Temporomandibular Disorders after Whiplash Injury: A Controlled, Prospective Study

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Aims: *Whiplash injury to the neck is often considered a significant risk factor for development of temporomandibular disorders (TMD), and has been proposed to produce internal derangements of the temporomandibular joint (TMJ). Few studies, however, have examined TMD-related pain in acute whiplash patients compared with a matched control group. The aim of the present study was to assess pain and sensorimotor function in the craniofacial region in an unselected group of patients sustaining a motor vehicle accident involving a rear collision.* ***Methods:*** *Prospectively, 19 acute whiplash patients exposed to a motor vehicle accident involving a rear collision participated in a study of TMD. The control group consisted of 20 age- and gender-matched ankle-injury patients. Participants were seen within 4 weeks and again at 6 months post-injury. The masticatory system was examined in accordance with the research diagnostic criteria. Participants underwent structured interviews, filled out the McGill Pain Questionnaire (MPQ), and had their masticatory system examined by a trained dentist, blinded to their diagnosis. Pain detection threshold (PDT) to pressure stimuli, and maximal voluntary occlusal force (MVOF) were obtained at each visit.* ***Results:*** *One whiplash patient and 1 ankle-injury patient had jaw pain at the first visit. Palpation scores of the TMJ and the summated palpation scores only tended to be higher in patients sustaining a whiplash injury than in ankle-injury controls at the first visit. However, MPQ, TMD symptoms and signs, MVOF and PDT were not significantly different in whiplash-injury and ankle-injury patients after 4 weeks and 6 months.* ***Conclusion:*** *TMD pain after whiplash injury and ankle injury is rare, suggesting that whiplash injury is not a major risk factor for the development of TMD problems. Further studies are needed to identify which other factors may contribute to TMD pain.*
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Key words: whiplash injuries, bite force, pressure algometry, craniofacial pain, TMD pain

In a forced flexion-extension trauma of the neck (acute whiplash injury) seen after motor vehicle accidents and other mishaps, immediate sprain and strain of soft tissues in the neck and bony lesions may be produced. In acute whiplash injury, the patient may present a variety of symptoms, the most frequent being neck pain, tension-type headache, upper back pain, and muscle spasms.[1,2] Other symptoms less frequently reported are dysphagia/globulus, blurred vision/diplopia, hyperacusis/tinnitus, dizziness, and paresthesias.[3–5]

A proportion of acute whiplash-injured patients, which varies considerably in different prospective studies,[6–9] develops long-term sequelae, the so-called late whiplash syndrome. The designations late whiplash syndrome and synonymously chronic whiplash syndrome have been applied when symptoms persist for more than 6 months.[3,4,8]

The co-existence of temporomandibular disorders (TMD) and chronic whiplash syndrome has previously been noted,[10] and a relationship between the 2 conditions has been proposed, in which a whiplash injury acts on the masticatory system by means of a rapid and excessive opening of the jaw.[11] This could cause excessive stretching of ligaments and soft tissue and lead to internal derangements in the temporomandibular joint (TMJ)[11] and masticatory muscle pain.[12] Thus, commonly reported symptoms are pain in the craniofacial region, temporomandibular dysfunction, and TMJ sounds. Objective signs include limited jaw movements and tenderness to palpation of masticatory muscles and other craniofacial muscles. In a retrospective study on road traffic accidents, Probert and colleagues[13] found that 0.5% of whiplash injured patients received TMD treatment. The problem was more frequently encountered in women at a ratio of 5 to 2. In a prospective study by Kronn[14] of 40 consecutive acute whiplash patients and controls who underwent physiotherapy treatment for muscle pain and skeletal pain originating remote from the TMJ, the whiplash patients more often showed signs of TMJ pain (30%, $P < .001$), limited mouth opening (37.5%, $P < .01$), and tenderness of masticatory muscles (30%, $P < .01$).

