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RESEARCH ARTICLE

# Prevalence of malocclusion traits and orthodontic treatment in a Finnish adult population

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**ABSTRACT**

**Objective** The aim of the study was to examine the prevalence of malocclusion traits and the extent of orthodontic treatment in a Finnish adult population. **Materials and methods** The study population comprised subjects ($n = 1964$) from the Northern Finland Birth Cohort 1966 living in the city of Oulu and within 100 km of it. A clinical oral and dental examination with registration of occlusion was carried out in 2012 in connection with a 46-year follow-up survey. Data on previous orthodontic treatment were collected based on a questionnaire. **Results** In the clinical examination, 39.5% of the subjects had at least one malocclusion trait. The most common malocclusion traits were lateral crossbite (17.9%), overbite $\geq 6$ mm (11.7%) and overjet $\geq 6$ mm (9.7%). Crossbite on the left premolars, negative overjet and increased overbite were found more frequently in men. The prevalence of malocclusion traits was at the same level in treated and untreated groups. Overall, 18.6% of the subjects had undergone orthodontic treatment. Women showed a significantly higher prevalence of orthodontic treatment. **Conclusions** The most common malocclusion trait in the present study was lateral crossbite. Significant male dominance in the prevalence of malocclusion was observed, which has not been reported earlier in Finland. Orthodontic treatment of malocclusion traits was more common among females in Northern Finland. This study indicates that orthodontic treatment provided in childhood was, on average, adequate in reducing malocclusion traits to the level observed in the general population.

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## Introduction

Epidemiological studies in orthodontics have primarily focused on the prevalence of malocclusion among pre-adolescents, adolescents and young adults in an attempt to identify malocclusion traits and determine the need for orthodontic treatment within populations. Epidemiological studies of malocclusion in Finland have also almost exclusively focused on children and adolescents.[1–5] Fewer studies have investigated malocclusion traits among adults.[6–11] Earlier European studies on adults, with the exception of Stenvik et al.,[12] have investigated malocclusion traits within populations either cross-sectionally, focusing on selected age groups,[7,10,11] or longitudinally during the subjects' entire adulthood.[6,8] So far, there have been no studies investigating malocclusion traits within European adult populations belonging to the same birth cohort.

There is scarce epidemiological data available on the adult population in Finland. One older Finnish study on adults reviewed the prevalence of malocclusion among university students [13] and found differences between genders, but they were not statistically significant. Another more recent survey examined malocclusions involving an obvious risk of poor occlusion prognosis and concluded that one-third of the Finnish adult population has one or more occlusal deviations.[14] However, potential gender differences in malocclusions have yet not been characterized in a Finnish adult population.

The prevalence of malocclusion in adulthood is a complex issue, which might be a result of orthodontic relapse, insufficient treatment during early years of life, tooth loss or normal occlusal changes over time.[10,15] The stability of orthodontic treatment results is an important question when planning treatment. With the exception of maxillary overjet,[10] the studies on adults so far have not found a lower prevalence of malocclusions in treated groups than in untreated groups.[8,12] In fact, even higher frequencies of malocclusions have been detected among patients having received orthodontic treatment in childhood, possibly reflecting unstable or unsuccessful treatment results.[10,13]

Occlusal characteristics have been found to vary ethnically and geographically due to different genetic backgrounds and environmental conditions.[4,16] The present study population, the Northern Finland Birth Cohort 1966, represents a genetically unique study population determined by national and regional isolation, genetic drift and the founder effect.[17] Furthermore, the individuals within this cohort have been exposed to relatively similar environmental factors during their lives.

In view of the above, the aim of the present study was to examine the prevalence of occlusal abnormalities and the extent of previous orthodontic treatment in the Northern

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Finland adult population. Based on earlier studies, we hypothesized that there are differences in the prevalence of malocclusions between genders and between treated and untreated groups.

