SELF-REPORTED SEVERITY OF TASTE DISTURBANCES CORRELATES WITH SEVERITY OF TMD PAIN

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Abstract

Altered central neural processing of sensory information may be associated with temporomandibular joint disorders (TMD) pain. The study objectives were to compare the prevalence of self-reported taste disturbances in TMD pain patients and in a control population, and to determine whether frequency of taste disturbances is correlated with TMD pain severity. Subjects were 2026 people within a German population sample and 301 consecutive TMD pain patients diagnosed using the Research Diagnostic Criteria. Taste disturbances were measured using two questions from the Oral Health Impact Profile. Severity of TMD pain was measured using the Graded Chronic Pain Scale. A two-sample test of proportions revealed that TMD pain patients reported a greater frequency of taste disturbances, 6%, than did the general population subjects, 2% (p<0.001). Moreover, the frequency of taste disturbances correlated with the severity of TMD pain. For each 1-unit increase in taste disturbance, the odds of observing a higher grade of TMD pain increased by 29% (95%CI: 3–63%, p=0.03). Analysis by individual taste question and adjustment for age and gender did not substantially affect the results. Self-reported frequency of taste disturbances is greater in TMD pain patients than in the general population and the frequency of taste disturbances correlates with severity of TMD pain. These findings are consistent with a central neural dysfunction in TMD pain and suggest that a common neural substrate may underlie sensory disturbances of multiple modalities in chronic pain patients. Further research regarding taste disturbances and trigeminally-mediated pains, such as in TMD, is warranted.

Keywords

Taste; Orofacial Pain; Temporomandibular Disorders; Inhibitory Pain Control; Pain Modulation

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Introduction

The mechanisms involved in temporomandibular disorder (TMD) pain are not well defined (1, 2); however, evidence of a lack of progressive peripheral tissue destruction (3) and a disassociation between pain symptoms and tissue injury, when present, (4, 5) suggest that central modulation of nociception plays an important role. This is supported by research indicating enhanced responses to sensory stimuli evoked from regions not innervated by the trigeminal nerve (6–10). This suggests that at least a component of TMD pain is centrally-mediated and associated with a reduction in inhibitory pain pathways (11, 12), similar to other chronic pain conditions (13).

In a taste testing study, individuals with chronic back pain, a complex musculoskeletal pain disorder with elusive underlying mechanisms, reported higher intensity ratings to standard taste concentrations than matched controls did (14). The authors suggested that since taste perception is modulated in brain regions that also process nociceptive signals (15, 17), there is an inherent interaction between these two sensory systems. Their data suggest that changes in these regions could affect both pain and taste in the same manner. Changes in the thresholds of other sensory modalities, such as noise and light in people with migraine headaches (20, 21), have also been reported to change with pain, suggesting an interaction between trigeminally-mediated pain and these special senses. This is also likely to include olfaction, since the sensations of taste and smell are closely linked (18). Injury to trigeminal somatosensory afferents resulted in increased olfactory thresholds (19). Overall, results from a number of different lines of research support a potential interaction between trigeminal somatosensory pain processing and the special senses.

Informal feedback from TMD patients suggest they experience alterations in their ability to taste, yet only one case report was found in the literature that explicitly reported this sensory disturbance (22). Others have reported taste sensation to be associated with other chronic orofacial pain conditions, specifically decreased taste threshold with burning mouth syndrome (23) and as a triggering stimulus for idiopathic trigeminal pain (24). The aims of this exploratory study were to determine if TMD pain patients differ from the general population in the frequency of self-reported taste disturbances, and whether the frequency of taste disturbances correlates with the severity of the TMD pain. This study is a preliminary step towards assessing whether future research investigating the relationship between taste sensibility and TMD pain is warranted.

Material and Methods

This research was conducted in accordance with accepted ethical standards for research practice, undergoing review and approval by the Institutional Review Board at the University of Leipzig. Written informed consent was obtained from all participants prior to their enrollment.