A German study proposed that stretching of craniofacial tissues could produce a brainstem-mediated antinociceptive dysfunction and reported changes in the exteroceptive suppression (ES) periods of the jaw-closing muscles following acute whiplash injury with shortened duration of the late part of the reflex (ES2) and prolongation of the early part (ES1).[15,16] Thus, craniofacial pain in the whiplash syndrome could be related to a dysfunction of the endogenous antinociceptive control systems. Nonetheless, it is currently unknown why some patients develop chronic craniofacial pain and TMD problems after a whiplash injury. Furthermore, it is a common clinical experience that whiplash patients with craniofacial pain are positioned in a twilight therapeutic zone between medical doctors and dentists. TMD problems may not be recognized by medical doctors in the early phase, which might worsen the outcome for the patient. The aim of the present study was, therefore, to assess pain and sensorimotor function in the craniofacial region in an unselected group of patients sustaining a motor vehicle accident involving a rear collision. In particular, we tested whether pain and tenderness in the temporomandibular region and other features of TMD were encountered with higher frequencies or intensities in patients with acute whiplash injury compared with controls sustaining an acute injury remote from the cervical spine.

Materials and Methods

Participants

During the period August 1997 to April 1998, 19 consecutive patients exposed to cervical whiplash injury were invited to participate in the study if the following criteria were fulfilled: *(1)* involvement in a motor vehicle accident involving a rear collision; *(2)* preservation of consciousness during collision; *(3)* no amnesia after the accident; *(4)* contact with the local emergency unit within 2 days after the injury and presenting with whiplash-related complaints; and *(5)* age between 20 and 35 years. The exclusion criteria included: *(1)* cervical fractures and dislocations after the injury; *(2)* fractures in the craniofacial region after the injury, no direct contact between face and steering wheel during collision; *(3)* previous history of head injuries and cervical injuries with sequelae; *(4)* previous history of general joint diseases such as rheumatoid or psoriatic arthritis; *(5)* any chronic or pre-existing pain condition in the craniofacial region; *(6)* psychiatric illness, and *(7)* abuse of drugs or alcohol. Twenty age- and sex-matched controls without previous head or neck trauma, having sustained an acute talocrural ligament distortion, were recruited at Aarhus University Hospital, and served as controls. These ankle-injury controls had been in contact with the Emergency Unit of the Department of Orthopaedic Surgery, Aarhus University Hospital, within 2 days after injury with initial pain complaints and reduced mobility of the ankle without bony lesions on X-ray. The controls were excluded if they showed previous history of head injuries or cervical injuries with sequelae; previous history of general joint diseases such as rheumatoid or psoriatic arthritis; any chronic or preexisting pain condition in the craniofacial region; psychiatric illness; or abuse of drugs or alcohol.

Protocol

Participants were interviewed and examined within 4 weeks post-injury and again at 6 months post-injury. Participants underwent a structured interview with pain assessment on a VAS_{0-100} scale (0 = no pain; 100 = most imaginable pain) and filled out the Danish version of the McGill Pain Questionnaire (MPQ).[17,18] Information on use of analgesics was obtained. Pain detection thresholds (PDTs) were measured by the same examiner. The same medical doctor performed a neurological examination of all participants at the first visit. A dentist not knowing the clinical diagnosis of the participants but who was skilled in the examination of the masticatory system performed the clinical TMD examination, in accordance with research diagnostic criteria (RDC),[19] and also measured maximal voluntary occlusal force (MVOF) in all individuals.

Participants who did not show up at the second examination would be filling out a structured questionnaire that used the same wording as the structured interview applied at examinations.

