Original article

Relationships between dental appearance, self-esteem, socio-economic status, and oral health-related quality of life in UK schoolchildren: A 3-year cohort study

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Summary

Objectives: To examine the relationships between dental appearance, characteristics of the individual and their environment, and oral health-related quality of life (OHQoL) in young people over time.

Methods: A total of 374 young people (122 boys, 252 girls) aged 11–12 years from seven different XX schools were recruited at baseline and 258 (78 boys, 180 girls) followed-up 3 years later, aged 14–15 years (69 per cent response rate). Participants completed a measure of OHQoL (CPQ11–14 ISF-16) and self-esteem (SE, CHQ-CF87). A clinical examination was undertaken, including clinician and self-assessed normative measures of need [Index of Orthodontic Treatment Need (IOTN)] and dental caries. The Index of Multiple Deprivation was used to indicate socio-economic status (SES).

Results: There was a general improvement between baseline and follow-up in the measures of malocclusion, as well as OHQoL. Multiple linear regression indicated that there were significant cross-sectional associations at baseline between OHQoL and SES (rho = −0.11; P = 0.006), SE (rho = −0.50; P < 0.001), and self-assessed IOTN (rho = 0.27; P < 0.001). There were significant longitudinal associations between the change in OHQoL and change in SE (rho = −0.46; P < 0.001) and change in the decayed, missing, or filled surfaces (rho = −0.24; P = 0.001). The mean improvement in the total CPQ11–14 ISF-16 score for those with a history of orthodontic treatment was 3.2 (SD = 6.9; P = 0.009) and 2.4 (SD = 8.8; P < 0.001) for those with no history of treatment. The difference was not statistically significant (P = 0.584).

Conclusions: OHQoL improved in young people over time, whether they gave a history of orthodontic treatment or not. Individual and environmental characteristics influence OHQoL and should be taken into account in future studies.
Introduction

A recent systematic review has found a modest association between malocclusion and poor oral health-related quality of life (OHQoL) (1); however, the authors conclude that most studies contributing to these findings have been cross-sectional, involving patients groups and with no theoretical basis for the outcomes collected or analyses conducted. Several studies have suggested that orthodontic treatment leads to an improvement in OHQoL, but again these are mainly cross-sectional and clinic based (2).

In many studies it is assumed that there is a direct relationship between the clinical features of malocclusion and OHQoL, without taking into account other factors that might influence this relationship, such as the individual’s psychological well-being or their socioeconomic status (SES) (3–5). Agou et al. (6, 7), in Canada, found a significant correlation between OHQoL and self-esteem (SE); however, the authors were not confident about the direction of the association, i.e. whether improved psychological well-being led to improved OHQoL or vice versa.

The Wilson and Cleary theoretical model of health (8) has been used to conceptualize the relationships between clinical factors, characteristics of the individual, their environment and health-related quality of life (9). The model proposes a taxonomy of different measures of health outcomes at five levels: biological and physiological, symptoms, functioning, general health perceptions, and overall quality of life. Each of the levels is related and influenced by characteristics of the individual and of the environment.

Baker et al. (10) used the Wilson and Cleary model to inform their choice of outcomes in a longitudinal study investigating the OHQoL of young people. They found that by including outcomes, such as the participant’s sense of coherence (a characteristic of the individual) and parental income (a characteristic of their environment) they were able to explain more fully the impact of oral health on well-being.

The aim of this study was to examine, within a cohort of UK schoolchildren, the relationship between the appearance of the teeth, dental health, and OHQoL over time, as well as any influences of the characteristics of the individual and their environment, using the Wilson and Cleary model of health as a theoretical basis.

The specific objectives were to:
- Examine the cross-sectional relationships between OHQoL and SES, SE, gender, self-assessed appearance of the teeth and decayed, missing, or filled surfaces (DMFS) at age 11–12 years;
- Examine the longitudinal relationships between change in the OHQoL between the ages of 11/12 and 14/15 years and SES, changes in SE, self-assessed appearance of the teeth and DMFS, as well as gender and history of orthodontic treatment.

