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TEMPOROMANDIBULAR DISORDERS AND HEADACHE IN ADOLESCENTS

by

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ABSTRACT

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Temporomandibular disorders and headache in adolescents
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The aim of the study were to investigate the occurrence of and changes in signs and symptoms of temporomandibular disorders (TMD) over time in adolescents with and without headache, the association between TMD signs and primary headaches and headache-associated factors, and predictors of TMD signs, as well as familial occurrence of TMD signs.

The studies are based on two large samples of school children in the city of Turku, Southwestern Finland. At the age of 13, the children of the first study (n = 311) were followed for three years. In the second study on 13-year-old children (n = 154) the mothers (n = 154) were also examined to study the occurrence of TMD and headache in two successive generations in a nested case-control setting.

After a thorough questionnaire, a face-to-face interview and somatic and pediatric examination by a paediatrician, the children were divided into primary headache groups and healthy controls according to the IHS criteria (1988). Headache of the mothers was diagnosed by a physician on the bases of a questionnaire. A stomatognathic interview and examination were performed in all children and mothers.

The results revealed a clear female predominance of TMD signs at both prepubertal and pubertal ages. TMD signs and symptoms were mostly mild. Both migraine and episodic tension-type headache were associated with TMD signs. A significant change in TMD signs during a 3-year follow-up was observed. No change was observed in TMD symptoms. Neck-muscle pain was associated with TMD signs at the age of 13. None of the studied factors emerged as predictors for later TMD signs. No familial occurrence of TMD signs could be observed.

The results of the present study indicate that children with primary headache, especially migraine, are probably more prone to pain conditions, including TMD and neck-shoulder pain. It seems that the complex co-occurrence of headache, TMD and neck-shoulder pain at the age of 13 and 16 may be of a temporary or changing nature without permanent structural changes, as yet.

Key words: adolescents, change, children, epidemiology, familial occurrence, headache, migraine, muscle, pain, predictors, temporomandibular disorders, tension-type headache.

TIIVISTELMÄ

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13–16-vuotiaiden purentaelimistön toimintahäiriöt ja päänsärky
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Tutkimuksen tarkoituksena oli selvittää purentaelimistön toimintahäiriöihin (TMD) liittyvien oireiden ja kliinisten löydösten esiintyvyyttä ja muutosta kolmen vuoden seurannan aikana päänsärystä kärsivillä nuorilla ja heidän verrokeillaan, TMD-löydösten yhteyttä eri tyyppisiin päänsärkyihin ja päänsärkyyn liittyviin tekijöihin, TMD-löydöksiä ennustavia tekijöitä sekä perhetaustan osuutta TMD-löydösten esiintyvyyteen.

Tutkimus perustui kahteen laajaan koululaismateriaaliin Turun seudulla. Ensimmäinen 13-vuotiaiden nuorten ryhmä (n = 311) osallistui myös 16-vuotiaana seurantatutkimukseen. Toisen 13-vuotiaiden nuorten ryhmän (n = 154) äidit (n = 154) osallistuivat myös tutkimukseen, jossa selvitettiin tapaus-verrokkiasetelmassa TMD-löydösten ja päänsärkyjen esiintyvyyttä kahdessa sukupolvessa.

Nuoret jaettiin päänsärkyryhmiin ja terveisiin kontrolleihin IHS (1988) päänsärky-kriteerien mukaisesti kyselykaavakkeen ja lääkärin suorittaman haastattelun ja kliinisen tutkimuksen antamien tietojen perusteella. Lääkäri määritteli äitien päänsärkydiagnoosin kyselykaavakkeen tietojen perusteella. Kaikki nuoret ja heidän äitinsä haastateltiin ja heille tehtiin kliininen purentafysiologinen tutkimus sokkoutetusti.

Tutkimuksen tulokset osoittivat, että tytöillä esiintyi TMD-löydöksiä selvästi enemmän kuin pojilla sekä ennen puberteettia että sen jälkeen. Tutkimuksessa havaittiin selkeä yhteys TMD-löydösten ja molempien päänsärkytyyppien, migreenin ja episodisen tensiotyyppisen päänsäryn, välillä. Kolmen vuoden seurannan aikana TMD-löydöksissä havaittiin runsasta muutosta ja iän myötä vähenemistä, mutta TMD-oireiden kohdalla ei vastaavaa muutosta todettu. TMD-löydösten ja niska-hartiaseudun lihaskipujen välillä havaittiin yhteys 13-vuotiailla nuorilla. Mikään päänsärkyyn liittyvistä tekijöistä 13-vuotiailla ei osoittautunut ennustavaksi taustatekijäksi myöhemmille TMD-löydöksille. TMD-löydösten suhteen ei todettu perheyhteyttä.

Päänsäryistä kärsivillä nuorilla on enemmän myös muita kiputiloja, kuten purentaelimistön toimintahäiriöitä ja niska-hartiaseudun kipuja, kuin heidän terveillä verrokeillaan. 13–16 vuoden iässä nämä löydökset ovat valtaosaltaan lieviä ja vaihtelevia.

Avainsanat: epidemiologia, ennustavat tekijät, esiintyvyys perheittäin, kipu, lapset, lihas, migreeni, muutos, nuoret, purentaelimistön toimintahäiriöt, päänsärky, tensiotyyppinen päänsärky.

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ABBREVIATIONS

The following abbreviations appear in the text:

CI	confidence interval
COR	cumulative odds ratio
HA	headache
ICHD	International Classification for Headache Disorders
IHS	International Headache Society
TMD	temporomandibular disorders

1. LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which are referred to in the text by the Roman numerals I to IV.

I Liljeström M-R, Jämsä T, Le Bell Y, Alanen P, Anttila P, Metsähonkala L, Aromaa M, Sillanpää M. Signs and symptoms of temporomandibular disorders in children with different types of headache.
Acta Odontol Scand 2001;59:413-7.

II Liljeström M-R, Le Bell Y, Anttila P, Aromaa M, Jämsä T, Metsähonkala L, Helenius H, Viander S, Jäppilä E, Alanen P, Sillanpää M. Headache children with temporomandibular disorders have several types of pain and other symptoms.
Cephalalgia 2005;25:1054-60.

III Liljeström M-R, Aromaa M, Le Bell Y, Jämsä T, Helenius H, Virtanen R, Anttila P, Metsähonkala L, Rautava P, Alanen P, Sillanpää M. Familial occurrence of signs of temporomandibular disorders in headache children and their mothers.
Acta Odontol Scand 2007;65(3):134-40.

IV Liljeström M-R, Le Bell Y, Laimi K, Anttila P, Aromaa M, Jämsä T, Metsähonkala L, Vahlberg T, Viander S, Alanen P, Sillanpää M. Are signs of temporomandibular disorders stable and predictable in adolescents with headache?
Submitted.

2. INTRODUCTION

Temporomandibular disorders (TMD) is defined as a cluster of signs and symptoms involving the masticatory muscles, the temporomandibular joints and associated structures, or both. In adults, signs and symptoms of TMD frequently occur. In the few available population-based follow-up studies in children and adolescents, both signs and symptoms of TMD have been shown to be mild, and seldom progress to severe pain. On the other hand, headache is a common pain symptom and an important public health problem (Leonardi et al. 1998, Stovner et al. 2007). Most people suffer from headache during some phase of their lives. Headache also occurs frequently among children, although its reported prevalence varies greatly depending on the criteria and the classification used, and on the age of the children (Aromaa, thesis 1999).

Several studies in adults have shown a strong association between TMD and headache (Magnusson & Carlsson 1978, Schocker et al. 1990), and a reduction of headache has been reported after treatment of TMD (Magnusson & Carlsson 1983, Forssell et al. 1985, Lamey & Barclay 1987, Karppinen et al. 1999, Ekberg et al. 2002, Wahlund et al. 2003). In adults, an association is usually considered to exist between TMD and tension-type headache (Forssell & Kangasniemi 1984b, Molina et al. 1997), but also migraine patients suffer from TMD (Forssell & Kangasniemi 1984a, Steele et al. 1991).

Studies in children and adolescents have shown that subjects with TMD report concomitant headache, which seems to be one of the most common symptoms of TMD also in children. However, in most of these studies the frequency and type of headache have not been addressed specifically. The co-occurrence of childhood headache with neck, shoulder, back and stomach pains has also been observed, and it seems that different pains aggregate in the same children, and in the same families (Aromaa et al. 2000).

Both TMD and headache are more common in women, especially those around 35 to 40 years of age, than in men (Steward & Lipton 1993, Kuttila et al. 1998). Mothers' headache has been found to be a predictor of headache in preschool children (Aromaa et al. 1998b). Migraine studies from the early 1950's revealed that there is a strong family history of migraine (Vahlquist 1955). Twin studies have shown evidence of genetic inheritance of migraine (Honkasalo et al. 1993, 1995, Ziegler et al. 1998, Svensson et al. 1999, Mulder et al. 2003). Unlike in headache, the family history of TMD is unclear, and there are only a few studies suggesting that relatives of TMD patients are not at higher risk of TMD or other musculoskeletal conditions than the relatives of controls (Raphael et al. 1999, Michalowicz et al. 2000, List et al. 2001).

Longitudinal studies trying to find predictors of TMD have shown that several factors related to TMD and occlusion may have an influence on later TMD problems. Tooth wear, TMJ clicking, bruxism, oral parafunctions, deep bite, open bite, overjet, mesial and distal molar occlusion, and occlusal interferences, were all found to predict later TMD (Carlsson et al. 2002, Pahkala et al. 2002). On the other hand, depressive symptoms, sleeping difficulties and neck pain have been shown to be predictors of headache (Aromaa et al. 1998b, Laimi et al. 2007b).

The co-occurrence of TMD, headache and neck pain may suggest a common pathogenesis, a causal association, or a common confounding factor. Because pain and dysfunction in the head, jaw and neck region are frequently reported not only in adults, but also in children and adolescents, there is a need to understand the association between these pains, and the factors behind the processes contributing to the development of chronic pain disorders.

3. REVIEW OF THE LITERATURE

3.1 Temporomandibular disorders (TMD)

3.1.1 Definition of TMD

TMD is generally defined as pain which is usually localized in the muscles of mastication, the preauricular area, and/or the temporomandibular joint (TMJ) (The American Academy of Orofacial Pain). TMD pain is usually aggravated by chewing or other jaw function. In addition to complaints of pain, patients with these disorders frequently have limited or asymmetric mandibular movement and TMJ sounds (Okeson (ed) 1996). The International Headache Society introduced the term oromandibular dysfunction (OMD) to show the connection between temporomandibular disturbances and tension-type headache (1988). Several earlier terms have been used for temporomandibular disorders, such as Costen’s syndrome (Costen 1934), Temporomandibular joint pain-dysfunction syndrome (Schwartz 1956), Myofascial pain dysfunction syndrome (Laskin 1969), TMJ dysfunction syndrome (Farrar 1972), Mandibular dysfunction (Helkimo 1974, Agerberg & Carlsson 1975), and Temporomandibular pain-dysfunction syndrome (Merskey 1986). The term Craniomandibular disorders (CMD) is still commonly used for TMD (McNeil et al. 1980).

During the last decade, the term Temporomandibular disorders (TMD) has been in general use, and can be defined as a cluster of symptoms and signs involving the masticatory muscles, the temporomandibular joints and associated structures, or both (McNeil 1993). It includes spontaneous pain in the area of the ear, the temporomandibular joint, or the musculature of mastication, limitations in the range of movement, and clicking and popping sounds in the temporomandibular joints during jaw function. Pain is often elicited by mandibular function or palpation of the muscles involved in chewing, and pain is the most common reason for patients to seek help.

3.1.2 Diagnosis and diagnostic systems of TMD

For the diagnosis of TMD, the patient must report subjective symptoms of pain and/or dysfunction, and clinical signs of TMD must be detected at clinical examination. Because TMD comprises a variety of musculoskeletal problems, ideal and standardized diagnostic criteria are difficult to develop.

A variety of different diagnostic systems has been introduced during recent decades (Table 1). Many studies have reported TMD signs and symptoms separately. Helkimo’s indices were the first to be developed mainly for epidemiological purposes (Helkimo 1974). The Helkimo Anamnestic Index (A_i) includes degree of subjective symptoms of TMD (A_i0 = no symptoms, A_iI = mild symptoms, A_iII = severe symptoms). The mild symptoms reflect joint sounds and feeling of stiffness or fatigue of the jaw. The Helkimo Clinical Dysfunction Index (D_i) includes degree of clinical signs of TMD (D_i0 = no signs, D_iI = mild dysfunction, D_iII = moderate dysfunction, D_iIII = severe dysfunction) based on an impaired range of movement and pain on movement of the mandible, impaired function of temporomandibular joints (TMJs), and pain of TMJs, as well as pain in the masticatory muscles. The diagnosis is based on the severity of the findings, and it is characterized numerically.

Table 1. Diagnostic systems of TMD.