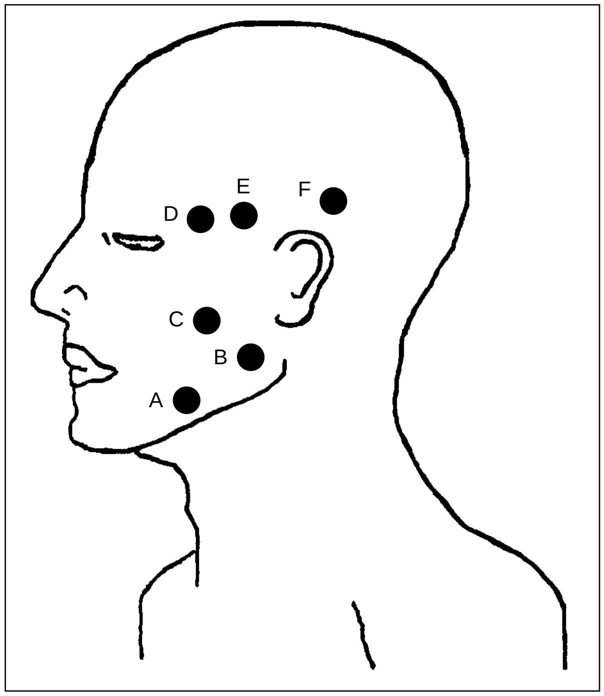

Fig 1 Measurement sites of pain detection thresholds in the craniofacial region (A). The thresholds were determined in whiplash-injury patients and in ankle-injury patients at baseline at 4 weeks and at 6 months post-injury.

Subjective Description of Pain

Self-reported neck pain, craniofacial pain, and headache were scored on 3 separate VAS_{0-100} scales. Moreover, the subjects filled out the Danish version of the MPQ,[17] and the pain rating indices of the sensory (PRI-S), affective (PRI-A), evaluative (PRI-E), and miscellaneous (PRI-M) dimensions of pain, plus the total pain rating (PRI-T) as well as number-of-words-chosen (NWC) were calculated.[17,18] These measures were obtained at each visit.

Pain Detection Thresholds

An electronic pressure algometer (Somedic AB, Farsta, Sweden[20]) was applied with a probe diameter of 1 cm, and a constant application rate of 30 kPa/s. Measurements (Fig 1) were performed on the following 3 sites of the masseter muscle: *(A)* its anterior insertion at the mandibular body; *(B)* 1.5 cm superiorly and proximally from the mandibular angle; and *(C)* insertion at the zygomatic arch. The following 3 sites of the temporalis muscle were examined: *(D)* the anterior part, situated 5 cm proximally from the upper anterior part of the auricle; *(E)* the central part, situated 1.5 cm proximally from the upper anterior part of the auricle; and *(F)* the posterior part, situated 2 cm posterior to and 1 cm above the auricular helix. In addition, a site at the left third finger's proximal interphalangeal joint was chosen as an extratrigeminal control site. Subjects were instructed to keep their teeth slightly apart (about 1 to 2 mm) to avoid contraction of the jaw-closing muscles during pressure stimulation.[21] The PDTs were defined as the amount of pressure applied (kPa) that the participant first recognized as painful. The subject pushed a small thumb switch, which froze the pressure on a digital display when the threshold was reached. The PDTs were determined in triplicate, and the mean value used for statistical computations. The interval between successive pressure stimuli was approximately 20 seconds.

Maximal Voluntary Occlusal Force

A U-shaped bite force transducer (7 mm high, 1.1 x 1.1 cm area, Aalborg University, Denmark) was covered with plastic tubes in order to protect the teeth.[22,23] The MVOFs were measured from both the right and left sides between the first molars, and subjects were instructed to clench their teeth as hard as they could for 3 to 4 seconds. Verbal

Table 1 Demographic Characteristics of the 2 Study Populations

	Whiplash injury	Ankle injury	
Gender	Women = 10; Men = 9	Women = 11; Men = 9	
Age	26.3 ± 4.5 years	25.4 ± 5.7 years	NS
Height	174.4 ± 8.3 cm	174.2 ± 10.6 cm	NS
Weight	70.6 ± 11.6 kg	70.6 ± 10.8 kg	NS

Mean values ± SD are given.
NS = not statistically significant difference.

