Journal of Oral Rehabilitation

Journal of Oral Rehabilitation 2014 **41**; 59–68

Review article

Prevalence of whiplash trauma in TMD patients: a systematic review

B. HÄGGMAN-HENRIKSON[*†], M. REZVANI[†] & T. LIST[†‡] *[*]Department of Odontology/Clinical Oral Physiology, Umeå University, Umeå, [†]Department of Orofacial Pain and Jaw Function, Malmö University, Malmö and [‡]Department of Rehabilitation Medicine, Skåne University Hospital, Lund, Sweden*

SUMMARY The purpose of this systematic review was to describe the prevalence of whiplash trauma in patients with temporomandibular disorders (TMDs) and to describe clinical signs and symptoms in comorbid TMD/whiplash compared with TMD localised to the facial region. A systematic literature search of the PubMed, Cochrane Library and Bandolier databases was carried out for articles published from 1 January 1966 to 31 December 2012. The systematic search identified 129 articles. After the initial screening of abstracts, 32 articles were reviewed in full text applying inclusion and exclusion criteria. Six studies on the prevalence of neck trauma in patients with TMD met the inclusion criteria and were included in the review. Two of the authors evaluated the methodological quality of the included studies. The reported prevalence of whiplash trauma ranged from 8·4% to 70% (median 35%) in TMD populations, compared with 1·7–13% in the non-TMD control groups. Compared with patients with TMD localised to the facial region, TMD patients with a history of whiplash trauma reported more TMD symptoms, such as limited jaw opening and more TMD pain, and also more headaches and stress symptoms. In conclusion, the prevalence of whiplash trauma is higher in patients with TMD compared with non-TMD controls. Furthermore, patients with comorbid TMD/whiplash present with more jaw pain and more severe jaw dysfunction compared with TMD patients without a history of head–neck trauma. These results suggest that whiplash trauma might be an initiating and/or aggravating factor as well as a comorbid condition for TMD.

KEYWORDS: facial pain, jaw pain, neck pain, systematic review, temporomandibular joint disorder, whiplash injuries

Accepted for publication 27 November 2013

Introduction

Pain and dysfunction are common in the population and can have a negative effect on health and well-being, especially when the oro-facial region is affected (1). Patients with temporomandibular disorders (TMDs) typically report jaw/face pain, pain on jaw movements, and impaired jaw mobility (2). The perceived treatment need owing to TMD is estimated within the range of 5–15% (3), which means that dentists will frequently meet patients with TMD of varying severity in their daily practice.

The aetiology of TMD is considered to be multifactorial, with factors such as general health, systemic diseases, psychological, psychosocial, and gender factors, together with local factors such as overload due to bruxism, contributing to the overall risk. It has also been reported that indirect trauma caused by a whiplash trauma can be a contributing factor (4). It has been suggested that as many as one of four patients with TMD has a history of head/neck trauma in proximity to the development of their TMD pain (5) and that these patients have a poorer prognosis (6). There is however a limited number of studies reporting on

doi: 10.1111/joor.12123

the prevalence of TMD related to neck trauma, and thus, there is currently a gap in the knowledge in this area.

The term whiplash describes a hyperextension–flexion trauma to the neck. The incidence in Sweden is about 2 per 1000 inhabitants, mostly from traffic accidents but also from other traumas (7). Even though a majority of individuals exposed to a whiplash trauma will recover, about one in three will develop long-lasting problems; whiplash-associated disorders (WADs) (8). These patients report a range of symptoms such as dizziness, sleeping problems, cognitive problems, and a reduced quality of life (9), in addition to the most common symptoms, headaches and neck pain (9, 10).

Neck pain is often also reported in patients with TMD pain and vice versa. Thus, patients with TMD often report pain not only in the jaws and face, but also in the neck region (11–14), and patients with neck pain often report TMD (15, 16). Recent studies have suggested that the relation between symptoms in the trigeminal and spinal regions shows a dose–response-like pattern (17) as well as a reciprocal influence on the incidence of new symptoms in both regions (18). Furthermore, there is a functional integration between the jaw and neck regions (19, 20), and as jaw function rely on linked motor control of the jaw and neck motor systems, pain and dysfunction in the neck may impair jaw function. An association has been shown between neck pain and neck dysfunction and disturbed jaw function following whiplash trauma. The findings include disturbed jaw–neck motor function in terms of decreased movement amplitudes, disturbed coordination, and impaired endurance (21–23) as well as frequent jaw–face pain (24).