Diagnostic system	Year	Descriptive data
Farrar	1972	Emphasis on internal derangements of the TMJ
Helkimo	1974	Anamnestic Index (Ai) and Clinical Dysfunction Index (Di)
Block	1980	Pain and dysfunction based on neurological and orthopaedic models
Eversole and Machado	1985	Differentiation of myogenic and anthrogenous pain
Bell	1986	Differentiation of masticatory pain, restriction of mandibular movements, articular interferences and acute malocclusion
Wänman and Agerberg	1986a	Accumulated Anamnestic Index (AAi) measures symptoms including recurrent headache
Friction and Schiffman	1986	Craniomandibular Index (CMI) comprises the Dysfunction Index (DI) reflecting TMJ tenderness and functional problems, and The Palpation Index (PI) reflecting muscle tenderness. The Symptom Severity Index (SSI) measures the degree of symptoms
Fricton et al.	1988	Biopsychosocial model for chronic pain
American Academy of Craniomandibular Disorders	1990	Differentiation of myogenic and arthrogenous TMD
Truelove et al.	1992	Differentiation of muscle pain disorders. Permits multiple diagnosis
Dworkin and LeResche	1992	Research Diagnostic Criteria (RDC) for TMD. Axis I measures the clinical condition of TMD. Axis II measures pain intensity, disability, depression and non-specific symptoms

Wänman and Agerberg (1986a) introduced the Accumulated Anamnestic Index (AA_i) including seven symptoms and recurrent headache (AAI_0 = no symptoms, AAI_1 = one reported symptom, AAI_2 = 2–3 reported symptoms, AAI_3 = 4 or more reported symptoms). The diagnosis is based on the number of symptoms. With these criteria a gender difference in children could be observed earlier than with Helkimo's Anamnestic Index. This probably reflected the female predominance in headache observed in children already at a young age.

Dworkin and LeResche (1992) published the Research Diagnostic Criteria (RDC) for TMD for epidemiological and clinical research purposes. Axis I measures the clinical condition of TMD based on a multiple diagnosis of masticatory muscles and TMJs. Axis II measures pain intensity and disability, depression and non-specific physical symptoms, and the extent to which TMD interferes with normal jaw function. Nowadays, RDC/TMD has been largely adopted and is used at least for research purposes. All the earlier diagnostic systems have been created and used for adults. No special diagnostic system has been developed specifically for children. However, the RDC/TMD system has lately been evaluated and validated in Swedish samples of children (Wahlund et al. 1998).

3.1.3 Prevalence and fluctuation of TMD in children

Signs and symptoms of TMD in children can appear already at preschool age (De Vis et al. 1984, Widmalm et al. 1995, Bonjardim et al. 2003, Farsi 2003). On the whole, signs and symptoms of TMD in children are usually mild, and have a tendency to fluctuate considerably, and to some extent seem to increase with age (Heikinheimo et al. 1989, Magnusson et al. 1994, 2005, Könönen et al. 1996, Wänman 1996, Egermark et al. 2001). The prevalence figures for signs and symptoms of TMD in children vary greatly in different studies. This variation is probably caused by differences in population sampling, examination methods, choice of variables measured and diagnostic criteria. Some special problems may arise with children compared to adults. The feeling of pressure or discomfort can be reported as pain. The cognitive developmental stage of the child reflects his or her understanding of pain (McGranth & McAlpine 1993, Thomas et al. 1997). Schechter et al. (1993) postulates that a child’s perception of pain is not similar to that of adults before the age of 12 years, when the child has developed the ability to think abstractly. The difficulty may exist especially in differentiating mild symptoms from a normal condition during an examination. The level of maturity of the child affects his or her ability to understand the questions and to cooperate in the examination. Children can also have an intuitive desire to please and often answer according to what they believe are the adult’s expectations.

3.1.3.1 Clinical signs of TMD

The prevalence figures of clinical signs of TMD in cross-sectional and longitudinal studies on children and adolescents have been reported to be between 28% and 77%. Tenderness upon palpation of the masticatory muscles seems to be the most common sign of TMD in many of the studies (Nilner 1981, Nilner & Lassing 1981, Wänman & Agerberg 1986b,d, Heikinheimo et al. 1990, Mohlin et al. 1991, Magnusson et al. 1994, 2005, Farsi 2003, Bonjardim et al. 2005). TMJ sounds and impaired function of the mandible are also common findings (Könönen et al. 1993, 1996).

In a 2-year follow-up study by Wänman and Agerberg (1986b,d), the prevalence of clinical signs measured by the Helkimo Clinical Dysfunction Index (D_i) was 32–47% (DiI-mild), 6–20% (DiII-moderate), and 0–2% (DiIII-severe) at the age 17 to 19. With three examinations during the follow-up, the prevalence figures according to the clinical dysfunction index for signs of TMD remained unchanged in half of the cases during the subsequent years, but considerable fluctuation occurred in TMD signs. The most common sign was muscle pain (prevalence 6–26%) followed by TMJ sounds (12–26%), and impaired function of the mandible (0–9%).

Masticatory muscle tenderness to palpation was reported by 26% of 12-year-olds and by 31% of 15-year-olds in a 3-year follow-up study by Heikinheimo and co-workers (1990). The prevalence of TMJ clicking remained constant at 6% during the subsequent years. However, substantial fluctuation occurred in the signs during the follow-up.

The prevalence of recorded TMJ clicking increased with age at every examination, from 11% at the age of 14 to 34% at the age of 23 in a 9-year follow-up study of 14-year-old children by Könönen and co-workers (1996). A considerable fluctuation was observed in TMJ clicking during the subsequent years in four different examinations, and none of the subjects developed locking during the follow-up.

Also in a 10-year follow-up study by Magnusson and co-workers (1994) on 15-year-old adolescents (n = 84), considerable fluctuation of signs was observed, but no significant change in any separate sign or the Helkimo Clinical Dysfunction Index was noted during the subsequent years at three different examinations. Neither did any subject have severe signs of dysfunction. Muscle pain on palpation was the most common sign during the whole follow-up period, with a prevalence of about 50% at the last examination. TMJ clicking (prevalence of 7–22%) was common, but no subject developed locking of the joints during the 10 years.

At the 20-year follow-up of the same subjects (n = 100), the authors concluded that the clinical signs still fluctuated considerably (Magnusson et al. 2005). The clinical signs of TMD increased during the first five years in the 7- and 11-year age groups, but remained unchanged during the first 10 years in the 15-year age group. Between the ages of 25 and 35 a reduction was observed in the clinical index. Among the occlusal factors, lateral forced bite between RCP and ICP was strongly correlated with TMJ clicking, other TMD symptoms and treatment need for TMD. A correlation was observed between crossbite and TMJ-related problems.

3.1.3.1.1 Assessment of the clinical signs of TMD and examiner variation

There seems to be general agreement that measuring the clinical signs of TMD can be affected by uncertainty and inaccuracy. Especially the non-parametric variables (e.g. the number of tender sites on palpation of the masticatory muscles) have shown more intra- and inter-examiner variation than the parametric variables (e.g. maximal mouth opening capacity) (Kopp & Wenneberg 1983, Wahlund et al. 1998). However, an acceptable or good reliability, or reproducibility, can be achieved even in manual palpation of the masticatory muscles after training and calibration of the examiners (Carlsson et al. 1980, Kopp & Wenneberg 1983, Duinkerke et al. 1986, Dworkin et al. 1990, Goulet et al. 1998, John & Zwijnenburg 2001). Pressure pain threshold measurements of muscle pain in the masticatory system have been shown to have good reliability and validity (Reeves et al. 1986, List and Helkimo 1987, List et al.

1989, Wahlund et al. 1998). A high correlation was observed between the manual palpation technique and pressure pain threshold measurements (List et al. 1989, Wahlund et al. 1998). TMJ clicking has been shown to cause most problems in achieving good consistency, which may be due to the variability in the sounds itself (Dworkin et al. 1990, Goulet & Clark 1990, John & Zwijnenburg 2001).

In some studies, the intra-examiner reliability was more easily achieved than agreement between examiners (Carlsson et al. 1980), while in other studies there were no differences between intra- and inter-examiner reliability (Duinkerke et al. 1986). The best consistency is achieved when the subjects are examined on the same day, because signs of TMD fluctuate considerably (Kopp & Wenneberg 1983, John & Zwijnenburg 2001). According to the guidelines of the Research Diagnostic Criteria (RDC/TMD) (Dworkin & LeResche 1992), palpation should be carried out with a pressure equivalent to 0.91 kg, at the most, for the extraoral muscles, and 0.45 kg for the inraoral muscles and joints.

3.1.3.2 Subjective symptoms of TMD

Different subjective symptoms of TMD have been reported with prevalence figures between 6% and 84% in cross-sectional and longitudinal studies on children and adolescents. Headache and TMJ clicking have been the most prominent symptoms in many studies with frequencies of 6–29% (Nilner 1981, Nilner & Lassing 1981, Wänman & Agerberg 1986a,c, Mohlin et al. 1991, Könönen et al. 1993, Magnusson et al. 1993, 1996, Egermark et al. 2001, Bonjardim et al. 2005). Bruxism has been reported in 15–37% and seems to increase with age, while other parafunctional habits, such as biting of nails, lips, cheeks and tongue, seem to decrease with age.

In a cross-sectional study on 12- to 18-year-old children and adolescents (n = 862) by List and co-workers (1999), TMD-related myofascial pain based on RDC/TMD classification was reported with a prevalence figure of 7%. Pain prevalence seemed to be higher in older children. TMJ sounds were reported by 11% of the subjects, and the prevalence increased when pain was present. In the study by Nilsson and co-workers (2005, 2007), the prevalence of TMD-related pain among 12–19-year-old children and adolescents (n = 28 899) was 4%. Both prevalence and incidence seemed to be higher in older adolescents compared to the younger. A fluctuating pattern of TMD pain was seen over a three year follow-up.

The prevalence of subjective symptoms at the age of 17 (n = 285) to 19 years (n = 258) were 9–27% (mild) and 0–12% (severe) in the two-year follow-up study by Wänman and Agerberg (1986a,c). The prevalence figures remained the same during the subsequent years, but within the index groups there was a considerable change in subjects, reflecting fluctuation of TMD symptoms.

In a three-year follow-up study by Heikinheimo and co-workers (1989) on 12-year-old children (n = 167), occasional symptoms of TMD were quite common and reported by 64–67% of the children. The prevalence of single recurrent symptoms varied between 0 and 7% and remained quite constant during the subsequent years, although substantial fluctuation in the symptoms occurred within individuals. Half of those who experienced TMJ clicking, ear symptoms or bruxism at the beginning no longer had this symptom by the end of the follow-up.

The prevalence figures for TMD pain symptoms ranged between 6 and 12%, and for dysfunctional symptoms between 12 and 28% in an 8-year follow-up study including three examinations by Suvinen and co-workers (2004) on 15-year-old adolescents (n = 128).

In a 9-year follow-up study of 14-year-old children (n = 128) by Könönen and co-workers (1996), the prevalence of reported TMJ clicking increased with age at every examination, from 11% at the age of 14 to 31% at the age of 23. The fluctuation showed no pattern and no subject developed locking.

Jaw pain or fatigue during mastication was the symptom most frequently reported with prevalences of 3–11% (frequent) and 33–56% (occasional), but it increased only up to the age of 11 in a 10-year follow-up study with three examinations on children and adolescents (n = 293) by Magnusson and co-workers (1993). TMJ sounds with a prevalence of 0–12% (frequent), 6–22% (occasional), and tooth clenching and bruxism with a prevalence of 1–13% (frequent), 10–38% (occasional) increased during the follow-up. Fluctuation of TMJ sounds was reported during the subsequent years.

Ten years later, in their 20-year follow-up study with four examination points (n = 320), the authors concluded that symptoms of TMD fluctuated considerably over the years (Magnusson et al. 2005), but seldom progressed to severe pain and dysfunction. On the other hand, spontaneous recovery from more pronounced symptoms was also rare. At the last examination, the prevalence figure for one or more frequent TMD symptoms was 13%, while 33% reported occasional symptoms. The laterally forced bite between RCP and ICP correlated significantly with symptoms of TMD. The overall symptoms of TMD increased during the first 10 years in all three age groups (7, 11 and 15 years), but no further increase was observed after that in any age group. At the last examination, frequent or occasional oral parafunctions were reported by over half of the subjects, and 16% reported bruxism. A correlation was found between tooth-clenching and tooth-grinding and TMD symptoms, including headache.

On the other hand, Wänman (1996) observed an increase in TMD symptoms during a 10-year follow-up of 17-year-old adolescents to adulthood. Of children who had received orthodontic treatment, a tendency towards less frequent TMD symptoms than in the control group was observed, but the difference between the groups did not reach a significant level (Egermark et al. 2003).

3.1.4 Gender

There are studies that report signs and symptoms of TMD in equal frequencies in girls and boys (Nilner & Kopp 1983, Magnusson et al. 1985, Wänman & Agerberg 1986a,b,c,d, Könönen et al. 1987, List et al. 1999, Bonjardim et al. 2005). This seems to be the case especially in younger children. After puberty, the gender difference in

TMD signs and symptoms starts to appear more and more clearly with age (Wänman & Agerberg 1986a,b,c,d, Magnusson et al. 1993, 1994, 2000, 2005, Wänman 1996, Conti et al. 1996, List et al. 1999, Egermark et al. 2001, Pahkala et al. 2002, Suvinen et al. 2004).

