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Original Article

Costs and duration of orthodontic-surgical treatment with mandibular advancement surgery

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Abstract

Objectives: The aim was to analyse the costs and duration of orthodontic-surgical treatment with mandibular advancement in the public health care sector in Finland.

Materials: The study was conducted as a retrospective registry study in a public district hospital on all nonsyndromic patients that were ethnic Finns and treated with full fixed appliances and mandibular advancement surgery in 2016–2020.

Results: The mean treatment duration of the included 45 patients was 28.1 months, including 18.9 months pre and 9.2 months postoperative orthodontics. The median number of visits was 27, including 17 visits before and 9 visits after surgery. The mean total treatment time was 14.5 h. The mean total direct costs per course of treatment were 7574 € to the municipality and 947 € to the patient. The costs positively correlated with the duration of the treatment (rho = 0.71, P = .000), but were not associated to gender or age of patient. The mean surgery time was 78 minutes, and significantly less with an experienced surgeon (P = .002). It was calculated that the mean minimum treatment costs would be 45% of the present total, achievable with a patient with optimum dental arches at the start of treatment.

Limitations: The major limitation of the study is the relatively small number of study subjects.

Conclusion: A 55% share of the costs is influenced by case- and operator-dependent factors. This indicates that the complexity and performance of the orthodontic phases of treatment are important determinants in the cost structure.

Keywords: orthognathic surgery, orthodontics, duration of treatment, cost of treatment, mandibular advancement

Introduction

In Finland, children and adolescents are screened for malocclusions in public oral health care. The screening is generally based on a 10-step scoring scale to target treatment to individuals most in need of care during the phases of dental development and facial growth [1, 2]. On the scale of 1 to 10, the usual requirement for being entitled orthodontic treatment in public health centres is grade 7 malocclusion, with features suggesting poor long-term prognosis, or a higher grade [1]. Primary dental care in Finnish public health centres is free for patients under 18 years of age and covered by public resources (www.eu-healthcare.fi/what-you-pay/costs-of-treatment-in-finland/treatment-costs-in-public-health-care/). The annual number of orthodontic treatments initiated in Finnish public health centres approximated 24 000 in 2018 [3]. For comparison, the annual number of live births was 47 577 in 2018 in Finland (Statistics Finland, https://www.stat.fi/index_en.html).

A frequent indication for orthodontic treatment in growing individuals in Finland is deep bite, often associated with distal malocclusion and excess overjet and/or overbite. Selection of these children and adolescents for free treatment in public health care is motivated also to possibly prevent development of severe malocclusion that would even require later orthodontic-surgical treatment with lengthening of the mandible to correct the sagittal jaw disharmony and traumatic deep bite. According to a Finnish study among 185 patients receiving orthognathic-surgical treatment, the majority (64%) suffered from mandibular retrognathia and 56% underwent bisagittal split osteotomy (BSSO), without maxillary surgery [4]. Distal malocclusion is common in Finnish children, with the following prevalence numbers of associated features at the age of 4 to 8 years: a distal step in 33.1%, class II canine relationship in 52.4%, and overjet ≥ 4 mm in 26.7% [5]. In the Finnish adult population, some form of malocclusion was observed in 39.5% (in 44.1% of males and 35.5% of females) of the 46 year olds among a cohort of people born in 1966 [6]. The cohort included both orthodontically treated and untreated individuals. Prevalence figures for increased overbite (≥6 mm) and distal bite in Finnish adults were reported as 9.7% and 15%, respectively [6, 7]. People with enlarged overjet experience their health-related quality of life markedly worse than those with normal overjet [8].

The relatively high prevalence of class II malocclusions among adults implies that some of those in need of care do not receive or want treatment in adolescence, interrupt treatment, fail to wear functional appliances as instructed, or despite treatment fail to achieve an acceptable occlusion, or show relapse [7, 9]. Because of this, a need for correction of the sagittal dentoalveolar and skeletal relationship may be encountered in the adult population. In Finland, these patients are referred to specialized care, where the selection of those entitled to comprehensive orthodontic treatment or a combination of orthodontic therapy and orthognathic surgery is based on common scoring criteria; point requirement for admission to subsidized treatment is 9 on the 1 to 10 scale [1].

