10msec/division. The peak to peak amplitude of each muscle was then recorded (Microvolt). The patients were instructed to relax between each movement with jaw in the rest position.

**IV-Magnetic resonance image:** Magnetic resonance image was performed at sayed Galal University Hospital with MRI machine of 1.5 tesla (Siemens Magnetom vision). 7.5cm surface coil was used to examine the TMJ bilaterally at the same time. Images were performed before treatment and 6 months after treatment.

**Splints fabrication:** Fabrication of splints was don at the maxillofacial surgery department Alazhar faculty of dental medicine and plastic surgery.

The finished splint was smooth with indentation on its occlusal surface that corresponds to the cusp tips and the incisal edges of the opposing dentition. For both groups the patients were instructed to wear the splint 24 hour a day except at meal time.

Magnetic resonance images were performed after 6 months of treatment to examine disc recapture.

**Statistical analysis:** Data were presented as means and standard deviation values. *Student's t-test* was used to compare between the two groups.

**Paired t-test** was used to study the changes by time in each group. The significance level was set at ***P≤ 0.05*** Statistical analysis was performed with SPSS 19.0® (Statistical Package for Scientific Studies)for Windows.

## RESULTS

In group I, the mean value of VAS during function was 70.0 before treatment, and 48, 33.5, 21.5, and 5.7 at 15, 30, 90, and 180 days post treatment respectively. In group II, the mean value of VAS during function was 70.3 before treatment, and 48.6, 33.9, 21.6, and 6.3 at 15, 30, 90 days post treatment respectively. There was no statistically significant difference between VAS of the two groups. But there was a statistically significant difference in mean VAS before and after treatment

**Table 1: Show changes in VAS in both groups before and after treatment.**

| Group Period | Centric splint group | | Anterior repositioning splint group | | *P*-value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| **Preoperative** | 70.0 | 4.7 | 70.3 | 5.1 | **0.826** |
| **15 day** | 48.0 | 9.7 | 48.6 | 9.9 | **0.908** |
| **30 day** | 33.5 | 8.1 | 33.9 | 8.1 | **0.220** |
| **90 day** | 21.5 | 6.6 | 21.5 | 6.6 | **0.914** |
| **180 day** | 5.7 | 2.4 | 6.3 | 2.7 | **0.208** |

**Table 2: Show *P* value of VAS in both groups at different treatment intervals.**

| | Mean difference | Preoperative – 15 day | Preoperative – 30 day | Preoperative – 90 day | Preoperative – 180 day |
|---|---|---|---|---|---|
| **Centric splint group** | ***P*-value** | 0.007* | 0.023* | 0.45* | <0.001** |
| **Anterior repositioning splint group** | ***P*-value** | 0.005* | 0.012* | 0.029* | 0.010** |

**:Significant at P ≤ 0.05* ***:Significant at P ≤ 0.01*

**Table (3) changes in EMG in both groups before and after treatment.**

| Muscle | Measurement | Group Peroid | Centric splint group | | Anterior repositioning group | | p-value |
|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | |
| Anterior Temporal | Amplitude | Preoperative | 122.0 | 21.8 | 120.4 | 20.6 | **0.001**** |
| | | 3 month | 324.5 | 37.2 | 323.2 | 36.0 | **0.001**** |
| | | 6 month | 818.9 | 131.6 | 816.6 | 130.6 | **0.001**** |
| | Duration | Preoperative | 15.8 | 3.2 | 16.4 | 3.1 | **0.001**** |
| | | 3 month | 8.8 | 0.3 | 8.8 | 0.4 | **0.001**** |
| | | 6 month | 3.9 | 0.6 | 3.9 | 0.6 | **0.001**** |
| Masseter | Amplitude | Preoperative | 124.5 | 18.0 | 127.5 | 15.7 | **0.001**** |
| | | 3 month | 329.8 | 44.78 | 330.3 | 45.2 | **0.001**** |
| | | 6 month | 829.2 | 116.7 | 820.4 | 107.7 | **0.001**** |
| | Duration | Preoperative | 15.9 | 3.2 | 16.4 | 2.7 | **0.001**** |
| | | 3 month | 8.8 | 0.4 | 8.8 | 0.4 | **0.001**** |
| | | 6 month | 3.8 | 0.6 | 3.9 | 0.6 | **0.001**** |