No gender difference was observed in the study by Nilner and Kopp (1983) on children and adolescents of 7–18 years of age (n = 749). In the study on 14-year-old children by Könönen and co-workers (1987) no gender difference was observed in TMD signs or symptoms or in the Helkimo Clinical Dysfunction Index. Also in a cross-sectional study on 12- to 18-year-old children and adolescents (average 13 years) by Bonjardim and co-workers (2005) no gender difference was observed in TMD symptoms or TMD signs evaluated with the CranioMandibular Index (CMI), except for tenderness to palpation in the lateral pterygoid muscle, which was significantly higher in girls. The authors were sceptical about this finding due to the well known difficulties in diagnosing tenderness in this muscle.

TMD-related myofascial pain based on RDC/TMD classification, headache, pain in temples, as well as pain on chewing and opening the jaw wide, were reported significantly more often in girls than in boys in a cross-sectional study on 12–18-year-old children and adolescents by List and co-workers (1999). No gender differences were seen in TMD-related symptoms, disc displacement, arthralgia, arthritis or arthroses. However, TMD-related pain was more common in 12–19-year-old girls in the study by Nilsson et al. (2005).

In the studies by Wänman and Agerberg (1986a,b,c,d), a gender difference was observed in some of the subjective symptoms (TMJ sounds and pain in the face or jaw at the age of 19, tiredness of the jaw at the age of 17 and 18, and locking at the age of 18), while for most of the symptoms (difficulties in chewing or opening the mouth, pain on movement), there was no difference between boys and girls. Girls more often reported parafunctions related to stress. Of the clinical signs of TMD, girls more often reported muscle tenderness upon palpation at the age of 17 and 18, but no gender difference was observed in mandibular mobility or TMJ pain.

Female predominance was observed in symptoms of TMD (TMJ sounds, locking of the jaw and difficulties in jaw opening), and in signs of TMD (TMJ sound and muscle tenderness upon palpation), while men showed more occlusal wear in the canine and premolar region, as well as maximal opening capacity, in the 10-year follow-up studies conducted by Magnusson and co-workers (1993, 1994). The same female predominance was observed ten years later in the 20-year follow-up (Magnusson et al. 2005).

3.2 TMD and concomitant pains and psychiatric disorders or symptoms

There are only a few studies on children showing the association between overall TMD or signs and symptoms of TMD and multiple pain symptoms (List et al. 2001, Wahlund et al. 2005) and psychiatric symptoms (List et al. 2001, Suvinen et al. 2004).

In the study by List and co-workers (2001), adolescents with TMD had pain in the back, arms and legs more frequently than adolescents in the control group (average 15 years, range 12–18, n = 127). No significant difference between the groups was observed in abdominal pain. Adolescents with TMD also had higher levels of total stress, fatigue, somatic complaints, aggressive behaviour, and internalizing and externalizing syndromes than the control group. No difference between the groups was observed in sleeping difficulties. In this study, overall pain and psychiatric complaints were measured by a questionnaire, and the Youth Self-Report (YSR) (Achenbach 1991) was used to measure emotional and behavioural problems.

Significantly greater sensitivity to positive and negative somatic stimuli was observed in these same TMD patients compared to healthy controls in the report by Wahlund and co-workers (2005). On the other hand, the difference was not significant in emotional positive or negative stimuli. Pressure pain threshold measurements in the masticatory area (temporal and masseter muscles, and TMJs) also showed significantly lower scores for TMD patients compared to healthy controls. The authors concluded that adolescents suffering from TMD pain seem to be more sensitive and more somatically focused than their healthy controls.

In an 8-year follow-up study on adolescents, a correlation between psychosomatic symptoms and TMD pain, or a combination of TMD pain and dysfunction symptoms, was reported (Suvinen et al. 2004). The prevalence of psychosomatic symptoms was 7–11%.

On the whole, pain is a common complaint of children and adolescents, and it has a high impact on daily activities and quality of life. The behavioural consequences of long-lasting pain may be higher rates of absence from school and of medication consumption.

3.3 Predictors of TMD

In order to find preventive measures and avoid long-lasting pain symptoms, researchers have tried to find predicting factors or risk factors for TMD in longitudinal studies. In a 20-year follow-up study by Carlsson and co-workers (2002), tooth wear and nocturnal bruxism were the strongest predictors of reported TMJ clicking 20 years later. Most of the subjects with parafunctional habits reported consistent bruxism during the follow-up period. Clinically reported TMJ clicking was a predictor of TMJ clicking 20 years later, while reported TMJ clicking at the start was a significant predictor of other TMD symptoms 20 years later. Deep bite, bruxism and other oral parafunctions and clinical TMJ clicking were found to be predictors of later TMD signs. In an 8-year follow-up study by Pahkala and co-workers (2002), lateral open bite at the age of seven and tendency to anterior open bite at the age of 10 were risk factors for palpatory tenderness of the masticatory muscles at the age of 15. Those children who had palpatory tenderness of TMJ at the age of 10 were at risk of clicking at the age of 15. Children with inaccuracy in oral motor skills at the ages of seven and 15 years were at risk of limited jaw movements later. However, the predictive value of signs or symptoms of TMD in these two studies was considered to be poor for manifest or severe later TMD.

3.4 TMD in families

Unlike in the case of headache, recent studies have shown no evidence of a family history or inheritance of TMD. In the study by Raphael and co-workers (1999), 164 adult female myofascial TMD patients, their 174 demographically-matched controls and first-degree relatives (parents, siblings, children, (n = 106 + 118) were interviewed by phone. The results suggested that relatives of TMD patients are not at higher risk of symptoms of TMD or other musculoskeletal pain conditions. In the study by Michalowicz and co-workers (2000), twin pairs (48 monozygous reared apart, 98 monozygous reared together, 35 bizygous reared apart, and 61 bizygous reared together) were interviewed and examined, and no genetic transmittance of signs and symptoms of TMD could be observed. The results also indicated that environmental components do not influence familial occurrence of signs and symptoms of TMD; nor does such an influence persist into adulthood. In another twin study with monozygotic and bizygotic twins, no genetic transmittance was observed (Heiberg et al. 1980). In the study by List and co-workers (2001), among 12- to 18-year-old children, no difference was found between the answers of those with diagnosed TMD and those without TMD, when asked about TMD-related pain experience of their parents. On the other hand, there are studies which indicate that familial occurrence of TMD might exist. In an uncontrolled study, 55% of daughters from painful mother/daughter pairs reported TMD symptoms (Hartrick et al. 1986). In another study, symptomatic patients with MRI-determined anterior disc displacement were twice as likely as healthy controls to report TMD in their families (Morrow et al. 1996). Researchers have doubted "family history" studies where subjects with a specific disorder have been asked about the occurrence of that disorder in their relatives because patients are unlikely to know all the intimate medical histories of their relatives and most likely underestimation occurs (Chapman et al. 1994). If instead, the answers of the sick individuals are compared to the answers of healthy individuals, overestimation is most likely to occur, because healthy individuals are even less likely than sick individuals to identify illness in their relatives. Thus, interviewing the relatives directly, the "family study" method, is likely to be more biased.

3.5 Definition and classification of headache

The definition of headache has varied greatly over the decades. Because headache is a subjective symptom and there are no reliable tests available to confirm it, defining the occurrence of headache will remain problematic. Many patients may also have co-existing different headaches. Several earlier headache classifications have been published based on the location of pain, symptom description, or pathophysiology (Ad Hoc Committee 1962, Rothner 1984, Diamond and Dalessio 1986). Of the different earlier criteria for migraine, probably the most widely used has been the criteria by Vahlquist (1955).

In order to set a uniform formula for clinical headache research, The Committee of the International Headache Society (IHS 1988) has formulated classification and diagnostic criteria for headache disorders, cranial neuralgias, and facial pain (Table 2). The diagnostic criteria for migraine are presented in Table 3, and for tension-type headache in Table 4.

Table 2. Headache classification of the International Headache Society (IHS 1988).

1.	Migraine
2.	Tension-type headache
3.	Cluster headache and chronic paroxymal headache
4.	Miscellaneous headaches unassociated with structural lesion
5.	Headache associated with head trauma
6.	Headache associated with vascular disorders
7.	Headache associated with non-vascular intracranial disorder
8.	Headache associated with substances or their withdrawal
9.	Headache associated with non-cephalic infection
10.	Headache associated with metabolic disorder
11.	Headache or facial pain associated with disorder of cranium, neck, eyes, ears, nose, sinuses, teeth, mouth or other facial or cranial structures
12.	Cranial neuralgias, nerve trunk pain and deafferentation pain
13.	Headache not classifiable

Table 3. Diagnostic criteria for migraine of The International Headache Society (IHS 1988).

1. Migraine

1.1 Migraine without aura
- a) At least 5 attacks fulfilling b–d
- b) Headache attacks, lasting 2–48 hours
- c) Headache has at least 2 of the following characteristics:
  1. Unilateral location
  2. Pulsating quality
  3. Moderate or severe intensity
  4. Aggrevation by routine physical activity
- d) During headache at least one of the following:
  1. Nausea and/or vomiting
  2. Photophobia and phonophobia
- e) At least one of the following:
  1. History, physical and neurological examination do not suggest organic disorders

2. History, physical and/or neurological examination do suggest such a disorder but it is ruled out by appropriate investigations
3. Such a disorder is present, but migraine attacks do not occur for the first time in close temporal relation to the disorder

1.2 Migraine with aura
- a) At least 2 attacks fulfilling b
- b) At least 3 of the following 4 characteristis:
  1. One or more fully reversible aura symptoms indicating focal cerebral cortical and/or brain stem dysfunction
  2. At least one aura symptom develops gradually over more than 4 minutes, or 2 or more aura symptoms occur in succession
  3. No aura symptom lasts more than 60 minutes. If more than one aura symptom is present, accepted duration is proportionally increased
  4. Headache follows aura with a free interval of less than 60 minutes
- c) At least one of the following:
  1. History, physical and neurological examination do not suggest organic disorders
  2. History, physical and/or neurological examination do suggest such a disorder but it is ruled out by appropriate investigations
  3. Such a disorder is present, but migraine attacks do not occur for the first time in close temporal relation to the disorder

1.7 Migrainous disorders not fulfilling above criteria

Table 4. Diagnostic criteria for tension-type headache of The International Headache Society (IHS 1988).

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2. Tension-type headache

2.1 Episodic tension-type headache
- a) At least 10 previous headache episodes fulfilling criteria b–d listed below. Number of days of such headache < 180/year (< 15/month)
- b) Headache lasting from 30 minutes to 7 days
- c) At least 2 of the following pain characteristics:
  1. Pressing/tightening quality
  2. Mild or moderate intensity
  3. Bilateral location
  4. No aggravation by routine physical activity
- d) Both of the following:
  1. No nausea or vomiting (anorexia may occur)
  2. Photophobia and phonophobia are absent, or one but not the other is present

2.1.1 Episodic tension-type headache associated with disorder or pericranial muscles

2.2 Chronic tension-type headache

a) Average headache frequency ≥ 15 days/month (≥ 180 days/year) for ≥ 6 months fulfilling criteria b–d listed below
b) At least 2 of the following pain characteristics:
    1. Pressing/tightening quality
    2. Mild or moderate intensity
    3. Bilateral location
    4. No aggravation by routine physical activity
c) Both of the following:
    1. No vomiting
    2. No more than one of the following: nausea, photophobia, phonophobia

2.2.1 Chronic tension-type headache associated with disorder of pericranial muscles

2.3 Tension-type headache not fulfilling above criteria

Because the earlier headache classifications and the earlier version of IHS (1988) were mostly formulated for differentiation of adult headaches, the new version of the headache classification (ICHD 2004) by the Subcommittee of the International Headache Society, The International Classification of Headache Disorders, 2nd edition, may differentiate childhood headaches better. The criteria for migraine without aura in children include 1–72 hour duration of the attack, while in adults the duration must be 4–72 hours. In children, the headache attack can be bilateral, while in adults it is mostly unilateral.

In a study by Anttila and co-workers (2002a), headache characteristics were studied in children. The IHS criteria (1988) were used for diagnoses of headache type. Many children with diagnosed tension-type headache expressed typical characteristics for migraine. The results of several other studies on children have also indicated that the IHS 1988 criteria for classifying childhood headaches have different sensitivity and specificity for pediatric headaches compared to adult headaches (Seshia et al. 1994, Maytal et al. 1997).

3.6 Headache in children

3.6.1 Prevalence

Prevalence of headache in children varies in different studies and in different age groups. Cross-sectional and longitudinal studies have shown that headache prevalence increases with age in children (Bille 1962, Sillanpää 1976, 1983). Many studies report the prevalence of overall headache, which means that the child has had a headache attack on some occasion during his or her lifetime, or during the previous year. Headache prevalence can also report recurrent headache, which usually means headache attacks occurring more than once a month. However, the prevalence of headache attacks disturbing daily activities are reported in some studies.

