UDC: 616.314:616.74

EMG-ACTIVITY OF MUSCLES OF THE CRANIO-MANDIBULAR SYSTEM DURING FUNCTIONS OF THE DENTO-FACIAL REGION

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The work is a fragment of the research project "An interdisciplinary approach to the diagnosis, prevention and treatment of patients with dental malocclusion and jaw deformations", state registration No. 0018U004343.

In the framework of the modern functional development of a human during the evolution of functions such as speech, mental activity, self-awareness and social behavior, we can conclude: "Masticatory organ is a highly organized multifunctional cybernetic system that works independently and interacts with various internal and external components, adapts permanently to the changing environmental factors, maintains a constant state of instable homeostasis" (R. Slavicek, 2016) [2]. The dento-facial region is an integral part of the whole somatognathic system of the person. The structural components of this cybernetic system are the cranio-mandibular (TMJ), neuro-muscular systems of the dento-jaw area and occlusion. The cranio-mandibular system, as a component of the neuro-muscular system of the human body, consists of the muscular apparatus (temporalis, masseter, lateralis and medialis pterygoideus muscles) and ligaments (spheno-mandibularis, stylo-mandibularis, stylo-hyoideus) [2, 3, 4]. These components are necessary for human life because of functions, that are perfomed (chewing, swallowing, speech, breathing, etc.), and can be indicators of overall somatic health [5, 7]. That is why, studies of the imbalance of neuromuscular connections between components of the dento-facial region are important for current diagnostic research.

The purpose of the study was to investigate the electromyographic activity of some muscles of the cranio-mandibular system during performing the functions of the dento-facial region.

Methods and materials. A clinical examination and a surface electromyography (EMG) of 30 patients of 20-28 years aged were used to find the peculiarities in the work of muscles of the cranio-mandibular system. The average age of patients was 23.4 ± 2.1 years. 13 (30.0%) were men, 17 (70%) were women. All patients did not have any malocclusion. A clinical examination was carried out according to the standard algorithm (the form of the orthodontic card No. 043-1/o, confirmed by order of the Ministry of Health of Ukraine dated May 29, 2013). All patients were "healthy": without somatic pathology, morphological, functional and esthetic disorders of masticatory system. EMG of anterior temporal, masseter, orbicularis oris, chin (m. mentalis) and sternocleidomastoid muscles was performed according to the recommendations of Sforza et al. and Tartaglia et al [9]. The masseter, anterior temporal, sternocleidmastoid muscles of both sides (left and right) were examined. Disposable silver chloride surface electrodes (diameter 10 mm, Neirosoft, Russia) were positioned on the muscular bellies parallel to muscular fibers [6, 8, 9]. The skin was cleaned with 70% alcohol prior to the placement of the electrodes. The surface electrodes were attached to the skin, according to the relevant anatomical orientation. A disposable reference electrode was applied to the forehead. EMG-activity was recorded using a computerized instrument Synapsis and software by Neirotech (Russia). The analog EMG signal was amplified and digitized. Patients were sitting in a natural position without muscular tension, arms, legs were not crossed, head was held equally without support. Lips were kept closed slightly, tooth – in physiological rest. To avoid the effect of fatigue, there was three minutes-rest between each test.

EMG-activity was recorded in 4 tests, lasted 10s for each one: maximum voluntary clenching, moving the lower jaw forward (protrusion), swallowing of a sip of water and swallowing of saliva ("dry" swallowing). Maximum voluntary clenching was performed in intercuspal position (without any material placed on the molar teeth). The maximum activity of the muscle contractions (μV) was analyzed during the electromyography analysis. EMG data were processed using Neurotech's Synapsis software.

The procedures received approval from the Bioethics Committee of the Ukrainian Medical Stomatological Academy (Poltava, Ukraine). All girls and their parents signed a statement of informed consent.

The obtained data was statistically analyzed using the Student's t-test and the Fisher's criterion X2. The hypotheses were verified at the level of significance $p<0,05$.

Results. EMG-activity of muscles in a state of physiological rest was not detected in all tests that were carried out. EMG-activity was registered during muscle work and constrictions. The characteristics of the bioelectric activity of the muscles were different in each test. The EMG-characteristics of the muscles in the tests are presented in table 1.

