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Changes of trapezius muscle blood flow and electromyography in chronic neck pain due to trapezius myalgia

Romy Larsson[a], P. Åke Öberg[b], Sven-Erik Larsson[a,*]

[a]*Department of Orthopaedics, University Hospital, S-581 85 Linköping, Sweden*
[b]*Department of Biomedical Engineering, University Hospital, S-581 85 Linköping, Sweden*

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Abstract

Chronic neck pain may increase the transmitter activity of neuropeptides in the upper cervical medulla causing impairment of the blood flow in the local muscle because of a lack of vasodilatatory substances excreted axonally. We have been using a new single-fibre technique for clinical determination of the microcirculation (LDF) in the trapezius muscles in relation to electromyography (EMG). This study pertains to the 76 patients (46 women and 30 men) who received a final diagnosis of chronic trapezius myalgia out of a total series of 300 cases with chronic neck pain which had been remitted to the National Insurance Administration Hospital in Tranås, Sweden, because their complaints interfered with their working ability. The purpose was to derive more objective medical information upon which to base rehabilitation. Sixty percent had continuous pain and 40% had pain after physical effort, or at work. Twenty healthy women volunteered to participate as a normal control group. The right and left trapezius muscles of all individuals were examined simultaneously with laser-Doppler flowmetry (LDF) and surface EMG during a fatiguing series of stepwise-increased contractions, each of 1 min duration with 1 min rest in between. The most painful side was compared with the opposite side in all patients and, in the female patients, also with the right shoulder of the healthy control women. The patients showed consistently low local blood flow in the painful side. The difference was statistically significant at low contraction intensities. Muscle tension was somewhat elevated, as evidenced by a slight increase of the rms-EMG that was statistically significant at high contraction intensities. The mean power frequency (MPF) of the EMG showed no change. The lowered local blood flow was not explained by a changed intramuscular pressure which is low in the trapezius during ordinary activities that do not normally impair the local blood flow (Larsson, S-E., Cai, H. and Öberg, P.Å., Microcirculation in the upper trapezius muscle during varying levels of static contraction, fatigue and recovery in healthy women. A study using percutaneus laser-Doppler flowmetry and surface electromyograpy, Eur. J. Appl. Physiol., 66 (1993) 483–488). We conclude that an impaired regulation of the microcirculation in the local muscle is of central importance in chronic trapezius myalgia, causing nociceptive pain which can be differentiated objectively from neuralgic neck-shoulder pain by the atraumatic technique described. © 1999 International Association for the Study of Pain. Published by Elsevier Science B.V.

Keywords: Shoulder; Muscle; Static loads; Blood flow; Laser-Doppler; Electromyography; Trapezius myalgia; Neck pain

1. Introduction

Chronic trapezius myalgia causes local pain and weakness in the neck-shoulder. It is a frequent cause of long-lasting work disability, especially among female employees who do highly repetitive assembly work in a sitting posture for a major part of the work days. The static work load is considered to cause the disability (Hagberg and Wegman, 1987, Larsson et al., 1988).

In this category of patients who had long-term work absence, we previously had performed a combined, open biopsy and circulatory study of the trapezius by applying a 2 mm wide laser-Doppler probe to the exposed muscle surface (Larsson et al., 1988, 1990). The local muscle showed lowered microcirculation on the most painful side, and there were morphological signs of disturbed mitochondrial function confined to discrete regions of the slow, type I fibres ('ragged red fibres'). These changes showed a significant relationship to the presence of chronic, local pain (Larsson et al., 1990). However, the procedure necessitated

* Corresponding author. Tel.: +46 13 222000; fax: +46 13 224503.

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surgical exposure of the muscle and is not suited for routine examination of a large number of persons.

We have now been studying the microcirculation in the trapezius muscles using atraumatic techniques based upon single-fibre laser-Doppler (Salerud and Öberg, 1987) which we have adopted for clinical research (Larsson et al., 1990, 1993, 1998a). An optical fibre with a 0.5 mm outer diameter was inserted into the right and left trapezius muscles directly through the skin via an 0.8 mm Venflon cannula. Continuous, dynamic measurements of the blood flow were made during static contractions of stepwise increased intensity, defined by simultaneous surface EMG (Larsson et al., 1993).