3.6.1.1 Prevalence of overall headache

The following prevalence figures of overall headache have been reported in studies on children: during the previous year in 6% of 136 four-year-old children (Borge et al. 1994), a lifetime prevalence of 20% in 4405 five-year-olds (Sillanpää et al. 1991), during the previous 6 months in 51% of 1433 seven-year-olds (Sillanpää & Anttila 1996), and during the previous year in 82% of 3784 14-year-olds (Sillanpää 1983). Recurrent headache at least once a week was 3–4% among 2355 12- to 14-year-olds (Larsson & Sund 2005). Overall headache disturbing daily activities was reported by 22% of 968 6-year-old children (Aromaa et al. 1998a), and during the previous 6 months in 37% of 3580 eight- to nine-year-old children (Metsähonkala & Sillanpää 1994).

3.6.1.2 Prevalence of migraine

Migraine prevalence during the previous year has been reported in 3% at the age of five, and 19% at the age of 13 in 1754 children (Abu-Arafeh & Russell 1994), in 3% of 1445 eleven- to fourteen-year-olds (Raieli et al. 1995), and in 11% of 1850 seven- to fifteen-year-olds (Laurell et al. 2004). During the previous 6 months, a prevalence of 3% of 3580 eight to nine-year-olds (Metsähonkala & Sillanpää 1994), and 14% of 1135 children at the age of 12 (Anttila et al. 2002a) has been reported.

3.6.1.3 Prevalence of tension-type headache

Prevalence of tension-type headache has been reported during the previous 6 months in 12% of 1135 children at the age of 12 (Anttila et al. 2002a). During the previous year, the prevalence has been 73% in 538 ten- to eighteen-year-olds (Barea et al. 1996), and 11% in 1850 seven- to fifteen-year-olds (Laurell et al. 2004). Prevalence of lifetime recurrent non-migrainous headache has been reported in 4–7% of 4235 seven-year-olds (Sillanpää 1976), and during the previous year in 24% of 1445 eleven- to fourteen-year-olds (Raieli et al. 1995).

3.6.2 Gender

Headache predominates in girls already during adolescence (Bille 1962, Sillanpää 1983, Abu-Arafeh & Russell 1994, Raieli et al. 1995, Barea et al. 1996, Larsson & Sund 2005). However, some studies have shown a male predominance of migraine among twelve-year-old boys or younger (Abu-Arafeh & Russell 1994, Metsähonkala et al. 1997). Tension-type headache occurred equally often in boys and girls at the age of 12 in the study by Anttila and co-workers (2002a), but female predominance is seen already in children of 14 and 18 years of age (Barea et al. 1996). Girls of 13 to 16 years of age had more frequent headache compared to boys in the study by Laimi and co-workers (2006). Both migraine and tension-type headaches were three times more common in 12- to 14-year-old girls than in boys, and persistency of headache was highest in 13- to 14-year-old girls in a study by Larsson and Sund (2005).

3.6.3 Changes in headache

Headache in children fluctuates, and the type of headache can change from one to another during the growth of the child. In two follow-up studies, an increase in both headache prevalence in 6- to 12-year-old children (n = 798) (Virtanen et al. 2002) and in headache frequency in 13- to 16-year-old children (n = 228) (Laimi et al. 2006) has been observed. The change in headache has been followed in migraine patients by Bille (1997) for 40 years. In this study, 23% of migraine children (n = 73) were migraine-free before the age of 25, boys significantly more often than girls. However, around the age of 50, more than half of the group still had migraine attacks. In a 10-year follow-up study by Dooley and Bagnell (1995), change in headache type occurred mostly from migraine to tension-type headache (26%), and only in 11% from tension-type headache to migraine. Headache persisted in 73% (n = 77) of the children. Monestero and co-workers (2006) followed migraine children (n = 55) for 10 years and reported persistency in 42%, remission in 38%, while 20% converted to episodic tension-type headache. In an 8-year follow-up study of 100 children by Guidetti and Galli (1998), those with migraine without aura at the start of the study, reported migraine in 44% and tension-type headache in 26% at the end of the follow-up period. Of children with episodic tension-type headache at the start of the study, 26% reported episodic tension-type headache at the end of the follow-up period, and in 11% of the children the headache type had changed to migraine. Nearly 80% of 122 children still had headache at a 3-year follow-up in the study by Laurell et al. (2006). Of those with tension-type headache, 20% changed to migraine, and vice versa, during the follow-up.

3.6.4 Concomitant pains

Studies have shown that children who suffer from headaches tend to have other pains as well. Typical pains associated with headache are stomach, back, neck and shoulder pain. One fourth of 10- to 18-year-old children and adolescents with headache also reported pain in neck, shoulder, or back of the head in the study by King and Sharpley (1990). Children with recurrent headaches reported more other pains, such as stomach, back and neck pain than headache-free subjects in the study by Carlsson et al. (1996). In the study by Kristjansdottir (1997), the monthly prevalence of combinations of three common pains, i.e. headache, stomach pain and back pain, was 78% in 11- to 12-year-old and 15- to 16-year-old schoolchildren, whereas 40% of the children experienced one or more instances of pain weekly. In a study by Anttila and co-workers (2001, 2002b), children with migraine reported more pain symptoms in neck and shoulder region, back pain and otalgia compared with 13-year-old children with episodic tension-type headache or headache-free controls. These migraine children had other pains, especially stomach and limb pain, more often than children with episodic tension-type headache or headache-free controls (Metsähonkala et al. 2006). Also in the study by Laurell et al. (2005), children with headache, and especially those with migraine, reported other pains and physical symptoms more frequently than children without primary headache. In addition, first-degree relatives of headache children suffered more from migraine, other pains, and physical symptoms, compared to first-degree relatives of headache-free children. Of the pre-adolescents with neck pain, 62% reported headache at least once a week in the study by Mikkelsson et al. (1997).

3.6.5 Psychiatric disorders or symptoms associated with headache

Studies have shown that headache children have more psychiatric disorders or symptoms (depression and somatization) than headache-free children. Children with migraine had higher levels of somatic symptoms compared to children with tension-type headache or without headache in the study by Anttila and co-workers (2004), and children with tension-type headache had more symptoms than headache-free children. Seventeen percent of children with tension-type headache have reported depressive symptoms, which was significantly more often than in children without headache (Anttila et al. 2002a). In a study of schoolchildren with recurrent headaches, children with both migraine and tension-type headache had significantly higher levels of somatic complaints than children with only tension-type headache (Carlsson et al. 1996). The results of this study also indicated that psychological symptoms increase with age. In the study by Pine and co-workers (1996), headache was twice as common in depressed adolescents as in non-depressed adolescents. Girls with depression had a four times higher prevalence of headache than non-depressed girls (Egger et al. 1998). In an 8-year follow-up study on children, persistence of anxiety was related to persistence of migraine in 75% of the children (Guidetti & Galli 1998). Adolescents with frequent headache had higher levels of anxiety or depressive symptoms, problems with everyday life, and other pains in the study by Fichtel and Larsson (2002). Fear and anxiety have been shown to be triggers for recurrent headache in children (Aromaa et al. 1998a), and sleeping difficulties and behavioural problems predictors of later headache (Aromaa et al. 1998b).

3.6.6 Predictors of headache

Many studies have focused on different predicting factors or risk factors of children's headache. With the help of these factors, the researchers hope to gain a better understanding of childhood headache, and to find preventive measures. At the age of three years, depression and sleeping difficulties were strong predictors of later headache in the study by Aromaa and co-workers (1998b), while at the age of 5 years, long-term disease, nocturnal enuresis, travel sickness, concentration difficulties, behavioural problems, high sociability and unusual tiredness were headache predictors. Female gender, frequent use of analgesics, non-headache pain, daily neck pain, consistent migraine, and higher basic educational level of one parent were predictors of unfavourable development of frequent headache in 13- to 16-year-old children in the study by Laimi and co-workers (2006, 2007b).

3.7 Headache in families

Migraine studies from as early as the 1950's have revealed that there is a strong family history of migraine (Vahlquist 1955). Bille (1997) followed 73 Swedish subjects with pronounced migraine in childhood for 40 years. Of those who had become parents, 52% had at least one child who had developed recurrent headache, usually of migraine-type. Among Finnish migraine families (n = 906), the high percentage (56%) of subjects suffering from migraine with aura indicates a strong hereditary component especially in this type of migraine (Kallela et al. 2001). An unexpectedly high percentage (40%) of the subjects also suffered from both types of migraine (migraine with aura and migraine without aura) and showed more severe forms of the attacks compared to the "pure" migraine types. In the study by Aromaa and co-workers (1998b), mothers' headache was found to be a predictor of pre-school headache in children. A change in prevalence of children's headache during a six-year follow-up was observed to be greater for children whose mothers suffered from headache (Virtanen et al. 2002).

Twin studies have shown evidence of genetic inheritance of migraine (Honkasalo et al. 1993, 1995, Ziegler et al. 1998, Svensson et al. 1999, Mulder et al. 2003). New molecular studies suggest that there are several genetic markers predisposing to migraine (Hershey et al. 2004, Wang et al. 2004, Anttila et al. 2006). While the genetic factors seem to explain about 40 to 70 percent (Honkasalo et al. 1995, Larsson et al. 1995) of the inheritance of migraine and non-migrainous headache, there is a strong belief that environmental factors play an important role in headache and other pains. A psychosomatic family model by Minuchin et al. (1975) presents one way of observing the importance of the psychological patterns of behaviour inside a family, and the role of the sick child. It is possible that the child learns the model of pain and stress-coping at home. There are a number of studies showing an association between different pain symptoms of the child, and specific reaction patterns in the family (Øster 1972, Magni et al. 1987, Larsson et al. 1988, Pillay & Lalloo 1989). Maternal depression was also shown to be more common among headache children than among controls in the studies by Zuckerman et al. (1987) and Mortimer et al. (1992).

3.8 TMD and headache

Headache seems to be one of the most common symptoms associated with TMD, and it has been shown that treatment of TMD has reduced overall headache, migraine, tension-type headache or combination headache (Forssell et al. 1985, Lamey & Barclay 1987, Vallon et al. 1991, Karppinen et al. 1999, Ekberg et al. 2002, Wahlund et al. 2003, Ekberg & Nilner 2006). Many cross-sectional epidemiological studies (Nilner 1981, Nilner & Lassing 1981, Bernal & Tsamtsouris 1986, Könönen et al.

1987, 1993, Heikinheimo et al. 1989, Mohlin et al. 1991, List et al. 1999, Farsi 2003, Bonjardim et al. 2005, Nilsson et al. 2006), and longitudinal epidemiological studies (Egermark-Eriksson 1982, Magnusson et al. 1985, 1986, 1993, 2005, Wänman & Agerberg 1986e, Heikinheimo et al. 1989, Wänman 1996, Egermark et al. 2001, 2003) in children and adolescents have shown that subjects suffering from signs and symptoms of TMD also have concomitant overall headache.

In the studies by Nilner and Lassing (1981) on 7–14-year-old children, and Nilner (1981) on 14–18-year-old adolescents, overall headache prevalence was 11–16%. Parafunctions, such as nail and lip biting, grinding and clenching, correlated directly with headache, which was associated with TMJ and muscle tenderness (m. temporalis anterior and m. masseter). Girls had more headache than boys.

Increased TMD clinical dysfunction and wear of the teeth were reported among those children who had overall headache and other subjective symptoms of TMD in the study by Egermark (1982) on 7–15-year-old children and adolescents (n = 402). Overall headache prevalence was 23%, and it was associated with bruxism and other symptoms of TMD.

During the 2-year follow-up in the study by Wänman and Agerberg (1986e) on 17–19-year-old adolescents, a clear female predominance was observed in overall headache prevalence of 18% (weekly headache) and 29–31% (monthly headache). Headache intensity was also higher in girls. More than half of the subjects reported over one-year duration of headache. No headache was consistently reported by 54% of the adolescents. The frequency and intensity of headache were related to the presence of one or more subjective symptoms (pain on movement of the mandible, fatigue of the jaw, and chewing difficulties) and signs (muscle tenderness to palpation, impaired mandibular mobility) of TMD. A significant relationship was observed between the frequency of TMD symptoms and recurrent headache. The Helkimo Clinical Dysfunction Index was related to frequency of headache: of those with recurrent oveall headache, 88% had signs of TMD compared with 48% of those who never had headaches. Parafunctional habits (grinding, clenching) were positively related to headache frequency, but not to the intensity. Of the masticatory muscles, m. temporalis (insertion), m. masseter superficialis and m. pterygoideus lateralis were related to both frequency and intensity of headache.

In the study by Mohlin and co-workers (1991) on 12-year-old children (n = 1018), frequent overall headache was associated with several signs and symptoms of TMD. Moreover, higher modified Helkimo Dysfunction Index was related to headache. Occasional headache was reported by 46% of the subjects, and frequent (daily) headache was reported by 3%.

Twelve- to eighteen-year-old children and adolescents reported a 21% prevalence of tension-type headache once a week or more often in the study by List and co-workers (1999). A female predominance was observed in overall headache, and in pain of the temple region. In the study by Nilsson et al. (2006) on 12–19-year-old children and adolescents with TMD pain, 63% had episodic and 15% chronic tension-type headache, which was significantly more than among control children.

In the study by Wahlund et al. (2005), overall headache was reported by all TMD patients (n = 30). Of these, 87% (n = 26) reported headache once a week or more compared to 16% (n = 5) in the TMD-free control group.

