ACTA ODONTOLOGICA SCANDINAVICA
2023, VOL. 81, NO. 8, 633–640
https://doi.org/10.1080/00016357.2023.2236229

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RESEARCH ARTICLE

Associations between pain-related temporomandibular disorders and dental anxiety at 46 years of age in the Northern Finland Birth Cohort 1966

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ABSTRACT

Objectives: The aims were (1) to study the association between dental anxiety (DA) and temporomandibular disorders (TMDs) and whether subgroups formed differ in psychological symptoms and pain sensitivity in the Northern Finland Birth Cohort 1966 and (2) to confirm the factor structure of the Hopkins Symptom Checklist-25 assessing psychological symptoms.

Materials and methods: Data were acquired using questionnaires and clinical examinations at age 46 years (n = 1889). Dental anxiety was assessed with Modified Dental Anxiety Scale (MDAS). Pain-related TMD (myalgia, arthralgia) were assessed according to modified diagnostic criteria for temporomandibular disorders. Pressure pain threshold and tolerance were measured with an algometer. Explanatory factor analysis revealed three factors, named 'depression', 'anxiety' and 'distress'.

Results: Those with high DA and myalgia and/or arthralgia reported higher depression (mean = 1.52), anxiety (mean = 1.61) and distress (mean = 2.06) scores, and lower pressure pain threshold (mean = 496 kPa) and tolerance (mean = 741 kPa) values than those with only DA (1.22; 1.56; 1.84; 613; 875), TMD (1.21; 1.39; 1.83; 600; 908) or neither (1.12; 1.29; 1.58; 707; 1006), respectively.

Conclusions: Patients with DA and/or myalgia/arthralgia have similar profiles regarding pain sensitivity and psychological symptoms, the burden being highest among those with DA and a TMD diagnosis.

ARTICLE HISTORY
Received 8 February 2023
Revised 7 June 2023
Accepted 8 July 2023

KEYWORDS
Chronic pain; dental fear; myalgia; arthralgia; pain threshold

Introduction

Patients who do not respond to conventional dental treatment, avoid dental treatment or use it only when in pain, can cause challenges for dental professionals. For example, in three British studies conducted in 1988, 2004 and 2019, challenging patients were seen as causes of occupational stress among UK dentists [1–3]. Of patients with temporomandibular disorder (TMD), 10–20% have complex and chronic conditions impairing the treatment response [4,5]. On a population level, 10% of people report high dental anxiety (DA) and are likely to use oral health care service non-habitually [6,7].

Patients with DA and TMD share several common features, and consistent differences between males and females have been reported in the prevalence of both DA and TMD. For example, females report higher levels of DA [6] and TMD [8,9], and both DA and TMD are associated with increased pressure pain sensitivity [10,11] as well as with psychological symptoms and disorders (e.g. general anxiety, depression) [4,12–23]. Elevated pain sensitivity may also predispose dental patients to experience more pain during dental treatment, which may further lead to developing DA.

Both DA and TMD have also been presented to have two etiological background factors, which for DA are called exogenous (such as direct experiences and vicarious learning) and endogenous (internal factors such as temperament and genetics) [24,25]. Regarding TMD, the two factors are high psychological distress (mood, anxiety, depression, somatization, stress response) and high state of pain amplification (impaired pain regulation, autonomic and neuro-endocrine function, pro-inflammatory state) [26]. These factors may act especially in the background of pain-related TMD, such as myalgia and arthralgia [11,25,26].

These background factors of DA and TMD can be seen as somewhat overlapping, suggesting that there may also be overlap between patient groups with either DA or TMD, especially those with severe or treatment resistant forms. However, previous studies on the association between DA and TMD on a population level could not be identified. Thus, the aims were to study (1) whether DA and TMD are associated and (2) whether subgroups formed based on DA and pain-related TMD differ according to psychological symptoms and pain sensitivity in the Northern Finland Birth Cohort 1966 (NFBC1966). An additional aim was also to confirm the

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factor structure of the 25-item version of the Hopkins Symptom Checklist (HSCL-25) used to assess psychological symptoms in the NFBC1966.

Materials and methods

Study population

The study population is part of the NFBC1966 (n = 12,231) [27,28]. The NFBC1966 study began antenatally, and the participants have been followed at 1, 14, 31 and 46 years of age. At the beginning of the follow-ups, the sample included a total of 12,058 live-born children (5890 girls and 6168 boys) [28].

In the follow-up at 46 years of age (years 2012–2014), a total of 10,331 participants with a known address were sent four questionnaires and invited to a clinical examination. Of these 3185 did not participate in the questionnaires or denied the use of their data, and 4499 did not participate in the clinical examination. In total, 7146 (69%) answered the questionnaires, with 5055 answering all four (71%; variation between questionnaires 5643–6834) [28]. In the 46-year follow-up, participants were more often women than men. Participants were also more likely to be married, having children, and employed. A higher SES and higher education also associated with participation [28].

This study used data from the NFBC1966 follow-up at 46 years of age, forming a subpopulation living within 100 km of the city of Oulu who were examined in a field study. This consisted of 3150 alive participants with known addresses, of whom 1899 responded (response rate 60%). Data regarding TMD diagnoses was partially missing from 14 participants. Of these, four had a myalgia diagnosis but data regarding arthralgia were missing. This led to the formation of the subsample, which included a total of 1889 participants (n = 1889).