**:Significant at P ≤ 0.05* ***:Significant at P ≤ 0.01*

**Table 4: Show *P* value of EMG in both groups at different treatment intervals.**

| | | | Mean difference | Preoperative – 3 month | Preoperative – 6 month |
|---|---|---|---|---|---|
| Centric splint group | Anterior Temporal | Amplitude | ***P*-value** | 0.256 | <0.001** |
| | | Duration | ***P*-value** | 0.139 | <0.05 |
| | Masseter | Amplitude | ***P*-value** | 0.137 | <0.001** |
| | | Duration | ***P*-value** | 0.232 | <0.05 |
| Anterior repositioning splint group | Anterior Temporal | Amplitude | ***P*-value** | 0.289 | <0.001** |
| | | Duration | ***P*-value** | 0.226 | <0.05 |
| | Masseter | Amplitude | ***P*-value** | 0.126 | <0.001** |
| | | Duration | ***P*-value** | 0.216 | <0.05 |

**:Significant at P ≤ 0.05* ***:Significant at P ≤ 0.01*

**Magnetic resonance image:**

**Fig. (1): T1-weighted image in closed mouth position shows anterior disc displacement**

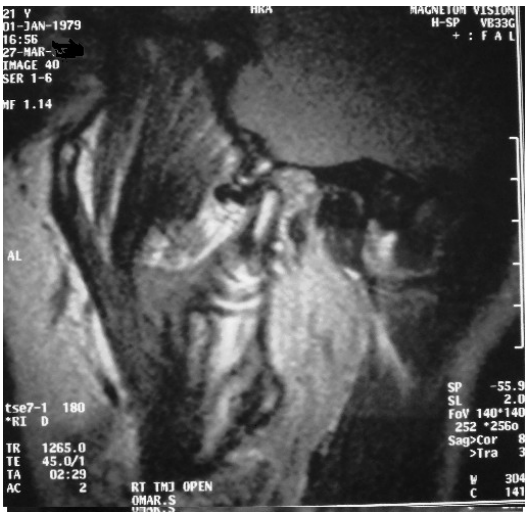


**Fig. (2): T2 weighted image in open position shows anterior disc displacement without reduction, no joint effusion**

through all periods in the two groups with highly significant difference at 180 days. Regarding the electromyography results (EMG); Mean and SD of the amplitude & duration of the motor unit potentials for both groups are collected in table (3).

In group I, the mean amplitude of Anterior temporal muscle was 122, 324.5, and 818.5 μv before treatment, and at 3, and 6 months after treatment respectively. The mean duration of masseter muscle was 15.8, 8.8, and 3.9 msec before treatment, and at 3, and 6 months after treatment respectively Fig. (tab3).

The mean amplitude of masseter muscle was 124.5, 329.8, and 829.2 μv before treatment, and at 3, and 6 months after treatment respectively. The mean duration of temporalis muscle was 15.9, 8.8, and 3.8 msec before treatment, and at 3, and 6 months after treatment respectively.

In group II, the mean amplitude of Anterior temporal muscle was 120.4, 323.2, and 816.6 μv before treatment, and at 3, and 6 months after treatment respectively. The mean duration of masseter muscle was 16.4, 8.8, and 3.9 msec before treatment, and at 3, and 6 months after treatment respectively.The mean amplitude of masseter muscle was 127.5, 330.3 and 820.4 μv before treatment, and at 3, and 6 months after treatment respectively. The mean duration of temporalis muscle was 16.4, 8.8, and 3.9 msec before treatment, and at 3, and 6 months after treatment respectively.

There was statistically significant difference between amplitude of motor unit of anterior temporal and Masseter muscles of the two groups .There was no a significant difference between amplitude of motor unit of anterior temporal and masseter muscles of the two groups before and after treatment at three months in the two groups . Also there was a highly significant difference between amplitude of motor unit of anterior temporal and masseter muscles of the two groups before and after treatment at six months in the two groups. In both groups there was marked reduction in joint effusion and decrease in the signal intensity of the retro-discal tissue (become pseudo-disc). The disc cannot be reduced into its normal physiologic relation with the condyle and the articular eminence in the both groups.

