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DELIVERY, OUTCOME, AND COSTS OF ORTHODONTIC CARE IN FINNISH HEALTH CENTRES

by

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To my family

ABSTRACT

Ilpo Pietilä. Delivery, outcome, and costs of orthodontic care in Finnish health centres. Department of Public Health Dentistry, and Department of Oral Development and Orthodontics, Institute of Dentistry, University of Turku. Annales Universitatis Turkuensis. Sarja-Ser D Medica-Odontologica Osa-Tom 920, ISSN 0355-9483, ISBN 978-951-29-4394-4

The goal of the study was to analyse orthodontic care in Finnish health centres with special reference to the delivery, outcome and costs of treatment. Public orthodontic care was studied by two questionnaires sent to the chief dental officers of all health centres (n = 276) and to all specialist orthodontists in Finland (n = 146). The large regional variation was mentioned by the orthodontists as the most important factor requiring improvement.

Orthodontic practices and outcome were studied in eight Finnish municipal health centres representing early and late timing of treatment. A random sample of 16- and 18-year-olds (n = 1109) living in these municipalities was examined for acceptability of occlusion with the Occlusal Morphology and Function Index (OMFI). In acceptability of occlusion, only minor differences were found between the two timing groups. The percentage of subjects with acceptable morphology was higher among untreated than among treated adolescents. The costs of orthodontic care were estimated among the adolescents with a treatment history. The mean appliance costs were higher in the late, and the mean visit costs higher in the early timing group. The cost-effectiveness of orthodontic services differed among the health centres, but was almost equal in the two timing groups.

National guidelines and delegation of orthodontic tasks were suggested as the tools for reducing the variation among the health centres. In the eight health centres, considerable variation was found in acceptability of occlusion and in cost-effectiveness of services. The cost-effectiveness was not directly connected with the timing of treatment.

Key words: public orthodontic care, timing of treatment, orthodontics, acceptability of occlusion, outcome of treatment, costs of treatment, cost-effectiveness

TIIVISTELMÄ

Ilpo Pietilä. Terveyskeskusten oikomishoitotoiminta sekä sen tulokset ja kustannukset. Sosiaalihammaslääketieteen oppiaine ja Hampaiston kehitys- ja oikomisopin oppiaine, Hammaslääketieteen laitos, Turun yliopisto. Annales Universitatis Turkuensis. Sarja-Ser D Medica-Odontologica Osa-Tom 920, ISSN 0355-9483, ISBN 978-951-29-4394-4

Tutkimuksen tavoitteena oli arvioida Suomen terveyskeskuksissa järjestettävää oikomishoitoa: erityisesti hoidon ajoitusta, hoitotulosten hyväksyttävyyttä ja hoitotoiminnan kustannuksia. Terveyskeskusten oikomishoitojärjestelyjä tutkittiin kahden kyselyn avulla. Terveyskeskusten hammashuollon johdolle (n = 276) suunnattu kysely kartoitti vuonna 2001 järjestettyä oikomishoitoa. Oikomishoidossa olevien 0-18-vuotiaiden osuus vaihteli 2 – 43% välillä eri terveyskeskuksissa. Kaikille työikäisille hampaiston oikomishoidon erikoishammaslääkäreille (n = 146) suunnattu kysely kartoitti heidän mielipiteitään terveyskeskusten oikomishoidon järjestelyistä sekä hoidon indikaatioista ja ajoituksesta. Erikoishammaslääkärit mainitsivat suurimmaksi ongelmaksi terveyskeskusten välisen vaihtelun oikomishoitoon pääsyssä ja hoidon järjestelyissä.

Oikomishoitokäytäntöjä arvioitiin tarkemmin vuosina 2003-2005 kahdeksassa terveyskeskuksessa, joista kolme sovelsi varhaista ja viisi myöhäisempää hoidon ajoitusta. Satunnainen otos terveyskeskusten alueilla asuvista 16- ja 18-vuotiaiden nuorten ikäluokista (n = 1109) tutkittiin ja heidän purentansa hyväksyttävyys arvioitiin OMF-indeksin avulla. Nuorten purennan hyväksyttävyys ei eronnut merkittävästi varhais- ja myöhäishoitoa soveltavien terveyskeskusten välillä. Niiden nuorten osuus, joilla oli hyväksyttävä purenta, oli kuitenkin hieman suurempi varhaishoitoa soveltaneissa terveyskeskuksissa. Molemmissa ajoitusryhmissä hyväksyttävä purenta oli harvemmalla oikomishoitoa saaneella nuorella verrattuna nuoriin, jotka eivät olleet saneet oikomishoitoa lainkaan. Hoidon kustannuksia tarkasteltiin kahdeksassa terveyskeskuksessa potilasasiakirjoista kerätyn hoitotiedon avulla. Keskimääräiset kojekustannukset olivat korkeammat myöhäisen ajoituksen ryhmässä ja keskimääräiset käyntikustannukset korkeammat varhaisryhmässä. Ryhmien sisällä vaihtelu oli suurta sekä kustannusten että kustannus-hyötysuhteen osalta, vaikka kustannus-hyötysuhteessa ei havaittu ajoitusryhmien välisiä eroja.

Hoidon laajuus oli kasvanut 1990-luvun alkuun verrattuna, mutta laajuudessa havaitut yli 20-kertaiset erot olivat ennallaan. Erojen vähentämiseksi erikoishammaslääkärit ehdottivat kansallisia ohjeita ja laajempaa oikomishoidon työnjakoa. Hyväksyttyjen purentojen osuus sekä hoidon kustannus-hyötysuhde vaihtelivat kahdeksassa tutkimusterveyskeskuksessa. Oikomishoidon kustannus-hyötysuhde ei kuitenkaan näyttänyt olevan yhteydessä hoidon ajoitukseen.

Avainsanat: kunnallinen oikomishoito, oikomishoidon ajoitus, purennan hyväksyttävyys, oikomishoidon tulos, hoidon kustannukset, kustannus-hyötysuhde

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ABBREVIATIONS

ICON	Index of Complexity, Outcome and Need
NOTI	Need of Orthodontic Treatment Index
OMFI	Occlusal Morphology and Function Index
PAR	Peer Assessment Rating Index
SBU	The Swedish Council on Technology Assessment in Health Care
TMD	Temporo-Mandibular Disorder
TPI	Treatment Priority Index

LIST OF ORIGINAL ARTICLES

I. Pietilä I, Pietilä T, Varrela J, Pirttiniemi P, Alanen P. Trends in Finnish public orthodontic care from the professionals' perspective. Int J Dent, vol. 2009; Article ID 945074, 6 pages, 2009. doi:10.1155/2009/945074

II. Pietilä I, Pietilä T, Pirttiniemi P, Varrela J, Alanen P. Orthodontists' views on indications for and timing of orthodontic treatment in Finnish public oral health care. Eur J Orthod 2008; 30: 46-51.

III. Pietilä I, Pietilä T, Svedström-Oristo A-L, Varrela J, Alanen P. Orthodontic treatment practices in Finnish municipal health centres with differing timing of treatment. Eur J Orthod 2009; 31: 287-93.

IV. Pietilä I, Pietilä T, Svedström-Oristo A-L, Varrela J, Alanen P. Acceptability of adolescents' occlusion in Finnish municipal health centres with differing timing of treatment. Eur J Orthod 2010; 32:186-92.

V. Pietilä I, Pietilä T, Svedström-Oristo A-L, Varrela J, Alanen P. Comparison of costs and outcome of orthodontic services in Finnish public dental care. Eur J Orthod (Submitted)

The articles are referred to in the text according their roman numerals.

1. INTRODUCTION

Equality in access to treatment is one of the key objectives in the provision of public health services in Finland (Ministry of Social Affairs and Health, 1989). Public orthodontic treatment is offered, free-of-charge to children and adolescents up to the age of 18 years. Even though public dental health care is partly financed by the government, the independence of communities in the organization and provision of services is supreme (Widström et al., 2005). Consequently, different policies in the arrangement and allocation of local health care resources lead to variation in access to services and treatment outcome. Moreover, the wide variation arouses apprehension about whether there is a risk of unnecessary or insufficient delivery of orthodontic services.

A wide variation has been found in the provision of orthodontic care in Finnish health centres; both the volume of services and treatment modalities vary even in neighbouring health centres (Pietilä et al., 1997). Generally, in the public dental service, the initiation of orthodontic treatment is most often made by professionals (Shaw et al., 1979; Pietilä and Pietilä, 1994; Bergström, 1996). In Finland, the first guidelines for the prioritization of orthodontic treatment were published in 1988 (Finnish Medical Board). Further, in 2005, the compilation of uniform grounds for access to non-emergency health care including oral health was undertaken by the Ministry of Social Affairs and Health. In orthodontic care, the guidelines aimed to steer the allocation of public health services, in order to ascertain that children with similar malocclusion should have equal access to treatment.

The availability of professional resources, a sufficient number of specialist orthodontists, dentists and ancillary personnel is an important prerequisite for the provision of orthodontic treatment. An equally important prerequisite for efficient treatment provision is sufficient professional knowledge and skills. However, despite the uniform education and training of professionals, there is generally a wide variation in all treatment decisions (Luke et al., 1998). In orthodontics, the variation can be expected, e.g. in the assessment of treatment need, in opinions on the feasibility of treatment, or the consequences of non-treatment, the optimal timing of treatment, and the selection and use of appliances. The economic depression in Finland in the 1990s, and the changing focus in public dental health care towards increasing adults' dental services, may have reduced orthodontic resources.

As regards the outcome of orthodontic treatment, the assessment usually covers mainly the quality of treatment results. The assessment of publicly funded orthodontic care should take place at population level and evaluate whole age cohorts, including children with and without a treatment history (Fernandes et al., 1999; Cadman et al., 2002). Crucial questions need to be answered; are the resources directed to the children most in need of treatment, do all treated children benefit from their treatment, and are the applied measures optimal as to outcome and costs?

2. REVIEW OF THE LITERATURE

2.1. Orthodontics in the public health context

Orthodontic treatment is an important part of modern oral health care for children and adolescents. The status of orthodontic care varies considerably in different countries, and several western welfare states have made arrangements for remunerating the costs of orthodontic treatment. In the case of third-party financing, orthodontic treatment is generally remunerated only if there is a risk of physical and/or psychosocial disorders. In this process, the professional acts as a goal-keeper determining who is entitled to be treated (ter Heege, 1997).

In dentistry, the benefit of treatment is most often regarded as the improvement on a biological level (Petersen, 2007). However, in orthodontics, the sociological and psychosocial aspects should also be emphasized (Jenny, 1975; Helm, 1990). According to current opinion, malocclusions only seldom seriously threaten oral health or the longevity of dentition. The greatest benefit from orthodontic treatment is seen as a better self-esteem and quality of life (Shaw and Turbill, 2007).

In orthodontic care, family support is needed both in the initiation of treatment and during the treatment process. Socio-economic differences, which lead to polarization in the manifestation of oral diseases, appear in orthodontics as unequal possibilities to carry out the treatment process (Turbill et al., 2003). However, it is important that the selection for orthodontic treatment is as objective and equitable as possible, and that the needs of patients and parents are met on an individual basis. The merely normative and professionally-based assessment of treatment need has been criticized (Sheiham and Tsakos, 2007). According to Prahl-Andersen (1978), orthodontists, patients, and lay people interpret malocclusions differently. Above all, the assessment of treatment need should include comprehensive risk-benefit evaluation, and the patients and parents should be involved in and informed about this evaluation (Shaw and Turbill, 2007).

Stenvik (1997) stresses the dual perspective in the assessment of orthodontic treatment need; need both on the individual and population level. On the individual level, the psychosocial aspects should be considered, because a similar deviation does not always appear as the same treatment demand. On the population level, professionals have to outline the goal of orthodontic services and disclose necessary norms and health objectives. Further, they have to adapt the decisions to the available work force and financial resources and to ascertain justified resource allocation (Linge, 1987; Pietilä et al., 1992).

2.2. Public orthodontic services in the Nordic countries

In the Nordic countries, orthodontic care for children and adolescents is financed, remunerated or supported by the society. In Denmark, Finland and Sweden, the public

services play a major role in children's orthodontic care. In Norway, the great majority of orthodontists work in the private sector, and orthodontic treatments are remunerated by public funding according to the severity of the child's malocclusion. In Iceland, the public dental clinics were closed in 2002, but the national health insurance supports orthodontic treatment by a fixed subsidy (Widström et al., 2005).

In Norway, all orthodontic treatments are given by specialists, while in Sweden and Denmark general dentists are involved in the treatment of every fifth, and in Finland of almost half of the cases. The ratio of orthodontist to population is almost equal in Sweden (1:31 000) and in Finland (1:32 700), while it is slightly lower in Denmark (1:34 700), and higher in Norway (1:25 000) (Stenvik and Torbjørnsen, 2007).

In all Nordic countries, the authorities have wanted to regulate the access to orthodontic treatment. In Sweden, the first recommendations were published already in 1967 (Socialstyrelsen, 1967), but so far no official guidelines exist. Still in the late 1990s, 55% of public orthodontic clinics applied the recommendations given in 1967 (Enberg et al., 1999). In Norway, the governmental remuneration is combined with the national treatment need index, the NOTI (Espeland et al., 1992). In Denmark, orthodontic screening has been guided by national priority guidelines (Solow, 1995), updated in 2007. In Finland, the first recommendations for prioritization of orthodontic treatment were given in 1988 (Finnish Medical Board, 1988).

Comparison of the volume of orthodontic services in different countries is hampered by several factors. In general, the organization of services, private or public funding, involvement of insurances, and cultural aspects vary considerably between countries. In the Nordic countries with rather similar circumstances, the main problem in the comparisons is the differing ways of calculating the extent of care. Even though the neighbouring countries Finland and Sweden have a rather similar organization of services (Bergström, 1996; Pietilä, 1998), the national tradition for measuring the extent of orthodontic services differs considerably. The regional variation is high in both countries, probably higher in Finland than in Sweden (Pietilä et al., 1997; SBU, 2005). In this respect, orthodontic treatment is no exception among health services. A regional variation has also been described both in children's general health status (Gissler et al., 2000) and in medical and dental treatments (Keskimäki et al., 1994; Balogh et al., 2004; O'Brien et al., 1989). According to Wennberg (1986), the wide regional variation encourages the discussion on the appropriate volume of services.

2.3. Orthodontic services in Finnish health centres

After 1956, the Finnish communities were obligated by law to organize dental treatment for children in primary schools (Kalijärvi, 1958). At that time, orthodontic treatment was given only rarely, mainly in the largest cities. In 1972, the Primary Health Care Act was introduced and the municipalities established health centres to provide primary health care. Dental treatment for children and adolescents became systematic and more comprehensive, and health promotion and the preventive approach were introduced on a national level. Orthodontic services, free-of-charge for children and adolescents up to the age of 18 years, were also included in municipal

health services. However, during the first decades, the main focus in public oral health care was on the prevention and treatment of caries, while the governmental authorities tended to restrict the increase in the volume of orthodontic services.

In 1988, the Finnish Medical Board recommended that orthodontic treatment should be limited to the most severe cases and priority was given to functionally disturbing malocclusions. As a part of the recommendations, the Finnish Medical Board published a 10-grade scale for assessment of orthodontic treatment need (Heikinheimo, 1989). The scale was a modification of the Treatment Priority Index (TPI) (Grainger, 1967), and it ranked the indications for orthodontic treatment according to the severity of the deviation, with the emphasis on functionally disturbing occlusal deviations. In 2001, this 10-grade scale was used in 53% of health centres (Pietilä et al., 2004).

Since the early 1990s, the Finnish public health care has been guided more by governmental authorities' recommendations than by direct regulations. In addition, the municipalities deliver health services according to their own priorities and financial capacity. According to the statement of the Parliamentary Ombudsman in 2003, orthodontic treatment given for health-related indications is an essential part of children's general oral health care, and Finnish municipalities are responsible for organizing the services. However, the orthodontic services have to compete for resources within the dental care of the municipality.

In the1990s, every fourth dental visit of children and adolescents to the health centres was connected with orthodontic treatment (Nordblad et al., 2004). However, the focus in public dental health care was gradually changing, and since 2002, dental care for adults of all ages has become a part of the services. Despite this development, it was generally accepted that children's dental services should not be endangered.

An earlier study revealed up to a twenty-fold difference among health centres in the percentage of children receiving orthodontic treatment in 1992, when the number of 0-18-year-old children receiving orthodontic treatment ranged from 1% to 19%. The high percentage of children with treatment history was connected with an early starting age (Pietilä et al., 1997). Since 2005, the allocation of public health services, including orthodontic care, has been regulated by national guidelines for access to non-emergency treatment. These guidelines state that children with similar malocclusion should have equal access to treatment. The 10-grade scale for assessment of orthodontic treatment need was also updated in connection with the compilation of the national guidelines (Ministry of Social Affairs and Health, 2005).