Rehabilitation treatments for occlusion in adulthood are extensive. Duration from the beginning of orthodontic treatment and transition to the retention phase takes an average of 31 months [4]. As regards orthodontic-surgical therapy, it most often involves mandibular lengthening through BSSO [4]. Based on the national register data, approximately 300 such operations are conducted annually in Finnish hospitals (Hilmo registry, Finnish Institute for Health and Welfare, 2022, https://thl.fi/en/web/thlfi-en/statistics-and-data). In Finland, the cost of visits to specialized care is shared between the patient and the patient's home municipality according to Health Care Act (Finlex. Health Care Act 12/31/2010/1326. https://www.finlex.fi/en/) so that the patient pays a regular customer fee. In contrast, the home municipality carries the majority of the costs according to preagreed price groups that are dependent on the content of the treatment visits.

In Finland, in the 21st century, research has been conducted on the costs of orthodontic treatments for children and adolescents [2], but has not been published on costs of orthodontic-surgical treatments. Therefore, the aim of the present study was to explore the cost structure of orthodontic-surgical treatment in specialized care in Finland. We selected mandibular advancement treatment through BSSO, the most common orthognathic-surgical operation [4], as a model to identify general factors associated with the economic burden of the treatment both to society and to patients.

Methods

The study follows the STROBE (Strengthening the reporting of observational studies in epidemiology) guidelines. The study was carried out as a patient register study at Oral and Maxillofacial Unit of Pori Central Hospital (Satahospital, Pori, Finland) on patients with occlusal rehabilitation therapy carried out during 2015–2021 and mandibular advancement surgery during 2016–2020. The study was performed under the research-ethical permission of Satakunta Medical District (Licensing Decision 41/2021).

The inclusion criteria were: Finnish ethnicity, mandibular retrognathia as the main orthodontic diagnosis (ICD-10 code K07.13), orthodontic therapy carried out using full fixed appliances with straight wire technique, and BSSO as the orthognathic-surgical procedure with operational code EDC 10, in NOMESCO (The Nordic Medico-Statistical Committee) Classification of Surgical Procedures (https://norden.diva-portal.org). Excluded from the study were patients with any diagnosed craniofacial syndrome or cleft lip or palate, as well as patients with other multidisciplinary treatment, including for instance dental implantations, that would distort the overall cost and duration of the treatment.

For data collection, patients were registered with a code identifier for anonymization. Data were collected on gender, date of birth, dates of orthodontic treatment visits (starting from onset of orthodontics and ending with the date of transition to retention), date of surgery, initials of the oral surgeon, length of ward period, allocated time for orthodontic visits in minutes, duration of the surgical procedure in minutes, type of visit, municipality invoice of visits, the patient fee of visits, costs of the surgical phase for the municipality and the patient, visits conducted by the surgeon pre and postoperatively and during hospital period, as well as visits to oral hygienist during the course of the treatment.

The oral surgeons were allocated in two groups according to their grade of experience. The criterion as experienced versus less experienced was the number of performed BSSO operations before the study period (before 2016) as either < 30 or ≥ 30. This number was based on earlier research that analysed the number of performed surgeries required for achieving learning-curve plateau or proficiency regarding several types of surgical operations in the head and neck area [10, 11].

The costs were calculated from fees that are annually determined by the hospital district council, consisting of municipal billing and patient fees. For outpatient visits, municipal billing is determined in different price groups depending on the scope of the treatment (price groups 1–5), while the patient's outpatient visit fees remain constant. The cost of surgical operation is charged from the municipality according to a specified surgery package cost, while the patient pays the standard bed ward daily fee. The costs cover working spaces, staff, orthodontic and surgical materials and laboratory products (models, retention devices, etc.), radiographic imaging, and other costs.

The data were collected for Excel tabulation to yield: (i) the costs of the treatment for the municipality and the patient, (ii) the number of visits, and (iii) the duration of treatment for the entire treatment period and divided into the preoperative orthodontic phase, surgical phase, and postoperative orthodontic phase.

Additionally, we modelled the costs of hypothetical orthodontic-surgical treatment with lengthening of the mandible with BSSO, in theoretical cases where the dental arches are 'optimal' before the onset of treatment. This would mean that there is no need for alignment of teeth or levelling of the occlusal plane, and that the arches fit in form and size in all three planes, sagittal, transverse, and vertical, immediately following the surgery. This was done by analysing the contents and costs of the actual treatment visits and including costs only from placement of fixed appliances, preoperative visit, surgical phase, and transition to retention.