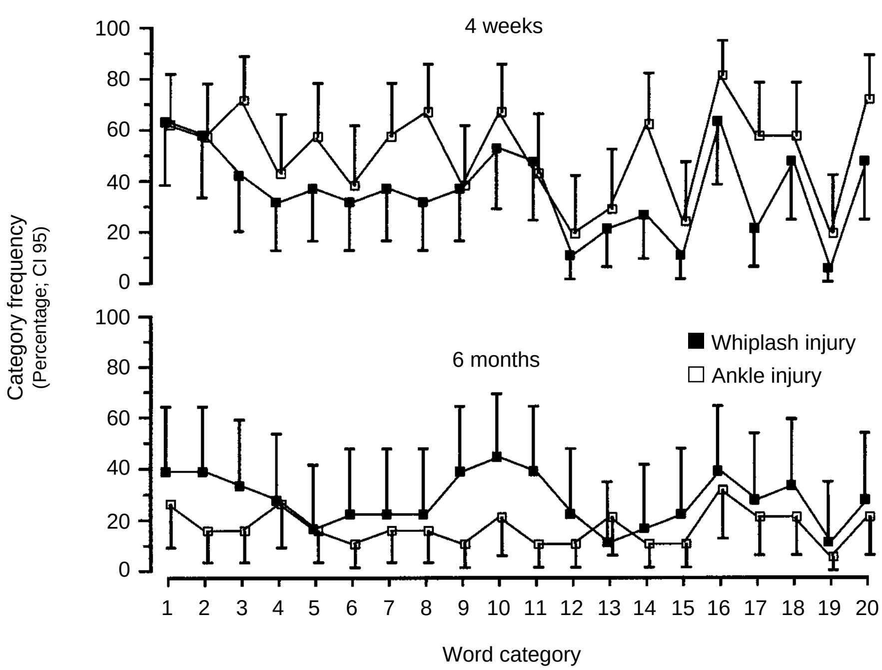

Fig 2 The frequencies by which the 20 word categories in the McGill Pain Questionnaire have been chosen after 4 weeks and after 6 months in whiplash-injury patients and in ankle-injury patients. CI 95 = 95% confidence interval.

encouragement was given to obtain the maximal effort. The MVOF was determined in quadriplicate, and the mean value used for further statistical analysis.

TMD Examination

Clinical signs and symptoms were assessed through the use of the RDC/TMD.[19] The following signs and symptoms were assessed: pain sites; mandibular range-of-motion (mm) and associated pain (jaw-opening pattern, maximum unassisted opening, maximum assisted opening, unassisted opening without pain, mandibular excursive and protrusive movements); TMJ sounds (click, fine crepitus, coarse crepitus); and muscle and joint palpation (no pain/pressure only, mild pain, moderate pain, severe pain). The examiner was not aware if the participant had sustained a whiplash injury or an ankle injury, and all participants had their lower legs covered with a blanket in order not to provide any clues about prior ankle injury.

Table 2 Pain Detection Thresholds in Whiplash-Injury and Ankle-Injury Patients

	Whiplash injury		Ankle injury		CI 95 Diff*		
	Mean	SD	Mean	SD	Lower	Upper	*P* value
4 weeks							
Control site	532.2	223.3	532.7	194.4	–134.1	133.3	.99
A	137.7	62.3	148.5	59.9	–50.0	28.3	.58
B	120.1	44.5	128.3	66.8	–45.3	28.8	.65
C	132.1	50.9	142.5	75.1	–52.2	31.4	.62
D	173.9	74.1	204.0	77.9	–79.5	19.2	.22
E	196.8	67.6	233.0	96.9	–90.3	17.8	.18
F	227.4	76.3	259.6	106.6	–92.6	28.3	.29
6 months							
Control site	445.0	162.6	467.2	166.8	–137.2	92.9	.70
A	159.9	57.4	161.8	61.9	–43.6	39.8	.93
B	129.1	60.2	129.4	58.0	–41.6	41.0	.99
C	156.4	60.3	151.1	55.7	–35.2	45.9	.79
D	204.4	69.3	203.5	62.7	–45.3	47.1	.97
E	233.7	82.2	219.6	78.3	–41.9	70.2	.61
F	259.3	92.6	260.0	104.0	–69.5	68.1	.98

For examination points (A to F) refer to Fig 1.
*CI 95 = 95% confidence interval.

Statistics

A sample size of 40 persons with 20 in each group would yield a power of 0.80, based on an anticipation of 20% of the acute whiplash-injury patients reporting TMD pain and approximately none of the controls reporting TMD pain after injury.