Various explanatory models have been presented for the development of TMD after whiplash trauma. An early theory proposed that a whiplash trauma to the head and neck could cause a 'mandibular whiplash' by overstretching or compression of the temporomandibular joint (TMJ) (25). Later studies refuted this idea (26) and instead suggested an indirect injury mechanism (27). The notion of a neurobiological basis is supported by prospective studies showing that about a third of individuals develop TMD pain after neck injury, despite not showing any structural damage to the TMJ (28). In a recent systematic review, we reported an increased prevalence of TMD pain in whiplash populations (29). This finding suggests that a whiplash trauma could be a risk factor for the development of TMD. If this is the case, it would be reasonable to assume that among TMD populations, i.e. patients seeking care for jaw pain and dysfunction, a higher prevalence of a history of head/neck trauma would be present compared with healthy control groups without TMD. There is, however, limited knowledge to whether this is the case, and therefore, the aim of this review was to address this research question.

The aim of this study was to assess by systematic review of the literature, (i) the prevalence of whiplash trauma in patients with TMD and (ii) clinical signs and symptoms in comorbid TMD/whiplash compared with TMD localised to the facial region.

Materials and methods

Inclusion and exclusion criteria

Inclusion criteria for this review were clinical studies in adult patients (>18 years) reporting history of whiplash trauma in a TMD population. Articles were excluded if they were not based on a TMD population or if data from the same cohort had been reported in another article (dual publication). Experimental studies and narrative reviews were excluded from the review.

Literature search

The search strategy was designed to identify studies that reported the prevalence of whiplash trauma in patient populations with TMD. The search encompassed all articles that were (i) indexed in PubMed, the Cochrane Library, and Bandolier, (ii) published in English, Swedish, or German, and (iii) published between 1 January 1966 and 31 December 2012.

The search terms used for PubMed were as follows:

'Whiplash injuries' [MeSH] or 'Whiplash Associated Disorders' or 'Whiplash' and
'Temporomandibular joint disorder' [MeSH] or 'Craniomandibular disorders' or
'Temporomandibular disorders' or 'Temporomandibular Joint Dysfunction' or
'Jaw pain' or 'Facial Pain'.

For the Cochrane Library and Bandolier database, the search strategy included the terms 'Whiplash' and

'Craniomandibular disorders' or 'TMJ' or 'TMD'. After the search of the databases, reference lists in original articles and review articles were hand-searched to identify additional studies.

Procedure

After the database search, two of the authors (BH and MR) independently read all titles and abstracts to identify potentially eligible articles for inclusion. All studies identified as potentially eligible by one of the reviewers were retrieved in full text and reviewed by both reviewers applying the inclusion criteria. Disagreement was resolved by discussion among the investigators. Authors were not contacted for missing information.

The data extracted from the studies were study setting, study design, study sample, number of subjects (age and gender), the diagnostic criteria for TMD and whiplash, the prevalence of whiplash trauma, main results, and author's conclusions.

Quality assessment

Two of the authors (BH and TL) independently evaluated the quality of the included studies using a scoring system with a standardised 21-item checklist modified from MacFarlane (30). Each criterion was scored as 'yes', 'no' or 'unable to determine'. Only criteria scored as 'yes' gave a score, which added up to give the total quality score, and results were presented as percentages of total attainable score for each paper. After the independent assessments of the individual items, which rendered the total quality scores, the interreliability of the two reviewers was calculated with kappa statistics. All articles were discussed to verify appraisal process until consensus was reached. Disagreements on individual item scores were resolved with discussion. The reviewers were experienced oro-facial pain researchers.

Results

The systematic search of three databases together with the hand search identified a total of 129 articles (Fig. 1). After the initial screening of abstracts, 32 articles were retrieved and reviewed in full text. Of these, a total of 26 articles were excluded (Table 1). The main reasons for exclusion were that studies were not based on TMD populations (62%), did not report original data (27%), or did not define TMD/trauma groups (11%). Six studies (5, 31–35) on the prevalence of whiplash trauma in patients with TMD met the inclusion criteria and were deemed eligible for inclusion (Table 2).

