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Comparison of treatment costs and outcome in public orthodontic services in Finland

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SUMMARY The objectives of the study were to compare the costs and outcome of orthodontic treatment in eight municipal health centres in Finland. A random sample of the age groups of 16- and 18-year-olds (n = 1109) living in these municipalities was clinically examined by two calibrated orthodontists. The acceptability of the morphology and function of the occlusion were assessed with the Occlusal Morphology and Function Index (OMFI). The data concerning previous orthodontic treatment were collected from the patient records of all subjects (n = 608) who reported previous or ongoing orthodontic treatment or who could not recall if they had received orthodontic treatment. The health centres were grouped into an early and a late timing group according to the mean age of starting the treatment. The mean age for starting orthodontic treatment was 8.0 years (SD 1.9) in the early group and 10.7 years (SD 2.3) in the late group. The visit costs and the costs of orthodontic appliances without overheads comprised the operating costs. The cost-effectiveness of orthodontic services was measured by estimating how much each health centre had to have paid for one per cent unit of acceptable morphology and acceptable function of occlusion. The mean appliance costs were higher in the late timing group and the mean visit costs higher in the early timing group. The mean operating costs per case were €720 in the early and €649 in the late timing group. However, there was a great variation within both groups. The cost of one per cent unit of acceptable morphology was the same in the two timing groups, while the cost of one per cent unit of acceptable function was lower in the early timing group. The low operating costs as such did not totally explain the better cost-effectiveness of orthodontic care. Furthermore, the cost-effectiveness was not directly connected with the timing of treatment.

Introduction

In Finland, orthodontic treatment is included in the public dental services offered, free of charge, to children and adolescents up to the age of 18 years. In the early 1990s, every fourth dental visit of children and adolescents to the health centres was connected with orthodontic treatment (Pietilä, 1998). However, during the economic depression in the 1990s, most health centres had to restrict their expenditure. At the same time, the focus in public dental health care was gradually changing to include all adults regardless of age, subject to a fee, in the services. Because of all these changes, evaluation of the costs and outcome of orthodontic care is important in order to identify the features of the treatment process that tend to affect the expenditure.

Drummond *et al.* (1997) have defined economic evaluations as comparative analyses of alternative courses of action in terms of their costs and consequences. So far, only few economic evaluations have been published on orthodontic treatment and orthodontics combined with surgical treatment (Severens *et al.*, 1998; Cunningham and Hunt, 2000; Kumar *et al.,* 2006). Richmond *et al.* (2004) found considerable differences in the costs and effectiveness among clinicians and service settings when comparing self-employed practitioners and clinics with salaried practitioners. Earlier evaluation of the productivity of orthodontic care in Finnish municipal health centres showed that work division and providers' experience were the main features explaining the average total costs (Pietilä *et al.*, 1998).

The great variation in the delivery and organization of services is due to the uneven distribution of orthodontic manpower. In western countries, the majority of specialists work in the larger cities or in the more densely populated areas. In sparsely populated areas, this may lead either to restrictions in access to orthodontic treatment or to orthodontic treatment given by general dentists (Bergström and Halling, 1996). In Finland, the availability of specialist expertise varies in different areas of the country. In most health centres, the role of specialist orthodontists is essential in the diagnostics and treatment planning, while general dentists often provide a significant part of the treatment, except in the largest health centres (Pietilä *et al.*, 1997).

In countries with publicly funded orthodontic services, dentists play a dominant role in the initiation of orthodontic treatment (Shaw *et al.*, 1980; Bergström, 1996). The access to orthodontic treatment is mainly influenced by two factors; first, the rates of referrals to orthodontists for assessment

and secondly, the sufficiency of services. In this context, the elective aspect in the assessment of orthodontic treatment need and the prerequisite of a thorough risk-benefit evaluation of orthodontics highlight the importance of economic considerations (Lavelle *et al.*, 2004).

In Finnish health centres, the starting age for orthodontic treatment is on average 9.5 years, but there is a wide variation in the timing of treatment (Pietilä *et al.*, 1997). Consequently, the timing of orthodontic treatment has been under debate both in Finland and in many other countries. Recently, several studies have been published on the association of timing with orthodontic treatment outcome. The studies have evaluated the outcome and/or effectiveness of early intervention (Keeling *et al.*, 1998; O'Brien *et al.*, 2003a, 2003b; Keski-Nisula *et al.*, 2008) or compared effectiveness of early and late intervention (Tulloch *et al.*, 2004; O'Brien *et al.*, 2009). However, studies comparing the costs or cost-effectiveness in clinics with different timing of treatment are practically non-existent.

