Effect of Treatment of Temporomandibular Disorders (TMD) in Patients with Cervicogenic Headache: A Single-Blind, Randomized Controlled Study

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ABSTRACT: The present study was comprised of 43 patients (16 men) with cervicogenic headaches for over three months, diagnosed according to the International Classification of Diagnostic Criteria of Headaches (ICDH-ll). The patients were randomly assigned to receive either manual therapy for the cervical region (usual care group) or additional manual therapy techniques to the temporomandibular region to additionally influence temporomandibular disorders (TMD). All patients were assessed prior to treatment, after six sessions of treatment, and at a six-month follow-up. The outcome criteria were: intensity of headaches measured on a colored analog scale, the Neck Disability Index (Dutch version), the Conti Anamnestic Questionnaire, noise registration at the mandibular joint using a stethoscope, the Graded Chronic Pain Status (Dutch version), mandibular deviation, range of mouth opening, and pressure/pain threshold of the masticatory muscles. The results indicate in the studied sample of cervicogenic headache patients, 44.1% had TMD. The group that received additional temporomandibular manual therapy techniques showed significantly decreased headache intensities and increased neck function after the treatment period. These improvements persisted during the treatment-free period (follow-up) and were not observed in the usual care group. This trend was also reflected on the questionnaires and the clinical temporomandibular signs. Based on these observations, we strongly believe that treatment of the temporomandibular region has beneficial effects for patients with cervicogenic headaches, even in the long-term.

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There is evidence that long-term upper cervical dysfunction may influence the function of the temporomandibular region and vice versa.[1-4] However, there are no well-designed studies that demonstrate that temporomandibular treatment provided by physical therapists has an influence on craniocervical dysfunction and the resulting complaints.[4] An effect study by Hoving, et al.,[5] demonstrated that directly referring patients with neck complaints to a manipulative physical therapist is more effective and cost-saving than guidance from a first-line medical professional. It has also been stated that in randomized effect studies, regarding neuromusculoskeletal treatment of long-term neck complaints, temporomandibular disorders (TMD) are rarely incorporated in the inclusion and exclusion criteria.[6-13] Furthermore, a literature review revealed that the temporomandibular region can influence the cervical region, although most studies included had a low level of evidence.[4] An investigation by the Netherlands Institute for Health Services Research (NIVEL) showed that in

daily practice, TMD is rarely considered during neuro-musculoskeletal treatment of long-term, nontraumatic neck and headache complaints. In 2006,[11,12] patients undergoing physical therapy were classified as nonspecific neck complaints (n=1,220) and specific neck syndromes (n=714), of which 63.5% and 66.9% received more than six treatments (average, 8.1 and 8.9: SD, 14.3 and 17.6), respectively. After 13 weeks, 24.2% (n=297) of the nonspecific neck complaints group and 26.5% (n=189) of the neck syndrome group were still being treated. This group of nonspecific neck complaints occupies the second place after the nonspecific shoulder complaints[14] in the list of the longest and highest number of treatments.

Therefore, patients with chronic neck complaints, including headaches related to neck dysfunction, need more treatment in relation to other neuromusculoskeletal syndromes, and it is unknown to what extent TMD plays a causal and/or a contributing role in this patient population. A subgroup of chronic neck complaints forms the group of cervicogenic headache patients,[15] which is recognized by the International Headache Society (IHS) as a separate entity (Headache Committee of the International Headache Society, 2004).

The diagnostic criteria for cervicogenic headaches described by the IHS contain subjectively described complaint patterns and dysfunction (impairments) that might be found during a cervical functional examination (IHS, 2004) (**Table 1**).

Although the hypothesis is supported that the craniocervical region can be a contributing factor in different types of headache, such as migraine and tension headache, neuromusculoskeletal dysfunctions of the cervical spine appear to play a role in only 14% to 18% of chronic headaches.[16,17] Some authors suggest that in patients who are diagnosed with cervicogenic headaches, the cervical spine as the potential source of the symptoms is often overvalued and other contributing factors, such as TMD, do not receive sufficient attention.[18,19] Headaches may therefore be a symptom of TMD. It is known that significantly more (p<0.001) headache complaints occur in a TMD group diagnosed according to the RDC/TMD criteria compared to a usual care group without headaches.[20] Some authors advocate that the same pathophysiologic mechanisms form the basis for different types of headaches, such as myofascial TMD, tension-type headaches, and cervicogenic headaches.[21,22] Also, in children, significantly more (p<0.05) TMD was detected in different headache typologies,[23,24] which suggests that in children, the temporomandibular region plays an important (associated) role in the etiology of different types of headache. When TMD is associated with maintaining cervicogenic headaches, treatment of TMD may be successful, if the clinical signs and symptoms are relevant to the patient's complaints. Hence this study aimed to:

1. Identify the prevalence of TMD in a sample of patients diagnosed with cervicogenic headaches;
2. Determine the tests that are clinically relevant to detect TMD in cervicogenic headache patients; and
3. Evaluate the effect of additional orofacial physical therapy (the experimental group) after three and six months in comparison with the usual care group (control group).

Material and Methods

Patients

Forty-three (43) patients (27 women and 16 men, age range 18-65 years: average age 36±7.7 years) and diagnosed with cervicogenic headache by a neurologist met the following criteria: (i) diagnosed with cervicogenic headache according to the International Classification of Diagnostic Criteria of Headache (ICDH, 2004), with headaches for >3 months, and no prior TMD treatment, and (ii) Neck Disability Index (NDI) >15 points. Anesthetic blockades were not used as a criterion for cervicogenic headache, as the procedure was considered too invasive and costly for this study and is not readily accessible to most clinicians. To be certain that the recruited patients could be treated with orofacial physical therapy, a minimum of one of the four signs of TMD: joint sounds, deviation during mouth opening, extraoral muscle pain at a minimum of two tender points in the masseter or temporalis muscles and pain during passive mouth opening, had to be present.[25,26]

In addition, the patients had not received any orthodontic treatment and had not experienced any neuropathic pain in the head region during the previous three years. The subjects were recruited from different physical therapy practices in The Netherlands. The project was conducted in accordance with the Helsinki guidelines and approved by the Ethics Committee of the Rehabilitation Center 'Het Roessingh' in Enschede, the Netherlands (**Table 1**, **Figure 1**).