Subjects and Methods

This study was conducted in a convenience sample of schoolchildren attending seven publicly funded schools in the UK. Ethical approval for the study was obtained from the School of Health and Related Research Ethics Committee on behalf of University of Sheffield (February 2006) and permission obtained from the Local Education Authority of each area sampled. The schools were selected to represent areas with both good and poor access to orthodontic services (11). Baseline data collection was undertaken with children in school year seven (aged 11–12 years) to represent the stage at which a malocclusion of the secondary teeth becomes apparent, but is usually before any active intervention has taken place. A follow-up examination was undertaken 3 years later when the children were in school year 10 (aged 14–15 years) and it was anticipated that most orthodontic treatment would have been completed. The baseline examinations were carried out in 2007–08 and the follow-up examinations in 2010–11.

Two weeks before each school visit potential participants were given written information about the study to take home, as well as a consent form for the parents to sign and return. Participants attending on the day provided written assent to take part and were invited to complete a measure of OHQoL (CPQ11–14) (12) and the Child Health Questionnaire SE measure (CHQ-CF87) (13). It was stressed that the participants should complete the measures by themselves, without consultation with their friends or teacher. This took place immediately prior to the clinical examination by the trained and calibrated research team.

Children were excluded at baseline if they had a previous history of orthodontic treatment, were wearing an orthodontic appliance, if they had a cleft lip or palate or syndrome or if they were unable to complete the questionnaire without minimal assistance.

Variables

Variables were chosen to reflect a simplified version of the Wilson and Cleary model of health, which was used as the analytical framework (Figure 1). These included characteristics of the individual, their environment, as well as clinical indicators of malocclusion, together with oral symptoms and functional status (OHQoL).

Characteristics of the individual

SE was found to be the individual characteristic most frequently described in relation to malocclusion (7, 14–16). The SE of participants was assessed using a 14-item measure, which was part of the CHQ-Child Self-Report Form (CHQ-CF87) developed specifically for use with children and adolescents (13). It aims to capture the following dimensions of SE: satisfaction with school and athletic ability, looks/appearance, ability to get along with others and the family, and life overall over the previous 4 weeks. Scale scoring was carried out according to the CHQ manual (17). The response options were coded 1 = Very badly to 5 = Very good. Raw scores were generated by calculating the mean of the 14 items for those participants who responded to seven items or more and the raw scores were transformed to standardized scores from 0 to 100. Higher scores are an indication of higher SE.

Characteristics of the environment

The SES of each participant was indicated using the Index of Multiple Deprivation (IMD) derived from their home postcode (18). If the participant was reluctant or unable to provide their home postcode, then the postcode of the school was substituted. The IMD score was recoded into quartiles based on the 2010 rankings from 1 (most deprived) to 4 (least deprived).

Physiological (clinical) variables

Several clinical variables were used to describe the malocclusion. The Index of Orthodontic Treatment Need (IOTN) (19) has been used extensively to evaluate actual and self-perceived treatment needs. The IOTN Dental Health Component (DHC) was assessed clinically by two trained and calibrated orthodontists. Higher values suggest a greater need for treatment. To obtain a self-perceived IOTN Aesthetic Component (AC), the 10 standard pictures of teeth were shown to the children, who were then asked to choose where they thought the appearance of their teeth was on the scale of 1 to
Again higher IOTN AC scores indicate a worse aesthetic appearance. To derive the clinician-assessed IOTN AC a frontal view of the anterior teeth with the lips retracted was taken, for each participant, using a digital camera and examined at a later date by a trained and calibrated orthodontist. These assessments were repeated 2 weeks later and there was substantial agreement between the two readings (unweighted kappa = 0.72, 95 per cent confidence interval [CI]: 0.65–0.79).

Before the start of the study the two orthodontic assessors received training in the use of the IOTN DHC and AC with an experienced examiner who acted as the gold standard. Inter-examiner agreement was almost perfect or substantial (DHC-weighted kappa = 0.87, 95 per cent CI: 0.73–1.00; AC-weighted kappa = 0.80, 95 per cent CI: 0.69–0.99).

Caries experience was assessed by two examiners who were trained and calibrated. They determined the mean number of decayed, missing, and filled permanent tooth surfaces based on the criteria recommended by the British Association for the Study of Community Dentistry (20).