2.4. Orthodontic work force

The availability of orthodontic services is greatly influenced by the number and distribution of specialist manpower. In the other Nordic countries, the education of specialist orthodontists was started in the 1950s (Stenvik and Torbjørnsen, 2007). In Finland, the first specialist orthodontists were registered in 1975, and the first specialists graduated from a three-year full-time postgraduate programme in 1988. In the early 1990s, every fifth health centre employed an orthodontist, covering half of the

Finnish population. Most rural municipal health centres did not employ a full-time orthodontist, but the expertise was purchased from consultant orthodontists (Pietilä et al., 1997). According to statistics of the Finnish Dental Association, there were 131 actively working specialist orthodontists in Finland in 2005. Half of them worked in municipal health centres, one third mainly in the private sector, and every tenth at the universities. The availability of specialist expertise varied in different areas of the country, with the fewest specialists working in the northern and eastern part of the country.

In 2003, sixteen of the twenty-one central hospital districts in Finland arranged complex orthodontic services by their own salaried orthodontist, while specialist orthodontic treatment was purchased as a commissioned service by ten of the districts. Surgical orthodontic treatment was included in the majority of the orthodontic treatments given by all but one of the clinics of oral and maxillofacial surgery of the central hospitals. Half of the central hospitals also offered orthodontic consultation services for the health centres of their own district (Tiainen et al., 2004).

In Finnish municipal health centres, orthodontists and general dentists work together in the same organization, thus facilitating joint action and a flexible work division. The screening for orthodontic treatment is usually carried out by general dentists or dental hygienists, who refer a child with apparent treatment need to the orthodontist. In most cases, the orthodontist makes the diagnosis, draws up the treatment plan, and in the case of delegation to a general dentist, guides the treatment during the treatment process (Pietilä et al., 1992, 1997). Since the early 2000s, there has been a continuous lack of general dentists in Finland. This has restricted possibilities to delegate orthodontic treatments to general dentists.

The delegation of orthodontic tasks to ancillary personnel is a common practice in Europe, even though there is a wide variation between countries (Seeholzer et al., 2000). In the United Kingdom, there has been a profound discussion on possibilities to improve the orthodontic work division (O'Brien and Shaw, 1988; Turner and Pinson, 1993). Recently, a training programme for orthodontic teams including the training of orthodontic nurses was introduced in the UK (Cure and Ireland, 2008).

In the Nordic countries, delegation is very widely applied; in Sweden systematic training of orthodontic assistants has been used to facilitate the division of work (Stenvik and Torbjørnsen, 2007). Presently, there is no official training of orthodontic assistants in Finland. However, the work division between specialist orthodontists and ancillary personnel is not restricted by the Finnish authorities. In fact, there is a general expectation that by delegating routine tasks to auxiliary personnel, the capacity of orthodontic services could be increased.

2.5. Features of orthodontic treatment

In orthodontics, the decision to treat a malocclusion is based on an elective choice, and there is an apparent inconsistency in the professionals' views on the benefits and feasibility of orthodontic treatment (Shaw and Turbill, 2007). In addition, there are

differing opinions on the most appropriate timing of orthodontic treatment (Gianelly, 1994; Yang and Kiyak, 1998; Jang et al., 2005).

Intervention in the early mixed dentition is frequently recommended, for example, in the case of posterior crossbite or Class III relationship (Kennedy and Osepchook, 2005; Ngan, 2005). Subtelny (2000) suggests two main indications for early intervention; first, severe skeletal-related problems, which without treatment may develop into more characteristic skeletal malocclusions, and secondly, visible malocclusions, which may produce negative psychosocial sequelae.

The definition of early orthodontic treatment differs according to treatment traditions. In recent studies evaluating early treatment, the starting age varies between 8 and 13 years (Tulloch et al., 2004; Hsieh et al., 2005; Dolce et al., 2007). In Finland, only the orthodontic treatment given in the primary or early mixed dentition is generally regarded as early treatment. In the early 1990s, the average starting age for orthodontic treatment was 9.5 years (Pietilä et al. 1997). The most common indications for starting early orthodontic treatment in Finland are anterior and lateral crossbite, excess overjet, deep bite and crowding (Keski-Nisula et al., 2003; Väkiparta et al., 2005). Similar indications for starting the treatment in the early mixed dentition period have been reported in Germany by Tausche et al. (2004). Väkiparta et al. (2005) found a significant reduction in orthodontic treatment need from 8 to 12 years in a group of Finnish children treated systematically by early intervention. A considerable reduction in treatment need was also found in a Finnish study reporting treatment using an eruption guidance appliance during early mixed dentition. During treatment from the age of 5 to 8 years, it was found to be effective in the correction of Class II malocclusions, Class II tendency, and several other deviations (Keski-Nisula et al., 2008a, 2008b).

When orthodontists' perceptions on treatment timing were studied in Italy, Turkey and the USA, the majority of orthodontists preferred to treat malocclusions, such as an anterior crossbite and severe arch constriction, early, during the primary or early mixed dentition (Kiyak et al., 2004). However, there were more obvious differences in the preferred timing of treatment of other occlusal or skeletal deviations, e.g. large overjet and severe crowding.

As disadvantages of early intervention, a longer treatment time and a higher rate of premature termination of treatment have been mentioned (Proffit and Tulloch, 2002; Hsieh et al., 2005). Further, treatment in the late mixed dentition in the case of Class II division 1 malocclusions or in the permanent dentition in the case of crowding has been recommended (Ghafari et al., 1998; Gianelly, 1994). The treatment of Class II division 1 malocclusions in the permanent dentition has also been recommended for the better efficiency of treatment (von Bremen and Pancherz, 2002).

In the USA, three clinical trials on the treatment timing of Class II division 1 malocclusion showed that several dental and skeletal changes could be achieved by early intervention. However, at the end of the two-stage treatment, the differences

between the early and late treatment group had to a great extent levelled off (Ghafari et al., 1995; Keeling et al., 1998; Tulloch et al., 1998). These studies were unable to identify any factors which could predict which of the children would benefit from early intervention. Tulloch et al. (2004) concluded that the optimal timing for treatment of a Class II malocclusion remains controversial, and that the decision on treatment timing should be based on individual indications for each child.

The choice of treatment methods reflects the educational tradition and professional preferences in each country. Traditionally, European orthodontists have shown a greater preference for functional appliances compared with their American colleagues (Graber, 1998), but increasing collaboration between professionals in different countries may have lessened the differences. In Finland, the possibility to screen whole age cohorts at a young age has contributed to the popularity of early intervention.

In the early 1990s, the most frequently used appliances in Finnish health centres were quadhelix and headgear at seven years of age (Pietilä et al., 1997). Later, in the 1990s, the eruption guidance appliance became increasingly popular in the early mixed dentition (Keski-Nisula et al., 2008a). In the early 2000s, a quadhelix and headgear were among the three most frequently used appliances (Svedström-Oristo et al., 2003). Kirjavainen et al. (2000) and Pirttiniemi et al. (2005) have shown that headgear is effective both in the expansion of the maxillary arch and in the inhibition of forward displacement of the maxilla. Further, the eruption guidance appliance has proved to be successful in restoring normal occlusion and eliminating occlusal deviations (Keski-Nisula et al., 2008b).

A fixed appliance was found to be the most common appliance in the late mixed or permanent dentition, followed by headgear and activator (Pietilä et al., 1997). The finishing of treatment with fixed appliances in the permanent dentition has been recommended for a good and stable treatment result (Birkeland et al., 2000; Fox and Chapple, 2004). In the United Kingdom, practitioners with an orthodontic qualification tended to start treatment more often with fixed appliances. The age of the patient was associated with the choice of appliance, with fixed appliances being more common in the treatment of older patients. In the mixed dentition, the treatment was commonly carried out with removable or myofunctional appliances (Turbill et al., 1999). In Norway, the children treated with fixed appliances had better treatment outcome than those treated with removable appliances (Birkeland et al., 2000).

2.6. Evaluation of orthodontic treatment outcome

In publicly funded orthodontic care, where services are often organized on a population level, the evaluation of individual treatment outcome as such is important. However, this alone is not sufficient, and therefore whole age cohorts need to be assessed. Both children with and without a treatment history should be evaluated to find out whether the resources are targeted optimally as regards the needs of a whole age group (Fernandes et al., 1999). Resources are generally scarce and the competition for resources emphasizes the demand to find and treat the children who will benefit most from the orthodontic treatment (Cadman et al., 2002).

Traditionally, assessment of the treatment results has been the main approach when evaluating the outcome of orthodontic services. Several indices and procedures have been developed for the assessment of treatment outcome. The Peer Assessment Rating index (PAR) introduced by Richmond et al. in 1992 has been used in the assessment of the standard of treatment in Norway and Sweden (Birkeland et al., 1997; Berset et al., 2002). In Finland, the index has also been used in the assessment of treated cohorts (Kerosuo et al., 2008; Krusinskiene et al., 2008). In the United Kingdom, the PAR has been used to evaluate treatment outcome in community-based services (Radnzic, 1999). However, the PAR has been criticized because it does not include an evaluation of the function of occlusion (Kelly and Springate, 1996; Birkeland et al., 1997; Riedmann and Berg, 1999). Moreover, the assessment of the PAR is carried out using dental casts, which are seldom available when whole age groups including even untreated individuals are evaluated.

In 2000, Daniels and Richmond published the Index of Complexity, Outcome and Need (ICON) for the assessment of orthodontic treatment need, complexity, and outcome. The index is based on the consensus of an international panel of 97 orthodontists who gave subjective judgements on a sample of 240 initial and 98 treated study models. The index has been considered valid in the assessment of treatment need, complexity and outcome, but its validity in the assessment of the degree of improvement has been questioned (Firestone et al., 2002; Savastano et al., 2003).

The Occlusal Morphology and Function Index (OMFI) has been developed in Finland to measure the acceptability of occlusion on the population level (Svedström-Oristo, 2004). Svedström-Oristo et al. (2001) showed that a group of Finnish orthodontists regard a good function as the most important feature of acceptable occlusion compared to the morphology and appearance of dentition. The OMFI includes criteria to assess both the morphology and function of occlusion. In addition, it is suitable for the assessment of whole age groups and is based entirely on a direct clinical assessment (Svedström-Oristo et al., 2002). The OMFI has been found to successfully distinguish between the acceptable and unacceptable features of occlusion among treated and untreated adolescents (Svedström-Oristo et al., 2003).

2.7. Economic aspects of orthodontic care

In general, dental care in Finnish municipal health centres is financed by a combination of national and local taxation. In addition, adult patients pay fees for their treatment. Dental services including orthodontic treatment are free-of-charge up to the age of 18 years, but usually by that age the treatment in the great majority of orthodontic patients has been completed.

Economic evaluations of health services include studies with several different viewpoints. Cunningham and Hunt (2000) mention the three most useful questions which should be answered in the economic evaluation: 1) can the intervention work (efficacy of procedure), 2) does the intervention work (effectiveness of procedure), and 3) is it reaching those who need it (availability of services)? Generally, economic evaluations have been expanded to cover health care, but have only seldom involved

orthodontics. Especially in publicly funded orthodontic care with third-party financing, the economic aspects should be given special attention.

In Denmark, Sweden and Finland, orthodontic treatment for children and adolescents in public health care is free-of-charge. In Norway, orthodontic treatment provided by private practitioners is subsidized by the state up to 100%, 75% or 40% of the costs according to the severity grade of the child's malocclusion. In Iceland, the national insurance company supports orthodontic treatment with a fixed subsidy (equal to EUR 1750) per patient treated (Widström et al., 2005).

The economic aspects of orthodontic treatment have been evaluated in only few studies. In a Finnish central hospital, 29% of the total costs of surgical-orthodontic care were caused by the orthodontic treatment (Panula et al., 2002). It was concluded that surgical-orthodontic treatment is an expensive way to correct dentofacial malocclusions because of the high costs of the surgical phase. Pietilä et al. (1998), who estimated the productivity of orthodontic care in Finnish health centres, found that savings might be obtained if treatments were devolved to specialist orthodontists or well-versed dentists, or if treatments were started early.

Studies of the costs of orthodontic treatment have been published both on orthodontic treatment and orthodontics combined with surgical treatment (Severens et al., 1998; Cunningham and Hunt, 2000, Panula et al., 2002; Kumar et al., 2006). Variation in the surgical-orthodontic costs was explained by the differences in the difficulty and complexity of the procedure, differences in the clinical practices or in the efficacy of patient care (Kumar et al., 2006).

The direct costs of orthodontic treatment consist of the salaries and material costs involved in treatment. In particular, duration of treatment and number of visits as such have their effect on the costs of orthodontic treatment. Salary costs are mainly connected with the level of education and seniority of manpower. On the other hand, the division of work has been recommended as a tool to reduce treatment costs. Delegation of orthodontic tasks to auxiliaries is widely permitted in Finland, compared with many European countries (Seeholzer et al., 2000). According to recent Finnish studies, the cost-efficiency of public dental services could be improved by increasing the use of dental auxiliaries (Linna et al., 2003; Widström et al., 2004).

The duration of treatment and the number of visits are influenced by both the decisions and the skill of the provider and the personal characteristics of the patient. The severity of malocclusion and the complexity of treatment have an effect on the duration of treatment. Moreover, the provider's choice of treatment methods and appliances also influences the burden on the patient caused by treatment and, consequently, cooperation during treatment (Skidmore et al., 2006).

Only a few studies have been published discussing the cost-effectiveness of orthodontic treatment. Richmond et al. (2005) found that the cost-effectiveness of orthodontic care varied considerably within and between orthodontists, as well as in

different provider settings. They compared the cost-effectiveness among three groups of orthodontists in Wales; self-employed practitioners, and salaried orthodontists in hospital and in community clinics, and found that the least expensive way to deliver treatment was trough orthodontists in community clinics. Deans et al. (2009) concluded that the differences in the cost-effectiveness of treatment among orthodontic practitioners were largely explained by the cost level of the country. In their study, the cost-effectiveness of orthodontic care was evaluated in seven European countries by calculating the cost per ICON point reduction of orthodontic treatment need during the orthodontic treatment process.

During economic depressions, the costs of publicly provided health care and prioritization of services are often hotly debated. According to Wennberg (1986), when attempting to control the rising costs, governments tend to interfere with the clinical decision-making, and at the same time they ignore the medical consequences of cutbacks. Therefore, it is important that evaluation of the costs and costs-effectiveness of health services are carried out to identify the best treatment modalities. The consequences of economic restraints on the public orthodontic services have been discussed in Denmark and in Sweden (Mavreas and Melsen, 1995; Linder-Aronson et al., 2002).

2.8. Current challenges in Finnish orthodontic care

Although orthodontic treatment is provided in all Finnish health centres, a wide variation has been found among health centres in many features of treatment provision and practices, such as the volume and timing of orthodontic treatment (Pietilä, 1998). Great variation in the volume of treatment results in an inequality in the access to treatment. It is hardly possible to draw explicit conclusions about the optimal volume of treatment (Helm, 1990), but, nevertheless, the consequences of and reasons for the variation need to be revealed.

When comparing the timing of treatment in Nordic countries, early orthodontic treatment seemed to be commonly applied especially in Finland. Finnish studies on early treatment have shown that it is possible to achieve good treatment results by using early orthodontic intervention (Väkiparta et al., 2005; Kerosuo et al., 2008; Keski-Nisula et al., 2008b). However, the influence of timing on several other variables of treatment provision such as the duration, efficiency and costs of treatment needs to be studied.

The weakened economic situation in Finnish municipalities and the growing shortage of dental professionals might threaten the provision of orthodontic services in the future. This also calls for a better knowledge of economically and clinically favourable treatment practices and efficient work division. The assessment of resource allocation and treatment practices should be carried out within the framework of an acceptable treatment outcome.

3. AIMS OF THE STUDY

The goal of the study was to analyse the features of orthodontic treatment provision in Finnish health centres with special reference to the delivery, outcome and costs of treatment.

The specific aims were:

1) to examine orthodontic care in Finnish municipal health centres, and to assess the prevailing state and development during the past ten years (I)

2) to analyse the variation in the views of Finnish orthodontists concerning the indications for orthodontic treatment, the timing of orthodontic assessment and treatment, and the treatment methods used (II)

3) to compare differences in the indications, extent and duration of treatment, and in the choice of appliances in eight Finnish municipal health centres using early or late timing of treatment (III)

4) to compare the acceptability of occlusion among orthodontically treated and untreated 16- and 18-year-old adolescents in eight Finnish municipal health centres applying early or late timing of treatment (IV)

5) to analyse the costs and cost-effectiveness of orthodontic treatment in eight municipal health centres applying early or late timing of treatment (V)

4. SUBJECTS AND METHODS

4.1. Subjects

4.1.1. Professionals' views on public orthodontic care in Finland (I, II)

In April 2002, two different semi-structured questionnaires were sent out to survey the views on orthodontic care in Finland. A questionnaire was sent to all chief dental officers in 276 Finnish municipal health centres.

