Influence of self-esteem on perceived orthodontic treatment need and oral health-related quality of life

Lea Kragt[1,5], Eppo B Wolvius[1,5] ,Vincent W V Jaddoe[2,3,5],Henning Tiemeier[3,4,5], Edwin M Ongkosuwito[1,5]

[1]Department of Maxillofacial Surgery, Special Dental Care and Orthodontics, Erasmus Medical Centre Rotterdam, The Netherlands; [2]Department of Pediatrics, Erasmus Medical Centre Rotterdam, The Netherlands; [3]Department of Epidemiology, Erasmus Medical Centre Rotterdam, The Netherlands; [4]Department of Child and Adolescent Psychiatry, Erasmus Medical Centre Rotterdam, The Netherlands [5]The Generation R Study Group, Erasmus Medical Centre Rotterdam, The Netherlands

Short running title: Self-esteem and subjective orthodontic measures

To be submitted to: European Journal of Orthodontics

Correspondence to L Kragt, P.O Box 2040, 3000CA Rotterdam, The Netherlands, tel: 010 - 7036995, fax: 010 - 704 46 45l, e-mail: l.kragt@erasmusmc.nl

Word count: 3449

Number of tables: 3

Number of references: 41

Summary

Background Self-esteem (SE) is suggested to influence the relationship between orthodontic treatment need and oral health related quality of life (OHRQoL), but evidence lacks. The aim of the present study was to investigate SE in the relationship between subjective orthodontic treatment need (SOT) and OHRQoL in children.

Methods This cross-sectional study was embedded in the Generation R Study, a multi-ethnic population-based cohort. In total, 3849 10-year old children participated in the present study. OHRQoL, measured with the Child Oral Health Impact Profile-ortho, and SOT were assessed within parental questionnaires. SE was measured with a modified version of the Harter's self-perception profile rated by the children. The role of SE in the association between SOT and OHRQoL was evaluated with linear regression models. Furthermore, the difference in this association between children with high and low SE was investigated.

Results SOT was significantly inversely associated with OHRQoL (borderline: β(95%CI) = -0.55 (-0.77, -0.33); definite: -1.65 (-1.87, -1.54)). Children with lower SE scores showed a stronger relationship between borderline and definite SOT with OHRQoL (β (95%CI) = -0.56 (-0.81, -0.31) resp. -1.68 (-1.94, -1.42)) than children with higher SE scores did (β (95%CI) = -0.51 (-0.97, -0.04) resp. -1.43 (-1.90, -0.95)).

Conclusion The relationship between SOT and OHRQoL is not based on SE of children. However, SE modifies the relationship between SOT and OHRQoL. Work still needs to be done to find an explanation for the effect modification by SE in the relationship between subjective health perceptions and OHRQoL.

Keywords: quality-of-life, self-esteem, subjective need, malocclusions, children

Introduction

Oral health related quality of life (OHRQoL) is the most commonly used patient reported outcome measure in dental research (1). It measures the subjective impact of one's own oral health on daily life in different domains, including functional limitations, social emotional wellbeing, school performance and peer interaction (2). Especially in the dental field of orthodontics, OHRQoL gained increasing importance to supplement ordinary objective clinical measures (3). Because objective clinical measures often cannot explain the demand for orthodontic treatment need, OHRQoL is a valuable complementary measure to understand some of the variation between subjective and objective orthodontic treatment need (4, 5).

A useful framework for research on OHRQoL is the Wilson and Cleary model (6). Based on this model, biological/physical variables influence OHRQoL via symptom status, functional status and general oral health perception. Moreover, this pathway is influenced by environmental factors, like socio-economic position, and individual characteristics, like self-esteem (SE) (7). SE is described as the subjective ability to deal with the environment and is impacted by the interactions with others (8). In contrast to OHRQoL, SE is considered to be a stable construct (2, 9).

In the case of orthodontics, the association between biological/physical variables and OHRQoL has been extensively investigated (10-12). Children with malocclusions perceive significant impacts on OHRQoL (10). Also, different studies investigated the role of SE in the relationship between malocclusion and OHRQoL. It has been shown that OHRQoL is positively associated with SE (13, 14). However, orthodontic treatment could not be proven to advance SE, neither had children with malocclusions consistently lower SE (15-18). In contrast, the association between perceived orthodontic treatment need and OHRQoL is less widely investigated and to our knowledge, the role of self-esteem has not at all been investigated in the association between subjective orthodontic treatment need (SOT) and OHRQoL. SE possibly influences the relation between biological/physical variables and OHRQoL, presumably by acting on general oral health perception and OHRQoL, rather than the functional or symptoms status (see figure 1) (19). Therefore, the aim of the present study was

to investigate the role of self-esteem in the relationship between SOT, as one representative for oral health perception, and OHRQoL among 9 year old children living in Rotterdam, The Netherlands.