Table 1

EMG - activity of masticatory, mimic and sternocleidomastoid muscles

Muscles		**Maximum amplitude of constriction**							
		Maximum teeth clenching test		Movement of the lower jaw forward (protrusion) test		A sip water swallowing test		Salvia swallowing («dry» swallowing) test	
		μV	%	μV	%	μV	%	μV	%
m.masseter	Left	1636,25 ±36,45	36,4	594,09 ±17,43	21,1	366,5 ±9,55	16,9	565,0 ±12,77	23,7
	Right	1722,25 ±38,92		630,0 ±18,76		416,75 11,39		575,25 ±12,85	
m. temporalis	Left	1335,75 ±26,54	27,4	379,75 ±13,28	17,5	392,75 ±10,04	27,3	530,5 ±12,04	21,2
	Right	1474,0 ±28,71		413,5 ±15,44		349,25 ±8,76		441,5 ±11,14	
m. orbicularis oris		839,5 ±15,34	11,4	350,53 ±9,54	15,2	625,0 ±13,45	20,8	498,75 ±11,69	18,2
m. mentalis		999,75 ±20,06	13,2	661,0 ±20,51	28,9	628,5 ±13,98	27,3	557,0 ±12,54	21,5
m. sternocleidomastoideus	Left	838,25 ±16,23	11,5	393,0 ±13,08	17,3	443,25 ±11,34	19,0	384,25 ±8,54	15,5
	Right	898,02 ±17,65		430,65 ±16,75		414,4 ±10,84		423,87 ±10,74	

In the maximum teeth clenching test the highest EMG-activity was registered in the masticatory muscles (1679,25 μV ± 37,58), the lowest – in the sternocleidomastoid ($p <0,05$) and the orbicularis oris muscles ($p <0.05$) – 868.13 ± 16.94 μV and 839.5 ± 15.34 μV, respectively, as shown in Figure 1.