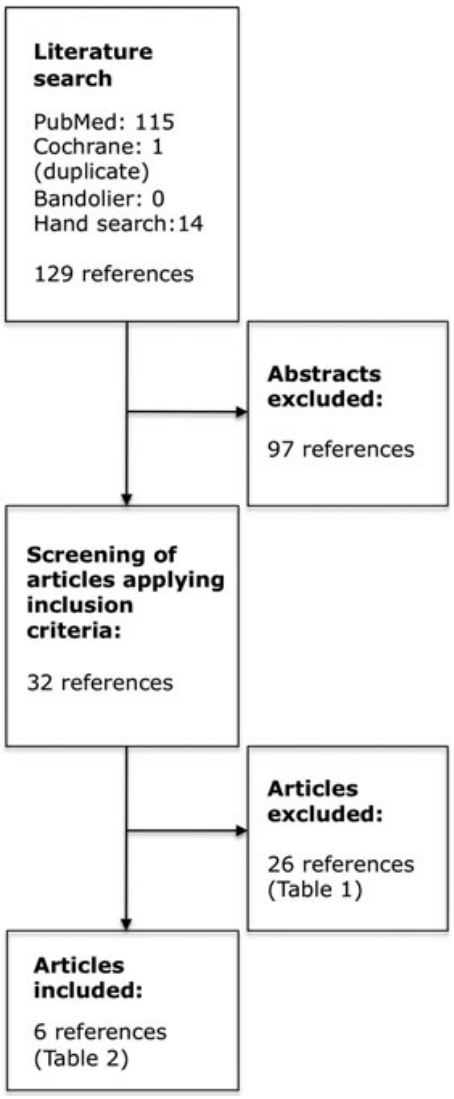

Fig. 1. Flow diagram of search result, screening of abstracts, and included and excluded articles.

Two of the authors independently evaluated the methodological quality of each identified study. The quality score for the included studies ranged from 20% to 65% with a median score of 50%. There was a good agreement between the two investigators in the scoring of the individual items (kappa: 0·82), which were used to calculate the total quality score.

Table 1. Papers excluded from the study (n = 26)

Study	Reasons for exclusion
Abd-Ul-Salam *et al.* (54)	Not TMD population
Boniver (55)	No original data
Burgess (56)	Not TMD population
Burgess & Dworkin (57)	Not TMD population
Burgess *et al.* (4)	Not TMD population
Epstein (58)	No original data
Freund & Schwartz (59)	Not TMD population
Friedman & Weisberg (60)	No original data
Garcia & Arrington (61)	Not TMD population
Goldberg *et al.* (36)	Not TMD population
Gray & Al-Ani (62)	No original data
Greco *et al.* (63)	TMD/trauma groups not defined
Huang *et al.* (64)	TMD/trauma groups not defined
Kim *et al.* (65)	TMD/trauma groups not defined
Kolbinson *et al.* (37)	Not TMD population
Kolbinson *et al.* (6)	Not TMD population
Kolbinson *et al.* (66)	Not TMD population
Kolbinson *et al.* (67)	Not TMD population
Krogstad *et al.* (68)	Not TMD population
Lader (27)	No original data
McKay & Christensen (69)	No original data
Olin (70)	No original data
Pressman *et al.* (71)	Not TMD population
Romanelli *et al.* (72)	Not TMD population
Seligman & Pullinger (73)	Not TMD population
Weinberg & Lapointe (25)	Not TMD population

For all included studies, the history of whiplash trauma was self-reported. The criteria for TMD diagnosis varied between the studies, with only one study applying the research diagnostic criteria/temporomandibular disorders (RDC/TMDs).

The reported prevalence of whiplash trauma in the TMD groups ranged from 8·4% to 70% (median 35%). Two of the six included studies reported a prevalence of whiplash trauma for non-TMD control groups of 1·7% (32) and 13% (33).

Compared with TMD patients without a history of neck injury, TMD patients with a history of whiplash trauma reported more TMD pain, more severe jaw dysfunction, and more headaches, stress, dizziness, and sleeping problems (Table 2).

Discussion

This systematic review suggests that the prevalence of whiplash trauma is higher in patients with TMD compared with non-TMD control groups, suggesting that neck trauma is a comorbid condition for TMD. In addition, the data suggest that TMD patients with a history of whiplash trauma have more TMD pain and more severe jaw dysfunction, compared with TMD patients without a history of neck injury.

In the present review, there were large variations between the primary studies in the reported prevalence of whiplash trauma, with the highest prevalence (70% and 54%) reported in two private TMD clinics (33, 34). The other studies based in TMD clinics reported prevalence between 24·5% and 39·7% (5, 31, 32), whereas the only study not based in a TMD clinic reported the lowest prevalence of 8·4% (35). This study also had the lowest quality score of all included studies, and thus there are uncertainties with regard to the reliability of the reported data from this study. It is reasonable to assume that the variation between studies reflects the differences in TMD populations between the clinics, with patients with more severe TMD symptoms being more likely to seek care in, or be referred to, specialist TMD clinics. The reported median prevalence of whiplash trauma was 35%, which compared with the data from the non-TMD control groups in two of the included studies (32, 33) provide some evidence of increased prevalence of neck trauma in TMD. There is no reliable data on the prevalence of whiplash trauma in the general population, but it has been estimated that approximately 6% of the US population have late whiplash syndrome (8).