The objectives of the study were to compare the costs and outcome of orthodontic treatment in eight municipal health centres representing early and late treatment timing.

Subjects and methods

In 2003–2005, a random sample of 2325 adolescents from two age groups, 16- and 18-year-olds, in eight municipalities, was invited to participate in the study. The health centres were selected on the basis of information gathered in an earlier study to represent different timing of treatment (Pietilä, 1998). The composition of the work force varied; six of the eight health centres had employed salaried orthodontists, while in two health centres, the orthodontic expertise was purchased from a consultant orthodontist. In all eight health centres, general dentists were participating in orthodontic treatments, and dental auxiliaries were to a larger extent involved in orthodontic treatments in two of the health centres (Table 1).

The health centres were dichotomized into an early (A–C) and a late (D–H) timing group according to the mean age for starting the treatment (cut-off earlier versus later than nine years of age). The mean age for starting orthodontic treatment was 8.0 years (SD 1.9) in the early timing group and 10.7 years (SD 2.3) in the late timing group. The most frequently used appliances in the early timing group were a headgear (Health Centres A and B) and an eruption guidance appliance (Health Centre C) and in the late timing group, a headgear (Health Centres E and G) and an upper fixed appliance (Health Centres D, F, and H). The treatment modalities of the eight health centres are described in detail in an earlier paper (Pietilä *et al.*, 2009).

A total of 1109 adolescents arrived for the clinical examination. Before the examination, informed consent was obtained, and the subjects were requested to fill in a semi-structured questionnaire. In addition to age and gender, the questionnaire included questions on the history of orthodontic treatment. One respondent did not answer the question on his treatment history and was therefore excluded from the study. The files of the non-participants were available only in one health centre (E), where the data on the orthodontic treatment history of all the adolescents (n = 128) who failed to participate in the study examination were checked from dental files.

All participants were clinically examined by one of two calibrated orthodontists (ALS-O and TP) for the acceptability of occlusion using the Occlusal Morphology and Function Index, OMFI (Svedström-Oristo *et al.*, 2003, Appendix 1). The examiners did not know beforehand which adolescents had been orthodontically treated. The outcome of orthodontic treatment in the evaluated health centres is described in detail in an earlier paper (Pietilä *et al.*, 2010).

The data concerning previous orthodontic treatment were collected from the patient records of all subjects (n = 608) who had reported previous or ongoing orthodontic treatment or who could not recall if they had received orthodontic

Table 1 Application of expertise and orthodontic work force in the eight health centres 2003–2005.

Health centre	Type of specialist orthodontist expertise	Ratio orthodontist per 0- to 17-year-olds	General dentists, limiting their work to orthodontics	General dentists, also treating other than orthodontic patients	Full-time orthodontic hygienist
Early timing group					
A	Salaried	1:15 600	—	>5	—
B	Salaried	1:7000	—	>5	—
C	Consultant	*	—	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	**	2	—	—
H	Salaried	1:11 500	1	<5	—

*Six consultant working days per 1200 0- to 17-year-olds per year.
**Four consultant working days per 6800 0- to 17-year-olds per year.

treatment. Five of them had not received orthodontic treatment and were moved into the 'no treatment history' group. The detailed data on the features of orthodontic treatment were collected using the same pre-formulated protocol in each health centre (Table 2). The subjects treated outside the evaluated health centres ($n = 46$) were excluded, and the remaining 557 subjects with a treatment history were included in the treatment group. The group with no treatment history consisted of 505 subjects.

Orthodontic treatment was regarded to have started when a fixed or removable appliance was first used. The treatment was regarded as completed when a removable retention appliance was used less often than every night and when there was no longer a need for regular orthodontic check-ups of fixed retainers.

The chief dental officers of the evaluated health centres were requested to fill in a semi-structured questionnaire reporting, e.g. orthodontic work division and duration of orthodontic visits in each personnel category.

In this study, the operating costs comprised 1. the costs of orthodontic visits, i.e. estimates of the salary costs of an orthodontic visit in each manpower category and 2. the costs of orthodontic appliances.