Subjects

This exploratory study used data previously collected for a cross-sectional study of the oral health-related quality of life in patients with TMD (25). From 2002 to 2006, 416 patients at least 14 years of age and with at least one diagnosis of TMD were recruited from a series of consecutive patients seeking treatment for complaints in the masticatory muscles and the temporomandibular joints at the Department of Prosthodontics, Martin-Luther-University Halle-Wittenberg (Halle/Saale, Germany) or the Department of Prosthodontics and Materials Science, University of Leipzig (Leipzig, Germany) (25). Patients had either sought care on their own initiative or had been referred for treatment by their dentist, physician, or physical therapist. TMD was diagnosed by dentists experienced with TMD management and

according to the German version of the research diagnostic criteria for temporomandibular disorders (RDC/TMD) (26, 27). Because our goal in the present study was to test for an association between self-reported taste disturbances and TMD pain, we included only those patients with painful TMD, i.e., those with a score of I, II, III, or IV on the Graded Chronic Pain Scale. A total of 301 subjects in the original cohort met this additional criterion. Their mean age (± standard deviation) was 38.1 ± 16.05 years, and 78% were women. Other sociodemographic and clinical characteristics of the TMD pain group are summarized in Table 1.

General population subjects, the comparison group in our study, came from a probability sample of a German national prevalence survey (response rate 60%, n=2026) (28). The age and gender distributions for this comparison sample (52% female, mean age of 43 ± 16.2 years, age range from 16–79 years) were similar to data published by Federal Statistical Office for the German population.

Assessment of pain severity and taste disturbances

TMD pain severity was measured with the Graded Chronic Pain Scale (GCPS). This 7-item questionnaire yields a grade of I–IV that ranks the level of functional limitation associated with the respondent's chronic pain (29). Grade I is functionally normal with chronic pain, grade II is mild functional impairment, and grades III and IV are dysfunctional chronic pain states (29). The GCPS is a valid indicator of functional limitation in TMD pain patients (30, 31) and a predictor of persistence of chronic pain in such patients (29). The GCPS is obtained from the RDC/TMD. The validated German version of the RDC/TMD was used in this research (27).

Taste disturbances were measured with two questions (items 6 and 26) from the German version (32) of the Oral Health Impact Profile (OHIP) (33). Patients were asked:

> [#]6. Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures?

> [#]26. Have you felt that there has been less flavour in your food because of problems with your teeth, mouth or dentures?

For each question, patients were asked to rate the frequency of oral problems on an ordinal scale of 0-never, 1-hardly ever, 2-occasionally, 3-fairly often, and 4-very often during the last month. In our analyses, ratings of 3-fairly often and 4-very were considered problematic.

Data analysis

Correlations between the two taste items, and between the two taste items and GCPS score, were computed by using the Spearman rank coefficient. To compare the prevalence of frequent taste problems (problems mentioned fairly or very often) between TMD patients and general population subjects, a two-sample test of proportions was used. To compare the frequency of the full ordinal response range of OHIP taste items between the two populations, a Wilcoxon rank-sum (Mann-Whitney) test was used. Logistic regression was used to determine whether higher levels of pain severity (GCPS status of I–IV) were related to higher frequency of taste disturbances (0–4). Simple logistic regression was applied to determine how the prevalence of frequent taste problems increased with higher graded chronic pain status. In addition, ordinal logistic regression was used to analyze how the frequency of taste disturbances rated within each OHIP question increased with GCPS. These analyses were performed with and without adjustment for age, a continuous variable, and gender.

Analyses were conducted with the statistical software package STATA, release 9 (StataCorp LP, College Station, TX). A level of p<0.05 was considered statistically significant.

Results

Prevalence of dysfunctional chronic pain and frequency of taste problems

In TMD pain patients, the prevalence of dysfunctional chronic pain (grades III or IV on the GCPS) was 13% (Table 1) and the frequency of problematic taste disturbances (ratings of fairly often or very often) was 6% (Table 2). Compared with general population subjects, TMD pain patients reported a greater frequency of taste disturbances for both of the OHIP questions (Table 2; two-sample test of proportions, P= 0.002 and P= 0.001). However, when the severity of taste problems was compared for the groups, only *felt less flavour in food* was statistically significant (Wilcoxon rank-sum test, P<0.001).

Responses to the two individual taste questions correlated moderately with each other for both the general population sample ($r_{Spearman}$=0.61, P<0.001) and TMD pain patients ($r_{Spearman}$=0.52, P<0.001). For TMD pain patients, responses to individual taste questions correlated weakly with responses for GCPS status (*worsened sense of taste:* $r_{Spearman}$=0.13, P<0.03; *felt less flavour in food:* $r_{Spearman}$=0.11, P<0.05).