Responses to the first questionnaire were received from 177 chief dental officers, and after a follow-up letter, from a further 30 respondents. The total response rate was 76%. The non-responding chief dental officers worked mainly in small health centres with fewer than 10 000 inhabitants. Six non-responding chief dental officers worked in health centres with 10 000 – 20 000, another six with 20 000 – 50 000, and one with over 50 000 inhabitants.

Another, different semi-structured questionnaire was sent to all 146 specialist orthodontists under 65 years of age living in Finland in 2001, regardless of their type of employment. The names and addresses of the orthodontists were obtained from the files of the Finnish Dental Society. Seventy-six per cent of orthodontists were female. The geographic distribution of the orthodontists was even, with the exception of the most northern area, the County of Lapland.

The second questionnaire was returned by 83 orthodontists (57%). The response rate was 68%, when only the respondents and non-respondents working in or co-operating with the health centres were included. Seventy-seven orthodontists worked actively in clinical practice. The majority of them (76%) worked in the southern and western part of Finland, where the majority of the country's inhabitants live **(Table 4.1.).**

Table 4.1. Geographic distribution of specialist orthodontists under 65 years of age in Finland in 2001, and the number of 0- to18-year-old subjects per specialist orthodontist. (II)

	County					
	Southern Finland	**Western Finland**	**Eastern Finland**	**County of Oulu**	**County of Lapland**	**Finland**
Number of specialists	65	49	15	16	1	146
Number of 0- to 18-year-old per specialist	7 320	8 570	8 470	7 400	43 390	8 109

Of the seventy-seven actively working orthodontists, twelve (16%) also gave other dental treatments than orthodontic treatment. Two-thirds of actively working orthodontists worked as salaried orthodontists in a municipal health centre and half as private practitioners. Thirteen of the respondents had no connection with health centres. Several respondents worked in more than one employment sector **(Table 4.2)**.

Table 4.2. Distribution of actively working respondents by type of employment (several respondents worked in more than one employment sector). (II)

Type of employment (n = 77)	**Respondents**	
Salaried in a municipal health centre	51	(66%)
Full-time		31
Part-time		20
Consultant in a municipal health centre	37	(48%)
2-20 consultant days a year		18
24-60 consultant days a year		16
65-94 consultant days a year		3
Private clinic	38	(49%)
Central hospital	18	(23%)
University clinic	14	(18%)

4.1.2. Subjects in the municipal health centres (III, IV, V)

In order to analyse the effect of timing on the features of orthodontic treatment, acceptability of occlusion among adolescents, and the cost-effectiveness of treatment, eight municipal health centres were selected for the study. The health centres were selected on the basis of the results of an earlier study (Pietilä, 1998) in order to represent early and late timing of treatment. In 2003-2005, a random sample (2325 adolescents) from two age groups, 16- and 18-year-olds, living in the area of these eight municipalities was invited to participate in the study. In 2004, the total population living in the area of these health centres was about 370 000, which is 7.4% of the total population of Finland. The number of children and adolescents aged 0-17 years living in the eight health centres was 75 200 (**Table 4.3**).

Table 4.3. Population in the eight Finnish health centres and grouping of the participants. (III)

Health Centre	Total population	Number of 0-17- year-olds	Number of invited adolescents	Examined n (% of invited)	Boys %	Girls %	16 yrs %	18 yrs %
			Early timing group					
A	35 700	7 800	310	133 (43)	37	63	19	81
B	36 200	7 000	306	130 (43)	44	56	35	65
C	4 700	1 200	113	68 (60)	50	50	59	41
Subtotal	76 600	16 000	729	331 (45)	44	56	34	66
			Late timing group					
D	83 500	17 000	374	146 (39)	34	66	40	60
E	76 000	14 200	300	172 (57)	30	70	51	49
F	43 000	9 700	312	156 (50)	42	58	55	45
G	27 600	6 800	300	144 (48)	38	62	44	56
H	56 800	11 500	310	160 (52)	38	62	42	58
Subtotal	293 400	59 200	1 596	779 (49)	36	64	47	53
Total	370 000	75 200	2 325	1 109 (48)	38	62	43	57

4.2. Methods

4.2.1. Questionnaires mapping out professionals' views (I, II)

The questionnaire sent to chief dental officers was based on an earlier questionnaire, which mapped out the orthodontic care in Finnish health centres in 1992 (Pietilä et al., 1997), and it inquired about the number of personnel involved in orthodontic care, their work division, the number of orthodontic patients and visits, the use of orthodontic appliances, changes in orthodontic care in the previous ten years, and the chief dental officers' own views on what further orthodontic research is needed (**Appendix 1**). A follow-up letter was sent to the chief dental officers who did not respond by the appointed time.

In the questionnaire sent to the specialist orthodontists, the structured questions concerned the orthodontists' living area, type of employment, working experience, and where their postgraduate training had been carried out. In open questions, the respondents were asked to consider at what age they preferred to assess a child's occlusion for the first time, and then for a second and third time. They were asked to report the indications according to which they prefer to start orthodontic treatment in a child in the primary, early mixed, late mixed, or permanent dentition, and in adulthood. They were also asked which orthodontic appliances they preferred when treating children during the primary (4-6 years), early mixed (7-9 years), late mixed (10-13 years), or permanent (14-18 years) dentition by mentioning the three appliances they have most often used in those age groups. Further, the orthodontists were asked to evaluate, in open questions, orthodontic services and optimal work division in municipal health centres, to report recent changes in their treatment practices, to give suggestions for improvement of orthodontic care, and to suggest orthodontic issues needing further research (**Appendix 2**).

4.2.2. Characteristics of orthodontic services in the eight health centres (III, IV, V)

In six of the health centres (A, B, D, F, G, H), the orthodontic resources and treatment modalities had been stable during the previous 10 years, while major changes had been taken place in two (C,E). In Centre C, a new treatment modality was adopted in the 1990s, and orthodontic treatment was offered to all children with signs of malocclusion. Centre E had suffered from insufficient orthodontic resources for several years in the 1990s, and thus the intake of patients was restricted to the most severe cases. At the same time, the work division had changed, with an increasing number of treatments being carried out by general dentists.

Six of the eight health centres had employed salaried orthodontists, and the ratio of orthodontist to the 0-17-year-old population varied from 1:7000 to 1:17 000. In the remaining two health centres, the orthodontic expertise was purchased from a consultant orthodontist. In all eight health centres, diagnosis and treatment planning were usually carried out by a specialist, and in all health centres, general dentists participated in the orthodontic treatments. The orthodontist-population ratio, and the number of general dentists and auxiliaries involved in orthodontic treatments in each health centre are given in **Table 4.4**.

Table 4.4. Application of expertise and work force in the eight health centres during 2003 – 2005. (III)

Health Centre	Type of specialist orthodontist expertise	Ratio: orthodontist per 0-17-year-olds	General dentists treating mainly orthodontic patients	Other dentists involved in orthodontic treatments	Full-time orthodontic hygienist
		Early timing group			
A	salaried	1:15 600	-	>5	-
B	salaried	1:7000	-	>5	-
C	consultant	6 days per year for 1200	-	1	-
		Late timing group			
D	salaried	1:17 000	1	-	1
E	salaried	1:9500	1	>5	1
F	salaried	1:9700	1	-	-
G	consultant	4 days per year for 6800	2	-	-
H	salaried	1:11 500	1	<5	-

The eight health centres were grouped according to the average timing of treatment to an early (A, B, C) and a late (D, E, F, G, H) treatment group according to the mean age for starting the treatment on a child (earlier versus later than 9 years of age).

4.2.3. Questionnaire to the adolescents and the clinical examination (III, IV, V)

In the younger age group (16-year-olds), every third class of the 9th grade of the lower secondary schools in the municipality was selected after allotting a starting number. In the older age group (18-year-olds), every third class of the second school grade of the upper secondary schools in the municipality was selected after allotting a starting number. Furthermore, the names and addresses of all 18-year-olds were received from the registers of the local health authorities, and after the pupils from upper secondary schools were extracted from the list, every third name on the list was selected after allotting a starting number. In one small health centre (C), with fewer than 5000 inhabitants, all the individuals in these two age groups were invited to participate in the study.

An invitation letter was sent via the school to the pupils of the lower and upper secondary schools and by a posted letter to the home address of other adolescents in the older age group. All adolescents were offered the opportunity to telephone and change or cancel the visit. For practical and economic reasons, only a single examination period could be allocated to each municipality.

A total of 1109 adolescents (48%) arrived for the examination. The subjects were asked to fill in a semi-structured questionnaire before the examination. In addition to the demographic data: age, gender, type of school (lower or upper secondary vs. vocational school vs. no school), the questionnaire included questions on previous orthodontic treatment. One respondent did not answer the question about treatment history.

The clinical examination was carried out by two calibrated orthodontists (A-L S-O, TP).The examiners did not know which subjects had been orthodontically treated. After obtaining informed consent, the subjects were clinically examined for acceptability of occlusion with the OMFI (Svedström-Oristo, 2004) consisting of six morphological and four functional measurements (**Appendix 3**).

4.2.4. Features of orthodontic treatment history (III, IV, V)

The data concerning orthodontic treatment were retrospectively collected from the patient records of all the subjects (n = 608) who reported previous or ongoing orthodontic treatment or who could not recall whether they had received orthodontic treatment. The detailed data on the features of orthodontic treatment rendered were collected by one orthodontist (TP) who used the same pre-formulated protocol in each health centre. The form for collecting the features comprised the following items; the demographic data on the subject, the diagnoses given, the data on starting, finishing/discontinuation of treatment, the type and number of arch wires and appliances, the number of teeth extracted for orthodontic reasons, the number of visits to the orthodontist, dentist and/or ancillary personnel, and the number of non-cancelled visits. Orthodontic treatment was considered to have started when a fixed or removable appliance was placed into the mouth, and considered completed when a removable retention appliance was used less often than every night, or when regular check-ups of fixed retainers were no longer needed. The subjects with ongoing

treatment (n = 39) and those treated elsewhere (n = 46) were excluded. The remaining 518 treated subjects were included in the treatment group. The group with no treatment history consisted of 505 subjects.

The files of the non-participants were available only in one health centre (E), where the gender, age, school type and possible orthodontic treatment history were checked from the dental files of all the adolescents (n = 128) who failed to participate in the study examination.

4.2.5. Estimation of costs (V)

Labour costs

The chief dental officers in the eight health centres were asked by means of a semi-structured questionnaire to report on the orthodontic work division in connection with different orthodontic treatments, and the duration of orthodontic visits in each personnel category. The average duration of an orthodontic visit was calculated for the adjustment and control visits of each appliance type for every work force category according to the replies given by the chief dental officers (**Table 4.5**).

Table 4.5. Average duration of an orthodontic visit in each personnel category in connection with treatment by different appliance types. (V)

Type of visit	**Orthodontist – dental nurse minutes**	**General dentist – dental nurse minutes**	**Dental hygienist minutes**
Bonding of a fixed appliance	30	45	75
- control visit for one arch appliance	10	15	20
- control visit for two arch appliances	20	30	30
Fixation of palatal/lingual bar	15	25	20
- control visit for palatal / lingual bar	10	15	15
Construction of headgear	30	40	40
- control visit for headgear	10	15	5
Impression and construction bite for functional appliance	20	30	30
Adjustment of eruption guidance appliance / functional appliance	15	20	30
- control visit for functional appliance	10	15	15
Average duration of a visit	15	30	30

The average monthly salary for each personnel category in 2004 was received from the national labour market organization. The total salary costs also include social security costs of 30.51%. Finally, the average costs per orthodontic visit were calculated separately for every work force category (**Table 4.6**).

Table 4.6. Monthly salary costs, average duration of orthodontic visit, and average salary costs per visit in each personnel category. (V)

Personnel category	Monthly salary cost (including social security costs 30.51%)	Salary costs of a working hour per team*	Average duration of an orthodontic visit	Average total salary costs per visit
	€	€	minutes	€
Orthodontist	6354.90	54.02	15	13.51
Dental nurse	2288.71			
General dentist	5757.42	50.29	30	25.15
Dental nurse	2288.71			
Dental hygienist	2524.53	15.78	30	7.88

* monthly salary costs divided by 160

Appliance costs

Information about the numbers of brackets, bands, arch wires, face bows, extra oral devices and removable appliances used during individual treatment procedures was collected from the patient records of 557 study subjects. The costs of fixed appliances consisted of material costs estimated according to the average market prices given by the deliverers in Finland. The costs of removable appliances were computed according to average prices given by technical laboratories working in on the area of the health centres.

Percent unit of acceptability

In the cost-effectiveness analysis of orthodontic services, outcome was described as the one percent unit of acceptability. The acceptability was measured on a health centre level by determining what percentage of treated subjects had acceptable morphology and function when measured using the OMFI. The mean operating costs per case were used as the marker of the costs. The calculation of cost-effectiveness was made by figuring out how much each health centre had to have paid for one percent unit of acceptability, that is, by dividing the mean cost per case by the percentage of subjects with acceptable morphology or function.

The study protocol was approved by the Ethics Review Committee of the Hospital District of South-West Finland and the local Ethics Review Committees of the eight health centres.

4.2.6. Statistical methods

In study I, the statistical significance of the differences in the volume of orthodontic services between the health centres grouped according to their size, was tested by the variance analysis (ANOVA). P-value less than 0.05 was interpreted as statistically significant.

In study II, the association between an orthodontist's experience and timing of Class II division 1 and Class III treatment, was tested by Fisher's exact test. Stepwise logistic regression analysis, with the backward elimination method was used to estimate the association between the demographic characteristics of orthodontists and the tendency to start Class II division 1 treatment early.

In studies III and V, differences between the features of orthodontic treatment (in study III, the duration of treatment, the number of appliances, and the number of visits, and in study V, the number of appliances, and the number of visits) in the early starting health centres and the late starting health centres were analysed using the two-tailed t-test.

In study IV, the inter-examiner agreement between the two examiners was analysed using the Kappa statistic (Fleiss, 1986). The impact of the history and timing of treatment on the acceptability of occlusion was analysed with logistic regression analysis using the backward elimination method.

5. RESULTS

5.1. Provision of orthodontic care in municipal health centres in 2001 (I)

Features of orthodontic services

Orthodontic services were provided in all the responding health centres. The volume of orthodontic services was measured by the percentage of 0-18-year-olds wearing orthodontic appliances. In 2001, the mean percentage was 11.4 (range 2 – 43%). The mean percentage of children wearing an appliance was highest in small health centres with fewer than 10 000 inhabitants. The mean percentage was slightly smaller in larger centres, but the difference was not statistically significant (ANOVA, p=0.180). Orthodontic visits accounted for 30% of all dental visits of the 0-18-year-olds on average (range 2 – 66% among health centres); the size of the health centre was not associated with the ratio of orthodontic visits.

Orthodontic expertise

The most frequent way to obtain orthodontic expertise, used by 74% of health centres, was by making a contract with a consultant orthodontist. Every fifth health centre had employed salaried orthodontist manpower. Commissioned services were purchased in 34% of health centres. The purchasing of commissioned services was most frequent in the small health centres with fewer than 20 000 inhabitants. Five per cent of health centres did not have any specialist expertise at their disposal.

In almost all the health centres (94%), the general practitioners treated some of the orthodontic patients. Delegation of orthodontic tasks to dental auxiliaries was used in 61% of health centres. Specialist orthodontists accounted for 22%, general dentists 64%, and dental auxiliaries 14% of the total working time spent on orthodontic treatments in the health centres.

Seventy-four per cent of chief dental officers reported major changes in the organization of orthodontic services during the previous five years. In thirty-four health centres, major changes had taken place in the volume of orthodontic services **(Table 5.1).** Most of these changes concerned orthodontic specialist services. The number of specialist orthodontists had increased in twenty-seven and decreased in seven health centres.

A quadhelix was the most frequently used appliance in primary dentition, followed by an eruption guidance appliance. A headgear was the most frequently used appliance both in the age group of 7 to 9 years, and in the age group of 10 to 13 years **(Table 5.2).**

Table 5.1. Changes in the volume of orthodontic services during the previous five years reported by local chief dental officers (n = 34). (I)

Changes reported (n)	Explanations given by respondents (n)
Volume of orthodontic treatment increased (27)	Specialist manpower increased (17) Orthodontic services better organized (15) Commissioned services increased (4) More general dentists participated in orthodontic treatments (4)
Volume of orthodontic treatment decreased (7)	Weakened economic situation (5) Increased need for adults' dental services (4) Lack of specialist manpower (3)

Table 5.2. The first, second and third most frequently used appliance in the health centres in the age groups 7–9 and 10-13 years. (I)

At the age of 7–9 years (n = 205)			
Appliance	**First n**	**Second n**	**Third n**
Headgear	91	59	32
Quadhelix	64	64	32
Eruption guidance appliance	34	35	41
Removable plate	6	4	8
Functional appliance	3	16	18
At the age of 10–13 years (n = 204)			
Appliance	**First n**	**Second n**	**Third n**
Headgear	91	43	27
Fixed appliance	71	69	44
Functional appliance	16	58	54
Eruption guidance appliance	13	12	20
Quadhelix	12	7	7

5.2. Orthodontists' views on orthodontic care in health centres (I, II)

Opinions concerning the indications for treatment

The majority of respondents mentioned a lateral crossbite (88% of respondents) as the most frequent indication for treatment during the primary dentition, followed by an anterior cross bite (78%), and scissors-bite (34%). During the early mixed dentition, the most frequently mentioned indication was an anterior crossbite (73%), followed by a lateral crossbite (67%). A severe Class II division 1 malocclusion with an increased overjet was mentioned as the third most frequent indication for treatment in the early mixed dentition (53%), and as the most frequent (42%) in the late mixed dentition. In late mixed dentition, the second and third most frequent indications were severe crowding (40%), and Class II division 2 with a severe deep bite (40%).