The average duration of an orthodontic visit was calculated for an orthodontist–dental nurse work force team, for a dentist–dental nurse work force team, and for a dental hygienist, according to the replies given by the chief dental officers (Table 3). The average monthly salary for each personnel category in 2004 was received from a national labour market organization. The total salary costs also included social security costs of 30.51 per cent. Finally, the average costs per orthodontic visit were calculated separately for each work force category (Table 4).

The data on the numbers of brackets, bands, arch wires, face bows, extraoral devices, and removable appliances used during individual treatment procedures were collected from the patient records of the 557 study subjects. The costs of fixed appliances consisted of material costs estimated according to the average market prices, while the costs of removable appliances were computed according to average prices given by technical laboratories.

In this study, the cost-effectiveness of orthodontic services was assessed as the one per cent unit of acceptability. The acceptability was measured on a health centre level by determining what percentage of treated subjects had acceptable morphology and function according to the criteria of the OMFI. The mean operating costs per case were used as the marker of the costs. The calculation of the one per cent unit of acceptability was made by calculating out how much each health centre had to have paid for one per cent unit of acceptability, i.e. by dividing the mean cost per case by the percentage of subjects with acceptable morphology or function.

Table 2 Data collected from the dental files of all adolescents reporting a history of orthodontic treatment ($n = 608$).

DATA
Date of birth
Indication(s) for treatment
Date of starting treatment
Date of discontinuing treatment
Date of finishing treatment
Type of appliance(s)
Number of appliances
Number of teeth extracted
Number of orthodontic visits
To the orthodontist
To the dentist
To auxiliary personnel
Number of non-cancelled visits

Results

Description of participants and non-participants

In all but one health centre, females formed the majority of participants (range 56–70 per cent). Fifty-seven per cent of

Table 3 Average duration (in minutes) of an orthodontic visit in each personnel category in connection with treatment by different appliance types

Type of visit	Orthodontist–dental nurse	General dentist–dental nurse	Dental hygienist
Bonding of a fixed appliance	30	45	75
Control visit, one arch fixed	10	15	20
Control visit, two arch fixed	20	30	30
Banding of palatal/lingual bar	15	25	20
Control visit	10	15	15
Construction of headgear	30	40	40
Control visit	10	15	5
Impressions and construction bite for a functional appliance	20	30	30
Control visit	10	15	15
Adjustment of eruption guidance appliance/functional appliance	15	20	30
Average duration of a visit	15	30	30

Table 4 Monthly salary costs including social security costs (30.51 per cent), salary costs per team and working hour, average duration of orthodontic visit (in minutes), and average total salary costs per visit in each personnel category.

Personnel category	Monthly salary costs (€)	Salary costs per team* (€)	Duration of a visit	Total salary costs per visit (€)
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.

subjects (n = 636) belonged to the older age group. Among the dropouts (Health Centre E), the percentage of boys was higher than among the participants (50 versus 30 per cent). Further, the participants had more often a history of orthodontic treatment (43 versus 38 per cent).

Operating costs

The mean operating costs per case were €720 in the early and €649 in the late timing group (range €517–€926). The mean appliance costs were higher and the mean visit costs lower in the late timing group, but there was a wide variation within both groups (Table 5).

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 highest visit costs were found in the two health centres (B and G), where the general dentists played a major role in the treatment process (Table 5).

The percentage of completed treatments was 75 in the early timing group and 85 in the late timing group. The percentage of discontinued treatments was 21 in the early and six in the late group. The mean number of orthodontic visits was highest among those with ongoing treatment. The mean numbers of visits among adolescents with completed, ongoing, and discontinued treatment are given in Table 6.

Cost-effectiveness

The costs depicting the cost-effectiveness of orthodontic services, i.e. the costs for one per cent unit of acceptable morphology, were the same in the two timing groups. The costs for one per cent unit of acceptable function were lower in the early timing group (Figure 1). The lowest costs in both categories of cost-effectiveness were found in Health Centre F. Instead, the health centre with the highest costs differed; in the category of morphology, it was Health Centre G, and in category of function, Health Centre D.

Table 5 Mean costs (€) of orthodontic treatment per subject with treatment history*.

Health centre (n)	Appliance costs	Visit costs	Operating costs
Early timing group			
A (87)	95	522	617
B (88)	101	672	773
C (58)	160	640	800
Early timing group n = 233	112	608	720
Late timing group			
D (39)	222	466	688
E (57)	124	454	578
F (73)	166	386	552
G (73)	184	742	926
H (82)	152	365	517
Late timing group n = 324	167	482	649

*Includes completed, ongoing, and discontinued treatments.