Study Design and Procedure

The study is a randomized clinical trial (RCT). To calculate the sample size, a pilot study was performed to determine the changes (before and after six treatments) in patients with standard physical therapy, including manual techniques and treatment of the temporomandibular region. The measuring tool used as the primary outcome parameter was the colored analog scale (CAS). This analog scale was initially designed to record the pain

intensity in children, but also showed a good concurrent and construct validity in adult headache patients and others.[27] These results were applied to calculate the group sizes: An alpha value of 0.05 and a power value of 0.8 were used. To obtain a difference of three points on the CAS with a SD of three points, 17 patients were required in each group. According to this required minimum number of patients, 43 patients were divided into two groups by a third researcher, using a computerized random number generator. Subsequent measurements were obtained after 4-6 weeks of treatment and at six-months follow-up (see flow diagram of **Figure 1**). The patients in the experimental group (n=22) received treatment from a manual therapist who specialized in orofacial pain. Both therapy groups were discharged after six treatments. A blinded investigator performed three assessments, as follows: before the first treatment, after six treatments within a time period of 4-6 weeks, and after six months.

Investigators

All investigators participating in the study were first contact practitioners, had more than five years of work experience, and had completed a training program for manual therapy recognized by the International Federation of Orthopedic Manual Therapy (IFOMT). The group of therapists who treated the experimental group had moreover received an additional regular training consisting of 200 hours, focusing on the assessment and management of the craniomandibular and craniofacial pain.

Measurements

During the study, the following standardized measuring instruments were used:
- *Colored analog scale* (CAS): The CAS is a pain intensity scale similar to the visual analogue scale

(VAS) that was designed especially for patients with headache of different age categories.[27] The patient indicates the intensity of the craniofacial complaints by marking the point on an increasingly colored line that best represents his or her symptoms. On the back, the marking line gives a score corresponding to the VAS.
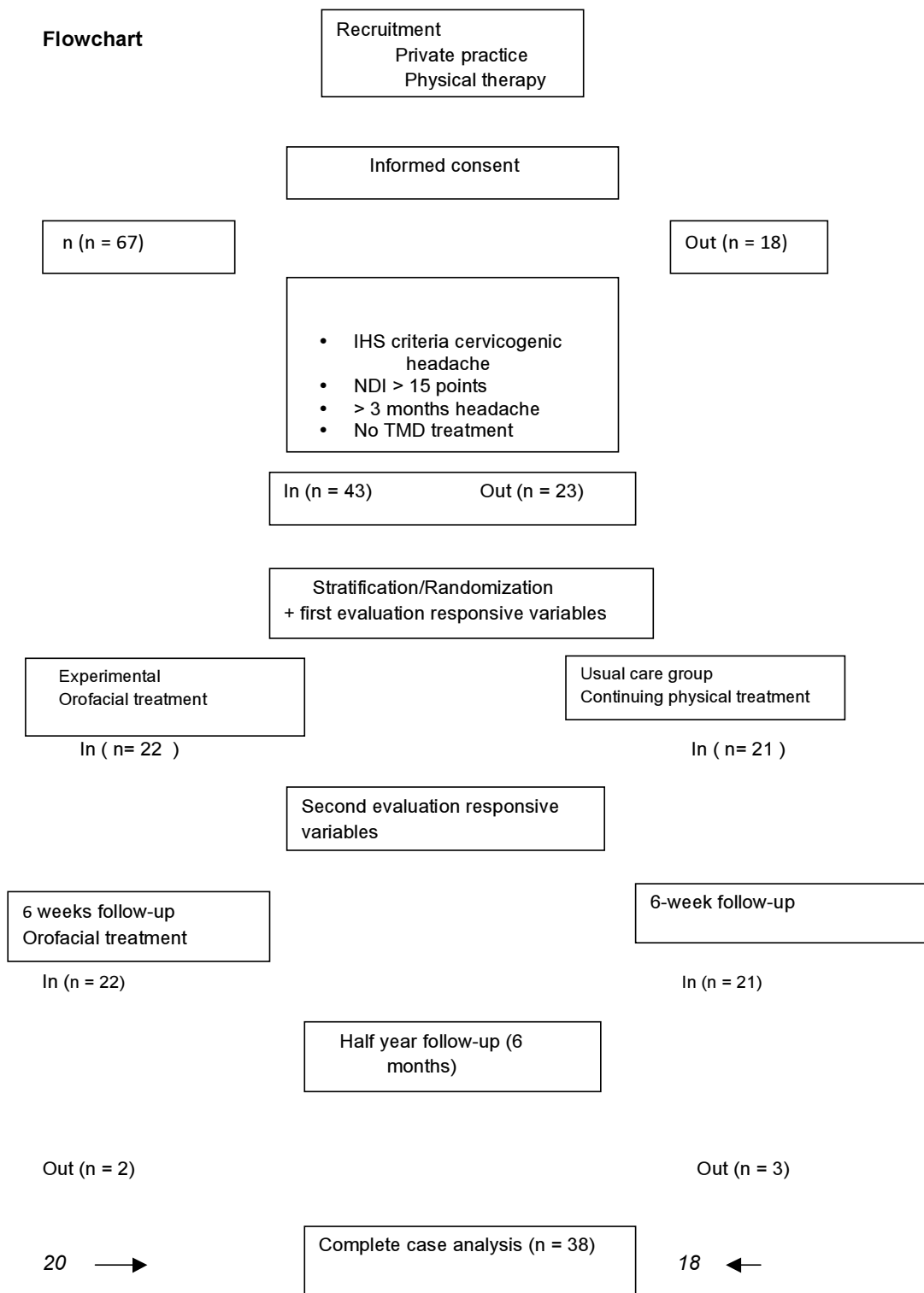
- *Neck Disability Index* (NDI) Dutch version: the NDI is a questionnaire commonly used in clinical trials to measure the functional status of patients with neck pain and is a dimension-specific index that reflects the domain "functional limitation" (disability) of the International Classification of Function (ICF). The questionnaire includes 10 items (activities) with six different response options, ranging from "no disability" (0) to "complete disability."[5] The total score is 50. A higher score indicates more pain and disability.[28]