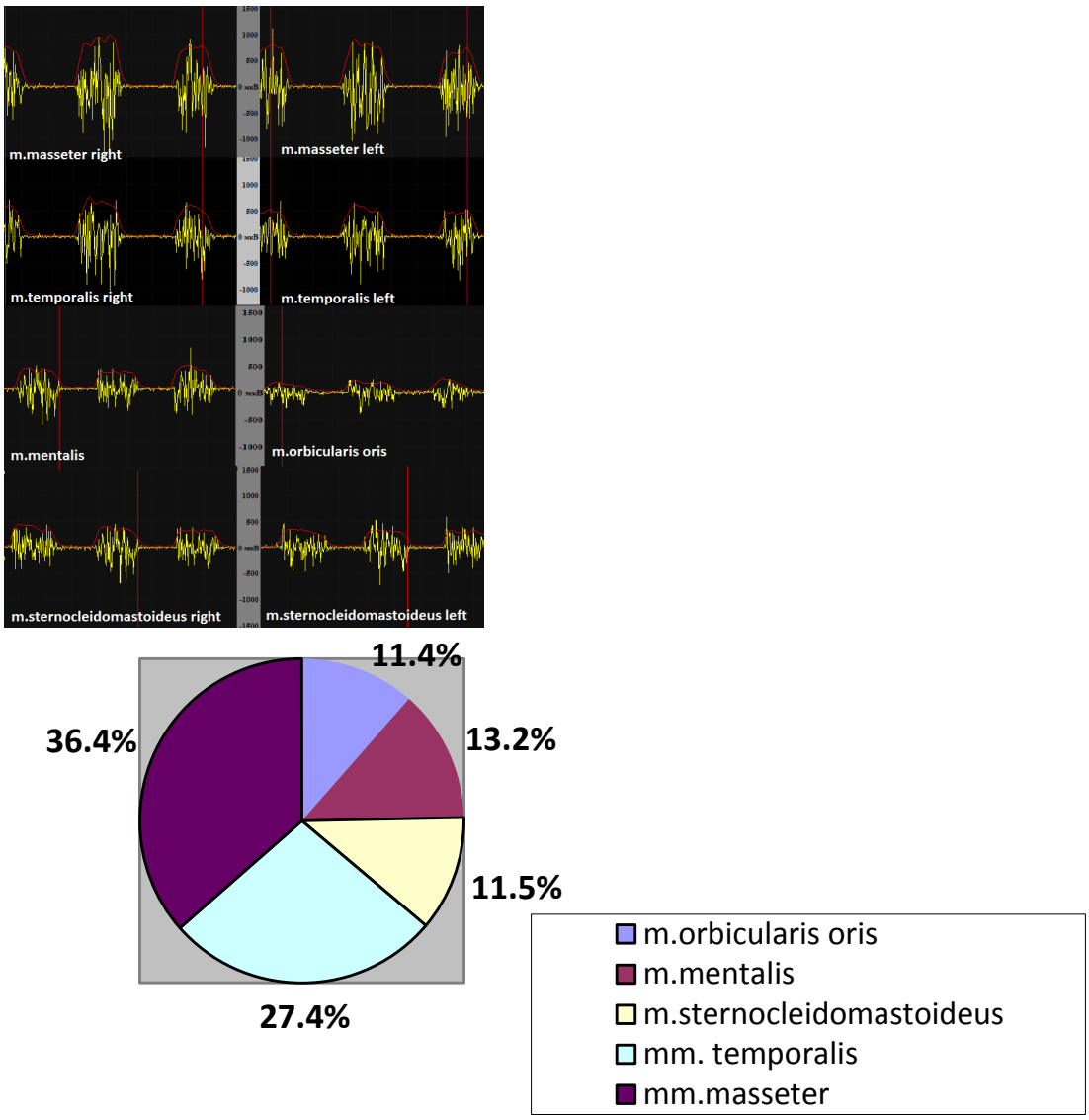

Fig. 1 Fragment of the electromyogram of patient K., 25 years. A graphical representation of the muscle activity in the maximum teeth clenching test.

In the mandibular movements (protrusion) test, the highest EMG-activity was determined in the mentalis (661.8 μV ± 20.51) and masseter muscles (612.05 μV ± 18.09). EMG-activity of the temporal and sternocleidomastoid muscles in this test was almost the same (average for the temporalis muscle – 396,62 μV ± 1436, p> 0,05, sternocleidomastoid muscles – 411.82 μV ± 14.92, p> 0.05). An example of the electromyogram in this test is shown in Figure 2.

