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MASTICATORY MUSCLE ELECTROMYOGRAFIC ACTIVITY DURING TEMPOROMANDIBULAR JOINT MOVEMENT IN RHEUMATOID ARTHRITIS PATIENTS AND HEALTHY SUBJECTS: ASSOCIATIONS WITH ACTIVITIES OF DAILY LIVING AND RADIOGRAPHIC FINDINGS

Master Thesis in Physiotherapy

(Kinesiology and Biomechanics)

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ABBREVIATIONS

ADL – activities of daily living

E.g. - *exempli gratia*, for example

Etc. - *et cetera*, and so on

I.e. - *id est*, it is

EMG - electromyography

LIM – less involved masseter

LIT – less involved temporalis

LM – left masseter

LT – left temporalis

LTR - laterotrusion

MIM – more involved masseter

MIS – more involved side

MIT – more involved temporalis

OPTG - orthopantomography

RA – rheumatoid arthritis

RM – right masseter

RMS – roote mean square

RT – right temporalis

TMD – temporomandibular disorder

TMJ – temporomandibular joint

1. INTRODUCTION

I was inspired to write about temporomandibular joint (TMJ) problems by two seminars I attended that discussed the role of physiotherapy in the management of temporomandibular disorders (TMD). TMJ physiotherapy is quite a new field in Estonia that needs to be introduced.

Rheumatoid arthritis (RA) is an autoimmune disease with an unclear etiology that is characterized by symmetric erosive synovitis and less often extra articular damages (Reumatoidartriidi ravijuhend Eestis, 2013). RA mostly effects small joints of hands and feet, knees, wrists, elbows, shoulders and cervical spine (Sidebottom and Sala, 2013), but the TMJ might also be involved. Patients with the TMJ involvement by RA may present with joint tenderness on palpation, pain on movement, limited movement, TMJ sounds and masticatory muscle pain on palpation (Bessa-Nogueira *et al*., 2008).

The aim of this study was to elucidate the masticatory muscles' activity during TMJ movement in association with ADL scores and radiographic findings. This work has practical value as it gives guidelines to work with patients with temporomandibular disorders.

2. REVIEW OF LITERATURE

2.1. Rheumatoid arthritis

Rheumatoid arthritis (RA) is a systemic autoimmune disease whose main characteristic is persistent joint inflammation that results in joint damage and loss of function. RA has unclear etiology and it can be described by symmetric erosive synovitis and sometimes extra-articular manifestations. The prevalence of RA is about 1-2% of population (Louie *et al*., 2003). Clinical symptoms in the TMJ have been found in 34-35% of patients (Syrjänen, 1985, Tegelberg and Kopp, 1987). There are about 14 000 patients in Estonia. Women are three times more likely to be diagnosed than men; with the increase of age the difference decreases. RA is diagnosed most often between the ages 20-60 years. There is a genetic predisposition associated with HLA-DR1 and -DR4 (Reumatoidartriidi ravijuhend Eestis, 2013).

The pathogenesis of RA involves synovial proliferation over the surface of the cartilage, which produces a tumor-like mass (pannus) that destroys the articular cartilage and underlying bone, and causes erosions. Clinical features include pain, stiffness, and swelling of the small joints of the hands and feet, which is worst in the morning and improves during the day. The disease is polyarticular, and most commonly affects the hands, feet, wrists, elbows, shoulders, knees and cervical spine (Sidebottom and Sala, 2013)

2.2. Temporomandibular joint

TMJ is located in front of the ear canal (Fig. 1). The condyles of the mandibula are placed inside the glenoid fossa. An intra-articular disk between the two surfaces smoothens the motion in the joint. The disc is associated with the lateral pterygoid muscle (Herring, 2003). These joints serve as one anatomic control for both mandibular movement and the occlusion, surrounded by a capsule which consists of fibrous material, and a synovial lining. The capsule is quite thin anteromedially and medially (~ 0.7 mm) and thick laterally and posteriorly (~ 1.8 mm). The inner layer of the capsule or synovial membrane is highly vascularized layer of endothelial origin cells, producing synovial fluid. The capsule stretches from the edge of the mandibular fossa to the neck of the mandible, proximal to the pterygoid fovea, and envelops the articular eminence. Temporomandibular and sphenomandibular ligaments reinforce the TMJ (Sommer *et al*., 2003).

Mandibular condylar cartilage plays a crucial role in temporomandibular joint (TMJ) function, which includes facilitating articulation with the TMJ disc, reducing loads on the underlying bone, and contributing to bone remodeling (Singh and Detamore, 2009).

TMJ condyles are covered by cartilage that is categorized as a secondary cartilage formed by periosteum or endosteum, while hyaline cartilage is a primary cartilage, which precedes bone formation. TMJ condylar cartilage falls under the classification of fibrocartilage, with a strong presence of both collagen types I and II. However, hyaline cartilage contains predominately collagen type II in all zones (Wang *et al*., 2009).

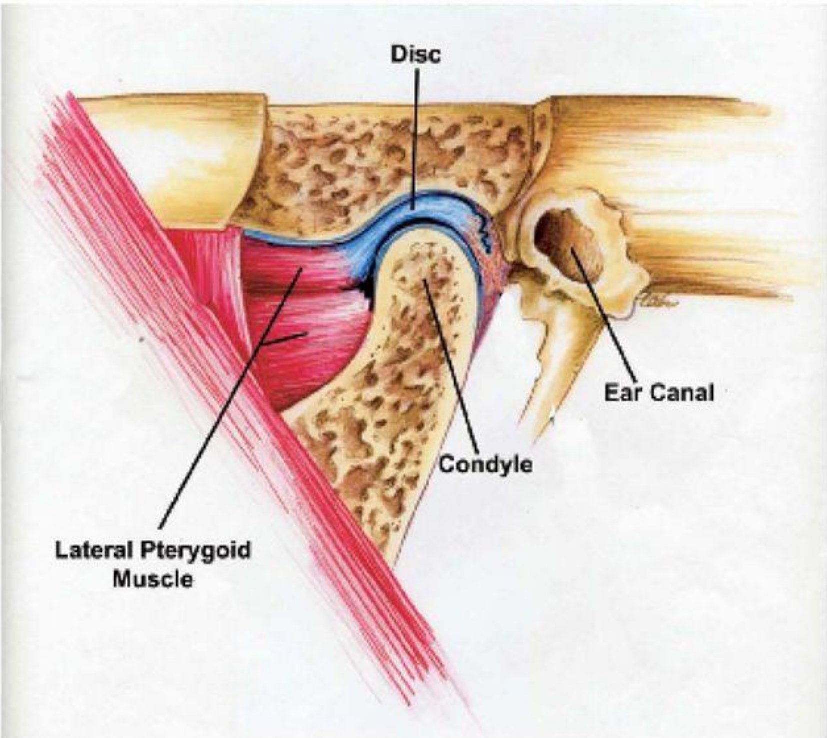


Figure 1. Sagittal view of the temporomandibular joint (Chiropractic Help, 14.05.2014).

The disc of the TMJ exhibits a somewhat biconcave shape, being thicker in the anterior and posterior bands and thinner in the intermediate zone. The disc, which is certainly an anisotropic and nonhomogeneous tissue, consists almost entirely of type I collagen. Compression studies are conflicting, but evidence suggests the disc is compressively stiffest in the center (Detamore and Athanasiou, 2003).

The articular disc is interposed between the temporal bone and the mandible, dividing the articular space into upper and lower compartments. The anterior and posterior ridges of the disc are termed anterior and posterior bands and are longer in the mediolateral than in the anteroposterior dimension. The smaller anterior band attaches to the articular eminence, condylar head, and joint capsule. The posterior band blends with highly vascularized, loose connective tissue, the bilaminar zone, and the capsule, the bilaminar zone residing in the retrodiscal space in the mandibular fossa and attaching to the condyle and temporal bone. Medially and laterally, the disc is firmly attached to the capsule and the condylar neck. Anteromedially, it is attached to the superior part of the pterygoid muscle (Sommer *et al*., 2003).

Roh *et al.* (2012) found that the joints with anterior disk displacement with and without reduction showed a bigger ratio of degenerative changes and joint effusions compared with joints with a normal disk position. These results clearly show that the risk of degenerative changes and joint effusions increase with displacement of the disk position in patients with temporomandibular disorders.

2.3. Masticatory muscles

The muscles of mastication are responsible for the complex movement of the jaw. There are four pairs of skeletal muscles whose primary function is to move the mandible and these are considered being the muscles of mastication as they are involved in biting and chewing (Okeson, 2008).

The masseter muscle (Fig. 2) is positioned superficial to the mandibular ramus, extends from the zygomatic arch to the angle of the mandible, and is readily palpable. The masseter is a thick, somewhat quadrilateral muscle, consisting of two portions, superficial and deep. The superficial portion, the larger part, lies more anteriorly than the deeper part and is composed of fibers that pass slightly posteriorly from the above downward. The deep portion is much smaller, and more muscular in texture. The deeper part is positioned more posteriorly, and consists of more vertically oriented fibers. The deep portion of the muscle is partly concealed, in front, by the superficial portion; behind, it is covered by the parotid gland. The fibers of the two portions are continuous at their insertion (Gray, 1918, Pratt and Oatis, 2009).