Correlation between grades of chronic pain and frequency of taste problems

In the TMD pain group, the prevalence of taste problems increased with increasing chronic pain grade in a dose-related fashion (Table 3). The presence of any taste problem (fairly or very often) was related to dysfunctional chronic pain (grade III or IV), with an overall odds ratio of 3.4 (95% CI: 1.1–10.2). That is, subjects with frequently reporting taste problems were 3.4 times more likely to have a dysfunctional level of chronic TMD pain that those who did not report taste problems. Trend analysis using an ordinal logistic regression revealed that for each 1-unit increase in the 5-point response scale for the taste disturbance questions, the odds of observing a higher grade of TMD pain increased by 39% (95%CI: 6–80%, p=0.02) for the "*worsened sense of taste*" question; by 39% (95%CI: 7–79%, p=0.01) for "*felt less flavour in food*" question; and by 29% (95%CI: 3–63%, p=0.03) for "*any taste problem."* Adjustment for age and gender did not substantially change the results and are therefore not reported.

The prevalence and grade of TMD pain was not measured in the population sample; thus, an exploration of whether frequent reports of taste problems were associated with TMD pain could not be performed for this group.

Discussion

In this exploratory study, subjects with TMD pain self-reported greater frequencies of taste disturbances when compared with a general population sample. Our results also suggest that there is a graded interaction between perceived taste and TMD pain with worse pain associated with a greater frequency of taste complaints. These findings were not different when adjustments for age and gender were performed. Our results provide preliminary evidence for an interaction or common dysfunction between taste and trigeminally-mediated pain.

Researchers have suggested that taste disturbances are associated with the development of chronic orofacial pains such as burning mouth syndrome (BMS), neuropathic tooth pain, and TMD pain. One possible mechanism for this association is loss of inhibitory activity by taste on trigeminal nociception (34, 35). Investigations of tongue innervation revealed that compared to controls, individuals with BMS show evidence of thin nerve fiber dysfunction

with both hyper- and hypo-responsiveness, measured by thermal quantitative sensory testing (36), and reduced epidermal nerve fiber density in the anterolateral border region, measured by immunohistochemistry (37). In other work, the taste threshold of individuals with BMS were elevated compared to pain-free controls, as well as controls with local reasons for an oral burning sensation (38). Recent evidence suggests that the pathophysiology of both neuropathic tooth pain (39–41) and TMD pain (42, 43) are associated with central pain mechanisms. However, an evaluation of tasting ability under such chronic pain conditions has not been previously reported. Medications that affect GABAergic mechanisms, the main inhibitory transmitter in the brain, also reduce pain in some individuals with BMS (44) and TMD pain (45). Both BMS and TMD pain are trigeminally-mediated pain conditions, share multiple pain characteristics (46) and may result from a reduction of inhibitory controls (11, 35).

Sensory Thresholds and Chronic Pain

Taste perception and pain processing may be represented in similar regions of the cerebral cortex and other brain areas (15, 16). These findings would predict that increased central neural activity associated with the development of chronic pain conditions, would result in increased sensitivity to tastants in a similar manner as hypersensitivity to somatosensory stimuli in patients with chronic back pain. When compared to matched pain-free controls, chronic back pain patients rated their various taste sensations as more intense, with a trend for having a lower detection threshold (14). Also, induced pain from both venopuncture and propofol injection was shown to be greater in adults with an increased sensitivity to bitter taste (47).

Research assessing other sensory systems, such as auditory and vision, also demonstrate that subjects with chronic pain have decreased thresholds (20, 21, 48). The common central mechanisms involved in modulating sensory perception and why pain and other sensory systems are represented in common brain areas is not certain (49). Emerging evidence implies there are multiple and distinct functions of individual cortical regions, such as the insula that integrate features of sensory input such as magnitude rather than sensory modality (50), features not previously separated due to methodological limitations. Therefore, at present, it is unknown how different sensory systems thresholds are modulated.