Oral health-related quality of life

Data were collected using the CPQ ISF-16 for children aged 11–14 years of age (12). Each response was coded from 0 = ‘Never’ to 4 = ‘Everyday/almost everyday’ and a total CPQ$_{11,14}$ ISF-16 score calculated. This measure was supplemented with several questions to evaluate a global rating of oral health (0 = ‘Excellent’ to 4 = ‘Poor’), a global rating of impact on life overall (0 = ‘Not at all’ to 4 = ‘Very much’), and a rating of satisfaction with the appearance of their own teeth (0 = ‘Very satisfied’ to 4 = ‘Very dissatisfied’) (21). Higher scores indicate worse OHQoL.

Data analysis

Data from a previous cross-sectional study involving UK schoolchildren (22) was used to inform a sample size calculation based on uneven group sizes (treated and untreated groups). The original data were skewed, therefore logged values were applied to transform the data to a normal distribution. The calculation determined that a final sample size of 198 would be required to detect a difference in means of 0.100 (logged value of difference in the total CPQ$_{11,14}$ ISF-16 score between treated and untreated samples) assuming that the common standard deviation is 0.200 (logged value), when the proportion of those with a history of orthodontic treatment by the age of 15 years is 32 per cent (23) with a power of 90 per cent and significance level of $P < 0.05$. Allowing for 40 per cent dropout at the baseline examination and 80 per cent attendance at follow-up, 400 children would be needed at the 11–12 years old baseline data collection.

Data analysis was undertaken to examine two relationships:

Cross-sectional relationships at baseline

A bivariate analysis and multivariate linear regression were used to evaluate the associations between the dependent variable of OHQoL (total CPQ$_{11,14}$ ISF-16 score) at baseline and the explanatory variables of gender, SES (IMD), SE (CHQ-CF87), self-assessed IOTN AC and dental health (DMFS). The self-assessed IOTN AC was the only indicator of normative orthodontic need included in the model, as significant correlations were found between the self-assessed IOTN AC and the clinician-assessed IOTN AC (Pearson’s correlation coefficient = 0.452, $P < 0.001$) and the clinician-assessed IOTN AC and the clinician-assessed IOTN DHC (Pearson’s correlation coefficient = 0.469, $P < 0.001$). The self-assessed IOTN AC was considered to be the most meaningful variable describing the extent of the malocclusion to the young person.

Longitudinal relationships

A bivariate analysis and multivariate linear regression were used to investigate the longitudinal associations between the change in the OHQoL (total CPQ$_{11,14}$ ISF-16 score) from baseline to follow-up (dependent variable) and the independent variables of gender, the SES (IMD) at follow-up, the change in the SE score (CHQ-CF87), change in self-assessed IOTN AC, and change in self-assessed IOTN DHC.

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**Figure 1.** The theoretical framework based on a simplified Wilson and Cleary Model linking the clinical and non-clinical variables.
AC, change in the DMFS score, and whether the young person reported having orthodontic treatment since the baseline examination.

The descriptive, bivariate, and multivariate analyses were conducted using SPSS v20 (IBM Corp, Armonk, New York, USA).

Results
The flow of participants through the study is shown in Figure 2. A total of 404 children from the seven schools initially consented to take part and 24 withdrew their consent or were wearing orthodontic appliances on the day. A further six participants were lost from the baseline data collection due to non-completion of more than four missing responses in their questionnaires leaving a baseline sample of 374 participants aged 11–12 years. A measure of SE was not included in the baseline examination for the first two schools visited, but was added for the remaining five schools and for the follow-up data collection. There were, therefore, 300 participants with full baseline data, including demographics, clinical assessment,
OHQoL, and SE. Two participants had missing DMFS values, one had a missing self-assessed IOTN AC score and one participant had both missing DMFS and self-assessed IOTN AC score; therefore, 296 participants were included in the cross-sectional analysis of the relationships in the baseline data.

At the follow-up visit 3 years later, 116 of the original participants withdrew consent, were absent or otherwise not available on the day of the visit; therefore, data were collected on 258 (69 per cent response rate). Twenty participants were wearing orthodontic appliances and were excluded, 21 completed the questionnaire, but subsequently withdrew consent for the clinical examination; therefore, 217 participants had complete demographic, clinical, and OHQoL data (58 per cent response rate). Nine individuals had four or fewer missing responses and these were replaced with a mean value for their school. The number of participants with complete demographic, clinical, OHQoL, and SE data was 173 (58 per cent response rate for those with baseline SE scores). This was the sample included in the longitudinal analysis examining the relationships with the change in OHQoL.