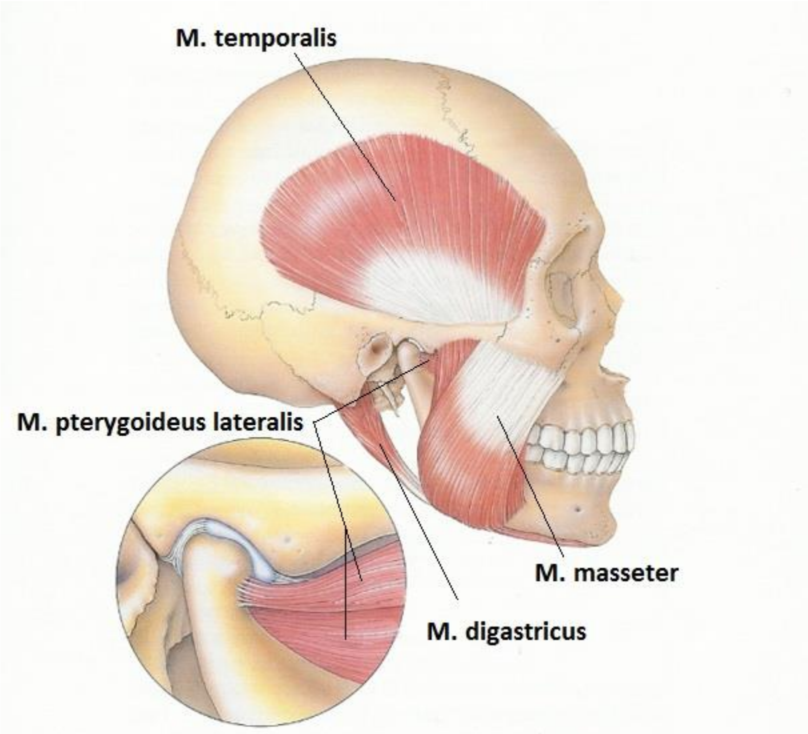


Figure 2. Masticatory muscles – temporalis and masseter (The Posturology Blog, 14.05.2014).

The temporalis muscle (Fig. 2) is a broad, radiating muscle, situated at the side of the head. It arises from the whole of the temporal fossa and from the deep surface of the temporal fascia. Its fibers converge as they descend, and end in a tendon that is inserted into the medial surface and anterior border of the coronoid process, and the anterior border of the ramus of the mandible nearly as far forward as the last molar tooth. Even though it is commonly divided into anterior, middle and posterior parts, the anterior and middle parts (vertical fibers) and the posterior part (horizontal fibers) form two functional units (Gray, 1918, Pratt and Oatis, 2009).

The medial pterygoid muscle (Fig. 3) is thick and quadrilateral in shape. It is the deepest of the muscles of mastication and is oriented obliquely in both the sagittal and frontal planes. Its sagittal orientation is similar to that of the superficial part of the masseter, so that it inclines posteriorly from superior to inferior. It is more oblique in the frontal plane and inclines considerably laterally as it projects from the skull to the mandible (Gray, 1918, Pratt and Oatis, 2009).

The lateral pterygoid muscle (Fig. 3) is short and thick, somewhat conical in form. The muscle is oriented horizontally and has distinct superior and inferior parts. From the cranium, the fibers of the two parts converge and pass more obliquely laterally that the medial pterygoid. As a result, balanced bilateral activity of the two lateral pterygoidei is necessary if the mandibular and maxillary teeth are to be aligned normally (Gray, 1918, Pratt and Oatis, 2009).

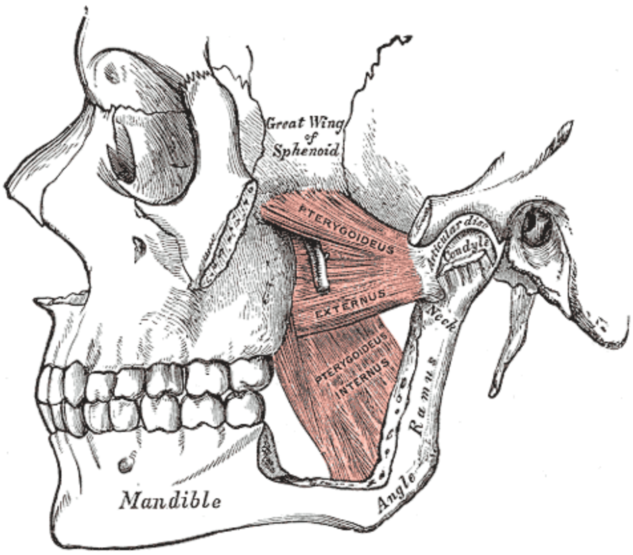


Figure 3. Masticatory muscles – lateral (externus) and medial (internus) pterygoidei (Dr. Sigona's Head and Neck Anatomy website, 14.05.2014).

Functions

The temporalis, masseter, and medial pterygoid muscle raise the mandible against the maxilla with great force. Unilateral activity of the masseter produces ipsilateral deviation, slight protrusion and elevation. The lateral pterygoid muscles assist in opening the mouth, but its main action is to draw forward the condyle and articular disk so that the mandible is protruded and the inferior incisors projected in front of the upper; in this action, it is assisted by the medial pterygoideus. The mandible is retracted by the posterior fibers of the temporalis. During maximal mouth opening, the temporalis may help to prevent dislocation of the TMJ by limiting anterior translation of the mandibular condyle. If the medial and lateral pterygoidei of one side act, the corresponding side of the mandible is drawn forward while the opposite condyle remains comparatively fixed (Gray, 1918, Pratt and Oatis, 2009).

Bite force

The highest voluntary force generated by the jaw elevator muscles is during maximal clenching. Bite-force levels increase when clenching is performed with increased jaw opening until about 15 to 20 mm of interincisal distance, bite force then decreases with further opening. This so-called length-tension relationship should be considered when assessing maximum bite force with a bite-force meter that increases bite height and jaw separation. There is a close positive relationship between the bite force and the electromyographic activity of the jaw elevator muscles (the temporal, the masseter, and the medial pterygoid muscles) during isometric contractions. For the same individual, during the same recording session, the level of electromyographic activity fairly accurately reflects the level of bite force during submaximal isometric contractions (Bakke, 2006).

However, the relationship between maximum bite forces measured in different subjects and the corresponding elevator muscle activities is much more variable, due to differences in electrode placements in relation to fiber direction, as well as different anatomical and morphological relations in terms of muscle thickness and craniofacial dimensions (Bakke, 2006).

Men achieve a higher masseter activity at maximum effort than women. Angle class II (retrognathism, overjet) shows higher activity than other classes for the temporalis muscle in deglutition, while class III (prognathism, negative overjet) shows higher activity than other classes for all muscles in maximum effort. The presence of a posterior crossbite affects the behaviour of anterior temporalis and masseter muscles (Moreno *et al.*, 2008).

2.4. Rheumatoid arthritis in temporomandibular joint

The TMJ is a synovial joint and can be affected by RA. The frequency of TMJ involvement based on clinical and radiological findings is rather diverse and involvement may manifest as pain, restricted range of movement and locking of the joint (Ozcan *et al*., 2008). 70.5% of RA patients present with at least one sign or symptom of TMJ (Bessa-Nogueira *et al*., 2008).

Clinical findings involve sounds (crepitus, clicking), pain, stiffness, limitations of movement, muscle soreness, tenderness of the joint and muscles and deviated mouth opening (Sidebottom and Sala, 2013, Koh *et al.*, 1999). Restricted mouth opening is common but non-specific in RA, and there may be a number of causes that include pain, fibrous adhesions, internal derangement, inflammation, muscular contraction, or severe degeneration of the joint. Muscle tenderness and pain in the TMJ are suggestive of active disease (Sidebottom and Sala, 2013).

The most common radiographic changes are (Fig. 4 and 5): decreases in the joint space, mandibular subchondral cysts, temporal subchondral cysts, degeneration, shape and height anomalies of the mandibular condyle, condylar head resorption, erosion of the mandibular condyle and demineralization (Sidebottom and Sala, 2013, Bayar *et al*., 2002).

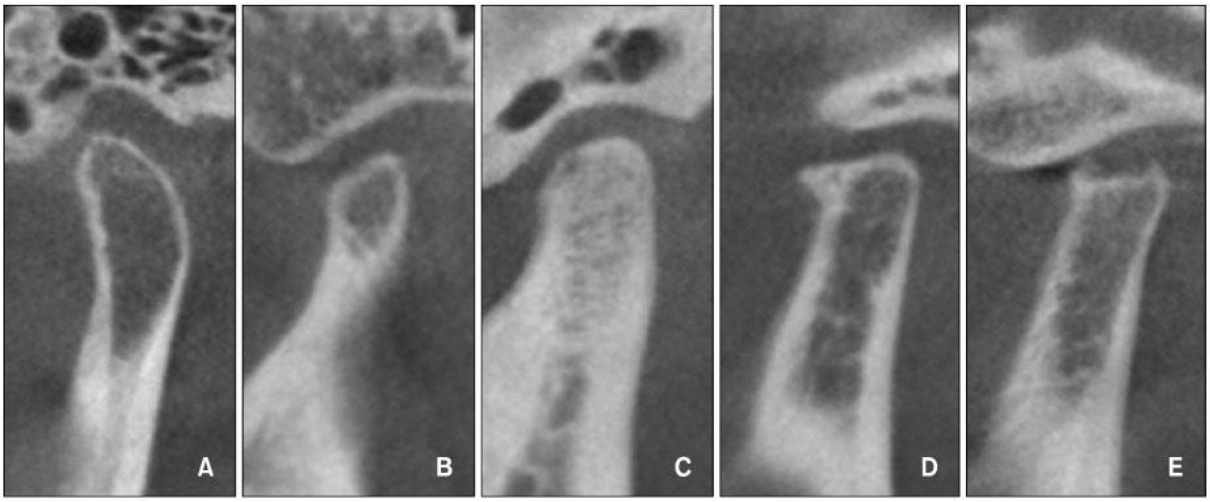


Figure 4. Different types of condylar shapes in cone beam computer tomography sagittal imaging (A - normal; B - flattening; C – sclerosis; D – osteophyte; E – erosion) (Lee *et al.*, 2010).