The purpose of this clinical study has been to ascertain if there are local, physiological changes in trapezius myalgia upon which to base objective medical diagnosis and work rehabilitation.

2. Materials and methods

2.1. Patients

The 76 patients (46 women and 30 men) had long-lasting neck pain and work inability but few clinical abnormalities at physical examination. They were referred from different parts of the country by the local, official insurance authorities for thorough medical examination with the purpose of obtaining objective medical information upon which to base work rehabilitation. Patient costs were covered by the national insurance. All subjects were Caucasian. They gave informed agreement to participating in the study. Consent to the study was given by the Research Ethics Committee at our hospital.

Table 1

Data from patients and controls

Variable	All patients	Female patients	Female controls
N	76	46	20
Gender (male/female)	30/46	0/46	0/20
Mean age (range) (years)	42 (23–58)	42 (26–57)	44 (25–63)
Ethnic origin (Swedish/other)	63/13	39/7	20/0
Mean height (range) (cm)	162 (152–174)	161 (150–172)	163 (153–176)
Mean weight (range) (kg)	63 (44–82)	62 (43–81)	66 (47–85)
Smoker	53	24	12
Disability compensation, 100%	62	36	0
Disability compensation, 50%	3	10	0
Work insurance compensation	22	12	0

Table 2

Previous work factors

Variable	All patients	Female patients	Controls
Total work period (years)	17	15	15
Working at the time of the examination	0	0	20
Lost earlier employment	18	7	0
Light job previously	44	15	8
Job including elevated arms and lifting	46	17	12
Highly repetitive manual work	32	32	0
Stress at work	24	22	6
Nursing staff	12	12	16
Office job	7	7	4

2.2. Controls

The female patients were compared with a normal control group of healthy women so that the results of the sexes were not mixed. Twenty healthy women gave informed consent to participating as normal controls. They had no complaints and took no medication that could interfere with the results of the study.

Clinical data of patients and controls are shown in Tables 1 and 2.

2.3. Exposure to static load

The right and left trapezius muscles were simultaneously exposed to stepwise increased static load for periods of 1 min each with 1 min of rest in between. The patient was sitting upright in a standard office chair with relaxed, hanging arms (rest position). On command, the patient raised straight arms symmetrically in the scapular plane (approximately midway between abduction and flexion) to subsequently 30°, 60°, 90° and 135°, i.e. the load positions. This was then repeated with a 1 kg (women) or 2 kg (men) load carried in each hand. Finally, a fatigue test was performed with straight arms elevated at 45° holding a 1 kg (women) or 2 kg (men) load in each hand. Recovery was then achieved with hanging arms and no hand load. LDF and EMG signals were recorded continuously during the three 10 min tests.

2.4. Laser-Doppler flowmetry

Laser-Doppler flowmetry (LDF) was used for simultaneous measurements of the micro-circulation in the upper portion of the right and left trapezius muscles, as we have described in detail previously (Larsson et al., 1993). The optical single fibres used had a diameter of 0.5 mm and were placed percutaneously within the muscle halfway between the spinous process of the C7 vertebra and the acromion. Insertion was made via a plastic cannula (Venflon 2 i.v. cannula, 0.8 mm outer diameter, Viggo, Helsingborg, Sweden) that had been inserted into the muscle to lead the optical

fibre to the maximal depth for the recordings, i.e. 5–10 mm from the point where the subject noted the somewhat painful passage of the cannula through the muscle fascia. A laser-Doppler flowmeter (modified Periflux, Pfld Peri-med, Stockholm, Sweden) was used for the measurements (time constant 0.2 s; 4 kHz; gain 1). All determinations were performed in a quiet laboratory room and at a temperature of 20–22°C.

2.5. EMG

EMG was recorded simultaneously with LDF by using bipolar surface electrodes (Medicotest pre-gelled child ECG-electrodes), placed over the right and left trapezius muscle halfway between the spinous process of the C7 vertebra and the acromion. The centre-to-centre inter-electrode distance was 2.0 cm. The reference electrode was placed over the spinous process of C7. EMG signals were visualized on an oscilloscope for testing electrode function.

