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TEMPOROMANDIBULAR DISORDERS

IN THE ELDERLY

A 5-YEAR FOLLOW-UP OF SIGNS AND SYMPTOMS OF TMD

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Academic dissertation
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Contents

Abstract

Hiltunen K. Temporomandibular disorders in the elderly. A 5-year follow-up of signs and symptoms of TMD. Department of Stomatognatic Physiology and Prosthetic Dentistry, Institute of Dentistry, University of Helsinki, Finland, 2004.

Temporomandibular disorders (TMD) are widely studied in the younger population but not in older subjects. Because previously reported associations of TMD with radiographic findings and occlusal support status are unclear and controversial, updated knowledge about these associations is therefore needed when planning oral rehabilitation meant especially for elderly subjects.

The present study is part of the Helsinki Aging Study, a population-based medical and oral survey, on a random sample of subjects born in 1904, 1909, and 1914. Study of the TMD included a questionnaire and clinical and radiographic baseline and 5-year follow-up examinations. At baseline, in 1990-1991, a total of 364 subjects aged 76, 81, and 86 years filled in the questionnaire and participated in clinical examinations; 294 of these participated in a radiographic examination. After 5 years, 112 subjects participated, which provided complete longitudinal data on 94 elderly 81-, 86-, and 91-year-old subjects.

Subjective symptoms and clinical signs of TMD were assessed by Helkimo anamnestic and clinical indices, the occlusal support status by the Eichner index with and without removable dentures. Radiographic status was assessed by panoramic radiographs of mandibular condyles.

Subjective symptoms and clinical signs of TMD decreased with age, the most severe signs disappearing in the 5-year follow-up. Women had more symptoms than did men: 34% vs. 4% at baseline and 28% vs. 8% at the end of follow-up. Occlusal support status with and without removable dentures was associated neither with subjective symptoms nor with clinical signs of TMD. At baseline, radiographic findings appeared in the condyles in 36% of the 76-year-olds and in 24% of the 86-year-olds. Flattening of the condyle was the most common of the radiographic findings, appearing in 17% of all subjects at baseline and in 13% at follow-up. Among the oldest, flattening of the condyle appeared in 18% at baseline and in 9% at follow-up of the same subjects. These changes were unrelated to occlusal support status with or without removable dentures. Changes in other radiographic findings during follow-up were minimal. Based on the present study, it can be concluded that risk for TMD signs and symptoms in the elderly is low, having no associations with occlusal support status either with or without removable dentures. In addition, radiographic findings in the mandibular condyle were not associated with occlusal support status with or without removable dentures. Based on the present results, prosthodontic treatment can be recommended to the very old elderly only for prosthodontic indications, not with the aim to treat or prevent TMD signs and symptoms.

1. List of original publications

I. Schmidt-Kaunisaho K, Hiltunen K, Ainamo A. Prevalence of symptoms of craniomandibular disorders in a population of elderly inhabitants in Helsinki, Finland. Acta Odontol Scand 1994;52:135-139.

II. Hiltunen K, Schmidt-Kaunisaho K, Nevalainen J, Närhi T, Ainamo A. Prevalence of signs of temporomandibular disorders among elderly inhabitants of Helsinki, Finland. Acta Odontol Scand 1995;53:20-23.

III. Hiltunen K, Vehkalahti M, Ainamo A. Occlusal imbalance and temporomandibular disorders in the elderly. Acta Odontol Scand 1997;55:137-141.

IV. Hiltunen K, Vehkalahti MM, Peltola JS, Ainamo A. A 5-year follow-up of occlusal status and radiographic findings in mandibular condyles of the elderly. Int J Prosthodont 2002;15:539-543.

V. Hiltunen K, Peltola JS, Vehkalahti MM, Närhi T, Ainamo A. A 5-year follow-up of signs and symptoms of temporomandibular disorders and radiographic findings in the elderly. Int J Prosthodont 2003;16:631-634.

1. Abbreviations

Ai	Helkimo´s anamnestic index for subjective symptoms
CMD	craniomandibular dysfunction
CNS	central nervous system
CT	computerized tomography
Di	Helkimo`s index for clinically diagnosed signs
E t+br	Eichner index for occlusion with natural dentition including fixed constructions
E t+br+p	Eichner index for occlusion with natural dentition including fixed constructions and removable dentures
HAS	Helsinki Aging Study
MD	mandibular dysfunction
OAi	osteoarthritis
OAo	osteoarthrosis
TMD	temporomandibular disorders
TMJ	temporomandibular joint
95% CI	95% confidence interval

3. Introduction

A trend common to Scandinavian and most industrialized countries is the rapid growth of the oldest age group. From among all those old elderly or very old aged 75 and more, the proportion of those 85 years and older is predicted to increase to about one-third of the elderly population by 2030 (Ainamo and Österberg 1992, Official Statistics in Finland 2003, McMichael et al. 2004). Limited information is available concerning home-dwelling elderly and their oral health, the common belief being that oral status deteriorates with aging (MacEntee and Scully 1988). In the present study, the terms elderly, old elderly, or very old population refer to those aged 75 years or older.

The first epidemiological studies of temporomandibular disorders (TMD) were carried out in the 1970s in Scandinavia. Agerberg and Helkimo published their doctoral dissertations in 1974, and Helkimo developed his dysfunction indices, which are still in use (Helkimo 1974). At the same time, several other researchers in Scandinavia published their early works on TMD: Agerberg and Carlsson (1972), B Heløe and LA Heløe (1978), Kirveskari (1978), Magnusson (1981), Egermark-Eriksson (1982), and Mejersjö (1984).

The term TMD includes many disorders, including masticatory muscle disorders such as myositis, muscle spasm, muscle contracture, and myofascial pain syndrome; temporomandibular joint disorders such as inflammatory disorders and derangements of the condyle-disk complex; and chronic mandibular hypomobility and growth disorders (Bell 1985, Okeson 2003). Recent studies have concluded that the signs and symptoms of TMD are common in non-patient populations (de Kanter 1993, Ow 1995, Matsuka 1996, Pow 2001, Wahlund 2003, Gesch 2004). Gender differences indicate that usually more women than men suffer from TMD (Carlsson 1984, Johansson et al. 2003). Risk for TMD at an older age has been minimal (Österberg et al. 1992, de Kanter 1993, Matsuka et al. 1996, Pow 2003), but controversial results have also appeared (Swanljung and Rantanen 1979, Agerberg and Bergenholtz 1989, Dworkin et al. 1990, Salonen et al. 1990), probably because of differences in definitions of signs and symptoms of TMD. Individuals seeking professional help for TMD seem to be predominantly women between 20 to 40 (Helkimo 1979, Rieder et al. 1983, de Kanter et al. 1993).

The relationship between occlusal status and TMD is unclear and controversial. Discussion as to the need to replace missing posterior teeth in the elderly population to prevent the signs and symptoms of TMD continues with no consensus (Zarb et al. 1978, Käyser 1981, de Boever and Adriaens 1983, de Boever et al. 2000). Since implantology is nowadays a common prosthodontic therapy, the desire to

replace all missing premolars and molars is increasing also in regard to elderly patients (Bryant and Zarb 2002). According to traditional beliefs, TMD increases concomitant with the loss of natural teeth (de Boever 1979), but TMD patients represent all types of morphologic and functional occlusal factors (McNamara et al. 1995). According to Käyser (1981) absence of molar support is not a risk for TMD, and wearing removable dentures has little impact on that risk (Witter et al. 1994). Maintenance of natural dentition or provision and maintenance on dentures may also have an impact on quality of life and nutrient intake (Marshall et al. 2002). Age and reduction in dental arch may be involved in disintegration of load-bearing surfaces of TMJ (Luder 2002).

Studies of degenerative joint disease have confirmed continual change in the surface of the mandibular condyle (Boering 1966, Kreutzieger and Mahan 1975, Sato et at. 1996). Confirmation of changes in the bony part of the mandibular condyle by radiographic examination is necessary (Larheim 1995). Loss of molar support, tooth wear, and asymmetrical occlusion all has an impact on radiographically confirmed findings in the osseous part of the temporomandibular joint (TMJ) (Griffin et al. 1979, Hodges 1991). Loss of molar support is may be involved, particularly in the initiation of lesions in mandibular condyles beginning along load-bearing surfaces (Luder 2002). On the other hand, several studies offer no support to the concept of replacing missing molars routinely to prevent osteoarthrosis of the TMJ (Axelsson et al. 1987, Whittaker et al. 1990, Holmlund and Axelsson 1994, Widmalm et al. 1994).

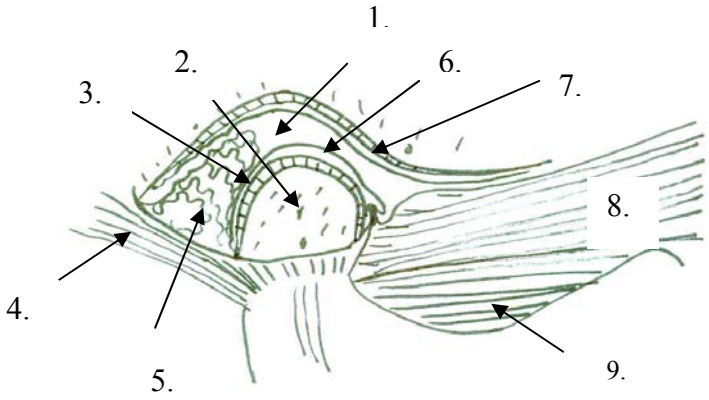
4. Review of the literature

4.1. Masticatory system

The masticatory system is extremely complicated (Itoh 2000). Movements of the jaw are regulated by an intricate and a peripheral neurologic system (Okeson 2003). Knowledge of the anatomy and function of the system is compulsory for understanding the main problems of the system.

4.1.1. TMJ and masticatory muscles

The temporomandibular joint (TMJ) is considered one of the most complex joints of the body (Haley et al. 2001). It is formed by the mandibular condyle fitting into the mandibular fossa of the temporal bone, and the articular disk between these permits movement of the joint (Haley et al. 2001, Emshoff et al. 2002). The TMJ is classified as a compound joint made up of two bones and the disk between the bones, a disk considered functioning like a third bone (Okeson 2003). (Fig. 1).



1. Disk
2. Condyle
3. Fibrocartilage
4. Capsular ligament
5. Retrodiscal tissue
6. Inferior joint cavity
7. Superior joint cavity
8. Superior lateral pterygoid muscle
9. Inferior lateral pterygoid muscle

Figure 1. Temporomandibular joint (with permission modified after Okeson 2003).

Four pairs of muscles form the muscles of mastication: the masseter, the temporalis, the medial pterygoid, and the lateral pterygoid. In addition, the digastric plays an important role in mandibular function (Okeson 2003) (Fig. 2). Jaw muscles in many ways differ from other skeletal muscles, among other differences, in having few slow, fatigue-resistant motor units (Hannam and McMillan 1994).

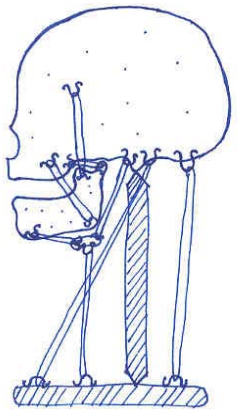


Figure 2. The jaw muscles act like elastic bands affecting the movements of each other (with permission modified after Okeson 2003)

The masseter is a rectangular muscle that originates from the zygomatic arch and extends downward to the lateral aspect of the lower border of the ramus of the mandible. This muscle is made up of superficial and deep portions or heads and makes possible the elevation and protrusion of the mandible and efficient chewing (Itoh 2000).