Children who had not received orthodontic treatment reported significantly more frequent overall headache, bruxism, and symptoms of TMD compared to orthodontically treated children in a 20-year follow-up by Egermark et al. (2003).

In conclusion, there are only a few longitudinal epidemiological studies on children and adolescents about changes and fluctuation of TMD, or signs and symptoms of TMD. Little is known about the predicting factors of later TMD, or about the familial occurrence of TMD. Earlier studies on adults, as well as on children and adolescents, have clearly shown a co-occurrence of TMD and headache. However, our knowledge about the association between TMD and specific primary headaches in a longer time perspective, as well as about the connection with other pain symptoms and headache characteristics, is still scarce.

4. AIMS OF THE STUDY

To investigate

1. the occurrence and change of signs and symptoms of temporomandibular disorders (TMD) in children and adolescents with and without headache during a 3-year follow-up, as well as familial occurrence of TMD signs.
2. the association between TMD signs and primary headaches.
3. the association between TMD signs and headache-associated factors, depressive symptoms, sleeping disorders and overall pain sensitivity in children and adolescents.
4. predictors of TMD signs during a 3-year follow-up.

5. SUBJECTS AND METHODS

5.1 Study population 1 (I, II, IV)

In 1998, a total of 1409 12–13-year-old school children in the sixth grade in all of the 35 Finnish-speaking primary schools in the city of Turku, Southwestern Finland, were chosen for the original study population (Fig. 1). Altogether 1135 (81%) pupils returned the questionnaire which they had valuntarily filled in with the help of their guardians. The criteria of the Committee of the International Headache Society (IHS, 1988) were used for classifying the subjects into headache groups.

In 1999, when the children were 13 years of age, seventy children from each primary headache group (migraine; migraine-type not fulfilling the IHS criteria; tension-type headache; tension-type not fulfilling the IHS criteria), and from healthy controls were randomly selected. If the headache group included fewer than 70 children, as in the case of tension-type headache children not fulfilling the IHS criteria, the entire group was included in the study population. As a result, altogether 311 children participated in a face-to-face interview and in a clinical examination by a physician and a trained physiotherapist at the paediatric outpatient clinic in the city of Turku[*]. The children's headache was reclassified. After that, a total of 297 children came to the Institute of Dentistry, University of Turku, for a thorough stomatognathic examination.

In 2002, at the age of 16, the same adolescents were re-examined. The participation rate for the examination by a paediatrician was 73% (n = 228/311). Drop-outs from headache groups were 20–27%, and from headache-free controls 31%. Of those 297 children who had taken part in the stomatognathic examination at the age of 13, 212 (81.4%) adolescents participated in the stomatognathic follow-up study at the age of 16.

[*] The reported number of children, n = 310, in the original papers I and II is incorrect due to misinformation. In the original paper IV the number of children is correctly n = 311.

Year 1998 — 1135 school children fill in a questionnaire
Classification into headache groups according to IHS (1988)

↓

Random sampling
Maximum 70 children from each headache group + headache-free controls

↓

Year 1999 — 311 children (13 years) participate in somatic examination
Reclassification into headache groups

↓

Year 1999 — 297 children (13 years) participate in stomatognathic examination

↓

Year 2002 — 228 children (16 years) participate in somatic re-examination
Participation rate: 73% of the original 13-year-olds
Drop outs: in headache-groups 20–27%, in headache-free controls 31%
Reclassification into headache groups

↓

Year 2002 — 212 children (16 years) participate in stomatognathic examination
Participation rate 81.4% of those examined already at the age of 13

Figure 1. Flow-chart of study population 1.

5.2 Study population 2 (III)

In 1986, stratified random cluster sampling was performed in the region of Turku and Pori, in Southwestern Finland. The original study population consisted of 1582 families expecting their first child (Fig. 2). The sample of children and their mothers is part of the population-based follow-up study, The Finnish Family Competence Study. Of these families, 1443 (91%) filled in an informed consent form and participated, while 139 refused to participate. The mothers gave birth to 1294 children. There were three stillbirths, eight died in infancy, and five moved abroad. During the follow-up, 146 families dropped out of the study.

In 1993, a questionnaire inquiring about headache was sent to the remaining 1132 families with children (average age 6 years). The question about prevalence was answered by 968 parents on behalf of 968 (86%) of 1132 eligible children. Altogether 144 children had suffered from headache that disturbed their daily activities during the previous six months. All these children and their headache-free controls were invited to the Turku University Hospital, Department of Child Neurology, to participate in a clinical pediatric and neurological interview, and a clinical examination by a physician. Headache type was classified according to IHS criteria (1988) for primary headache groups (migraine; migraine-type not fulfilling the IHS criteria; tension-type headache; tension-type not fulfilling the IHS criteria). The controls were chosen from among those children who had never had headache (n = 764), and were matched for age, sex and domicile.

Year 1986	Questionnaire sent to 1582 families expecting their first child, 1443 (91%) answered, 139 refused
	↓
Year 1987	Birth of 1294 children → 1278 potential study population
	↓ → 146 refused
Year 1993	Questionnaire sent to 1132 children (6 years), 968 (86%) answered: 144 children with headache during previous 6 months, 764 headache-free children
	↓
	106 study children + 106 headache-free controls
	↓ → 10 drop-outs
	96 study children + 96 headache-free controls Interview, somatic examination and headache classification
	↓
Year 2000	75 (75%) study children + 79 (82%) headache-free controls and 154 mothers Stomatognathic examination, interview, somatic examination and headache classification

Figure 2. Flow-chart of study population 2.

Of the 144 children, 106 and their matched controls (n = 106) participated in the study. The reasons for refusal to participate were long distance, lack of time, several other hospital visits, family member with long-term disease, and anxiety that the examination might increase the headache attacks. The statistical difference between the participants and non-participants was analyzed. The child's long-term disease (excluding headache) such as allergy, asthma, diabetes, constipation and nocturnal enuresis, was more common among non-participants. Children with secondary headaches were excluded from subsequent examinations. There remained in the study 96 six-year-old children with primary headache and their 96 headache-free controls.

At the age of 13, the same children were again invited to a somatic examination by telephone or by mail in 2000. Altogether 75 (78%) headache children, their 79 (82%) headache-free controls from the original groups, and their 154 mothers participated in a stomatognathic examination at the Institute of Dentistry, University of Turku. Of the 154 children, 71 were girls and 83 boys. Their mean age was 13.0 years (range 12.6–13.6). Reasons for dropping out were living far away, lack of time, child's refusal, recent death of a family member, and intractability of the child/family.

From the original headache-free control group at age 6, twelve children had begun to suffer from headache at the age of 13. On the other hand, of the original headache children, 14 had become headache-free at age 13.

5.3 Questionnaire, interview and somatic examination by physician

Study population 1

The children's headache type was classified by a physician on the basis of a questionnaire and an interview. The main primary headache classification used for the analysis was: migraine without aura; migraine with aura; migraine-type headache not fulfilling the IHS criteria; episodic tension-type headache; tension-type headache not fulfilling the IHS criteria. Because the new International Classification of Headache Disorders (ICHD, 2004) had not yet been published at the time of data collection, IHS 1988 criteria were used throughout the whole study. Headache intensity was expressed by a trichotomic scale: mild, moderate or severe. The list of associated features included vomiting, nausea, loss of appetite, photophobia, phonophobia, pain aggravation due to physical activity, insomnia, hypersomnia, recurrent abdominal pain, and sensation of fainting. Sleep difficulties were asked about in more detail. The Children's Depression Inventory (CDI), a validated instrument for detecting major depression and depressive symptoms, is commonly used in epidemiological studies on children. At the age of 13, children were asked to complete the DSM-IV (The Achenbach Inventory) (Egger et al. 1998). At the age of 16, the short Beck Depression Inventory (R-BDI) was used (Beck et al. 1974, Kaitiala-Heino et al. 1999). A paediatric and neurological clinical examination was performed by a physician.

Study population 2
The type of children's headache was inquired about with several questions; age of onset of attacks, triggers of headache, predominant time of headache onset, aura symptoms, location of pain, duration of attacks, characterization of pain, concurrent symptoms, worsening or alleviating factors, medication etc. Clinical examination by a physician included an interview and a somatic examination. After that, children's headache type was classified by a physician according to IHS criteria 1988.

The classification of mothers' headache type was based on a headache questionnaire which included the same questions as the children's interview, and on IHS criteria (1988). The headache questionnaire was given to the mothers at the Institute of Dentistry and analyzed by a physician. Mothers were not examined clinically by a physician.

The validity of self-administered questionnaires in the diagnoses of headache has been shown to be reliable because the diagnosis was the same in both the questionnaire and the face-to-face interview (Anttila et al. 2002b), and a pre-test has been administered by wording the same issue in two different or opposite ways (Aromaa et al. 1993). The questionnaires and clinical interview and examinations can be seen in the appendixes of Aromaa thesis (1999), Anttila thesis (2000), Laimi thesis (2007).

5.4 Examination by physiotherapist

For study population 1, an examination by a trained physiotherapist was performed. It included manual palpation of muscle tenderness in the neck-shoulder area on seven bilateral pericranial and neck-shoulder tender points (the frontal and temporal muscles, insertion of the suboccipital muscle, anterior aspect of C5-7, midpoint of the upper trapezius muscle, origin of the supraspinatus muscle, insertion of the levator scapulae muscle). A modified version of the Total Tenderness Score System was applied (Langemark & Olesen 1987). Reaction to pain was classified into four categories: 0 = no pain, 1 = no visible reaction but reports mild pain, 2 = reports pain, distorting the face, 3 = reports considerable pain and withdraws. The total score (range 0–42) was used in the final analyses (Anttila et al. 2002b). The Fisher dolorimeter (1986) was used to measure the pressure pain threshold of five bilateral points (the frontal and temporal muscles, insertion of the suboccipital muscle, midpoint of the upper trapezius muscle, insertion of the levator scapulae muscle). The supraspinatus muscle and anterior aspect of C5-7 were excluded because of technical difficulties in measurement. The rubber tip of the instrument had a surface of 1 cm^2, and pain was measured in kg/cm^2 units. The range was 0 to 10 kg. The dolorimeter was placed on a selected point and pressure was increased at a rate of 1 kg/s. The child indicated verbally when he or she sensed a change from pressure to pain. Results were expressed as a mean dolorimetric score of 5 bilateral points for the final analyses. Both manual and dolorimetric recordings were also made at three bilateral fibromyalgic points: elbow 2 cm distal to the lateral epicondyle, medial fat pad of the knee proximal to the joint line, and upper outer quadrant of the buttock in the anterior fold of the muscle.

5.5 Stomatognathic interview and examination

The children and mothers were interviewed, examined clinically and scored for TMD signs in both study samples using exactly the same methods of stomatognathic examination. Before the study began, the examiner was trained by an experienced examiner at the Institute of Dentistry, and an intra-examiner test was performed at the beginning of the study. Throughout the follow-up study, the examiner was re-calibrated. The stomatognathic examiner was blinded to the results of the earlier examinations and the interviews. The stomatognathic examination was based on a standardized protocol which has been systematically used in clinical practice and studies between 1980 and 2000 at the Institute of Dentistry, University of Turku (Appendix).

In the interview, questions about joint sounds, jaw mobility, pain while chewing, sensation of fatigue in the jaw, pain or sensation in the ear or throat, and parafunctional habits, such as tooth clenching and nocturnal grinding, were asked about.

The stomatognathic examination included measurements of mandibular movements and recordings of joint sounds using a stethoscope. Pain, and locking or luxation of the joints during movements were examined. The temporomandibular joints were palpated laterally and posteriorly. The following masticatory muscles were palpated bilaterally: the anterior and posterior portions and the insertion into the coronoid process of the temporal muscle, the deep and superficial portion of the masseter muscle, the posterior portion of the digasticus muscle, and the medial and lateral pterygoid muscles. If the subject did not react to palpation, no tenderness was recorded. Mild tenderness was present if the subject verbally reported any pain during palpation. Moderate tenderness gave rise to blink reflex, and severe tenderness to withdrawal.

5.6 Scoring of TMD signs

The clinical signs were scored from 0 to 2 for every muscle, depending on the degree of tenderness (Table 5). Joint tenderness was graded according to whether it was on one or both sides, either lateral or posterior. One point was given to each joint if any sound was registered. Difficulties in guiding the mandible into the centric relation (CR) or pain recorded during this manipulation scored one point. When these points were added together (maximum 35) the subject was given a score for the severity of TMD signs.

Table 5. TMD score drawn from the clinical examination. (Study I)

Variable	Score 0	Score 1	Score 2	
Pain on opening	No	Yes		1
Pain on lateral and/or protrusive jaw movements	No	Yes		1
Muscle pain on palpation (14 sites)	No	Mild	Moderate	28
Pain on palpation of joints	No	One side	Both sides	2
Joint sounds	No	One side	Both sides	2
Pain or stiffness on guiding the mandible	No	Yes		1
				Max. 35

5.7 Testing intra-examiner variation of stomatognathic examination

At the age of 13 (study population 1), evaluation of intra-examiner variation (between two clinical examinations done by the same examiner) was performed by collecting clinical data from 33 subjects at a one to two week interval. The result of the test showed that the TMD signs score for 23 out of 33 subjects was identical. In six subjects, the difference between the two examinations, was one point, and in four subjects two points. There were some minor differences mainly in muscle palpation tenderness and TMJ sounds. In deflection of the opening, as well as lateral and protrusive movements, 70–80% of the measurements were identical or there was a 1 mm difference. In maximal mouth opening capacity, 35% of the measurements were identical or had a 1 mm difference, while 30% had a 2–3 mm difference.