- *Anamnestic Questionnaire CMD* (Conti): The Conti questionnaire contains 10 questions that are related to problems originating from the craniomandibular region. Each question has three ranking options (0=none: 1=present: and 3=strong or bilateral). The likelihood of a CMD is divided into 4 subgroups: 4-9, none: 9-14, minimal: 15-21, moderate: 21-23, strong.[29] The questionnaire has shown a strong statistical association to the modified Helkimo's Clinical Dysfunction index at a 95% level of confidence.[30]

- *Noise Registration at the Mandibular Joint*: By using a stethoscope, the sounds (cracking and crepitation) in the left and right mandibular joints were determined. Assessment: cracking or crepitation present or absent, both left and right.

- *Graded Chronic Pain Status* (GCPS-NL) Dutch version: The reliability coefficient of the GCPS on the Gutmann scale indicates that it is a highly reliable

Table 1
The Diagnostic Criteria of Cervicogenic Headache of the
International Classification of Headache (ICHD-II 2004)

A. Pain referred from the neck and perceived in one or more regions of the head and/or face, fullfilling criteria C and D.
B. Clinical laboratory and/or imaging evidence of a disorder within the cervical spine.
C. Evidence that the pain can attribute to the neck disorder or lesion based on at least one of the following:
   - Clinical signs that implicate a source of pain in the neck
   - Diagnostic blockade or cervical structures
D. Pain resolves within 3 months after successful treatment.

Figure 1

Flowchart

| Recruitment |
| Private practice |
| Physical therapy |

| Informed consent |

n (n = 67)   Out (n = 18)

- IHS criteria cervicogenic headache
- NDI > 15 points
- > 3 months headache
- No TMD treatment

In (n = 43)   Out (n = 23)

Stratification/Randomization
+ first evaluation responsive variables

| Experimental Orofacial treatment | | Usual care group Continuing physical treatment |
In (n= 22)   In (n= 21)

Second evaluation responsive variables

| 6 weeks follow-up Orofacial treatment | | 6-week follow-up |
In (n = 22)   In (n = 21)

Half year follow-up (6 months)

Out (n = 2)   Out (n = 3)

20 →   Complete case analysis (n = 38)   *18* ←

measuring tool for the classification of TMD pain.[30,31] The questionnaire results are based on the responses to seven questions: four are pain-related limitations and three items refer to pain intensity. The outcomes are classified into four subgroups, with grades I and II seen as a slight limitation (functional chronic pain) and grades III and IV as strong limitations (dysfunctional chronic pain).[31]

- *Mandibular Deviation*: Deviation of the mandible is another important clinical sign of TMD.[32] During maximum mouth opening and closing, the deviation is assessed visually by the researcher who stands in front of the patient at mouth level. A deviation is present if there is a difference of more than two mm to the midline.[33]

- *Mouth Opening Measurement*: (range and pain): Using a ruler of 15 cm, starting at 0, the mouth opening is measured. Measuring the mouth opening is seen as a nonstable biological variable and is strongly influenced by repeated measurements.[34-36] Repeated measuring reduces the standard error of measurement,[37,38] hence repeated measurements were also included in our study (three times) with the largest recorded range taken. During maximum mouth opening, the pain intensity is measured using the CAS.

- *Pain Threshold Measurement of the Masticatory Muscles by Means of Algometry* (Pain Threshold Meter [PTM]): The measurement is carried out at 12 points of the masseter and the temporalis muscles. A digital algometer (Wagner Instruments, 2004) was used (**Figure 2**). The algometer is a reliable instrument for measuring the sensitivity of the masticatory muscles. An increased pressure rate is expressed by an increased PTM value (mean regression coefficient b=0.70). The pressure is measured in kilogram force (Kgf).[39]

Treatment

Prior to the treatment, all patients in the experimental group received an orofacial examination by the treating physical therapist to guide the treatment schedule. The treatment techniques consisted of accessory (translatory) movements of the temporomandibular region and/or masticatory muscle techniques, such as tender-trigger point treatment and muscle stretching. Active and passive movements facilitating optimal function of cranial nerve tissue, coordination exercises, and home exercises were also included. The techniques used depended on the therapists' clinical decisions. The therapist could also, when necessary, opt for additional neuromusculoskeletal treatment of the cervical region (see "study design"). The usual care group continued their treatment of the cranio-

Figure 2
Pain threshold measurement (PTT) measured at 12 points of the masseter and temporalis muscles, left and right, using a digital algometer (Wagner Instruments, Model, FDI, 2004)

cervical region and the therapist selected the technique and treatment or exercise type he or she considered to be beneficial for the patient. The duration of the treatment was maximally 30 minutes, and the treatment interval depended on the therapists' decision. The six treatments had to be concluded after a minimum of 21 and a maximum of 42 days.