The data from the present review indicate that TMD patients with a history of whiplash trauma have more TMD pain and more severe jaw dysfunction, compared with TMD patients without a history of neck injury (5, 31–35). These results are in line with previous studies, which suggest that patients with TMD and whiplash comorbidity have more severe TMD pain and dysfunction (36), seem to have a poorer prognosis for recovery, and seek and demand more treatment (37). Taken together, these findings together with reports of a limited effect for this patient group from the treatment modalities conventionally used for TMD (38) support the view that TMD after whiplash trauma has a different patophysiology compared with localised TMD (29).

It has been suggested that TMD after a whiplash trauma may develop over time, rather than being part of an acute syndrome (29, 39). This notion is based on the fact that most studies in acute whiplash patients report a lower prevalence of TMD pain (28,

Table 2. Included studies reporting the prevalence of trauma in patients with TMD (n = 6)

Authors, year	Setting/ study design	Study sample	Subjects (n) (% females) Mean age	TMD and whiplash criteria	Prevalence of trauma	Clinical signs and symptoms	Quality score	Authors' conclusion	Comments
De Boever & Keersmaekers, 1996	Facial pain unit Case series	TMD only TMD + trauma	n = 302 38 years n = 98 36 years	TMD: Helkimos index Whiplash: self-reported trauma to head/neck	TMD group: 24·5%	Trauma group more: severe jaw pain and dysfunction $P < 0{\cdot}01$ limited jaw opening $P < 0{\cdot}01$	52%	Trauma to the head and cervical region is relatively common as an initiating factor in TMD. External trauma to the joint or jaw in general is an important initiating factor in the aetiology of TMD, but the prognosis is favourable	Gender of subjects not given
Grushka *et al.*, 2007	Oro-facial pain centre Treatment outcome study	TMD only TMD + trauma	n = 82 (84%) 39 years n = 54 (80%) 41 years	RDC/TMD Whiplash: self-reported trauma to the head/neck, MVA*	TMD group: 39·7%	Trauma group more: headache $P < 0{\cdot}002$ jaw tenderness $P < 0{\cdot}03$ stress $P = 0{\cdot}001$ poor sleep $P < 0{\cdot}001$ dizziness $P < 0{\cdot}001$	65%	Widespread and persistent pain complaints, including the jaw in post-MVA, despite the fact that many post-MVA patients demonstrate no evidence of jaw injury by bone scan and MRI. Treatment limited to the TMJs in post-traumatic patients with TMD may fail without consideration that pain may originate in structures other than the TMJs	Varying time interval between clinical examination and MRI/bone scan.
Pullinger & Monteiro, 1988	TMD/Oro-facial pain clinic Case–control	TMD All controls: Control 1 (no TMD) Control 2 (mild TMD)	n = 152 (67%) 18–35 years n = 331 (58%) n = 116 18–35 years n = 215 18–35 years	TMD: criteria not given Whiplash: self-reported trauma to head/neck	TMD group: 30·4% Control 1: 1·7% Control 2: 13·1%	TMD group vs. controls: more trauma history $P < 0{\cdot}001$ Trauma associated with: TMD $P < 0{\cdot}025$ headache/cervical pain $P = 0{\cdot}001$	50%	History of head–neck trauma characterised the TMD sample compared with age matched student comparison group. Students with mild TMD reported more trauma than asymptomatic students. Women seem at greater risk of responding adversely and irreversibly to trauma	Unclear TMD diagnosis. Inaccuracies in the Results section

Table 2. *(continued)*

Authors, year	Setting/ study design	Study sample	Subjects (*n*) (% females) Mean age	TMD and whiplash criteria	Prevalence of trauma	Clinical signs and symptoms	Quality score	Authors' conclusion	Comments
Pullinger & Seligman, 1991	Private TMD clinic Case–control	TMD Control 1 (no TMD) Control 2 (mild TMD) Control 3 (general patients)	*n* = 230 *n* = 61 *n* = 161 *n* = 150	TMD: criteria not given Whiplash: self-reported MVA or other head/neck trauma	TMD group: 55% Control 1: 13% Control 2: 18% Control 3: 11%	More trauma in TMD group $P < 0{\cdot}001$	45%	Patients with TMD have a higher prevalence of trauma history. Trauma may be an important cumulative and precipitating factor in TMD	Unclear TMD diagnosis. Age and gender of subjects not given. History of trauma investigated differently in patients (personal interview) and controls (questionnaire)
Steigerwald *et al.* 1996	Private TMD clinic Retrospective	TMD	*n* = 50 (76%) 34 years	TMD: criteria not given Whiplash: self-reported trauma to head/neck	TMD group: 70%	Trauma group: more pain Symptoms improved after arthroscopy $P = 0{\cdot}001$	50%	Whiplash-induced TMD may differ from insidious TMD and even other onset of TMD by the prevalence of neck pain, intensity of neck pain and concurrence of neck pain, shoulder pain, headache, and jaw pain. These symptoms resolved after surgery, indicating that TMJ pathology was the perpetutating force behind, if not the cause of, these symptoms	Unclear TMD diagnosis. No controls. Questionnaire filled in between 1 and 104 weeks after surgery
Uppgaard, 1992	Private clinic Case series	TMD	*n* = 382 (79%) 10–60+ years	TMD: criteria not given Whiplash: self-reported trauma to head/neck	TMD group: 8·4%	Not clearly reported	20%	Successful treatment is dependent on the overall assessment of the patient, understanding the patient's total problem and treatment options	Unclear TMD diagnosis. No control group. No material and methods, or statistics. Results not clearly presented

