ACTA ODONTOLOGICA SCANDINAVICA
2023, VOL. 81, NO. 5, 396–401
https://doi.org/10.1080/00016357.2022.2161623

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Early orthodontic treatment in a Finnish public health centre: a retrospective cross-sectional study

Annika Arpalahti[a,b,c], Anni Saarnio-Syrjäläinen[a,b], Sirkku Laaksonen[a] and Heidi Arponen[b,c,d]

[a]Riihimäki Region Health Center Federation of Municipalities, Riihimäki, Finland; [b]Department of Oral and Maxillofacial Diseases, University of Helsinki, Helsinki, Finland; [c]Head and Neck Center, Helsinki University Hospital, Helsinki, Finland; [d]City of Vantaa Oral Healthcare Corporation, Vantaa, Finland

ABSTRACT

Objectives: The aim of this observational cross-sectional one-centre study was to assess whether the previously described national orthodontic treatment practises and international recommendations are implemented in a public health care centre in Finland. We also assessed early treatment practices and appliances used.

Methods: The study group comprised 801 children born in 2011 and 2012 residing in the Riihimäki health centre catchment area in Finland, representing 80% of the age cohort. The patient records were examined for data on orthodontic treatment, timing of treatment, appliances used, and occlusal traits.

Results: The children had been examined by four orthodontist specialists and two orthodontic postgraduate students. Mean age at occlusal examination had been 9 years. Of the children, 212 (26%) were undergoing or had undergone orthodontic treatment. An additional 4.4% were scheduled for treatment. The proportion of children deemed to need treatment was significantly different between the different orthodontists. The most frequently used appliances were quad-helix (30%), eruption guidance appliance (20%), head gear (14%), fixed appliances (10%), protraction facemask (10%), and passive mandibular lingual arch (6%).

Conclusions: Nearly one-third of children aged less than 12 years in the health centre were currently or had been in orthodontic treatment. Approximately half had received treatment with either quad-helix or eruption guidance appliance.

ARTICLE HISTORY
Received 6 September 2022
Revised 27 November 2022
Accepted 13 December 2022

KEYWORDS
Orthodontics; early treatment; interceptive treatment; mixed dentition; public healthcare; implementation

Introduction

Early orthodontic treatment can be defined as treatment conducted in primary or early mixed dentition phase [1–3]. Early treatment can also be regarded as interceptive when it is implemented to prevent the development and progression of more severe occlusal problems [4]. Interceptive treatment usually has limited treatment goals compared with comprehensive treatment. The literature suggests that an early treatment approach should be adopted to correct posterior crossbite with functional mandibular shift [5], severe skeletal class III malocclusion [6], maxillary transverse deficiency [7], proclined upper incisors conjoint with incompetent lip seal [8], and deep bite with palatinal gingival contact [9]. The rationale for early correction of posterior crossbite with functional mandibular shift is the prevention of asymmetrical growth of the mandible and potential development of temporomandibular joint dysfunction later in life [10–13]. The association between temporomandibular disorder (TMD) and malocclusion remains a contoversial topic [14]. In individuals with a skeletal class III relationship, early treatment is usually justified, and facemask therapy has been shown to be effective in early mixed dentition phase [6]. Correction of transversal discrepancy early with a maxillary expander increases the arch width and creates space in the upper arch, thus reducing dental crowding [7,10,15]. A large overjet increases the risk for traumatic injury of the upper incisors [16]. Treating proclined upper incisors early during dental development potentially prevents dental trauma more than the need for a second phase of treatment [8]. An overjet threshold of 3 mm in primary dentition and 5 mm in early secondary dentition for increased dental trauma risk has been proposed [17], although for interceptive treatment a greater overjet with an incomplete lip closure is usually set as the threshold [18]. Furthermore, malocclusions affect oral health-related quality of life [19]. Especially malocclusion in the aesthetic zone has been shown to have a negative impact on emotional and social well-being [19].