Discussion

Finnish orthodontists tend to favour early treatment, and the starting age has shown to be on average 9.5 years (Pietilä *et al.*, 1997). In spite of a difference in the mean starting age between the two timing groups, 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 early timing of the treatment of anterior and lateral crossbites (Pietilä *et al.*, 2008). The purpose of the study was to pragmatically compare the treatment costs in health centres favouring early or late timing of orthodontic treatment. Differences in the treatment practices between the two timing groups were found, e.g. in the choice of orthodontic appliances (Pietilä *et al.*, 2009).

The information on adolescents' occlusal status was collected by a cross-sectional examination of two age cohorts, in which all the subjects had reached the permanent dentition stage. At that age, the orthodontic treatment was also in most cases completed. 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 dropouts included more males and those without orthodontic treatment history. However, the differences were slight and did not distort the reliability of the results.

The OMFI was regarded as a suitable method for the study because it has been developed to measure the acceptability of occlusion and is based entirely on direct clinical assessment (Svedström-Oristo *et al.*, 2003). The information on individual treatments was collected retrospectively from dental files. A prospective approach was considered unfeasible because it might have influenced the providers' decisions and thereby the costs of treatment.

Table 6 The mean number of visits in the groups of completed, ongoing, and discontinued treatments.

Health centre	Treatment completed mean (SD)	Treatment ongoing mean (SD)	Treatment discontinued mean (SD)	All together mean (SD)
Early timing group				
A	23.8 (11.3)	7.5 (3.5)	21.8 (12.3)	23.2 (11.5)
B	28.2 (15.8)	37.3 (24.1)	36.1 (22.8)	29.6 (17.2)
C	32.7 (16.2)	48.5 (30.6)	19.4 (10.8)	28.1 (17.4)
Early timing group	27.1 (14.4)	35.8 (27.5)	23.8 (15.9)	26.8 (15.9)
Late timing group				
D	28.5 (15.8)	23.1 (6.7)	19.3 (1.5)	26.7 (13.9)
E	21.0 (13.8)	11.7 (9.6)	28.0 (17.4)	21.0 (14.0)
F	20.5 (14.7)	21.0 (9.2)	10.7 (9.9)	20.0 (13.8)
G	30.4 (16.3)	48.3 (21.8)	36.0 (13.6)	31.7 (16.8)
H	17.7 (9.4)	24.7 (11.2)	15.0 (9.8)	17.8 (9.9)
Late timing group	22.9 (14.7)	24.4 (14.6)	22.6 (14.3)	23.1 (14.6)