**DISCUSSION**

Patients with TMD usually presented with decreased amplitude of motor unit action potential (MUAP), this is compatible with myopathy that might result from a reduced number of muscle fibers and their degeneration and regeneration (Finter *et al*.,1998). The mastication muscles of adolescents with TMD, especially those with a greater severity of signs and symptoms, exhibit higher MNF and MDF of the electromyographic signal, indicating hyperactivity of these muscles while at rest and during maximum activity (leandro *et al*., 2013). The motor unit capable of producing larger forces post-treatment tends to have action potential with larger amplitude. Improvement in the masseter and temporalis MUAP parameters resulted from decreased loading of the muscles may be a factor in the therapeutic effect of the splint therapy (Chung *et al*.,2002).

In this study MRI scans have been the main imaging tool for diagnosis and determining disc position as it is considered the golden standard in diagnosis of TMD (Schellhas,1989). MRI clearly differentiates the soft tissue components of the TMJ. Also MRI is useful for demonstrating the positional relationship between the disc and the osseous components. Magnetic resonance signaling in the images helps to identify fluids associated with inflammation, effusion, capsulitis, hematoma, cyst, tumor (Schellhas,1989).

Patient was excluded from this study if they had congenital malformation in the TMJ, or any systemic disease or who were on medication to relive pain. Hard acrylic interocclusal appliances have been used for management of patient with TMD. It was recommended as it is conservative reversible treatment. The efficacy of the splint is thought to be due to several factors. First, an inhibitory effect of the occlusal support which results in reduction of pain and improvement of the joint symptoms where the reduction of the bite force is accompanied by reduction on the joint load. Second, all splints cause occlusal decoupling and this can cause reorientation of established neuromuscular reflex mechanisms.

Centric splint has shown to be effective in treatment of ADDWOR; however, anterior repositioning splint is recommended by some authors since the direction of pull of lateral pterygoid muscle is anterior and medial, in derangement the disc is usually dislocated forward

and inward. Conceptually, keeping the mandible forward with splint would recapture the normal disc condyle relation.

Among 20 patients with temporomandibular disorder 16 patients were of female gender and 4 patients were male. The higher incidence of TMD in women verified in this study agrees with findings of Al-Hassan *et al*. (1986) who observed the prevalence of women seeking treatment for TMD in relation to male. This is related to hormonal and constitution factor, and behavior or psychological status between sexes.

In the present study the use of both splints resulted in pain reduction. This result is comparable to those of previous investigation, especially with those of Schmitter *et al*. (2003).They found that both splints resulted in an improvement, whereas the centric splint users displayed slightly greater improvement. In group I and II there was a significant decrease in the joint pain and there is no statistical significant difference between both groups. This is in agreement with the study of Schmitter *et al*. (2003).

The current study showed that centric and anterior repositioning splints are effective in reducing pain that associated with TMD. However, there was no statistical significant difference between groups and centric splint provide slightly greater improvement. This in agreement with Schmitter *et al*. (2003), Williamson (2005), Le Bell and Forssell (1993) and Lundh *et al* . (1992). Sato *et al*. (1995) compared patients using a centric splint with a control group and they found no statistically significant differences between both groups. However, they described a success rate of 41.9 % for the natural course group and 55.0 % for centric splint group. Therefore the use of centric splint may reduce the number of the patients asking for surgical intervention. In our study the mean value of VAS of both groups (centric splint group and anterior repositioning group). This is in accordance with the study of Schmitter *et al*. (2003), Mongini *et al*. (1996) and Dowrkin and Massoth (1994).

Ekberg *et al*.(1996) there study based on self assessment of temporomandibular pain using the VAS over 10 weeks to determine the effect of stabilization splint in comparison with placebo splint in patient with temporomandibular disorder of arthrogenous origin. A significant decrease in the severity of TMJ pain was observed in the splint group, suggesting that the stabilization splint is effective in TMD of arthrogenous origin.

The current study shows that in both treatment groups there was a significant reduction in the electrical activities of the temporalis and the masseter muscles were found. There was no significant statistical difference between both treatment groups. When the activities of the masseter muscles are relatively larger than the activities of the temporal muscles, the bite force will provoke a larger load on each joint. From practical point of view, the occlusl splint not only can reduce temporomandibular pain but can diminish the relative activities of the temporal muscle and increment muscular symmetry (Ekberg *et al*., 1996). The reduced electrical activities may be explained by an inhibitory effect of the occlusal support, and it is a first factor in the reduction of acute pain: the smaller the bite force, the smaller the joint load. Interocclusal appliance interposed between the occlusal surfaces, interrupts propriceptive information from mechanoreceptors located within periodontal ligament enabling the muscle to return a balanced activity.