## Materials and methods

### Subjects

The study population is part of an unselected population cohort, the Northern Finland Birth Cohort 1966 (NFBC 1966). The NFBC 1966 is an epidemiological and longitudinal research program aiming to promote the health and well-being of the population. The research program is co-ordinated by the Department of Health Sciences, Faculty of Medicine, University of Oulu and has been approved by the Ethical Committee of the Northern Ostrobothnia Hospital District on 22 September 2011. The entire NFBC 1966 cohort consists of 12 058 individuals who were born in 1966 in the two northernmost provinces of Finland, Oulu and Lapland. These live-born children represent 96.3% of all births in Oulu and Lapland in 1966. Of the 12 058 individuals of the entire cohort, 3150 lived in the city of Oulu or within 100 km of it and were invited to take part in a clinical oral and dental examination. Of these 3150 individuals, 1964 (62%; 912 men and 1052 women) volunteered to participate in an oral and dental health examination that took place in 2012 as a part of a wider health examination. Participation was voluntary and the subjects were asked to provide written consent. The subjects also had the right to refuse participation at any time point during the study. The subjects were provided with feedback regarding their general health status and treatment needs.

### Clinical examination

The subjects participated in a standardized clinical oral and dental examination, including registration of occlusion, performed by six calibrated dentists. The site of the clinical examination was the Institute of Dentistry of the University of Oulu. The repeatability of the examination was ensured by having the investigators train under experienced specialized dentists before the beginning of the study. Also inter-examiner agreement was determined regularly during the study by a gold standard senior dentist (Table 1).

Occlusal registration was done in a standardized clinical examination according to criteria described by Björk et al. [18] and Harris and Corruccini.[19] Overjet was measured in millimetres with a manual scaler (with 1-mm intervals) horizontally in the maximal inter-cuspal position from the right central maxillary incisor to the labial surface of the antagonist mandibular incisor. In cases where the mandibular incisor was more labial than the maxillary incisor, a negative value was recorded (negative overjet). Overbite was measured in millimetres with a manual scaler vertically in the inter-cuspal position from the incisal edge of the maxillary right central incisor to the incisal edge of the corresponding mandibular central incisor. In anterior openbite cases, a negative value was recorded. Lateral crossbites were registered if one or more maxillary buccal cusps occluded lingually to the mandibular teeth. Scissors bite was recorded if one or more maxillary lingual cusps occluded buccally to the opposing mandibular teeth.

Table 1. Intra- and inter-observer agreements.

| | Intra-observer agreement | | Inter-observer agreement | |
|---|---|---|---|---|
| Observer | ICC overjet | ICC overbite | ICC overjet | ICC overbite |
| 1 | 0.908 | 0.762 | 0.882 | 0.922 |
| 2 | 0.989 | 0.929 | 0.802 | 0.891 |
| 3 | 0.966 | 0.923 | 0.763 | 0.838 |
| 4 | 0.966 | 0.922 | 0.899 | 0.957 |
| 5 | 0.964 | 0.803 | 0.892 | 0.94 |
| 6 | 0.943 | 0.865 | 0.938 | 0.767 |
| Total | 0.969 | 0.912 | 0.865 | 0.913 |

ICC: Intra-class correlation.

Information about previous orthodontic treatment was gathered with a questionnaire distributed to all the subjects at the time of the clinical examination. The following questions were asked: 'Have you undergone orthodontic treatment before the age of 20?' and 'Have you undergone orthodontic treatment after the age of 20?'

### Statistical analysis

The data were analysed with IBM SPSS Statistics version 22.0. For categorical variables, Pearson's Chi-square test ($\chi^2$ test) was used to calculate differences between genders and between treated and untreated groups. Fisher's exact test was used if over 20% of the cells had an expected count of less than five. Pearson's Chi-square test of independence was performed to examine the relation between scissors bite and increased overbite as well as between negative overjet and crossbite on premolars. Also, the relation between deep bite and missing teeth was calculated with Pearson's Chi-square test of independence. *P*-values less than 0.05 were considered to be statistically significant.

## Results

Intra- and inter-examiner agreements are presented in Table 1. The range of intra-observer agreement varied in overjet and overbite from 0.908–0.989 and from 0.762–0.929, respectively. The range of inter-observer agreement was 0.763–0.938 in overjet and 0.767–0.957 in overbite. These values justified the subsequent analyses of the results.