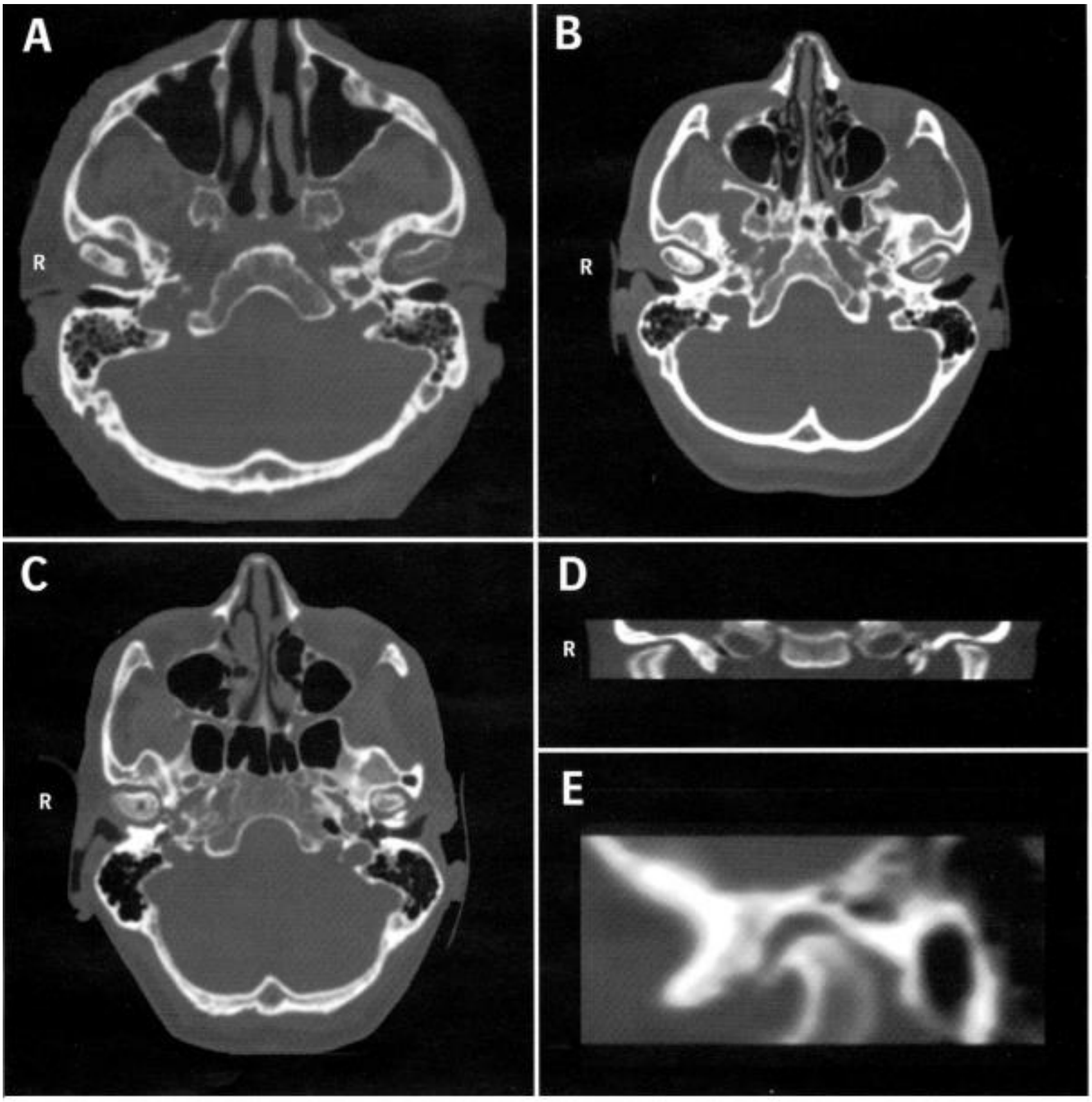


Figure 5. A. Sing of erosion in the medial part of the right mandibular condyle in an axial view of computed tomography. B. Sign of sclerosis in the medial and central parts of the right mandibular condyle in an axial view of computed tomography. C. Sign of pseudocyst in the central part of the right mandibular condyle on an axial view of the computed tomography. D. Sign of flattening of the right mandibular condyle in a coronal view of computed tomography. E. Sign of osteophyte in the right mandibular condyle in a sagittal view of computed tomography (Voog *et al*., 2003).

Involvement of TMJ correlates with severity and duration of RA (Sidebottom and Sala, 2013). Patients with RA, who had prolonged disease duration of RA and active peripheral joints, tended to have osteoarthrosis of the TMJ. Presence of rheumatoid factor or peripheral joint erosions was not associated with TMJ osteoarthrosis (Koh *et al.*, 1999).

In a longitudinal study it was found that radiographic changes that occur in the TMJ of patients with well-controlled RA during a period of 25-46 months seems to be related to the blood levels of CRP, 5-HT and IL-1sRII. However, only minor changes of the radiographic status could be expected to occur during this period in RA patients but with considerable individual variation (Voog *et al.*, 2004).

Juvenile onset can lead to changes in facial appearance suggestive of contralateral condylar hyperplasia with occlusal cant and unilateral loss of ramal height. In severe bilateral cases, loss of condylar height results in retrognathia, loss of ramal height, and anterior open bite (Fig. 6). Severe cases may have associated episodes of upper airway obstruction (sleep apnea), particularly when supine (Sidebottom and Sala, 2013).

Figure 6. Collapse of the joint leading to development of deformed anterior open bite (Sidebottom and Sala, 2013).

It is indicated that pain/discomfort from the TMJ in patients with RA has a significant negative impact on activities of daily living (ADL) (Voog *et al.*, 2003). Jagur *et al.* (2010) noted that ADL were influenced by TMJ pain/discomfort in all participants at different levels.

2.5. Disease management

The goals of the disease management should be lowering the systemic inflammatory activity, reducing the pain and maintaining the range of motion and muscle strength.

Load reduction is very important in the management of pain. Functional overuse and bruxism are aggravating factors for pain and arthritic processes (Leibur and Voog-Oras, 2008). Patient's self-management is inevitable in this point. Behavior modification is intended to help patients understand and avoid stress-related lifestyle and other parafunctional habits (holding tension in the masticatory muscles, clenching teeth, chewing gum, yawning wide, resting the jaw on the hand). Teeth should be held slightly apart, muscles relaxed and the tongue slightly resting on the top of the mouth in relaxed position. Psychological consultation may be indicated for stress management (Medlicott and Harris, 2006).

Load reduction in the TMJ is also achieved by modifying the patient's diet to reduce joint loading from forces of mastication. This could be done through a non-chewing diet such as liquid or pureed food or just limiting hard food (nuts, carrots *etc.*). As the joint pain improves, the diet may be advanced (Medlicott and Harris, 2006).

Excessive load on the TMJ can also derive from the loss of molars and therefore loss of posterior support. It is important to restore missing teeth to prevent the genesis of a painful osteoarthritis (Leibur and Voog-Oras, 2008).

Interocclusal appliances (occlusal splints, orthotics, night guards, bite guards) are widely used for bruxism control and muscle relaxation. Prolonged use of repositioning appliances can cause undesirable and irreversible changes in dental occlusion, skeletal structure, and muscle dynamics (Medlicott and Harris, 2006).

Exercises became important after acute pain has reduced. These could be beneficial for prevention of muscle atrophy, relaxation of hyperactive muscles, reduction of the risk of contraction of the joint capsule and the increase of TMJ range on motion. Combining heat with exercises can be more effective as heat increases the elasticity of tissues (Leibur and Voog-Oras, 2008; Medlicott and Harris, 2006; Sidebottom and Sala, 2013).

The nonsteroidal anti-inflammatory drugs (NSAID) are the mainstays for pain and inflammation. Low dose tricyclics are effective in controlling pain from nighttime bruxism, when doses are adjusted to provide improved sleep (Medlicott and Harris, 2006).

Joint pain can be confirmed and temporarily relieved by injection of local anesthetic into the joint space, and pain relief suggests that arthroscopy will provide a therapeutic and diagnostic aid. Synovitis that does not improve 4–6 weeks after arthrocentesis (which it commonly does) may benefit from intra-articular steroids. Myofascial pain and spasm can be relieved by needling with long-acting local anesthetic such as bupivacaine, or by botulinum injections into the masseter and temporalis muscles (Sidebottom and Sala, 2013). Arthroscopic surgery has been an effective treatment for TMJ disorders refractory to nonsurgical treatments (Leibur *et al*., 2013).

3. OBJECTIVES OF THE STUDY

The main aim

The main aim of this study was to compare EMG activity of the masticatory muscles during TMJ movements in patients with RA and healthy subjects in comparison with ADL scores and radiographic findings.

Hypothesis

Masticatory muscle fatiguability is higher in RA patients than healthy subjects evaluated by the shift of EMG power spectrum during submaximal clenching.

The specific aims of this study were:

1. To assess EMG activity in masticatory muscles during rest, active opening and closing of the mouth and maximal clenching.
2. To assess masticatory muscle fatiguability in sustained submaximal clenching.
3. To assess the relationship between EMG activity, ADL scores and radiographic findings.