*MVA, motor vehicle accident.

40) compared with studies based on chronic WAD patient groups (28, 41–44). When comparing different study populations after whiplash injury, it should also be remembered that a majority with an acute whiplash injury will recover and that the individuals who develop long-term symptoms report greater initial pain and disability (45). It is therefore reasonable to assume that these individuals are more at risk of developing pain also in the jaw/face region. The development of pain and dysfunction in the jaw region may reflect spread of pain related to close sensorimotor linkage between the jaw and neck, as well as lowered sensory and pain thresholds due to central sensitisation. There is support, both in experimental (46–49) and clinical (17) studies of spread and referral of pain between the cervical and trigeminal regions. Disturbed jaw motor function has been demonstrated after whiplash injury, both in terms of amplitudes and coordination of head and jaw movements and endurance of chewing (50). Furthermore, a recent study shows that experimental pain in the masseter muscle in healthy individuals can affect jaw–neck motor behaviour (51). Taken together, these findings further underline the tight sensorimotor coupling between the jaw and neck regions.

In the present review, using a scoring system modified from MacFarlane (30), the median score for the study quality was 50%. This is comparable with previous studies using the same scoring system to evaluate the prevalence of oro-facial pain (29, 30) reporting median quality scores ranging from 55% to 70%. However, for the present review, there were considerable variations between the primary studies, not only in the study quality scores, but also with regard to study populations, methodology, and criteria for TMD diagnosis. To improve the diagnosis of TMD, the research diagnostic criteria/temporomandibular disorders (RDC/TMDs) were introduced in 1992 (2) and are now widely used by clinicians and researchers. In the present systematic review, most of the primary studies were carried out before 1992 and only one study (31) used these criteria, which have a proven reliability and validity for the diagnosis of TMD (52). A new evidence-based DC/TMD protocol for use in both clinical and research setting has recently been developed (53). The new DC/TMD is an important step towards the goal of developing a mechanism- and aetiology-based DC/TMD that will more accurately direct the clinicians in providing personalised care for their patients. In the present review, there were also uncertainties with regard to the history of whiplash trauma, as these data were collected with different methods, for example questionnaires versus personal interviews, and for all studies, were based on patients' self-reports. Only two of the studies included control groups without TMD (32, 33). All these limitations need to be taken into account as it makes it difficult to draw firm conclusions from the present review. More well-designed studies on the development of TMD after whiplash trauma using the DC/TMD criteria in epidemiological population-based studies are needed.

The results from the present review have implications for assessment of patients with TMD. Examination of these patients should include the neck region, which could provide a more individualised rehabilitation regimen. A multidisciplinary rehabilitation programme should be advocated in TMD patients with whiplash-related neck pain. As the aetiology for TMD is multifactorial, further studies on the mechanisms of the association between whiplash trauma and TMD, and to what extent a neck injury can contribute to the development of TMD, are warranted.

Conclusions

In conclusion, the prevalence of whiplash trauma is higher in patients with TMD compared with controls. In addition, the data suggest that TMD patients with comorbid TMD/whiplash have more jaw pain and more severe jaw dysfunction, compared with TMD patients without a history of neck injury. These results suggest that whiplash trauma might be an initiating and/or aggravating factor as well as a comorbid condition for TMD.

Disclosures

The authors report no conflict of interest declared. This investigation was carried out without funding.