The prevalence of different malocclusions is shown in Tables 2–4. The most common malocclusion traits were lateral crossbite (17.9%), overbite $\geq$ 6 mm (11.7%) and overjet $\geq$ 6 mm (9.7%). Regarding the overall prevalence of malocclusion, 39.5% of the subjects had at least one malocclusion trait. Men presented with significantly ($p < 0.001$) more malocclusion traits (44.1%) than women (35.5%). Regarding the vertical incisal relationship, the prevalence of overbite > 7 mm (2.2%) was higher than that of anterior open bite (1.3%) (Table 2). In the sagittal plane, overjet > 9 mm (1.3%) was almost as rare as negative overjet (1.2%) (Table 3). In the transverse plane, lateral crossbite was more frequent (17.9%) than scissors bite (7.6%) (Table 4).

**Table 2.** Incisor relationship, vertical.

| | Women (*n*) | Men (*n*) | Total (*n*) | Women (%) | Men (%) | Total (%) | *p*-value |
|---|---|---|---|---|---|---|---|
| Normal 0–5 mm | 933 | 760 | 1693 | 89.5 | 84.2 | 87.0 | 0.000*** |
| Overbite 6–7 mm | 83 | 101 | 184 | 8.0 | 11.2 | 9.5 | 0.016* |
| Overbite > 7 mm | 16 | 27 | 43 | 1.5 | 3.0 | 2.2 | 0.030* |
| Overbite ≥ 6 mm | 99 | 128 | 227 | 9.5 | 14.2 | 11.7 | 0.001** |
| Anterior open bite | 10 | 15 | 25 | 1.0 | 1.7 | 1.3 | 0.171 |

Incisor relationship vertical could not be registered in 19 subjects. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, Pearson's Chi-square test.

**Table 3.** Incisor relationship, sagittal.

| | Women (*n*) | Men (*n*) | Total (*n*) | Women (%) | Men (%) | Total (%) | *p*-value |
|---|---|---|---|---|---|---|---|
| Normal 0–5 mm | 928 | 803 | 1731 | 89.1 | 89.0 | 89.0 | 0.980 |
| Overjet 6–9 mm | 94 | 70 | 164 | 9.0 | 7.8 | 8.4 | 0.319 |
| Overjet > 9 mm | 16 | 9 | 25 | 1.5 | 1.0 | 1.3 | 0.294 |
| Overjet ≥ 6 mm | 110 | 79 | 189 | 10.6 | 8.8 | 9.7 | 0.182 |
| Negative overjet | 4 | 20 | 24 | 0.4 | 2.2 | 1.2 | 0.000*** |

Incisor relationship sagittal could not be registered in 20 subjects. ***$p < 0.001$, Pearson's Chi-square test.

**Table 4.** Transversal malocclusion.

| | Women (*n*) | Men (*n*) | Total (*n*) | Women (%) | Men (%) | Total (%) | *p*-value |
|---|---|---|---|---|---|---|---|
| Crossbite on right premolars | 72 | 67 | 139 | 6.9 | 7.4 | 7.1 | 0.664 |
| Crossbite on left premolars | 57 | 73 | 130 | 5.5 | 8.1 | 6.7 | 0.021* |
| Crossbite on right molars | 71 | 76 | 147 | 6.8 | 8.4 | 7.6 | 0.183 |
| Crossbite on left molars | 50 | 49 | 99 | 4.8 | 5.4 | 5.1 | 0.530 |
| Crossbite total (lateral) | 170 | 178 | 348 | 16.3 | 19.7 | 17.9 | 0.051 |
| Scissors bite on right premolars | 31 | 35 | 66 | 3 | 3.9 | 3.4 | 0.274 |
| Scissors bite on left premolars | 38 | 48 | 86 | 3.6 | 5.3 | 4.4 | 0.074 |
| Scissors bite on right molars | 7 | 4 | 11 | 0.7 | 0.4 | 0.6 | 0.502 |
| Scissors bite on left molars | 5 | 6 | 11 | 0.5 | 0.7 | 0.6 | 0.588 |
| Scissors bite total | 69 | 79 | 148 | 6.6 | 8.7 | 7.6 | 0.078 |

Transversal malocclusion could not be registered in 17 subjects excluding scissors bite on left molars and scissors bite tot (missing 19 subjects) and crossbite or scissors bite (missing 18 subjects). *$p < 0.05$, Pearson's Chi-square test.