Data on health and well-being were acquired using questionnaires. Questionnaires inquiring psychological well-being were filled out at home before the clinical examination. Dental anxiety was assessed two hours before the clinical health examination. Oral health examination was performed at the beginning of the clinical health examination. This was followed by pressure pain threshold and tolerance measurements two hours later.

The study followed the principles of the Declaration of Helsinki. The Ethics Committee of the Northern Ostrobothnia Hospital District approved the research (74/2011). Participants' rights have been protected by an appropriate Institutional Review Board. Written informed consent was obtained from all participants [10,27,28].

Dental anxiety

Dental anxiety was assessed using the Modified Dental Anxiety Scale (MDAS), which is a valid (concurrent and discriminant) and reliable five-item instrument for self-rating DA, translated also to Finnish [17–19]. MDAS has shown high internal consistency (Cronbach's alpha = 0.93) and reliability over time (intraclass correlation coefficient = 0.93) [19]. The questions in MDAS are: ('1) 'If you went to your dentist for treatment tomorrow, how would you feel?', ('2) 'If you were sitting in the waiting room (waiting for treatment), how would you feel?', ('3) 'If you were about to have a tooth drilled, how would you feel?', ('4) 'If you were about to have your teeth scaled and polished, how would you feel?' and ('5) 'If you were about to have a local anaesthetic injection in your gum, above an upper back tooth, how would you feel?'.

Each item offered five response options, ranging from 1 (not anxious) to 5 (extremely anxious), with the range for the total sum score being 5–25. The cut-off point for high DA was set at 19 [19]. Participants with MDAS values ≥ 19 were classified as the high DA group. Participants with MDAS values < 19 were classified as low/moderate DA.

Temporomandibular disorders

The assessment of TMD was based on a symptom questionnaire and clinical TMD examination performed using the mDC/TMD (modified diagnostic criteria for temporomandibular disorders), which was presented at an International Association for Dental Research (IADR) conference in 2010 [29,30].

In the mDC/TMD protocol, participants received questionnaires including the following questions (with responses yes/no): 'During the prior 30 days, have you felt pain that was modified by jaw movement, function, para-function or being at rest?', 'Have you had jaw locking in the closed position that restricted maximum mouth opening?', 'Did this restricted opening cause difficulty in mastication?', 'Have you had clicking noises in the TMJ during opening or closing jaw movements or during mastication?' and 'Have you had crepitation in the TMJ during opening or closing jaw movements or during mastication?' [9].

The clinical TMD examination was conducted by five calibrated dentists who were trained by experienced specialized dentists before the examination. The clinical examination included registration of the maximal opening of the mouth without assistance by the examiner, lateral and protrusive movements, and maximal assisted opening of the mouth (jaw actively pushed by the examiner). Participants were also asked if they experienced any familiar pain during any of the movements. Familiar pain was defined as pain similar to that experienced by the participant at the same location during the last 30 days [9].

TMJ noises (clicking, crepitus) during opening, closing, lateral and protrusive movements were registered at a distance of 15 cm. Palpations for familiar pain in the masticatory muscles were conducted bilaterally at the temporalis (anterior, middle, posterior) and masseter (origin, deep, insertion) muscles using a force of 1.0 kg. Palpations for familiar pain in the TMJ region were conducted using a pressure of 1.0 kg around the pole of the TMJ and 0.5 kg at the lateral pole of the TMJ. The forces used during palpations were calibrated using a digital postage scale [9].

TMD diagnoses were divided into five sub-diagnoses based on the mDC/TMD protocol [9]. Of these, the pain-related

diagnoses myalgia and arthralgia were used in the present study. These were defined as follows:

- *Myalgia*: reported pain during the last 30 days in the areas of the face, jaws, temples, ears/behind the ears, pain modified by movement, and familiar pain in the masticatory muscles during jaw movements and/or familiar pain on palpation at previously mentioned muscle palpation sites.
- *Arthralgia*: reported pain in areas of the face, jaws, temples, ears or behind the ears and pain modified by movement during the prior 30 days, and familiar pain in the TMJs during jaw movement and/or pain on palpation (familiar pain) in the right or left TMJ (around the lateral pole or laterally).

Based on DA and TMD diagnoses (dg), the following subgroups were formed: (1) low/moderate DA, no dg: MDAS < 19, no myalgia and/or arthralgia diagnosis, (2) low/moderate DA, yes dg: MDAS < 19, myalgia and/or arthralgia diagnosis, (3) high DA, no dg: MDAS ≥ 19, no myalgia and/or arthralgia and (4) high DA, yes dg: MDAS ≥ 19, myalgia and/or arthralgia diagnosis.

Explanatory variables

Symptoms of anxiety and depression were assessed using HSCL-25 at 46 years, which is a reliable and valid measuring instrument consisting of 25 questions regarding general anxiety and depressive symptoms [31,32]. HSCL-25 has shown varying factor structures across populations and has not yet been confirmed in this population [32–38].

Sex was categorized into male or female based on the sex defined at birth. Pressure pain threshold and pressure pain tolerance were tested using an algometer (Somedic AB, Hörby, Sweden) with a 10 mm contact head, which was applied perpendicularly to the skin to produce pressure pain. The algometer was chosen due to being computer-aided; the data produced did not require conversion. The pressure was increased from 0 kPa at a constant rate of 50 kPa/s. Participants were instructed as follows: 'A pressure will be applied at a gradual rate. Allow the pressure to increase until it reaches a point where it feels uncomfortable and then press the button down. As we continue increasing the pressure, release the button when you cannot tolerate the pressure anymore'. The former pressure value was recorded as the pain threshold and the latter as pain tolerance. Pressure was terminated at the latest when the safety maximum of 1200 kPa was reached.