Statistical Analysis

The outcomes of the first, second, and third measurements were analyzed using ANOVA's (with Tukey-Kramer *post hoc* analysis when significant) or Kruskal-Wallis (with Dunn's multiple comparison when significant) or chi-square test. The level of significance was set at 0.05.

Results

The patient sample consisted of 43 patients. Of this group, 71.8% had unchanged headache complaints for >12 months. There was no significant difference among age, gender, and duration of the complaints between the usual care (control) and experimental groups (**Table 2a**).

All underwent the first measurement, participated in all six treatments, and also underwent the second measurement. Between the second and the third evaluation, three patients in the usual care group dropped out for the following reasons: an increase in complaints (n=2) and a household accident (fall down the stairs [n=1]). In the experimental group, two patients dropped out because of an increase in complaints (n=1) and a sudden death in the family (n=1). As a result, 38 patients (25 women

Table 2(a)
Average Age, Gender Distribution, and Total Duration of Cervicogenic Headache in the Control (usual care) and the Experimental Groups During the First Measurement

	Control Group (n=21)	Experimental Group (n=22)
Age	36.1 (6.5)	34.7 (7.1)
Gender % female	66.7	63.6
Duration %		
0-6 months	0	0
6-9 months	9.1	14.3
9-12 months	18.2	14.3
>12 months	72.7	71.4

Table 2(b)
Average Age, Gender Distribution, and Total Duration of Cervico Headache in the Control (Usual Care) and the Experimental Groups After the Final Measurement (Six Months)

	Control Group (n=18)	Experimental Group (n=20)
Age	35.1 (6.4)	35.5 (6.9)
Gender % female	66.7	65.0
Duration %		
0-6 months	0	0
6-9 months	11.1	20.0
9-12 months	16.7	20.0
>12 months	72.2	60.0

and 13 men) with an average age of 32 years (SD 6.5), and a range between 18 and 62 years remained, of which 18 were in the usual care group and 20 in the experimental group (**Table 2b**).

The primary outcome measure was the intensity of headaches measured using the CAS (**Figure 3a**). The change in TMD complaints (AQ, GCPS, and TMD tests) and neck complaints (NDI) were the secondary and third measurements and are displayed in **Figure 3** (**b,c**) and **Figures 4, 5**, and **Table 3**.

Based on the results of the primary outcome (CAS), it was observed that there was no significant difference between the usual care group and the experimental group (p<0.05) at baseline, whereas the ANOVA results of the

CAS and the two questionnaires at the times of the second and the third measurements displayed a significant difference between the groups (p<0.001). After six treatments, the average values (mean range) of CAS and AQ had decreased by more than 50%. The decreasing trend of the CAS, the AQ, and the NDI was also observed when comparing the second and the third measurement. In the usual care group, there was a significant increase of the average value, indicating a possible deterioration of the headache complaints (**Figure 3**).

The outcomes of the GCRS at the first measurement showed an average score in the control and the experimental group. After the third measurement, the scores in percentages in the grade II and III groups were clearly reduced in the experimental group and slightly increased in the usual care group (**Figure 4**).
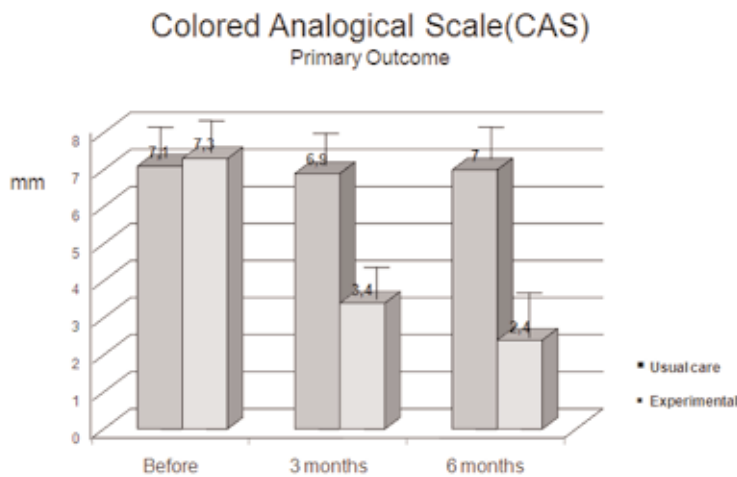
The results of mouth opening in mm and the presence of mandibular deviation and mandibular joint sounds are presented in **Table 3**.

The distribution of the data on the pain threshold measurement for the masticatory muscles displays a less even distribution: there was no significant difference (p<0.05) for 10 of the 12 examined tender point regions. Only tender points, both left and right in the anterior temporal muscle, did display a significant difference (p>0.001) at the second and third measurement. These results and those for the anterior masseter muscle are shown in **Table 4**.
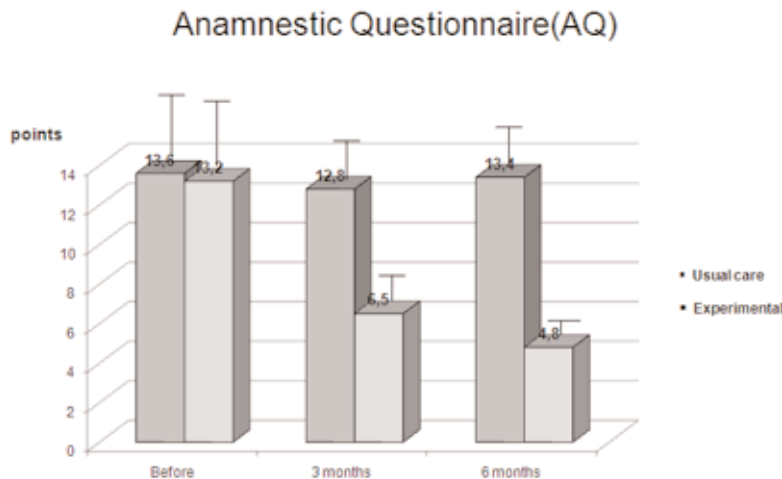
Effect of the Intervention