**Descriptive statistics**

Descriptive data concerning the demographics, IOTN, and caries experience for 374 participants at baseline (T1) and 217 participants at follow-up 3 years later (T2) are shown in **Table 1**. Baseline assessments for those individuals lost-to-follow-up are also shown. There was a higher proportion of girls recruited than boys, as the two London schools sampled were girls only; however, the girl:boy ratio is approximately equal to the gender proportions receiving orthodontic treatment in the UK (24). Those who were lost-to-follow-up had slightly increased proportions from higher socio-economic groups and had more severe malocclusions judged by the IOTN DHC, clinician, and self-assessed IOTN AC.

The IOTN DHC was judged to have improved between T1 and T2 in approximately one-third of participants (35.0 per cent), irrespective of whether they had a history of orthodontic treatment or not. In 39.2 per cent there was no change; however, in a quarter of participants (25.8 per cent) the IOTN DHC was scored higher at T2. Generally, the clinician-assessed IOTN AC improved between T1 and T2 (51.6 per cent) or there was no change (40.1 per cent). Only in 18 out of 217 participants (8.3 per cent) was the clinician-assessed IOTN AC worse at T2 compared to T1. This trend was also observed, but was less marked, in the self-assessed IOTN AC (43.3 per cent improved; 29.0 per cent no different); however, a significant minority of participants (27.6 per cent) judged their own IOTN AC to be worse at T2.

The caries data at T1, with 64.8 per cent free from obvious dental caries, were very close to the national average for 12 year olds in the UK, which is currently 66.6 per cent (25). The mean number of DMFS was 1.30 (95 per cent CI: 1.03–1.65). The DMFS was significantly worse at T2 (mean difference = 1.2, SD = 3.0; \( p < 0.001 \), paired \( t \)-test).

**Table 1** also shows the baseline and follow-up data for the total CPQ\(_{11-14}\) ISF-16 scores, as well as the CHQ-CF87 scores. The CPQ\(_{11-14}\) ISF-16 domain scores are available in an online supplementary data. There was a significant reduction in the total CPQ\(_{11-14}\) ISF-16 score between T1 and T2 (mean difference = 2.0, SD = 8.7; \( p = 0.003 \) paired \( t \)-test) suggesting that OHQoL improved over time; however, there was also a significant reduction in SE (mean difference = 5.4, SD = 14.9; \( p < 0.001 \) paired \( t \)-test). There were no differences between the baseline SE scores of those participants who were followed-up and lost-to-follow-up (\( p = 0.137 \) independent \( t \)-test). Data for the global oral health, life overall, and satisfaction questions at baseline and follow-up are available in the online supplementary data.

The proportion with a history of undergoing orthodontic treatment, but not still wearing appliances was much lower than originally anticipated (35 out of 217, 16.2 per cent). The mean improvement in the total CPQ\(_{11-14}\) ISF-16 score was 3.2 (SD = 6.9; \( p = 0.009 \) paired \( t \)-test) in those with a history of orthodontic treatment and 2.4 (SD = 8.8; \( p < 0.001 \) paired \( t \)-test) in those with no history of orthodontic treatment, but the difference was not statistically significant (\( p = 0.584 \); independent \( t \)-test).

**Cross-sectional relationships at baseline**

The multivariate analysis found significant cross-sectional associations between OHQoL (total CPQ\(_{11-14}\) ISF-16 scores) and three independent variables at baseline (SES, SE, and self-assessed IOTN AC) (Table 2). Examination of the bivariate relationships in the multivariate analysis showed that there was a significant negative association between SES and OHQoL (\( r = -0.11; p = 0.034 \)), i.e. the lower the SES, the worse the OHQoL at baseline. There was also a significant negative association between the CHQ-CF87 scores (SE) and the total CPQ\(_{11-14}\) ISF-16 scores (\( r = -0.50; p < 0.001 \)), which suggests that those participants with low SE had poorer OHQoL and vice versa. There was a significant positive association between the self-assessed AC scores and the total CPQ\(_{11-14}\) ISF-16 scores (\( r = 0.27; p < 0.001 \)), i.e. those who assessed the appearance of their teeth to be poor had worse OHQoL.