2.6. Signal processing

The experimental set-up was similar to that used in our previous study (Larsson et al., 1993). LDF and EMG signals were converted into digital form in an A/D converter (AT.MIO-16, National Instruments, USA) with a resolution of 12 bits and processed on-line by a computer (Intel 485/66 MHz processor). Fast Fourier transform was performed using the Lab-Windows program. Root mean squared EMG (rms-EMG) as well as mean power frequency (MPF) were calculated by using 0.5 s segments. For each 1 min examination period we used 20 segments representing the 40–50 s part with exclusion of the first and the last segments to avoid disturbances from sample processing. A total of 18 432 points were used per measurement. LDF was calculated for each consecutive 1 min examination period by using the last 20 s of each period. Before filtering, 2048 points/s were used. Processing in a digital Butterworth low-pass filter of eighth order was used for a frequency range of 0–8.2 Hz, which corresponded to the blood flow spectrum of interest. MPF was calculated mainly according to Basmajian and DeLuca (1985).

2.7. Statistical analyses

t-Tests were used according to Snedecor and Cochran (1967). The paired *t*-test was used when the two shoulders of each patient were compared, and also for comparison of the different group mean values obtained in the test series. The unpaired *t*-test was used when the female patient group was compared with the female control group. $P < 0.05$ was considered significant.

3. Results

The obtained clinical data from the patients and controls are given in Tables 1–3. The prevailing work absence caused by neck-shoulder complaints was 26 months on average in the patients. Numbness and paraesthesia in the ulnar part of the lower arm was reported by 39 patients and 26 of them showed slightly reduced 2-point discrimination. None had any clear neurological symptoms.

Table 3

Clinical features of patients and controls

Variable	All patients	Female patients	Controls
Cervical trauma (light)	46	24	0
Immediate pain	22	13	0
Delayed onset pain	24	11	0
Head trauma	0	0	0
Continuous neck-shoulder pain	44	29	0
Pain on lifting	42	17	0
Unilateral pain	36	35	0
Bilateral pain	40	11	0
Headache, occipital	38	26	0
‘Tension’	2	13	0
Migraine	18	7	0
‘Trigger points’	8	5	0
Fibromyalgia	3	2	0
Segmental cervical pain	21	2	0
Cervical vertigo	18	16	0
Neurologic vertigo	1	1	0
Psychological consultation, anxiety	5	5	0
Depression	2	2	0
Diazepam overuse	1	1	0

At physical examination, somewhat restricted range of motion of the neck and shoulder was found in 43 patients due to a painful trapezius muscle. None had cervico-brachial pain. Passive range of motion of the shoulder joint was found to be slightly restricted in 12 patients, and two had a positive impingement test for supraspinatus tendinitis. Sixteen patients complained of lumbago and 11 of lumbago-ischias, besides their neck pain.

Radiography of the cervical spine was done in 47 patients, and was normal in 33. The remaining 14 patients had disc degeneration (eight), spondylosis (four) and spondylarthrosis (two). Two patients had kyphosis of the cervical spine.

Magnetic resonance imaging of the cervical spine was performed in nine patients; four had a bulging disc that was classified as cervical disc hernia, three had stenosis of the spinal canal, and two stenosis of a nerve hole. A Cloward operation was performed in the four patients with disc hernia.

3.1. LDF and EMG signals

The processed recordings of LDF and EMG from one of our patients are shown in Fig. 1.

The rms-EMG showed stepwise increased levels during the periods of 0°, 30°, 60°, 90° and 135° arm elevation and even more so when repeated with a 1 kg (women) or 2 kg

(men) hand load. The painful side differed from the opposite side in that the rms-EMG showed an increased level during the rest periods, and reached considerably higher levels during the load periods. The LDF recorded simultaneously with the EMG showed a tendency at lower levels in the painful side compared with the opposite side.

The overall results are shown in Fig. 2. In the patients with predominantly unilateral pain, the rms-EMG of the most painful side showed somewhat higher values in comparison with those of the opposite side. The difference was statistically significant on three testing occasions representing the most intense contractions. When the female patients were compared with the normal control women the worst side of the patients showed only a tendency at higher values and the difference was not statistically significant (Fig. 3).

As regards the mean power frequency of the EMG (MPF), the patients showed significantly lower values (Fig. 3). A lowering of the MPF with an increase of the rms-EMG is generally considered to represent EMG-signs of local muscle fatigue. These results suggest an accelerated fatigue development in the most painful muscle of the patients. They had also a short endurance time (not shown) and reported intensified local pain in the involved muscle during the test.