Standardized pain threshold and pain tolerance measurements were performed at four anatomical sites in the following order: (1) shoulder; mid belly of the upper trapezius muscle (participant in prone position), (2) mid belly of the tibialis anterior muscle (supine position), (3) dorsal aspect of the wrist joint line (supine position) and (4) L5/S1 interspinous space (prone position). The test sites were identified, and the participants were positioned in a standardized manner. The measurements were conducted twice at each site.

Each site was tested only two times, as even though a small piece of soft paper was used between the contact head and the skin to soften the sharp borders of the contact head, the pressure left an imprint in the skin. Thus, adding repetitions was not justified. The exact anatomical point of pressure was shifted slightly between the tests to prevent sensitization of nociceptors at the contact site. The measurements were conducted twice per site before moving on to the next site. The average pressure pain threshold and tolerance of wrist, shoulder, low back and leg were used as pain threshold and pain tolerance scores.

Statistical analyses

To assess the factor structure of HSCL-25, explanatory factor analysis was conducted on the 25 items using maximum-likelihood extraction and Varimax rotation. After that, three confirmatory factor analyses were conducted to compare the factor structures of the original 25-item version (item 'Headache' excluded) [31], of the 23-item version (items "Sleep (difficulty falling asleep or staying asleep)', 'Appetite (poor appetite)' and "Headache' excluded) and of that obtained from the explanatory factor analysis. The 23-item version previously used in this population by Liukkonen et al. [39], but subscales were based on factor analysis.

The fit indices used were normed Chi-square (χ^2/df), normed fit index (NFI), comparative fit index (CFI), root mean square error of approximation (RMSEA) and Akaike information criterion (AIC). Values χ^2/df < 5, CFI > 0.90 and RMSEA < 0.08 indicate reasonably close fit, and values χ^2/df < 2, CFI > 0.95 and RMSEA < 0.05 indicate very close fit. NFI values close to 1 indicate a good fit. Regarding AIC, the lower the value, the better the fit [40,41].

Bivariate associations were evaluated using non-parametric methods according to the distributions of variables. Mann–Whitney's *U*-test and Chi-squared test were used to examine MDAS, TMD diagnoses, and HSCL-25 variables stratified by sex. The associations of MDAS values and TMD diagnoses were examined using crosstabulations and Chi-squared test. The Kruskal–Wallis test was used to examine HSCL-25 variables, pressure pain threshold and pressure pain tolerance in relation to DA/TMD subgroups.

Results

Explanatory factor analysis revealed a three-factor structure with factors named as 'depression', 'anxiety' and 'distress'. The factor structure, factor names, item loadings and common variance explained are presented in Table 1. The item 'headache' did not have a sufficient correlation (r > 0.3) with any of other items and was removed. In addition, the items 'Faintness (faintness, dizziness or weakness)' and 'Appetite (poor appetite)' loaded poorly, and were removed from the three-factor model, which improved the fit. The three-factor model showed the best fit (Table 2), and the factor 'depression' explained the majority of the common variance of the model.

The distributions of DA, TMD diagnoses, and covariates by sex are presented in Table 3. Females had higher prevalence of high DA, myalgia and arthralgia diagnoses, as well as higher scores of psychological symptoms than males.

Table 1. Factor loadings of the Hopkins Symptom Checklist-25 items and percentage of common variance explained by the factors.

Item	Loading
Depression (39.6% of variance explained)	
Hopeless (feeling hopeless about the future)	0.601
Lonely (feeling lonely)	0.534
Effort (feeling everything is an effort)	0.490
Worthlessness (feelings of worthlessness)	0.662
Crying (crying easily)	0.362
Self-blame (blaming oneself for things)	0.610
Blue (feeling blue)	0.660
Interest (feeling no interest in things)	0.586
Suicide (thoughts of ending one's life)	0.461
Anxiety (5.8% of variance explained)	
Scared (being suddenly scared for no reason)	0.644
Terror (spells of terror or panic)	0.586
Restless (feeling restless or can't sit still)	0.679
Trembling (trembling)	0.368
Fearful (feeling fearful)	0.565
Heart (heart pounding or racing)	0.355
Trapped (feeling trapped or caught)	0.446
Distress (5.0% of variance explained)	
Nervousness (nervousness or shakiness inside)	0.493
Tense (feeling tense or keyed up)	0.662
Worrying (worrying too much about things)	0.572
Sex (loss of sexual interest or pleasure)	0.345
Energy (feeling low in energy, slowed down)	0.525
Sleep (difficulty falling asleep or staying asleep)	0.338
Faintness (faintness, dizziness or weakness)	[a]
Appetite (poor appetite)	[a]
Headaches (headaches)	[b]

[a]Poor factor loading, not included in the factor structure.
[b]No correlations observed at level $r > 0.3$, not included in the factor structure.

The association of DA with TMD diagnoses is shown in Table 4. The prevalence of myalgia and arthralgia was approximately two times higher in participants with high DA than in those with low/moderate DA. When stratifying by sex, a similar tendency in females was observed although the associations were not statistically significant.