Relation between Subjective Taste Alterations and Taste Testing Results

Subjective reports of taste alterations do not correlate well with psychophysical taste testing (51, 52), which is a potential limitation of using self-reported responses regarding taste disturbances. One explanation for this is the high degree of integration between the sense of taste and smell, with alteration of either sense resulting in a self-report of a decreased enjoyment eating foods (53). Temporary alteration of taste after application of local anesthesia to the chorda tympani nerve alters taste perception, mostly bitter and metallic tastes that are then perceived as being unpleasant, as well as contralateral taste phantom sensations (54). Intentional injury to the trigeminal ganglion for the treatment of trigeminal neuralgia also resulted in taste complaints in some but not all individuals (19) suggesting that significant individual variability in impaired taste ability. Given that metallic taste sensation measured by questionnaire has recently been shown to be predictive for the development of chronic orofacial pain following head and neck treatment in 5-year survivors of cancer (55), asking about taste perception may be a valid means for assessing taste and chronic pain. A further limitation of our study is that information on smoking status, presence of dentures, number of remaining teeth, and medication use was not obtained, yet each of these factors may alter taste perception. Therefore, even though self-report of taste and psychophysical measurement of taste do not correlate well at the level of

the individual, meaningful information about the relationship of taste and chronic pain can be obtained using questionnaires in moderate sized groups.

An alternative explanation for why a correlation between self-report of taste disturbances and TMD pain status is that the increased awareness of taste disturbances may result from increased attention to orofacial functions in people with TMD pain compared to those who do not have pain. This possibility is supported by the observation that greater self-reported prevalence of taste disturbances in our TMD pain population, 5%, as compared to 2–2.5% in the general population (28, 56). Mood disorders, such as depression and anxiety, and the medications commonly used to treat them, also are known to alter taste perception (57). Since mood disorders are commonly co-morbid with TMD pain (3), as seen in this group of patients, they can have a modifying effect on the self-report of taste. These reasons likely contribute to the weak correlation between GCPS pain grade and OHIP frequency of taste disturbances, suggesting that a relationship may exist between TMD pain and taste alterations. Correlation results per se cannot be considered causal, however, they demonstrate the need for taste testing in TMD pain patients to support or refute the above-presumed associations.

Injury to Taste is Likely to be Common

Reductions in the ability to taste are known to occur with disease states (58), head trauma (59), and medication intake (60). They can also be induced by various anticancer therapies (61, 62). Dental procedures, especially third molar extraction (63) and inferior alveolar nerve block anesthesia, (63, 64) have been reported to sporadically cause lingual and chorda tympani nerve injury affecting the sense of taste. Interestingly, patients can be unaware of a reduction in their ability to taste (59), sometimes even when assessed with direct questioning (52). Deficits in the ability to taste have been shown to be associated with increased exposure to dental deafferentation, specifically tooth extractions and root canals. Research suggests that individuals who have 7 or more deafferented teeth have higher taste thresholds than those with 6 or less deafferented, even when adjusted for age (65). Emerging evidence suggests that genetic factors may also be involved (66, 67). Tooth extractions and root canal procedures are ubiquitous within the practice of dentistry (68), and the consequences of these treatments are unknown. Despite the apparent weak relationship between taste injury and the development of chronic trigeminally-mediated pain, further research on this association is warranted because of the prevalence of taste disturbances in the general population.

Conclusions

Self-reported frequency of taste disturbances is more common in people with TMD pain than in the general population. In patients with TMD pain, frequency of taste disturbances correlates with severity of TMD pain in a graded manner. This supports the hypothesis that alterations of taste may be part of the pathophysiology of TMD pain. This relationship may be related to changes in peripheral taste sensation and/or central processing of sensory stimuli. Further investigations regarding taste disturbances and TMD pain are warranted in an effort to elucidate the potential relationships underlying the pathophysiology of this chronic pain disorder.

Acknowledgments

References

1. Management of temporomandibular disorders. NIH Technology Assessment Statement. 1996:1–32.

2. Baragona, PM.; Bertrand, PM.; Black, DF.; Carlson, DF.; Cohen, JR.; Dury, DC., et al. Temporomandibular disorders. In: de Leeuw, R., editor. Orofacial pain: guidelines for assessment, diagnosis, and management. 4. Chicago: Quintessence; 2008. p. 129-204.

3. Drangsholt, M.; LeResche, L. Temporomandibular disorder pain. In: Crombie, IE.; Croft, PR.; Linton, SJ.; LeResche, L.; VonKorff, M., editors. Epidemiology of pain. 1. Seattle: IASP Press; 1999. p. 203-233.