Opinions concerning the timing of orthodontic assessments

Most orthodontists (81%) recommended the first assessment of the occlusion before seven years of age, and only two respondents recommended it later than this. However, the optimal age ranged from three to 10 years (mean 5.5 years). The second assessment ranged from the early mixed to the late mixed dentition (mean 8.2 years, range 6-12 years), and the third from the late mixed to the permanent dentition (mean 11.2.years, range 9-16 years).

Opinions concerning the selection of appliances

The orthodontists reported that in the primary dentition the most frequently used appliance was a quadhelix, followed by an eruption guidance appliance. In the early mixed dentition, the most frequently used appliances were a headgear and a quadhelix. The quadhelix was not mentioned for age groups over nine years. A functional appliance was used in the age range of 7-9 years upwards and was the second most frequently used appliance in the 10- to 13-year-old age group and in the 14- to 18-year-old age group. A fixed appliance was used most frequently in the 10- to 13- year-old age group, and it was also the appliance predominantly used in the permanent dentition.

Opinions concerning the starting age of orthodontic treatment

Orthodontists who had graduated between 1975 and 1987 tended to favour early treatment more often than those who had graduated more recently, i.e. 49% of those who had graduated earlier preferred to start Class II division 1 treatment during early mixed dentition, while this was the case for only 34% of those who had graduated more recently. This difference was not statistically significant (Fisher's exact test, $p=0.142$). The same tendency was seen in connection with Class III treatment, 32% vs. 24% (Fisher's exact test, $p=0.296$). No differences were seen in the timing of treatment of Class II division 2 malocclusions.

Approximately 50% of the orthodontists who worked full time in municipal health centres preferred to start the treatment of a Class II division 1 malocclusion during the early mixed dentition, a view agreed on by 28% of those working part-time and 41% of those working outside health centres. Correspondingly, the share of respondents emphasizing early treatment of Class III malocclusion was 35% among orthodontists working full-time in health centres, 24% among orthodontists working part-time in health centres, and 22% among those working outside health centres. Early initiation in the case of Class II division 2 malocclusion was preferred by all three groups (92% vs. 72% vs. 67%, respectively).

When consultant orthodontists were compared, similar differences were seen only in connection with Class II division 1 treatment. More than half (58%) of those working as consultants at least twice a month preferred to start treatment during the early mixed dentition, a view agreed on by 17 per cent of the orthodontists who worked less often as consultants.

Explanatory factors

The characteristics of respondents explaining the differences in the opinions on timing of Class II division 1 treatment were studied by logistic regression analysis **(Table 5.3).** The characteristics of orthodontists were: experience, graduated early (1975-1987) or late (1988-2002), graduation institution, working at a health centre, and working as a consultant. None of the chosen explanatory factors had a significant association with opinion on the timing of Class II division 1 treatment.

Table 5.3. Variables associated with tendency to start Class II division I treatment early (stepwise logistic regression analysis) (II)

	B	**SE**	**Wald**	**df**	**Sig. = *P***	**Exp(B)**
Experience	-0.481	0.505	0.905	1	0.341	0.618
University	0.343	0.495	0.478	1	0.489	1.409
Salaried	-0.006	0.533	0.000	1	0.992	0.994
Consultant	-0.238	0.493	0.234	1	0.629	0.788
Constant	-0.174	0.594	0.086	1	0.770	0.840

Experience, experience as a specialist orthodontist.
University, institute of orthodontic graduation.
Salaried, working in a health centre as a salaried orthodontist.
Consultant, working as a consultant orthodontist in health centre/centres.

Specialist orthodontists' views on orthodontic care delivery in health centres

The specialist orthodontists proposed that specialists should not give simple orthodontic treatment but concentrate on treatment planning, consultation, and difficult treatment. Forty-five respondents (64%) wanted to change the work division between specialists and general dentists; thirty-three (47%) wanted to increase the share of general dentists, mainly by delegating simpler treatments to them; treatment with appliances such as quadhelix, headgear, activator, face mask and removable appliances. Seventeen respondents (24%) wanted to reduce the involvement of general dentists in difficult treatments and the number of treatments started independently, without consultation.

Only one specialist orthodontist wanted to reduce delegation to auxiliaries, while 65 of them wanted to increase delegation by devolving routine tasks more often. The most common tasks to be delegated were the taking of impressions (51% of respondents answering this question), rebonding (50%), setting of bands (50%), health education and motivation (42%), bonding of brackets (15%), and changing of ligatures and arch wires (8%).

Eighty-one per cent of specialist orthodontists had made some changes in their treatment practices during the preceding ten years. The most frequent changes concerned the application of new treatment techniques (71%), and of these, the adoption of an eruption guidance appliance was most common (36%). Secondly,

respondents reported changes in the timing of treatment (54%), with the majority (75%) moving to an earlier starting age. Thirdly, fourteen respondents were delegating orthodontic tasks to general dentists or auxiliaries more often.

When the specialist orthodontists were asked to name those features of Finnish orthodontic care they considered to be of good quality, 55% listed the population-based system in the organization of orthodontic services, 25% the good professional skills of specialists, and 20% professional skills in the execution of early treatment. The orthodontists most often mentioned the lack of national guidelines as a challenge for development. Orthodontists' opinions on the aspects which need improvement and the suggested tools for improvement are given in **Table 5.4.**

Table 5.4. Aspects needing improvement and the suggested tools for improvement according to specialist orthodontists (percentage of respondents in parenthesis). (II)

Aspects needing improvement	**%**
Lack of national guidelines for orthodontic care	40
Weak routines in documentation, planning and follow-up of treatments	36
Insufficient work division in orthodontic care	35
Lack of orthodontic skills among general dentists	30
Suggested tools for improvement	**%**
Increased education of specialist orthodontists	39
Additional orthodontic resources needed for public health services	30
Better cooperation between central hospitals and health centres	19
Remuneration of orthodontic treatment by sickness insurance or by introducing orthodontic service vouchers for private services	16

Both chief dental officers and orthodontists gave various suggestions for subjects of future research. Both respondent groups stressed the need for research on treatment outcome and stability of treatment results. The efficacy of treatment methods was similarly mentioned by both groups, while the need for studies on cost-effectiveness was emphasized by orthodontists.

5.3. Orthodontic services in the eight health centres (III, IV, V)

5.3.1. Features of orthodontic treatment in the eight health centres (III)

Description of subjects

The percentage of participation in the study was lowest (39) in the largest and highest (60) in the smallest health centre. Females formed the majority among the subjects in all but one health centre. Fifty-seven per cent of subjects (n = 636) belonged to the older age groups, with 76% of them studying in the upper secondary, and 23% in vocational schools. One per cent of the 18-year-olds were not studying at any school. In Centre E, the percentage of boys was higher among the non-participants than among the participants (50% vs. 30%). Fewer non-participants than participants had a history of orthodontic treatment (38% vs. 43%).

Orthodontic treatment history

A history of orthodontic treatment in the study health centres was reported by 50% of all subjects. The percentage of subjects who had received or were receiving orthodontic treatment ranged from 27 to 85, and was lowest in the two largest health centres, D and E (**Figure 5.1.)**.

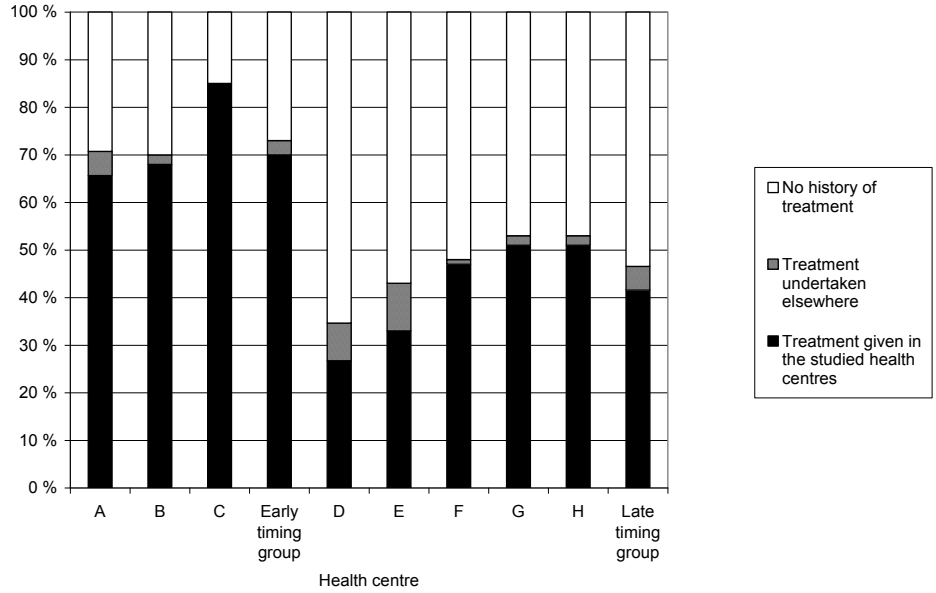

Figure 5.1. Subjects grouped according to the history of their orthodontic treatment.

Twelve per cent of all subjects had a history of discontinued treatment. The percentage of discontinued treatments was highest in the health centres with a high percentage of subjects with a treatment history that is in the early timing group. Only a few treatments were still continuing, with the percentage of subjects under treatment ranging from 2 to 21 **(Figure 5.2).**

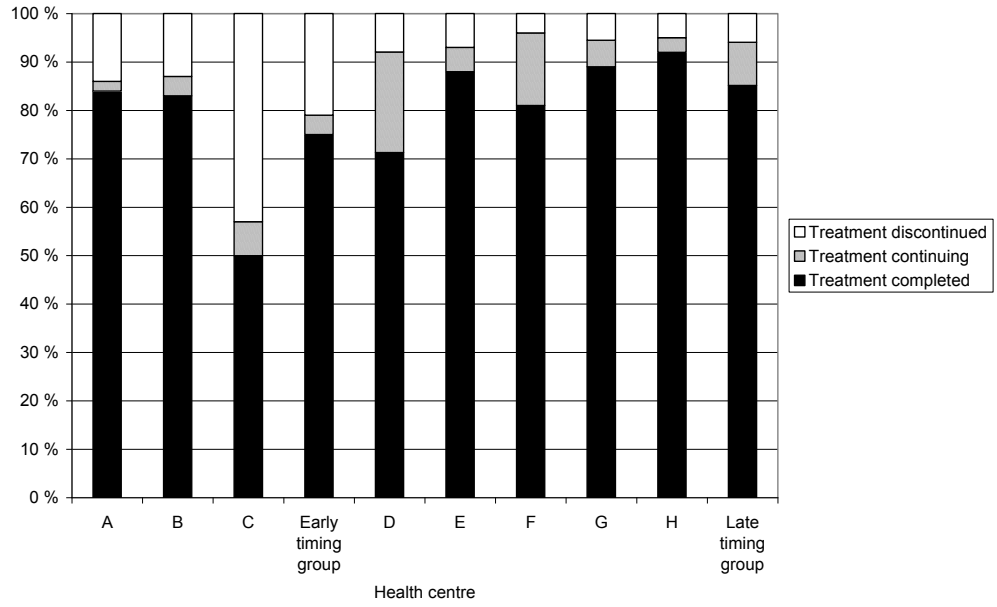

Figure 5.2. The phase of treatment in the groups with orthodontic treatment history.

Features of treatment

The mean age for starting orthodontic treatment in the studied health centres varied from 7.8 to 11.7 years; it was 8.0 years (SD=1.9) in the early group, and 10.7 years (SD=2.3) in the late group. The variation in starting ages of the subjects in the two groups is given in **Figure 5.3.**

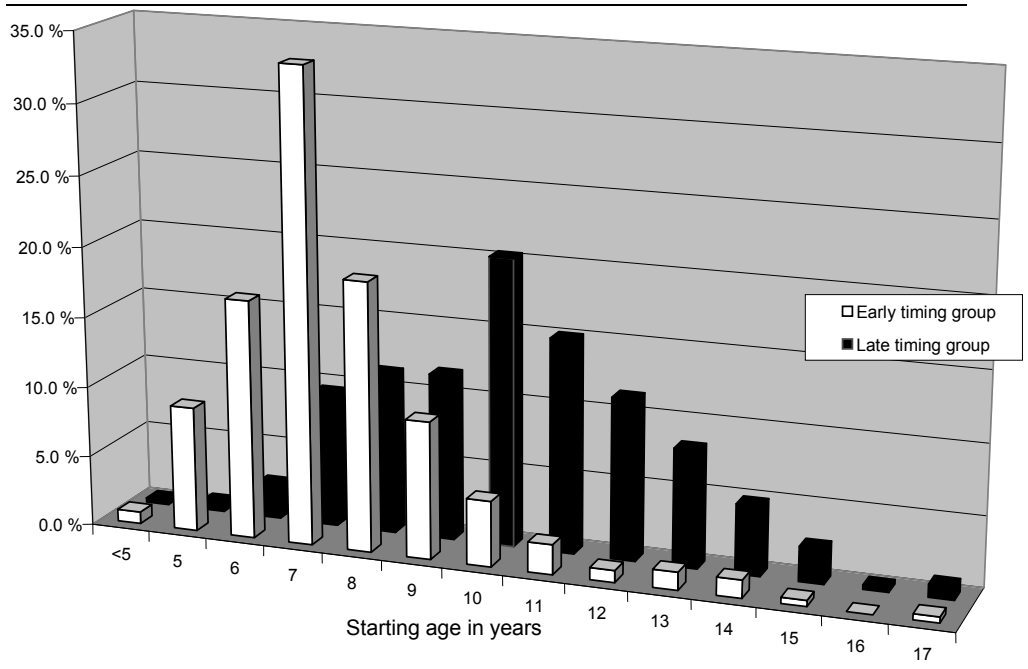

Figure 5.3. Distribution of starting age of orthodontic treatment in health centres with early or late timing of treatment (adjusted distribution). (IV)

The mean duration of treatment in the group with completed treatment ranged from 20.1 to 67.1 months **(Table 5.5)**. In the group with discontinued treatment, the mean duration of treatment ranged from 15.5 to 47.3 months, being 39.2 months (SD=26.3) in the early group and 29.5 months (SD=20.1) in the late group. The duration of treatment was higher in the early group (t-test, $p<0.001$) (III).

Crowding had been the most frequent indication for orthodontic treatment in four health centres (B, E, F, G), a Class II malocclusion in three health centres (A, C, H), and in one health centre (D) these two indications were equally frequent. The next most frequent indications were deep bite, lateral crossbite and anterior crossbite. The most frequently used appliance among all subjects was a headgear followed by fixed appliances, the eruption guidance appliance, and a quadhelix. The headgear was the most frequently used appliance in four, and an upper fixed appliance in three health centres. In Centre C, the eruption guidance appliance was the prevailing appliance **(Table 5.6).**

Table 5.5. Mean age for starting treatment and mean duration of treatment. (III)

Health Centre	Mean age of starting treatment years (SD)	Mean duration of completed treatment months (SD)
	Early timing group	
A	7.8 (2.5)	35.6 (20.1)
B	8.0 (1.3)	39.0 (23.1)
C	8.5 (1.6)	67.1 (31.8)
Subtotal	8.0 (1.9)	42.3 (26.0)
	Late timing group	
D	11.0 (2.4)	43.4 (25.0)
E	10.4 (2.7)	26.5 (18.6)
F	10.3 (2.2)	38.3 (27.9)
G	10.3 (1.7)	39.4 (22.3)
H	11.7 (2.2)	20.1 (13.9)
Subtotal	10.7 (2.3)	32.1 (23.0)

Table 5.6. Use of different appliances in the eight health centres (the most frequently used in bold)*.

Health Centre	Headgear	Eruption guidance	Upper fixed	Lower fixed	Quadhelix
			Early timing group		
A	**76**	11	16	5	21
B	**77**	0	15	5	11
C	26	**82**	30	4	19
			Late timing group		
D	33	0	**35**	18	12
E	**36**	34	34	9	30
F	38	10	**46**	31	30
G	**64**	29	49	33	6
H	6	9	**76**	44	3

* One or several appliances per patient.