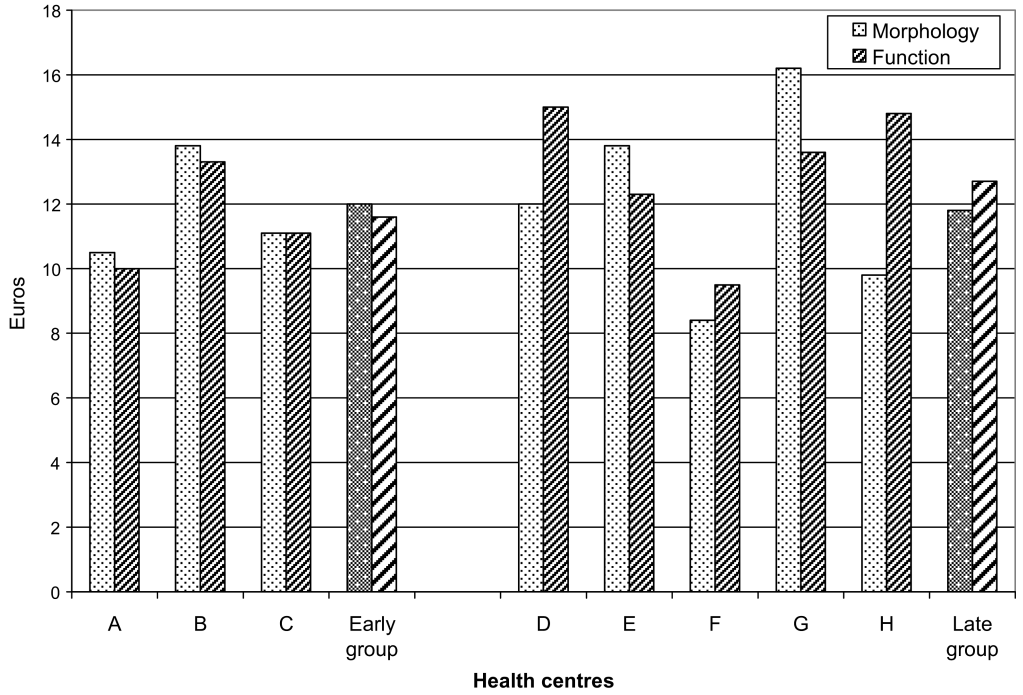

Figure 1 The costs of one per cent unit of acceptability of morphology and acceptability of function separately in each evaluated health centre and together in the early and late timing groups.

Comparisons between the two timing groups should be interpreted with caution. Besides timing of treatment, there was variation among the health centres also in other service features, e.g. in the availability of orthodontic expertise and the extent of services (Pietilä *et al.*, 2009).

In this study, the focus was on the direct costs paid by the municipalities. The overheads, e.g. costs of administration and facilities were not included in the operating costs because the variation among municipalities was estimated to be rather limited. Further, in this retrospective study arrangement, it was not possible to measure indirect costs of treatment, such as loss of production, education, domestic responsibilities, or social activities. The economic evaluation comprised not only the operating costs of the adolescents with completed treatment but also those of adolescents with ongoing and discontinued treatment. Thereby, the effect of variation in the percentage of discontinued treatments was also taken into account.

According to Radnzic (1999), the average cost of a course of orthodontic treatment in community clinics in the United Kingdom was €655, which is in line with our finding of €649. He found a wide range among different clinics, from €36 to €2941, whereas the range was more moderate in our study, from €517 to €926. However, the different methods used to estimate costs hamper the comparability of the two studies (Richmond *et al.*, 2004). We found distinct differences between individual health centres in both measures of cost-effectiveness although the differences between the early and late timing groups were more moderate. The costs of an acceptable morphology per cent unit were almost the same in the early and late timing groups, while the 'late' health centres had higher costs for an acceptable function. The low operational costs *per se* seemed to influence the cost-effectiveness but did not explain it totally.

Dunstan *et al.* (2008) have stressed the importance of identifying differences in the case mix when measuring orthodontic clinical outcomes and cost-effectiveness. In this study, the appliance costs were highest in the late timing Health Centre D that limited its treatment to only the most severe malocclusions. Apparently, there must be factors other than timing, volume and work division, which affect the cost-effectiveness. Such factors might be, e.g. the work division between orthodontist and general dentists, the application of the orthodontist's skills and variation in the providers' expertise.

Mandall and Read (1999) encourage the delegation of orthodontic tasks to dental auxiliaries, although in their study design, the efficiency of the auxiliaries' performance was not as high as that of the experienced orthodontists. 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 our study, only two of the health centres (D and E) employed a full-time orthodontic hygienist, and therefore, it was not possible to draw a clear conclusion on this issue of delegating orthodontic tasks.

The fabrication costs of different appliances determine the basic costs as such. The appliance costs were lowest in the two

early timing health centres (A and B), where a headgear was the preferred appliance. However, the type of appliance, especially if it requires the patient's cooperation, may also have an effect on the duration of treatment (Turbill *et al.*, 1999; Popowich *et al.*, 2005; Skidmore *et al.*, 2006). According to Beckwith *et al.* (1999), the use of a headgear tends to increase the duration of treatment. In general, the abundant use of appliances demanding good cooperation and compliance may increase the risk of discontinuation of treatment, thereby decreasing the possibilities of reaching the treatment goal.

Conclusions

Considering the cost-effectiveness of orthodontic treatment, we found no clear differences between the early and late timing groups. However, the early group seemed to reach a more consistent level of good function. The better cost-effectiveness could not be explained by the low operational costs as such. In addition to the timing, there are probably several other factors, such as availability of specialist expertise, work division, or economical use of appliances, which may cause differences in the cost-effectiveness of orthodontic care among the health centres.

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Appendix 1 Morphological and functional criteria in the Occlusal Morphology and Function Index

	Cut-off for acceptability	Conventions
Morphological criteria		
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. Post-normal 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 inference 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.