In the Finnish public healthcare system, orthodontics forms a considerable proportion of the dental treatment given to children and adolescents [20]. A report from 2018 states that a national average of 27% of visits to the dental office by individuals aged 6–17 years are related to orthodontic treatment [21]. Riihimäki municipality estimates that 13% of its inhabitants aged between 6 and 17 years undergo orthodontic treatment [21]. Similarly to other Nordic

CONTACT Annika Arpalahti annika.arpalahti@fimnet.fi Head and Neck Center, Helsinki University Hospital, Helsinki, Finland

countries, in Finland the patient selection evaluation for publicly funded orthodontic care is done based on professionally defined need [22–24]. Severe malocclusion, graded with a 10-point scale according to severity, warrants universal orthodontic treatment in public healthcare clinics [25]. The Finnish 10-point scale used in the public healthcare system is adapted from Grainger's Treatment Priority Index (TPI) [26,27]. The index includes evaluation of possible craniofacial malformations and developmental disturbances, molar sagittal relationship, anterior overjet, deep bite, open bite, congenital absence of teeth, transverse discrepancies, tooth displacement, and crowding. The adapted TPI index has no aesthetic component. In developing dentition, a grade equal to or higher than 8, or the potential of worsening to grade 8, corresponding to severe malocclusion or craniofacial discrepancy, warrants treatment free-of-charge for all individuals aged under 18 years. In fully developed dentition, the criteria are more stringent. In the past, large regional variation in access to orthodontic treatment and unsatisfactory routines in the treatment processes have been identified as the main concerns of orthodontists in Finnish public healthcare clinics [28].

The aim of this retrospective cross-sectional study was to assess whether the previously described national orthodontic treatment practices and international recommendations have been implemented in a public healthcare centre in Finland. The study hypothesis was that the number of children receiving early treatment resembles that of previous national investigations. We also hypothesised that early orthodontic treatment is most often conducted due to crossbite, crowding, deep bite, large overjet, and anterior crossbite.

Materials and methods

Study population

The Riihimäki region of the federation of municipalities has approximately 47,000 inhabitants. Of the total population aged 20 years and over in Riihimäki municipality, 29% have higher education qualifications and 44% upper secondary education [29]. Median income is 3026 euros/month, which is in line with the national median of 3217 euros/month [30]. The study material consisted of patient records of children born in 2011 and 2012 residing in the Riihimäki health centre region. All of the children had undergone a clinical occlusal examination in primary or mixed dentition phase between the age of 5.2 and 10.7 years by a specialist orthodontist or an orthodontic postgraduate student. All the specialist orthodontists had more than 2 years of experience and the postgraduate students had been in the clinical specialising program for more than a year. All orthodontists and postgraduate students had received similar training in implementing the Treatment Priority Index, as part of their education. The clinical examinations and treatments had been conducted by four orthodontists and two postgraduate orthodontic students. The postgraduate students had been calibrated against the gold standard of an experienced orthodontist (two different orthodontists). No calibration had been carried out between the orthodontists, as is typical in Finnish healthcare centres.

The municipality's patient records were examined between October 2021 and March 2022 for data on occlusion and orthodontic treatment of children of the 2011 and 2012 birth cohort. In total, 801 children's records were eligible for the study. The Riihimäki region of the federation of municipalities approved this study (7/2021).

Outcome measures

The main outcome measure was the number of children receiving orthodontic treatment in primary or early mixed dentition phase. A secondary outcome measure was the frequency of use of different orthodontic appliances. We also collected data on malocclusion diagnosis and occlusal characteristics of the cohort.