Subgroups were formed based on DA and TMD diagnoses. Differences between subgroups according to HSCL-25 factors and pain threshold/tolerance are presented in Table 5. Only a small portion of participants had both high DA and a TMD diagnosis ($n = 10$), forming the 'high' subgroup. Participants in the high subgroup had the highest levels of psychological symptoms. When comparing the high subgroup to the intermediate subgroups, the differences in mean values were approximately 20% for depression, 3–13% for anxiety and 11–12% for distress. The mean pressure pain threshold value of the high subgroup was approximately 17–19% lower than that of the intermediate subgroups. The differences in psychological symptoms between the high and low subgroups were approximately 26% for depression, 20% for anxiety and 23% for distress. Those in the high subgroup also had approximately 30% lower mean pressure pain threshold than those in the low subgroup. Figure 1 illustrates how subgroups 'Low/moderate DA, yes dg' and 'High DA, no dg' formed intermediate subgroups according to pain threshold and tolerance, having relatively similar profiles.

Table 2. Fit indices for the three confirmatory factor models on the Hopkins Symptom Checklist-25.

	χ^2	df	p	NFI	CFI	RMSEA	AIC
Derogatis	7314.1	251	<.001	0.897	0.900	0.063	7460.1
Liukkonen	6701.6	208	<.001	0.902	0.904	0.066	6835.6
Three-factor model	5707.0	206	<.001	0.916	0.919	0.061	5845.0

χ^2: Chi-square; df: degrees of freedom; NFI: normed fit index; CFI: comparative fit index; RMSEA: root mean square error of approximation; AIC: Akaike information criterion.
Derogatis: original 25-item model with item "Headache' removed. Liukkonen: revised 23-item model without items "Sleep (difficulty falling asleep or staying asleep)', 'Appetite (poor appetite)' and "Headache' removed. Three-factor model: without items "Headache', 'Faintness (faintness, dizziness or weakness)' and 'Appetite (poor appetite)'.

Table 3. The distribution of dental anxiety, temporomandibular disorder (TMD) diagnoses (dg) and Hopkins Symptom Checklist-25 means.

	Women $n = 1010$	Men $n = 879$	p
MDAS[a] total score, mean/Md (IQR)	10.11/9 (7–12)	8.31/8 (6–10)	<.001[†]
High dental anxiety % (n)	6.9 (70)	1.9 (17)	<.001[†]
TMD diagnoses, % (n)			
Myalgia diagnosis	7.6 (77)	2.3 (20)	<.001[‡]
Arthralgia diagnosis	8.4 (85)	1.9 (17)	<.001[‡]
No dg[b]	90.2 (909)	97.4 (855)	<.001[‡]
Myalgia but no arthralgia[b]	1.4 (14)	0.7 (6)	<.001[‡]
Arthralgia but no myalgia[b]	2.4 (24)	0.5 (4)	<.001[‡]
Both myalgia and arthralgia[b]	6.1 (61)	1.5 (13)	<.001[‡]
No dg[c]	90.0 (909)	97.3 (855)	<.001[‡]
Myalgia or/and arthralgia[c]	10.0 (101)	2.7 (24)	<.001[‡]
Hopkins Symptoms Checklist-25 factors			
Depression	1.35/1.22 (1.00–1.56)	1.31/1.11 (1.00–1.44)	<.001[†]
Anxiety	1.15/1.00 (1.00–1.14)	1.14/1.00 (1.00–1.14)	.001[†]
Distress	1.65/1.50 (1.33–2.00)	1.57/1.50 (1.17–1.83)	<.001[†]

Statistical significance of the differences between men and women was evaluated using Mann–Whitney's U-test[†] and Chi-squared test[‡].
[a]Modified Dental Anxiety Scale.
[b]Participants with myalgia diagnosis, missing arthralgia data excluded (women $n = 3$, men $n = 1$).
[c]Participants with myalgia diagnosis, missing arthralgia data included.

Table 4. Association between categories of dental anxiety (MDAS[a]) and temporomandibular disorder (TMD) diagnoses (dg).

All	*n*	Myalgia	*p*	Arthralgia	*p*	Dg[b]	*p*
High dental anxiety	87	9.2	.077	11.8	.014	11.8	.042
Low/moderate dental anxiety	1812	4.9		5.1		6.2	
Women							
High dental anxiety	70	10.0	.479	11.8	.060	14.5	.204
Low/moderate dental anxiety	944	7.4		5.1		9.5	
Men							
High dental anxiety	17	5.9	.324	0	.571	0	.508
Low/moderate dental anxiety	868	2.2		2.0		2.7	

Statistical significance analysed using Chi-squared test. High dental anxiety: MDAS 19+; low/moderate dental anxiety: MDAS 5-18.
[a]Modified Dental Anxiety Scale.
[b]Both diagnoses (myalgia and arthralgia).

Table 5. Mean and median values of HSCL-25[a] factors and pressure pain threshold and tolerance in dental anxiety (DA)/temporomandibular disorder (TMD) diagnosis (dg) groups[b].