4. Schiffman EL, Anderson GC, Fricton JR, Lindgren BR. The relationship between level of mandibular pain and dysfunction and stage of temporomandibular joint internal derangement. J Dent Res. 1992; 71:1812–1815. [PubMed: 1401443]

5. Look JO, Tai F, Haugen M, Schiffman E. A prediction model for detection of TMJ intra-articular disorders. J Dent Res. 2007; 86(Spec Iss A):1318.

6. Reid KI, Gracely RH, Dubner RA. The influence of time, facial side, and location on pain-pressure thresholds in chronic myogeneous temporomandibular disorder. J Orofac Pain. 1994; 8:258–265. [PubMed: 7812223]

7. Maixner W, Fillingim R, Booker D, Sigurdsson A. Sensitivity of patients with painful temporomandibular disorders to experimentally evoked pain. Pain. 1995; 63:251–341. [PubMed: 8628591]

8. Maixner W, Fillingim R, Sigurdsson A, Kincaid S, Silva S. Sensitivity of patients with painful temporomandibular disor- ders to experimentally evoked pain: evidence for altered temporal summation of pain. Pain. 1998; 76:71–81. [PubMed: 9696460]

9. Sarlani E, Grace EG, Reynolds MA, Greenspan JD. Evidence for up-regulated central nociceptive processing in patients with masticatory myofascial pain. J Orofac Pain. 2004; 18:41–55. [PubMed: 15029872]

10. Ayesh EE, Jensen TS, Svensson P. Hypersensitivitytomechanical and intra-articular electrical stimuli in persons with painful temporomandibular joints. J Dent Res. 2007; 86:1187–1192. [PubMed: 18037653]

11. Svensson P, Graven-Nielsen T. Craniofacial muscle pain: review of mechanisms and clinical manifestations. J Orofac Pain. 2001; 15:117–145. [PubMed: 11443825]

12. Sarlani E, Greenspan JD. Evidence for generalized hyperalgesia in temporomandibular disorders patients. Pain. 2003; 102:221–226. [PubMed: 12670662]

13. Fields, HL.; Basbaum, AI.; Heinricher, MM. Central nervous system mechanisms of pain modulation. In: McMahon, SB.; Koltzenburg, M., editors. Wall and Melzack's textbook of pain. 5. Philadelphia: Elsevier; 2006. p. 125-142.

14. Small DM, Apkarian A. Increased taste intensity perception exhibited by patients with chronic back pain. Pain. 2006; 120:124–130. [PubMed: 16360267]

15. Faurion A, Cerf B, Van De Moortele PF, Lobel E, Mac Leod P, Le Bihan D. Human taste cortical areas studied with functional magnetic resonance imaging: evidence of functional lateralization related to handedness. Neurosci Lett. 1999; 277:189–192. [PubMed: 10626845]

16. Small DM, Zald DH, Jones-Gotman M, Zatorre RJ, Pardo JV, Frey S, et al. Human cortical gustatory areas: a review of functional neuroimaging data. Neuroreport. 1999; 10:7–14. [PubMed: 10094124]

17. Apkarian AV, Bushnell MC, Treede RD, Zubieta JK. Human brain mechanisms of pain perception and regulation in health and disease. Eur J Pain. 2005; 9:463–484. [PubMed: 15979027]

18. Vander, AJ.; Sherman, JH.; Luciano, DS. The sensory systems. In: Vander, AJ.; Sherman, JH.; Luciano, DS., editors. Human physiology. 6. New York: McGraw-Hill; 1994. p. 233-271.

19. Siqueira SR, Nobrega JC, Teixeira MJ, Siqueira JT. Olfactory threshold increase in trigeminal neuralgia after balloon compression. Clin Neurol Neursurg. 2006; 108:721–725.