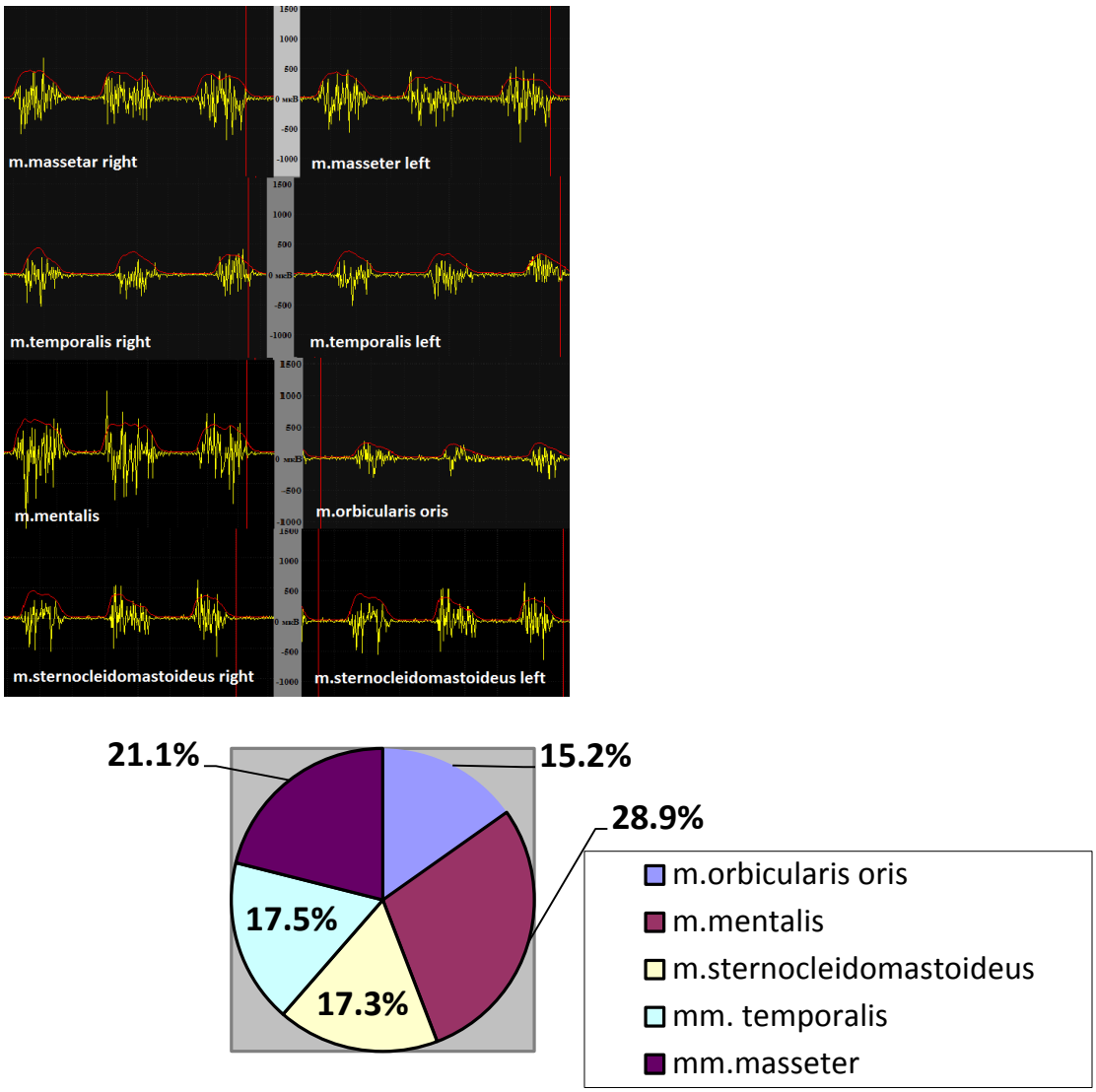

Fig. 2. Fragment of the electromyogram of patient K., 25 years. A graphical representation of the muscle activity in the protrusion test.

The orbicularis oris (625.0 μV ± 13.45) and chin muscles were observed the highest EMG-activity in the swallowing test (628.5 μV ± 13.98). The EMG-activity of the sternocleidomastoid muscle was significantly less (443.25 ± 11.34 μV, 414.4 ± 10.84 μV on the left and right sides, respectively, $p < 0.05$).

The values of the maximal amplitude of contractions of the temporal and masseter muscles were the lowest and did not significantly differ ($p > 0.05$). An example of the electromyogram in this test is shown in Figure 3.