Subgroup	Low		Intermediate				High		
All *n* = 1889	Low/moderate DA, no dg *n* = 1689		Low/moderate DA, yes dg *n* = 115		High DA, no dg *n* = 75		High DA, yes dg *n* = 10		
	Mean	Md (IQR)	Mean	Md (IQR)	Mean	Md (IQR)	Mean	Md (IQR)	*p*
Depression	1.12	1.0 (1.0–1.1)	1.21	1.1 (1.0–1.3)	1.22	1.1 (1.0–1.3)	1.52	1.3 (1.1–1.8)	<.001
Anxiety	1.29	1.1 (1.0–1.4)	1.39	1.2 (1.1–1.6)	1.56	1.4 (1.0–1.9)	1.61	1.6 (1.1–1.9)	<.001
Distress	1.58	1.5 (1.2–1.8)	1.82	1.8 (1.5–2.0)	1.84	1.7 (1.4–2.3)	2.06	2.2 (1.3–2.8)	<.001
Pain threshold	707	680 (532–860)	600	599 (448–683)	613	609 (436–708)	496	419 (391–499)	<.001
Pain tolerance	1,006	1,063 (878–1,181)	908	923 (769–1,074)	875	871 (717–1,056)	741	695 (587–891)	<.001

Statistical significance analysed using non-parametric Kruskal–Wallis test.
[a]Hopkins Symptoms Checklist-25.
[b]Both myalgia and arthralgia included.

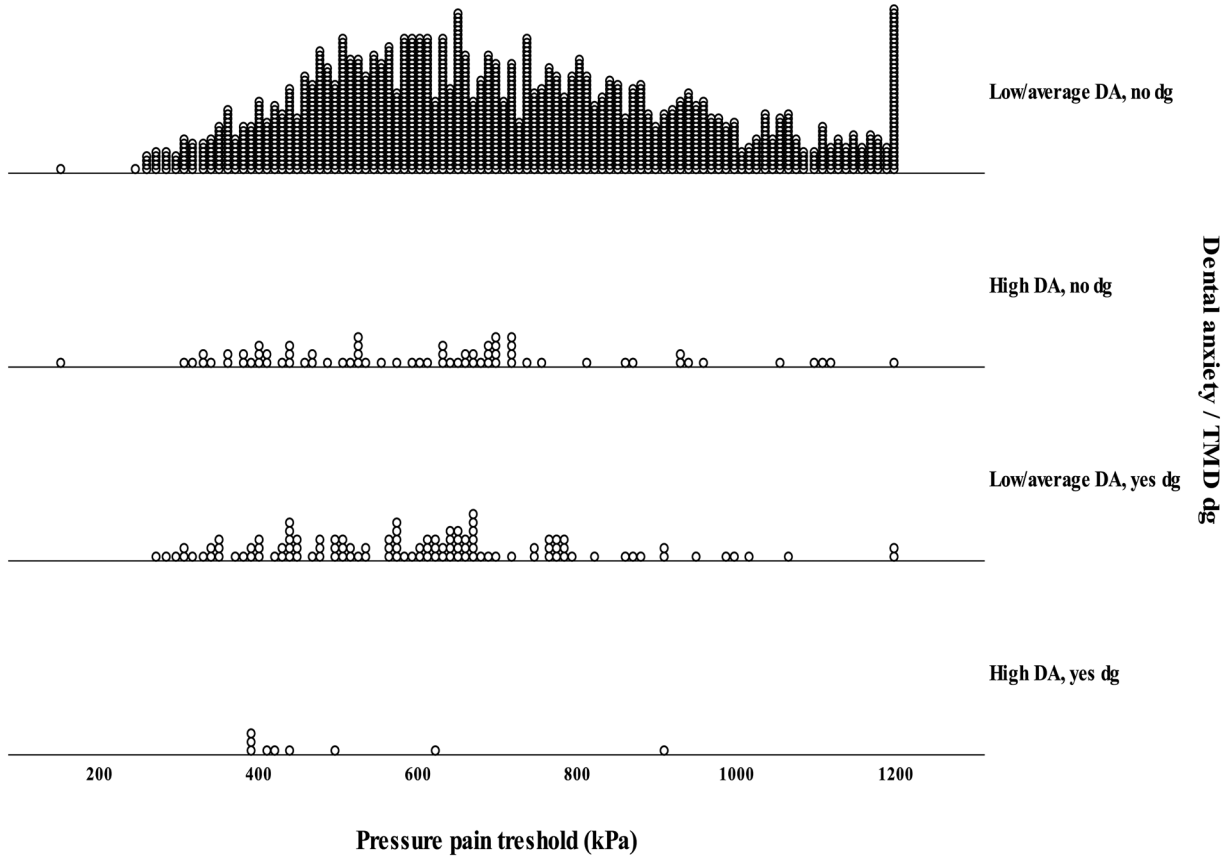

Figure 1. Distribution of pressure pain threshold according to dental anxiety (DA) and temporomandibular disorder (TMD) diagnosis (dg).

In pairwise comparisons (Mann–Whitney's *U*-test) of the groups presented in Table 5, 'Low/moderate DA, no dg' group differed statistically significantly from the 'Low/moderate DA, yes dg' and 'High DA, no dg' groups in all five measurements (all *p* values ≤.001). 'Low/moderate DA, yes dg' and 'High DA, no dg' groups were similar in all measurements (all *p* values

>.05). 'High DA, yes dg' group differed from 'Low/moderate DA, no dg' group in anxiety (p = .001), pain threshold (p = .002) and pain tolerance (p = .001), but not in depression (p = .071). The 'High DA, yes dg' group also differed from the 'Low/moderate DA, yes dg' group in pain tolerance (p = .027), but not in anxiety (p = .053) and pain threshold (p = .065). When comparing the 'High DA, yes dg' group to the 'High DA, no dg' group, all p values were >.05, but a tendency in anxiety (p = .068), pain threshold (p = .071) and pain tolerance (p = .071) was observed.