The LDF showed consistently lower values in the painful side in comparison to the opposite side (Fig. 3). The difference was statistically significant on four testing occasions, mostly at low contraction intensity.

4. Discussion

To study the influence of chronic neck pain on the microcirculation of the trapezius muscles we have been using an atraumatic single-fibre laser-Doppler technique, which we have adopted for clinical use with no need for surgical exposure of the muscle. It was found to be well suited for clinical examination of a large number of persons. A 0.5 mm thin optical fibre was inserted directly into the muscle through the skin via an 0.8 mm thin plastic cannula. This did not cause any disturbance to the intramuscular blood flow. The microcirculation was recorded continuously during static contraction of stepwise increased intensity determined by simultaneous electromyography (Larsson et al., 1993)

Laser-Doppler techniques for blood flow measurements are very sensitive to ‘motion artefacts’ caused by tissue movements other than blood cells. These are easily detected and did not affect the results of the present study. Laser-

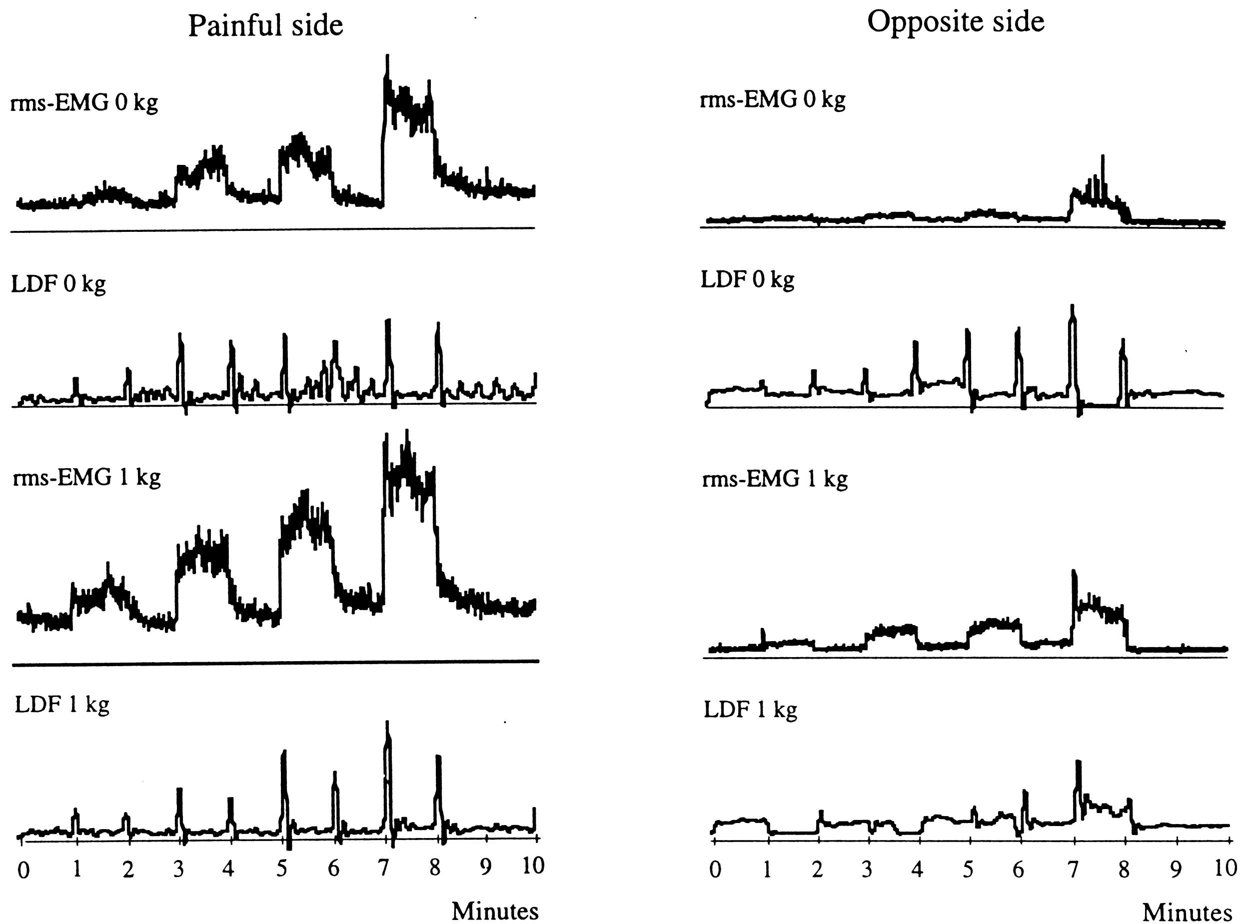

Fig. 1. The processed recordings of one of our patients. The rms-EMG shows elevated levels both at rest and at contraction in the painful side compared with the opposite side. Motion artefacts are seen during raising and lowering of the arms at the beginning and end of each testing period.

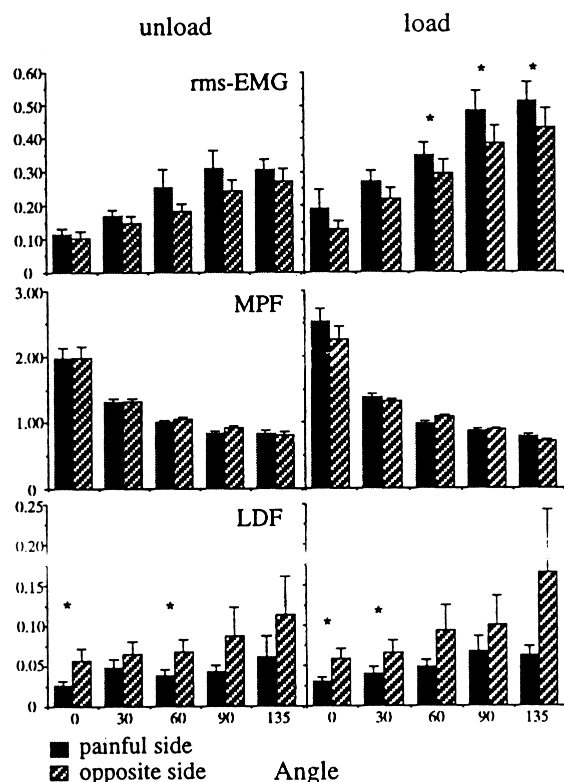

Fig. 2. This diagram summarizes the results of rms-EMG (top), the MPF (middle) and LDF (muscle blood flow, bottom). The values of the two sides are compared. The rms-EMG shows significantly higher values in the most painful side (shaded columns) than in the opposite side (black columns), especially at intensive contraction. The MPF, as well as the LDF, shows low values in the painful side compared with the opposite side. The stars denote the significance level. The bars represent SEM.