The participant’s DMFS score was not a significant variable in the regression model, but the bivariate analysis suggested that there was a significant association (\( p = 0.039 \)); however, the correlation was low (\( r = 0.10 \)). The gender of the participant was not significantly associated with OHQoL in either the multivariate or bivariate analysis (\( r = 0.35; p = 0.275 \)). The regression model had an \( R^2 \) value of 0.32 (adjusted \( R^2 = 0.31 \)).

**Longitudinal relationships**

The multivariate analysis demonstrated significant longitudinal associations between the change in OHQoL from baseline to follow-up (change in total CPQ\(_{11-14}\) ISF-16 scores) and two independent variables, namely SE and DMFS (Table 3). Examination of the bivariate relationships in the multivariate analysis showed that there was a significant negative association between the changes in the CHQ-CF87 scores (\( r = -0.46; p < 0.001 \)) and changes in the total CPQ\(_{11-14}\) ISF-16 scores. This suggests that as the SE improves (a higher CHQ-CF87 score) the OHQoL improves (a lower total CPQ\(_{11-14}\) ISF-16) and vice versa.

There was also a significant negative association between the change in the DMFS score and change in the total CPQ\(_{11-14}\) ISF-16 scores (\( r = -0.24; p = 0.001 \)). This suggests that if the DMFS score increased between baseline and follow-up, the OHQoL improved, which is difficult to explain. Further examination of the DMFS data showed that the majority of participants (59 per cent) had no change in their DMFS scores and this was reflected in a small change in their total CPQ\(_{11-14}\) ISF-16 scores (mean change = −0.9). In a significant minority of participants (37.6 per cent) the DMFS scores worsened; however, they recorded a mean reduction of 4.1 in their total CPQ\(_{11-14}\) ISF-16 scores. In only a small proportion of participants (3.5 per cent) the DMFS score improved and they demonstrated a mean reduction in their total CPQ\(_{11-14}\) ISF-16 scores of 2.5, which was smaller than those in whom the DMFS score increased.
Table 1. Descriptive statistics showing the demographics, clinical malocclusion assessments, caries rates, total CPQ_{11-14} ISF-16 scores, as well as self-esteem scores from CHQ-CF87 for all participants at baseline (T1), the follow-up group after 3 years (T2) and the baseline assessments for those individuals lost-to-follow-up.

<table>
<thead>
<tr>
<th></th>
<th>Baseline—T1 (n = 374)</th>
<th>Follow-up—T2 (N = 217)</th>
<th>Lost-to-follow-up baseline scores (N = 157)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>122</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>Girls</td>
<td>252</td>
<td>156</td>
<td>96</td>
</tr>
<tr>
<td><strong>SES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First quartile (most deprived)</td>
<td>157</td>
<td>105</td>
<td>50</td>
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<tr>
<td>Second quartile</td>
<td>83</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Third quartile</td>
<td>62</td>
<td>38</td>
<td>19</td>
</tr>
<tr>
<td>Fourth quartile (least deprived)</td>
<td>72</td>
<td>34</td>
<td>43</td>
</tr>
<tr>
<td><strong>IOTN DHC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No need</td>
<td>96</td>
<td>71</td>
<td>35</td>
</tr>
<tr>
<td>Borderline need</td>
<td>138</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Definite need</td>
<td>139</td>
<td>55</td>
<td>61</td>
</tr>
<tr>
<td><strong>Clinician-assessed IOTN AC</strong></td>
<td>373</td>
<td>216</td>
<td>156</td>
</tr>
<tr>
<td>1–4</td>
<td>255</td>
<td>187</td>
<td>97</td>
</tr>
<tr>
<td>5–7</td>
<td>101</td>
<td>28</td>
<td>48</td>
</tr>
<tr>
<td>8–10</td>
<td>9</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td><strong>Self-assessed IOTN AC</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1–4</td>
<td>319</td>
<td>204</td>
<td>129</td>
</tr>
<tr>
<td>5–7</td>
<td>31</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>8–10</td>
<td>23</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td><strong>Caries</strong></td>
<td></td>
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<tr>
<td>Free obvious caries</td>
<td>241</td>
<td>105</td>
<td>93</td>
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<tr>
<td>Mean DMFS (SD)</td>
<td>1.30</td>
<td>3.1</td>
<td>2.5</td>
</tr>
<tr>
<td>95% CI</td>
<td>1.03</td>
<td>1.65</td>
<td>3.11</td>
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<tr>
<td><strong>Oral health-related quality of life</strong></td>
<td>372</td>
<td>217</td>
<td>153</td>
</tr>
<tr>
<td>Total CPQ_{11-14} ISF-16 score (mean and SD)</td>
<td>13.7</td>
<td>8.2</td>
<td>11.2</td>
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<tr>
<td><strong>Self-esteem</strong></td>
<td></td>
<td></td>
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<tr>
<td>CHQ-CF87 standardized score (mean and SD)</td>
<td>80.0</td>
<td>75.6</td>
<td>78.6</td>
</tr>
</tbody>
</table>