The temporalis is a large, fan-shaped muscle that originates from the temporal fossa and the lateral surface of the skull. The temporalis forms a tendon that inserts on the coronoid process and the anterior border of the ascending ramus, and is made up of anterior, middle, and posterior portions. The direction of its function is mainly elevation and retrusion (Itoh 2000).

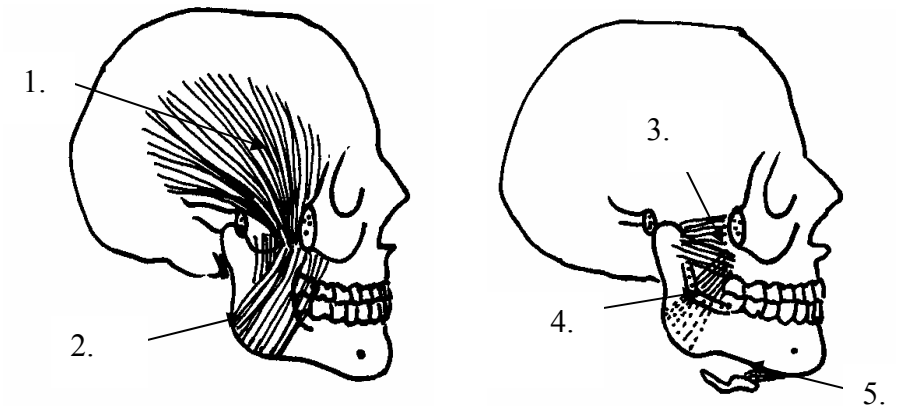
The medial pterygoid originates from the pterygoid fossa and extends downward, backward, and outward, to insert along the medial surface of the mandibular angle. As does the masseter, it forms a sling to support the mandible. While this muscle is contracting, the mandible is elevated, protrudes, or moves laterally (McDevitt 1989).

The two bellies of the lateral pterygoid function differently and are even considered to be different muscles. The inferior belly originates at the outer surface of the lateral pterygoid plate and extends backward, upward, and outward to its insertion into the pterygoid fovea on the anterior surface of the condylar neck. This muscle contracts when the mandible protrudes or moves laterally or downward (Mahan et al. 1983, ten Cate 1994).

The superior belly originates at the infratemporal surface of the greater sphenoid wing, extending almost horizontally, backward and outward, to its insertion on the articular capsule, the disc, and the neck of the condyle. The majority of the fibers of the superior lateral pterygoid attach to the neck of the

condyle (Okeson 2003); the superior portion remains inactive during opening. This muscle is active especially during clenching the teeth (McDevitt 1989).

The digastric is divided into two bellies. The posterior belly originates from the mastoid notch, the fibers running to the intermediate tendon attached to the hyoid bone. The anterior belly originates at the fossa on the lingual surface of the mandible and inserts into same intermediate tendon as does the posterior belly. This muscle functions during backward motion of the mandible and swallowing (Okeson 2003). (Fig. 3).



1. Temporal muscle
2. Masseter muscle
3. Lateral pterygoid muscle
4. Medial pterygoid muscle
5. Digastric muscle

Figure 3. Masticatory muscles.

Sensory receptors are neurologic structures providing information to the central nervous system (CNS). They monitor the status of muscles, tendons, joints, periosteum, fascia, and subcutaneous tissues. To provide mandibular movements, the CNS needs precise information received through afferent fibers, an input that creates contraction or inhibition of the muscle groups. Muscle activity is determined in the CNS, and is affected by a complex response system (Okeson 2003).

4.1.2. Occlusion: dentition, partial dentition, and edentulousness

Optimal occlusion is considered to consist of the maximal possible amount of tooth contact of antagonist jaws, being even and simultaneous. Contact between the teeth occurs at the end-point of mandibular closure when the teeth in the upper jaw meet the teeth in lower jaw, and when the

mandibular condyle is in the most super anterior position and resting against the posterior slope of the articular eminence with the disc properly positioned (Posselt 1952). The force directed to each individual tooth should go through its long axis (Korioth and Hannam 1990). The harmful type of tooth contact, called occlusal disturbances, are widely discussed, being so common in the non-patient population that it is difficult to consider one perfect occlusion type as possible (Seligman and Pullinger 1991).

Much discussion has concerned missing molar teeth (De Boever 1979, Hylander 1979, Kirveskari and Alanen 1985, Zarb and Carlsson 1994, Sato et al. 1996, de Boever et al. 2000). Replacement of these teeth is justified by osteoarthritis of the joints, unfavorable loading of the joint, pain, and dysfunction (Hylander 1979, Kirveskari and Alanen 1985, Abdel-Fattah 1996, Hatch et al. 2001). Suitable and desirable dentures fulfill the function of partial dentition, improve masticatory function or appearance, and minimize damage to the remaining teeth or other tissues (Drummond et al. 1995, Mohl et al. l988). To treat edentulousness, the possibilities are few: conventional complete dentures or dental implants (implant-supported over-dentures or fixed contructions). Implants are considered to improve jaw movement and velocity (Naert et al. 1983), although it is also assumed that aging has a more important effect on decrease in velocity than does the state of the dentition (Karlsson et al. 1991).

Several methods to evaluate occlusal support status are the Eichner index, functional tooth units, good or bad quadrants, or occlusal units (Eichner 1955, Käyser 1981, Gordon et al. 1994, Hatch et al. 2001). A modified version of the original Eichner index was created to evaluate the support of removable dentures, as well (Österberg and Landt 1976).

4.1.3. Changes in masticatory system with increasing age

The basic concept of aging is loss of the organism's adaptability. Aging is an intrinsic mechanism influenced by a whole series of extrinsic factors (Pathy 1991). Several changes affect oral health: periodontal tissues are affected by the altered immune response, the oral mucosa loses its epithelial thickness, several conditions affect saliva secretion, the soft tissue changes, loss of teeth affects bite force and bone structure, and adaptation decreases (Grant et al. 1994, Drummond et al. 1995, Raustia et al. 1996, Närhi 1998, Hatch et al. 2001). It is also discernable that age constitutes the predominant factor associated with degeneration of the TMJ, even with other known age-related factors controlled for (Luder 2002).

Age is currently thought to be the cumulative cause of a multitude of minor influences (Ship et al. 1996, Hatch et al. 2001). The influence of age on masticatory muscles is in reduction of muscle mass, development of aponeurotic structures, significant reduction in maximum tension, and loss of isometric and dynamic muscle strength (Drummond et al. 1995, Raustia et al. 1996, Brunel et al. 2003). The effect of tooth loss on masticatory muscles is controversial (Newton et al. 1993, Raustia et al. 1996, Miura et al. 2001, de Boever et al. 2000, Österberg et al. 2002), although the number of functional units and bite force have been assumed to be the key factors for masticatory function or performance (Boretti et al.1995, Hatch et al. 2001, Österberg et al. 2002). Reduced mechanical load due to tooth loss affects the density, stiffness, and strength of bone structure (Giesen et al. 2003). The difference between dentate and edentulous subjects also involves bone mass, morphology, and mechanical properties of components of the masticatory system, e.g., teeth, muscles, mandibular condyles, and the position of the glenoid fossa (Hongo et al. 1989, Kawashima et al. 1997, Raustia et al. 1998, Bassi et al. 1999, Giesen et al. 2003).

Impaired adaptability and general physical slowing accompany aging. Impaired adaptability depends partly on poor function of the homeostatic system, and general slowing affects all levels of the nervous system (Marshall 1987). For instance, headache is ranked as one of the most frequent complaints in the elderly (Hale et al. 1986). Headaches often caused by depression (Wang et al. 1999), of course affects day-to-day coping.

4.2. History, terminology, and definitions of TMD

The history of temporomandibular disorders began in 1934 when studies of signs and symptoms of the Costen syndrome were published (Costen 1934). In 1966, Krough-Poulsen made a list to screen the symptoms of craniomandibular disorders (CMD). The list comprised limited mouth opening, deviation of the mandible, pain of the musculature and the TMJ, occlusal disharmony, occlusal wear, local and aspecific changes in the periodontal tissues, and tooth mobility.

Longitudinal and epidemiological studies of TMD have been contributed by several researchers from Scandinavia (Agerberg and Carlsson 1972, Helkimo 1974, Heløe 1980, Magnusson 1981, Egermark-Eriksson 1982, Mejersjö 1984, Wedel 1988) (Table 1).

The terminology of TMD is confusingly extensive, such as mandibular stress syndrome (Ogus and Toller 1981), craniomandibular dysfunction (CMD) (Zarb 1985), mandibular dysfunction (MD) (Zarb 1979), myoarthopathy of the TMJ (Graber 1972), occlusomandibular disturbances (Gerber 1971),

functional TMJ disturbances or disorders (Ramfjord and Ash 1971), arthrosis deformans of the TMJ (Boering 1966), and Costen syndrome (Costen 1934). Bell (1983), Griffiths (1983), and McNeill and co-workers (1990) introduced the most recent term, "temporomandidular disorders" (TMD).

4.2.1. Symptoms and signs of TMD

The term TMD describes diffuse pain and uncomfortable symptoms troughout the masticatory system: teeth, muscles, neuromuscular system, and joint. Essential symptoms or signs are considered to be: pain and tenderness in and around the TMJ and in the chewing muscles, impaired mobility of the mandible, and TMJ sounds (de Boever 1979). The symptoms and signs of TMD include disorders related to the TMJ and masticatory system and should be considered as a multiple group of fluctuating symptoms (de Boever and Carlsson 1994).

The Helkimo dysfunction indices Ai and Di are tools to gather the different symptoms and signs into one particular index value (Helkimo 1974). Helkimo in 1974 specified dysfunction by its symptoms: pain, tenderness, limited function, and TMJ sounds. The indices he created are still widely used in epidemiological studies, although criticism also has arisen (van der Weele and Dibbets 1987, Kopp 1976, Carlsson et al. 1980, Mejersjö and Carlsson 1983), and several efforts have been made to improve these indices (Smith 1981, Fricton 1986, van der Weele and Dibbets 1987).

Okeson (2003) made up three categories of symptoms and signs according to the affected structures: the muscles, TMJ, and the dentition. A symptom is considered to be a complaint reported by the patient and a sign an objective clinical finding diagnosed by the dentist during examination (Okeson 2003). A generally known fact is that the number and severity of the patient´s symptoms and the clinically diagnosed signs do not necessarily match.

4.2.2. Prevalence and etiology of TMD in the adult and elderly populations

Many researchers who have concentrated on studying the elderly are in Scandinavian countries (Österberg and Carlsson 1979, Budtz-Jörgensen et al. 1985, Tervonen and Knuuttila 1988, Agerberg and Bergenholtz 1989, Salonen et al. 1990, Österberg et al. 1992). Outside Scandinavia are researchers such as Zarb (1979), McCarthy and Knazan (1987), and Harriman and co-workers (1990) (Table 1).

Helkimo (1974), studing prevalences in a population of Lapps in the north of Finland, found that 57% of the population suffered from anamnestic symptoms, and 88% were diagnosed as having clinical signs. In 1990 de Kanter reviewed the published studies of TMD and found a range of 11% to 58% for

anamnestic symptoms and 28% to 88% for clinical signs. In his studies of the adult Dutch population, approximately 5% had moderate to severe signs and symptoms depending on age, gender, and status of dentition (de Kanter 1990).