Effects after the Treatment Series (Second Measurement) and at Follow-up (Third Measurement)
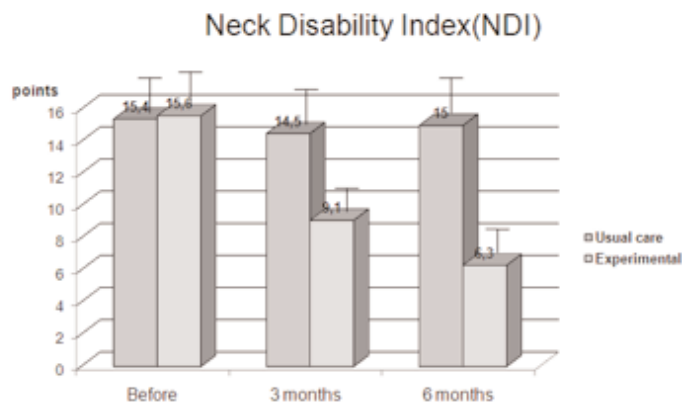
In the usual care group, the results for CAS , NDI , AQ and TMD signs, (mouth opening: pain and range, deviation, sounds and PTM of the anterior temporal muscles) were not significantly different, observed at the second and third measurements compared with the first measurement (**Figure 3**, **Tables 3** and **4**). The results of the second measurement for CAS, NDI, AQ, the TMD signs (mouth opening, range and pain) and PTM from the anterior temporal muscles) of the experimental group differed significantly from the results of the usual care group (**Figures 3**, **5** and **Table 3**). During the treatment-free period (comparing the second with the third measurement), the experimental group showed a trend towards decreased headache symptoms (CAS) and a reduction of TMD signs that was not observed in the usual care group. Only the NDI and the range of the mouth opening did not change significantly. Comparing the results of the initial and the third measurement in Chronic Pain Status (CPGS), the experimental group shows a clear shift towards grade

Colored Analogical Scale(CAS)
Primary Outcome

a

Before control vs Experimental ns p>0.05. Experimental: before vs 3 months sign. p>0.001 , 3 vs 6 months sign. p>0.001

Anamnestic Questionnaire(AQ)

b

Before control vs Experimental ns p>0.05. Experimental: before vs 3 months sign. p > 0.001 , 3 vs 6 months s p>0.05

Figure 3 (a, b, c)
Results of the response variables before
(**a**) after three months (**b**) and six months
post-intervention (**c**) in two treatment
groups (usual care group, n=21: experi-
mental group, n=22) and after six months
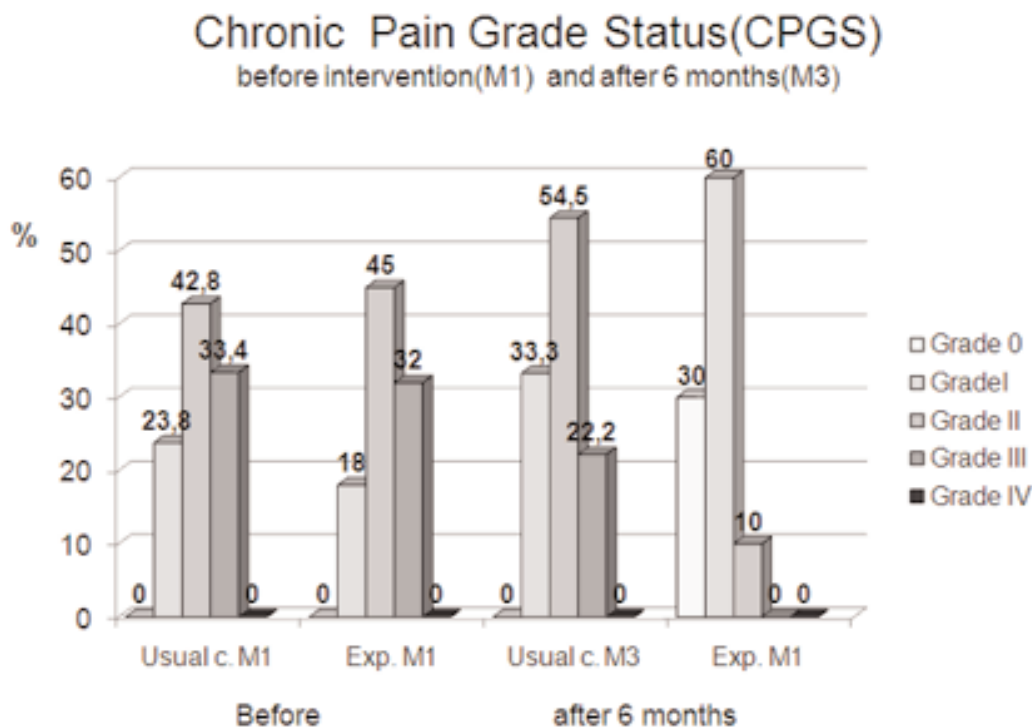(usual care group, n=18: experimental
group, n=20).

Neck Disability Index(NDI)

c

Before control vs Experimental ns p>0.05. Experimental: before vs 3 months sign. p > 0.001 , 3 vs 6 months ns p>0.05

Figure 4
Chronic Pain Grade Status: Prevalence of Grade I-IV on the Chronic Pain Grade Classification of the control and experimental group during the first measurement (before intervention) and after the third measurement (six weeks after the last intervention) scored according to the research criteria/temporomandibular disorder (RCD/TMD) grade I, low intensity; grade II, high intensity; grade III, moderately limiting; grade IV, severely limiting.