Individuals with scissors bite were diagnosed with overbite (≥ 6 mm) in 23.6% of cases, whereas individuals without scissors bite were diagnosed with overbite in 10.7% of cases. Both of the malocclusions were found in 35 subjects (1.8%). The association between these two variables was statistically significant ($p < 0.001$). When the relationship between the presence of a negative overjet and a crossbite on the left premolars was studied, the relation between the variables was significant ($p < 0.001$). Of those individuals who had negative overjet, 41.7% also had crossbite on the left premolars. Individuals without negative overjet were diagnosed with crossbite on the left premolars in 6.3% of cases.

The frequency of occlusal traits varied according to gender. Regarding the vertical incisor relationship, overbite ≥ 6 mm ($p = 0.001$), overbite 6–7 mm ($p = 0.016$) and overbite > 7 mm ($p = 0.030$) were significantly more common among men (Table 2). Negative overjet ($p < 0.001$) was also found more frequently in men (Table 3). The results revealed a tendency for higher frequencies of larger overjet in women, but the sex differences were not statistically significant (Table 3). Also, men presented with crossbite on the left premolars ($p = 0.021$) significantly more often than women (Table 4).

When the prevalence of missing teeth was examined, left and right sides were combined in all analyses. Ignoring third molars, the frequency of one or more missing maxillary molars or mandibular molars was 17.9% and 23.0%, respectively. When the relation between overbite > 7 mm and the frequency of missing one or more maxillary molars (excluding third molars) was examined, no statistically significant difference was found ($p = 0.581$). Analogously, the relation between overbite > 7 mm and the frequency of one or more missing mandibular molars (excluding third molars) was not statistically significant ($p = 0.677$). All mandibular molars were missing in 0.5% of the subjects (two women; eight men). When the relationship between overbite > 7 mm and missing all mandibular molars was studied, no statistically significant relation between the variables was found ($p = 1.000$).

Differences in the prevalence of malocclusion traits between treated and untreated subjects are displayed in Table 5. Although there was some variation in the results, no statistically significant differences between treated and untreated subjects were found.

The prevalence of previous orthodontic treatment experience is shown in Table 6. Overall, 18.6% of subjects had undergone orthodontic treatment. The prevalence of treatment was more than 2-times higher before the age of 20 (13.8%) compared with treatment in adulthood (6.2%). In addition, significantly more women than men (20.3% women; 16.6% men) reported having had orthodontic treatment ($p = 0.041$).

## Discussion

The prevalence of malocclusion (39.5%) in the present study is comparable with the 42% detected in a previous Finnish sub-population study.[13] However, crowding was not examined in the current study because the study concentrated on occlusal relationships.

**Table 5.** Prevalence of malocclusion traits in treated and untreated subjects.

| | Treated (*n*) | Untreated (*n*) | Treated (%) | Untreated (%) | *p*-value |
|---|---|---|---|---|---|
| Overjet 6 mm or over | 36 | 147 | 10.3 | 9.6 | 0.690 |
| Negative overjet | 3 | 21 | 0.9 | 1.4 | 0.601 |
| Overbite 6 mm or over | 45 | 179 | 12.8 | 11.6 | 0.549 |
| Anterior open bite | 4 | 18 | 1.1 | 1.2 | 1.000 |
| Crossbite on premolars | 49 | 174 | 13.9 | 11.3 | 0.176 |
| Crossbite on molars | 41 | 162 | 11.6 | 10.5 | 0.551 |
| Scissors bite on premolars | 17 | 113 | 4.8 | 7.3 | 0.091 |
| Scissors bite on molars | 7 | 14 | 2.0 | 0.9 | 0.092 |

Overjet and negative overjet could not be registered in 75 subjects. Overbite, open bite and scissors bite on molars could not be registered in 74 subjects. Crossbite and scissors bite on premolars could not be registered in 72 subjects. Variables were tested with Pearson's Chi-square test and Fisher's exact test.