CHQ, Child Health Questionnaire; CI, confidence interval; DMFS, decayed, missing or filled surfaces; IOTN AC, Index of Orthodontic Treatment Need Alternating Current; IOTN DHC, Index of Orthodontic Treatment Need Dental Health Component; SD, standard deviation; SES, socio-economic status.
Table 2. Cross-sectional baseline relationships investigated using multivariate regression analysis with dependent variable baseline total CPQ$_{11-14}$ ISF-16 score ($n = 296$).

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized coefficients</th>
<th>95% CI for B</th>
<th>Standardized coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B$</td>
<td>$SE$</td>
<td>Lower limit</td>
<td>Upper limit</td>
</tr>
<tr>
<td>Gender</td>
<td>$-0.9$</td>
<td>$-3.0$</td>
<td>$1.1$</td>
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<tr>
<td>Socio-economic status</td>
<td>$-1.1$</td>
<td>$-1.8$</td>
<td>$-0.3$</td>
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<tr>
<td>Self-esteem score</td>
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<td>$-0.3$</td>
<td>$-0.2$</td>
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<tr>
<td>Child self-assessed IOTN AC</td>
<td>$1.0$</td>
<td>$0.5$</td>
<td>$1.4$</td>
</tr>
<tr>
<td>DMFS</td>
<td>$0.2$</td>
<td>$-0.1$</td>
<td>$0.4$</td>
</tr>
</tbody>
</table>

CI, confidence interval; DMFS, decayed, missing or filled surfaces; IOTN AC, Index of Orthodontic Treatment Need Alternating Current; SE, standard error.

Table 3. Longitudinal relationships investigated using multivariate regression analysis with dependent variable change in total CPQ$_{11-14}$ ISF-16 scores ($n = 173$).

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized coefficients</th>
<th>95% CI for B</th>
<th>Standardized coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B$</td>
<td>$SE$</td>
<td>Lower limit</td>
<td>Upper limit</td>
</tr>
<tr>
<td>Gender</td>
<td>$-5.6$</td>
<td>$-13.0$</td>
<td>$1.7$</td>
</tr>
<tr>
<td>Socio-economic status</td>
<td>$0.3$</td>
<td>$-0.8$</td>
<td>$1.7$</td>
</tr>
<tr>
<td>Change in self-esteem score</td>
<td>$-0.2$</td>
<td>$-0.3$</td>
<td>$-0.2$</td>
</tr>
<tr>
<td>Change in child self-assessed IOTN AC</td>
<td>$0.4$</td>
<td>$-0.2$</td>
<td>$1.0$</td>
</tr>
<tr>
<td>Change in DMFS</td>
<td>$-0.4$</td>
<td>$-0.8$</td>
<td>$0.0$</td>
</tr>
<tr>
<td>History of orthodontic treatment</td>
<td>$-1.1$</td>
<td>$-4.3$</td>
<td>$2.0$</td>
</tr>
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</table>

CI, confidence interval; DMFS, decayed, missing or filled surfaces; IOTN AC, Index of Orthodontic Treatment Need Alternating Current.