The following variables were recorded:

- age at occlusal evaluation timepoint
- treatment status (no treatment need, in treatment, or waiting for treatment onset)
- orthodontic appliance(s) used
- main diagnosis code of the malocclusion according to ICD-10 classification [31] for the children deemed in need of orthodontic treatment
- first permanent molar relationship according to Angle classification
- horizontal incisor overjet
- vertical incisor overbite

Statistics

Mean value and standard deviation or range were calculated for continuous variables. Prevalence percentage was determined for Angle class molar relationship and different appliances used. The number of children examined by different orthodontists and postgraduate students was recorded, and the percentages of children deemed eligible for treatment were calculated. Mean differences in overjet and overbite between children in orthodontic treatment and those with no current treatment need were compared with an independent samples *t*-test. Statistical significance was set at $p < .05$. Correlation between age and appliance type was evaluated with a point-biserial correlation. Chi-square test was applied to analyse the association between appliance type and primary malocclusion diagnosis as well as between orthodontists' and postgraduate students' evaluation of treatment need. No data were missing for the primary outcome variables of age and treatment status. Missing completely at random were individual measurements on occlusal features due to inconsistency in patient documentation.

Results

Of the 1088 children in the municipality birth cohort of children born in 2011 and 2012, altogether 801 (80%) had been clinically examined by one of four specialist orthodontists

and/or two postgraduate orthodontic students working in the municipality (Table 4). One of the postgraduate students (student 2, Table 4) had been calibrated against the gold standard of an experienced specialist orthodontist with a subsample of 16 children for overjet, overbite, Angle molar relationship, and crossbite. The percentage agreement for the two raters was 93% for horizontal overjet, 87% for vertical overbite, and 80% for unilateral molar Angle classification. The percentage agreement for the two raters was 100% for crossbite. The average age of children at the time of clinical examination had been 9.0 (range 5.2–10.7) years.

Primary outcome

Of the children, 212 (26.5%) were undergoing or had undergone orthodontic treatment (Table 1). An additional 4.4% were waiting for the onset of treatment. Furthermore, 26.8% of the children were deemed to need occlusal follow-up. By contrast, 41.8% were considered either not to have malocclusion or the malocclusion severity did not warrant treatment in public healthcare.

Secondary outcome

The most frequently used appliances were quad-helix (QH), eruption guidance appliance (EGA), and headgear (HG) (Tables 2 and 3). No association was found between age of the child and the appliance used ($r_{pb} = 0.065$, $p = .342$).

Selection for treatment

In our sample, the proportion of children selected for orthodontic treatment ranged between 18 and 38% among the four orthodontist specialists and two postgraduate students (Table 3). The variation was significant ($\chi^2(5) = 405.5$, $p < .001$). Notably, the number of children examined varied between the orthodontists, the great majority of evaluations being done by one orthodontist and two postgraduate students (Table 3).

Malocclusion diagnosis and occlusal characteristics

Diagnosis of malocclusion had been established for the children selected for orthodontic treatment and for some children scheduled for follow-up. The most prevalent diagnostic codes given were crowding, deep bite, and crossbite (Table 4). The protocol for using diagnostic codes varied between the professionals. Some patients had only one main diagnosis, while others had several codes listed.

Of the study subjects, 66% displayed a class I molar relationship, 31% a class II molar relationship, and 1% a class III molar relationship. In 18% of the children, the molar relationship was asymmetrical. In the whole sample, the mean overjet was 3.7 mm (SD 1.6) and the mean overbite 3.5 mm (SD 1.6). Overjet and overbite were significantly greater in those who had received treatment or were undergoing treatment ($t(796) = -3.991$, $p < .001$, 95% CI −0.750 to −0.255 and $t(790) = -2.239$, $p = .025$, 95% CI −0.518 to −0.034, respectively). Presence/absence of functional mandibular shift had not been systematically recorded. A significant association was present between appliance type and primary malocclusion diagnosis ($\chi^2(160, 211) = 550.5$, $p < .001$) (Table 3).

Discussion

In this retrospective cross-sectional study, we found 26.4% of children in mixed dentition phase to have undergone orthodontic treatment and an additional 4.4% were waiting for the treatment to commence. The most frequently used appliances were quad-helix and prefabricated eruption guidance appliance.