4. MATERIALS AND METHODS

4.1. Subjects

All together 23 subjects were recruited: 11 of them had RA (3 men, 8 women) and 12 were healthy control subjects (all women). The diagnosis of RA was determined according to the 1987 classification criteria of the American Rheumatism Association (Arnett *et al.*, 1988). The patients were referred to the Clinic of Stomatology from the Clinic of Rheumatology at the University of Tartu or from general practitioners. The patients had not been subjected to any recent treatment of the TMJ. Inclusion criteria were diagnosis of systemic inflammatory joint disease (RA), pain localized to the TMJ region and tenderness to digital palpation of the TMJ. Exclusion criteria were any disease that may cause orofacial pain or an infection in the TMJ region. Age, sex and clinical characteristics are shown in table 1.

Tabel 1. Age, sex and clinical characteristics of the subjects.

RA patients						**Healthy subjects**		
Nr	**Age**	**Sex**	**MIS**	**Duration**	**Pain**	**Nr**	**Age**	**Sex**
1.	31	F	L	4	1	**1.**	24	F
2.	52	F	R	10	3	**2.**	62	F
3.	26	F	L	2	5	**3.**	44	F
4.	65	F	R	10	8	**4.**	62	F
5.	48	M	R	8	1	**5.**	63	F
6.	26	F	L	6	5	**6.**	54	F
7.	41	F	R	5	4	**7.**	58	F
8.	45	M	R	1	0	**8.**	49	F
9.	64	F	R	5	7.5	**9.**	55	F
10.	82	M	R	4	0	**10.**	52	F
11.	28	F	R	8	7	**11.**	67	F
						12.	24	F
Mean	46.2				3.8		50.5	
±SD	±17.6				±2.9		±14.1	

MIS – more involved side; duration is in years; pain – ADL scores of the question “How much does the pain/discomfort affect your daily activities?” rated in points (0-10).

More involved side in RA patients was determined by radiographic and clinical findings. Craniofacial morphology, jaw muscle size and occlusion were not taken in consideration, although they can affect bite force (Pereira *et al.*, 2007). Subjects with prostheses could ware their appliances if these did not interfere.

The study was approved by the Ethical Committee of Human Studies of the University of Tartu. All participants gave their informed consent before the start of the study.

4.2. Methods

Examination of the masticatory muscles and temporomandibular joints

Active range of motion (ROM) in the TMJ was measured in following directions: opening, laterotrusion (sideways) to the left and right, protrusion (forward) and retrusion (backward) (Tab. 2). A maximum jaw opening of less than 40 mm, and laterotrusive and protrusive movements of less than 7 mm, are judged to be restricted (Carlsson and Magnusson, 1999). The jaw movements are measured with a ruler. Deviations during opening were noted and subjects were asked about pain during movement (pain/no pain).

Muscle and joint tenderness was examined with palpation. Masseter and temporalis were palpated on the surface of the face, pterygoidei were palpated intraorally. TMJ was palpated laterally and posteriorly. Joint noises were examined through listening and palpation.

Activities of daily living and pain

All participants were asked to evaluate the influence of pain/discomfort in the TMJ on daily activities. A rating scale based on methods elaborated in medical and behavioural science and modified by List and Helkimo (1995) was used (translated into Estonian, see appendix 1). The scale ranged from 0 (activity without pain/discomfort in the TMJ) to 10 (activity impossible due to pain/discomfort in the TMJ). The patients were asked to mark the number that best described their present ability to perform each activity considering their pain/discomfort in the TMJ. The questions used in the study were (English original versions): If you feel pain/discomfort in the area of TMJ are you able to:

1. Socialize with family and close friends?
2. Perform daily work?
3. Perform daily household chores (preparing meals, cleaning, taking care of small children)?
4. Sit in a company or participate in other social activities (*e.g.* parties)?
5. Exercise (walk, bicycle, jog, *etc.*)?
6. Perform hobbies (read, fish, knit, play an instrument)?
7. Sleep at night?
8. Concentrate?
9. Eat (chew, swallow)?
10. Talk (laugh, sing)?
11. Yawn, open mouth wide?
12. How much does the pain/discomfort affect your daily activities?

Electromyography

During the whole EMG examination, the volunteers sat relaxed in a half-lying position in a dental chair with head support. They kept their eyes open and arms on their legs.

Paired bipolar surface electrodes (Ag-AgCl, 8 mm diameter, 20 mm interelectrode distance) were used on masseter and temporalis for measuring EMG activity. Before electrode placement, the volunteer's skin was previously cleaned with alcohol. The electrodes were positioned in relation to muscle fiber length. Masseter muscle: electrodes positioned on muscle belly that could be better located during dental clenching (2 cm above of the external angle of the jaw) (Pedroni *et al*., 2004). Anterior portion of the temporalis muscle: on the muscle belly located by the application of muscle function test (Fig. 7). 8 electrodes were recording EMG signals and 4 reference electrodes were placed on electrically inactive tissue.

Figure 7. Experimental setup for the measurement of EMG activity. Active electrodes are indicated red and ground electrodes are indicated black.

Recordings were made on 4 channels of simultaneous EMG signals. The output signals from EMG preamplifiers were digitized on-line (sampling frequency 1kHz) by analogoue-to-digital converter installed in personal computer. The digitized signals were stored on a hard drive for further analysis.

The EMG signals were amplified and displayed with biomonitor ME6000 (Mega Electronics, Koupio, Finland). In rest, opening, closing and maximal clenching, the EMG signal was analyzed in time domain by the root mean square (RMS, μV·s) application. For the submaximal clenching EMG power spectrum mean frequency (MPF, Hz) was calculated by using Fast Fourier Transform algorithms. The MPF values for the EMG signals were calculated as the average from two periods: 5 seconds from the beginning and 5 seconds from the end.

Radiography

Bilateral TMJ images were obtained with the orthopantomograph (OPTG) apparatus CRAEX 3 (Soredex orion corporation LTD, Finland). The OPTG were evaluated for presence of radiographic signs of bone structural changes as erosions, flattening and osteophytes of the condyle and temporal bone (Rohlin *et al*., 1986). Most patients had OPTG taken as a part of their regular examination (only one patient did not have it done). An independent specialist who noted the presence of joint erosions, flattening and osteophytes assessed the OPTGs. The result were added together for both joints for further analyses.

4.3. Study design

RA patients were either called back for testing or asked to join the study after the visit to the TMJ specialist. Healthy subjects were recruited among the employees of Department of Stomatology, University of Tartu. All subjects filled a consent form before examination. The anamneses (age, sex, diagnose, duration of the disease) was collected by the researcher (Nele Pihla) or stomatology students. Students also measured TMJ ROM and palpated muscles and joints.

After that, the subjects were asked to take the ADL questionnaire. Subjects were asked to sit in a dental chair for EMG testing. All the tasks were explained and demonstrated if needed. Subjects were also explained about the function of EMG electrodes before placing them on their faces.

EMG activity was registered during these tasks in this order:

1. Rest.
2. Maximum active opening and closing of the mouth (3 times).
3. Maximal clenching of the teeth for 2 seconds (3 times).
4. Maximal clenching of the teeth for 20 seconds (1 time).
5. Submaximal clenching of the teeth (with 50% force) for 1 minute (1 time).

Rest time muscle activity was registered before maximum opening and closing task for 5 seconds. Subjects' teeth were in an intercuspal position during clenching tasks. During maximal clenching subjects were asked to press their teeth together as hard as they could. For submaximal clenching, subjects were asked to clench with half of the force used before. The recorder instructed the application of force by comparing the activity level with the level from previous task.

4.4. Statistics

Standard statistical methods were used for the calculation of means and standard deviations (±SD). Unpaired t-test was used to compare variables between groups and sides. Paired t-test was used to evaluate the differences of MPF measured in the beginning and in the end of submaximal clenching. Variables were correlated using the Spearman coefficient calculated with Statistica 7 and the statistical significance was accepted at $p<0.05$.

5. RESULTS

5.1. Examination of masticatory muscles and temporomandibular joints

Mean ROM of the TMJ is shown in figure 8. There was no significant difference in RA patients and healthy subjects (p>0.05).

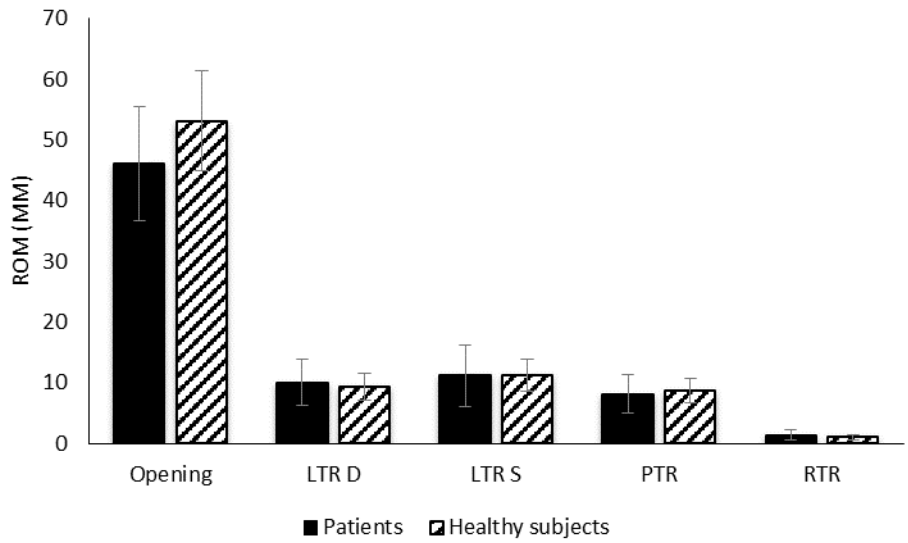


Figure 8. Range of motion (ROM) of the temporomandibular joints in RA patients and healthy subjects (mean±SD). Opening – maximal opening of the mouth; LTR D - laterotrusion to the right; LTR S – laterotrusion to the left; PTR – protrusion; RTR – retrusion.