A second phase of treatment was found in 22% in the early and in 17% in the late group. During the first treatment phase, a specialist was involved in the treatment procedure in every tenth case in the early group and in every third case in the late group. The specialist was involved in the treatment procedure in approximately half of the cases during the second treatment phase in both groups (**Table 5.7).**

Table 5.7. Percentage of treatments undertaken by specialist orthodontist and/or general dentist. (III)

	Early timing group		Late timing group	
Provider	**1st treatment phase (n = 231) %**	**2nd treatment phase (n = 50) %**	**1st treatment phase (n = 321) %**	**2nd treatment phase (n = 55) %**
Specialist orthodontist	7	42	25	31
General dentist	90	48	68	58
Both together	3	10	8	11

5.3.2. Acceptability of occlusion in the eight health centres (IV)

Acceptability of morphology

There was greater inter-examiner agreement between the two examiners in the assessment of morphology (Kappa 0.70) than in the assessment of function (Kappa 0.51).

The share of subjects with acceptable occlusion after the completion of treatment ranged from 42% to 72% among the health centres. In both groups the percentage of subjects with acceptable morphology was higher among untreated than among treated adolescents (**Figure 5.4**). Among the subjects with discontinued treatment, every third adolescent had an acceptable morphology of occlusion when measured by the OMFI, with the share being higher in the early than in the late timing group (35% vs. 27%).

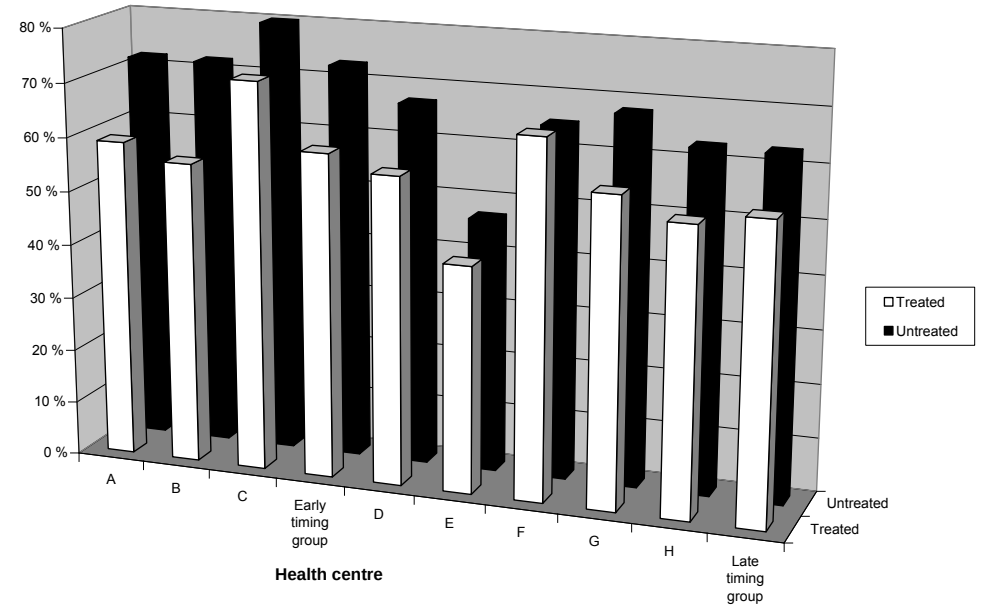

Figure 5.4. Percentages of subjects with acceptable morphology as measured using the OMFI according to health centre.

In the logistic regression analysis, both explanatory factors, the history and timing of treatment, had a statistically significant association with the acceptability of the morphology of occlusion. A history of orthodontic treatment decreased the odds (OR=0.719, 95% CL, p=0.016), while the early timing of treatment increased the odds (OR=1.370, 95% CL, p=0.042) for the acceptability.

In all groups, the most frequent feature leading to the non-acceptance of morphology was an unfavourable canine relationship (from 9% to18%), followed by deep bite (from 11% to 14%). In the early timing group, anterior crossbite was more common among treated than among untreated adolescents (7% vs.1%).

Acceptability of function

The percentage of subjects with functionally acceptable occlusion after completion of the treatment ranged from 46 to 72 in the health centres. In the early group, the percentage was quite similar among the untreated and treated adolescents, while in the late group, the proportion of functionally acceptable occlusions was higher among the untreated adolescents (**Figure 5.5**).

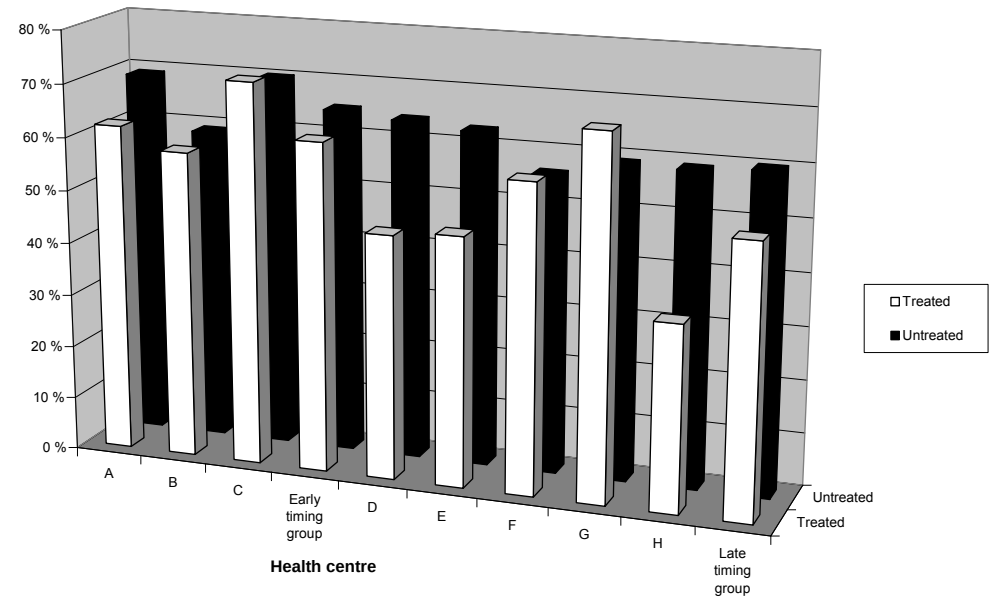

Figure 5.5. Percentages of subjects with acceptable function as measured using the OMFI according to health centre.

In the logistic regression analysis, both explanatory factors, the history and timing of treatment, had a statistically significant association with the acceptability of the function of occlusion. The history of orthodontic treatment decreased the odds (OR=0.724, 95% CL, p=0.018), while the early timing of treatment increased the odds (OR=1.420, 95% CL, p=0.023) for the acceptability.

In all groups, a protrusion interference was the most frequent feature leading to non-acceptance of function (from 26% to 37%), followed by disturbances in guided lateral occlusion (on right-hand side from 11% to 21%, and on left-hand side from 6% to 14%). Centre C had no subjects with a discrepancy between CR and ICP.

5.3.3. Costs of orthodontic treatment in the eight health centres (V)

Operating costs

The operating costs comprise the costs of orthodontic visits, i.e. estimates of the salary costs of an orthodontic visit in each manpower category, and the costs of orthodontic appliances. The mean operating costs per case were 720 euros in the early and 649 euros in the late timing group. The mean operating costs varied from 517 to 926 euros between individual health centres. The mean appliance costs were higher in the late timing group and the mean visit costs higher in the early timing group, but there was a great variation within both groups (**Figure 5.6).**

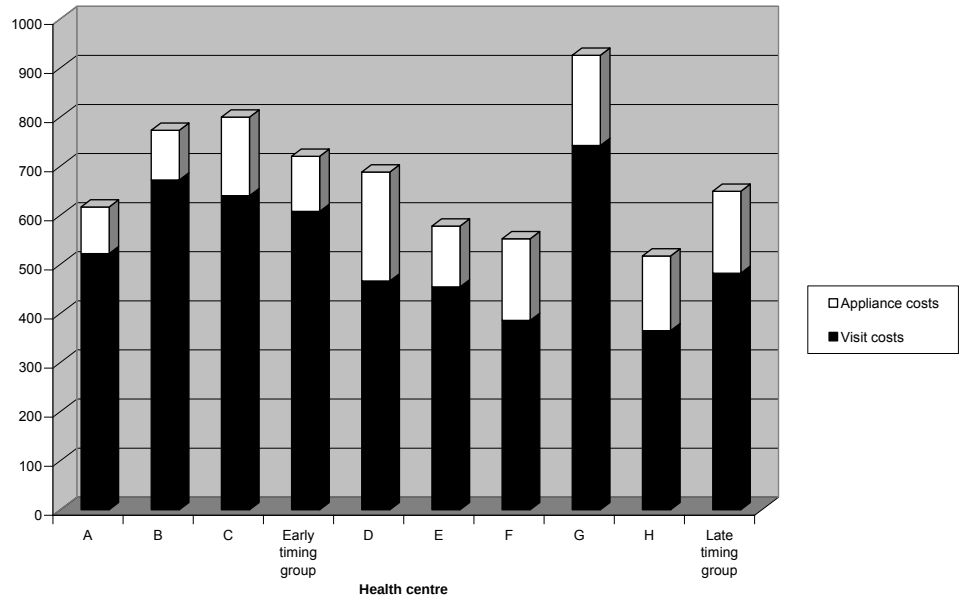

Figure 5.6. Mean costs of orthodontic treatment per case with treatment history according to health centre (includes completed, continuing, and discontinued treatments).

The visit costs were lowest in the two late timing health centres (F and H), where the upper fixed appliances were the dominating treatment modality, and the orthodontist was responsible for the majority of treatments. The visits costs were highest in the two health centres (B and G), where the general dentists had a major role in the treatment process.

The percentage of completed treatments was 75 in the early timing group and 85 in the late timing group, while the percentage of discontinued treatments was 21 in the early timing and 6 in the late timing group. The mean number of orthodontic visits was higher in the early timing group, and the difference between the early and late timing groups was statistically significant (t-test, p=0.004) (III). The mean number of visits among adolescents with completed, continuing and discontinued treatment in eight health centres is given in **Table 5.8.**

Table 5.8. The mean number of visits in the groups of completed, continuing, and discontinued treatments according to health centre. (V)

Health Centre	Treatment completed mean (SD)	Treatment continuing mean (SD)	Treatment discontinued mean (SD)
		Early timing group	
A	23.8 (11.3)	7.5 (3.5)	21.8 (12.3)
B	28.2 (15.8)	37.3 (24.1)	36.1 (22.8)
C	32.7 (16.2)	48.5 (30.6)	19.4 (10.8)
Subtotal	28.2	31.1	25.8
		Late timing group	
D	28.5 (15.8)	23.1 (6.7)	19.3 (1.5)
E	21.0 (13.8)	11.7 (9.6)	28.0 (17.4)
F	20.5 (14.7)	21.0 (9.2)	10.7 (9.9)
G	30.4 (16.3)	48.3 (21.8)	36.0 (13.6)
H	17.7 (9.4)	24.7 (11.2)	15.0 (9.8)
Subtotal	23.6	25.8	21.8

In the groups with completed and discontinued treatment, the mean number of orthodontic appliances was approximately twofold in the late timing group when compared with the early timing group. The difference in the mean number of appliances was statistically significant (t-test, $p<0.001$) (III). The mean number of appliances among adolescents with completed, continuing and discontinued treatment in eight health centres is given in **Table 5.9.**

Table 5.9. Number of orthodontic appliances in the groups of completed, continuing, and discontinued treatments according to health centre. (V)

Health Centre	Treatment completed mean (SD)	Treatment continuing mean (SD)	Treatment discontinued mean (SD)	All subjects* mean (SD)
		Early timing group		
A	2.9 (2.3)	1.0 (0.0)	1.8 (1.0)	2.7 (2.2)
B	3.1 (2.8)	7.0 (5.7)	2.8 (1.7)	3.3 (2.9)
C	4.0 (2.3)	8.0 (5.7)	2.6 (2.2)	3.6 (2.9)
Subtotal	3.3	5.3	2.4	3.2
		Late timing group		
D	7.1 (4.5)	9.5 (4.2)	16.7 (1.2)	7.2 (4.6)
E	4.3 (3.3)	5.3 (4.5)	3.5 (1.9)	4.3 (3.2)
F	5.8 (4.7)	5.7 (2.7)	3.3 (4.0)	5.7 (4.4)
G	6.7 (5.3)	8.8 (4.2)	8.0 (6.5)	6.7 (5.3)
H	7.5 (4.5)	7.3 (1.5)	2.5 (3.0)	7.2 (4.5)
Subtotal	6.3	7.3	6.8	6.2

* includes completed, continuing, and discontinued treatments

Cost-effectiveness

The criterion depicting the cost-effectiveness of orthodontic services, that is, the costs for one per cent unit of acceptable morphology, was the same in both timing groups. The costs for one per cent unit of acceptable function, was lower in the early timing group (**Figure 5.7).** In these comparisons, Centre F had the best cost-effectiveness in both categories. However, the health centre with the poorest cost-effectiveness varied for the two categories; in the morphology it was Centre G, and in the function Centre D.

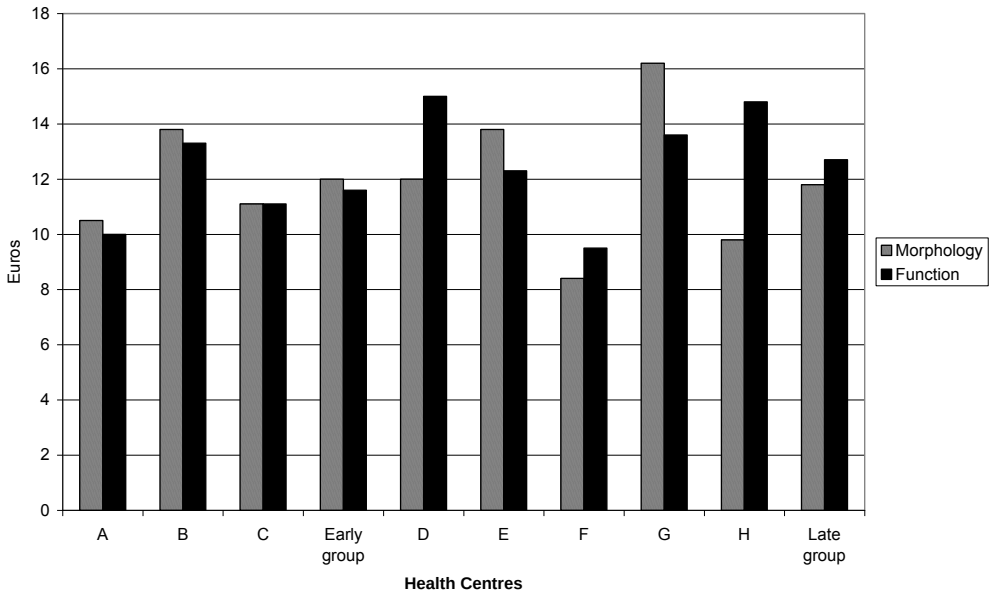

Figure 5.7. The costs of one per cent unit of acceptability of morphology and acceptability of function in each health centre and in the two timing groups. (V)

6. DISCUSSION

6.1. Methodological considerations

The approach of the present study was both retrospective and cross-sectional. It was partly based on questionnaires, partly on clinical registrations and patient files. The intention was to draw a realistic and pragmatic picture of clinical orthodontic activities in Finnish municipal health centres. The principal attributes chosen to describe the services were the volume of services, the timing and duration of treatment, the acceptability of occlusion among both treated and untreated adolescents, and the costs of services.

Questionnaires

The main focus in the questionnaire sent to the Finnish health centres was on the extent of services, treatment timing and practices, and delegation of work. In order to facilitate comparisons, several questions were deliberately formulated similarly to those in an earlier survey depicting public orthodontic care of children and adolescents in Finnish municipal health centres in 1992 (Pietilä et al., 1997). Additionally, in order to complement the general view, the respondents were also asked to estimate changes that had taken place during the last decade. The questions were constructed in detail in order to ensure the necessary homogeneity of the replies. In most of the large and medium-sized health centres, such data are usually collected using computer software. The gathering of data might have caused difficulties for some smaller health centres with limited data collection resources. Generally, studies based on questionnaires may suffer from some weaknesses; is the response rate good enough, are the answers reliable, and does the loss of replies have an effect on the representativeness of the results? It is usually estimated that a response rate of over 60% is acceptable (Chadwick et al. 1984). As regards the reliability, subjects have a tendency to give a good picture of themselves, especially if personal and intimate questions are posed. In the current study, however, the questions did not touch any sensitive areas of the respondent's life, as they concerned mainly administrative data. The loss of replies may have led to some loss in the representativeness of the results but there is no reason to suppose that this has caused differences in the comparisons between the subgroups.