20. Woodhouse A, Drummond PD. Mechanisms of increased sensitivity to noise and light in migraine headache. Cephalalgia. 1993; 13:417–421. [PubMed: 8313457]

21. Vanagaite J, Pareja JA, Storen O, White LR, Sand T, Stovner LJ. Light-induced discomfort and pain in migraine. Cephalalgia. 1997; 17:733–741. [PubMed: 9399002]

22. Kahn LJ. Altered taste in a 58-year-old patient. Cranio. 1986; 4:367–368. [PubMed: 3465469]

23. Grushka M, Sessle B. Taste dysfunction in burning mouth syndrome. Gerodontics. 1988; 4:256–258. [PubMed: 3271722]

24. Sharav Y, Benoliel R, Schnarch A, Greenberg L. Idiopathic trigeminal pain associated with gustatory stimuli. Pain. 1991; 44:171–174. [PubMed: 2052384]

25. John MT, Reissmann DR, Schierz O, Wassell RW. Oral health- related quality of life in patients with temporomandibular disorders. J Orofac Pain. 2007; 21:46–54. [PubMed: 17312641]

26. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review criteria, examinations and specifications, critique. J Craniomandib Disord Fac Oral Pain. 1992; 6:301–355.

27. John MT, Hirsch C, Reiber T, Dworkin S. Translating the research diagnostic criteria for temporomandibular disorders into German: evaluation of content and process. J Orofac Pain. 2006; 20:43–52. [PubMed: 16483020]

28. John MT, LeResche L, Koepsell TD, Hujoel P, Miglioretti DL, Micheelis W. Oral health-related quality of life in Germany. Eur J Oral Sci. 2003; 111:483–491. [PubMed: 14632684]

29. Von Korff M, Ormel J, Keefe FJ, Dworkin SF. Grading the severity of chronic pain. Pain. 1992; 50:133–149. [PubMed: 1408309]

30. Yap AU, Chua EK, Dworkin SF, Tan HH, Tan KB. Multiple pains and psychosocial functioning/psychologic distress in TMD patients. Int J Prosthodont. 2002; 15:461–466. [PubMed: 12375461]

31. Dworkin SF, Sherman J, Mancl L, Ohrbach R, LeResche L, Truelove E. Reliability, validity, and clinical utility of the research diagnostic criteria for Temporomandibular Disorders Axis II Scales: depression, non-specific physical symptoms, and graded chronic pain. J Orofac Pain. 2002; 16:207–220. [PubMed: 12221737]

32. John MT, Patrick DL, Slade GD. The German version of the oral health impact profile: translation and psychometric properties. Eur J Oral Sci. 2002; 110:425–433. [PubMed: 12507215]

33. Slade GD, Spencer AJ. Development and evaluation of the oral health impact profile. Community Dent Health. 1994; 11:3–11. [PubMed: 8193981]

34. Grushka M, Epstein JB, Gorsky M. Burning mouth syndrome and other oral sensory disorders: a unifying hypothesis. Pain Res Manag. 2003; 8:133–135. [PubMed: 14657979]

35. Bartoshuk LM, Snyder DJ, Grushka M, Berger AM, Duffy VB, Kveton JF. Taste damage: previously unsuspected consequences. Chem Senses. 2005; 30(Suppl 1):i218–i219. [PubMed: 15738123]

36. Forssell H, Jaaskelainen S, Tenovuo O, Hinkka S. Sensory dysfunction in burning mouth syndrome. Pain. 2002; 99:41–47. [PubMed: 12237182]

37. Lauria G, Majorana A, Borgna M, Lombardi R, Penza P, Padovani A, et al. Trigeminal small-fiber sensory neuropathy causes burning mouth syndrome. Pain. 2005; 115:332–337. [PubMed: 15911160]

38. Eliav E, Kamran B, Schaham R, Czerninski R, Gracely RH, Benoliel R. Evidence of chorda tympani dysfunction in patients with burning mouth syndrome. J Am Dent Assoc. 2007; 138:628–633. [PubMed: 17473041]

39. List T, Leijon G, Helkimo M, Oster A, Dworkin SF, Svensson P. Clinical findings and psychosocial factors in patients with atypical odontalgia: a case–control study. J Orofac Pain. 2007; 21:89–98. [PubMed: 17547120]

40. List T, Leijon G, Helkimo M, Oster A, Svensson P. Effect of local anesthesia on atypical odontalgia: a randomized con- trolled trial. Pain. 2006; 122:306–314. [PubMed: 16564621]

41. List T, Leijon G, Svensson P. Somatosensory abnormalities in atypical odontalgia: a case–control study. Pain. 2008; 139:333–341. [PubMed: 18571324]