I that was not present in the usual care group (**Figure 4**).

Smallest Detected Difference (SDD) and Clustering of Tests

The CAS is seen as a sensitive instrument for measuring neck pain intensity and headache,[27-39] and was therefore chosen as the primary outcome parameter. Research has revealed that clustering of the CAS with other reliable instruments, such as questionnaires and manual test combinations (known as manual examination procedures [MEP]) in patients with neck pain, results in an increase of the diagnostic value.[40,41] Cut-off points are often used that correspond to the smallest statistically significant change measured with the particular measuring instrument, and also called the smallest detectable change (SDC) or difference (SDD).[42,43] The SDD thus measures the minimal statistical and clinical relevant change that may result in improved clinical decision-making.[44]

For cervicogenic headaches, it has been shown that the SDD on a VAS[45] was determined as >20 mm,[46] as 3.5 points[47] for the NDI, as five mm for the restriction of mouth opening, and as 22 mm[48] for the minimal and maximal pain intensity during the mouth opening on a VAS.

In daily practice, the question occurs to what degree the amount of improvement of mouth opening and pain are prognostic indicators for the treatment course. In this study, all subjects with an improvement of >5 mm and a decrease in pain intensity of >22 mm between the first, second, and third measurements were rated. Subsequently, it was determined how many patients had a SDD of mouth opening range (>5 mm) and pain (>22 mm), the NDI >3.5 and a VAS for the headache >20 mm improvement. In this case, 17 of the 20 patients (85%) of the experimental group met these criteria, while there were none in the usual care group (0%). **Table 5** lists the average values of the measurements of the 17 subjects from the initial and the third measurement.
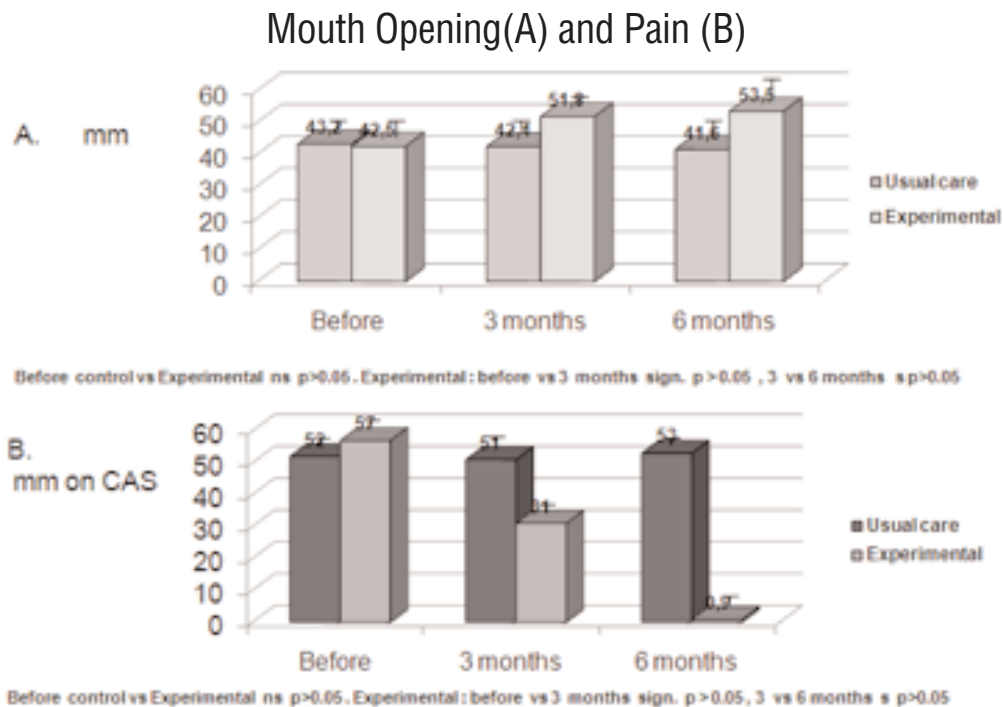
Figure 5
Results of the range of mouth opening in mm (**A**) and the pain intensity measured by the CAS in mm (**B**) before, after three months, and after six months post-intervention, in two treatment groups (usual care group, n=21: experimental group, n=22) and after six months (usual care group, n=18: experimental group, n=20).

Discussion

The Prevalence of TMD in Cervicogenic Headache Patients

It is known that TMD signs do not need to be relevant for the presence of complaints. Population-based studies report that the prevalence of TMD ranges from 8% to 15% in women and from 3% to 10 % in men.[49] In headache patients, the prevalence of TMD is estimated to be much higher 51.6%.[50] In this study, a preselected sample of cervicogenic headache patients, who did not respond to neuromusculoskeletal therapy, were randomized without prescreening for TMD. Based on the reference values for TMD in other studies, participants were classified as TMD patients when all outcomes agreed with the reference values described in **Table 6**. From this point of view, it can be concluded that in the present sample of patients with cervicogenic headache, 44.1% (n=19) have a TMD, a result that is significantly higher than the described prevalences in studies on healthy populations but lower than the described prevalence in head-

ache studies.

The average score for the NDI at the initial measurement is 15.4 and 15.6 points for the usual care and the experimental group respectively, indicating a moderate neck disability (maximal score is 50 points). Similar results were reported by other authors in studies on neck pain.[5] The experimental group shows a tendency to a further reduction of neck disability even after the orofacial physical treatment was stopped (**Figure 3c**).