Usually the term "elderly" refers to the population aged over 65 years. Interest in the elderly population has recently grown because of this proportion of the age group in industrialized counties has increased (Kochaned and Smith 2002). Several studies have indicated an increased risk for TMD with advancing age (Swanljung and Rantanen 1979, Tervonen and Knuuttila 1988, Agerberg and Bergenholtz 1989, Salonen et al. 1990); opposing studies have reported lower frequencies of symptoms with increasing age (Österberg et al. 1992). Some studies have even shown no relation to age (Harriman et al. 1990, Dworkin et al. 1990).

Before the consensus — although vacillating — concerning etiologic factors, several theories existed: mechanical displacement, psychophysiology, neuromuscular, muscle, and psychologic theories. Ramfjord and Ash (1971) supported the muscular and neuromuscular theory associating occlusion with dysfunction. Their conclusion was that the adaptive capacity of adult TMJ is limited. In agreement with them were Boering (1966) and de Bont (1985), who studied the association between the TMJ and the function of the masticatory system. Solberg and co workers (1985) followed with their theory of "deviation in form". The multifactorial etiological approach has been widely discussed, and de Boever (1979) concluded that etiology is a combination of dental, psychological, and muscular factors.

The generally accepted etiologic concept nowadays is the multifactorial and biopsychosocial approach (de Boever and Carlsson 1994, Okeson 2003). The group of factors said affecting simultaneously is anatomical, neuromuscular, and psychological. Trauma, anatomy, and general diseases besides the above factors confuse the etiologic portrait even more. The balance between function and dysfunction is said to be dynamic and periodic (de Boever and Carlsson 1994). For instance, condylar displacement (Stohler 1994), internal derangement, and osteoarthrosis (Zarb and Carlsson 1994) can be considered either the cause or result of TMD (de Boever and Carlsson 1994). Studies with different designs have changed the role of occlusion as an etiologic factor; nowadays, it is considered to be a TMD-related or a co-etiologic factor (Könönen et al. 1987, Szentpétery et al. 1987, Pullinger et al. 1988, Kirveskari et al. 1989, Runge et al. 1989).

4.2.3. Treatment need for TMD

The early epidemiologic studies of TMD estimated that 20% to 25% of the general population had severe signs of dysfunction and were in need of treatment (Helkimo 1979). After knowledge of TMD increased, estimations of treatment need have decreased, although opinions vary greatly (Carlsson 1984, Rugh and Sohlberg 1985, De Kanter et al. 1990, Magnusson et al. 1991). In recent studies, the group needing active treatment was about 10% (Kuttila et al. 1997, Magnusson et al. 2002). In the older population however, the need or demand for treatment seems to decrease with age (Greene 1994). It is obvious that it is impossible to relate these prevalence figures directly to treatment need, while etiology, diagnosis, and definitions have led to variation in estimations (Magnusson et al. 1991, Zarb and Carlsson 1994).

Table 1. Epidemiological studies (N ≥ 100, age ≥ 50) based on signs (Di) and symptoms (Ai) of TMD.

Author/ year	N	Male/ female	Age	Di(%)	Ai(%)	R/S	population & method
Agerberg et al. 1974	194	86 108	70	74	23	R	citizens in Sweden: TMD def-; H-ind-
Helkimo 1974	321	156 165	15-65	88	57	R	Lapps in Finland: TMD def+; H-ind+
Hansson et al. 1975	1069	987 82	10-79	79	23	S	workers in Sweden (reported symptoms 6-23): TMD def-; H-ind-
Heloe et al. 1978	241	113 128	65-79	27	8	R	Norway (sign: clicking and crepitation, symptom: pain): TMD def-; H-ind -
Norheim et al. 1978	332	163 169	20-69	—	15	R	village in Norway (grinding was included to symptoms): TMD def-; H-ind-
Swanljung et al. 1979	583	238 345	18-64	41	58	R	citizens in Finland: TMD def-; H-ind-
Österberg et al. 1979	384	186 198	70	86	59	R	citizens in Sweden: TMD def-; H-ind+
Ingervall et al. 1980	389	389 —	21-54	60	15	S	soldiers in Sweden: TMD def-; H-ind+

Rao et al. 1981	1187	626 561	16-56	20	—	S	patients of dental clinics (men having more symptoms): TMD def+; H-ind-
Alanen et al. 1982	599	599 —	18-62	30	—	R	sick-leaves in shipyard: TMD def+; H-ind-
Abdel-Hakim 1983	215	215 —	17-65	39	8-24	S	Bedouins in Egypt (Di: palpated muscles, Ai: diff symptoms): TMD def-; H-ind-
Gross et al. 1983	1000	407 593	3-89	31	—	R	patients of general dental practice (Di: clicking): TMD def-; H-ind-
Mohlin 1983	272	— 272	20-45	66	37	R	citizens in Sweden: TMD def-; H-ind
Rieder et al. 1983	1040	387 653	13-86	50	—	S	patients of private pract. in USA (max. signs and symptoms): TMD def-; H-ind –
Budtz-Jörgen-sen et al. 1985	146	81 65	60-75	71	—	S	dental clinic patients in Denmark: TMD def-; H-ind-
Szentpétery et al. 1986	600	285 315	12-85	80	21	R	urban residents in Hungary: TMD def-; H ind+
Locker et al. 1988	677	300 377	18-65	—	49	R	citizens in Canada (telephone survey): TMD def-; H-ind+
Tervonen et al. 1988	1275	584 691	25-65	44	—	R	age cohort study in Finland: TMD def-; H-ind-
Agerberg et al. 1989	1992	995 997	25-65	25	—	R	Sweden (Di: clicking sounds): TMD def-; H-ind-
Locker et al. 1989	148	57 91	18-82	82	64	R	subsample of 1988 study ((n=677) true positives report pain): TMD def-; H-ind+

Agerberg et al. 1990	637	314 323	18-64	88	10-18	R	urban residents: TMD def-; H-ind+
Duckro et al. 1990	500	251 249	21-65	—	30	R	telephone survey (bruxism included in symptoms) TMD def -; H-ind-
Dworkin et al. 1990	1016	— —	18-75	35	12	R	citizens in USA (different groups): TMD def; H-ind-
Harriman et al. 1990	117	— 117	75-94	22	—	S	nuns (signs and symptoms pooled): TMD def-; H-ind-
Salonen et al. 1990	967	477 490	20-80	54	40-20	R	Swedish population (Di increased with age, Ai decreased): TMD def+; H-ind +
Mazengo et al. 1991	100	61 39	35-74	40	26	R	Tanzanians: TMD def-; H-ind-
Mercado et al. 1991	201	48 153	47-89	30	—	S	complete denture wearers: TMD def-; H-ind-
Jagger et al. 1992	219	100 119	16-80	34	36	R	routine dental patients (Di: muscle tenderness, Ai: joint sounds): TMD def+ ;H-ind-
de Kanter et al. 1993	3468	1653 1815	15-74	44	22	R	nationwide study of Dutch population: TMD def+; H-ind+
Ow et al. 1995	891	312 579	55-91	—	22	R	elderly Singapore citizens (decreasing symptoms with age): TMD def+; H-ind+
Matsuka et al 1996	672	304 368	20-92	21	24	R	Japanese population (Di: masticatory muscle tenderness, Ai: TMJ sounds, signs and symptoms decreased with age): TMD def-; H-ind-
Gray et al. 1997	160	70 90	31-70	18	27	S	complete denture wearers ((80) and dentate subjects (80); Di: joint tenderness Ai: direct questions; dentate subjects had more signs and symptoms)TMD def-; H-ind-

Pow et al. 2001	1526	768 758	18-55	—	33	R	telephone survey in China (prevalence of jaw pain): TMD def-: -ind-
Johansson 2003	6043	3010 3033	50	—	12 16	R	mail questionnaire (Ai: joint sounds): TMD def-; H-ind-

Di= clinical signs
Ai=subjective signs
R= randomly selected population
S=selected population
TMD def= includes definition of temporomandibular disorders
H-ind= Helkimo indices
— = no information

4.3. Radiography of the mandibular condyle

A functional impairment in the masticatory system can cause diagnostic difficulties, because causes can be various (Magnusson and Karlsson 2002). To evaluate differential diagnoses and exclude other kinds of pathological conditions with painful TMD, radiographic examination of the patient is essential (Mejersjö and Hollender 1984). As radiographic changes in the TMJ develop late after the acute phase, the radiographic examination is said to play a minor role in diagnosis and management, however (Nilner and Petersson 1995).

Different types of radiographic modalities are appropriate for TMJ radiographic examination (Larheim 1995). For basic information, the panoramic radiograph is suitable (Habets et al. 1989, Magnusson and Karlsson 2002) and is also justified by its small dose of radiation (Danforth and Clark 2000) and for providing sufficient information on TMJ pathology (Blair and Chalmers 1972, Habets et al. 1989). A cursory visualisation of connecting tissues in the maxilla and mandible is also obtained (Howard 1990), although the panoramic radiograph has been criticized in regard to uncertainties in the structures and debatable value of the information (Brooks et al. 1997, Sato et al. 1996).

A three-dimensional TMJ view is possible with a set of films: axial projection, lateral oblique transcranial projection, and transorbital projection. The evaluation of slight changes in bony structure of the TMJ is considered insufficient (Brooks et al. 1997). For further examination, conventional tomography, computerised tomography (CT), and magnetic resonance imaging (MRI) techniques are available (Brooks et al. 1997). The most recent and promising technique is panoramic digital subtraction radiography (Masood et al. 2002).

4.3.1 Radiographic findings in the mandibular condyle in the elderly population

Degenerative abnormality of the temporomandibular joint of the mandibular condyle is generally regarded as osteoarthrosis, as it is a common finding in the elderly (Boering 1966). The term osteoarthritis in the TMJ is often used when symptoms (e.g., pain, limited opening) are connected with a joint disorder, whereas an asymptomatic degenerative condition in the TMJ is called osteoarthrosis (Zarb and Carlsson 1994). If the degenerative disease in the joint is considered to be a continuing process the following alternative categories are acceptable: osteoarthritis (OAi), osteoarthrosis (OAo), and polyarthitides (Okeson 2003).

According to Okeson (2003), OAi, also known as degenerative joint disease, is one of the most common arthritides affecting the TMJ. The factor most common in OAi is assumed to be overload of

the joint after disk dislocation and retrodiscitis. This is an inflammatory condition in which the articular surfaces and their underlying bone deteriorate (Stegenga et al. 1989, Stegenga et al. 1991, Luder 2002, Okeson 2003). Generally pain and limited mandibular opening are associated, and the crepitation can be typical. Diagnosis can be confirmed by radiographic examination. The usual findings are in the subarticular bone of the condyle or fossa: flattening, osteophytes, erosion, microcysts, subcortical sclerosis, or periarticular ossicles (Stegenga et al. 1991).

After the active phase (OAi), the condition of the TMJ bone can stabilize, but at least model and structure have been altered. The non-inflammatory and adaptive stage has been referred to as OAo (Stegenga et al. 1991, Luder 2002, Okeson 2003). As with OAi, the cause of OAo is thought to be overloading, bony adaptation to functional demands, or a normal physiologic process when the condyle is adapting to changes in occlusal status and vertical height (Tzakis et al. 1994, Holmlund and Axelsson 1994). A considerable variation occurs in the normal morphology of each human condyle: as it is not unusual that the right and left condyle differ (Pharoah 1999).