The results of this study are in accordance with previous studies. In the study of Khalifa *et al*. (2005) who found a significant reduction in electrical activity of the masseter muscle after 3 months of treatment. The existence of an asymmetric muscular activities in patient with temporomandibular disorders has been supported by Clark *et al*. (1979) and Holmegren *et al*. (1990).The increased symmetry in muscle activities has been reported by Ferrario *et al*. (2002), Humsi *et al*,(1989), Naeije and Hansson(1991), Visser *et al*. (1994)and Abekura *et al*. (1995).

The present study shows that, the therapeutic aim of disc recapture in patient with anterior disc displacement without reduction could not be achieved by splint therapy. The aim of splint therapy is to adapt TMJ, decrease pain and permit unlimited movements. This study shows that disc recapture cannot occur in both treatment groups. However, significant changes after occlusal therapy have been found. These are visualized as changes in signal intensity of the disc or the bilaminar zone. Changes in signal intensity of the bilaminar zone can be interpreted as a pseudo disc for functional substitution of the permanent anterior displaced disc. Also changes in the joint effusion have been occurring.

According to this study presence of joint inflammation, which is manifested by joint effusion and joint pain, is considered as negative factor in recapturing the displaced disc . Also the displacement of the disc in the medial plane is a negative factor for success of disc recapture. These results are compatible with results of Kurita *et al*. (2001) Westesson and Lund.,(1989).

Study of Simmons and Gibbs,(1995) showed recapture of disc in 25 out of 26 reducing displacement (96per cent), but no recapture of partially reducing or non-reducing joints in 30 patients seeking treatment for painful TMJ. Treatment with splint appliance provides effective pain relieve, regardless of disc status. The findings of the present study are consistent with the results of Simmons and Gibbs, who also found no recapture of disc in non-reducing joints.

Eberhard *et al*. (2002) in their study showed that immediate post-insertion MRI demonstrated that recapture of the discs with protrusive splint in 15 out 18 reducing displacements. Recapture was seen in only 2 out 4 joint with anterior disc displacement with partial disc reduction. There was no recapture in non-reducing joint.

Hosoki *et al*. (1995) reported in one subject with post-insertion MRI, the right TMJ disc changed within 18 months under the effect of an occlusal splint from an anterior position to superior position. In the left TMJ the disc changed from an anterior disc displacement without reduction to an anterior disc displacement with reduction. The results reported by those authors, that non-reducing joint changes into reducing joint under the effect of occlusal splint therapy could not be confirmed from the findings of the present study.

The accuracy of clinical examination and MRI findings in diagnosis of TMJ has been evaluated in several investigations. Muller-Leisse *et al*. (1996) determined the value of MRI in TMJ disorders by correlating cases of MRI-proven anterior disc displacement without reduction with clinical history and data. MRI investigation revealed various abnormalities in 22 joints, five of which were without any pathological clinical findings. It was concluded that anterior disc displacement without reduction is difficult to diagnose with clinical methods alone. This is in agreement with the present study, since many cases are present with signs and symptoms of anterior disc dislocation without reduction (ADDWoR) while MRI does not confirm the clinical examination.

The use of anterior repositioning splints was slightly less successful in the present study than the use of the stabilization splint keeping in the mind these findings and the results of Sato *et al*,. (1995) and Schmitter *et al*. (2003) the use of anterior repositioning splint might eliminate the little difference between patients using splints and controls. Thus, the use of the less successful repositioning splint cannot be recommended in the therapy of anterior disc displacement without reduction, as the number of patients demanding surgical intervention might increase.

Passive and active stretching exercises, isometric tension, and relaxation exercises are effective at increasing mouth opening and improving mandibular movements. Exercise is beneficial in the treatment of TMD. This is in agreement with study of McNeely *et al*. (2006) who found that demonstrated that the use of active and passive oral exercises decreased symptoms related to TMD and also with Tuncer *et al*. (2013).

## CONCLUSION

The treatment of anterior disc dislocation without reduction (ADDWoR) with either of the two types of splint was acceptably successful and a significant reduction in the leading symptoms could be achieved.The use of interocclusal appliance is efficient to improve the electrical activity of the masseter and temporalis muscles.

**Conflicts of interest:** The authors stated that no conflicts of interest.

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