Analyses of the data were performed using Microsoft Excel 2016 program. Descriptive statistics were calculated. For statistical analysis, age, costs, duration of treatment, total treatment time, and surgery time were treated as continuous variables, and gender and surgeon´s experience as binary variables. Correlations were tested using Spearman correlation test for continuous variables. T-test (nonpaired, two-tailed, and without assumption of the equality of variance) was used to test the significance of differences of continuous variables (such as treatment time) between two groups (such as between the two genders). Outcomes were assessed independently without adjustment for covariates. Statistical significance was set at $P < .05$.

Results

The total number of orthognathic-surgical operations in this hospital during the 5-year follow-up period was 66. Of these, 56 (85%) were mandibular advancement surgeries through BSSO. Of these, 45 were performed to patients fulfilling the inclusion criteria. The majority of those patients, 34 (76%), were female (Table 1). The mean age of patients at the beginning of treatment was 32.8 years (SD 13.5, range 17.3–60.8) with no statistically significant age difference between males and females (Table 1).

The mean total cost of orthodontic-surgical BSSO treatments to lengthen the retrognathic mandible (Table 2) was 8530 € (SD 1072 €). The share of the mean costs for the home municipality was 7574 € (88.8%) and for the patient 947 € (11.1%). Modelled minimum mean cost of treatment in an hypothetical situation where the patient has optimal dental arches and comprising placement of fixed appliances, preoperative visit, surgical phase, and transition to retention was 3864 € (Table 3). This corresponds to 45% of total average costs.

The mean total duration of these treatments was 28.1 months (SD 6.2). The median number of outpatient visits was 27 (SD 6), of which 17 were preoperatively (Table 4). The majority of all visits were to the orthodontist, while there were some visits to the surgeon or general practitioner preoperatively (median 1, range 1–4) and postoperatively (range 0–2). Visits to oral hygienist counted a maximum of two during the entire treatment. The mean total treatment time that included outpatient treatment visits (time reserved) and the surgical operation (actual length) was 871 min (SD 140), with a mean preoperative share of 509 min (SD 91).

The mean duration of the surgical operation was 78 min (SD 30, range 49–192 minutes). Out of the 45 BSSO operations, one experienced surgeon performed 37, with operation time ranging from 49 to 105 min (mean 68, SD 13). Eight operations were performed by three professional dentists (A–C) near completion of their specialist training in oral surgery but with less experience from such operations: (A) one operation with operation time of 92 min, (B): three operations with operation time of 88 to 117 min, and (C): four operations with operation time of 119 to 192 min. With the experienced surgeon compared to the group of less experienced ones (Fig. 1), the operation time was significantly shorter (t-test, $P = .002$).

During the hospital period, the patients underwent the orthognathic-surgical procedure and were followed-up for postoperative recovery by oral surgeon, at 1 to 4, most commonly 2, visits. The average hospital stay after surgery was 2.5 nights (range 1–7). Additional nights were needed due to asthenia, i.e. fatigue after surgery. The single patient staying for 7 nights suffered from sinus tachycardia.

Regarding the costs or duration of their treatments, the differences between males and females were not statistically significant (Table 1). Regarding associations between the continuous variables (Table 5), the only statistically significant association was found between the length and costs of the treatment (Spearman correlation, rho = 0.71, $P = .000$).

Discussion

This one-centre study from Finland analysed orthognathic-surgical BSSO treatment from the view of its duration and costs. It offers an insight into how these have evolved after the previous report from the 1990s [12]. It also reports the total time allocated for treatment visits, and the actual duration of the surgical operation, the latter clearly showing the positive impact of the surgeon's experience. An additional advantage of the present study was that the same, experienced orthodontist had performed the orthodontic treatments. Therefore, the procedure and duration of visits were highly comparable between different treatment cycles, also making this part of the results probably the best transferable one to other centres nationally and internationally. As a weakness of this paper, the exact numbers given here are from the consecutive series of 45 patients, fulfilling the inclusion criteria, in one hospital, and may not as such be generalized. Moreover, the true costs from medical treatments are extremely difficult to evaluate, since they include not only costs of the medical staff and non-reusable materials, but they should be allocated costs from establishment and maintenance of the instrumentation and infrastructure. Counting the combined costs charged from municipalities and patients was considered here the best available method, but may not be directly transferable to centres—in other countries or in the private sector—with differing cost accounting.