The small number of specialist orthodontists in Finland enabled the sending of the second questionnaire to all orthodontists of working age. The questionnaire was regarded as a feasible tool for inquiring about orthodontist's treatment decisions. Thus, the collection of data was quick and inexpensive (Chadwick et al., 1984), and the bias caused by observer variation was avoided (Helöe, 1972). The questionnaire also gave the respondents the possibility to answer at the most convenient time. This was especially important because the questionnaire was comprehensive and partly asked for the respondents' opinion on optimal treatment decisions rather than on decisions they are used to make in real life situations. Many Finnish orthodontists work in several sectors: in public health care, hospital or university clinics, and in private practice. The

orthodontists working only in private practice or university clinics with less knowledge of the practices in health centres might have felt the questions difficult or awkward to answer. However, the good response rate (68%) among the orthodontists working in or co-operating with health centres makes it possible to draw reliable conclusions on public orthodontic care.

Subjects

The eight health centres were selected from among medium-sized municipalities on the basis of the results of earlier surveys to represent different orthodontic treatment timing practices (Pietilä, 1998) to be able to study the effect of the starting age of orthodontic treatment on the acceptability of occlusion. Centre C was smaller than the others, but was included in the study because it was applying a new early treatment approach using the eruption guidance appliance.

The studied age groups were selected to ensure that most subjects would have completed their orthodontic treatment. Further, the 16-year-olds were the oldest age group that could be easily reached for the examination via schools. Approximately half of the adolescents invited to the study arrived for the clinical examination. This was satisfactory when considering the phase of life at this age. In the present study, the evaluation of non-participants showed that the drop-outs included more males and those without orthodontic treatment history. However, the differences were minor and were not considered to distort the reliability of the results.

Assessment of acceptability

No generally valid or acceptable method is available for measuring the success of orthodontic services; only the morphological and functional effects of treatment can be measured comparably enough. However, operator variability is regarded as a significant problem in reducing the power of such comparisons (Vig et al., 1995). In this study, the evaluation of treatment outcome was based on a clinical examination instead of dental casts, and therefore the OMFI was chosen as the method for the assessment. The OMFI is a comprehensive method measuring the acceptability of both the morphology and the function of occlusion (Svedström-Oristo, 2004).

The inter-examiner agreement between the two examiners was measured as the proportion of agreement by using the Kappa statistic. The agreement in the assessment of function (Kappa 0.51) was moderate and in the assessment of morphology (Kappa 0.70) good (Altman, 1991). Thus, the agreement was satisfactory. The blinding of the examiners was assured by hiding the information on the adolescents' history of orthodontic treatment before the examination. Moreover, all the detailed facts on the indication of treatment, type of appliances, or number of visits were gathered later on without being aware of the information from the clinical examinations.

Logistic regression analysis using the backward elimination method was used to evaluate the associations with explanatory variables (the treatment history and the early versus late timing of treatment) and the acceptability of occlusion. Logistic regression

analysis was chosen, because it analyses the adjusted effects of each single factor when the effects of other factors have been taken into consideration.

In order to improve the comparability among the health centres, the adolescents with continuing or discontinued treatments were excluded from the assessment of the acceptability of occlusion. The acceptability was thereby evaluated only among those adolescents whose orthodontic treatment was completed.

Assessment of costs

In the eight health centres, the treatments studied had often been given already in the 1990s. The estimations of the time spent on treatments were collected according to routines applied at the time of the study. This might have caused bias especially in the economic evaluation in the health centres with major changes in the 1990s. In Centre C, the new treatment approach might have led to extra visits at the start. Similarly, in Centre E, the changes in the availability of specialist resources might have had an effect on, for example, the number of visits.

The economic evaluation was focused on the direct costs paid by the municipalities. The overheads were not included in the operating costs, because in a retrospective study arrangement, it was not possible to measure indirect costs of treatment, such as the loss of production, education, domestic responsibilities or social activities. Unlike in the evaluation of acceptability of occlusion, the economic evaluation comprised not only the operating costs of the adolescents with completed treatment but also those of adolescents with continuing and discontinued treatment. Thereby, the effect of variation in the percentage of discontinued treatments was also taken into account.

Generalizability of results

The retrospective nature of the inquiries from health centres might have tempted them to estimate some data instead of giving plain measurements. However, the amount of estimated data collected was moderately small. An earlier study on Finnish health centres (Pietilä et al., 1997) gave an opportunity to repeat the evaluation of orthodontic care, and thereby to describe the eventual changes that had taken place during the past decade. Further, by choosing the OMFI for the assessment tool, the results could be compared with an earlier Finnish study using the OMFI (Svedström-Oristo et al., 2003).

The detailed data on the treatment provided in the eight health centres were gathered from the adolescents' dental files using a written protocol. Because of lack of time and financial resources it was not possible to repeat the collection in order to measure the reliability of the data. However, any possible flaws in recording would be likely to scatter randomly, so this was not considered to jeopardize comparisons between the groups. According to Hausen et al. (2001), caries data collected from public health records are not inferior to the data collected by trained and calibrated examiners. This may be generalized also to concern orthodontic recordings. In Finland, the itemized registration of dental procedures is obliged by law. In addition, the codes describing

clinical procedures are nationally identical, which improves the comparability of the data. The dentists receive a fee for several clinical procedures they accomplish, which also promotes a careful registration and the precise use of codes.

The results of the present study elucidated the main features of orthodontic care in Finnish health centres. The pragmatic examples of the eight health centres made it possible to describe and compare different ways of organizing orthodontic services. Probably, this is the first study evaluating orthodontic care including both treated and untreated individuals in the assessments. Therefore, it was possible to illustrate the allocation of resources, the applicability of chosen treatment modalities and the feasibility of work division derived from a real-life situation from the perspective of the health care system.

6.2. Characteristics of orthodontic service delivery in Finnish health centres

An earlier study on orthodontic care in health centres in 1992 enabled the evaluation of changes in the service delivery during the ten-year period from the beginning to the end of the 1990s (Pietilä et al., 1997). The overall extent of services had generally increased, but the 20-fold differences among health centres reported in 1997 still prevailed. Even though the health centres which had earlier provided orthodontic treatment on a minimum level had increased their orthodontic services, the health centres with affluent service provision, had also increased the volume of their services. Unexpectedly, the economic depression in the 1990s had not been directly reflected in the extent of orthodontic services, and more health centres had increased than decreased their services during the last decade. However, according to the chief dental officers, the weak economic situation was the most frequent reason for reducing children's orthodontic services.

Two interesting changes had taken place in the delivery of orthodontic care during the 1990s. First, a new appliance, the eruption guidance appliance seemed to have largely replaced the use of removable plates and other functional appliances in the early treatment. Secondly, the delegation of orthodontic tasks to auxiliaries had increased considerably, and the delegation was generally favoured by the orthodontists.

Even though the survey gave opportunities to compare the features of orthodontic practices in Finland, comparisons with other Nordic countries are complicated. Above all, the methods of measuring the volume of orthodontic treatment vary in different countries, which hampers the comparisons. Furthermore, no nationwide data have been published on subsidized orthodontic care in other Nordic countries. In 2005, the Swedish Council on Technology Assessment in Health Care (SBU) published data on orthodontic services in Swedish counties. The volume of orthodontic treatment was calculated as treatments started during one year per one age group. The volume is not comparable as such with the present data, but large regional variation, four-fold differences in the percentage of started treatments, was also found in Sweden. Moreover, in the United Kingdom, Chestnutt et al. (2006) found that the extent of

orthodontic treatment had increased between 1993 and 2003, a tendency which was also seen in Finnish health centres.

The average share of orthodontic visits of all dental visits of children and adolescents in municipal health centres had increased only slightly from 26% in 1992 to 30% in 2001, even though the percentage of orthodontic patients had increased more clearly. In 1998, the National Research and Development Centre for Welfare and Health published a report recommending longer clinical examination intervals in children and adolescents (Eerola et al., 1998), and this may partly explain the minor increase in the share of visits. The reduction in general dental visits has also been reported by Nordblad et al. (2004). In addition, another explanation for the small increase in orthodontic visits may also be the fact that in the early 2000s, the focus in public dental health care was gradually changing, when adults of all ages also become entitled to municipal oral health services.

Finnish orthodontists tend to favour early treatment, and the average starting age of nine years is low when compared with the other Nordic countries (Rølling, 1978; Espeland et al., 1992; SBU, 2005). One explanation may be the tradition in Nordic universities to emphasize growth and development in orthodontics. The great majority of children regularly visit the health centres for oral examination and treatment (Nordblad et al., 2004). This allows the possibility to follow the development of a child's occlusion from birth to adulthood, and thereby it is feasible to carry out an early intervention. Furthermore, parents also favour early interventions (Pietilä and Pietilä, 1994).

All municipalities, regardless of their size, have an equal responsibility to organize treatment even in the most severe cases, and this may be one of the reasons for a pronounced increase in the purchase of commissioned services. When compared with an earlier study, the availability of health centres' own orthodontic expertise had also slightly increased (Pietilä et al., 1997). In the chief dental officers' responses, most of the changes in the provision of orthodontic services were related to the availability of specialist manpower. An increase in the number of orthodontists was reported considerably more often than a lack of specialists. However, the possibilities to organize specialist services varied between small and large health centres.

Although the orthodontists were interested in devolving simpler orthodontic treatments to general dentists, the decreasing number of general dentists and the increased challenges in oral heath care for adult patients do not encourage this kind of change. The orthodontists definitely wanted to carry out the diagnosis and planning of treatment, and the most difficult treatments. Still, the share of health centres applying delegation of orthodontic tasks to auxiliaries had been doubled from 1991 (Pietilä et al., 1997). This development seemed to be largely supported by the orthodontists.

6.3. The features of orthodontic treatment in the eight health centres

There were several differences in the features of orthodontic services provided by these eight health centres, which might have brought about confounding factors in the

assessment of the acceptability of occlusion and function. First, in six of the health centres (A, B, D, F, G, H), the orthodontic resources and treatment modalities had been stable during the previous 10 years, while major changes had taken place in two health centres (C, E). In Centre C, a new treatment modality with the eruption guidance appliance was adopted in the 1990s, and orthodontic treatment was offered to all children with even minor signs of malocclusion. Centre E had suffered from inadequate orthodontic resources for several years in the 1990s, and thus the intake of patients had been restricted to the most severe cases. At the same time, the work division had been changed, with an increasing number of treatments being carried out by general dentists. Moreover, there were differences in the work division and the availability of specialist expertise in the eight health centres. In the early timing group, treatments were mainly carried out by general dentists applying less demanding treatment methods, while in the late timing group, specialists were more closely involved in the treatment.

The results (Figure 5.1., page 36) depict that in spite of a distinct difference in the average starting age between the two timing groups, both early and late treatments were often applied in each group. The incidence of malocclusions does not vary considerably either in different regions in Finland or among the studied health centres. However, in the three early timing health centres the choice of appliances had inevitably guided the timing; both orthopaedic headgear and the eruption guidance appliance are especially effective during the early mixed dentition (Kirjavainen et al., 2000; Keski-Nisula et al., 2008b).

In the late timing group, the percentage of adolescents with an orthodontic treatment history (42%) was similar to that in earlier Finnish studies (Pietilä and Pietilä, 1996; Svedström-Oristo et al., 2003). In contrast to this, among the adolescents of the early timing group the percentage with a treatment history was much higher (70%). The differences in the volume of treatment between the groups may also have caused variation in the case mix; in Centres D and E with low treatment volume (27% and 33 %), only the most severe cases were entitled to treatment, while in the early timing group also minor malocclusions were treated.

In the health centres of the early timing group, the principles of treatment were based on one dominating appliance; in Centres A and B on headgear and in Centre C on the eruption guidance appliance. In the health centres of the late timing group, the use of different appliances varied more widely, and the fixed appliances were more commonly used. The variation in appliances was in line with the practices in Finnish health centres in 2001. The only exception was the use of functional appliances. They were found to be among the three most frequently used appliances only in Centre H, where it was the third most frequently used after the upper and lower fixed appliances. On the contrary, in 2001, the use of functional appliances was reported much more often in Finnish health centres. The eruption guidance appliance might have partly replaced the other types of functional appliances.

There was a difference in the mean starting age among the two timing groups, but still both early and late treatments were applied in each group. The orthodontists in the eight health centres had probably had converging opinions, e.g. on the appropriate timing of the treatment of anterior and lateral crossbites. On the other hand, some malocclusions, such as impacted canines and scissors bite of premolars and second molars can not be treated until during the late mixed dentition.

The need of the second treatment phase was almost the same, 22% in the early and 17% in the late timing group. Thus, early interventions were also applied in the late timing group. As for the total treatment duration, the treatment time was longer in the early than in the late timing group, 43 versus 32 months, although the total treatment time also varied in both the timing groups. The results were in line with earlier findings showing that a longer duration of treatment is connected with the use of more than one treatment phase and/or appliances demanding good cooperation (Beckwith et al., 1999; Mavreas and Athanasiou, 2008). Consequently, the mean number of visits was also more frequent in the early than in the late timing group. In the early timing group, orthodontic treatment was given more often by general dentists, and this may partly explain the difference. According to Nihtilä and Widström (2009), orthodontic treatments given by general dentists seem to increase the number of visits. Generally, in the late timing group, a greater number of treatments were still continuing as compared to the early timing group, but there was a great variation among the health centres of the late timing group.

According to earlier Finnish studies (Pietilä and Pietilä, 1996; Svedström-Oristo et al., 2003), the percentage of discontinued treatments varies between 11% and 13%. In the present study, a lower percentage was found in the late timing group. In the early timing group, every fifth subject had discontinued his/her orthodontic treatment. The share of discontinued treatments was highest in Centre C, where 43% of treatments were discontinued. Richmond and Andrews (1995) have noticed that an older starting age is connected with discontinuation of treatment, but the present study did not confirm their finding. On the other hand, Richmond's and Andrews' finding that the use of extra-oral traction is connected with discontinuation was supported. Both headgear and the eruption guidance appliance demand good cooperation and need a longer treatment time to be effective, and this can partly explain the higher discontinuation rates in the early timing group. Another explanation might be that in the early timing health centres, the treatment had been offered generously, and therefore children with originally weak compliance and/or minor perceived need may have been selected for treatment.

In the provision of health services, regional variation has frequently been reported (Keskimäki et al., 1994; Gittelsohn and Powe, 1995). An explanation characterizing this variation is professional uncertainty caused by the lack of evidence on different treatment practices (Wennberg et al., 1982). Consequently, the development of guidelines has been thought to reduce variation in the provision of health care services (O'Brien et al., 1996). In Finland, there are no Current Care guidelines steering orthodontic treatment practices, although guidelines have been developed for some

other dental procedures, e.g. diagnostics of oral cancer, TMD and dental caries. However, the compiling of guidelines for orthodontic treatment might be especially demanding in a country like Finland, because of the uneven distribution of specialist orthodontists in the country.

6.4. Outcome of orthodontic treatment

The share of subjects with acceptable occlusion was slightly higher in the early than in the late timing group, when both the morphological and functional criteria of the OMFI were taken into consideration. However, the wide variation in orthodontic appliances between and within the two timing groups complicated the appraisal of whether the use of different appliances as such influences the acceptability of occlusion. The early timing health centres used one type of appliance more frequently, but the variety of appliances used in the late timing health centres was great. In this study population, the frequency of treatments with an upper fixed appliance, varied from 34% to 76% in the late group compared to from 15% to 30% in the early group. In Norway, children treated with fixed appliances had better treatment outcome than those treated with removable appliances (Birkeland et al., 2000). However, in our study, Centre C, where the removable eruption guidance appliance was the most commonly used appliance, had the highest rates of acceptability in both morphology and function. Favourable treatment results have also been reported earlier by Keski-Nisula et al. (2008a) concerning the use of the eruption guidance appliance.

Svedström-Oristo et al. (2003) found acceptable morphology more frequently among untreated than treated adolescents. The same result was found here with one exception (Centre F), where both groups had a similar percentage of acceptability. The most frequent features causing unacceptability, poor canine relationship and large overbite, were identical with the findings of Svedström-Oristo et al. (2003). In contrast, crossbites and large overjet were found less often in the present study when compared with the study of Svedström-Oristo et al. (2003).

The early timing of treatment seemed to increase the odds for the acceptability of the function of occlusion. Further, an acceptable function was more often found among untreated than among treated subjects in both timing groups and in nearly all health centres. A corresponding tendency among treated and untreated adolescents has been reported earlier by Svedström-Oristo et al. (2003). In both studies, protrusion contacts were the most common features causing the non-acceptance.

A better acceptability of occlusion in the untreated group may appear contradictory, especially in countries where only a minority of children receives orthodontic treatment, and the treatment is not subsidized. However, in a country like Finland, where orthodontic treatment is organized and offered on a population basis, the treatment can be regarded as beneficial when those adolescents who at the beginning had a malocclusion had improved almost to the same level as the untreated adolescents with an acceptable occlusion. One explanation for these findings might be the high coverage of orthodontic treatment in general, and especially in the early timing health centres. Presumably, only the occlusions with a favourable prognosis had been left

untreated. This indicates that the selection for treatment had been successful, as most untreated individuals had an acceptable occlusion. In support of the present findings, in Norway, the lowest share of adolescents with residual treatment need among untreated individuals was found in a region with the highest treatment rate (Espeland and Stenvik, 1999).