5. Aims of the study

To study in a very old population:

1. prevalence of symptoms of TMD (I).

2. prevalence of signs of TMD (II).

3. impact of occlusal status on TMD (III).

4. radiographic findings and their associations with TMD and occlusal status (IV-V).

6. Hypotheses of the study

(only H_1 is shown for each hypothesis)

1. Signs and symptoms of TMD in the elderly decrease with age (H_1).

2. Occlusal support status has an impact on signs and symptoms of TMD in the old elderly by age (H_1).

3. Occlusal support status has an impact on changes in radiographic findings in the mandibular condyles of the old elderly by age (H_1).

7. Subjects and methods

7.1. Study design

The study design is both cross-sectional and longitudinal, with a 5-year follow-up.

The oral health study is part of a comprehensive longitudinal medical and dental survey, the Helsinki Aging Study (HAS). HAS comprised a random sample of subjects in three birth cohorts: 1904, 1909, and 1914, who were residing in Helsinki, Finland, on the first of January, 1989. The medical study was carried out from 1989 to 1990, with a total of 651 subjects examined (Valvanne et al. 1996). One year later, participants in the medical study were invited to the baseline oral examination, and 5 years later, to the follow-up examination.

7.2. Subjects

An invitation to the comprehensive baseline oral examination, together with a questionnaire, was mailed to each of 600 eligible subjects, and 364 subjects (61%) were investigated (Table 2, Fig. 3). No information was obtained from 103 citizens: 3 had died before the examination, 70 were in poor health, and 30 were not located. Of those who refused to come to the examination, 133 (22% of the whole population) were interviewed by phone or by mail.

Table 2. Participants in oral clinical (C) and radiographic (R) examinations at baseline, 1990-91.

Age	76		81		86		Total	
	C	R	C	R	C	R	C	R
Male	48	44	34	28	20	14	102	86
Female	117	106	72	59	73	42	262	207
Total	165	150	106	87	93	56	364	293

Five years after the baseline medical study, in 1995, a total of 236 subjects were eligible and were invited to the follow-up examinations; 112 (47%) subjects participated. The present follow-up study includes those subjects who participated in the radiographic examination both at baseline and at the end of follow-up. Comprehensive data from both examinations were obtained from 94 subjects (Table 3, Fig. 4).

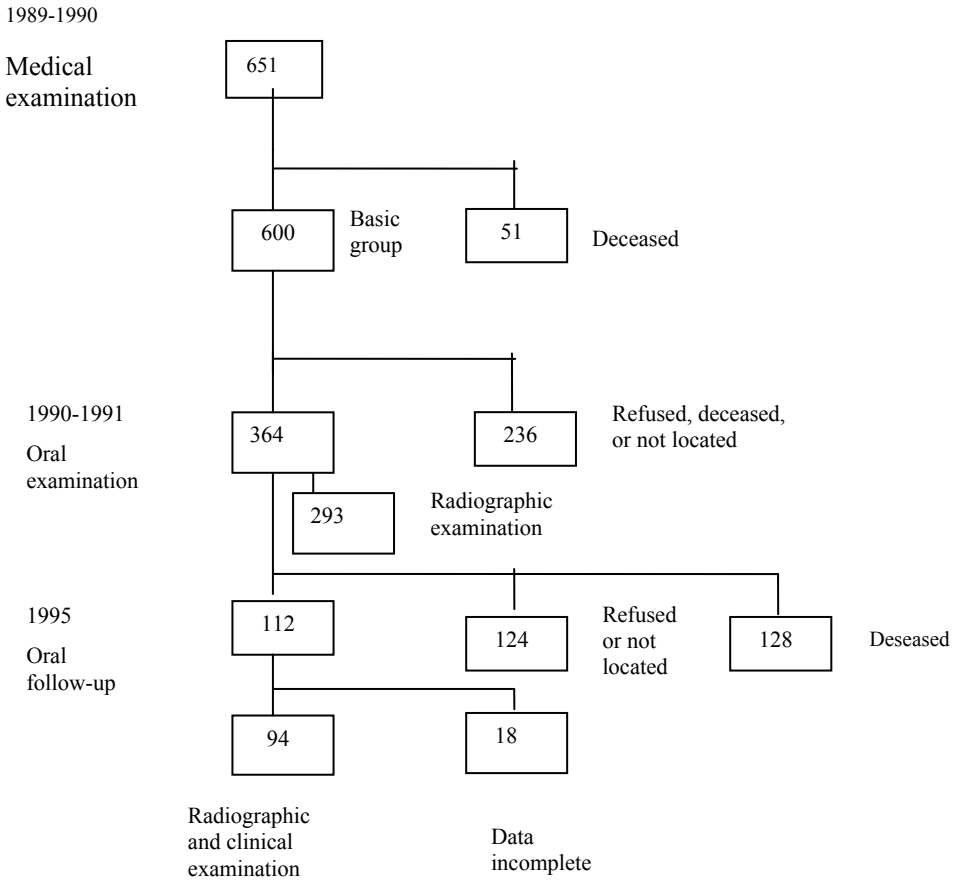


Figure 4. Flow chart of the population studied.

Table 3. Radiographic follow-up study group, 1995.

Age	81	86 °	91 °	Total
Male	14	9	4	27
Female	44	16	7	67
Total	58	25	11	94

° age-groups combined in analysis

Because of the small number of subjects in the oldest age groups in the follow-up study, the two oldest groups (86 and 91) were combined.

7.3. Examinations

The baseline oral examination consisted of a questionnaire to be filled in at home, plus clinical and radiographic examinations, the whole examination lasting 1 to 2 hours. Of the 364 subjects, 293 were examined at the Institute of Dentistry, University of Helsinki. In addition, 71 subjects unable to come to the Institute of Dentistry because of poor health or logistic problems were examined in their homes, in old people's homes, or in hospitals (Vehkalahti et al. 1996).

7.3.1 Oral examination and questionnaire

The comprehensive oral examination included periodontal (Ajwani and Ainamo 2001), cariologic, (Närhi et al. 1998), prosthodontic (Nevalainen et al. 1996), and radiographic sections (Ainamo et al. 1994, Soikkonen et al. 1994), clinical stomatognathic examination, and completion of the questionnaire. Four faculty members and clinical teachers at the Institute of Dentistry, Helsinki University, conducted the baseline clinical examination using standard dental equipment. Three faculty members and clinical teachers, one of them being the same person as at baseline, carried out the follow-up examination. Due to parallel examinations in both of the studies, the examiners had at all times the possibility to discuss with each other the classifications and criteria used in the clinical examination.

The questionnaire was intended to be completely filled in at home before the examination. In cases of unanswered questions, these were clarified with explanations or further questions to respondents, in an attempt to keep the effect of the interviewer as small as possible.

The questionnaire required each respondent to assess his or her subjective symptoms: symptoms of the TMD, occurrence of pain in the face and head area, and frequency of headache (Table 4).

7.3.2. Clinical stomatognathic examination

The TMD examination consisted of a questionnaire for subjective symptoms (Ai) and an examination for clinical signs (Di). Symptoms of TMD were assessed according to the Helkimo anamnestic index (Helkimo 1974), which has three grades: Ai0 = no symptoms and AiI = mild symptoms such as TMJ sounds, feeling of fatigue in the jaws, and feeling of stiffness in the jaws on awakening or on movement of the lower jaw. AiII = severe symptoms like difficulties in opening the mouth wide, locking, luxations, pain on movement of the lower jaw, pain in the region of the mandible or in the

muscles (Helkimo 1974). In addition, tooth pain, headache, and pain in the neck and shoulders were determined.

Table 4. Questions concerning the Helkimo anamnestic index (Ai).

1. Do you clench or grind your teeth while sleeping?
   0 no
   1 yes, sometimes
   2 yes, often
   3 do not know

2. Do you clench or grind your teeth in the daytime? (Choices as in 2)

3. Here is list of different parts of the head. Mark every site where you have had pain.
   0 ears
   1 forehead
   2 cheeks
   3 eyes
   4 back of the neck
   5 teeth
   6 I have no pain in areas listed

4. Does your jaw lock or luxate during its function?
   0 no
   1 yes, but only with wide motions
   2 yes, even with small motions
   3 do not know

5. Do you feel pain in your TMJ when you open your mouth as wide as you can?
   0 no
   1 yes, on right side
   2 yes, on left side
   3 yes, on both sides
   4 do not know

6. Are you able to open your mouth wide enough?
   0 no
   1 yes
   2 do not know

7. Do you feel pain in your TMJ while eating? (Choices as in 5)

8. Have you noticed any kind of noises in the TMJs? (Choices as in 5)

9. Do you feel tiredness or fatigue in your jaws in the morning while awakening? (Choices as in 5)

10. Do you feel pains in your cheeks while eating? (Choices as in 5)

11. Do you feel pain in your cheeks when you open your mouth as wide as possible? (Choices as in 5)

12. If you have symptoms in jaws or TMJs, how long have you had them?
    0 no symptoms
    1 1-4 weeks

2 1-6 months
3 6-12 months
4 1-2 years
5 2-5 years
6 over 5 years
7 do not know

13. How would you describe the severity of your symptoms?
0 no symptoms
1 very mild
2 mild
3 tolerable
4 quite severe
5 very severe

Based on these answers, the anamnestic dysfunction index was divided into three groups similar to those of the standard Helkimo anamnestic index Ai (Table 5). If subjects had at least one of the symptoms in Table 5 they were classified as belonging to the group with symptoms (Helkimo 1974).

Table 5. Anamnestic index based on subjective findings (Helkimo 1974).

Grading	Explanation
Ai0	Free of any symptoms
AiI	TMJ sounds
	Fatigue in the jaws
	Stiffness in the jaws on awakening or on movement of the lower jaw
AiII	Difficulties in opening mouth wide
	Locking
	Luxations
	Pain on movement of the mandible
	Pain in the region of the TMJ or masticatory muscles

The clinical TMD examination was conducted with ordinary dental equipment. The clinical dysfunction index (Di) is divided into four groups according to severity of recorded signs: Di0, DiI, DiII, and DiIII (Table 6).

Table 6. Clinical dysfunction index (Di), based on evaluation of five different signs and modified mobility index (Helkimo 1974)

	Point
A. Impaired range of movement by modified mobility index	
Maximal opening from the edge of upper to edge of lower incisor	
Normal range of movement ≥ 40 mm	0
Slightly impaired mobility 30-39 mm	1
Severely impaired mobility < 30 mm	5
B. Impaired TMJ function	
Smooth movement without TMJ sounds or deviation in opening or closing movements ≤ 2mm	0
TMJ sounds in one or both joints and/or deviation ≥2mm on opening or closing movements	1
Locking and/or luxation of the TMJ	5
C. Muscle pain	
No tenderness to palpation in masticatory muscles	0
Tenderness to palpation at 1-3 sites	1
Tenderness to palpation at ≥ 4 palpation sites	5
D. TMJ pain	
No tenderness to palpation	0
Tenderness to palpation laterally	1
Tenderness to palpation posterior	5
E. Pain on movement of the mandible	
No pain on movement	0
Pain on 1 movement	1
Pain on 2 or more movements	5

Maximal opening and vertical overbite were measured with an ordinary ruler. Maximal opening was measured from edge to edge of the middle upper and lower incisor in the natural dentition or fixed constructions, or in false teeth. Maximal opening added to vertical overbite was considered to be normal when it was over 40 mm, reduced at 39 to 30 mm, and extremely reduced at less than 30 mm. Neither maximal movement to right and left nor maximal protrusion were measured. TMJ sounds were determined with a stethoscope for diagnosis of clicking or crepitation. The site of the sound was also recorded as connected to opening or closing and being single or reciprocal.