Material & Methods

Study design and study population

The study was performed within the Generation R Study, which is a prospective multiethnic population-based cohort in Rotterdam, The Netherlands. Details of the Generation R Study have been extensively described elsewhere (20, 21). The Generation R Study was approved by the Medical Ethics Committee of the Erasmus University Medical Centre (MEC- MEC-2012-165). All participants provided written informed consent before data collection started.

All pregnant women which had a delivery date between April, 1 2002 and January 31, 2006 living in the study area were invited to participate in the study. Of these, n = 8548 participants were still eligible to participate in the study phase at the offspring's age of 10 years, and n = 7393 participants gave full consent for participation. Data on children's OHRQoL and SOT assessed at the age of 10 was available from n = 3849, which compromise the study population for the present study.

Oral health-related quality of life

OHRQoL and perceived orthodontic treatment need of the children at the age of 10 was assessed by questionnaires, which were sent by post to the mothers of the children. When the questionnaire has not been returned within 3 weeks, a kind reminder letter was sent. After 6 weeks, if the questionnaire still has not been returned, the parents received a phone call in which help with completing the questionnaire was offered and the importance of filling out the questionnaire was explained once more. The parents could either send the questionnaire back by post or bring it to the appointment at the research center at which examinations took place. OHRQoL was measured with an 11-item version of the Children's Oral Health Impact Profile (COHIP). This version of the COHIP has been validated to measure OHRQoL related to malocclusions (22). The questions of the short COHIP version were answered on a five-point Likert scale and covered five domains of children's oral health:

oral symptoms, functional well-being, emotional well-being, school and peer interaction. All answers were added up to a final OHRQoL score (range 11-55 points), with the highest score indicating the best quality of life. Missing values in the responses to the questionnaire were replaced by the personal mean score of the remaining answers, as proposed by other researchers using the original version of the COHIP (23). If there were more than 30% of the answers missing, the participant was excluded from the study sample, which was the case for 145 of all excluded children. The individual questions of the 11-item version of the COHIP are presented in the appendix (Table S1).

Perceived orthodontic treatment need

Perceived orthodontic treatment need was measured with the question "Do you want your child to get braces?". This question was also included in the maternal questionnaires. The mother answered the question on a five point Likert scale, with answer possibilities ranging from "strongly disagree" to "strongly agree". For the data analysis answers are categorized into perceived need (strongly / somewhat agree), borderline perceived need (do not agree/ do not disagree) vs no need (strongly / somewhat disagree).

Self-esteem

Self-esteem was assessed in questionnaires sent directly to the children. For this an adapted question format of the Harter's self-perception profile according to Wichstrom (1995) was used (24). Because younger children were studied, the question format as Wichstrom suggested was applied to the validated self-perception profile for children (CBSK in Dutch) (25). Four subscales of the CBSK were used: school competence (5 items), social acceptance (5 items), athletic competence (3 items) and physical appearance (3 items). One item from the physical appearance scale and one from the school competence scale of the CBSK, because of spatial limitations and those items seemed to be most redundant. Two items were added as global indicators of self-worth. Also, slight adaptions of wording were made, to make the questionnaire more up to date. In addition, the four point coding was revised into a three point coding system. That is, because it has been established by Achenbach that variability of items scores is higher when a three point coding system is used (26). Thus, the children

answered the questions of the CBSK with one of the three options: ‘not true’, ‘somewhat true’ or ‘true’. All answers were added up to a final SE score (range 18 - 54 points) or SE subscale score respectively, with the highest score indicating the highest SE. Missing values in the responses to the CBSK were replaced by the mean score of the remaining answers for the particular subscale. If there were more than 30% of the answers missing per subscale the SE score was coded as missing value. The overall SE score was categorized into high and low based on a 20 % cut-off at a SE score of 28.0. The individual items of the adapted format of the Harter’s self-perception profile are presented in the appendix (Table S2).