The individual professional skills of the providers apparently have an influence on the amount of acceptability. In the early timing group, treatments were mainly carried out by general dentists applying simpler treatment methods. In the late timing group, specialists were more closely involved in the treatment. In general, the provider effect has a strong influence on treatment practices (Fox et al., 1997), and this may partly mask the impact of timing of treatment.

In spite of several difficulties in the comparison, the timing of treatment seemed to associate with the acceptability of occlusion. The early timing of orthodontic treatment slightly increased the odds for higher acceptability of morphological and functional features of occlusion. However, within both the early and the late group, a considerable variation in acceptability was found. Obviously, there were several factors other than timing which may have caused differences between the health centres. Nevertheless, the stability in the provision of services may be one of the key factors influencing the selection of orthodontic patients and the acceptability of treatment results.

6.5. Economic aspects of orthodontic care

There were distinct differences among the eight health centres in both measures of cost-effectiveness, i.e. the costs of one percent unit of acceptable morphology and one percent unit of acceptable function. However, the differences between the early and late timing groups were more moderate. The costs of an acceptable morphology percent unit were almost the same in the early and late timing groups, while the health centres of the late timing group had higher costs for an acceptable function. The low operating costs per se seemed to influence the cost-effectiveness but did not explain it totally. For example, Centre H with the lowest operating costs was not the most effective due to the high costs of acceptable function.

Richmond et al. (2004) found that clinicians working in community clinics were more cost-effective than clinicians working in hospital settings and self-employed clinicians. They stated that buying a consultant's service tended to increase the costs in hospital clinics. Similarly, higher visit costs were found in the two health centres (C and G), one with early and one with late timing, which purchased all their orthodontic expertise from consulting orthodontists.

The delegation of orthodontic tasks to dental auxiliaries has been widely encouraged (O'Brien and Shaw, 1988; Mandall and Read, 1999; Clarke, 2002). In addition, the cost effectiveness of public dental care could be improved by increasing the share of auxiliaries in the dental work force (Linna et al., 2003; Widström et al., 2004). This could be enabled by the systematic training of orthodontic assistants. Because the labour costs of a dental hygienist were only one third those of a dentist-nurse team, it

could be suggested that especially tasks which can easily be carried out in daily practice, should be increasingly devolved to dental auxiliaries. In this study, only two of the health centres (D and E) employed a full-time orthodontic hygienist, but the treatment costs of orthodontic care in these health centres were not found to be especially low. However, just these two health centres had restricted their orthodontic treatment to the most severe cases, so employing an orthodontic hygienist did not seem to be sufficient to compensate for the burden of a more difficult case mix.

The weakened economic situation in Finnish municipalities invites a discussion on the restriction of orthodontic treatment. The effects of economic restraints on public orthodontic services have been evaluated in Denmark and in Sweden (Mavreas and Melsen, 1995; Linder-Aronson et al., 2002). According to Linder-Aronson et al. (2002), the cutting of orthodontic resources should be justified purely on economic arguments, because restrictions on orthodontic services can not be justified by a decreasing need of treatment. However, the cutting of resources does not lead to savings in the long term, because the restriction of access to early orthodontic treatment seems rather to lead to an increased consumption of resources later on (Mavreas and Melsen, 1995). In fact, surgical-orthodontic treatment is an expensive way to correct dentofacial malocclusions, and these costs could be reduced by the systematic screening of children and orthodontic treatment during growth (Panula, 2002).

In Sweden, the economic restraints seemed to emphasize the importance of specialist orthodontists, while the number of treatments provided by general dentists was reduced (Josefsson and Halling, 2000). The results of the present study give grounds for this type of change, because the lowest costs of one percent unit of acceptability of morphology and function were reached by Centre F. In this health centre, orthodontic treatment was provided mainly by one orthodontist and one well-trained general dentist, the treatment modalities had been stable for a long time, and the volume of treatment as measured by the treatment history among subjects, was moderate (47%).

There were no clear differences between the early and late timing groups in the cost-effectiveness of treatment, but in the early timing group the costs of one percent unit of acceptability of morphology and function were almost on the same level. In all health centres of the early timing group, the costs of one percent unit of the acceptability of function were lower, or at least on the same level as those of morphology. In the late timing group, the variation in the costs of one percent unit of acceptability of function was much greater. This may indicate that by favouring early treatment, a better function of occlusion can be reached.

7. CONCLUSIONS

In Finnish health centres, orthodontic services are generally an established part of children's and adolescents' public health care. However, a wide variation in the extent of orthodontic care prevails in spite of the general efforts made to increase equality in the access to treatment. The economic depression in the 1990s has not been directly reflected in the extent of orthodontic services; a greater number of health centres have increased rather than decreased their services.

Finnish orthodontists prefer to treat e.g. crossbites and Class II malocclusions early, but the opinions vary considerably about the preferred age for treatment of other types of malocclusions. Accordingly, a wide variation is reported in the choice of appliances.

In the comparison of the eight health centres, clear differences are found in the number of visits, duration of treatment, type and number of appliances, and in the availability of orthodontic expertise and skills. In the early group, treatments are mainly carried out by general dentists applying simpler treatment methods. In the late group, specialists are more closely involved in the treatment process and fixed appliances are commonly used.

The early timing of orthodontic treatment seems to have a slight association with a higher acceptability of morphological and functional features of occlusion when assessed at the age of 16-18 years. However, the longer duration of treatment and the higher number of discontinued treatments connected with an early treatment timing reduce this gain. Consequently, the cost-effectiveness of orthodontic treatment seems to be the same in the health centres applying either early or late timing.

There are several factors other than timing of treatment which may cause differences in the cost-effectiveness of orthodontic care among the health centres. The costs depend, e.g. on the availability of specialist expertise, work division, and economical use of appliances. Moreover, stability in the provision of services may have an effect on the successful selection of orthodontic patients and the acceptability of treatment results.

Further research should reveal other factors which could guide the development of orthodontic services in the future. For example, the adolescents' own opinions were not included in this study, even though these might have broadened the scope of the study. Patients' own views on the timing and duration of treatment, the selection of appliances and the perception of treatment results should be assessed in this context. Furthermore, measuring the effects of orthodontic treatment and combining them with the quality of life measures might give a more coherent picture.

8. RECOMMENDATIONS

On the basis of the achieved results, the following recommendations for the organization of orthodontic care in Finnish health centres are made.

In the screening and selection of children for orthodontic treatment, the main focus should be on the children with severe malocclusions and most in need of treatment. In the treatment of milder deviations a sufficient cost-benefit ratio should also be achieved.

Because comprehensive orthodontic expertise and skills are necessary for the effective delivery of services, specialist orthodontists should have the irrefutable responsibility for the diagnosis, treatment planning, and the choice of treatment options and appliances.

A systematic follow up scheme and the evaluation of the progress of treatment are needed for the effective delivery of orthodontic care. The treatment should be discontinued or the treatment plan changed early enough, if the treatment is not proceeding successfully. In aiming for successful use of resources, orthodontic treatment with fewer visits and shorter overall treatment duration should be deliberately pursued.

Measures that could be used for levelling out unfavourable differences in treatment outcome and cost-effectiveness are systematic evaluation of treatment results, benchmarking of successful treatment delivery, and continuous education and training in clinical skills.

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REFERENCES

Altman DG. Practical statistics for medical research. Chapman & Hall, TJ Press (Ltd), Padstow, Cornwall, 1991.

Balogh RS, Ouellette-Kuntz H, Hunter DJ. Regional variation in dental procedures among people with an intellectual disability, Ontario, 1995-2001. J Can Dent Assoc 2004;70:681, 681a-681f.

Beckwith FR, Ackerman RJ, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1999;115:439-47.

Bergström K. Orthodontic care in Sweden. Thesis, Karolinska Institutet, Stockholm, 1996.

Berset GP, Eilertsen IM, Lagerström L, Espeland L, Stenvik A. Outcome of a scheme for specialist orthodontic care. Swed Dent J 2002;24:39-48.

Birkeland K, Furevik J, Bøe OE, Wisth PJ. Evaluation of treatment and post-treatment changes by the PAR Index. Eur J Orthod 1997;19:279-88.

Birkeland K, Bøe OE, Wisth PJ. Relationship between occlusion and satisfaction with dental appearance in orthodontically treated and untreated groups. A longitudinal study. Eur J Orthod 2000;22:509-18.

Cadman KC, Glover KE, Heo G, Warren S, Major PW. Orthodontic treatment outcome in a First Nation population in Alberta, Canada: A comparative study. Am J Orthod Dentofacial Orthop 2002;121:396-402.

Chadwick BA, Bahr HM, Albrecht CL. Survey Research: Questionnaire studies. In: Chadwick BA, Bahr HM, Albrecht CL. (eds). Social Science Research Methods. Englewood Cliffs, N.J., Prentice-Hall Inc, 1984:135-62.

Chestnutt IG, Burden DJ, Steele JG, Pitts NB, Nuttall NM, Morris AJ. The orthodontic condition of children in the United Kingdom, 2003. Br Dent J 2006;200:609-12.

Clarke J. The dental team-PCDs. Where are we now? Dent Update 2002;29:110-3.

Cunningham SJ, Hunt NP. A comparison of health care utilities for dentofacial deformity as derived from patients and members of the general public. Eur J Orthod 2000;22:335-42.

Cure RJ, Ireland RS. The development of an outreach training programme in orthodontics. Br Dent J 2008; 204:631-4.

Daniels C, Richmond S. The development of the index of complexity, outcome and need (ICON). J Orthod 2000;27:149-62.

Deans J, Playle R, Durning P, Richmond S. An exploratory study of the cost-effectiveness of orthodontic care in seven European countries. Eur J Orthod 2009;31:90-4.

Dolce G, McGorray SP, Brazeau L, King GJ, Wheeler TT. Timing of Class II treatment: Skeletal changes comparing 1-phase and 2-phase treatment. Am J Orthod Dentofacial Orthop 2007;132:481-9.

Eerola A, Hausen H, Lahti S, Widström E. Tutkimus- ja tarkastusvälit lasten ja nuorten suun terveydenhuollossa. Stakes, Raportteja 225, Helsinki, 1998.

Enberg K, Stöckel Hansson A, Lennartsson B. Behandlingsbehovindex och vårdprioriteringar inom ortdontivården i Sverige. Tandläkartidn 1999;91:31-6.

Espeland L, Stenvik A. Residual need in orthodontically untreated 16-20-year-olds from areas with different treatment rates. Eur J Orthod 1999;21:523-31.

Espeland L, Ivarsson K, Stenvik A. A new Norwegian index of orthodontic treatment need related to orthodontic concern among 11-year-olds and their parents. Community Dent Oral Epidemiol 1992;20:274-9.

Fernandes LM, Espeland L, Stenvik A. The provision and outcome of orthodontic services in a Norwegian community: a longitudinal study. Community Dent Oral Epidemiol 1999;27:228-34.

Finnish Medical Board. Lääkintöhallituksen ohjekirje nro 6/88. Hampaiston oikomishoidon järjestäminen. Helsinki, 1988.

Firestone AR, Beck FM, Beglin FM, Vig KW. Validity of the Index of Complexity, Outcome, and Need (ICON) in determining orthodontic treatment need. Angle Orthod 2002;72:15-20.

Fleiss JL. The design and analysis of clinical experiments. New York: John Wiley and Sons, 1986.

Fox NA, Chapple JR. Measuring failure of orthodontic treatment: a comparison of outcome indicators. J Orthod 2004;31:319-22.

Fox NA, Richmond S, Wright JL, Daniels C. Factors affecting the outcome of orthodontic treatment within the General Dental Service. Br J Orthod 1997;24:217-21.

Ghafari JG, Shofer FS, Laster LL, Markowitz DL, Silverton S, Katz SH. Monitoring growth during orthodontic treatment. Semin Orthod 1995;1:165-75.

Ghafari JG, Shofer FS, Jacobsson-Hunt U, Markowitz DL, Laster LL. Headgear versus function regulator in the early treatment of Class II, division 1 malocclusion: a randomized clinical trial. Am J Orthod Dentofacial Orthop 1998;113:51-61.

Gianelly AA. Crowding: timing of treatment. Angle Orthod 1994;64:415-8.

Gissler M, Keskimäki I, Teperi J, Järvelin M, Hemminki E. Regional equity in childhood health-register-based follow-up of the Finnish 1987 birth cohort. Health Place 2000;6:329-36.

Gittelsohn A, Powe NR. Small area variations in health care delivery in Maryland. Health Serv Res 1995;30:295-317.

Graber TM. Foreword to conference proceedings. Am J Orthod Dentofacial Orthop 1998;113:1-4.

Grainger RM. Orthodontic treatment priority index. Public Health Service Publication No. 1000, Series 2, No. 25. U.S. Government Printing Office. Washington, D.C., 1967.

Hausen H, Kärkkäinen S, Seppä L. Caries data collected from public health records compared with data based on examination by trained examiners. Caries Res 2001;35:360-5.

Heikinheimo K. Need of orthodontic treatment and prevalence of craniomandibular dysfunction in Finnish children. Thesis, University of Turku, 1989.

Helm S. Reappraisal of the criteria for orthodontic treatment. Thesis, University of Oslo, 1990.

Helöe LA. Comparison of dental health data obtained from questionnaires, interviews and clinical examination. Scand J Dent Res 1972;80:495-9.

Hsieh TJ, Pinskaya Y, Roberts WE. Assessment of orthodontic treatment outcomes: Early versus late treatment. Angle Orthod 2005;75:158-66.

Jang JC, Fields HW, Vig KWL, Beck FM. Controversies in the timing of orthodontic treatment. Semin Orthod 2005;11:112-8.

Jenny J. A social perspective on need and demand for orthodontic treatment. Int Dent J 1975;25:148-56.

Josefsson E, Halling A. Influence of economic restraints and reduced specialist resources on delivery and quality of orthodontic care. Swed Dent J 2000;24:165-72.

Kalijärvi E. Kansakoululaisten hampaiden huollon järjestelystä. Suom Hammaslääkl 1958;5:7-13.

Keeling SD, Wheeler TT, King GJ et al. Anteroposterior skeletal and dental changes following early Class II treatment with bionators and headgear: results from a randomized controlled trial. Am J Orthod Dentofacial Orthop 1998;113:40-50.

Kelly BM, Springate SD. Specialist orthodontics in the General Dental Service. Br Dent J 1996;180:209-15.

Kennedy DB, Osepchook M. Unilateral posterior crossbite with mandibular shift: a review. J Canad Dent Assoc 2005;71:569-73.

Kerosuo H, Väkiparta M, Nyström M, Heikinheimo K. The seven-year outcome of an early orthodontic treatment strategy. J Dent Res 2008;87:584-8.

Keskimäki I, Aro S, Teperi J. Regional variation in surgical procedure rates in Finland. Scand J Soc Med 1994;22:132-8.

Keski-Nisula K, Lehto R, Lusa V, Keski-Nisula L, Varrela J. Occurrence of malocclusion and need of orthodontic treatment in early mixed dentition. Am J Orthod Dentofacial Orthop 2003;124:631-8.

Keski-Nisula K, Hernesniemi R, Heiskanen M, Keski-Nisula L, Varrela J. Orthodontic intervention in the early mixed dentition: A prospective, controlled study on the effects of the eruption guidance appliance. Am J Orthod Dentofacial Orthop 2008a;133:254-60.

Keski-Nisula K, Keski-Nisula L, Salo H, Voipio K, Varrela J. Dentofacial changes after orthodontic intervention with eruption guidance appliance in the early mixed dentition. Angle Orthod 2008b;78:324-31.

Kirjavainen M, Kirjavainen T, Hurmerinta K, Haavikko K. Orthopedic cervical headgear with an expanded inner bow in Class II correction. Angle Orthod 2000;70:317-25.

Kiyak HA, Haluk I, Miotti FA. Orthodontists' perspectives regarding treatment timing: a cross-national study. World J Orthod 2004;5:40-7.

Krusinskiene V, Kiuttu P, Julku J, Silvola AS, Kantomaa T, Pirttiniemi P. A randomized controlled study of early headgear treatment on occlusal stability - a 13 year follow-up. Eur J Orthod 2008;30:418-24.

Kumar S, Williams AC, Sandy JR. Orthognathic treatment: how much does it cost? Eur J Orthod 2006;28:520-8.

Linder-Aronson S, Bjerrehorn K, Forsberg CM. Objective and subjective need for orthodontic treatment in Stockholm County. Swed Dent J 2002;26:31-40.

Linge L. The role of the general practitioner and the orthodontist in the provision of orthodontic care. Int Dent J 1987;37:86-90.

Linna M. Nordblad A, Koivu M. Technical and cost efficiency of oral health care provision in Finnish health centres. Soc Sci Med 2003;56:343-53.

Luke LS, Atchison KA, White SC. Consistency of patient classification in orthodontic diagnosis and treatment planning. Angle Orthod 1998;68:513-20.

Mandall NA, Read MJF. The effectiveness and efficiency of hygienists in carrying out orthodontic auxiliary procedures. Br J Orthod 1999;26:229-32.