Table 1. Summary table of orthodontic-surgical treatments of 45 patients with mandibular retrognathia and lengthening of the mandible.

	N	Age; mean (SD) years	Treatment duration; mean (SD) months	Treatment costs; mean (SD) euros	Treatment time mean (SD) minutes	Surgery time; mean (SD) minutes
All	45	32.8 (13.5)	28.1 (6.2)	8530 (1072)	871 (140)	78 (30)
Female	34 (76%)	32.9 (14.6)	28.0 (6.0)	8581 (1099)	873 (134)	80 (33)
Male	11 (24%)	32.6 (9.50)	28.8 (7.2)	8377 (1020)	864 (169)	71 (18)
t-test (female vs. male)		$P = .948$ ns	$P = .743$ ns	$p = .580$ ns	$P = .874$ ns	$P = .242$ ns

ns: not significant, limit set at $P < 0.05$.

Noteworthy, the majority of orthodontic-surgical treatments in our country are performed in publically funded hospitals that also serve as sites of specialist training. As shown here regarding the oral surgery, differences in the experience and individual learning curves of professionals executing the treatments may be considerable.

Occlusal rehabilitation in adulthood through orthodontic-surgical treatment is time-consuming and requires visits every 1–2 months to dental specialists, commitment to treatment, and financial contributions from the patient, society, and indirectly, the patient's employer through frequent absence from work. The total treatment time in our study averaged 28 months, of which preoperative care lasted 19 and postoperative care lasted 9 months. Our results correspond well to figures reported in previous studies: where total treatment time lasted from 22 to 31 months, of which 15 to 24 months were preoperatively and 5 to 11 months were postoperatively [4, 13–15].

Similarly, the mean total number of 28 visits, divided into 18 preoperative and 10 postoperative ones, is in line with the total numbers of 26 and 28 visits previously reported [12, 16]. The latter of the studies was conducted on patients with mandibular advancement surgery, similar to our study [16]. A somewhat lower number of visits were also documented [17]. As shown before, the severity of malocclusion and dental extractions as part of the treatment plan extend the duration of treatment [4, 18]. Nonetheless, gender and age, as indicated by the present study, did not display any significant association with the duration of treatment. Unplanned visits, patient time cancellations, and unexpected factors such as Covid-19 pandemic, are likely to increase the duration of the treatment.

Previous studies reporting total treatment visit times were not found to allow comparison, but the duration of the surgical procedure has been reported in a number of studies. The mean BSSO surgical operation time of 78 min (SD 30) was shorter than for instance 103 min (SD 33) reported in a Danish study, while the average of 2.5 postoperative nights at the hospital exceeded the reported Danish study mean of 1.3 postoperative nights [19].

After the operation, patients are signed off, normally for 4 weeks. In case of a working individual, this causes several indirect costs: (i) for the patient, depending on his/her collective agreement, possibly a lower income, (ii) for the employer the employee's absence from work and hence reduced outcome, and (iii) for the society, reduced tax revenue due to the both. The median earnings of full-time monthly wage earners in

Table 2. Costs of different phases of orthodontic-orthognathic surgical mandibular advancement treatment, paid by the community and the patient.

	Whole treatment		Preoperative orthodontics		Surgical phase		Postoperative orthodontics	
Total costs	Euros	%	Euros	%	Euros	%	Euros	%
Mean	8530	100	4087	47.7	2464	29.1	1982	23.4
SD	1072		741		214		668	
Max	10 949		6449	62.3	2829	36.3	3692	37.8
Min	6751		2382	32.7	1986	22.2	1090	13.0
Community	Euros	%	Euros	%	Euros	%	Euros	%
Mean	7574	100	3611	47.7	2316	30.6	1647	21.7
SD	926		684		206		553	
Max	9630		4600	59.1	2695	37.8	3178	37.1
Min	6090		2170	32.3	1870	21.4	910	13.0
Patient	Euros	%	Euros	%	Euros	%	Euros	%
Mean	947	100	477	50.8	143	15.2	327	32.5
SD	171		93		32		128	
Max	1494		689	63.3	269	28.4	625	52.5
Min	681		349	34.8	78	9.0	180	19.6

Table 3. Modelled minimum costs of orthodontic-surgical mandibular advancement treatment in case of ideal dental arches.