Data are presented in the text, the figures and the tables as mean values ± standard deviations (SD) for normal distribution of data and medians with 25th and 75th percentile when transformation (see below) was not possible. Non-parametric data were analyzed with the Mann-Whitney *U* test; categorical data were analyzed with chi-square analysis or Fisher's exact test. The paired *t* test was applied for analysis of paired data with a normal distribution.

Data was analyzed with a multivariate general linear model (GLM) with patient type (whiplash- and ankle-injury patients) as 1 factor and examination time (results after 4 weeks and 6 months) as the repeated factor. For pressure algometry data with 3 consecutive measurements, and for MVOF with 4 measurements, sex and patient type were also included as factors in a general linear model for repeated measurements. This was performed to control if measurements in triplicate and quadruplicate were different in the 2 patient groups or between sex types—for example, if measurement 1 was different from the following 2 measurements. Measurement 1 was usually different from 2 and 3, but there was no influence of patient type or sex type on this phenomenon. Therefore, we found it appropriate to apply mean values of triplicate measurements of pressure algometry data and quadruplicate bite force values as described above.

In case data were not normally distributed, they underwent a square-root transformation (palpation) or a logarithmic transformation (PDT, MVOF). Significance was accepted at P values < .05. Demographic characteristics were compared between groups with the use of unpaired *t* tests.

Results

Nineteen consecutive whiplash patients, WAD grade 1,[1] were included in the study. They performed normal neck mobility test initially and had no neurological deficits at examination. Ankle-injury controls also had normal neurological features and neck mobility.

Initially, whiplash-injury patients were seen at a median of 24 days (25 to 75 percentile: 16 to 28), and ankle-injury controls at a median of 19 days (11 to 23) (Mann-Whitney *U*; P = .07) after their injuries. Subsequently, whiplash-injury patients underwent examination at 189 days (170 to 217), and ankle-injury patients at 195 days, after injury (176 to 241) (Mann-Whitney *U*; P = .46) at the 6-month follow-up. One whiplash-injury participant dropped out after the first examination (did not show up at 3 scheduled occasions and did not complete the questionnaires), 16 were interviewed and

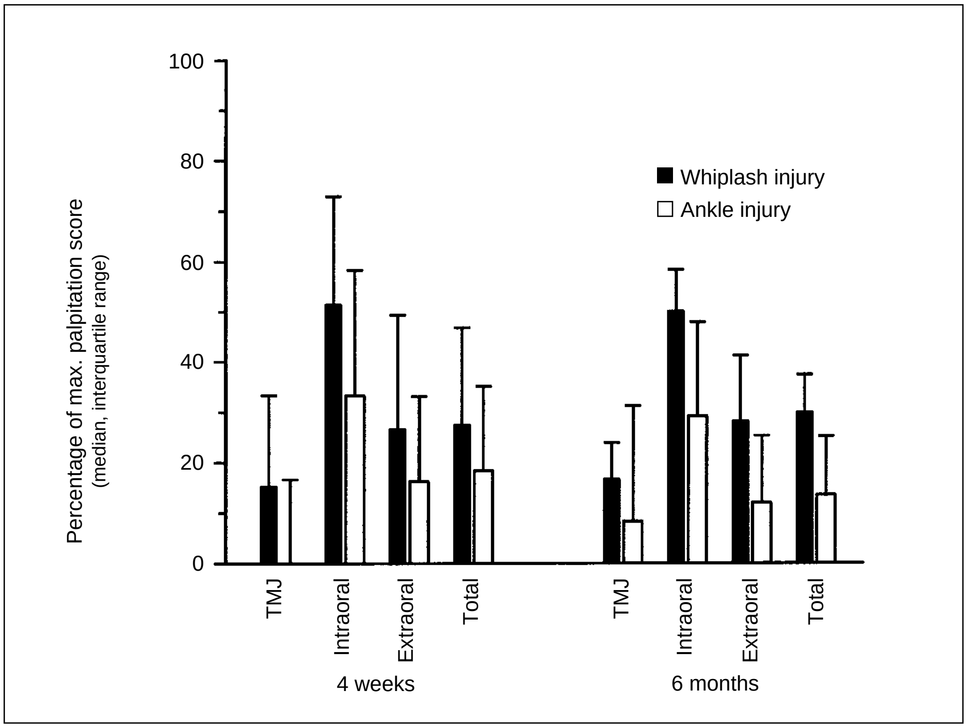

Fig 4 Bar graph of palpation scores for the temporomandibular joint (TMJ), intraoral and extraoral muscle sites, and the total scores for intraoral and extraoral muscles. Bars represent median percentage of maximal tenderness score with 25th and 75th percentiles for whiplash-injury patients and for ankle-injury patients.