References

1. Dahlstrom L, Carlsson GE. Temporomandibular disorders and oral health-related quality of life. A systematic review. Acta Odontol Scand. 2010;68:80–85.
2. Dworkin S, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations

and specifications, critique. J Craniomand Disord. 1992;6:301–355.
3. Al-Jundi MA, John MT, Setz JM, Szentpetery A, Kuss O. Meta-analysis of treatment need for temporomandibular disorders in adult nonpatients. J Orofac Pain. 2008;22:97–107.
4. Burgess JA, Kolbinson DA, Lee PT, Epstein JB. Motor vehicle accidents and TMDS: assessing the relationship. J Am Dent Assoc. 1996;127:1767–1772; quiz 1785.
5. De Boever J, Keersmaekers K. Trauma in patients with temporomandibular disorders: frequency and treatment outcome. J Oral Rehabil. 1996;23:91–96.
6. Kolbinson DA, Epstein JB, Senthilselvan A, Burgess JA. A comparison of TMD patients with or without prior motor vehicle accident involvement: treatment and outcomes. J Orofac Pain. 1997;11:337–345.
7. Björnstig U, Hildingsson C, Toolanen G. Soft-tissue injury of the neck in a hospital based material. Scand J Soc Med. 1990;18:263–267.
8. Freeman MD, Croft AC, Rossignol AM, Weaver DS, Reiser M. A review and methodologic critique of the literature refuting whiplash syndrome. Spine (Phila Pa 1976). 1999;24:86–96.
9. Sterner Y, Gerdle B. Acute and chronic whiplash disorders–a review. J Rehabil Med. 2004;36:193–209.
10. Spitzer W, Skovron M, Salmi L, Cassidy J, Duranceau J, Suissa S *et al.* Scientific monograph of the Quebec task force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine. 1995;20:1S–73S.
11. Clark G, Green E, Dorman M, Flack V. Craniocervical dysfunction levels in a patient sample from a temporomandibular joint clinic. J Am Dent Assoc. 1987;115:251–256.
12. De Wijer A, Steenks M, De Leeuw J, Bosman F, Helders P. Symptoms of the cervical spine in temporomandibular and cervical spine disorders. J Oral Rehabil. 1996;23:742–750.
13. Visscher C, Lobbezoo F, de Boer W, van der Zaag J, Naeije M. Prevalence of cervical spinal pain in craniomandibular pain patients. Eur J Oral Sci. 2001;109:76–80.
14. Wiesinger B, Malker H, Englund E, Wänman A. Back pain in relation to musculoskeletal disorders in the jaw-face: a matched case-control study. Pain. 2007;131:311–319.
15. Ciancaglini R, Testa M, Radaelli G. Association of neck pain with symptoms of temporomandibular dysfunction in the general adult population. Scand J Rehabil Med. 1999;31:17–22.
16. De Wijer A, Steenks M, Bosman F, Helders P. Symptoms of the stomatognathic system in temporomandibular and cervical spine disorders. J Oral Rehabil. 1996;23:733–741.
17. Wiesinger B, Malker H, Englund E, Wänman A. Does a dose-response relation exist between spinal pain and temporomandibular disorders? BMC Musculoskelet Disord. 2009;10:28.
18. Marklund S, Wiesinger B, Wänman A. Reciprocal influence on the incidence of symptoms in trigeminally and spinally innervated areas. Eur J Pain. 2010;14:366–371.
19. Eriksson PO, Häggman-Henrikson B, Nordh E, Zafar H. Coordinated mandibular and head-neck movements during rhythmic jaw activities in man. J Dent Res. 2000;79:1378–1384.
20. Kohno S, Matsuyama T, Medina R, Arai Y. Functional-rhythmical coupling of head and mandibular movements. J Oral Rehabil. 2001;28:161–167.
21. Eriksson P-O, Zafar H, Häggman-Henrikson B. Deranged jaw-neck motor control in whiplash-associated disorders. Eur J Oral Sci. 2004;112:25–32.
22. Häggman-Henrikson B, Zafar H, Eriksson PO. Disturbed jaw behavior in whiplash-associated disorders during rhythmic jaw movements. J Dent Res. 2002;81:747–751.
23. Zafar H, Nordh E, Eriksson P-O. Impaired positioning of the gape in whiplash-associated disorders. Swed Dent J. 2006;30:9–15.
24. Häggman-Henrikson B, Gronqvist J, Eriksson PO. Frequent jaw-face pain in chronic Whiplash-Associated Disorders. Swed Dent J. 2011;35:123–131.
25. Weinberg S, Lapointe H. Cervical extension-flexion injury (whiplash) and internal derangement of the temporomandibular joint. J Oral Maxillofac Surg. 1987;45:653–656.
26. Howard RP, Bowles AP, Guzman HM, Krenrich SW. Head, neck, and mandible dynamics generated by 'whiplash'. Accid Anal Prev. 1998;30:525–534.
27. Lader E. Cervical trauma as a factor in the development of TMJ dysfunction and facial pain. J Craniomandibular Pract. 1983;1:85–90.
28. Sale H, Isberg A. Delayed temporomandibular joint pain and dysfunction induced by whiplash trauma: a controlled prospective study. J Am Dent Assoc. 2007;138:1084–1091.
29. Häggman-Henrikson B, List T, Westergren HT, Axelsson SH. Temporomandibular disorder pain after whiplash trauma: a systematic review. J Orofac Pain. 2013;27:217–226.
30. Macfarlane TV, Glenny AM, Worthington HV. Systematic review of population-based epidemiological studies of orofacial pain. J Dent. 2001;29:451–467.
31. Grushka M, Ching VW, Epstein JB, Gorsky M. Radiographic and clinical features of temporomandibular dysfunction in patients following indirect trauma: a retrospective study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104:772–780.
32. Pullinger AG, Monteiro AA. History factors associated with symptoms of temporomandibular disorders. J Oral Rehabil. 1988;15:117–124.
33. Pullinger AG, Seligman DA. Trauma history in diagnostic groups of temporomandibular disorders. Oral Surg Oral Med Oral Pathol. 1991;71:529–534.
34. Steigerwald DP, Verne SV, Young D. A retrospective evaluation of the impact of temporomandibular joint arthroscopy on the symptoms of headache, neck pain, shoulder pain, dizziness, and tinnitus. Cranio. 1996;14:46–54.
35. Uppgaard RO. Conservative and successful treatment of temporomandibular dysfunction in a private rural practice. Cranio. 1992;10:235–240.
36. Goldberg M, Mock D, Ichise M, Proulx G, Gordon A, Shandling M *et al.* Neuropsychologic deficits and clinical features of posttraumatic temporomandibular disorders. J Orofac Pain. 1996;10:126–140.