**Table 6.** Previous orthodontic treatment experience.

| | Women (*n*) | Men (*n*) | Total (*n*) | Women (%) | Men (%) | Total (%) | *p*-value |
|---|---|---|---|---|---|---|---|
| Treatment experience $<$ 20 years | 151 | 113 | 264 | 14.8 | 12.7 | 13.8 | 0.186 |
| Treatment experience $>$ 20 years | 70 | 48 | 118 | 6.9 | 5.4 | 6.2 | 0.185 |
| Treatment experience (total) | 207 | 148 | 355 | 20.3 | 16.6 | 18.6 | 0.041* |

Treatment experience could not be registered in 55 subjects. *$p < 0.05$, Pearson's Chi-square test.

The most common malocclusion trait in the present study was lateral crossbite (17.9%), which is similar to the 19% reported in an earlier Finnish study done among adults.[13] Our results, similarly to that previous study,[13] show that crossbite is the most common malocclusion trait among this Finnish adult population when crowding is excluded. Based on epidemiological data from other studies, crowding has been identified as one of the most prevalent malocclusion traits in Europe.[11] The prevalence of lateral crossbite in the present population is higher than those reported within populations from Germany,[11] Sweden [8] and Iceland.[10]

The prevalence of overbite $\geq$ 6 mm in the present study was higher than reported in the earlier Finnish adult study.[13] In regards to anterior open bite, our results revealed a lower percentage (1.3%) than reported in the Health 2000 survey [14] as well as in Dutch [6] and German [11] adult populations. However, the anterior open bite results of the present study are in agreement with the results of an Icelandic adult population study.[10]

Furthermore, the prevalence of overjet $\geq$ 6 mm was higher than that detected in the Health 2000 Survey [14] and among Finnish university students.[13] However, the overjet cut-off in the present study was slightly lower than in the Health 2000 survey. The subjects in the Finnish sub-population study [13] were born earlier, on average, and their age distribution was larger compared with the present cohort population, which might explain the difference in the prevalence of overbite and overjet. The present study showed that the prevalence of negative overjet is very rare in Northern Finland. Overall, negative overjet is uncommon in Finland [13] as well as in European adult populations in general.[6,10,11] However, a considerably higher prevalence of negative overjet has been detected in Sweden.[8]

The prevalence of extreme overjet ($>$ 9 mm) was 1.3% in the current study. Somewhat higher prevalence of large overjet ($>$ 8 mm) has been detected among Finnish children.[4] Large overbite ($>$7 mm) was observed in 2.2% of the subjects in the present study. It is known that molar occlusion is important for occlusal stability in deep bite. However, this study showed no relation between large overbite ($>$ 7 mm) and prevalence of missing molars. The result regarding large overbite in the present study is not directly comparable with earlier Finnish adult studies [13,14] because of the different threshold. However, the prevalence of traumatic deep bite in the earlier Finnish study [14] was higher compared with our results.

Our results showed significant gender differences (men 44.1%, women 35.5%) regarding the prevalence of one or more malocclusion traits, thus supporting our study hypothesis. An opposite result has been reported in Sweden, although the results were not statistically significant.[8] Crossbite on the left premolars, negative overjet and overbite were all found more frequently in men. Malocclusions were reported to vary slightly according to gender also in an earlier Finnish adult study, but the differences in this previous study were not statistically significant.[13] Our results, therefore, support earlier findings. The higher prevalence of left lateral crossbite and negative overjet among men and the significant relationship between these variables in the present study can be explained by prognathic malocclusion. Laine [20] has also found a positive correlation between negative overjet and crossbite. The results of the present study are consistent with the gender differences in late mandible growth demonstrated by Behrents.[21] In this study, men expressed more growth in adulthood and their growth was more horizontal with forward rotation of the mandible.[21] A higher prevalence of negative overjet in men has also been found in Swedish [8] and British subjects.[22] Class III malocclusion was more prevalent among men in Sweden,[8] Iceland [10] and Germany.[11] Deep bite has been observed significantly more often in Finnish boys than in girls.[5] Deep bite without gingival contact has been found more prevalent among men in the German adult population.[11] Jonsson et al. [10] have found a higher prevalence of scissors bite in men, but this difference was not found in the present study. However, the present study showed a positive relation between scissors bite and increased overbite. The result is in line with the results of an earlier Finnish study.[20] Also, a higher frequency of increased overjet in women has been reported in Dutch