Orthodontic treatment services are organised and financed differently in Nordic countries. In Finland, the national

Table 2. Appliances used in early orthodontic treatment in 212 subjects.

	N	%
Quad-helix	64	30
Eruption guidance appliance	43	20
Headgear	30	14
Fixed appliances	25	12
Protraction facemask	22	10
Passive mandibular lingual arch	14	7
Intermaxillary elastics	6	3
Rapid maxillary expander (RME)	3	1
Functional appliance	3	1

Table 3. Differences between four specialist orthodontists and two orthodontic postgraduate students in patient selection to treatment.

Orthodontist/dentist	Number of evaluations	In need of treatment *N*	Selection for treatment %
Orthodontist 1	329	98	30
Orthodontist 2	50	16	32
Orthodontist 3	56	10	18
Orthodontist 4	87	30	34
Postgraduate student 1	130	37	29
Postgraduate student 2	144	55	38

Table 1. Study group characteristics.

	N = 801	Missing data *N*	
Age, mean (range) in years	9.0 (5.2–10.7)	0	
Ongoing orthodontic treatment	195		
Planned treatment	35		
Previously completed treatment	17		
Horizontal overjet, mean (range) in millimetres	3.7 (−3–11)	1	
Vertical overbite, mean (range) in millimetres	3.5 (−2–11)	7	
Angle class molar relationship		8	% Of the cohort
Class I	531		66
Class II	252		31
Class III	9		1.1

Table 4. Number of patients by malocclusion diagnostic code (ICD-10) and orthodontic appliance.

Appliance	K07.30 Crowding	K07.23 Deep bite	K07.25 Crossbite	K07.22 Overjet	K07.24 Open bite	K07.11 Prognathic mandible	K00.00 Congenital missing of permanent tooth	K07.38 Another abnormal location or position of a tooth	K07.27 Scissor bite	K07.55 A malocclusion caused by abnormal use of tongue, lips, or fingers	K07.20 Distal bite	K00.10 Supernumerary tooth in maxillary incisal area	K07.13 Retrognathic mandible	K07.14 Retrognathic maxilla	K07.35 Impacted or embedded teeth with abnormal position of such teeth or adjacent teeth	K00.68 Other specified disturbances in tooth eruption	K07.19 Anomalies of jaw-cranial base relationship, unspecified	Total
QH	25	7	26	1	1	0	0	1	0	2	0	1	0	0	0	0	0	64
EGA	0	33	1	2	2	0	1	0	0	2	0	0	2	0	0	0	0	43
FA	8	10	1	0	0	0	1	3	0	0	0	0	0	0	1	0	1	25
RME	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
FM	0	0	9	0	0	9	0	0	0	0	0	0	0	4	0	0	0	22
LA	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
IME	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6
HG	21	4	1	1	0	0	0	0	0	2	1	0	0	0	0	0	0	30
TPA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Schwarz-plate	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
Functional appliance	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	3
Total	72	56	44	4	3	9	2	4	1	6	3	1	3	4	1	1	1	214

QH: quad-helix; EGA: eruption guidance appliance; FA: fixed appliances; RME: rapid maxillary expander; FM: facemask; LA: passive mandibular lingual arch; IME: intermaxillary elastics; HG: head gear; TPA: passive transpalatinal arch.

healthcare system offers full financial coverage for orthodontic treatment of severe functional malocclusion in individuals aged under 18 years. In Norway, orthodontic treatment costs are reimbursed according to the criteria for need [32], and in 2018 around 17% of children aged 9 years were estimated to be undergoing orthodontic treatment [33]. In Denmark, an estimated 25–33% of children and adolescents receive free orthodontic treatment by public healthcare up to the age of 18 years [23]. A Swedish report described a treatment need in 37% of 12- to 13-year-olds, as assessed by the Index of Orthodontic Treatment Need (IOTN) [34].