Table 7. Clinical index based on clinical examination.

Grading	Explanation	Points
Di0	Clinically symptom-free	0 point
DiI	Mild dysfunction	1-4 points
DiII	Moderate dysfunction	5-9 points
DiIII	Severe dysfunction	10-25 points

The palpated muscles were: masseter, temporalis (tendon), lateral pterygoid, medial pterygoid, and the anterior part of the digastric. The extra-orally palpated muscles were the medial pterygoid, and digastric. Exact palpation sites of the muscles and force of the palpation with one finger was calibrated to be the same between the examiners.

The lateral part of the TMJ was palpated extra-orally approximately 5 mm anterior from the outer acoustic duct. The posterior part of the TMJ was palpated with the little finger in the acoustic duct and by asking the subject to open and close the jaw to find the exact site of the head of the condyle.

Pain on movement of the mandible was recorded by asking the subject to open the mouth maximally and to move the jaw laterally and to protrude it. The pain reaction that the subject reported instantly or reported when asked was recorded.

7.3.3. Occlusal status

In the present study, occlusion was recorded first according to Eichner (1955) for the natural dentition including any fixed construction without removable dentures (E t+br), and secondly by taking account of the support of removable dentures according to Österberg and Landt (1976) (E t+br+p). Occlusal contacts of antagonist jaws serve as the basis for the Eichner index. The zone is called supporting if it has at least one contact in the region. The maximum number of supporting zones is four. Molar and premolar contacts define the classification: class A contains four support zones in the premolar and molar zones; class B contains one to three support zones in the molar or premolar region or support in the frontal region only. In class C is no occlusal contact, although there might be a few remaining teeth (Eichner 1955, Österberg and Landt 1976). In the present study, three main classes were recorded (classes A, B, C), ignoring their subgroups of the original and modified Eichner index (Fig. 5).

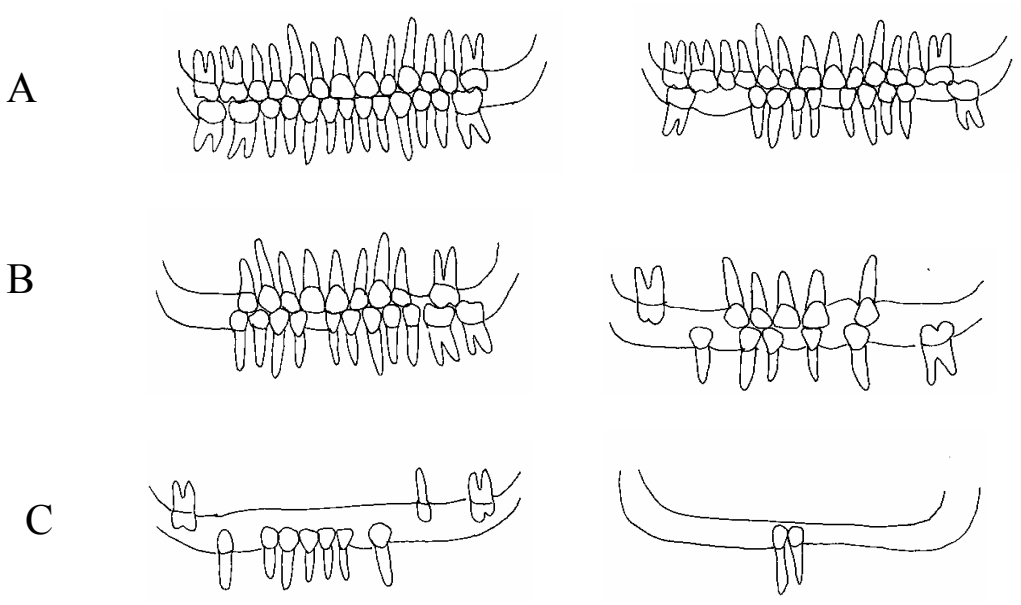


Figure 5. Examples of the original Eichner index (Eichner 1955) in the natural dentition: class A has four contacts in premolar or molar zones, class B has 1-3 contacts in premolar or molar, or in the frontal zone only, and class C has no contact.

The Eichner group with natural dentition with fixed constructions if any and the Eichner group with removable dentures were evaluated separately.

7.3.4 Radiographic examination

The radiographic examination was performed to evaluate the mandibular condyles. Radiographic examination included a panoramic radiograph taken at the Department of Oral Radiology, Institute of Dentistry, University of Helsinki, before the subject's oral examination, following the same protocol both at baseline and follow-up. Panoramic radiographs were taken with PM 2002 CC-radiograph equipment (Planmeca Co, Helsinki, Finland) and Trimax GT film and a Trimax T-16 intensifying screen.

One radiologist evaluated all the radiographs. Evaluation at the follow-up was done blindly, without any information on the baseline examination. The radiographs were evaluated in the standard way concerning pathological findings, infections, and findings requiring any dental treatment. In both examinations, the radiologist used an ordinary light table and a viewer according to Mattson (1953).

Seven different types of radiological abnormalities in the condyles were recorded: flattening of the articular surface of the condyle, subcortical sclerosis, microcysts, osteophytes, marginal erosion, periarticular ossicle, and other signs including deformities (Peltola 1995) (Fig. 6) (Table 13). All radiographs in which both condyles were not visible were excluded. Finally, radiographic findings from the osseous part of the mandibular condyle were dichotomized as being present or absent (Table 12, 14, 15, Fig. 11).

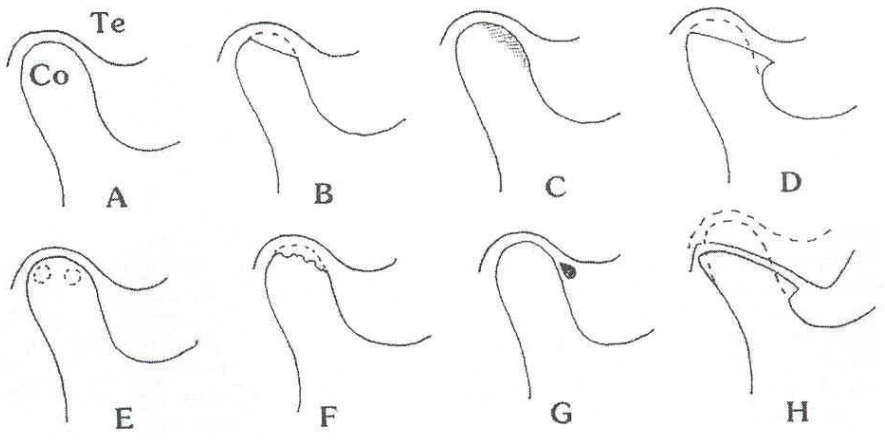


Figure 6. Te= temporal bone, Co= condyle. (A) Normal condyle of the tempomandibular joint, (B) flattening of the articular surface of the condyle, (C) subcortical sclerosis, (D) osteophyte, (E) microcyst, (F) marginal erosion, (G) periarticular ossicle, (H) deformity.
(By permission of Peltola 1995).

7.2. Statistical evaluation

Statistical evaluation was performed by means of the chi-squared test for differences of frequencies in various subgroups. A *p*-value less than 0.05 was considered statistically significant. Further, a logistic regression model was fitted to the data, and corresponding odds ratios and their 95% confidence intervals were calculated (Fleiss 1981).

8. Results

8.1. Symptoms of TMD at baseline (I)

Two-thirds of the subjects in this population were symptom-free; judged according to the Helkimo anamnestic dysfunction index (Ai), 14% had mild symptoms (AiI). Women tended to report symptoms more often ($p<0.10$) than did men. Although 34% of the population reported symptoms of TMD, and 20% reported them to be quite severe, only 2% called them very severe (Table 4, Table 8).

Table 8. Distribution of anamnestic dysfunction index Ai (%) at baseline by gender and age (N=364).

	Age			Gender		
Ai	76 %	81 %	86 %	Men %	Women %	Total %
0	63	68	70	73	63	66
I	15	16	9	15	14	14
II	22	16	21	12	23	20

Of all the subjects, 30% reported pain in the head and neck region in the baseline population. Frequent headaches (once or twice a week) were reported by 16% and daily headaches by 4% (Table 9).

Table 9. Reported frequent headaches (%) (once or twice a week) (N= 364).

	Age			
	79 %	81 %	86 %	Total %
Men	23	3	11	14
Women	18	17	12	16
Total	19	13	12	16

8.2. Signs of TMD at baseline (II)

One of five subjects in the baseline population according to Di had no signs (Di0), 57% mild signs (DiI), 19% moderate signs (DiII), and 4% severe signs (Table 10).

Table 10. Distribution of clinical dysfunction index (Di) (%) in baseline population (N=342).

	Age			Gender		
Di	76 %	81 %	86 %	Men %	Women %	Total %
0	17	23	22	32	15	20
I	58	59	53	59	57	57
II	22	15	20	7	24	19
III	3	3	5	2	4	4

Clinical signs of TMD occurred more frequently in women than in men (85% vs. 68%, $p<0.001$). Clinically symptom-free were 32% of the men in the baseline population, and 47% of the oldest men. No such age difference appeared among women. Over 20% of 86-year-old women had painful muscles at three or more palpation sites (temporalis, masseter, lateral pterygoid, medial pterygoid or posterior part of digastric). None of the men at baseline had such a pain. No age-related differences appeared in the dysfunction index Di among the baseline population. The most frequent signs were impaired range of movement and impaired TMJ function (Fig. 7).

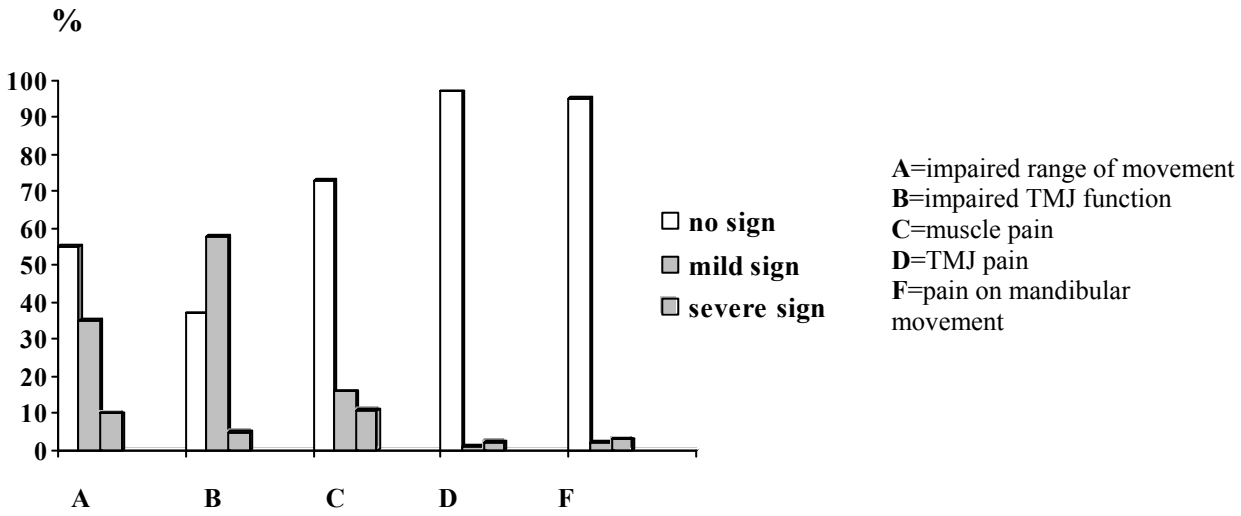


Figure 7. Distribution (%) of the five signs of the clinical dysfunction index judged by severity.