There were no associations between the change in the OHQoL and gender (rho = 0.059; $P = 0.219$) or SES (rho = $-0.001$; $P = 0.493$). Neither were there associations between changes in OHQoL and changes in the self-assessed IOTN AC (rho = 0.089; $P = 0.121$) or in those that reported a history of orthodontic treatment; however, as noted previously the number of individuals who had worn braces was quite small (33 out of 173 with full longitudinal data, 19.1 per cent). The model had an $R^2$ value of 0.25 (adjusted $R^2 = 0.22$).

Discussion

This longitudinal study of UK schoolchildren examined the cross-sectional and longitudinal relationships between OHQoL and various factors. The study used a theoretical model of health to inform the choice of variables and analyses. The main finding was to further support the premise in the Wilson and Cleary model that factors concerning the individual (SE) and their environment (SES) have an important direct relationship with OHQoL. Although there was a significant relationship at baseline, between OHQoL and the opinions of young people concerning the appearance of their teeth (self-assessed IOTN AC), there were no longitudinal relationships between changes in the OHQoL and changes in the self-assessed IOTN AC or in those with a history of orthodontic treatment.

Effect of SE

The findings of this study suggest that those with higher SE have less frequent impacts from their malocclusion and any improvement in OHQoL over time is associated with an increase in SE. One possible explanation for why those with severe malocclusion, but high SE apparently have less frequent OHQoL impacts than those with low SE; is that high SE is a psychological resource that protects an individual from the effects of a condition (7, 26). Another alternative explanation could be that children with low SE focus more on their malocclusion and believe that if this were to be corrected it might be the key to solving other problems (27).

The apparent direction of the relationship between SE and OHQoL needs to be investigated further. If SE is shown to have a direct relationship with OHQoL, this might suggest that interventions to improve SE could provide an opportunity to reduce the impact of malocclusion. Indeed, therapeutic interventions to boost SE have already been recommended to reduce the impact of other conditions, including cleft lip and palate (28). Such interventions may reduce an individual's perceived need for orthodontic treatment; however, further research is needed. Further discussion of the effects of SE is available in the online supplementary data.

The effect of SES

A relationship was found between SES and OHQoL at baseline. This concurs with Locker who found that there were disparities in OHQoL among a group of Canadian schoolchildren, with children from low income households having the poorest OHQoL (26). Moreover, Mtaya et al. (29) suggested that children’s concerns about their dental appearance are influenced by the social and cultural context in which they live.

These studies confirmed the link between SES and OHQoL and convincingly demonstrate that SES can influence the frequency of impacts of malocclusion on OHQoL. This link can be explained in different ways (30). First, income has a direct effect on the ability to access goods, services, and other resources that promote health. Second, there may be an indirect mechanism in terms of differential exposure to risk factors and health behaviours. Third, the relationship between SES and health outcomes may be the result of
Several cross-sectional studies have suggested that individuals who
ment has been shown to have an adverse effect on OHQoL (31). Further discussion of the effects of SES is available in the online supplementary data.

The effect of clinical factors
There was a significant cross-sectional association between the child self-assessed IOTN AC and OHQoL at baseline; however, there was no relationship between the improvement in the self-assessed IOTN AC and OHQoL over time. The IOTN AC was developed to more accurately reflect the psychosocial opinion of schoolchildren about the appearance of their teeth and our study appears to confirm this cross-sectionally, but not longitudinally. This agrees with the work of Kok et al. (32); however, more work needs to be undertaken to assess the validity and responsiveness of IOTN AC in young people over time.

There was no association between the change in the OHQoL and a self-reported history of undergoing orthodontic treatment. Participants who were wearing orthodontic appliances at the time of the follow-up data collection were excluded, as orthodontic treatment has been shown to have an adverse effect on OHQoL (33). Several cross-sectional studies have suggested that individuals who have undergone orthodontic treatment have a better OHQoL than those who have not had treatment (2, 7, 34, 35). Although this study found a slightly greater improvement in the total CPQ11,16, ISF-16 score in those with a history of orthodontic treatment, this was not statistically significant and we were unable to find a relationship between a history of orthodontic treatment and an improvement in OHQoL with time. The proportion of participants at 3-year follow-up who were wearing appliances or who reported having worn appliances was lower than expected at 23 per cent. This is compared to 32 per cent in the most recent child dental health survey in the UK (23), but was the same as a New Zealand sample of 255 children aged 16 years (36). More longitudinal studies are required in patients undergoing orthodontic treatment to determine the effect of correcting malocclusion on OHQoL.