The presence of joint sounds (clicking and crepitation) in RA patients and healthy subjects is shown in table 2. RA patients had more sounds than healthy subjects did. Movement caused some pain in all subjects (RA patients more than healthy subjects) but there was no significant difference. RA patients had more crepitation and that was significantly different (right side p=0.03, left side p=0.02).

Table 2. Temporomandibular joint sounds presented in RA patients and healthy subjects.

	RA patients			Healthy subjects	
Nr	**Clicking**	**Crepitation**	**Nr**	**Clicking**	**Crepitation**
1.	-	-	**1.**	-	-
2.	-	+	**2.**	-	-
3.	-	-	**3.**	+	-
4.	+	+	**4.**	+	-
5.	+	+	**5.**	-	-
6.	+	+	**6.**	-	-
7.	-	-	**7.**	-	-
8.	+	-	**8.**	+	-
9.	+	+	**9.**	-	-
10.	-	-	**10.**	-	-
11.	+	-	**11.**	+	-
			12.	+	-

+ - sound is present; - - sound is not present

5.2. Electromyography

Electromyographic activity during rest is shown in table 3. There was no significant difference between RA patients and healthy subjects (p>0.05).

Table 3. EMG activity during rest (RMS in μV·s; mean±SD)

	MIM	**LIM**	**MIT**	**LIT**
RA patients	5.5±2.9	6.9±4.5	10.2±6.1	10.7±12.9
	RM	**LM**	**RT**	**LT**
Healthy subjects	5.5±2.2	5.0±1.0	8.1±3.1	9.3±5.6

MIM – more involved masseter; MIT – more involved temporalis; LIM – less involved masseter; LIT - less involved temporalis; RM – right masseter; LM - left masseter; RT – right temporalis, LT - left temporalis.

The EMG activity of masticatory muscles during opening and closing in RA patients is shown in figure 9. The difference in EMG activity was significant between all muscles (MIM/RM p=0.04, LIM/LM p=0.04, MIT/RT p=0.006, LIT/LT p=0.02).

The level of muscle activity was higher in healthy subjects during maximal clenching for 2 and 20 seconds but there was no significant differences between RA patients and healthy subjects (Fig. 10).

Mean power frequency slope in masticatory muscles between the beginning and the end of submaximal clencing for 1 minute in RA patients and in healthy subjects is shown in figure 11. The slope was bigger in RA patients group.

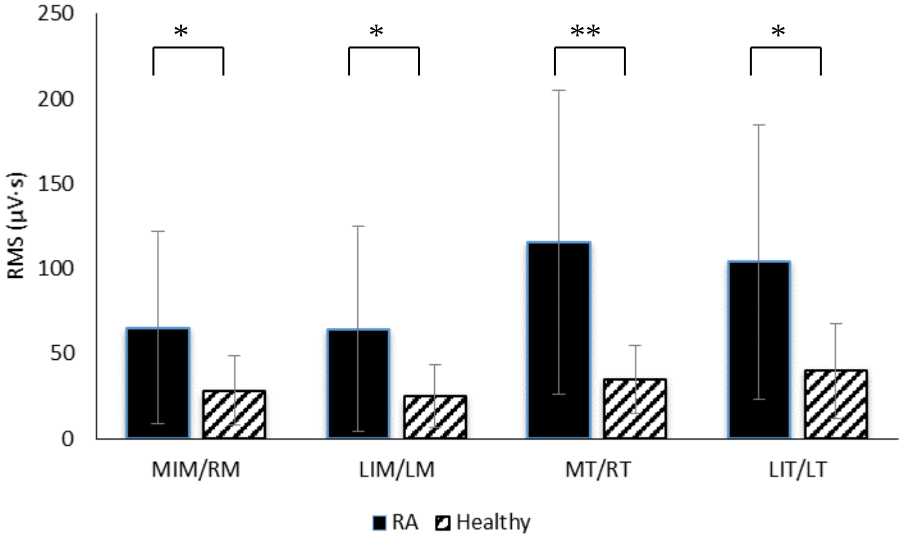


Figure 9. EMG activity (RMS, μV·s) of masticatory muscles during opening and closin in RA patients (RA) and healthy subjects (mean±SD). MIM – more involved masseter; MIT – more involved temporalis; LIM – less involved masseter; LIT - less involved temporalis; RM – right masseter; LM - left masseter; RT – right temporalis; LT - left temporalis; *p<0.05; **p<0.01.

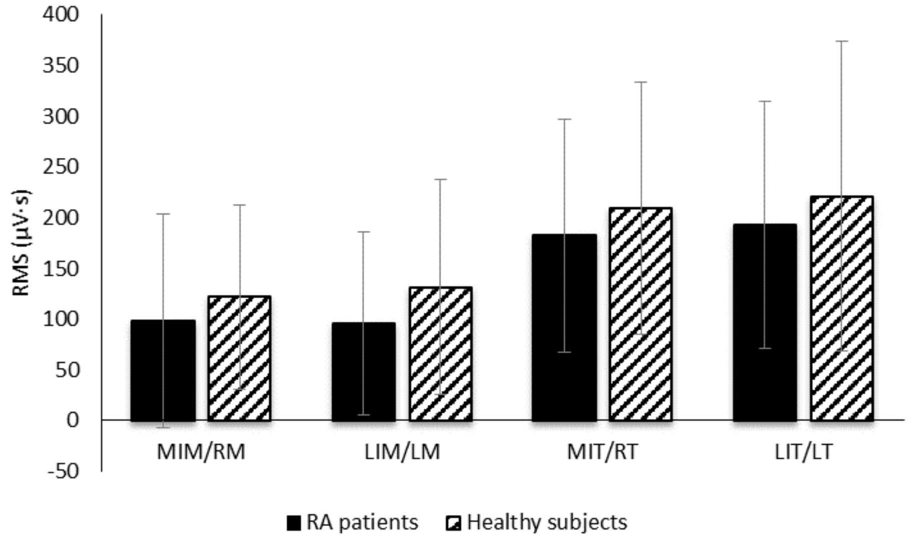


Figure 10. EMG activity (RMS, µV·s) of masticatory muscles in maximal clenching for 20 seconds (mean±SD). MIM – more involved masseter; MIT – more involved temporalis; LIM – less involved masseter; LIT - less involved temporalis; RM – right masseter; LM - left masseter; RT – right temporalis, LT - left temporalis.

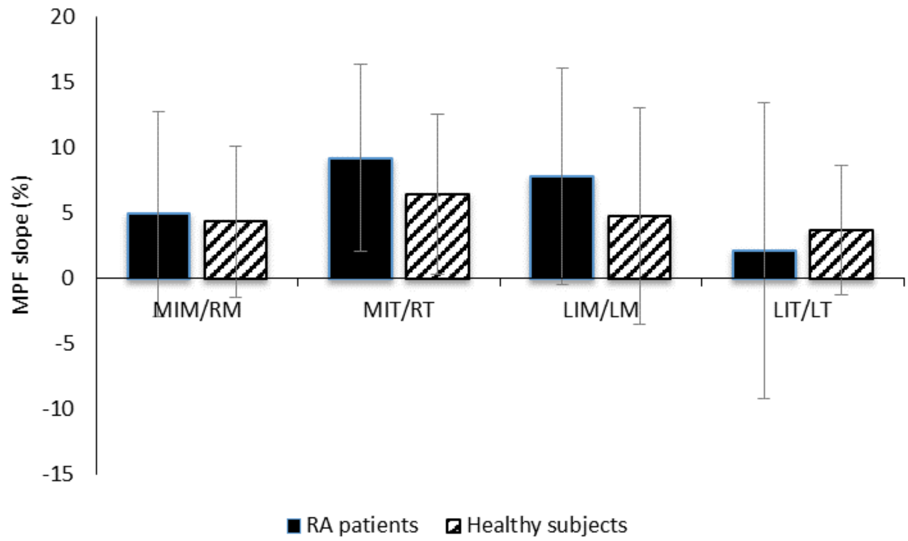
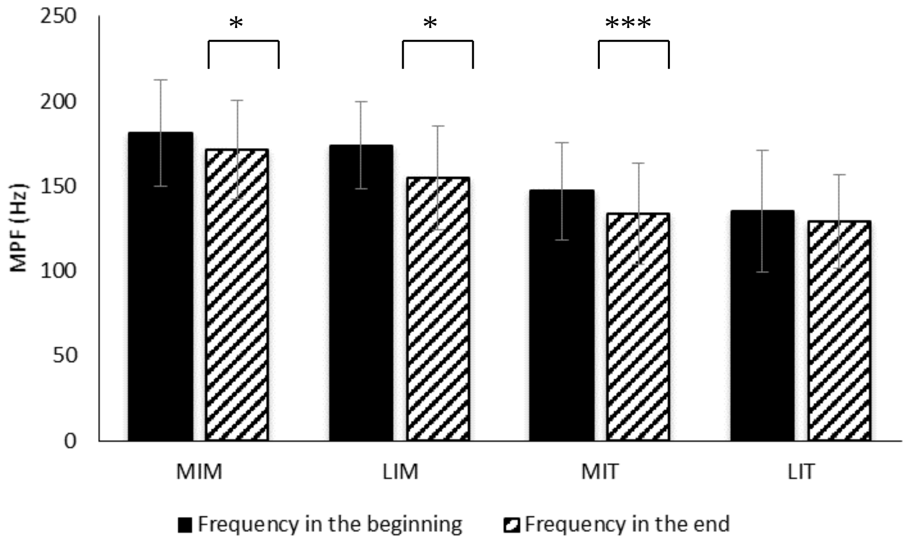


Figure 11. Mean power frequency slope (MPF slope) in masticatory muscles in submaximal clenching for 1 minute in RA patients and healthy subjects (mean±SD). MIM – more involved masseter; MIT – more involved temporalis; LIM – less involved masseter; LIT - less involved temporalis; RM – right masseter; LM - left masseter; RT – right temporalis, LT - left temporalis.