	Appliances		Preoperative visit		Surgical phase		Transition to retention		Total cost	
	Euros	%	Euros	%	Euros	%	Euros	%	Euros	%
Mean	764	19.8	312	8.1	2463	63.7	324	8.4	3864	100
SD	159		47		214		49			
Max	1024		465		2829		391			
Min	296		272		1986		147			

Table 4. Duration of the orthodontic-orthognathic surgical treatment, number of visits, and treatment time.

	Whole treatment		Preoperative orthodontics		Surgical phase		Postoperative orthodontics	
Duration	**Months**	**%**	**Months**	**%**			**Months**	**%**
Mean	28.1	100	18.9	68.0			9.2	31.0
SD	6.2		4.0				4.4	
Max	45.6		28.6	82.8			18.9	54.2
Min	15.4		11.0	45.8			4.2	17.2
Number of visits	**Count**	**%**	**Count**	**%**			**Count**	**%**
Mean	28.2	100	17.6	63.8			10.5	35.0
Median	27.0		17.0				9.0	
SD	5.8		2.9				4.4	
Max	42.0		23.0	75.0			21.0	52.8
Min	18.0		13.0	44.7			5.0	21.7
Treatment time	**Minutes**	**%**	**Minutes**	**%**	**Minutes**	**%**	**Minutes**	**%**
Mean	871	100	509	62.5	78	9.2	283	31.7
SD	140		91		30		112	
Max	1136		660	72.7	192	22.5	570	50.2
Min	583		390	43.9	49	5.1	130	15.4

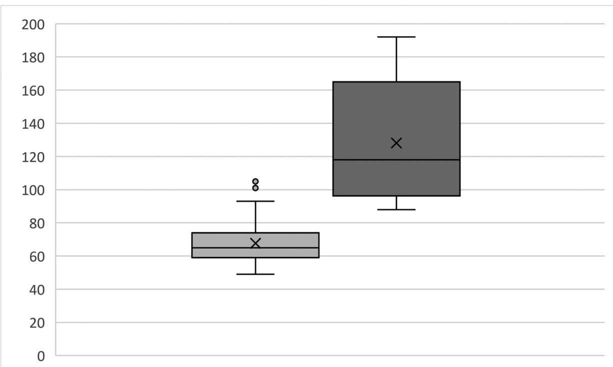

Figure 1. Operation time (minutes on *Y*-axis) of the experienced surgeon (left on *X*-axis) versus the less experienced ones (right on *X*-axis). The bar is the median, the cross is the mean, the box indicates the interquartile range and the whiskers the range. The small circles above upper range on the left are outlying findings.

Finland in 2020 was 3228 € (Statistics Finland, https://www.stat.fi/til/pra/index_en.html).

The cheapest modality of common orthognathic-surgical operations, is reportedly BSSO, compared with LeFort I osteotomy and bimaxillary surgery [20]. In question of bimaxillary surgery, which is more complex than BSSO, virtual surgical planning instead of conventional surgical planning reduces both costs and duration of the surgery [21]. However, when virtual surgical planning is applied on cases operated through BSSO, savings may be achieved regarding treatment duration but not regarding its costs [22]. The total cost of the current orthodontic-surgical treatments that included BSSO averaged 8530 € of which 70.9% were related to orthodontic costs. Similar cost analysis was carried out in a multi-centre study in the UK regarding treatments in the late 1990s [23]. However, the 352 orthodontic-surgical treatments analysed did not restrictively include BSSO only. In that study, which also included more complex surgeries, the median cost was 6075 € (interquartile range 5139–7069 €), of which orthodontics notably comprised 25% [23]. In Finland, an analysis of treatment costs was likewise carried out in the 1990s, reporting quite similar costs of treatment (6206 US $ ± 921 US $, corresponding to 5894 € ± 875 €), of which orthodontic costs were 39% [12]. Similarly, the Finnish study included bimaxillary surgical patients and showed a lower cost of single-jaw surgery. Compared to the present figures, the cost differences are partly explained by a more than 20-year time difference in evaluation. The Consumer Price Index in Finland has risen from 2000 to 2021 by 34.4% (Statistics Finland, https://statfin.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__khi/statfin_khi_pxt_11xr.px/). A better reference point is provided by Finnish research based on a similar cost structure. As an interesting finding, despite similar duration of treatment [12], the percentage of orthodontic costs is clearly higher at present. In a hypothetical situation where the patient displays optimal dental arches that are well-aligned, the calculated mean minimum cost of the orthodontic-surgical treatment with BSSO would be only 45% of the present total treatment cost, and be due to costs from placement of fixed appliances, preoperative visit, surgical phase, and transition to retention. Hence, a 55% share of the total cost seems to depend on occlusal features of the patient and other patient- and operator-dependent factors, and mainly constitutes from orthodontic visits. It could be considered whether the number of visits to treatment and the time of treatment can be modified for instance by combining visits, e.g. by placing appliances in both jaws on the same visit rather than on separate visits, extending visit intervals, and combining orthodontic visits with other treatment visits, e.g. oral hygienist's home care education. At