42. Kashima K, Rahman OI, Sakoda S, Shiba R. Increased pain sensitivity of the upper extremities of TMD patients with myalgia to experimentally evoked noxious stimulation: possibility of worsened endogenous opioid systems. Cranio. 1999; 17:241–246. [PubMed: 10650395]

43. Svensson P, List T, Hector G. Analysis of stimulus-evoked pain in patients with myofascial temporomandibular pain disorders. Pain. 2001; 92:399–409. [PubMed: 11376913]

44. Gremeau-Richard C, Woda A, Navez ML, Attal N, Bouhassira D, Gagnieu MC, et al. Topical clonazepam in stomatodynia: a randomised placebo-controlled study. Pain. 2004; 108:51–57. [PubMed: 15109507]

45. Herman CR, Schiffman EL, Look JO, Rindal DB. The effectiveness of adding pharmacologic treatment with clonazepam or cyclobenzaprine to patient education and self-care for the treatment of jaw pain upon awakening: a randomized clinical trial. J Orofac Pain. 2002; 16:64–79. [PubMed: 11889661]

46. Woda A, Turbert-Jeannin S, Bouhassira D, Attal N, Fleiter B, Goulet J, et al. Towards a new taxonomy of idiopathic orofacial pain. Pain. 2005; 116:396–406. [PubMed: 15979796]

47. Erden V, Basaranoglu G, Korkut Y, Delatioglu H, Yangin Z, Kiroglu S. Relation between bitter taste sensitivity and incidence or intensity of propofol injection pain. Eur J Anaesthesiol. 2007; 24:516–520. [PubMed: 17087841]

48. Geisser ME, Glass JM, Rajcevska LD, Clauw DJ, Williams DA, Kileny PR, et al. A psychophysical study of auditory and pressure sensitivity in patients with fibromyalgia and healthy controls. J Pain. 2008; 9:417–422. [PubMed: 18280211]

49. Hummel T, Doty RL, Yousem DM. Functional MRI of intranasal chemosensory trigeminal activation. Chem Senses. 2005; 30:i205–i206. [PubMed: 15738116]

50. Baliki MN, Geha PY, Apkarian AV. Parsing pain perception between nociception representation and magnitude estimation. J Neurophysiol. 2009; 101:875–887. [PubMed: 19073802]

51. Hillerup S, Hjorting-Hansen E, Reumert T. Repair of the lingual nerve after iatrogenic injury: a follow-up study of return of sensation and taste. J Oral Maxillofac Surg. 1994; 52:1028–1031. [PubMed: 8089786]

52. Soter A, Kim J, Jackman A, Tourbier I, Kaul A, Doty RL. Accuracy of self-report in detecting taste dysfunction. Laryngoscope. 2008; 118:611. [PubMed: 18182967]

53. Mattes, RD. Nutritional implications of taste and smell. In: Doty, RL., editor. Handbook of olfaction and gustation. 2. New York: Marcel Dekker; 2003. p. 881-903.

54. Yanagisawa K, Bartoshuk LM, Catalanotto FA, Karrer TA, Kveton JF. Anesthesia of the chorda tympani nerve and taste phantoms. Physiol Behav. 1998; 63:329–335. [PubMed: 9469723]

55. Logan HL, Bartoshuk LM, Fillingim RB, Tomar SL, Menden- hall WM. Metallic taste phantom predicts oral pain among 5-year survivors of head and neck cancer. Pain. 2008; 140:323–331. [PubMed: 18845396]

56. Bergdahl M, Bergdahl J. Perceived taste disturbance in adults: prevalence and association with oral and psychological factors and medication. Clin Oral Investig. 2002; 6:145–149.

57. Bromley, SM.; Doty, RL. Clinical disorders affecting taste: evaluation and management. In: Doty, RL., editor. Handbook of olfaction and gustation. 2. New York: Marcel Dekker; 2003. p. 935-957.