Mean power frequency in the beginning and in the end of submaximal clencing for 1 minute in RA patients is shown in figure 12A and in healthy subjects in figure 12B. In patients the frequency was lower in the end and was significantly different in three muscles (MIM p=0.03, LIM p=0.01, MIT p= 0.001). In healthy subjects the frequency in the end was also lower and in three muscles it was also significantly different (RM p=0.02, LM p=0.04, RT p=0.01).

A



B

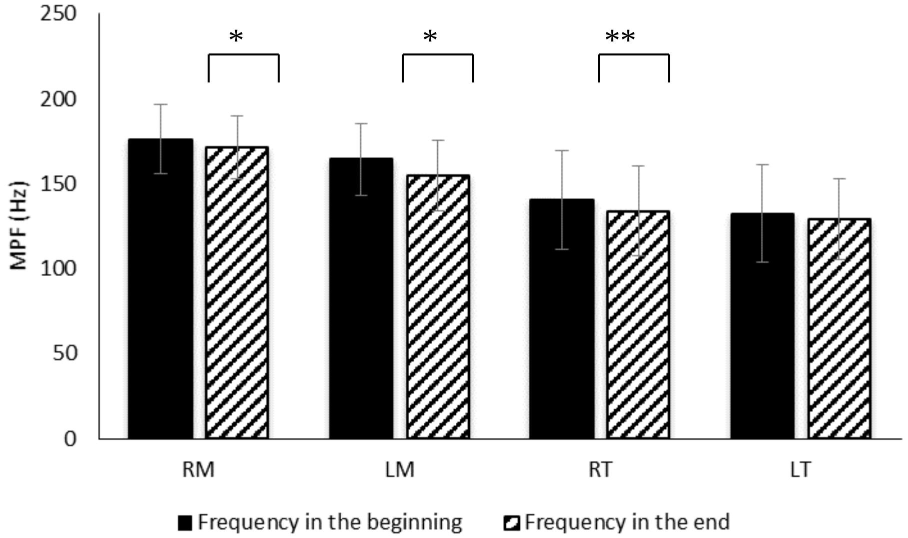


Figure 12. Mean power frequency (MPG, Hz) in the beginning and in the end of submaximal clencing for 1 minute in RA patients (A) and healthy subjects (B) (mean±SD). MIM – more involved masseter; MIT – more involved temporalis; LIM – less involved masseter; LIT - less involved temporalis; RM – right masseter; LM – left masseter; RT – right temporalis; LT – left temporalis; * p<0.05; *** p<0.001.

5.3. Activities of daily living

ADL questionnaire average scores are shown in table 4. There was almost no pain in the healthy subjects group; nine out of eleven RA patients had mild to severe pain in activities (appendix 2). RA patients had most pain/discomfort during eating, yawning, opening the mouth wide and in general daily activities.

Table 4. Average scores of activities of daily living questionnaire in rheumatoid arthritis patients and healthy subjects.

	Socialize with family and close friends?	Perform daily work?	Perform daily household chores (preparing meals, cleaning, taking care of small children)?	Sit in a company or participate in other social activities (*e.g.* parties)?	Exercise (walk, bicycle, jog, *etc.*)?	Perform hobbies (read, fish, knit, play an instrument)?	Sleep at night?	Concentrate?	Eat (chew, swallow)?	Talk (laugh, sing)?	Yawn, open mouth wide?	How much does the pain/discomfort affect your daily activities?
RA patients average	2.6	2.5	2.3	2.7	2.2	2.6	3.4	3.0	4.3	2.8	4.8	3.8
Healthy subjects average	0	0	0	0	0	0	0	0	0.1	0	0.1	0

Mean scores in points (0-10).

5.4. Radiography

Radiological findings in RA patients are shown in table 5. One patient did not have an OPTG taken by that time. Two patients out on ten did not have any radiological changes. Other had at least one. The most common finding was flattening of the condylar head.

Table 5. Ortopantomographic findings in rheumatoid arthritis patients.

NR	Dex Er 1-4	Dex Fl	Dex OF	Sin Er 1-4	Sin FL	Sin OF
1.	0	0	0	0	1	0
2.	0	1	0	0	1	0
3.	0	0	0	0	1	0
4.	0	1	0	0	1	0
5.	0	0	0	0	0	0
6.	0	0	0	0	0	0
7.	0	1	0	0	1	0
8.	MD					
9.	0	1	0	0	0	0
10.	0	1	1	0	1	0
11 .	2	1	0	2	1	1
%	10	60	10	10	70	10

Dex Er- erosions in the right joint; Dex Fl- flattening of the right joint; Dex OF – osteophytes in the right joint; Sin Er- erosions in the left joint; Sin Fl- flattening of the left joint; Sin OF – osteophytes in the left joint; MD – missing data; scores shown in points and in percent.

5.5. Correlations

All correlations presented were found in the RA patients group. EMG activity (RMS) in temporalis muscle during opening and closing and ADL questionnaire scores correlated as shown in figure 13.

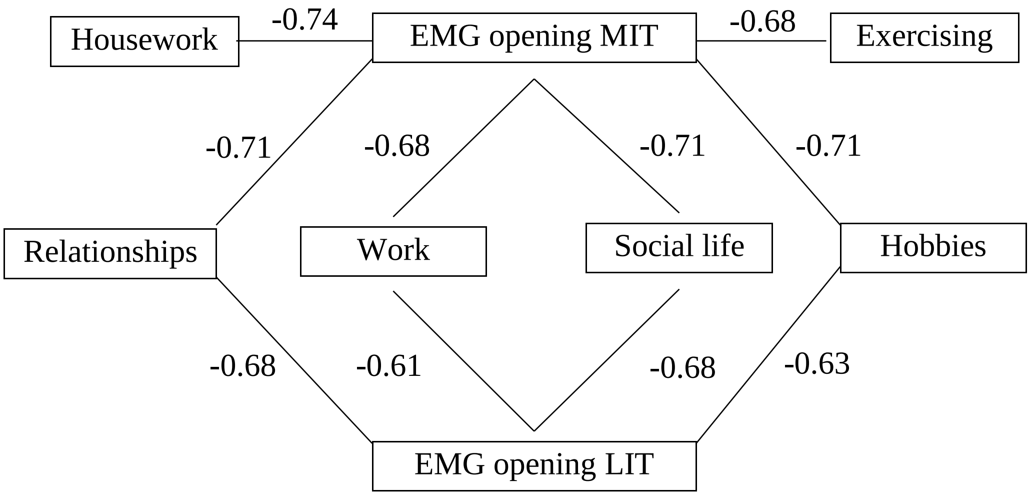


Figure 13. Correlations between EMG activity (RMS) in temporalis during opening and closing and active daily living tasks in RA patients. MIT – more involved temporalis; LIT – less involved temporalis; housework - performing daily household chores; relationships - socializing with family and close friends; work - performing daily work; social life - participating in social activities; hobbies – performing hobbies; (level of significance r=0.61, p<0.05; r=0.74, p<0.01; r=0.82, p<0.001).

Maximal clenching for 2 and 20 seconds was negatively correlated with the ADL questionnaire scores (Tab. 6). This shows that disturbances in the ADL causes lower muscle activity.

Grater digital tenderness of masticatory muscles correlated with lower muscle activity as shown in figure 14. This shows that if RA patients had more pain/difficulty in ADL then the EMG activity in masticatory muscles was lower.

Palpatory tenderness of the masseter muscles correlated positively with ADL questionnaire scores (Fig. 15). Eating as one of the ADL correlated negatively with maximal opening of the mouth (mm) with the significance of p=0.02. Difficulties with yawning correlated positively with the duration of disease (Spearman R=0.61; p<0.05).

Table 6. Correlations between EMG activity in masticatory muscles during maximal clenching for 2 seconds and 20 seconds in rheumatoid arthritis patients and sleeping.

	Valid N	Spearman R	p-level
EMG maximal clenching for 2 s MIT & sleeping	11	-0.74	0.01
EMG maximal clenching for 2 s MIT & sleeping	11	-0.80	0.00
EMG maximal clenching for 20 s MIT & sleeping	11	-0.70	0.02
EMG maximal clenching for 20 s MIT & sleeping	11	-0.70	0.02

MIT – more involved temporalis; sleeping – ADL score for sleeping.