According to the GCPS, 42.8% and 45% of the usual care and experimental groups, respectively, in this sample of cervicogenic headache patients, had a slight disability (low intensity) and a high disability (moderately limiting) of 33.4% and 32%, respectively (**Figure 4**). Also, the percentage of women in the four groups (I-IV) was >50% greater, which corresponds with studies on TMD-related headache.[50] The authors are not aware of the existence of any comparable studies of GCPS with cervicogenic headache. During the third measurement (after six months), a clear shift towards the Grade 0-1-11 classification was observed in the experimental group,

Table 3

Results of the Response Variables from Mouth Opening in mm: Pain During Mouth Opening (VAS) in mm: Presence of Mandibular Deviation and Sounds Before, After Three Months, and After Six Months Post-Intervention in Two Treatment Groups (After Three Months Control Group, n=21: Experimental Group, n=22), and After Six Months (Control Group, n=18: Experimental Group, n=20)

Response variables	Before intervention		After intervention (3 mos.)		Follow-up (6 mos.)	
	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group
Mouth opening (MO)						
Mean	43.2	42.5	42.4	51.8	41.6	53.5
SD	4.3	3.5	3.7	4.9	4.3	3.2
Range	34-50	35-49	35-49	42-62	34-49	49-62
VAS during MO (mm)						
Mean	52.0	57.0	51.0	31.0	53.0	0.9
SD	14.0	18.0	13.0	11.0	7.0	8.0
Range	29-80	33-85	29-74	10-50	40-65	0-33
Deviation						
Present (%)	38.9	45.0	33.3	20.0	33.9	10.0
Sound (click)						
Present (%)	44.4	55.0	44.0	35.0	42.0	25.0

indicating that according to von Korff, et al.,[31] the severity of chronic pain is clearly reduced. This may fit into the current concept that different entities like chronic tension headaches and myofascial temporomandibular disorders share the same pathobiological mechanisms. Similarities regarding sensitization of the nociceptive pathways, dysfunction of the endogenous pain modulatory systems, as well as contributing genetic factors play a role in these chronic pain state of headache.[22] Cervical headache may be one of these entities where neuromusculoskeletal treatment of TMD may alter pathobiological mechanisms, and thereby reduce chronification in a prospective setting such as present in this study.

The average mouth opening values of the usual care and experimental groups are 43.2 mm (±4.3) and 42.5 mm (±3.5), respectively, and are clearly below the average of most reference value studies among healthy volunteers who indicate an average value score >53 mm.[34-36] Pain intensity during maximal mouth opening in non-TMD patients has been reported, with an average of 32 mm on a VAS (±24.2).[51] In our sample, it ranged around 57 mm (±18) and 52 mm (±14) in the experimental and usual care group, respectively, and is therefore clearly higher than the published reference values (**Figure 5**).

Joint sounds are distinguished into *clicking* or *crepitation*. Clicking is often associated with internal derange-

ments of the mandibular joint, and crepitation is associated with degenerative changes of the mandibular joint.[52] Sounds of the mandibular joints may also indicate ligament or muscular morphologic changes.[25] The timing of cracking during mouth opening can also be classified and is related to the nature of the internal derangement.[25] Epidemiologic studies indicate that in a general population, the prevalence of temporomandibular joint sounds ranges from 15% to 40% and in adult TMD patients groups, it ranges from 56%[25] to 79%.[53] In the studied sample, the percentage in the usual care group is 38.9% and 45% in the experimental group, thereby corresponding more with the studies on populations without TMD. It should be noted that no distinction was made between the type of sound and the timing of the cracking as described previously.

Deviation of the mandible in the frontal plane can also be seen as a dysfunction caused by intra-articular or muscular imbalance.[54,55]

In a normal population, a deviation of >2 mm from the midline occurs in 0% to 14%,[56,57] whereas in TMD populations with or without headache, it ranges between 5% and 43%.[58,59] In the studied cervicogenic headache group, the percentage distribution of the control and experimental groups was 44.4% and 45%, respectively, indicating that the prevalence of mandibular deviation was clearly

Table 4

Results of the Response Variables from the Pain Threshold of the Tender Point of the Anterior Temporalis Muscle (Left and Right), Measured with a Pressure Threshold Meter (PTM) in kgf/cm^2 After Three Months and Six Months Post-Intervention in Two Treatment Groups (After Three Months, Control Group, n=21: Experimental Group, n=22) and After Six Months (Control Group, n=18: Experimental Group, n=20)

Response variables	First measurement		3 months		6 months	
	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group
Anterior temporalis muscle (left)						
Mean	0.98	0.97	0.10	1.14	1.01	1.31
SD	1.0	0.81	1.02	0.75	1.0	0.78
Range	0.3-2.3	0.8-3.2	0.3-3.3	0.3-3.2	0.6-3.3	0.2-3.2
Anterior temporalis muscle (right)						
Mean	0.35	0.36	0.38	0.62	0.36	0.91
SD	0.47	0.47	0.49	0.50	0.45	0.52
Range	0.2-1.4	0.2-1.4	0.1-1.4	0.3-1.5	0.2-1.3	0.3-1.9

greater than in a population without TMD, but corresponded reasonably with previously studied TMD populations.