37. Kolbinson DA, Epstein JB, Senthilselvan A, Burgess JA. A comparison of TMD patients with or without prior motor vehicle accident involvement: initial signs, symptoms, and diagnostic characteristics. J Orofac Pain. 1997;11:206–214.
38. List T, Axelsson S. Management of TMD: evidence from systematic reviews and meta-analyses. J Oral Rehabil. 2010;37:430–451.
39. Severinsson Y, Bunketorp O, Wenneberg B. Jaw symptoms and signs and the connection to cranial cervical symptoms and post-traumatic stress during the first year after a whiplash trauma. Disabil Rehabil. 2010;32:1987–1998.
40. Heise A, Laskin D, Gervin A. Incidence of temporomandibular joint symptoms following whiplash injury. J Oral Maxillofac Surg. 1992;50:825–828.
41. Klobas L, Tegelberg A, Axelsson S. Symptoms and signs of temporomandibular disorders in individuals with chronic whiplash-associated disorders. Swed Dent J. 2004;28:29–36.
42. Kronn E. The incidence of TMJ dysfunction in patients who have suffered a cervical whiplash injury following a traffic accident. J Orofac Pain. 1993;7:209–213.
43. Magnusson T. Extracervical symptoms after whiplash trauma. Cephalalgia. 1994;14:223–227.
44. Visscher C, Hofman N, Mes C, Lousberg R, Naeije M. Is temporomandibular pain in chronic whiplash-associated disorders part of a more widespread pain syndrome? Clin J Pain. 2005;21:353–357.
45. Carroll LJ, Holm LW, Hogg-Johnson S, Cote P, Cassidy JD, Haldeman S *et al.* Course and prognostic factors for neck pain in whiplash-associated disorders (WAD): results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. Spine (Phila Pa 1976). 2008;33:S83–S92.
46. Hellström F, Thunberg J, Bergenheim M, Sjölander P, Pedersen J, Johansson H. Elevated intramuscular concentration of bradykinin in jaw muscle increases the fusimotor drive to neck muscles in the cat. J Dent Res. 2000;79:1815–1822.
47. Schmidt-Hansen PT, Svensson P, Jensen TS, Graven-Nielsen T, Bach FW. Patterns of experimentally induced pain in pericranial muscles. Cephalalgia. 2006;26:568–577.
48. Svensson P, Wang K, Sessle B, Arendt-Nielsen L. Associations between pain and neuromuscular activity in the human jaw and neck muscles. Pain. 2004;109:225–232.
49. Sessle BJ, Hu JW, Amano N, Zhong G. Convergence of cutaneous, tooth pulp, visceral, neck and muscle afferents onto nociceptive and non-nociceptive neurones in trigeminal subnucleus caudalis (medullary dorsal horn) and its implications for referred pain. Pain. 1986;27:219–235.
50. Eriksson PO, Häggman-Henrikson B, Zafar H. Jaw-neck dysfunction in whiplash-associated disorders. Arch Oral Biol. 2007;52:404–408.
51. Wiesinger B, Häggman-Henrikson B, Hellstrom F, Wanman A. Experimental masseter muscle pain alters jaw-neck motor strategy. Eur J Pain. 2013;17:995–1004.
52. Look JO, Schiffman EL, Truelove EL, Ahmad M. Reliability and validity of Axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) with proposed revisions. J Oral Rehabil. 2010;37:744–759.
53. Schiffman EL, Ohrbach RK, Truelove E, Look JO, Anderson G, Goulet JP *et al.* Diagnostic Criteria for Temporomandibular Disorders (DC/TMD): Recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Orofac Pain. 2013. (In press).
54. Abd-Ul-Salam H, Kryshtalskyj B, Weinberg S. Temporomandibular joint arthroscopic findings in patients with cervical flexion-extension injury (whiplash): a preliminary study of 30 patients. J Can Dent Assoc. 2002;68:693–696.