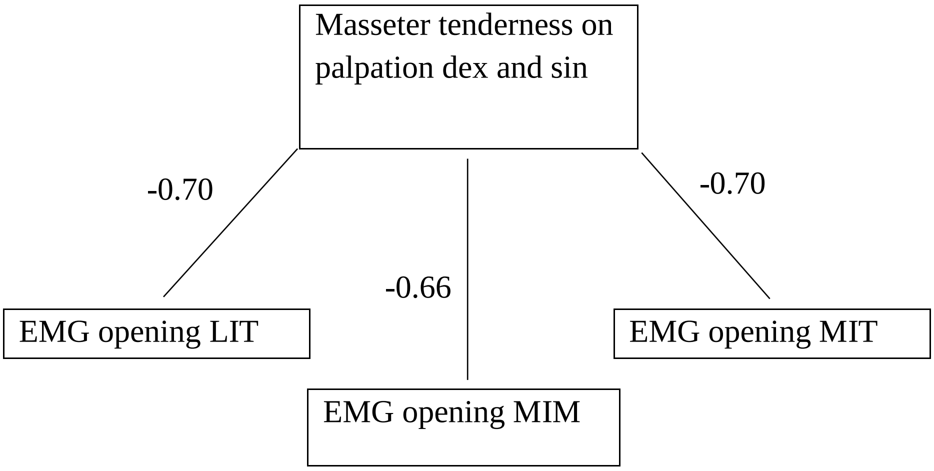


Figure 14. Correlations between digital tenderness of masseter muscle on palpation and EMG activity (RMS) during opening and closing in rheumatoid arthritis patients. LIT – less involved temporalis; MIM – more involved masseter; MIT – more involved temporalis; dex – right; sin – left (level of significance r=0.61, p<0.05; r=0.74, p<0.01; r=0,82, p<0.001).

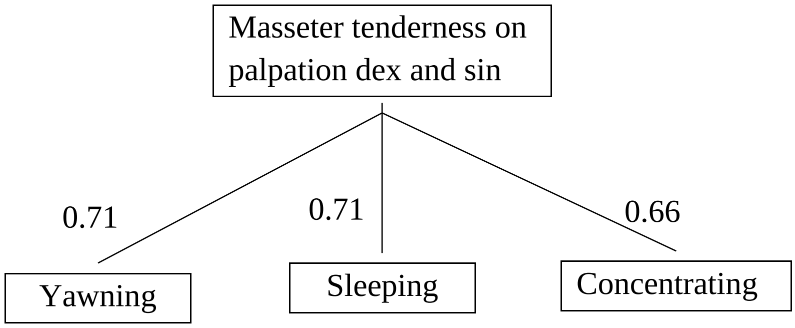


Figure 15. Correlations between digital tenderness of masseter muscle on palpation and activities of daily living questionnaire scores in RA patients dex – right; sin – left (level of significance r=0.61, p<0.05; r=0.74, p<0.01; r=0.82, p<0.001).

TMJ palpatory tenderness was positively correlated with fatigue in more involved temporalis muscle during submaximal sustained clenching for 1 minute and masseter muscle tenderness on digital palpation (Tab. 7). Flattening of the condyle correlated negatively with muscle activity in maximal clenching, protrusion and laterotrusion to the left (Tab. 7). Radiological findings (added) in the more involved side correlated negatively with muscle activity in maximal clenching (Tab. 7).

Table 7. Correlations of muscle activity, radiographic findings and temporomandibular joint palpatory tenderness.

Correlations between temporomandibular joint palpatory tenderness, fatigue in more involved temporalis during submaximal clenching and muscle tenderness on palpation.	**Valid N**	**Spearman R**	**p-level**
MPF slope in MIT submaximal clenching & TMJ palpatory tenderness lat dex	10	0.73	0.02
Muscle tenderness on palpation masseter dex & TMJ palpatory tenderness lat & post sin	10	0.67	0.04
Muscle tenderness on palpation masseter sin & TMJ palpatory tenderness lat & post sin	10	0.67	0.04
Correlations between flattening of the condyle and EMG activity (RMS) in more involved masseter muscle during maximal clenching for 2 seconds, laterotrusion to the left and protrusion in RA patients.	**Valid N**	**Spearman R**	**p-level**
Flattening & EMG maximal clenching MIM	10	-0.64	0.04
Flattening & laterotrusion sin	8	-0.80	0.02
Flattening & protrusion	8	-0.82	0.01
Correlations between added radiological findings (sides looked at separately) and EMG activity (RMS) in masticatory muscles during maximal clenching for 2 seconds.	**Valid N**	**Spearman R**	**p-level**
Radiology MIS & EMG maximal clenching MIM	11	-0.82	0.00
Radiology MIS & EMG maximal clenching LIM	11	-0.68	0.02
Radiology MIS & EMG maximal clenching MIT	11	-0.73	0.01
Radiology MIS & EMG maximal clenching LIT	11	-0.77	0.01

MIS – more involved side; MIM – more involved masseter; LIM – less involved masseter; MIT – more involved temporalis; LIT – less involved temporalis; TMJ – temporomandibular joint; lat – lateral; post – posterior; dex – right; sin – left.

6. DISCUSSION

This study compared masticatory muscle activity in temporomandibular joint movement in association with ADL scores and radiographic findings.

It was found that radiological findings in the more involved side correlated negatively with average EMG activity in all masticatory muscles in RA patients during maximal clenching. Flattening of the condylar head correlated negatively with more involved masseter muscle activity in clenching. The radiographic sign of flattening in RA can be considered as a cumulative sign of condyle bone tissue loss and changes in the masticatory muscles activity measured by EMG could be as a potential prognostic marker for bone tissue loss. So far there are no studies where the strong associations between radiological changes in the TMJ and masticatory muscle activity has been found.

Limiting factor of this study is that bite force was not measured because of the lack of appropriate device. Larheim and Flöystrand (1985) found that bite force in RA patients showed significantly lower values than in the healthy individuals. As Bakke (2006) noted, the level of electromyographic activity fairly accurately reflects the level of bite force and therefore it could be speculated that Larheim and Flöystrand's subjects' muscle activity was also lower. Based on these findings it can be concluded that radiographic changes negatively affect muscle activity of masticatory muscles in RA patients or vice versa.

It can be speculated that RA patients have a voluntary muscle activation deficit due to fear of pain or the habit to protect the joints. This mechanism can also be similar to arthrogenic muscle inhibition seen in other joints. Arthrogenic muscle inhibition is caused by a change in the discharge of articular sensory receptors due to factors such as swelling, inflammation, joint laxity, and damage to joint afferents (Rice and McNair, 2010).

When comparing RA patients with healthy subjects, the average of EMG activity in masticatory muscles during opening and closing was higher in RA patients. There was significant difference between more involved masseter in RA patients and right side masseter muscle in healthy subjects. There are no studies available where masticatory muscle EMG activity was measured only in RA patients. Similar studies have been used to compare the results.

Nielsen *et al.* (1990) found that the subjects with muscle pain use their anterior temporalis muscles with less frequency and with less intensity in several responses than normal subjects but the masseter muscle is impaired much less in its function. Their study demonstrates that subjects with muscle pain in craniomandibular muscles alter the recruitment of their jaw muscles, thus supporting the concept that the neuromuscular system is altered in patients with craniomandibular disorders.

These findings partially support the results of this study. It could be that the muscle function in RA patients is disturbed by pain and therefore they need to attain greater activity to complete the task. Findings by Nielsen *et al*. (1990) also support the correlation between TMJ palpatory tenderness and fatigue in the more involved masseter during submaximal clenching.

There was no significant difference between RA patients and healthy subjects in electromyographic activity during rest although Pedroni *et al*. (2004) noted that the most accepted hypothesis among scientific researchers involving the EMG activity of masticatory muscles is that the muscle activity necessary to keep the mandibular rest position is higher in TMD patients with myofacial pain than in control individuals. Pinho *et al.* (2000) found slightly higher mean resting activity in TMD patients compared to healthy subjects as well.

However As said, Pinho *et al.* (2000) only found slightly higher resting activity but it was the overall activity of all muscles measured. In this study muscles were looked at separately. Pinho *et al.* (2000) also measured the activity of more muscles: anterior temporalis, superficial masseter, deep masseter and anterior digastric.

The difference of activity during rest could also come from the fact that many TMDs are induced by stress-related parafunctional habits (*i.e.*, clenching and grinding) (Herb *et al.*, 2006) that could rise the muscle activity but RA patients' disorders arise from inflammation.

The level of muscle activity was higher in healthy subjects during maximal clenching for 2 and 20 seconds but there was no significant differences between RA patients and healthy subjects.

Santa-Mora *et al.* (2009) found lower masseter and temporalis EMG activation in patients with TMD. Patients with right-sided TMD demonstrated preferential use of their left-sided muscles and vice versa. Tartaglia *et al.* (2008) assessed myogenous, arthrogenous and psycogenous TMD patients and found significant difference during clenching in all groups compared to controls.

Strini *et al.* (2013) found similar values of maximal bite force, thickness and electrical activity of masticatory and cervical muscles on individuals with TMD when compared with controls. They have suggested that positive correlations observed between these variables may be because of a muscular alteration in TMD patients and a co-activation of masticatory and cervical muscles during mandibular movement.

The number of subjects in this study was rather small and occlusal aspects were not taken in consideration, which could alter the results. The patients group included three men when subjects group contained only women. Palinkas *et al*. (2010) found in their study that maximal molar bite force means of men were approximately 30% higher than those of women. If only women were used in the RA patients group then maybe the difference would have been significant.

Mean power frequency in the beginning and in the end of submaximal clenching for 1 minute was significantly different inside RA patients and healthy subjects groups but not between groups. There was no significant difference in mean power frequency slope in both groups.

There have been quite many studies about masticatory muscle activity during maximal clenching but not so many during submaximal clenching. Svensson *et al.* (2001) had 11 healthy men clenching on a bite-force meter for 60 min at 10% of the maximal voluntary contraction and found that the mean frequency of the EMG activity decreased in all muscles during the task.