5.8 Statistical methods

Study population 1

The overlaps in the clinical examinations of the physiotherapist and dentist regarding the frontal and temporal muscle were carefully excluded before the analyses. The lateral pterygoid muscle showed the highest frequency of tenderness. Results of the palpation of the lateral pterygoid muscles were excluded from all analyses due to the well known difficulties in obtaining reliable observations. The one subject with chronic tension-type headache was excluded from the analysis. Nausea and/or vomiting were asked about as a criterion for migraine in the classification of different headache types. However, in another analysis, it was combined with fainting sensation since they both reflect dysfunction of the autonomic nervous system.

The TMD sum score was divided into three categories before the analysis due to high skewness in the distribution. The children were scored as healthy regarding TMD if the sum score was zero, having very mild TMD when the score was between one and four, and mild or moderate TMD when the score was five or more. The analysis of associations between the TMD signs score and other variables was carried out using cumulative logistic regression analysis, which takes into account the ordinal scale in a polytochomous response variable. In addition to the p-value, the results of the analysis were quantified by cumulative odds ratios (COR) and 95% confidence intervals (95% CI). Gender and headache-adjusted analyses were carried out separately for each studied variable. Two multivariate analyses were done: the first one with variables recorded from all subjects, and the second one with variables recorded only from headache subjects. The statistical computations were performed with the SAS System for Windows, release 8.2/2001.

In the follow-up study, for the statistical analysis concerning the changes during the 3-year follow-up and predicting value of the parameters, we used n = 198.

The TMD sum score was divided as described above. The changes in distribution of TMD signs from the age of 13 to the age of 16 were tested with the marginal homogeneity test. Chi-square or Fisher's exact test was used to compare the single TMD symptoms between headache groups at the age of 13 and 16. The changes in single TMD symptoms during the 3-year follow-up were tested using McNemar's test. For the analysis of the join sounds binary response (no sound/clicking sometimes or continously) was used. The analysis of associations between the TMD signs score and other variables was carried out using cumulative logistic regression analysis, which takes into account the ordinal scale in a polytochomous response variable (Hosmer & Lemeshow 2000). In addition to univariate analysis, gender and headache-adjusted analyses were carried out separately for each predicting variable. The results of the cumulative logistic regression analysis were quantified by cumulative odds ratios (COR) and 95% confidence intervals (95% CI). Two multivariate analyses were done for variables measured at the age of 16 years: the first one with variables recorded from all subjects, and the second one with variables recorded only from headache subjects. The statistical computations were performed with the SAS System for Windows, release 9.1 (SAS Institute, Cary, NC, USA).

Study population 2

The TMD sum score was grouped into three categories as described above. The analyses of the associations between child's/mother's headache and child's/mother's TMD were carried out using cumulative logistic regression analysis. Individual matching (at age 6 years) of the headache children with their controls induced correlations between the observations. When data consist of individually matched pairs, it is constructed in such a way that the two subjects in each matched pair are expected to be more like each other than any two randomly selected subjects from different pairs. If this is not taken into account in statistical calculations, it will lead to underestimation of standard errors of the parameter estimates and to too small p-values in tests. This intra-class correlation was taken into account by applying the generalized estimation equations (GEE) technique in the estimation. In addition to the p-value of 5% significance level, the results of the analysis were quantified by cumulative odds ratios (COR) and 95% confidence intervals (95% CI). The statistical computations were performed with the SAS System for Windows, release 8.2/2001.

Approval of the study design

The study design was approved by the Joint Ethics Review Committee of the Turku University Medical Faculty and the Turku University Central Hospital.

6. RESULTS

6.1 Signs of TMD, gender, and changes during the 3-year follow-up (I, II, III, IV)

Throughout the whole study, TMD signs in children and adolescents were mostly mild. The highest score observed was between 13 and 14 (score range 0–35). At the age of 13, the most frequent signs were masticatory muscles tenderness on palpation, which was detected in 51% of all children with TMD signs (n = 234). Joint sounds were detected in 40% of children with TMD signs. At the age of 16, the most frequent TMD sign was joint sounds, which were detected in 45% of adolescents with TMD signs (n = 153). Masticatory muscle tenderness on palpation was detected in 25% of all adolescents with TMD signs.

In both study populations, there was a female dominance at the age of 13 (sample 1: p = 0.024, COR = 1.7, 95% CI = 1.07–2.66 and sample 2: p = 0.037, COR = 1.93, 95% CI = 1.06–3.51), as well as at the age of 16 (p = 0.037, COR = 1.93, 95% CI = 1.06–3.51).

A significant change (p < 0.001) was observed in the score of TMD signs from the age of 13 to the age of 16 (Table 6). There were fewer adolescents with a high score for TMD signs at the age of 16 compared to the 13-year-olds. Of those with a high TMD score (≥ 5, n = 41) at the age of 13, 71 % had mild TMD signs (1–4) at the age of 16. Ten percent of the subjects were completely free of TMD signs at both examinations, at the age of 13 and 16 years.

Table 6. Distribution (n) of TMD signs in 13-year-old and 16-year-old adolescents. (Study IV)

		TMD signs at the age of 16			
		0	**1-4**	**≥ 5**	**Total**
TMD signs at the age of 13	**0**	19	22	0	41
	1-4	28	79	9	116
	≥ 5	7	29	5	41
	Total	54	130	14	198

6.2 Subjective symptoms of TMD and changes during the 3-year follow-up (I, IV)

In general, the subjective symptoms were mild at all examinations. At the age of 13, the most frequent symptom was earache, tinnitus or locking of the ear, which was reported by 41% of children with TMD symptoms (n = 142). Clicking sounds of joints were reported by 40% of all children with TMD symptoms. Six percent of the children in the migraine-type headache group not fulfilling the IHS criteria, reported fatigue or stiffness of the jaw. In the headache-free group, none of the children had this symptom. Only the children in the tension-type headache group not fulfilling the IHS criteria, reported difficulties in opening the mouth. Some children with migraine and episodic tension-type headache reported locking of the joints. Migraine children had most earache. Nocturnal grinding was reported by 22% of the tension-type headache group not fulfilling the IHS criteria, by 11% of the migraine group, and 17% of the healthy control group. There were no statistically significant differences between the headache groups regarding subjective symptoms of TMD.

At the age of 16, clicking sounds of joints was most frequently reported by 50% of adolescents with TMD symptoms (n = 111). Tooth clenching or nocturnal grinding was reported by 36% and tinnitus by 26% of all adolescents with TMD symptoms. No significant differences in joint sounds, pain in the joints while chewing, earache or reported parafunctional habits were observed between the headache groups. Regarding other symptoms (fatigue or stiffness of the jaw, pain on opening, difficulties in opening, locking or luxation of the jaw) a statistically significant difference was observed between the groups ($p = 0.027$). Twenty-nine percent of the children in the migraine-type headache group not fulfilling the IHS criteria, had these symptoms, while the percentage in the migraine group was 18%. In the tension-type headache group not fulfilling the IHS criteria, 17% of the children had these symptoms, while the percentage in the tension-type headache group was 8. Two percent of the headache-free children had these symptoms.

No significant changes were seen in subjective TMD symptoms between the ages of 13 and 16.

6.3 Association between signs of TMD and primary headache groups (I, II, III, IV)

In our first report on study population 1 at the age of 13, all primary headache groups were similar with regard to TMD signs, and there were no statistically significant differences between the groups. However, the migraine-type headache group not fulfilling the IHS criteria, had the highest number of subjects with mild or moderate TMD signs. The children in the tension-type headache group not fulfilling the IHS criteria, had the most TMD signs on the whole, while the episodic tension-type headache group and healthy controls showed the least overall TMD signs.

Further analysis including adjustment for gender (II), showed no significant difference between the overall headache and TMD signs ($p = 0.115$). However, when the primary headache groups were compared separately with headache-free controls, children with migraine and migraine-type headache had significantly more signs of TMD (COR = 2.1, 95% CI = 1.1–4.2 for migraine, and COR = 2.2, 95% CI = 1.1–4.2 for migraine-type headache).

In study population 2 at the age of 13, a statistically significant association was found between the child's headache and signs of TMD in both migraine and episodic tension-type headache (Table 7). The headache groups did not differ from each other regarding the association with TMD signs. The overall p-value for headache groups was < 0.001.

Table 7. Association between 13-year-old children's TMD signs and migraine or episodic tension-type headache compared to headache-free children. Total n = 153. (Study III)

Child's headache	p-value	COR	95% CI
Migraine vs. no headache	< 0.001	4.3	1.8–9.9
Episodic tension vs. no headache	0.004	3.1	1.4–6.8
Migraine vs. episodic tension-type headache	0.539	1.4	0.5–3.7

COR = cumulative odds ratio

At the age of 16, there was a statistically significant difference in TMD signs between migraine and headache-free children (p = 0.0461, COR = 3.12, 95% CI = 1.02–9.55), but after adjusting for gender, the difference when comparing the headache groups with the headache-free controls was not significant (p = 0.372). The overall difference in TMD signs between the headache groups including only headache children was not significant (p = 0.610). Of the 14 children with a high TMD sign score (≥ 5) at the age of 16 years, seven had episodic tension-type headache, three migraine, two migraine-type headache not fulfilling the IHS criteria, one episodic tension-type headache not fulfilling the IHS criteria, and one was headache-free.

6.4 Association between signs of TMD and headache-related symptoms, sleeping difficulties, depressive symptoms and overall pain sensitivity (II, IV)

At the age of 13, after adjusting for both gender and headache, TMD signs were significantly associated with neck muscle palpation pain, dolorimeter values in the neck and shoulder musculature, headache frequency, and nausea or fainting sensation during headache attacks.

When the variables were analysed together in headache and headache-free children (n = 277), and after adjusting for gender and headache, the strongest association was seen between TMD signs and neck muscle pain (p < 0.001, COR = 1.09, 95% CI = 1.05–1.13). Dolorimeter values in neck muscles reached significance when only headache children (n = 195) were included in the analysis (p = 0.045, COR = 0.74, 95% CI = 0.55–0.99). The association was non-significant with depressive symptoms, sleeping difficulties, headache intensity, unilateral headache, headache aggravated by bright light, nausea or fainting sensation during headache attack, and headache frequency.

At the age of 16, in the multivariate logistic regression analysis, the variables were analysed together after adjusting for gender and headache. Neck muscle pain on palpation was significantly associated with TMD signs (p = 0.002, COR = 1.42, 95% CI = 1.18–1.71). Sleeping fewer hours during the night almost reached a significant association (p = 0.051) with TMD signs when only headache children (n = 139) were considered, but did not reach a significant level (p = 0.070) when both headache and headache-free children (n = 180) were included. The association was non-significant regarding dolorimeter values, depressive symptoms, headache intensity, unilateral headache, headache aggravated by bright light and headache frequency.

6.5 Predictors of TMD signs (IV)

Before adjusting for gender and occurrence of headache, headache intensity (p = 0.036) and dolorimeter values in the neck and shoulder area (p = 0.023) at the age of 13 predicted later TMD signs in the logistic regression analysis. Neck muscle pain, unilateral headache, depressive symptoms, headache frequency, photosensitivity or sleeping difficulties were not predicting factors for later TMD signs. However, after adjusting for gender and headache, no single headache-associated factor remained as a significant predictor for later TMD signs (Table 8). There was a tendency for dolorimeter values to predict later TMD signs. Primary headache type at the age of 13 did not predict signs of TMD at the age of 16 (p = 0.658). No subjective symptoms of TMD emerged as predictors for later TMD signs.

Table 8. Factors associated with headache at the age of 13 predicting signs of temporomandibular disorders at the age of 16. Cumulative logistic regression analysis adjusted for gender and headache. (Study IV)

	TMD signs at the age of 16		
Factors at the age of 13	P-value	COR	95% CI
Neck muscle palpation pain (n = 198)	0.201	1.03	0.99–1.07
Dolorimeter value (n = 198)	0.065	0.77	0.58–1.02
Depressive symptoms (n = 193)	0.473	1.03	0.95–1.11
Sleeping difficulties (n = 193)	0.140	1.06	0.98–1.15
Headache intensity (n = 157)	0.257		
moderate vs. mild		0.95	0.42–2.16
severe vs. mild		3.94	0.60–25.99
Unilateral headache (n = 157)	0.652	1.21	0.53–2.75
Headache frequency (n = 198)	0.537	0.96	0.86–1.08

COR = cumulative odds ratio
CI = confidence interval

6.6 TMD signs and headache in children and their mothers (III)

The association between TMD signs of 13-year-old children and their mothers was statistically non-significant, and no familial occurrence of TMD signs in children and their mothers could be demonstrated (p = 0.29) (Table 9). However, there was a significant association between the occurrence of headache in children and mothers (p = 0.043).