58. Heald AE, Pieper CF, Schiffman SS. Taste and smell complaints in HIV-infected patients. AIDS. 1998; 12:1667–1674. [PubMed: 9764787]

59. Landis BN, Lacroix JS. Postoperative / posttraumatic gustatory dysfunction. Adv Otorhinolaryngol. 2006; 63:242–254. [PubMed: 16733342]

60. Doty RL, Bromley SM. Effects of drugs on olfaction and taste. Otolaryngol Clin North Am. 2004; 37:1229. [PubMed: 15563912]

61. Ship JA. Gustatory and olfactory considerations: examination and treatment in general practice. J Am Dent Assoc. 1993; 124:55–62. [PubMed: 8505451]

62. Heckmann JG, Heckmann SM, Lang CJG, Hummel T. Neurological aspects of taste disorders. Arch Neurol. 2003; 60:667–671. [PubMed: 12756129]

63. Hillerup S, Jensen R. Nerve injury caused by mandibular block analgesia. Int J Oral Maxillofac Surg. 2006; 35:437–443. [PubMed: 16343853]

64. Hotta M, Endo S, Tomita H. Taste disturbance in two patients after dental anesthesia by inferior alveolar nerve block. Acta Otolaryngol Suppl. 2002; (Suppl 546):94–98. [PubMed: 12132627]

65. Boucher Y, Berteretche MV, Farhang F, Arvy MP, Azerad J, Faurion A. Taste deficits related to dental deafferentation: an electrogustometric study in humans. Eur J Oral Sci. 2006; 114:456–464. [PubMed: 17184225]

66. Kehlet H, Jensen TS, Woolf CJ. Persistent postsurgical pain: risk factors and prevention. Lancet. 2006; 367:1618–1625. [PubMed: 16698416]

67. Katz J, Seltzer Z. Transition from acute postsurgical pain: risk factors and protective factors. Expert Rev Neurother. 2009; 9:723. [PubMed: 19402781]

68. American Dental Association. Survey of dental services rendered and distribution of dentists in the United States by region and state, 1999. 2002

Table 1

Sociodemographic characteristics and frequency of RDC/TMD-based diagnoses and pain-related psychosocial disability in TMD pain patients

	TMD Group mean (sd) or %
Age in yrs	38.1 (16.0)
Women	78.1
Education	
10 or less yrs of schooling[+]	42.9
11/12 yrs of schooling	36.5
>12 yrs of schooling	16.6
Characteristic pain intensity in 0–100 scale	52.7 (18.4)
Presence of headache[#]	52.8
Axis I diagnoses	
Myofascial pain (Ia)	34.6
Myofascial pain with limited opening (Ib)	26.9
Disc displacement with reduction (IIa)	37.2
Disc displacement without reduction, with limited opening (IIb)	6.0
Disc displacement without reduction, without limited opening (IIc)	4.7
Arthralgia (IIIa)	36.5
Osteoarthritis of the TMJ (IIIb)	3.7
Osteoarthrosis of the TMJ (IIIc)	2.3
Axis II measures	
Graded Chronic Pain Scale	
Grade I	34.6
Grade II	52.5
Grade III	8.6
Grade IV	4.3
Jaw disability	
0–3 limited oral functions[†]	44.9
4–7 limited oral functions	41.2
8–12 limited oral functions	14.0
Depression	
Normal[*]	54.7
Mild to moderate depression	18.1
Severe depression	27.2
Somatisation	
Normal	51.5
Mild to moderate somatisation	26.9
Severe somatisation	21.6

Above noted fields missing data;

[†]N=12,

[#]N=5,

[*]N=36.

[†]Jaw disability score cut-points at 70th and 90th percentiles of a clinic-based TMD study (see Reissmann et al, 2007 for more details)

Table 2

Frequency of taste problems in 301 TMD patients and 2026 general population subjects

	Worsened sense of taste %		Less flavour %		Any taste problem %	
	TMD patients	*general population*	*TMD patients*	*general population*	*TMD patients*	*general population*
never	78	78	67	78	62	70
hardly ever	12	16	22	17	23	20
occasionally	7	5	7	4	10	7
fairly often	2	1	2	1	3	2
very often	2	0.1	2	0.2	3	0.4

Table 3

Prevalence of taste problems in TMD patients according to chronic pain classification (GCPS).

	N [%]	Worsened sense of taste [%]	Less flavour [%]	Any taste problem [%]	Odds ratio
GCPS I	105 (34.9)	1.0	1.9	2.9	Reference
GCPS II	157 (52.2)	3.8	3.2	5.1	1.8 (0.5–7.0)
GCPS III	26 (8.6)	7.7	11.5	11.5	4.4 (0.8–23.4)
GCPS IV	13 (4.3)	15.4	7.7	15.4	6.2 (0.9–41.1)