Treatment need estimation relies on the subjective evaluation of a dental professional [35]. Our findings confirm the subjectivity of treatment need evaluation. The proportion of patients deemed to need early orthodontic treatment assessed by the evaluator with the highest percentage was double that of the evaluator with the lowest percentage. Both postgraduate students selected patients to orthodontic treatment more frequently than the average of the specialist orthodontists. This finding might be related to experience and confidence level of the practitioner. In Finland, according to the 10-point scale of treatment need, the need for orthodontic treatment among 7-year-olds has previously been described to be 24%, whereas no treatment was required by 42% and follow-up of occlusal development was recommended for 35% [27]. A wider estimation of treatment need was suggested by Keski-Nisula et al. [2] who analysed the occlusion of 489 children at the onset of mixed dentition and noted the overall prevalence of malocclusion to vary between 68 and 93% depending on the parameters applied. Treatment need was not prioritised according to the 10-point scale. Class II malocclusion was found to be the most prevalent malocclusion in Finnish children at the onset of mixed dentition [2]. Our finding of the proportion of children in public orthodontic treatment is in line with the Danish report but is greater than in a previous Finnish investigation. In our sample, 31% of the children were in or had been deemed in need of orthodontic treatment before the age of 11 years. The discrepancy with previous Finnish findings could be explained by the older age in our cohort. At the time of data collection, our study participants were on average 9 years old. The estimate from the municipality of a 13% prevalence for the age group of 6–17 years may suggest a tendency for favouring early orthodontic treatment.

As Tausche and co-workers [4] state, early interceptive treatment aiming to eliminate factors that inhibit dental arch development and mandibular and maxillary growth is practiced varyingly by orthodontists, possibly because scientific evidence does not explicitly show the benefit of such interventions. By contrast, several investigations demonstrate a favourable preventive outcome with early interceptive treatment in lowering the prevalence of impacted maxillary canines [36,37]. In Finnish studies conducted more than a decade ago, the most frequently used appliances in early interceptive treatment of 7-year-olds in public healthcare centres were headgear and quad-helix [28,38]. Our study confirms partly the continuation of this preferred appliance selection. However, use of headgear was less frequent than

described in 2009 [28], and quad-helix and eruption guidance appliance were more often the treatment of choice.

In children in orthodontic treatment in our sample, dental crowding was the most prevalent main diagnosis (34%), followed by deep bite (26%) and crossbite (21%). Both crowding and crossbite malocclusions can be effectively treated with quad-helix appliance in early mixed dentition. Headgear has also been proposed to be advantageous in eliminating crowding when started in early mixed dentition [39]. Correction of transverse discrepancies is recommended before skeletal growth velocity peak in order to induce more skeletal transverse craniofacial changes [40]. Quad-helix is effective for posterior crossbite correction in children [41,42]. Our findings imply that the previous recommendation of early treatment of transverse discrepancy and elimination of crowding is practiced in the healthcare centre investigated.

Treatment of skeletal class III malocclusion and anterior crossbite with protraction facemask before the age of 10 years is effective [43,44]. The prevalence of class III malocclusion in individuals of European descent aged over 11 years is 4.9% (range 1.0–9.7%) [45]. In a Finnish study analysing children at onset of mixed dentition phase, the prevalence of anterior crossbite was 2.2% [2]. In our sample, 10% of patients in treatment (2.7% of the whole sample) had protraction facemask therapy, implying that class III malocclusion and/or anterior crossbite is treated early in this healthcare centre. Thus, the orthodontic treatment practice is in line with the recommendations in the literature.