55. Boniver R. Temporomandibular joint dysfunction in whiplash injuries: association with tinnitus and vertigo. Int Tinnitus J. 2002;8:129–131.
56. Burgess J. Symptom characteristics in TMD patients reporting blunt trauma and/or whiplash injury. J Craniomandib Disord. 1991;5:251–257.
57. Burgess JA, Dworkin SF. Litigation and post-traumatic TMD: how patients report treatment outcome. J Am Dent Assoc. 1993;124:105–110.
58. Epstein JB, Klasser GD, Kolbinson DA, Mehta SA. Orofacial injuries due to trauma following motor vehicle collisions: part 2. Temporomandibular disorders. J Can Dent Assoc. 2010;76:a172.
59. Freund B, Schwartz M. Post-traumatic myofascial pain of the head and neck. Curr Pain Headache Rep. 2002;6:361–369.
60. Friedman MH, Weisberg J. The craniocervical connection: a retrospective analysis of 300 whiplash patients with cervical and temporomandibular disorders. Cranio. 2000;18:163–167.
61. Garcia RJ, Arrington J. The relationship between cervical whiplash and temporomandibular joint injuries: an MRI study. Cranio. 1996;14:233–239.
62. Gray R, Al-Ani Z. Risk management in clinical practice. Part 8. Temporomandibular disorders. Br Dent J. 2010;209:433–449.
63. Greco CM, Rudy TE, Turk DC, Herlich A, Zaki HH. Traumatic onset of temporomandibular disorders: positive effects of a standardized conservative treatment program. Clin J Pain. 1997;13:337–347.
64. Huang G, LeResche L, Critchlow C, Martin M, Drangsholt M. Risk Factors for diagnostic subgroups of painful Temporomandibular Disorders (TMD). J Dent Res. 2002;81:284–288.
65. Kim HI, Lee JY, Kim YK, Kho HS. Clinical and psychological characteristics of TMD patients with trauma history. Oral Dis. 2010;16:188–192.
66. Kolbinson DA, Epstein JB, Burgess JA, Senthilselvan A. Temporomandibular disorders, headaches, and neck pain after motor vehicle accidents: a pilot investigation of persistence and litigation effects. J Prosthet Dent. 1997;77:46–53.
67. Kolbinson DA, Epstein JB, Senthilselvan A, Burgess JA. Effect of impact and injury characteristics on post-motor vehicle accident temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998;85:665–673.
68. Krogstad BS, Jokstad A, Dahl BL, Soboleva U. Somatic complaints, psychologic distress, and treatment outcome in two groups of TMD patients, one previously subjected to whiplash injury. J Orofac Pain. 1998;12:136–144.

69. McKay D, Christensen L. Whiplash injuries of the temporomandibular joint in motor vehicle accidents: speculation and facts. J Oral Rehabil. 1998;5:731–746.
70. Olin M. Components of complex TM disorders. J Craniomandib Disord. 1990;4:193–196.
71. Pressman BD, Shellock FG, Schames J, Schames M. MR imaging of temporomandibular joint abnormalities associated with cervical hyperextension/hyperflexion (whiplash) injuries. J Magn Reson Imaging. 1992;2:569–574.
72. Romanelli G, Mock D, Tenenbaum H. Characteristics and response to treatment of posttraumatic temporomandibular disorder: a retrospective study. Clin J Pain. 1992;8: 6–17.
73. Seligman DA, Pullinger AG. A multiple stepwise logistic regression analysis of trauma history and 16 other history and dental cofactors in females with temporomandibular disorders. J Orofac Pain. 1996;10:351–361.

Correspondence: B. Häggman-Henrikson, Department of Odontology/Clinical Oral Physiology, Umeå University, Umeå SE-901 87, Sweden. E-mail: birgitta.henrikson@odont.umu.se