Table 9. Association between the occurrence of TMD signs in 13-year-old children and their mothers (cumulative logistic regression analysis). Total n = 154. (Study III)

	TMD signs: Mothers		
	0	1–4	≥ 5
TMD signs: Children			
0	16	44	7
1–4	14	43	7
≥ 5	4	12	7

Seventy percent of headache children and 82 % of their mothers had TMD signs. On the other hand, 45% of the headache-free children and 74% of their mothers had TMD signs (Table 10). Headache children had significantly more signs of TMD compared to headache-free children, while no significant difference was observed between the groups of mothers.

Table 10. Comparison of the scoring of TMD signs between 13-year-old headache (HA) and headache-free children (p = 0.0002), and between their mothers (p = 0.12) (cumulative logistic regression analysis). (Study III)

Children's TMD signs score	HA children 13 years n = 72	HA-free children 13 years n = 81
0	21 (29%)	45 (56%)
1–4	32 (44%)	32 (40%)
≥ 5	19 (26%)	4 (5%)
Mothers' TMD signs score		
0	13 (18%)	21 (26%)
1–4	46 (64%)	52 (64%)
≥ 5	13 (18%)	8 (10%)

Comparing the different TMD signs in headache and headache-free children showed significant levels in pain on jaw movement and muscle pain on palpation. A significant difference was observed between the mothers of headache and headache-free children in pain on opening (Table 11).

Table 11. Comparisons of the occurrence of different TMD signs between 13-year-old headache (HA) and headache-free children, and between their mothers. The significant differences are in bold print; in children: pain on jaw movement (p = 0.03), muscle pain on palpation (p = 0.0002), in mothers: pain on opening (p = 0.04) (logistic regression analysis). (Study III)

Variable	HA children n = 72	HA-free children n = 81	Mothers of HA children n = 72	Mothers of HA-free children n = 80
Pain on opening	12 (17%)	8 (9%)	**12 (17%)**	**5 (6%)**
Pain on jaw movement	**16 (22%)**	**7 (9%)**	14 (19%)	11 (14%)
Muscle pain on palpation	**36 (50%)**	**17 (21%)**	28 (39%)	22 (28%)
Pain on palpa-tion of joints	20 (28%)	13 (16%)	14 (19%)	15 (19%)
Joint sounds	15 (21%)	9 (11%)	43 (60%)	46 (57%)
Pain or stiffness on guiding the mandible	-	-	5 (7%)	1 (1%)

In mothers, only the association between migraine and TMD signs reached statistical significance when the headache groups were compared to headache-free mothers (Table 12).

Table 12. Association between mother's TMD signs and migraine or tension-type headache compared to non-headache mothers (n = 145). The overall p-value for mothers' headache groups was 0.092. (Study III)

Mother's headache	p-value	COR	95% CI
Migraine vs. no headache	0.025	3.6	1.2–11.0
Tension vs. no headache	0.153	2.2	0.7–6.6
Migraine vs. tension	0.139	1.6	0.8–3.1

COR = cumulative odds ratio

7. DISCUSSION

Subjects and methods

The present study is the first to investigate the association between TMD and primary headache in two large samples of children: firstly, a population-based sample, which was followed prospectively, and secondly, a nested case-control sample, which was originally drawn from a population-based large sample. Earlier studies on headache, headache-related factors and predictors for headache had already given a large amount of information about these children in both study populations. Both study samples were representative of the unselected child population in Southwestern Finland (Rautava & Sillanpää 1989, Sillanpää & Anttila 1996, Anttila et al. 1999). The participation rates were good at all headache and TMD investigations during the subsequent years (Aromaa et al. 1998a,b, Aromaa, thesis 1999, Anttila, thesis 2000, Anttila et al. 2002a, Virtanen et al. 2002, Laimi et al. 2006, Laimi, thesis 2007). The subjects did not benefit economically from participation in the study, and no travel costs were paid. The thorough questionnaires provided a large amount of information about headache, pain, symptoms, functional aspects, and other related factors, and have been tested and validated in the above-mentioned earlier studies. The children were interviewed by a physician, and somatic and neurological examinations were carried out.

The methods of the stomatognathic examination had systematically been used at the Institute of Dentistry, University of Turku, in earlier studies during the period 1980–2000. The interviewers and the clinical examiner were blinded during the study. The clinical scoring system used was designed to enable different degrees of TMD signs for the analysis. In order to increase the reliability and validity of the study, the stomatognathic examiner went through a calibration period at the University of Turku with an experienced clinician before the study began, and re-calibrations were done during the study. All study subjects were examined by the same examiner throughout the stomatognathic study, and an intra-examiner variation test was carried out at baseline in study population 1. The training of, and the using of one and the same examiner should increase the reliability of the study (Carlsson et al. 1980, Kopp & Wennenberg 1983, Duinkerke et al. 1986, Dworkin et al. 1990, John & Zwijnenburg 2001). The studies have shown that it is difficult to achieve consistency in clinical examinations, which may be partly due to fluctuation in TMD signs. The influence of fluctuation in TMD signs would be best avoided by performing the intra- and inter-examiner examinations on the same day (Kopp 1977). However, for practical reasons we performed the re-examination after one to two weeks, which may have had an effect on the results. The result of our intra-examiner test showed some minor differences mainly in muscle palpation tenderness and TMJ sounds. Our result is in line with the study by Wahlund and co-workers (1998) on adolescents, where reproducibility of the joint sounds was found to be high, although we registered the joint sound as positive if one click was observed in three trials of opening movements, in contrast to two reproducible clicks in three trials. In our study, the differences in muscle tenderness between the two examinations were mainly in extraoral musculature. The lateral pterygoid muscle was excluded from the analysis, because of the well known difficulties in obtaining reliable observations. In the study by Wahlund and co-workeres (1998), low consistency on palpation tenderness was observed in intraoral musculature, as well as in posterior mandibular and submandibular regions, which the authors suggest should be excluded from the standard examination of children and adolescents. Our result of the intra-examiner test does not support this finding. In agreement with the study by Wahlund et al. (1998), we saw a high correlation between the reported joint clicking sounds with registered findings on joints in our whole study population of 13- and 16-year-olds. Our test showed acceptable reproducibility in maximal mouth opening capacity and deflection of the opening, as well as in lateral and protrusive excursions. This is in line with the earlier studies on adults (Duinkerke et al. 1986, Dworkin et al. 1990, John & Zwijnenburg 2001). Contrary to our result with lower consistency in the maximal opening capacity, reproducibility of vertical range of motion was high, while the reliability of lateral and protrusive excursions tended to be low in the study on children and adolescents by Wahlund et al. (1998).

Signs and symptoms of TMD, gender, and changes during the 3-year follow-up

TMD signs and symptoms were mostly mild in the present study at both prepubertal and pubertal ages, and considerable changes in signs of TMD were observed during the 3-year follow-up. These findings are in line with the results of other studies (Wänman & Agerberg 1986a,b,c,d, Heikinheimo et al. 1989, 1990, Könönen et al. 1993, Magnusson et al. 1993, 1994, 2005). Although a significant change in the occurrence of TMD signs according to the TMD signs score was observed during the follow-up, we did not see any increase in the signs. On the contrary, there were fewer adolescents with mild or moderate TMD signs at the age of 16 than at the age of 13. In particular, tenderness on palpation in masticatory muscles seems to have decreased, because the frequency of this finding was 25% lower in 16-year-olds. Reported joint sounds remained rather stable during the follow-up. Our findings are partly in accordance with the results of the study by Magnusson and co-workers (2005) where clinical signs of TMD increased during the first five years in the 7- and 11-year age groups, but remained unchanged during the first 10 years in the 15-year age group.

In our study, no change was observed in TMD symptoms during the follow-up. This finding contradicts the results in the study by Magnusson and co-workers (2005) where symptoms of TMD increased during the first 10-year follow-up in all age groups (7, 11 and 15 years), but no further increase was observed after that in any age group. Also in the study by Wänman (1996) an increase in TMD symptoms was observed during a 10-year follow-up of 17-year-old adolescents to adulthood. The differences in the results between our study and the above-mentioned studies may reflect the differences in the study populations. It is possible that recurrent headache may exceed other milder symptoms. Our follow-up was also shorter than in the other two studies.

The gender difference in TMD signs was already present, with female predominance at prepubertal age, which is in line with earlier studies (Magnusson et al. 1994, 2005, Conti et al. 1996, List et al. 1999, Pahkala et al. 2002). The reasons why girls and women have more pain symptoms compared to boys and men, are unclear. One probable contributing factor could be female reproductive hormones (Unruh 1996, LeResche et al. 1997, Dao et al. 1998, Cimino et al. 2000) because many pain parameters start to increase after puberty. There is a female predominance in prevalence figures especially at reproductive age, while the prevalence of pain symptoms declines in females after the post-menopausal years. This same pattern is seen in TMD, migraine, and other pain symptoms. There are several mechanisms that could explain the effect of hormones on pain sensitivity. Central mechanisms by neurotransmission through serotonin receptors, prostaglandin release, or modulation of endogenous opioids have been proposed (Silberstein & Merriam 1991), and the mechanisms for TMD and migraine could be the same. One hypothetical pathway could be differences in the C-fibre component and CNS processing of pain, since females showed a lower pain threshold and tolerance in the study by Fillingrim et al. (1998). In peripheral mechanisms, one explanation could be that estrogen enhances a number of specific inflammatory responses in TMJ (Haskin et al. 1995, Milam 1995). Estrogen is also known to increase joint laxity, at least during pregnancy (Westling 1992).

TMD signs and primary headaches

In the present study, an association between TMD signs and migrainous headaches was observed in a population-based sample of children at prepubertal age. On the other hand, in the nested case-control study of children with daily headache and headache-free controls of the same age, the association was observed between TMD signs and both migraine and episodic tension-type headache. At pubertal age, no association between TMD signs and different headache types was observed. The differences in our results between the study populations and at different ages could reflect the difficulty in classifying children's headache according to IHS criteria (1988), which may be more suitable for adults (Seshia et al. 1994, Maytal et al. 1997). According to the new International Classification of Headache Disorders (2004), it is probable that more children will receive a diagnosis of migraine, because the time-frame for the headache attack has been shortened in these new criteria. Different types of headache may also represent a continuum, not single entities, and thus the association between headache type and TMD signs and symptoms may differ from one age to another. It is possible that TMD was not associated with migraine at the age of 16, because the changes of migraine to other types of headache and considerable changes in headache characteristics were common during the follow-up, as reported by Laimi and co-workers (2006, 2007b). It may also be that the number of migrainous adolescents was too small at the age of 16 years to have statistical power in the analysis. Changes in headache have also been reported in other studies on children (Guidetti et al. 1998, Virtanen et al. 2002, Monestero et al. 2006).

Our results in prepubertal children are in accordance with other earlier studies which have also demonstrated a clear co-occurrence of TMD and overall headache in children and adolescents (Nilner 1981, Nilner & Lassing 1981, Bernal & Tramtsouris 1986, Wänman & Agerberg 1986a,c,e, 1987, Könönen et al. 1987, Heikinheimo et al. 1989, Mohlin et al. 1991, Wänman 1996, List et al. 1999, Egermark et al. 2001, Farsi 2003, Bonjardim et al. 2005, Magnusson et al. 2005). Contrary to the results from most of the earlier studies in adults, and from the study in children by List and co-workers (1999), we found the association to be stronger between migraine and TMD signs than between tension-type headache and TMD signs. These differences in results may be due to methodology and, at least when compared to the adult studies, to the different and more detailed headache classification applied in our study. In our analysis, there were no chronic tension-type headache children, contrary to the sample of List and co-workers, where the chronic form of tension-type headache was also represented, and only three children had migraine. There are studies suggesting increased pain sensitivity among patients with chronic tension-type headache (Lipchik et al. 1996, Ashina et al. 2006, Buchgreitz et al. 2007, Couppe et al. 2007), but also with migraine (Burstein 2001 review, Bartsch & Goadsby 2003 review, Bartsch 2005 review). In the study by List and co-workers (1999), children were diagnosed with TMD, while in our study signs of TMD were used in the analysis.

In mothers of the 13-year-old children, the association was significant between migraine and TMD signs, but not between tension-type headache and TMD, as has been demonstrated in earlier reports (Forssell & Kangasniemi 1984b, Molina et al. 1997). However, there are also studies that have shown an association between TMD and migraine in adults (Forssell & Kangasniemi 1984a, Steele et al. 1991). The association of TMD signs and migraine in both children and adults may, at least partly, be due to an overall pain sensitivity in migraine patients.