Uni- or bilateral class II molar relationship was common in our study sample (31%). However, the prevalence of class II malocclusion was not systematically reflected in the recorded diagnostic codes. Only 2.8% of children had been given the diagnosis of distal bite or retrognathic mandible. Class II malocclusion can be treated in mixed dentition phase or in late mixed dentition phase [46]. In our sample, activators or other functional appliances were rare, whereas early treatment was frequently done with EGA (20%). We could speculate with the frequent use of EGA that some of the class II treatments may be started early in the mixed dentition phase, instead of waiting for the pubertal growth spurt. EGA is widely used in some areas of Finland in early mixed dentition phase for treatment of class II malocclusion to avoid the need for a second phase of treatment in the growth spurt [9,47]. In our study group, open bite was rare and negative overbite was measured in only five subjects; an open bite diagnosis was assigned to four individuals.

Caution is warranted in interpreting our findings. Firstly, the study was limited to one healthcare centre and does not reflect the treatment practices throughout Finland. Secondly, the retrospective nature of the study hindered detailed analysis of occlusal features and treatment indications, as the orthodontists and postgraduate students had not been comprehensively calibrated.

Conclusions

The prevalence of children aged 9 years on average in early orthodontic treatment was 26%. The most prevalent appliances used were quad-helix, eruption guidance appliance, headgear, fixed appliances, and protraction facemask. The use of eruption guidance appliance is more frequent in our sample than in previous studies done in Finnish health centres. The proportion of patients selected for orthodontic treatment differed among the orthodontist specialists and postgraduate students. Thus, practitioners in public healthcare clinics should be calibrated in their assessment of orthodontic treatment need to ensure a standard evaluation of all patients.

Acknowledgments

We are grateful for financial support from the Finnish Women Dentists' Association. We thank Carol Ann Pelli for linguistic assistance.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the Finnish Woman Dentists' Association (personal grant to AA).

ORCID

Heidi Arponen http://orcid.org/0000-0003-0359-1486

References

[1] Thiruvenkatachari B, Harrison J, Worthington H, et al. Early orthodontic treatment for class II malocclusion reduces the chance of incisal trauma: results of a cochrane systematic review. Am J Orthod Dentofacial Orthop. 2015;148(1):47–59.

[2] Keski-Nisula K, Lehto R, Lusa V, et al. Occurrence of malocclusion and need of orthodontic treatment in early mixed dentition. Am J Orthod Dentofacial Orthop. 2003;124(6):631–638.

[3] Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 6th Edition. St. Louis, MO: Mosby; 2018.

[4] Tausche E, Luck O, Harzer W. Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need. Eur J Orthod. 2004;26(3):237–244.

[5] Proffit WR. The timing of early treatment: an overview. Am J Orthod Dentofacial Orthop. 2006;129(4 Suppl):S47–S49.

[6] Baccetti T, McGill JS, Franchi L, et al. Skeletal effects of early treatment of class III malocclusion with maxillary expansion and face-mask therapy. Am J Orthod Dentofacial Orthop. 1998;113(3):333–343.

[7] Geran RG, McNamara JA, Baccetti T, et al. A prospective long-term study on the effects of rapid maxillary expansion in the early mixed dentition. Am J Orthod Dentofacial Orthop. 2006;129(5):631–640.

[8] Batista KB, Thiruvenkatachari B, Harrison JE, et al. Orthodontic treatment for prominent upper front teeth (class II malocclusion) in children and adolescents. Cochrane Database Syst Rev. 2018;2018(3):1–90.

[9] Keski-Nisula K, Hernesniemi R, Heiskanen M, et al. Orthodontic intervention in the early mixed dentition: a prospective, controlled study on the effects of the eruption guidance appliance. Am J Orthod Dentofacial Orthop. 2008;133(2):254–260.

[10] Pirttiniemi P, Kantomaa T, Lahtela P. Relationship between craniofacial and condyle path asymmetry in unilateral cross-bite patients. Eur J Orthod. 1990;12(4):408–413.

[11] Bishara SE, Treder JE, Jakobsen JR. Facial and dental changes in adulthood. Am J Orthod Dentofacial Orthop. 1994;106(2): 175–186.