Discussion

The main finding was that participants with DA and a pain-related TMD diagnosis had similar profiles when examining the pressure pain thresholds and psychological burden within the NFBC1966 population. Psychological symptoms and sensitivity to pressure pain were more prevalent when high DA or a TMD diagnosis was present. The presence of both high DA and a TMD diagnosis also showed a mutual cumulative effect on pain sensitivity and psychological burden. A three-factor structure was found for the HSCL-25.

The groups with only DA or only TMD were similar with regard to pain sensitivity and psychological symptoms. Similarities between the TMD and DA groups are in line with previous studies showing association with psychological burden [12–15,20,21,42–45]. Both DA and TMD were more prevalent in females, who also reported lower pressure pain thresholds than male participants. These findings are also in line with previous studies [4,9–11,20,46]. Additionally, psychological distress is also a known risk factor of TMD and DA [5,14,43], and has been shown to increase sensitivity to painful stimuli [47–49].

Only a small proportion of participants had high DA combined with a pain-related TMD diagnosis, and they showed the highest level of psychological symptoms and the lowest pressure pain threshold and tolerance. This group is of great interest and may for example show a cumulative effect of simultaneous DA and TMD on an individual's distress and sensitivity to pain.

The three-factor HSCL-25 structure uncovered resembled those presented also in previous research [32,34,35]. In previous research, also several other structures have been presented, consisting of one to five factors [31,33,36–38]. It can thus be suggested that factor structure depends very much on the research population in question, and the structure used here was suitable for this population.

The main strength of this study was the large and extensive NFBC1966 dataset. The use of reliable and valid questionnaires is also a strength. Limitations include the small number of participants, leading to small sample size in separate subgroups. Thus, analyses stratified by sex could not be performed. The small group size also affected the pairwise comparisons concerning high DA of the TMD diagnosis group. Possible bias in the sample may also be caused by drop-outs. It has been reported that participants in the clinical examination of the NFBC1966's follow up at 46 years were more often females, employed and from higher social class. They were also more likely married, had children and a higher education [28]. As DA was measured in conjunction with oral examination, those with high DA might have avoided participating the examination. The lower percentage of especially men with high DA in this study (2%) compared to the national survey (4%) supports this [6]. For women, the percentages were 7% vs. 8%, respectively. Thus, the loss in the follow-up at 46 years of age seems more likely for those who experience high DA. The mDC/TMD protocol was used as the modern DC/TMD protocol was not available at the time of the clinical examinations [30]. In this modified version, TMD related headache and referred pain were not included, but these can be seen to be included in the myalgia and arthralgia sub-diagnoses, not limiting the study.

This study sheds new light on a possibly challenging patient group, as at the time of this study no other studies were found on associations between DA and TMD. The novel findings of the study concluded that TMD and DA associate and have similar profiles regarding pain sensitivity and psychological burden. These factors accumulate even more in those having both DA and TMD. It is important to identify patients with DA and/or TMD at an early stage and intervene with treatment as effectively as possible. This may enable to interrupt the processes before further development of TMD and/or developing (high) DA. As individuals with TMD and/or DA are associated with increased sensitivity to pain as well as psychological burden, those individuals may benefit from multi-professional co-operation (e.g. dentists, medical doctors and psychologists).

Acknowledgements

We thank the late professor Paula Rantakallio (launch of NFBC1966), the participants in the 46-year study and the NFBC project center. We would also like to acknowledge the Infrastructure for Population Studies at the Medical Faculty, University of Oulu, and the examiners behind the clinical stomatognathic examinations and pressure pain measurements at the Medical Faculty, University of Oulu.

Disclosure statement

The authors report there are no competing interests to declare.

Funding

NFBC1966 received financial support from University of Oulu under Grant No. 24000692, Oulu University Hospital under Grant No. 24301140 and ERDF European Regional Development Fund under Grant No. 539/2010 A31592.

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References

[1] Meyers HL, Meyers LB. 'It's difficult being a dentist': stress and health in the general dental practitioner. Br Dent J. 2004;197:19–23.