Association between signs of TMD and headache-related symptoms, sleeping difficulties, depressive symptoms and overall pain sensitivity

Even though studies on headache children have shown a clear association between headache and several factors, such as sleeping difficulties, depressive symptoms and overall pain sensitivity (Carlsson et al. 1996, Kristjansdottir 1997, Aromaa et al. 1998a,b, Guidetti et al. 1998, Anttila et al. 2001, 2002a,b, Laimi et al. 2007a,b), the association of these factors with TMD signs in our study was clearly shown only with neck muscle pain on palpation at both pre-pubertal and pubertal age. Dolorimeter values of the neck-shoulder region and the whole body area were associated with TMD signs at the age of 13. However, only a trend was observed between TMD signs and dolorimeter values of the neck-shoulder region at the age of 16. Tenderness on manual palpation has been reported to be a sensitive and specific test for disorders of pericranial muscles (Jensen & Olesen 1996). Also the sensitivity and specificity of the dolorimeter examinations in muscle tenderness have been evaluated in children (Neumann et al. 1996). There are studies in adults showing differences in the results when muscle pain has been evaluated with both methods. The result on manual palpation is dependent on the force used in the examination. In the studies by Jensen et al. (1993) and Jensen (1996), tenderness on palpation detected increased myofascial pain in patients with episodic tension-type headache, but the pressure pain threshold values were equal to those of healthy controls. On the contrary, dolorimeter values were also found to be in line with increased palpation tenderness in patients with chronic tension-type headache compared to healthy controls by Bendtsen et al. (1996). In the report by Anttila and co-workers (2002b) on the children of our study population, the mean pressure pain threshold values in the neck-shoulder region did not differ among children with primary headaches, while tenderness on manual palpation detected increased tenderness in pericranial points and neck-shoulder muscles in migraine children compared to children with tension-type headache or healthy controls. These findings could suggest that manual palpation may be more sensitive than dolorimeter examination, especially in milder pain conditions like TMD and episodic tension-type headache in children.

The other studied variables, depressive symptoms, sleeping difficulties, headache intensity, unilateral headache, headache aggravated by bright light, nausea or fainting sensation during headache attack, and headache frequency, showed no association with TMD signs. Studies on adults have shown an association between TMD and depressive symptoms or sleeping disorders (Epker et al. 2000, Sipilä et al. 2001, 2006, Rantala et al. 2004, Suvinen et al. 2005, Niemi et al. 2006). The reason why we did not observe this association may depend on the low scores of TMD signs in children and adolescents not showing the associations clearly enough.

Many studies on adults have shown the co-occurrence of TMD and other pains (Kirveskari et al. 1988, Sipilä et al. 2002, 2005, Rantala et al. 2004, Wiesinger et al. 2007), and there is evidence of altered pain perception in TMD patients compared to healthy controls (Maixner et al. 1995, 1998). An earlier study on adolescents with chronic TMD has shown that these patients have multiple pains, greater sensitivity to somatic stimuli, and a higher stress level than healthy controls (List et al. 2001, Wahlund et al. 2005). The co-occurrence of headache, TMD and neck pain could suggest a common pathogenesis, a causal association, or a common confounding factor. However, according to our results, it seems that these findings may be of a temporary or changing nature, with no permanent structural changes as yet in the muscles of children and adolescents.

Predicting factors for TMD signs

No subjective symptoms of TMD at the age of 13 years arose as predictors of later TMD signs. In the study by Magnusson and co-workers (2005), reported TMJ clicking predicted TMD symptoms 20 years later, whereas clinically recorded TMJ clicking predicted later TMD signs. Bruxism was a predictor for both TMD signs and symptoms. In our study, this could not be confirmed, but our follow-up was shorter than that of Magnusson et al. Neither did primary headache type nor headache-associated variables (sleeping difficulties, depressive symptoms, headache intensity or frequency, unilateral headache and headache aggravated by bright light) predict later TMD signs. It could have been expected that muscle tenderness and dolorimeter values of neck muscles might have had predictive value for TMD signs, because there was a clear association between TMD signs and neck muscle pain in both our cross-sectional studies. However, we could demonstrate only a trend ($p = 0.065$) of the dolorimetric values to predict later TMD signs. In the report by Laimi and co-workers

(2007b), measured neck muscle tenderness did not have predictive value for the outcome of headache. Instead, neck pain intensity (neck pain which interferes with daily activities) could increase headache frequency, especially in boys. Neck pain was not shown to predict change in primary headache type. There is still uncertainty about whether muscle tenderness is primary or secondary to headache (Bendtsen et al. 1996, Jensen 1999 review, Anttila et al. 2002b). The results of the present study and other reports on children and adolescents, have shown associations between single variables, but no clear causal trends have been found.

TMD signs and headache in children and their mothers

The reason for studying familial occurrence of TMD signs in a headache population, was the long follow-up time of these families with a large amount of available information. Among other things, familial occurrence of headache had been observed in this study sample (Aromaa et al. 1999). Therefore, it was thought that this study sample of headache children and headache-free healthy controls and their mothers might provide information not only about the familial occurrence of headache, but also about that of TMD. One could expect that headache as a sign of a symptomatic TMD might have a familial occurrence. On the other hand, children who suffer from headache from an early age could represent a group that is very different from a typical TMD patient group with the symptoms starting later in life. Mothers were chosen for the study as first-degree relative because earlier studies have shown that both headache and TMD are more common in women than in men (Steward & Lipton 1993, Conti et al. 1996, Kuttila et al. 1998). In our study sample, already at the age of 6 years, headache children had had more TMD-related signs and symptoms than control children (Aromaa et al. 1998b).

We could not demonstrate any association between children's and mothers' TMD signs in our study. This is in accordance with earlier studies, which have not been able to show any familial occurrence of TMD (Raphael et al. 1999, Michalowicz et al. 2000, List et al. 2001). There were, however, some differences in the study design of these studies. We focused on clinical signs of TMD, while Raphael and co-workers interviewed the subjects by phone, List and co-workers asked the children, and Michalowicz and co-workers interviewed and clinically examined twin pairs. However, the current results cannot exclude the possibility of a familial predisposition to the occurrence of TMD due to a variety of other causative factors. The co-occurrence of other causative factors such as occlusion or psychological stress may not be present in children at an early age in the same way as in mothers, so that it would form an effective causal complex of TMD. Thus, it is possible that the result might be different when the children reach an age when TMD signs and symptoms are more common. On the other hand, environmental and local factors may be more important than genetic factors regarding the occurrence of TMD. Pain experiences and behaviour seem to aggregate in certain families (Payne & Norfleet, 1986 review, Aromaa et al. 2000). There is a possibility that the child learns the model of stress and pain coping at home, and thus the behavioural model can be transmitted from one generation to the next (Minuchin et al. 1975).

8. CONCLUSIONS

The following conclusions can be drawn on the basis of the results:

- Girls have more TMD signs compared to boys at both pre-pubertal and pubertal age.
- TMD signs and symptoms are mostly mild and may change considerably during a 3-year follow-up.
- Both migraine and episodic tension-type headaches associate with TMD signs in 13-year-old children.
- Muscle tenderness in the neck-shoulder region is associated with TMD signs in children of 13 and 16 years of age.
- Occurrence of TMD signs seems unpredictable during adolescence.
- There is no familial occurrence of TMD signs in 13-year-old children with or without headache, and their mothers.

9. SUMMARY

This study was carried out to clarify the association between primary headaches and temporomandibular disorders (TMD) in children. It is a part of a long sequence of headache studies, which have focused on reasons for chronic headache in children and adolescents. The present study is based on two large samples of school children at the age of 13. The children in the first population-based study sample (n = 311) were followed for three years, and a re-examination was performed at the age of 16. In the second stratified random cluster study sample (n = 154), the mothers (n = 154) of the 13-year-old children were examined to study the occurrence of TMD and headache in two successive generations in a nested case-control setting.

The results showed that TMD signs and symptoms were mostly mild in children and adolescents, and a change in TMD signs was observed during the 3-year follow-up. Girls had more TMD signs than boys at the age of 13 and 16 in both study populations.

At the age of 13, TMD signs were associated with migrainous headache in the first study sample, and with both migraine and episodic tension-type headache in the second study sample. At the age of 16, no association was observed between TMD signs and headache in children. In mothers, the association was significant between TMD signs and migraine.

Neck muscle pain on manual palpation and on measurement with a pressure pain threshold dolorimeter was associated with TMD signs in 13-year-old children. At the age of 16, neck muscle pain on palpation was associated with TMD signs. No association was observed between TMD signs and depressive symptoms, sleeping fewer hours per night, headache frequency, headache intensity, unilateral headache, or headache aggravated by bright light.

Neither the studied headache-associated variables nor type of headache predicted later TMD signs. No familial occurrence of TMD signs was observed between the 13-year-old children and their mothers.

The results of the present study indicate that children with headache, especially with migraine, are probably more prone to other pain conditions, including TMD and neck-shoulder pain. It seems that the complex co-occurrence of headache, TMD and neck-shoulder pain at the ages of 13 and 16 may be of a temporary or changing nature with no permanent structural changes, as yet.

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12. APPENDIX

Stomatognathic interview

1. Have you had any previous ortodonthic or stomatognathic treatment? Yes / No
2. Have you heard sounds from the TMJ during mandibular movements?
   1 = no TMJ sounds
   2 = clicking sometimes
   3 = clicking continuously
   4 = crepitation
3. Have you had any of the following symptoms?
   1 = tiredness or stiffness of the mandible
   2 = intermittent locking of the mandible
   3 = continuous difficulties in opening the mouth
   4 = luxation of the mandible
   5 = pains on wide opening of the mouth
   6 = none of the symptoms mentioned above
4. Have you had pain during mastication?
   1 = no
   2 = pain in teeth
   3 = pain in TMJ or muscles in front of the ear
5. Have you had ear symptoms not associated with flu or otitis?
   1 = earache
   2 = tinnitus or hum
   3 = fullness (or fluid) in the ears
   4 = no ear symptoms
6. Have you felt a choking lump in your throat not associated with major sensations or feelings?
   1 = no
   2 = seldom (less than once a month)
   3 = often or all the time
7. Have you had difficulties in swallowing?
   1 = no
   2 = occasionally
   3 = often or continuously
8. Have you had hoarseness or loss of voice not associated with a common cold?
   1 = no
   2 = occasionally (1-2 times during the last year)
   3 = often
9. Have you noticed keeping your teeth tightly together (clenching) in any situations other than eating?
   1 = no
   2 = occasionally
   3 = often
   4 = nocturnal grinding

Stomatognathic clinical examination

1. Maximal active opening _______ mm   Overbite _______ mm

    Pain on movement:

    Yes / No, Left, degree _______   Right, degree _______

2. Locking, luxation: Yes / No
3. Maximal deviation in opening-closing _______ mm
4. Maximal lateral movement to the right _______ mm

    Pain on movement: Left, Yes / No, degree _______

    Pain on movement: Right, Yes / No, degree _______

5. Maximal lateral movement to the left _______ mm

    Pain on movement: Left, Yes / No, degree _______

    Pain on movement: Right, Yes / No, degree _______

6. Maximal protrusion _______ mm

    Pain on movement: Left, Yes / No, degree _______

    Pain on movement Right, Yes / No, degree _______

7.1. Palpation tenderness in anterior temporal muscle:

Left, Yes / No, degree _______

7.2. Palpation tenderness in posterior temporal muscle:

Left, Yes / No, degree _______

8.1. Palpation tenderness in anterior temporal muscle:

Right, Yes / No, degree _______

8.2. Palpation tenderness in posterior temporal muscle:

Right, Yes / No, degree _______

9.1. Palpation tenderness in deep portion of masseter muscle:

Left, Yes / No, degree _______

9.2. Palpation tenderness in superficial portion of masseter muscle:

Left, Yes / No, degree _______

10.1. Palpation tenderness in deep portion of masseter muscle:

Right, Yes / No, degree _______

10.2. Palpation tenderness in superficial portion of masseter muscle:

Right, Yes / No, degree ______

11. Palpation tenderness in medial pterygoid muscle:
    Left, Yes / No, degree _______
12. Palpation tenderness in medial pterygoid muscle:
    Right, Yes / No, degree _______
13. Palpation tenderness in posterior portion of digastric muscle:
    Left, Yes / No, degree _______
14. Palpation tenderness in posterior portion of digastric muscle:
    Right, Yes / No, degree _______
15. Palpation tenderness in insertion of temporal muscle:
    Left, Yes / No, degree _______
16. Palpation tenderness in insertion of temporal muscle:
    Right, Yes / No, degree _______
17. Palpation tenderness in lateral pterygoid muscle:
    Left, Yes / No, degree _______
18. Palpation tenderness in lateral pterygoid muscle:
    Right, Yes / No, degree _______

19.	TMJ tenderness: Lateral:	Left,	Yes / No,	degree _______
20.	TMJ tenderness: Lateral:	Right,	Yes / No,	degree _______
21.	TMJ tenderness: Dorsal:	Left,	Yes / No,	degree _______
22.	TMJ tenderness: Dorsal:	Right,	Yes / No,	degree _______
23.1.	TMJ sounds with palpation:	Left,	Yes / No,	degree _______
23.2.	TMJ sounds with stethoscope:	Left,	Yes / No,	degree _______
24.1.	TMJ sounds with palpation:	Right,	Yes / No,	degree _______
24.2.	TMJ sounds with stethoscope:	Right,	Yes / No,	degree _______
25.	Tooth contact in RCP:	Left,	Yes / No	
26.	Tooth contact in RCP:	Right,	Yes / No	

27. Difficulties in guiding the mandible in CR:
    Easy / Stiff / Difficult / Pain during manipulation: Left / Right

13. ORIGINAL PUBLICATIONS