[12] Thilander B, Bjerklin K. Posterior crossbite and temporomandibular disorders (TMDs): need for orthodontic treatment? Eur J Orthod. 2012;34(6):667–673.

[13] Sonnesen L, Bakke M, Solow B. Bite force in pre-orthodontic children with unilateral crossbite. Eur J Orthod. 2001;23(6):741–749.

[14] Gesch D, Bernhardt O, Kirbschus A. Association of malocclusion and functional occlusion with temporomandibular disorders (TMD) in adults: a systematic review of population-based studies. Quintessence Int Berl Ger 1985. 2004;35(3):211–221.

[15] McNamara JA, Franchi L, McClatchey LM. Orthodontic and orthopedic expansion of the transverse dimension: a four decade perspective. Semin Orthod. 2019;25(1):3–15.

[16] Elkhadem A. Large overjet may double the risk of dental trauma. Evid Based Dent. 2015;16(2):56.

[17] Arraj GP, Rossi-Fedele G, Doğramacı EJ. The association of overjet size and traumatic dental injuries-a systematic review and meta-analysis. Dent Traumatol. 2019;35(4–5):217–232.

[18] Heikinheimo K. Need of orthodontic treatment in 7-year-old finnish children. Community Dent Oral Epidemiol. 1978;6(3):129–134.

[19] Dimberg L, Arnrup K, Bondemark L. The impact of malocclusion on the quality of life among children and adolescents: a systematic review of quantitative studies. Eur J Orthod. 2015;37(3): 238–247.

[20] Linden J, Widström E, Sinkkonen J. Children and adolescents' dental treatment in 2001–2013 in the finnish public dental service. BMC Oral Health. 2019;19(1):131.

[21] Nordblad A, Partanen M-L, Ekvist M. Suun terveydenhuollon uudistustyö ja tavoitejohtamisen tietoperusta : suhat-verkoston toiminta 2000–2019 [internet]. Finnish Institute for Health and Welfare (THL); 2020. [cited 2022 dec 22]. Available from: https://urn.fi/URN:ISBN:978-952-343-598-8.

[22] Linder-Aronson S. Orthodontics in the swedish public dental health service. Trans Eur Orthod Soc. 1974;233–240.

[23] Gera A, Gera S, Cattaneo PM, et al. Malocclusion and oral health-related quality of life among young danish adults. Is there a difference between subjects who received orthodontic treatment during adolescence and subjects without treatment need? A cross-sectional study. Acta Odontol Scand. 2022;80(1):65–73.

[24] Espeland LV, 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(5):274–279.

[25] Ministry of Social affairs and Health. Uniform criteria for non-urgent care (In Finnish: Sosiaali- ja terveysministeriö, Yhtenäiset kiireettömän hoidon perusteet) [Internet]; 2019 [cited 2021 May 7]. Available from: http://urn.fi/URN: ISBN:978-952-00-4036-9.

[26] Grainger RM. Orthodontic treatment priority index. Vital Health Stat 2. 1967;(25):1–49.

[27] Heikinheimo K. Need of orthodontic treatment and prevalence of craniomandibular dysfunction in Finnish children. Finland: University of Turku; 1989.

[28] Pietilä I, Pietilä T, Varrela J, et al. Trends in Finnish public orthodontic care from the professionals' perspective. Int J Dent. 2009; 2009:945074.

[29] The Finnish Institute for Health and Welfare. Statistical information on welfare and health in Finland [Internet]; 2005 [cited 2022 Nov 16]. Available from: https://sotkanet.fi/sotkanet/en/haku?indicator=szYKsvYxt9Y1AgA=&region=szb3AAA=&year=sy5ztjbS0zUEAA==&gender=t.