[2] Cooper CL, Watts J, Baglioni AJJr, et al. Occupational stress amongst general practice dentists. J Occup Psychol. 1988;61(2):163–174. doi: 10.1111/j.2044-8325.1988.tb00280.x.
[3] Collin V, Toon M, O'Selmo E, et al. A survey of stress, burnout and well-being in UK dentists. Br Dent J. 2019;226(1):40–49. doi: 10.1038/sj.bdj.2019.6.
[4] Litt MD, Porto FB. Determinants of pain treatment response and nonresponse: identification of TMD patient subgroups. J Pain. 2013;14(11):1502–1513. doi: 10.1016/j.jpain.2013.07.017.
[5] Sipilä K, Mäki P, Laajala A, et al. Association of depressiveness with chronic facial pain: a longitudinal study. Acta Odontol Scand. 2013;71(3–4):644–649. doi: 10.3109/00016357.2012.704067.
[6] Liinavuori A, Tolvanen M, Pohjola V, et al. Changes in dental fear among Finnish adults: a national survey. Community Dent Oral Epidemiol. 2016;44(2):128–134. doi: 10.1111/cdoe.12196.
[7] Liinavuori A, Tolvanen M, Pohjola V, et al. Longitudinal interrelationships between dental fear and dental attendance among adult Finns in 2000–2011. Community Dent Oral Epidemiol. 2019;47(4):309–315. doi: 10.1111/cdoe.12458.
[8] Yekkalam N, Wänman A. Prevalence of signs and symptoms indicative of temporomandibular disorders and headaches in 35-, 50-, 65- and 75-year-olds living in Västerbotten, Sweden. Acta Odontol Scand. 2014;72(6):458–465. doi: 10.3109/00016357.2013.860620.
[9] Jussila P, Kiviahde H, Näpänkangas R, et al. Prevalence of temporomandibular disorders in the Northern Finland Birth Cohort 1966. J Oral Facial Pain Headache. 2017;31(2):159–164. doi: 10.11607/ofph.1773.
[10] Kankaanpää R, Auvinen J, Rantavuori K, et al. Pressure pain sensitivity is associated with dental fear in adults in middle age: findings from the Northern Finland 1966 Birth Cohort Study. Community Dent Oral Epidemiol. 2019;47(3):193–200. doi: 10.1111/cdoe.12443.
[11] Knuutila J, Kivipuro J, Näpänkangas R, et al. Association of temporomandibular disorders with pain sensitivity: a cohort study. Eur J Pain. 2022;26(1):143–153. doi: 10.1002/ejp.1844.
[12] Hägglin C, Hakeberg M, Hällström T, et al. Dental anxiety in relation to mental health and personality factors. A longitudinal study of middle-aged and elderly woman. Eur J Oral Sci. 2001;109(1):27–33. doi: 10.1034/j.1600-0722.2001.00946.x.
[13] Pekkan G, Kilicoglu A, Hatipoglu H. Relationship between dental anxiety, general anxiety level and depression in patients attending a university hospital dental clinic in Turkey. Community Dent Health. 2011;28:149–153.
[14] Tolvanen M, Hagqvist O, Luoto A, et al. Changes over time in adult dental fear and correlation to depression and anxiety: a cohort study of pregnant mothers and fathers. Eur J Oral Sci. 2013;121(3 Pt 2):264–269. doi: 10.1111/eos.12026.
[15] Tellez M, Kinner DG, Heimberg RG, et al. Prevalence and correlates of dental anxiety in patients seeking dental care. Community Dent Oral Epidemiol. 2015;43(2):135–142. doi: 10.1111/cdoe.12132.
[16] Armfield JM, Pohjola V, Joukamaa M, et al. Exploring the associations between somatization, dental fear and dental visiting. Eur J Oral Sci. 2011;119(4):288–293. doi: 10.1111/j.1600-0722.2011.00839.x.
[17] Humphris G, Crawford JR, Hill K, et al. UK population norms for the Modified Dental Anxiety Scale with percentile calculator: adult dental health survey 2009 results. BMC Oral Health. 2013;13(1):29. doi: 10.1186/1472-6831-13-29.
[18] Humphris GM, Freeman R, Campbell J, et al. Further evidence for the reliability and validity of the Modified Dental Anxiety Scale. Int Dent J. 2000;50(6):367–370. doi: 10.1111/j.1875-595X.2000.tb00570.x.
[19] Newton JT, Edwards JC. Psychometric properties of the Modified Dental Anxiety Scale: an independent replication. Community Dent Health. 2005;22:40–42.
[20] Sipilä K, Veijola J, Jokelainen J, et al. Association between symptoms of temporomandibular disorders and depression: an epidemiological study of the Northern Finland 1966 Birth Cohort. Cranio. 2001;19(3):183–187. doi: 10.1080/08869634.2001.11746168.
[21] Suvinen TI, Reade PC, Kemppainen P, et al. Review of aetiological concepts of temporomandibular pain disorders: a biopsychosocial model for integration of physical disorder factors with psychological and psychosocial illness impact factors. Eur J Pain. 2005;9(6):613–613. doi: 10.1016/j.ejpain.2005.01.012.
[22] Bair E, Gaynor S, Slade GD, et al. Identification of clusters of individuals relevant to temporomandibular disorders and other chronic pain conditions: the OPPERA study. Pain. 2016;157(6):1266–1278. doi: 10.1097/j.pain.0000000000000518.
[23] Fillingim RB, Slade GD, Greenspan JD, et al. Long-term changes in biopsychosocial characteristics related to temporomandibular disorder: findings from the OPPERA study. Pain. 2018;159(11):2403–2413. doi: 10.1097/j.pain.0000000000001348.
[24] Weiner AA, Sheehan DV. Etiology of dental anxiety: psychological trauma or CNS chemical imbalance? Gen Dent. 1990;38(1):39–43.
[25] Beaton L, Freeman R, Humphris G. Why are people afraid of the dentist? Observations and explanations. Med Princ Pract. 2014;23(4):295–301. doi: 10.1159/000357223.
[26] Maixner W, Diatchenko L, Dubner R, et al. Orofacial pain prospective evaluation and risk assessment study – the OPPERA study. J Pain. 2011;12(11):T4–T11.e2. doi: 10.1016/j.jpain.2011.08.002.
[27] University of Oulu. Northern Finland Birth Cohort 1966. University of Oulu; 2021 [cited 2021 Jun 5]. Available from: http://urn.fi/urn:nbn:fi:att:bc1e5408-980e-4a62-b899-43bec3755243
[28] Nordström T, Miettunen J, Auvinen J, et al. Cohort profile: 46-years of follow-up of the Northern Finland Birth Cohort 1966 (NFBC1966). Int J Epidemiol. 2022;50(6):1786–1787j. doi: 10.1093/ije/dyab109.
[29] Schiffman E. Diagnostic algorithms for TMJ disorders. Diagnostic criteria for TMD (DC/TMD): a new version of the RDC/TMD. J Dent Res. 2010;89(Spec Iss B):1954.
[30] Schiffman E, Ohrbach R, Truelove E, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Oral Facial Pain Headache. 2014;28(1):6–27. doi: 10.11607/jop.1151.
[31] Derogatis LR, Lipman RS, Rickels K, et al. The Hopkins Symptom Checklist (HSCL): a Self-Report Symptom Inventory. Syst Res. 1974;19(1):1–15. doi: 10.1002/bs.3830190102.
[32] Kuittinen S, Velázquez RG, Castaneda AE, et al. Construct validity of the HSCL-25 and SCL-90-somatization scales among Russian, Somali and Kurdish origin migrants in Finland. Int J Cult Ment. 2017;10(1):1–18. doi: 10.1080/17542863.2016.1244213.
[33] Skogen JC, Øverland S, Smith ORF, et al. The factor structure of the Hopkins symptoms checklist (HSCL-25) in a student population: a cautionary tale. Scand J Public Health. 2017;45(4):357–365. doi: 10.1177/1403494817700287.
[34] Glaesmer H, Braehler E, Grande G, et al. The German version of the Hopkins symptoms checklist-25 (HSCL-25) – factorial structure, psychometric properties, and population-based norms. Compr Psychiatry. 2014;55(2):396–403. doi: 10.1016/j.comppsych.2013.08.020.
[35] Ashaba S, Kakuhikire B, Vořechovská D, et al. Reliability, validity, and factor structure of the Hopkins Symptom Checklist-25: population-based study of persons living with HIV in rural Uganda. AIDS Behav. 2018;22(5):1467–1474. doi: 10.1007/s10461-017-1843-1.
[36] Rodríguez-Barrágan M, Fernández-San-Martín MI, Clavería-Fontán A, et al. Validation and psychometric properties of the Spanish version of the Hopkins Symptom Checklist-25 scale for depression detection in primary care. Int J Environ Res Public Health. 2021;18(15):7843–7858. doi: 10.3390/ijerph18157843.
[37] Nabbe P, Le Reste JY, Guillou-Landreat M, et al. The French version of the HSCL-25 has now been validated for use in primary care. PLOS One. 2019;14(4):e0214804. doi: 10.1371/journal.pone.0214804.
[38] Lundin A, Hallgren M, Forsell Y. The validity of the Symptom Checklist Depression and Anxiety Subscales: a general population study in Sweden. J Affect Disord. 2015;183:247–252. doi: 10.1016/j.jad.2015.05.024.
[39] Liukkonen T, Räsänen P, Jokelainen J, et al. The association between anxiety and C-reactive protein (CRP) levels: results from the