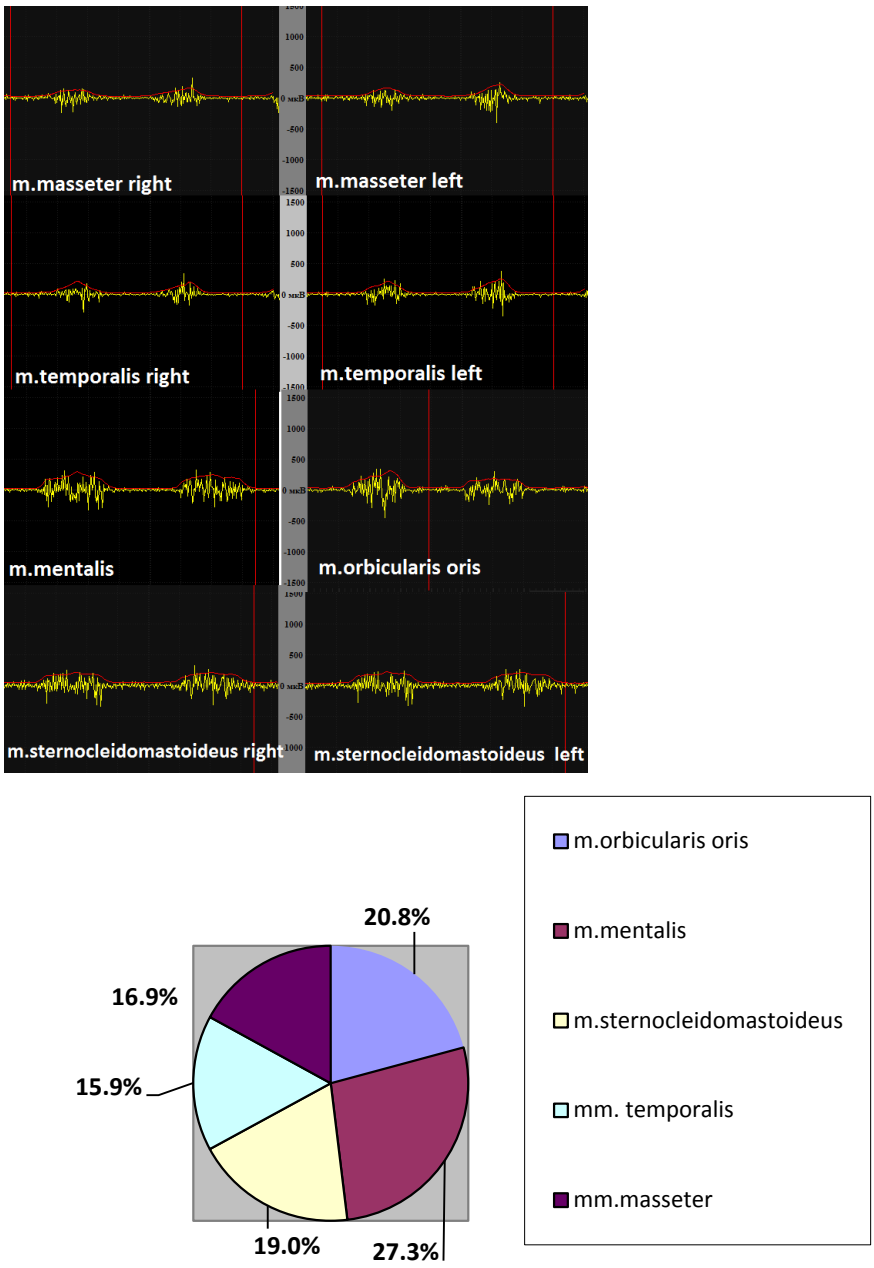

Fig. 3. Fragment of the electromyogram of patient B., 22 years. A graphical representation of the muscle activity in a swallowing test.

In the "dry" swallow test, the highest EMG-activity was recorded in the orbicularis oris muscle and masseter muscles, while the values of the temporal, sternocleidomastoid and mentlis muscles were at the same level and were not statistically different ($p > 0.05$).

We also investigated the symmetry of the EMG-activity of contractions of the muscles of the left and right sides (masseter, temporal and sternocleidomastoid muscles). In the majority of the examined patients (35.0 - 83.3%), symmetrical

bioelectric activity of the masseter, temporal, and sternocleidomastoid muscles of the left and right sides was observed, what corresponds to the physiological norm. Asymmetric work of these muscles was determined in 5 (16.7%) patients. Increasing of the maximum amplitude of contractions on one side (in 3 people (10.0%) –EMG-activity of the temporal and masseter muscles was higher on the right, in 2 people (6.7%) – on the left side) was found. The asymmetric work of the sternocleidomastoid muscles was also observed in these subjects. It is important to note that the side with the increased EMG-activity of sternocleidomastoid muscles was opposite to the side with the increased EMG-activity of the temporal and masseter muscles (which can be characterized by the term "cross" activity).

Therefore, the EMG-activity evaluation of the muscles of the dento-facial region should be performed in conjunction with the EMG-activity evaluation of the stomatognathic system muscles, which coincides with other studies [1,2, 3]. There are data in literature sources about EMG-activity of the upper and lower lip circular muscles, supra-, infragioid muscle during the following tests: physiological rest, pronunciation of certain sounds, swallowing, deep breathing, maximum teeth clenching and chewing [1]. Thus, it was found that the EMG-activity of the orbicularis oris muscle was higher in patients with impaired functions of lip closure and speech in comparison with subjects without such disorders. However, it should be noted that there are no a comparative study of the bioelectric activity of mimic, masticatory, and sternocleidomastoid muscles.

Conclusions. The study allowed us to determine the features of EMG-activity and the proportion of muscle work of the masticatory (masseter, temporal), mimic (chin, orbicularis oris muscles) and sternocleidomastoid muscle during functions of dento-facial region and movements of the mandible. The results of the study proved the involvement of facial and neck muscles in teeth clenching, mandible movements, swallowing. It was found that the EMG-activity of the orbicularis oris muscle during maximum teeth clenching, displacement of the mandible forward (protrusion) and swallowing correlated with the EMG-activity of the sternocleidomastoid muscles. The obtained data indicated the functional unity

of the neuromuscular component of the stomatognathic system and the need to study the bioelectric activity of these muscles in subjects with functional disorders, especially associated with movements of the mandible and tongue at all stages of orthodontic treatment.

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