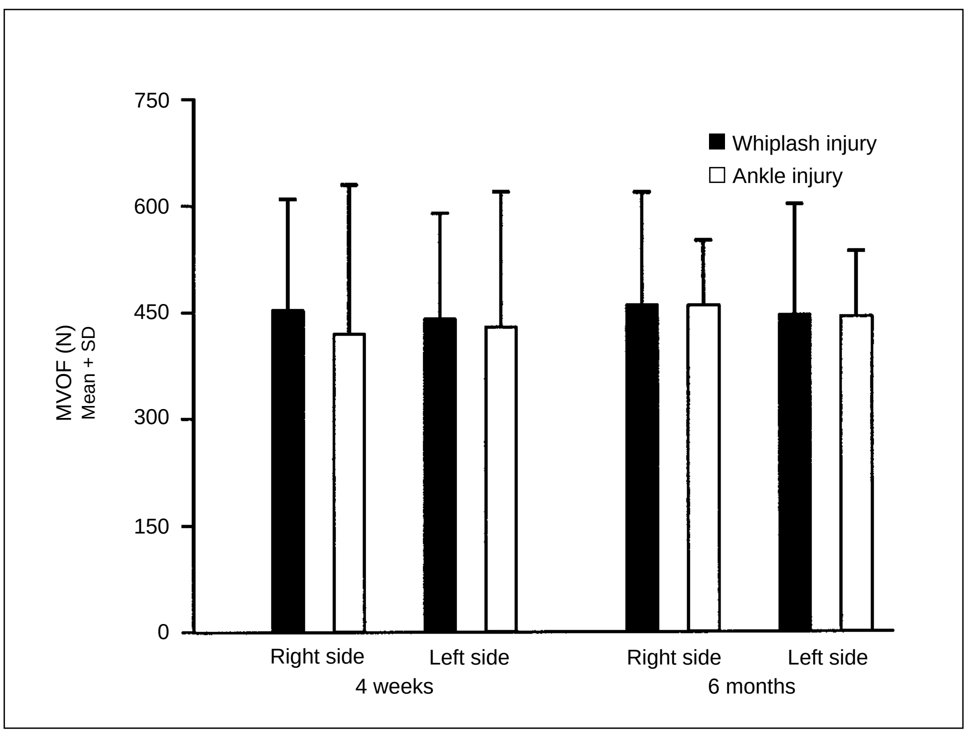

Fig 5 Bar graph of maximal voluntary occlusal force on left and right sides for whiplash-injury and ankle-injury patients. Bars represent mean values with standard deviation.

examined at the 6-month follow-up, and 2 completed the study by filling out a questionnaire, but did not show up for the 6-month examination. Seventeen controls were examined after 6 months, and 3 completed the study by filling out a questionnaire after 6 months. The demographic properties of whiplash-injury participants and controls were not significantly different, as shown in Table 1.

Subjective Description of Pain

Participants scored their present global pain on a VAS_{0-100} scale. Whiplash-injury patients had a median VAS_{0-100} of 11.5 (3.2 to 35.0) that was not significantly different from the intensity reported by ankle-injury patients, 15.7 (4.6 to 33.9) (Mann Whitney *U*; $P = .72$). There was no significant change in reported global pain intensity after 6 months in whiplash-injury patients who had a median VAS_{0-100} of 15.5 (0.0 to 29.2), with a mean VAS difference ($VAS_{4\ weeks}$ -$VAS_{6\ months}$) of 3.6 (paired *t* test; $P = .58$). There was no significant change in reported global pain intensity in controls, who had a median VAS_{0-100} of 0.0 (0.0