Mavreas D, Melsen B. Financial consequences of reducing treatment availability in a publicly-funded orthodontic service. A decision analysis problem. Br J Orthod 1995;22:47-51.

Mavreas D, Athanasiou AE. Factors affecting the duration of orthodontic treatment: a systematic review. Eur J Orthod 2008;30:386-95.

Ministry of Social Affairs and Health, Finland. Health for all by the year 2000. The Finnish national strategy. Second edition. Helsinki: Ministry of Social Affairs and Health, 1989.

Ministry of Social Affairs and Health, Finland. Uniform criteria for access to non-emergency treatment. Handbooks of the Ministry of Social Affairs and Health 2005:5.

Ngan P. Early timely treatment of Class III malocclusion. Semin Orthod 2005;11:140-5.

Nihtilä A, Widström E. Heavy use of dental services among Finnish children and adolescents. Eur J Paediatr 2009;10:7-12.

Nordblad A, Suominen-Taipale L, Rasilainen J, Karhunen T. Suun terveydenhuoltoa terveyskeskuksissa 1970-luvulta vuoteen 2000. Stakes, Raportteja 278, Helsinki, 2004.

O'Brien KD, Shaw WC. Expanded function orthodontic auxiliaries; a proposal for their introduction in the UK. Br J Orthod 1988;15:281-6.

O'Brien KD, Shaw WC, Roberts CT, Stephens CD. Regional variation in the provision and cost of General Dental Service orthodontic treatment in England and Wales. Br J Orthod 1989;16:67-74.

O'Brien K, McComb JL, Fox N, Bearn D, Wright J. Do dentists refer orthodontic patients inappropriately? Br Dent J 1996;181:132-6.

Panula K, Keski-Nisula L, Keski-Nisula K, Oikarinen K, Keski-Nisula S. Costs of surgical-orthodontic treatment in community hospital care: an analysis of the different phases of treatment. Int J Adult Orthod Orthognath Surg 2002;17:297-306.

Petersen PE. Inequalities in oral health: the social context for oral health. In: C Pine and R Harris (eds). Community Oral Health. Quintessence Publishing Co. Ltd, Berlin, 2007:31-58.

Pietilä T. Orthodontic treatment in Finnish health centres. Thesis, University of Turku, 1998.

Pietilä T, Pietilä I. Parents' views on their own child's dentition compared with an orthodontist's assessment. Eur J Orthod 1994;16:309-16.

Pietilä T, Pietilä I. Dental appearance and orthodontic services assessed by 15-16-year-old adolescents in Eastern Finland. Community Dent Health 1996;13:139-44.

Pietilä T, Pietilä I, Väätäjä P. Early screening for orthodontic treatment. Differences in assessments made by a consultant orthodontist and three public health dentists. Community Dent Oral Epidemiol 1992;20:208-13.

Pietilä T, Pietilä I, Widström E, Varrela J, Alanen P. Extent and provision of orthodontic services for children and adolescents in Finland. Community Dent Oral Epidemiol 1997;25:150-5.

Pietilä T, Sintonen H, Pietilä I, Varrela J, Alanen P. Cost and productivity analysis of orthodontic care in Finland. Community Dent Oral Epidemiol 1998;26:283-8.

Pietilä T, Alanen P, Nordblad A, Kotilainen J, Pietilä I, Pirttiniemi P, Varrela J. Hampaiden oikomishoito terveyskeskuksissa. Stakes, Raportteja 279, Helsinki, 2004.

Pirttiniemi P, Kantomaa T, Mäntysaari R et al. The effects of early headgear treatment on dental arches and craniofacial morphology: an 8 year report of a randomized study. Eur J Orthod 2005;27:429-36.

Prahl-Andersen B. The need for orthodontic treatment. Angle Orthod 1978;48:1-9.

Proffit WR, Tulloch JFC. Preadolescent Class II problems: Treat now or wait? Am J Orthod Dentofacial Orthop 2002;121:560-2.

Radnzic D. Effectiveness of community orthodontic services in England and Wales. Thesis, University of Manchester, 1999.

Richmond S, Andrews M. Discontinued orthodontic treatment in the General Dental Services of England and Wales (1990-1991). Br J Orthod 1995;22:263-8.

Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. Eur J Orthod 1992;14:180-7.

Richmond S, Durning P, Phillips CJ, Dunstan F, Daniels C, Leahy F. Measuring the cost, effectiveness and cost-effectiveness of orthodontic treatment. Orthodontics 2004;1:255-62.

Richmond S, Dunstan F, Phillips C, Daniels C, Durning P, Leahy F. Measuring the cost, effectiveness and cost-effectiveness of orthodontic care. World J Orthod 2005;6:161-70.

Riedmann T, Berg R. Retrospective evaluation of the outcome of orthodontic treatment in adults. J Orofacial Orthop 1999;60:108-23.

Rølling S. Orthodontic examination of 2,301 Danish children aged 9-10 years in a community dental service. Community Dent Oral Epidemiol 1978;6:146-50.

Savastano NJ Jr, Firestone AR, Beck FM, Vig KW. Validation of the complexity and treatment outcome components of the index of complexity, outcome, and need (ICON). Am J Orthod Dentofacial Orthop 2003;124:244-8.

SBU: Bettavvikelser och tandreglering i ett hälsoperspektiv. En systematisk litteraturöversikt. Statens beredning för medicinsk utvärdering; Mölnlycke, 2005.

Seeholzer H, Adamis JP, Eaton KA, McDonald JP, Sieminska-Piekarczyk B. A survey of the delegation of orthodontic tasks and the training of chairside support staff in 22 European countries. J Orthod 2000;27:279-82.

Severens JL, Prahl C, Kuijpers-Jagtman AM, Prahl-Andersen B. Short-term cost-effectiveness analysis of presurgical orthopedic treatment in children with complete unilateral cleft lip and palate. Cleft Palate Craniofac J 1998;35:222-6.

Shaw WC, Turbill EA. Public health aspects of oral diseases and disorders – dentofacial irregularities. In: C Pine and R Harris (eds). Community Oral Health. Quintessence Publishing Co. Ltd, Berlin, 2007:227-37.

Shaw WC, Gabe MJ, Jones BM. The expectations of orthodontic patients in South Wales and St Louis, Missouri. Br J Orthod 1979;6:203-5.

Sheiham A, Tsakos G. Oral health needs assessments. In: C Pine and R Harris (eds). Community Oral Health. Quintessence Publishing Co. Ltd, Berlin, 2007:59-79.

Skidmore KJ, Brook KJ, Thomson WM, Harding WJ. Factors influencing treatment time in orthodontic patients. Am J Orthod Dentofacial Orthop 2006;129:230-8.

Socialstyrelsen. Kungl. Medinalstyrelsens cirkulär den 13 december 1967. MF nr 71, 1967.

Solow B. Guest editorial: orthodontic screening and third party financing. Eur J Orthod 1995;17:79-83.

Stenvik A. Orthodontic care: need and demand. Thesis, University of Oslo, 1997.

Stenvik A, Torbjørnsen T. Vem gör vad inom ortodontin? Tandläkartidn 2007;99:46-9.

Subtelny JD. Early orthodontic treatment. Illinois, Quintessence Publishing Co, Inc. 2000.

Svedström-Oristo A-L. Morphological and functional analysis of occlusion in permanent dentition. Thesis, University of Turku, 2004.

Svedström-Oristo A-L, Pietilä T, Pietilä I, Alanen P, Varrela J. Morphological, functional and aesthetic criteria of acceptable mature occlusion. Eur J Orthod 2001;23:373-81.

Svedström-Oristo A-L, Helenius H, Pietilä T, Pietilä I, Alanen P, Varrela J. Reproducibility of characteristics assessing the occlusion of young adults. Angle Orthod 2002;72:310-15.

Svedström-Oristo A-L, Pietilä T, Pietilä I, Alanen P, Varrela J. Occlusal status in orthodontically treated and untreated adolescents. Acta Odont Scand 2003;61:123-8.

Tausche E, Luck O, Harzer W. Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need. Eur J Orthod 2004;26:237-44.

ter Heege G (ed). Euro Qual. Towards a quality system fir European orthodontic professionals. IOS Press, Amsterdam, 1997.

Tiainen L, Arpalahti I, Pietilä T, Pirttiniemi P. Selvitys oikomishoidon saatavuudesta erikoissairaanhoitona. Suom Hammaslääkl 2004; N.s. Vol 11:798-801.

Tulloch JFC, Phillips C, Proffit WR. Benefit of early Class II treatment: progress report of a two-phase randomized clinical trial. Am J Orthod Dentofacial Orthop 1998;113:62-72.

Tulloch JFC, Proffit WR, Phillips C. Outcomes in a 2-phase randomized clinical trial of early Class II treatment. Am J Orthod Dentofacial Orthop 2004;125:657-67.

Turbill EA, Richmond S, Wright JL. A closer look at General Dental Service orthodontics in England and Wales II: What determines appliance selection? Br Dent J 1999;187:271-4.

Turbill EA, Richmond S, Wright JL. Social inequality and discontinuation of orthodontic treatment: is there a link? Eur J Orthod 2003;25:175-83.

Turner PJ, Pinson RR. Training hygienists for an auxiliary role in orthodontics. Br Dent J 1993;175:209-13.

Väkiparta MK, Kerosuo HM, Nyström ME, Heikinheimo KA. Orthodontic treatment need from eight to 12 years of age in an early treatment oriented public health care system: a prospective study. Angle Orthod 2005;75:344-9.

Vig KWL, Bennett ME, O'Brien K, Vayda D, Vig PS, Weyant RJ. Orthodontic process and outcome: efficacy and effectiveness studies. In: CA Trotman and JA McNamara Jr (eds). Orthodontic treatment: outcome and effectiveness. Craniofacial Growth Series 30, Center of Human Growth and Development, The University of Michigan, Ann Arbor, 1995:227-54.

von Bremen J, Pancherz H. Efficiency of early and late Class II Division 1 treatment. Am J Orthod Dentofacial Orthop 2002;121:31-7.

Wennberg JE. Which rate is right? N Engl J Med 1986;314:310-1.

Wennberg JE, Barnes BA, Zubkoff M. Professional uncertainty and problem of supplier-induced demand. Soc Sci & Med 1982;16:811-24.

Widström E, Linna M, Niskanen T. Productive efficiency and its determinants in the Finnish Public Dental Service. Community Dent Oral Epidemiol 2004;32:31-40.

Widström E, Ekman A, Aandahl LS, Pedersen MM, Augustsdottir H, Eaton KA. Development in oral health policy in the Nordic countries since 1990. Oral Health Prev Dent 2005;3:225-35.

Yang EY, Kiyak HA. Orthodontic treatment timing: a survey of orthodontists. Am J Orthod Dentofacial Orthop 1998;113:96-103.

APPENDICES 1–3

Appendix 1. Questionnaire sent to the chief dental officer of the health centre

Description of the health centre

Name of the health centre
County
Total number of inhabitants
Total number of inhabitants in the age groups of 0-18-year-olds

Volume of orthodontic services in 2001

Total number of all dental visits in the age groups of 0-18-year-olds
Total number of orthodontic visits in the age groups of 0-18-year-olds
Total number of 0-18-year-old children receiving orthodontic treatment
Does the health centre purchase commissioned orthodontic services?
- If so, how many 0-18-year old children received these services?

Total number of visits in purchased orthodontic services in the age groups of 0-18-year-olds

Work division in orthodontics

Does the health centre employ an orthodontist / orthodontists?
- If so, how many orthodontists, calculated as a full-time equivalent?

Has the health centre made a contract with a consultant orthodontist?
- If so, how many days per year does the consultant orthodontist work in the health centre?

Do the general dentists participate in the treatments of orthodontic patients?
- If they do, how many of these general dentists are there?
- If they do, estimate their contribution as a full-time equivalent?

Do the auxiliaries perform orthodontic tasks?
- If they do, how many of these auxiliaries are there?
- If they do, estimate their contribution as a full-time equivalent?

Do the dental nurses perform orthodontic tasks?
- If they do, how many of these dental nurses are there?
- If they do, estimate their contribution as a full-time equivalent?

The use of orthodontic appliances in the health centre

If orthodontic treatment is given to the 4-6-year-old children, please mention the three most frequently used appliances

If orthodontic treatment is given to the 7-9-year-old children, please mention the three most frequently used appliances
If orthodontic treatment is given to the 10-13-year-old children, please mention the three most frequently used appliances
If orthodontic treatment is given to the 14-18-year-old children, please mention the three most frequently used appliances

Please state whether any noticeable changes have occurred in the use of orthodontic appliances during the years 1997-2001,
- If so, report what kinds of changes.

Please state whether any noticeable changes have occurred in the use of orthodontic appliances during the years 1992-1996,
- If so, report what kinds of changes.

Potential changes in the supply of orthodontic services in the health centre

The supply of orthodontic services is at present
a) appropriate b) too scarce c) too abundant

Has the supply of orthodontic services changed noticeably during the years 1997-2001?
- If so, please say how?

Did the supply of orthodontic services change noticeably during the years 1992-1996?
- If so, please say how?

Please estimate the reasons for these changes in the supply of orthodontic services. (Select the three most important reasons)
a) changes initiated by the personnel of the dental unit of the health centre
b) changes initiated by the parents of the children
c) changes initiated by the community members
d) changes initiated by the elected representatives of local councils
e) changes initiated by the discussion in the professional publications
f) changes caused by economic pressure
g) changes caused by the increase in dental care for adults
h) something else, please explain what

Please give suggestions for orthodontic issues needing further research.

Appendix 2. Questionnaire sent to the specialist orthodontists

Description of the responder

County, in which you are practising
Did you work clinically during the year 2001?
- Mention if you did not work at all during the year 2001.

The year of graduation as a specialist
The university where you graduated as a specialist
Estimate the share of orthodontic patients in your practice

Describe your working profile in 2001 (*mention all jobs, not only the main occupation*)

- in a health centre, with working time ___ hours per week
- as a private practitioner, with working time ___ hours per week
- in a hospital, with working time ___ hours per week
- as a clinical teacher at a university, with working time ___ hours per week
- as a researcher with working time ___ hours per week
- as a consultant in a health centre with working time ___ days per a year
- offering commissioned services to health centres, the number of orthodontic patients being _____ in 2001.

Your views on optimal timing of orthodontic screening and assessment of treatment need.

At what age do you like to assess a child's occlusion for the first time?
At what age do you then like to assess a child's occlusion for the second time?
At what age do you then like to assess a child's occlusion for the third time?

Please mention according to which indications you like to start orthodontic treatment in a child

- in the primary dentition
- in the early mixed dentition
- in the late mixed dentition
- in the permanent dentition
- in adulthood

Your own choice of appliances

Which orthodontic appliances did you prefer in 2001 when treating children at different stages.

Please mention the three appliances you used most frequently
- in the primary dentition
- in the early mixed dentition
- in the late mixed dentition
- in the permanent dentition

Have you made any changes in your treatment modalities during the past ten years?

- If so, please state what kinds of changes.
- If so, please state why you have made the changes.

Your views on optimal work division in orthodontic treatment in a health centre

The contribution of the specialist orthodontist
- should be increased, please describe how
- should be decreased, please describe how

The contribution of the general dentist
- should be increased, please describe how
- should be decreased, please describe how

The contribution of auxiliaries
- should be increased, please describe how
- should be decreased, please describe how

Evaluation of orthodontic care in Finland and suggestions for improvement

Please mention the aspects in which orthodontic care in Finland has succeeded.

Please mention the aspects in which the orthodontic care in Finland has not been successful.

Please give suggestions for the improvement of public orthodontic care in Finland.

Please give suggestions for orthodontic issues needing further research.

Appendix 3. Morphological and functional criteria in the Occlusal Morphology and Function Index (OMFI)

Morphological criteria	**Cut-off for acceptability**	**Conventions**
Coincidence of the facial midline and the midline of the upper dental arch	Max 3 mm deviation accepted	
Overjet	0-5 mm accepted	Measured from the most labial central incisor
Overbite	Occusal contact incisal to the gingival third of the palatal surface of upper incisors accepted. Open bite only accepted in laterals	
Canine relationship right/left	Normal ± 2 mm accepted. Postnormal relationship accepted in the case of missing upper incisors	
Crossbite, anterior	Not accepted	
Crossbite, lateral	Not accepted in canines. Accepted in one tooth pair/side without interference or slide between CR*-ICP†	
Scissors bite	Not accepted	
Functional criteria		
Discrepancy between CR* and ICP†	Max 2 mm accepted sagittally and vertically. No slide accepted laterally	Measured from pencil markings in one pair of premolars and incisors
Guided lateral excursions	Accepted: canine protection /group contact including canine/contacts in incisors, premolars and molars	Guided lateral gliding until upper and lower canines at same transversal level
Non-working side contacts	Accepted without disclusion of working side contacts	
Protrusion contacts	Anterior guidance accepted	

* Centric relation; †intercuspal position.