Muscle sensitivity (muscle tenderness) is an important clinical sign of TMD and can be observed in 90% of the patients with TMD.[60] The pain pressure threshold (PTT) is therefore a parameter that can easily be measured in daily practice with a reliable digital or pressure-measuring device, such as an algometer.[61] Due to the high standard deviations at all three measurements, no statement can be made regarding significant change to the most commonly selected muscle regions. Only the anterior masseter muscle (left and right) showed a highly reliable (p>0.001) sensitivity to pressure. These observations match the findings of a similar study by Silva, et al.,[61] that also detected the highest sensitivity (77%) and likelihood ratio in the anterior masseter muscle, while using a similar study set-up and an algometer as a measuring tool. A similar conclusion was drawn from a sample of female TMD patients (n=49) with approximately the same

Table 5

Mean, Standard Deviation, and Minimal and Maximal Ranges of Subjects in the Experimental Patient Group (n=20) Who Fulfilled the SDD (Smallest Detectable Difference) of VAS, Range of Mouth Opening, the Headache VAS, and the Neck Disability Index (NDI)

	VAS mouth opening (mm)	Mouth opening (mm)	VAS headache	NDI (points)
Measure 1				
Mean	59	42	74	16.2
SD	12	34	8	5.4
Range	33-85	35-48	59-89	10-28
Measure 3				
Mean	10	54	23	6.2
SD	9	32	14	3.0
Range	0-33	49-62	0-50	0-12

age distribution (mean, 28.8 years: range, 17-52 years) in which sensitivity, specificity, and the positive predictive values of the PTT of the anterior masseter muscle (48%) and the temporalis muscle (55%) were assessed. Reference values of the PTT from the usual care groups were 3.46 kgf/cm^2 ($\pm$1.08) on the right and 3.67 ($\pm$1.23) on the left (Silva, et al.[61]). The outcomes in this study were 0.35 kgf/cm^2 ($\pm$0.47) on the right and 0.98 kgf/cm^2 ($\pm$1.0) on the left, which is significantly lower than in the study by Silva, et al.[61]

According to the TMD reference values that include limited mouth opening, presence of deviation, cracking, and minimally lowered pain thresholds of the anterior masseter muscle, 42.1% of the studied patient sample had TMD. This is significantly more than the prevalence in studies on healthy populations that range between 5% and 10%,[48] but is also lower than the prevalence in headache studies[58,61,62] (**Table 6**).

Effects After the Treatment Series (Second Measurement) and At Follow-up (Third Measurement)

The CAS , NDI , AQ, mouth opening (range and pain), and the PTM from the anterior masseter muscle of the usual care group did not show any significant differences in the second and third measurements (p>0.05) in comparison with the first measurement. In the experimental group, there was a significant difference (p<0.001) at both the second and third measurements in relation to the first measurement (**Table 4**). There was a significant difference in the CAS, AQ and mouth opening (pain) and the PTM from the anterior temporal muscles, but not

from the NDI and the mouth opening range (**Table 7**). This suggests that the decrease of the sensitivity of the orofacial region on stress (mouth opening) and pressure (PTM anterior masseter muscles) did not relate directly to the amount of mouth opening. This supports the actual pathophysiological mechanisms derived from head-neck and facial pain[50] in the studied sample.

In general, it can be postulated that in the experimental group, a trend towards a decreased primary measure (headache intensity) and increased neck function was found after the treatment period (second measurement). This also applied to the treatment-free period (third measurement) in contrast to the usual care group (**Table 7**). Based on these observations, we strongly believe that treatment of the TMD region has beneficial effects in this patient population with cervicogenic headache, even in the longer term and can be explained by the existing (anatomical, biomechanical, and neurophysiologic models[4,26]).

Conclusions

From this study, it can be concluded that:
1. Cervicogenic headache patients in the investigated group showed a higher prevalence of TMD than the healthy population but a lower prevalence than in previously described headache samples.
2. Clustering of tests such as mouth opening (range and pain), NDI, and VAS of headaches, contribute to an improved diagnosis of TMD in chronic cervicogenic headache patients.

Table 6
Mean, Standard Deviation of the Anamnestic Questionnaire (AQ), Mouth Opening (MO-Range), Pain Pressure Algometry and Percentages of Joint Sounds of the Sample, and Reference Values

Measure	Sample (n=43)	Reference values	Authors
AQ	13.4 (SD 4.6)	9-14 points (minimal TMD)	Conti, et al.[29]
MO (range)	42.6 (SD 3.5)	53-55 mm	Wood, et al. [34] Achterberg[35] Mezitis, et al.[36]
MO (pain) VAS	58 mm (SD 14)	32 mm (SD 12.4)	Van der Kloot, et al.[51]
Joint sounds	42.3%	15-40%	Elving et al.[53]
PTM ant. mass. L Kgf/cm^2	0.35 (SD 0.47)	3.67 (SD 1.23)	Silva, et al.[61]
PTM ant. mass. R Kgf/cm^2	0.98 (SD 1.0)	3.46 (SD 1.08)	Silva, et al.[61]

Table 7

Significance of Changes (Effects) After Treatment Series (Second Measurement) and
At Follow-Up (Third Measurement) for Colored Analog Scale; Anamnestic Questionnaire;
Neck Disability Index; Mouth Opening; Pain Threshold Measurement (After Three Months, Control Group,
n=21; Experimental Group, n=22) and After 6 Months (Control Group, n=18; Experimental Group, n=20)

Parameter		CAS	NDI	AQ	MO range	MO pain	PTM
2nd measurement after 3 mos.	Control group	NS	NS	NS	NS	NS	NS
	Experimental group	S $p<0.001$	S $p<0.001$	S $p<0.001$	S $p<0.001$	S $p<0.001$	S $p<0.05$
3rd measurement after 6 mos.	Control group	NS	NS	NS	NS	NS	NS
	Experimental group	S $p<0.05$	NS	S $p<0.05$	NS	S $p<0.001$	S <0.05

CAS: colored analog scale; **AQ**: anamnestic questionnaire; **NDI**: neck disability index;
MO: mouth opening; **PTM**: pain threshold measurement

3. The beneficial treatment effect in the experimental group remains or is improved at six months follow-up and a decreased chronification occurs in contrast to the usual care group that remains status quo or worsens after discharge from the treatment and indicates that TMD may be a contributing or etiological factor in chronic cervicogenic headache patients.

4. Further research is required for other treatment interventions, such as splint therapy, and/or the combination with specialized physical therapy, such as applied here with a follow-up over a longer period (12 months).

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