Doppler measurements express the blood flow in relative units, and several factors influence the measurement values, depending upon the technique used. The measured tissue volume corresponded to a hemisphere with a radius of about 1 mm. Recently, we have been studying the importance of the fibre tip optics and wave-length for the depth with which the detecting light can penetrate into the tissue (Cai et al., 1996). To avoid bias we used the same optical fibres throughout, and the measurement system was calibrated regularly by using a rotating disc. As muscle microcirculation shows large biological variations, both temporally and spatially, we have based our results upon measurements of groups of individuals for comparison after statistical evaluation.

Chronic neck pain most likely elicits an increased transmitter activity of neuropeptides such as CGRP and substance P in the upper cervical medulla and brain stem. This may cause a peripheral, local lack of the vasodilatatory action of the neuropeptides which are secreted axonally. This explanation is supported by animal studies where experimental compression of nerve roots in pigs results in neuropeptide changes (Cornefjord et al., 1995).

Our present findings of impaired microcirculation in the local muscle conform to the results of our previous open biopsy studies in females with work-related, chronic trapezius myalgia. These showed the presence of ‘ragged red’ fibres, i.e. type I fibres with discrete morphological signs of mitochondrial disturbance (Larsson et al., 1988). Levels of energy-rich substances such as ATP and ADP were reduced, probably due to impaired synthesis. The levels of lactate, pyrovate, and glycogene were normal, as well as phosphoryl creatine and total creatine.