8.3. Occlusion and TMD at the baseline (III)

At baseline, occlusion without removable dentures (E t+br) comprised in Eichner class A 8%, class B 22%, and class C 70%; with occlusal support of the removable dentures taken into account (Et+br+p), figures were, respectively, 75%, 21%, and 4% (Fig. 8).

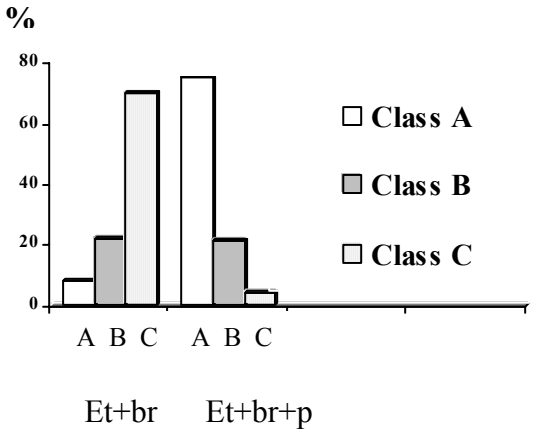


Figure 8. Distribution (%) of baseline subjects by classes of Eichner index.

In the anamnestic or clinical dysfunction index, differences were not significant either in E t+br or in E t+br+p, with no significant differences between men or women, or between age-groups (Table 11). In Table 11 Ai0 and AiI, and Di0 and DiI are combined.

Table 11. Distribution (%) of the elderly by anamnestic (Ai) and clinical (Di) dysfunction index in Eichner classes (A, B, C).

E t+br	A	B	C		A	B	C
Ai				Di			
0+I	76	81	80	0+I	84	82	75
II	24	19	20	II+III	16	18	25
E t+br+p							
Ai				Di			
0+I	80	79	86	0+I	76	79	90
II	20	21	14	II+III	24	21	10
N= 328			N=343				

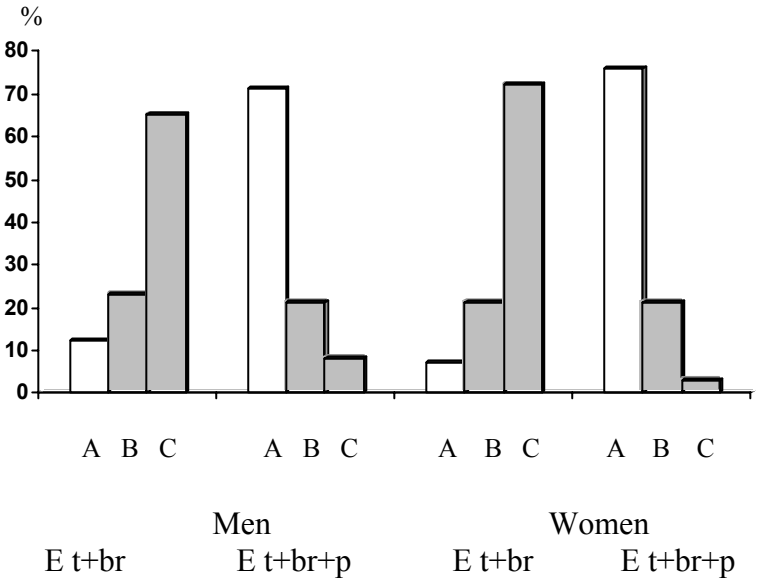


Figure 9. Distribution (%) of elderly men (n=102) and women (n=262) by Eichner classes.

Of the men 8%, and 3% of the women had no occlusal contacts (class C) even when removable dentures were included in the Eichner index (E t+br+p) (Fig. 9).

As regards the 76-year-olds, a significant difference ($p<0.05$) appeared between genders: without removable dentures 19% of the men and 6% of the women had contact in all four support zones (Et+br), class A. With removable dentures, only 6% of the 76-year-old men and none of the women belonged to class C, remaining without occlusal contact (class C). No such difference between genders existed in the two other age-groups.

8.4. 5-year follow-up of occlusal status and radiographic findings (IV)

The follow-up findings of the present study concern only those subjects (N=94) who participated in the radiographic examination both at baseline and at follow-up. The Eichner index with and without dentures, and radiographic findings in mandibular condyles remained stable during follow-up (Table 12).

Table 12. Subjects (%) without changes in symptoms or signs, in occlusal support without removable dentures or with removable dentures, in radiographic findings, and in reported pain over the 5-year period.

Indicator	Men	Women	p^1	All	n
	%	%		%	
Helkimo anamnestic index	91	58	0.005	67	87
Helkimo clinical index	54	65	ns	60	82
Eichner index in natural dentition	96	94	ns	94	89
Eichner index with dentures	91	83	ns	85	89
Radiographic findings	86	94	ns	92	88
Reported pain	100	83	0.04	87	87

[1] Chi-square test for differences by gender

At the end of follow-up, the majority of subjects (56%) had no occlusal contacts, and 8% had four support zones (E t+br class A) without removable dentures (E t+br class C). Absence of radiographic findings dominated in all categories for occlusal support status. Only minor changes occurred in radiographic findings during follow-up (Table 12, Table 13).

Table 13. Elderly (%) with radiographic findings in condyles, by age, at baseline and at the end of 5-year follow-up.

	Baseline		Follow-up	
		Age		
	76	81-86	81	86-91
Radiographic findings	%	%	%	%
-any finding	36	24	26	33
-flattening of articular surface	16	18	16	9
-subcortical sclerosis	12	9	6	11
-osteophytes	4	6	4	6
-microcysts	0	0	1	0
-marginal erosion	2	3	5	6
-deformity	12	11	11	9

In both examinations, flattening of the articular surface of the condyle was the most common of all radiographic findings, occurring in 17% of all subjects at baseline and in 13% at the end of follow-up. Between age-groups or genders at baseline or follow-up, no statistical difference appeared regarding radiographic changes, or findings between right and left condyle.

Table 14. Baseline factors related to radiographic findings at end of follow-up by logistic regression model.

Baseline factor	Estimate		SD	*p*	Odds ratio	95% CI
Eichner index with dentures	1.74		0.91	0.05	5.7	1.0-33.7
Helkimo anamnestic index	1.41	0.63		0.02	4.1	1.2-14.1
Radiographic findings	5.89		1.20	<0.001	356	34.5-3757
Deviance=39.5;df=81						

A logistic regression model using end-point radiographic findings in condyles as the dependent variable and baseline Eichner index with removable dentures and Helkimo´s anamnestic index and baseline radiographic findings as the independent variables revealed strong association with each of these (Table 14). Gender and age remained nonsignificant factors in the model which reached a reasonable fit.

8.5. Five-year follow-up of TMD and radiographic findings (V)

During the 5-year follow-up of the same subjects, Ai remained stable among men but not among women (91% vs. 58%; p=0.005). As regards age, Di was more stable in the younger than in the older age-group (p=0.04) (Table 15).

Table 15. Elderly (%) subjects without change in Helkimo anamnestic index, clinical index, or in radiographic findings during a 5-year period.

Parameter	Age at baseline 76 % (n=56)	81-86 % (n=33)	p^1	Total % (n=89)
Helkimo anamnestic index (Ai)	61	77	0.11	67
Helkimo clinical index (Di)	69	45	0.04	60
Radiographic findings	95	87	0.21	92

[1] Chi-square test for difference by age

More of the women than men had symptoms (Ai >0): 34% vs. 4% at baseline and 28 vs. 8% at the end of follow-up. In the 5-year follow-up, the severe symptoms and signs of TMD decreased in the very old population (Fig 10); for women, the severe symptoms decreased from 17% to 6%, and severe signs from 5% to 0% (Table 16).

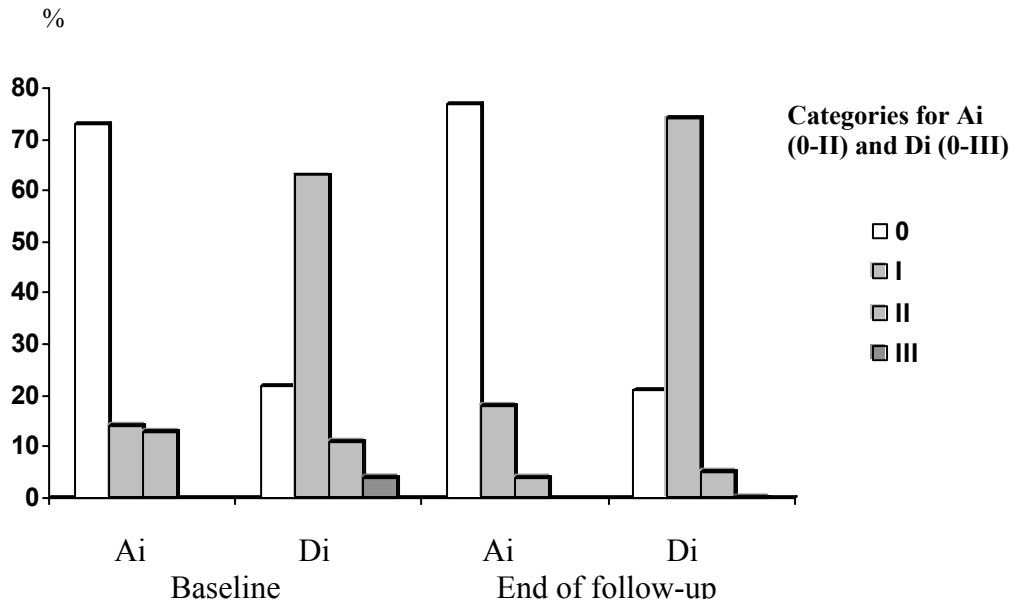


Figure 10. Distribution (%) of the elderly by Helkimo´s anamnestic (Ai) and clinical (Di) indices at baseline and at the end of 5-year follow-up.

Table 16. Distribution (%) of elderly subjects by Helkimo anamnestic index (Ai) (n=87) and clinical index (Di) (n=82) values at baseline and at end of follow-up.

	Baseline		End of follow-up	
Ai	Women %	Men %	Women %	Men %
0	66	96	72	92
I	17	4	22	8
II	17	0	6	0
Di				
0	15	39	17	30
I	66	57	78	65
II	14	4	5	4
III	5	0	0	0

At baseline, radiographic findings in the mandibular condyles appeared in 36% of the 76-year-olds and in 24% of the 81- to 86-year-olds (Fig. 11).