The EMG spectrum shift to the lower frequencies is caused by intracellular pH decrease due to lactate accumulation and H^+ concentration (Brody *et al.*, 1991) or extracellular K^+ accumulation (Linssen *et al.*, 1991). Number of factors have been suggested to influence the rate of EMG spectral shifts towards lower frequencies during fatiguing contractions: slowing of action potential velocity, synchronization of motor units, slowing of contraction (De Luca, 1984).

Although the time of submaximal clenching was quite short, it is possible that the mechanisms of fatigue already take place because both groups showed similar tendencies.

Average EMG activity in RA patients during opening and closing of the mouth correlated negatively with ADL scores for tasks like exercising, performing hobbies and being active in social life. Masseter digital tenderness on palpation correlated negatively with EMG activity during opening and closing of the mouth.

Peck *et al.* (2008) has proposed that the relationship is influenced by the functional complexity of the sensory-motor system and the multidimensional nature of pain. Their Integrated Pain Adaptation Model states that pain results in a new recruitment strategy of motor units that is influenced by the multidimensional (*i.e.*, biological and psychosocial) components of the pain experience. This new recruitment strategy aims to minimize pain and maintain homeostasis.

That indicates that patients with greater pain avoid excessive movement in the TMJ and therefore activate their muscles less. If there is pain in the masticatory muscles it could make talking also more painful and therefore it is more difficult to be social.

This study indicates that ADL are negatively affected in most RA patients. TMJ pain/discomfort was greatest during eating and jaw movements and smallest during exercising and performance of daily household chores. Masseter tenderness on digital palpation was correlated to yawning, sleeping and concentrating. It was also found that eating difficulties correlated negatively with maximal opening of the mouth in RA patients.

In the study by Ahmed *et al*. (2013) TMJ pain at rest, on maximum mouth opening, and on chewing was correlated with the impact of the TMJ pain on daily activities and quality of life. Partial correlations showed a significant interaction between TMJ pain on movement that explained the TMJ pain impact on daily activities and quality of life to a significant degree.

Voog *et al*. (2003) found that the impact of daily living by TMJ pain/discomfort was greatest on the performance of physical exercises and jaw movements, while it was smallest on the performance of hobbies and eating. Pain during maximum mouth opening and tenderness to digital palpation were correlated to difficulties with several activities such as to yawn and open mouth wide.

The high TMJ pain/discomfort during eating and moving the jaw was expected because patients can alter their diet and limit the movement but can not stop them completely. The amount of exercises and household chores may be altered more depending on amount of discomfort.

The most common radiographic finding in this study was flattening of the condylar head. The most common findings in the study of Bayar *et al*. (2002) were decreases in the joint space, mandibular subchondral cysts, temporal subchondral cysts, degeneration, shape and height anomalies of the mandibular condyle, condylar head resorption, erosion of the mandibular condyle, and demineralization. Bayar *et al.* (2002) used computed tomography instead of OPTG and compared more findings but they also noted the change in the shape of the condylar head.

Radiographic findings also support the fact that five patient out of eleven had TMJ crepitation and six had clicking. Radiographic finding are very common in RA patients and they were expected to correlate with the duration of disease but they did not.

Biggest difference in ROM between RA patients and healthy subjects was in maximal mouth opening. Opening average for RA patients was 46.1 mm and for healthy subjects 53.2 mm. There was no significant difference in ROM in all directions in RA patients and healthy subjects. Based on their findings, Gomes *et al.* (2014) did not associate any severity of signs and symptoms of TMD with mandibular range of motion.

Sidebottom and Sala (2013) have noted that objective differences in mouth opening are not different from those of the general population and may be because the TMJ contains more resistant fibrocartilage than hyaline cartilage which is found in other peripheral joints and that can also explain the finding of this study.

Even though there was no significant difference in ROM of TMJ, flattening of the condylar head correlated negatively with protrusion and laterotrusion to the left. It can be speculated that the ROM of TMJ is decreased due to the mechanical impediments of radiological changes or consequential pain although palpatory tenderness or pain during movement of the TMJ did not correlate with the ROM of TMJ.

The latter could be due to the fact that it was only noted if there was pain or no pain during movement and palpation of the TMJ. The use of a wider scale like visual analogue scale ranging from 0-10 could have given more correlations.

CONCLUSIONS

1. In patients with RA, the EMG activity of masticatory muscles during opening and closing movements of the mouth was higher compared with healthy subjects.
2. No significant difference was noted in fatiguability of masticatory muscles evaluated by EMG power spectrum during submaximal clenching in patients with RA and healthy subjects.
3. Correlation analysis demonstrated that level of radiological findings exert a significant negative influence on masticatory muscle EMG activity during TMJ movement in RA patients.
4. ADL scores were correlated negatively with EMG activity of masticatory muscles during TMJ movement in RA patients.

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MÄLUMISLIHASTE ELEKTROMÜOGRAAFILINE AKTIIVSUS LÕUALIIGESE LIIKUMISEL REUMATOIDARTRIIDIGA PATSIENTIDEL JA TERVETEL: SEOS PIIRANGUTEGA IGAPÄEVASTES TOIMINGUTES JA RADIOLOOGILISTE LEIDUDEGA.

Nele Pihla

RESÜMEE

Käesoleva uuringu peamine eesmärk oli võrrelda reumatoidartriidiga patsientidel ja tervetel mälumislihaste elektromüograafilist aktiivsust lõualiigese erineval liikumisel ning leida seoseid piirangutega igapäevastes toimingutes ja radioloogiliste leidudega.

Uuringus osales 11 reumatoidartriidiga patsienti (3 meest, 8 naist, keskmine vanus 46 a) ja 12 tervet isikut (naised, keskmine vanus 51 a). Patsiendid värvati Tartu Ülikooli Stomatoloogia kliiniku lõualiigese spetsialisti vastuvõtust ning vabatahtlikena osalesid sama kliiniku töötajad.

Uuriti kliinilisi näitajaid (lõualiigese aktiivne liikuvusulatus, mälumislihaste ja lõualiigeste palpatoorne hellus, liigeshääled), mõõdeti mälumislihaste elektromüograafilist aktiivsust puhkeolekus, suu avamisel ja sulgemisel, maksimaalsel kokkusurumisel ning submaksimaalsel kokkusurumisel. Patsiendid täitsid igapäevaste toimingute küsimustiku ning reumatoidartriidiga patsientidel vaadati muutusi ortopantomograafil.

Uuringu tulemustest võib järeldada, et suu avamise ja sulgemise liigutusel oli mälumislihaste aktiivsus reumatoidartriidi diagnoosiga patsientidel kõrgem kui tervetel. Submaksimaalsel surumisel ei leitud olulisi erinevusi mälumislihaste väsimuse näitajas uuritud gruppide vahel. Korrelatsioonianalüüsist selgus, et radioloogilised muutused reumatoidartriidiga patsientidel avaldavad negatiivset mõju mälumislihaste aktiivsusele. Reumatoidartriidiga patsientide suurem piiratus igapäevastel toimingutel korreleerus negatiivselt mälumislihaste aktiivsusega.

APPENDICIES

Appendix 1. Activities of daily living questionnaire

Patsiendi number

Kuupäev

ADL (igapäevane elutegevus)

Järgneb tegevuste loetelu. Tõmmake ring ümber selle numbri, mis iseloomustab hetkel kõige paremini Teie võimeid osaleda aktiivselt igal alal kui Teil on **valu/ebamugavustunne** alalõualiigese piirkonnas.

Kui ma tunnen valu/ebamugavust, siis ma olen võimeline:

Olema oma perekonna ja lähemate sõpradega seltsiv
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Sooritama igapäevast tööd
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Olema seltskonnas või osalema ühiskondlikes üritustes (n. peod)
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Harjutused (jalutamine, jalgrattaga sõitmine, sörkjooks, jne)
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Öine magamine
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Kontsentreerumine
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Söömine (neelamine, mälumine)
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Rääkimine (naermine, laulmine)
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Haigutamine, suu maksimaalne avamine
0 1 2 3 4 5 6 7 8 9 10
↑ aktiivsus ilma valuta aktiivsus võimatu kuna valu ↑

Kui palju mõjutab Teie päevaseid tegemisi valu/ebamugavustunne?
0 1 2 3 4 5 6 7 8 9 10

Appendix 2. Activities of daily living questionnaire scores in rheumatoid arthritis patients.

	Socialize with family and close friends?	Perform daily work?	Perform daily household chores (preparing meals, cleaning, taking care of small children)?	Sit in a company or participate in other social activities (*e.g.* parties)?	Exercise (walk, bicycle, jog, *etc.*)?	Perform hobbies (read, fish, knit, play an instrument)?	Sleep at night?	Concentrate?	Eat (chew, swallow)?	Talk (laugh, sing)?	Yawn, open mouth wide?	How much does the pain/discomfort affect your daily activities?
1.	2	2	3	3	1	3	4	3	5	3	6	1
2.	0	0	0	0		0	0	0	5	5	8	3
3.	2	2	1	1	1	1	6	7	5	1	4	5
4.	6	5	10	8	5	10	8	7	6	6	9	8
5.	0	1	0	0	1	0	1	0	1	0	0	1
6.	6	4	2	4	4	7	1	3	7	7	8	5
7.	6	9	7	7	7	6	5	6	2	2	0	4
8.	0	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	4	0	8	0	7.5	7.5
10.	0	0	0	0	0	0	0	0	0	0	1	0
11.	7	5	2	7	3	2	8	7	8	7	9	7

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