[30] Statistics Finland. Official Statistics of Finland (OSF): structure of earnings. ISSN = 1799-0092. 2020 Appendix table 1. Average monthly earnings and dispersion of earnings of full-time wage and salary earners in 2020 by region [Internet] e-publication; [cited 2022 Sep 11]. Available from: http://www.stat.fi/til/pra/2020/pra_2020_2022-03-11_tau_001_en.html.

[31] WHO. ICD-10: International statistical classification of diseases and related health problems. Geneva: World Health Organization; 2011.

[32] Grytten J, Skau I, Stenvik A. Distribution of orthodontic services in Norway. Community Dent Oral Epidemiol. 2010;38(3):267–273.

[33] Ekornrud T, Skjostad O, Texmon I. Tannregulering blant barn og unge. En analyse av behandlingsforløp og sosioøkonomiske forskjeller. [Internet]. Statistisk sentralbyrå [cited 2022 Aug 22]. Available from: chrome-extension://efaidnbmnnnibpcajpcgwww.ssb.no/helse/artikler-og-publikasjoner/_attachment/398789?_ts=16d7296cec8.

[34] Josefsson E, Bjerklin K, Lindsten R. Malocclusion frequency in swedish and immigrant adolescents–influence of origin on orthodontic treatment need. Eur J Orthod. 2007;29(1):79–87.

[35] Pietilä I, Pietilä T, Pirttiniemi P, et al. Orthodontists' views on indications for and timing of orthodontic treatment in Finnish public oral health care. Eur J Orthod. 2008;30(1):46–51.

[36] Bedoya MM, Park JH. A review of the diagnosis and management of impacted maxillary canines. J Am Dent Assoc. 2009;140(12): 1485–1493.

[37] Lövgren ML, Dahl O, Uribe P, et al. Prevalence of impacted maxillary canines-an epidemiological study in a region with systematically implemented interceptive treatment. Eur J Orthod. 2019; 41(5):454–459.

[38] Pietilä T, Pietilä I, Widström E, et al. Extent and provision of orthodontic services for children and adolescents in Finland. Community Dent Oral Epidemiol. 1997;25(2):150–155.

[39] Heino T, Kokko H, Vuollo V, et al. Effect of cervical headgear on dental arch area, shape and interarch dimensions : a randomized study. J Orofac Orthop. 2021;82(3):153–162.

[40] Baccetti T, Franchi L, Cameron CG, et al. Treatment timing for rapid maxillary expansion. Angle Orthod. 2001;71(5):343–350.

[41] Ugolini A, Agostino P, Silvestrini-Biavati A, et al. Orthodontic treatment for posterior crossbites. Cochrane Database Syst Rev. 2021;12(12):CD000979.

[42] Sollenius O, Golež A, Primožič J, et al. Three-dimensional evaluation of forced unilateral posterior crossbite correction in the mixed dentition: a randomized controlled trial. Eur J Orthod. 2020;42(4):415–425.

[43] Kim JH, Viana MA, Graber TM, et al. The effectiveness of protraction face mask therapy: a meta-analysis. Am J Orthod Dentofacial Orthop. 1999;115(6):675–685.

[44] Foersch M, Jacobs C, Wriedt S, et al. Effectiveness of maxillary protraction using facemask with or without maxillary expansion: a systematic review and meta-analysis. Clin Oral Investig. 2015; 19(6):1181–1192.

[45] Hardy DK, Cubas YP, Orellana MF. Prevalence of angle class III malocclusion: a systematic review and meta-analysis. OJEpi. 2012; 02(04):75–82.

[46] Kallunki J, Bondemark L, Paulsson L. Comparisons of costs and treatment effects-an RCT on headgear activator treatment of excessive overjet in the mixed and late mixed dentition. Eur J Orthod. 2022;44(1):86–94.

[47] Keski-Nisula K, Keski-Nisula L, Varrela J. Class II treatment in early mixed dentition with the eruption guidance appliance: effects and long-term stability. Eur J Orthod. 2020;42(2):151–156.