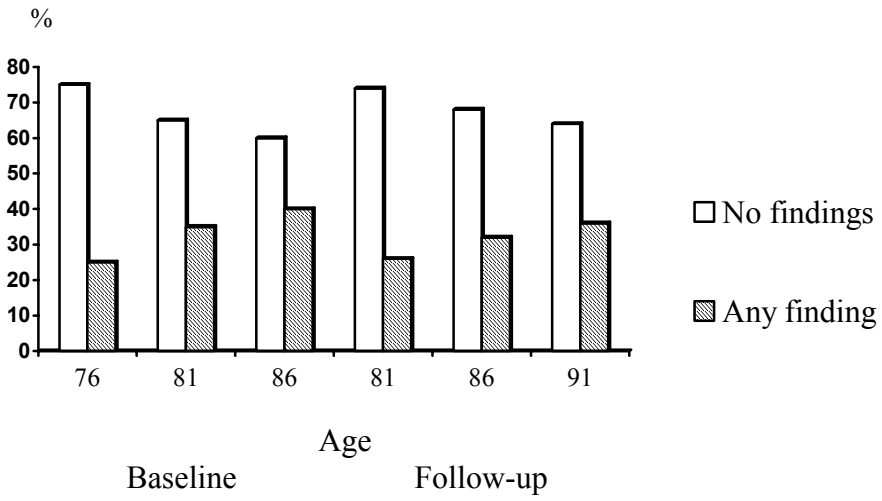


Figure 11. Distribution (%) of the elderly by radiographic findings in mandibular condyles at baseline and at end of 5-year follow-up, by age.

Findings changed only slightly during the 5-year follow-up among the same subjects. Among women, 95% of radiographic findings were stable, and 86% among men. No association existed between radiographic findings and Ai or Di of TMD either at baseline or at the end of follow-up.

9. Discussion

9.1. General discussion

The present study investigated temporomandibular disorders in old elderly inhabitants of Helsinki. The examination consisted of a questionnaire, and clinical and radiographic examinations at baseline and at the 5-year follow-up. The main issues of the present study were occurrence of and changes in symptoms and signs of temporomandibular disorders, occlusal support status, and radiographic findings in the condyles of the elderly population, and associations between these.

The first hypothesis that signs and symptoms of TMD decrease during aging was supported. The most severe symptoms and signs disappeared in the 5-year follow-up. Symptom-free subjects and those with only mild clinical signs dominated at the end of follow-up.

The second hypothesis was not supported by the results of baseline and follow-up studies. Occlusal support had no impact upon TMD signs or symptoms in regard to support with and without removable dentures.

Data on radiographic findings and occlusal support status gave no support to the third hypothesis, that occlusal support status with or without removable dentures has an impact on radiographic findings in the condyles during a 5-year follow-up time in the elderly. Radiographic findings in the mandibular condyles were minimal at baseline and remained unchanged during the follow-up. Radiographic findings in mandibular condyles were not associated with occlusal support status, despite the fact that occlusal support of the removable dentures was taken into account. Status of the mandibular condyles, evaluated by radiography, among these very old subjects seemed to be stable.

9.2. Discussion of subjects and methods

9.2.1. Subjects

The general problem with geriatric studies is the high attrition rate, also evident in the present study. The high mortality of the elderly population particularly in follow-up studies limits participation, but participation rates have been improved by researches organising the examinations at homes, arranging transport service to the examination, or collecting data by interview or questionnaire only (Locker et al. 1990, Salonen et al. 1990, Slade et al. 1990). In the present study, few subjects were, however, interviewed by phone and a few were examined at their homes (at baseline N=71). For the radiographic

study, subjects had to come to the Institute of Dentistry, University of Helsinki, and few received help with logistic problems.

Despite the logistic barriers, the participation rate (61%) at baseline was surprisingly high, and reasonable (47%) at follow-up. At baseline, willingness to participate seemed to relate to age, gender, distance between examination place and subject´s home, self-perceived general health, and state of the dentition (Vehkalahti et al. 1996). Men were more willing to participate than were the women; figures were a respective 69% and 58%. Participation among those elderly who lived in the neigborhood of the Institute of Dentistry was 75% compared to 60% among those from other areas. Similarly, dentates were over-represented, with 79%, compared to 63% of the edentulous.

For the follow-up section, the study design was longitudinal, with the same subjects examined first at baseline and second, 5 years later at the follow-up. From the follow-up, those subjects without radiographic examination in the baseline study were excluded, so the comprehensive follow-up data finally included 94 individuals. At the end of the follow-up, the oldest cohort was of 91-year-olds, and 128 members of the baseline population (35%) were deceased, which is in accordance with the mortality rate of the general Finnish population of that age (Official Statistics in Finland 2003).

9.2.2. Questionnaire

Differences between questionnaires and personal interviews have been discussed in several reports (Norheim and Heloe 1977, Doll et al. 1991).The influence of the interviewer was avoided, for instance with regard to lifestyle questions, by using a combination of questionnaire and interview (Rieder 1977, Doll et al. 1991). Furthermore, because of the very high age of some subjects, they may have had difficulties in fully understanding the written questions (Juva et al. 1993). Disadvantages of both the questionnaire and interview were avoided by having the questionnaires completed with some aid from the examiner.

9.2.3. Oral examination

Recommendations that one and the same observer would perform the clinical study, both the baseline examination and the follow-up, have been made by several researchers (Kopp and Wenneberg 1983, Dijkstra et al. 1995). The present study involved four examiners at baseline and three at follow-up, and the comparability of examiners in the TMD examination was considered to be sufficient (Duinkerke et al. 1986, John and Zwijnenburg 2001). Per subject, the clinical oral examination lasted from one to two

hours. Inevitably, the examination was exhausting to the very old subjects. To make data collection faster, the parallel examinations were going on simultaneously in the dental clinic, and examiners had all possibilities to discuss with each other their problems, criteria, and diagnoses to improve reliability.

9.2.4. Diagnosing TMD for epidemiological studies

Because reliable comparison of symptoms and signs of TMD between various epidemiologic studies is problematical or even impossible, variation in results is wide regardless of method used. The Helkimo index was originally constructed for epidemiologic studies as a tool to gather data, and it is still used this way. The index has been criticized as being insufficient for clinical examination or treatment-need studies, being inapplicable to identification of normal subjects, and being inappropriate in identification of variable etiology behind similar signs (Fricton and Schiffman 1987, van der Weele and Dibbets 1987, Stegenga et al. 1993, Mohl and Dixon 1994, Alanen et al. 1997, McNeill 1997).

The original Helkimo index (1974) includes a mobility index consisting of points for maximal opening, maximal movement to the right and to the left, and maximal protrusion. Inevitably several problems occur in examining very old subjects: the direction of the jaw movement can be difficult to understand for the elderly (Juva et al. 1993), and secondly, the movement itself can be difficult because of unstable dentures, rather than because of pain or discomfort (Karlsson et al. 1991). In the present study, these difficulties were avoided by measuring the mobility by maximal jaw opening. In maximal mouth opening, interexaminer reliability is considered to be high (de Wijer et al. 1995, Dijkstra et al. 1995, John and Zwijnenburg 2001)

In general, interexaminer reliability for muscle and joint palpation is moderate or fair without frequent calibration (de Wijer et al. 1995). In the present study, the palpation force needed to study the muscles of very old subjects, and often ones with complete dentures, was kept moderate as the literature suggests (Drummond et al. 1995, Raustia et al. 1996, Brunel et al. 2003). In addition, the examiners were faculty members or full-time teachers at the Institute of Dentistry or both, and their daily routines included frequent palpation of muscles. The palpation force of the masticatory muscles was calibrated between the examiners at baseline and follow-up.

9.2.5. Occlusal status

Number of teeth has often served as an indicator of oral health (Agerberg and Carlsson 1981, Vehkalahti and Paunio 1988), but it cannot describe the functionality of the masticatory system.

Occlusal conditions vary among subjects with the same number of teeth, making occlusal status or functional capacity or both, a complicated matter. Various methods emphasizing the importance of molar and premolar support have been used to study and classify dental occlusion, occlusal support status, and occlusal capacity (Eichner 1955, Österberg and Landt 1974, Käyser 1981, Gordon et al. 1994). Modification of the Eichner index, which includes support of removable dentures, makes the index more suitable for studies on aged subjects than is an index using the occlusal support of the natural dentition only (Eichner 1955, Österberg and Landt 1974, Österberg et al. 1984, Hellden et al. 1989, Österberg et al. 1990, Österberg et al. 1992, Nordström et al. 1995, Miura et al.1998).

9.2.6. Radiographic examination

Along with progression of radiography has arisen discussion of a suitable method to examine the mandibular condyle and its demonstrable parts (Raustia and Pyhtinen 1988). For instance, panoramic radiography is criticized as imprecise because anatomic differences in the longitudinal axis of the condyle, the size of the subject, and the position during the examination are sources of error (Rohlin et al. 1986, Epstein et al. 2001, Masood et al. 2002). Further, precise examination of bony structure around mandibular condyle is impossible (Abdel-Fattah 1989, Raustia et al. 1998). Conversely, the panoramic radiograph is considered to provide a sufficient view of TMJ pathology (Habets et al. 1989). Evaluation of bony changes of mandibular condyle from panoramic radiographs provides acceptable reliability and specificity but low sensitivity. Accordingly, positive findings are considered to be associated with disease, whereas negative ones do not exclude disease (Dahlström and Lindvall 1996).
The panoramic radiograph is a useful method for screening purposes. Its advantages are: a small dose of radiation, low price, speed, and convenience (Peltola 1995, Magnusson and Karlsson 2002). The long duration of the clinical examination also contributed to choice of a radiographic method, because the panoramic radiograph is faster than any other available method.

9.3. Discussion of results

9.3.1. Symptoms of TMD in an elderly population (I)

At baseline, 34% of this elderly population reported some subjective symptoms of TMD, and 20% reported pain in some areas of the masticatory system (AiII) (Table 8). Our findings are in agreement with those of similar populations (Österberg et al. 1992, Koidis et al. 1993, Nordström and Eriksson

1994). Women tended to report symptoms more frequently ($p<0.10$) than did men and had more severe symptoms (23% vs.12%), 73% of the men and 63% of the women were symptom-free, in accordance with others´ findings (Österberg et al. 1992, de Kanter et al. 1993, Johansson et al. 2003). Contradictory studies suggest, however, that symptoms of TMD occur equally often in men and women, or more often in men (Österberg and Carlsson 1979, Helkimo 1976, Ow et al. 1995).

Although headaches are not included in the Helkimo anamnestic index, they are certainly of interest when the specific pain control mechanism is evaluated in a geriatric population with all sorts of pain and discomfort. In the present study, the diagnosis of headache was not made according to the classification of the International Headache Society, making comparison with other studies difficult. At baseline, 16% suffered from frequent headaches (more than 1-2 days a week) (Table 9), in agreement with figures from Sweden (Agerberg and Bergenholtz 1989). Prevalence was higher in women in agreement with an aging study from Italy (Camarda and Monastero 2003). Headaches, like the symptoms of TMD, are considered to decrease with age (Iacopino and Wathen 1993, Camarda and Monastero 2003).

9.3.2. Signs of TMD in an elderly population (II)

At baseline, 20% of this population was without signs of TMD (Table 10). In epidemiological studies of those over 50 years old, 12 to 82% have been clinically symptom-free (Table 1). As with subjective symptoms, this range is incomprehensibly wide (de Kanter et al. 1993, Gesch et al. 2004). In Helkimo´s own studies, 22% had severe signs of TMD (Helkimo 1979). In the present baseline study, 4% of the signs of the TMD were severe, in accordance with other geriatric findings (Österberg and Carlsson 1979, Österberg et al. 1992). The most frequent signs were impaired range of movement and impaired TMJ function (Figure 7), in accordance with other findings concerning decreased mouth opening capacity in the elderly (Agerberg and Bergenholtz 1989).