One interesting finding from this study is that there was a general improvement in the assessment of the severity of malocclusion over time with both clinician and participant-assessed indices of treatment need. Foster Page et al. (37) found that nearly one-quarter of participants (23.9 per cent) demonstrated an improvement in their orthodontic treatment need category as measured with the Dental Aesthetic Index between the ages of 13 and 16 years. This compared with nearly half of participants (47.8 per cent) in the need category staying the same and just over one-quarter (28.2 per cent) getting worse. The greatest improvement was in the category of maxillary anterior irregularity. This is a very visible characteristic which will also be scored with IOTN AC.

The association between OHQoL and dental caries, in terms of DMFS, was inconsistent. There was no significant association between the two factors in the cross-sectional multivariate analysis, but the bivariate analysis suggested a very weak association. There was a significant association between the change in OHQoL and change in the DMFS, suggesting that even if the dental health worsened over time (the DMFS score increased) the OHQoL improved, which is difficult to explain. This inconsistency between OHQoL and caries data has been found in previous studies (38, 39) and needs to be investigated further. The effect of gender in this study is discussed in the online supplementary data.

Limitations of the study
It should be borne in mind that the sample used in this study was a convenience, rather than a random sample of schoolchildren in the UK. This method of sampling should be taken into account when making wider generalization of the findings to the population as a whole; however, attempts were made to include children from areas with varying levels of access to orthodontic services in the UK. In contrast, a number of previous studies evaluating OHQoL have used clinic-based, rather than school-based populations (40, 41).

The response rate for all participants from baseline to follow-up was a reasonable 69 per cent and comparable to other longitudinal, population-based, rather than clinic-based studies, at 3 years (14). Although we did achieve the estimated sample size of 198 in the follow-up examination, because CHQ-CF87 was not included in the baseline data collection for two schools early in the study, the response rate for the longitudinal element was 58 per cent ($n = 173/296$) for those with baseline SE data, but below half of the original baseline sample (46 per cent; $n = 173/374$). There is the risk that those participants who provided data for the follow-up examination were different to those who did not provide data, thereby introducing the possibility of non-response bias (42). We found it increasingly difficult to obtain the full cooperation of schools as the children got older, due to the pressures of formal examinations and assessments. Also participants withdrew for a variety of reasons, rather than in a systematic way, which might help to alleviate the risk of non-response bias.

Another possible limitation was the CPQ11,16, ISF-16 used to assess child OHQoL in this study. Marshman et al. (43) reported concerns expressed by young people with malocclusions about the face and content validity of CPQ ISF-16, and suggested that further consideration should be given to the need for a child-centred malocclusion-specific OHQoL measure.

Implications of the study
This study found no significant association between improvement in the OHQoL of a young person and a history of orthodontic treatment, although the numbers undergoing treatment were quite small and those still in treatment were excluded. One aim of orthodontic treatment is to reduce the social impact on a young person of the appearance of their teeth. This should, theoretically, lead to an improvement in their OHQoL. Orthodontic treatment is currently prioritized based on the IOTN in the UK National Health Services. Current UK policies, including the National Service Framework for Children, Young People and Maternity Services (44) recommend that services should be designed to meet the needs of children and their families. There is an apparent conflict between the prioritization of orthodontic treatment based on normative need and attempts to provide treatment based on children’s perceived needs. This study found that the impact of malocclusion, in terms of OHQoL, was inconsistently related to the aesthetic component of the IOTN index (i.e. there was a cross-sectional relationship at baseline, but not a longitudinal relationship). Moreover, there was a more consistent relationship between OHQoL and SE. These findings have implications for the assessment of the need for orthodontics treatment of individual children and populations in the future. Further research is needed to investigate methods of the assessment of treatment need that capture OHQoL, SE, and clinical need.
Supplementary material

Supplementary material is available at European Journal of Orthodontics online.

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