Northern Finland 1966 Birth Cohort Study. Eur Psychiatr. 2011;26(6):363–369. doi: 10.1016/j.eurpsy.2011.02.001.
[40] Kline RB. Principles and practice of structural equation modeling. 2nd ed. New York (NY): Guilford; 2005.
[41] Byrne BM. Structural equation modeling with AMOS: basic concepts, applications, and programming. 1st ed. London: Erlbaum; 2001.
[42] Locker D, Poulton R, Thomson WM. Psychological disorders and dental anxiety in a young adult population. Community Dent Oral Epidemiol. 2001;29(6):456–463. doi: 10.1034/j.1600-0528.2001.290607.x.
[43] Boman UW, Lundgren J, Berggren U, et al. Psychosocial and dental factors in the maintenance of severe dental fear. Swed Dent J. 2010;34:121–127.
[44] Hakeberg M, Hägglin C, Berggren U, et al. Structural relationships of dental anxiety, mood, and general anxiety. Acta Odontol Scand. 2001;59(2):99–103. doi: 10.1080/000163501750157252.
[45] Lahti S, Tolvanen M, Humphris G, et al. Association of depression and anxiety with different aspects of dental anxiety in pregnant mothers and their partners. Community Dent Oral Epidemiol. 2020;48(2):137–142. doi: 10.1111/cdoe.12511.
[46] Bartley EJ, Fillingim RB. Sex differences in pain: a brief review of clinical and experimental findings. Br J Anaesth. 2013;111(1):52–58. doi: 10.1093/bja/aet127.
[47] Maixner W, Fillingim R, Williams D, et al. Overlapping chronic pain conditions: implications for diagnosis and classification. J Pain. 2016;17(9):T93–T107. doi: 10.1016/j.jpain.2016.06.002.
[48] Jussila P, Knuutila J, Salmela S, et al. Association of risk factors with temporomandibular disorders in the Northern Finland Birth Cohort 1966. Acta Odontol Scand. 2018;76(7):525–529. doi: 10.1080/00016357.2018.1479769.
[49] Smith SB, Maixner DW, Greenspan JD, et al. Potential genetic risk factors for chronic TMD: genetic associations from the OPPERA case control study. J Pain. 2011;12(11):T92–T101. doi: 10.1016/j.jpain.2011.08.005.