In this situation, an increased number of muscle fibres has to become recruited in order to accomplish a certain amount of work. Our present findings of slightly increased amplitude of the rms-EMG during muscle contraction and rest as well, indicate increased basic muscle tension secondary to the impaired muscle microcirculation. This may cause a ‘vicious circle’ that maintains the chronic muscle pain. The damage to cell membranes might release irritating substances resulting in increased nociceptive activity. It may lead to elevated activity in the gamma-muscle-spindle system and cause increased basic muscle tonus or stiffness, according to the hypothesis put forward by Johansson and Sojka (1991).

Chronic trapezius myalgia may have different causes. A previous trauma to the soft tissues of the neck is often reported anamnestically. We have done similar studies as the present one in patients with chronic pain after a whiplash

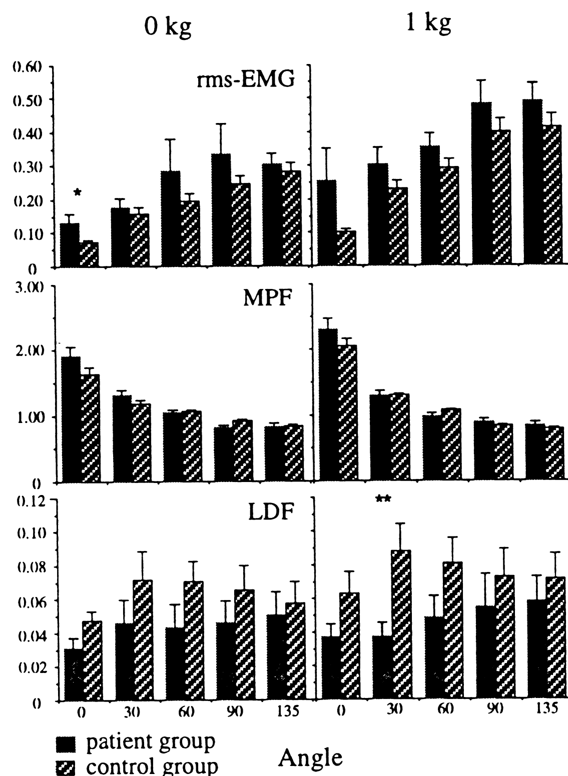

Fig. 3. The female patient group (black columns) was compared with a normal control group of healthy women (shaded columns). The rms-EMG shows consistently higher values in the patient group. However, the difference is not statistically significant due to high variation. The LDF and MPF show significantly lowered values in the painful side of the patients as compared with the healthy controls.

trauma to the neck (Larsson et al., 1994). The trapezius muscle on the most painful side showed lowered muscle blood flow and impaired regulation of the microcirculation in relation to contraction intensity. The rms-EMG showed a tendency towards an increase. It was concluded that chronic trapezius myalgia seems to be a prominent and important feature for maintenance of this common pain syndrome.

In the present study, 46 of the 76 patients anamnestically reported a light soft-tissue trauma to the neck that had occurred several years earlier. The remaining 30 patients did not recall any neck trauma at all. Our examinations did not disclose any obvious differences between the two categories of pain patients. None of the patients showed any clinical signs of the earlier trauma, and the clinical diagnosis was therefore trapezius myalgia of unspecified cause in all cases.

The hypothesis of neuropeptide imbalance in the neurones of the upper cervical medulla resulting from transmission of a steady flow of pain signals is supported by the results of our recent studies. Patients with neurogenic pain due to cervical disc hernia (Larsson et al., 1998b) as well as patients with chronic cervico-brachial syndrome (Larsson et al., 1998a) have lowered muscle blood flow, but characteristic central inhibition of the amplitude of the rms-EMG contrary to the patients with chronic trapezius myalgia who have elevated amplitude of the rms-EMG. These studies show that chronic neck pain can be visualized clinically and classified by determination of the local muscle blood flow in relation to muscle activity.

Trapezius myalgia does not seem to have psychological causes. Recently, we examined twenty-one patients (14 women and seven men) with psychosocial problems and chronic neck pain. As a group, they exhibited significantly lower local blood flow of the trapezius muscle compared with normal controls, but only at low contraction intensity. There was no difference between the most symptomatic side and the opposite side (Larsson et al., 1998b).

Impaired regulation of the blood flow in the local muscle appears to of central importance for the occurrence of trapezius myalgia and for the maintenance of chronic neck pain by nociceptive stimulation.

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