Women had a significantly higher prevalence ($p<0.001$) of clinical signs: only 15% at baseline were without clinical signs (Di0), versus 32% of the men (Table 10). Female sex seemed to be an increased risk factor for TMD pain in other studies, as well (de Kanter et al. 1993, Matsuka et al. 1996, Kamisaka et al. 2000, Gensch et al. 2004).

Treatment of TMD in old elderly subjects should be based first on subjective discomfort or pain and on each patients´ wishes, and secondly on clinically diagnosed pain. Concerning clinically diagnosed moderate dysfunction (DiII), it affected over 19% of the studied baseline population, and 4% of the

baseline population had severe clinical dysfunction (DiIII). The simplest method to calibrate treatment need is to ask an elderly patient whether the pain or discomfort is so disturbing that it needs treatment. Although 34% of the baseline population reported symptoms of TMD, and 20% reported severe symptoms, only 2% reported that their symptoms were extremely severe. It seems that some portion of the subjective severe symptoms of these very old subjects is connected to decrease in opening capacity and flexibility of the masticatory system. Both of these factors are also related to the aging process itself and to the loss of adaptation ability (Ship et al. 1996).

9.3.3. Occlusion and TMD in an elderly population (III)

The occlusion is said to affect not only oral function, but also general health and muscle strength (Österberg and Steen 1982, Österberg et al. 2002). Some background factors having an impact on occlusal status seem to be education, marital status, and smoking habits (Österberg et al. 1984, Ishijima et al. 1998).

A 1970 Swedish study on the occlusal status of a population similar to the present one had similar results (Österberg et al. 1984). It seems that Finland lags behind Sweden regarding the oral health of the elderly thus far, perhaps because subsidization of oral heath services in Sweden has been broader than that in Finland, including prosthodontic treatment. In 1980 in Finland, 68% of the institutionalized elderly had no natural teeth left (Ekelund 1989). Results from Canada suggest that oral status is better in the independent than in the institutionalized elderly (Slade et al. 1990). The main part of the present study population comprised the home-living independent elderly, 70% of these very old were occlusal invalids if their removable dentures were not included in their occlusal support status, whereas if the removable dentures were included only 4% of them lacked occlusal contacts between antagonist jaws (Figure 8).

No association appeared between occlusal support status and signs and symptoms of TMD in this very old population (Table 11). Several studies confirm these results, revealing a weak or no association between molar support and TMD in the non-patient population (Kirveskari and Alanen 1985, de Kanter 1990, Lundeen et al. 1990, Takenoshita et al. 1991, Ciancaglini et al. 1999, de Boever et al. 2000, Ciancaglini et al. 2003). In addition, the present results included no evidence that replacing the missing molars with dentures would have any impact on signs or symptoms of TMD. Contradictory findings have also been reported: tooth loss correlating positively with TMD (de Boever 1979, Budtz-Jörgensen et al. 1985, Hatch et al. 2001, Kurita et al. 2001, Dulcic et al. 2003). In Table 11, the results for

symptom-free subjects and those with mild symptoms were combined to evaluate the actual difference between Eichner classes, and to make the groups reliable. The same was done to compare the results of Di**.**

The major part of the present population was without occlusal support between antagonist jaws in their natural dentition (Figure 8). In the Eichner classification of the natural dentition, 70% of our baseline population was without occlusal contact, but if removable dentures were included, only 4%. In the present study the results were confounding: signs and symptoms were not significantly associated with contacts between natural teeth. In Eichner class C without the support of removable dentures, those subjectively symptom-free or with mild symptoms made up 80% of the baseline population, and those without clinical signs or with mild signs were 75% of the subjects with no contact in their natural dentition (E t+br) (Table 11). Similar results regarding complete-denture wearers have appeared in other studies, and furthermore, findings of dentates´ having a higher prevalence of TMD than did complete denture wearers (Gray et al. 1997). The difference in TMD signs and symptoms between complete-denture wearers and dentates has been explained for instance by alterations in TMJ function, in vertical dimension factors, or in wearing problems (Åkerman et al. 1984, Mercado and Faulkner 1991, Klemetti 1996). It seems that the occlusal status has little or no impact on TMD in this very old population and perhaps the lifelong ability to adapt to changes in the masticatory system has been underestimated (Wilding and Owen 1987, Harriman et al. 1990).

9.3.4. Changes in occlusal status and radiographic findings in an elderly population during follow-up (IV)

The worldwide tendency has been that edentulism as well as complete dentures and some partial removable dentures have been slowly vanishing (Slade et al. 1990, Marcus et al. 1996, Steele et al. 2000). A similar trend is evident also in Finland (Suominen-Taipale et al. 1999), and the change could be faster here than in some other countries, because in rural districts of Finland the changing old-fashioned tradition appreciates complete dentures more than it does the natural dentition (Klemetti 1996). In the present population the change in occlusal status (in natural dentition or in dentition with removable dentures included) was minimal and statistically insignificant during a 5-year follow-up time (Table 12). It seems that support of from removable dentures was required earlier in life than at the age of the present population (Nevalainen et al. 1996); it might also be the case that these old elderly were no longer eager to change their occlusal conditions.

Like occlusal status, neither did radiographic findings change during the follow-up period, also this change has already taken place earlier (Table 12). The most usual finding at baseline and at the end of follow-up was flattening of the articular surface of the condyle associated with osteoarthrosis (Table 13). Findings that suggest a continuing change — like subcortical sclerosis and increase in osteophytes and microcysts — was rarer at the end of follow-up than at baseline. It may be assumed that the condyle was already adapted to a change in occlusal status over the years, and the necessity to adapt no longer existed, because occlusal status changed no further. The Eichner index, which describes occlusal status with the natural dentition (Et+br), was not associated with any radiographic change in the bony part of the condyle, nor was any association apparent when removable dentures were included in the occlusal index (Et+br+p).

Furthermore, the stability of radiographic change was verified by a logistic regression model (Fleiss 1981). The strength of the factor was clear when simultaneously controlling for all other factors in the model. In the present study, baseline radiographic findings related to endpoint radiographic findings with their strong odds ratio confirmed the settled status of the condyles during the follow-up period. Furthermore, the baseline pain-related Helkimo anamnestic and occlusion-related Eichner indices with the removable dentures were related to endpoint radiographic findings, verifying the impression that they might have a slight impact on end-point radiographic findings (Table 14).

Deformity can be considered the verifying control finding among all radiographic findings, because the usual reason for deformity in the condyle is trauma (Boering 1966), and the changes in mandibular condyles remain for years. The reliability of the radiographic evaluation was confirmed because no change occurred in radiographic findings of deformity between the baseline and end-point radiographic results (Table 13). When the old age of the population is considered, it is obvious that many kinds of dynamic processes have modified the masticatory system along with adaptative changes not detectable from panoramic radiographs. For instance the duration of edentulousness has been considered as affecting on the position of the glenoid fossa (Raustia et al. 1998).

9.3.5. Changes of TMD and radiographic findings in an elderly population during follow-up (V)

For subjective symptoms in the baseline examination, the difference between the baseline study group and baseline radiographic study group was obvious, the total of symptom-free subjects (Ai 0) being 66% vs. 73%, and for those with severe symptoms (A II) 20% vs. 13% (Tables 8, 16). The baseline population included those unable to come to the Institute of Dentistry, who were examined, for

instance, in old people´s homes. Whereas all the radiographs were taken at the Institute of Dentistry, University of Helsinki, the baseline radiographic population comprised those healthy enough to attend also the 5-year follow-up. Unquestionably, the population that participated in follow-up was healthier and physically more capable than was the baseline population.

The signs and symptoms of TMD tend to cease or become milder with increasing age (Zarb et al. 1994, Okeson 2003), as verified by the present study as well. The most severe signs of TMD (DIII) vanished during the follow-up, so that 74% of the population had mild clinical signs, and only 21% were without any clinical signs. Evidently, in the Helkimo clinical index, points given for mild dysfunction (e.g., TMJ sounds) do not correlate with subjective complaints. In a sense, a subject can too easily be categorized as having clinical signs. The disparity between subjectively symptom-free subjects and those without clinical signs is obvious (Figure 10). Certainly the elderly must cope with several kinds of pains and accept the deterioration of the function of their own body (Ship et al. 1996, Hatch et al. 2001), but the present results support the predominant impression of decreasing signs and symptoms of TMD in aging — in accordance with those of several other studies (Zarb et al. 1994, Okeson 2003).

At the end of the radiographic follow-up, women had more symptoms and signs of TMD than did men (Table 16). According to several studies, the difference has been evident during the whole lifetime of women (Österberg et al. 1992, Koidis et al. 1993, Nordström and Eriksson 1994), but in the present study, the difference between the genders seemed to diminish with aging (Table 16), with the parameter variable changing most during the follow-up period being the Helkimo anamnestic index Ai among women (42%). Accordingly, 17% of women answered the pain-related questions (AiII) in the follow-up questionnaire and at baseline differently.

According to the present study, the most severe and the moderate signs become mild ones, and the reason may be that with aging acceptance of pain and discomfort increases, and attempts to seek treatment diminish (Marshall 1987). Some uncertainty in these results may result from large the number of removable dentures and soreness in the mucosa under the denture (Nevalainen et al. 1997). The common effects of the high age may also affect results (Juva et al. 1993). In the present very old population, removable dentures did not reduce risk for TMD signs or symptoms. No difference appeared between the Eichner index in the natural dentition and the Eichner index with removable dentures included, in accordance with some other findings (Witter et al. 1994, de Boever et al. 2000).

One difference between the younger and the current population is that those in the younger population generally have TMD signs or symptoms prior to any radiographic findings (Mejersjö and Hollender

1984). The present radiographic findings showed no association with subjective experience or clinical signs of TMD, and an autopsy study of subjects with known anamnestic and clinical findings of TMD came to a similar conclusion (Pereira et al. 1994). Of course the inaccuracy of the radiographic method used and its impact on conclusions has to be taken into account. From another point of view, the ability of the mandibular condyle of old patients to endure occlusal changes has diminished (Stegenga et al. 1991). The adaptation of the masticatory system is organic, and in aging tolerance of changing circumstances become more fragile. It seems that in the current old population, the largest changes in the condyle had already occurred before the baseline study, and the adaptation ability of condyle had decreased.

10. Conclusions

The present study indicates that TMD do not increase in the elderly population, since even the most severe clinical signs disappeared in the 5-year follow-up. Treatment decisions concerning TMD in the present type of the very old elderly should first and mainly be based on the patient's subjective symptoms, and only second on clinical and radiographic examinations. Thus, the main determinants in treating TMD should first be subjective pain, and second clinically diagnosed pain and severe restriction in function of the jaw.

In the present old population the change in occlusal status was minimal during the 5-year follow-up. Loss of teeth and loss of occlusal support seem to have only a minor impact on signs and symptoms of TMD or radiographic findings in this very old population during follow-up. Prosthodontic treatment of the elderly patient should thus be based on prosthodontic indications only for such reasons as to maintain appearance or masticatory function, whereas for prevention or management of signs and symptoms of TMD, treatment does not seem to be warranted.

During the 5-year follow-up period, radiographic findings for the mandibular condyles of the present old population were quite rare, with flattening of the condyle the most common, and changes in radiographic findings were minimal. In sum, radiographic findings were unrelated to signs and symptoms of TMD or to occlusal support status, measured either with or without any removable dentures. The challenge for dental professionals is to maintain masticatory function in the old elderly and to avoid such over-treatment as replacing the missing molars routinely.

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Let your own dreams fly with you.

Helsinki, Novenber, 2004

Kaija Hiltunen

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