Table 5. Cross-tabulation of the associations between selected continuous variables of orthodontic-surgical treatment of 45 patients with mandibular retrognathia and surgical lengthening of the mandible.

	Age	Treatment duration	Treatment costs
Age		rho = 0.02[a] P = .876	rho = 0.00[a] P = .899
Treatment duration	rho = 0.02[a] P = .876		rho = 0.71[a] P = .000*
Treatment costs	rho = 0.00[a] P = .899	rho = 0.71[a] P = .000*	

[a]Spearman correlation co-efficient; *statistically significant, $P < 0.05$.

the same time, it is important to try to prevent unplanned visits due to, for instance, breakage of appliances. Other potentially cost-saving means would be reduction of chair-side time and paying attention to eventual differences between the time reserved and the actual time spent on the treatment visits; not habitually overestimating the time required for different procedures would aid in increasing the patient flow. Moreover, costs could be potentially reduced by division of work between different professional groups, such as orthodontists, general practitioners, and oral hygienists, forming a well-functioning multidisciplinary orthodontic team, and by intensifying the time of care.

The studies of cost and duration of orthodontic-surgical treatment have mostly investigated treatments using full fixed appliances and straight wire technique [4]. The surgery-first paradigm, mainly used in correction of skeletal class III discrepancy, but also used in lengthening the mandible by BSSO, may considerably reduce treatment time [24], but interestingly not the costs of treatment [25].

A fundamental question remains to what extent we can make a difference in the need for rehabilitation treatments for adulthood malocclusion and reduce total costs by enhancing treatments for children and adolescents. Treatment of class II malocclusion in childhood reduces the need for further treatment later, whereas in untreated, bite defect correction almost never occurs [26]. Early treatment may also improve oral health and oral health-related quality of life. Studies on costs of orthodontic treatments of children and adolescents in Finland date back to 1998 and 2013 [2, 27]. In the former, the costs averaged FIM 7358, corresponding to 1237 € [27]. In the more recent study, the range of costs was 517–926 € [2]. Even the higher cost [27] of treating children by orthodontics makes only 14%, and after index correction 20% of the presently found costs of orthodontic-surgical treatment in adulthood.

Since treatment in childhood and adolescence is markedly cheaper and also devoid of risks of the surgery, the strong emphasis lies on treatment during the growth period. Even in cases where conventional treatment of class II malocclusion in adolescence may not result in an optimum sagittal relationship, the treatment period that likely ends with well-aligned teeth serves for the future. Careful retention of the treatment result not only preserves the obtained esthetics and reduces the risk of trauma or excessive wear of incisors, but also markedly simplifies an eventually needed surgical correction of the malocclusion. Retrospective clinical and patient-history analysis of patients entering BSSO treatment would be essential for assessing special risk factors for disadvantageous occlusal development.

Conclusion

Within the extensive and expensive orthodontic-surgical treatment with BSSO, a mean 55% share of the costs is influenced by case- and operator-dependent factors. In essence, the complexity and performance of the orthodontic phases of treatment are important determinants in the cost structure. This emphasizes the value of careful retention of treatment results of eventual orthodontics during childhood and adolescence to limit future treatment costs.

Author contributions

Pekka Niemi (Conceptualization [Lead], Data curation [equal], Formal analysis [equal], Investigation [equal], Methodology [equal], Project administration [equal], Resources [Equal], Visualization [equal], Writing—original draft [equal]), Mika Kortelainen (Methodology [equal], Supervision [equal], Writing—review & editing [equal]), Ulla Harjunmaa (Investigation [equal], Writing—review & editing [equal]), and Janna Waltimo-Siren (Conceptualization [equal], Formal analysis [equal], Methodology [equal], Supervision [equal], Visualization [equal], Writing—review & editing [equal]).

Conflict of interest

The authors declare that there is no conflict of interest.

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Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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