[6] and German [11] adult populations, whereas a similar tendency, but not significant, was found in the present study.

The present study showed no statistically significant difference in the prevalence of malocclusion as related to history of orthodontic treatment. Therefore, we have to reject our hypothesis of differences in the prevalence of malocclusions between treated and untreated groups, which was based on an earlier Finnish study on students.[13] Similar results have been reported also in Sweden and Norway.[8,12] However, a higher frequency of malocclusion among treated subjects has been detected in an earlier Finnish sub-population study [13] and in Icelandic [10] and Dutch [6] adult populations. Patients' self-assessment using the Aesthetic Component of IOTN has revealed that one-fifth of the treated adolescents were dissatisfied with the alignment of their own teeth.[23] One reason for this could be the habit of using an orthodontist's opinion as the level for treatment need in Finland, not the opinions of patients themselves. Considering that all the subjects in the treated group had a severe malocclusion in their childhood, our study shows that the treatment provided to these individuals in Northern Finland has likely been adequate in reducing their malocclusion traits to the level observed in the general population. Another possible explanatory factor for our results could be the lack of systematic screening of occlusal problems in Northern Finland in the 1960s and 1970s, causing variation in the degree of treatment.

The extent of previous orthodontic treatment experience, 18.6% in this study, is similar to the 19% reported in the earlier Finnish adult study (age group 30–44).[14] In contrast, a lower prevalence of orthodontic treatment experience (11%) was detected in 1982 among Finnish university students.[24] Orthodontic treatment in Finland became more common in the 1980s, which might explain the lower prevalence of orthodontic treatment experience among the Finnish students in the earlier study. The relatively high rate of orthodontic treatment in the present study may also be due to the close proximity of a large health centre to the study subjects, facilitating access to orthodontic care. In contrast, a previous study with an 11% orthodontic treatment rate [24] included subjects from a wider geographical area, including more rural areas with more basic-level dental healthcare. The limitation of the present study is undoubtedly the lack of information concerning the type and length of orthodontic treatment, due to the form of the questionnaire.

The present study showed a significantly higher history of orthodontic treatment among women, which is in concordance with the results of a Finnish sub-population study.[24] A higher percentage of women reported having been treated also in the Netherlands [6] and Iceland,[10] while no gender difference was found in a Swedish study.[8] A higher prevalence of malocclusion among men in the present study might be related to lower rates of orthodontic treatment among males. A higher frequency of malocclusion in men and their lower orthodontic treatment rate could reflect differences between genders in treatment seeking and attitude towards treatment. Perceiving the benefits of orthodontic treatment as enhancement of appearance has been reported to be significantly more frequent in girls than in boys among Finnish adolescents.[23] Also, boys were more satisfied with the alignment of their teeth without having had any orthodontic treatment, the difference not, however, being significant between genders.[23]

In conclusion, the most common malocclusion trait in the Finnish adult population was lateral crossbite, while negative overjet was very rare in the present study. The prevalence of increased overjet and overbite was higher in the present study compared with an earlier Finnish study. Men had both a higher prevalence of malocclusion traits and a lower prevalence of orthodontic treatment. Our study also showed a significant sex difference in the prevalence of malocclusion, which has not been detected earlier in Finland. This study showed that orthodontic treatment provided in childhood in the Oulu region in Northern Finland has been adequate in reducing malocclusion traits to the level observed in the general population.

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## Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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