Covariates

The collection of all covariates in the Generation R study is described extensively elsewhere (27). Potential confounding factors were considered from three domains: social economic position, individual child characteristics and clinical variables. Social economic position was captured with maternal and paternal education level (high: higher vocational training, university or PhD degree vs. low: no education, primary school, lower or intermediate vocational training, general school or first year of higher vocational training), with netto household income (≤ 2000€ vs. > 2000€), and maternal marital status (married, registered partnership, living together vs. no partner all, partner with whom I do not live). Individual child characteristics covered age, gender and ethnicity of the child. Children with parents born in the Netherlands were classified as Dutch. If one of the parents was born in a another country the child was classified as non-Dutch. If the parents were born in different countries, maternal ethnic background defined children’s ethnicity, because this takes into account their cultural background as mothers are most often the primary caregivers. Finally following clinical variables were considered: caries experience (diseased, missing and filled teeth (dmft) index = 0 vs. dmft index > 0), orthodontic treatment need based on the Dental Health Component (IOTN-DHC) and Aesthetic component (IOTN-DHC) of the Index of orthodontic treatment need (no need (IOTN-DHC ≤ 3) vs. need (IOTN-DHC > 3) and no need (IOTN-AC 1-4) vs. borderline need (IOTN-AC 5-7) vs. need (IOTN-AC 8-10)), tooth brushing frequency (once or less a day vs. twice or more a day) and dental visits (more than one year ago vs. less than one year ago). The dmft index has been assessed from

photographic records, which has been extensively described elsewhere (28). The IOTN was assessed from photographs and radiographs taken at the dedicated research center of the Generation R study and evaluated by an calibrated examiner as described in Kragt et al 2016 (29). All covariates were assessed, or verified, at the children's age of 10 years, except for maternal and paternal education level, marital status and caries experience, which were assessed at the children's age of 5 years.

Statistical analysis

The data collection was performed in 2016, after the study phase at the children's age of 10 years was completed. Differences in sample characteristics among children with no, borderline or definite SOT were evaluated with Chi-square tests for categorical data and Kruskall-Wallis-tests or analysis of variance for continuous data. Then, Spearman correlations analysis were conducted between SOT and the SE overall score as well as the SE subscale scores (Appendix Table S4), and overall SE with SOT as well as IOTN-AC (Appendix table S5). The difference in OHRQoL according to high and low overall SE was evaluated with a Mann-Whitney-U-test (Appendix table S6).

Finally, linear regression models with weighted leas squares were used to evaluate the role of SE in the association between SOT and OHRQoL. Generally, 3 different models with SOT as determinant and OHRQoL as outcome variable were built. A basic model adjusted for gender and age only, model 1 was additionally adjusted for paternal education level, household income and marital status, and model 2 was additionally adjusted for caries experience, IOTN-AC and IOTN-DHC. A confounding variables was included into the model based on the association between the covariates with SOT, OHRQoL and self-esteem. In a another step, overall SE was added to each model to assess the extra amount of variance explained for OHRQoL (R^2 change) and to evaluate the significance of this change. Also, the percentage change in estimate after adding SE to the model was calculated for borderline and definite SOT ((β_{model} - $\beta_{model+SE}$)/(β_{model})). Finally, the difference in the association between SOT and OHRQoL between children with high and low SE was evaluated with interaction terms between SOT and SE in the model and presenting in a stratified analysis. Interaction terms were built separately for the borderline perceived need and definite perceived need group with SE

(continuous variable). The association between SOT and OHRQoL is also presented stratified for high and low SE. Because there were missing data in the covariates and determinant variable, a multiple imputation was applied. For this, 10 imputed datasets were generated by using a fully conditional specified model, which takes into account the uncertainty of the data. Pooled estimates from these 10 dataset are presented as betas with 95% confidence intervals (β (95%CI)). For all analysis, a p-value < 0.05 was considered to be significant. Analyses were performed in SPSS 21.0 (IBM Statistics Inc, Chicago, IL, USA).

Non-response analysis

Children which were excluded from the study, because of loss to follow up or missing data on OHRQoL (n = 4752) were compared with children included into the study (n =3796) using chi-square tests and t-tests. The excluded population had more often a low maternal and paternal education level, low household income and were more often single parenting, from ethnic minorities and with a higher caries prevalence (all p-values < 0.001). The non-response analysis is presented in the Appendix (Table S7).

Results

Sample characteristics

In table 1 the family and child characteristics of the study population are presented by SOT. In total, 1914 (49.7%) boys and 1935 (50.3%) girls participated in the study. Of all participating children 1075 had no SOT (27.9%), 980 had borderline SOT (25.5%) and 1794 had definite SOT (46.6%). Parents from children with SOT were higher educated (p-values = 0.011/0.077) and had a higher household income (p-value = 0.036). Furthermore, children with SOT were more often female (p-value < 0.001), native Dutch (p-value < 0.001), brushed their teeth more often (p-value = 0.025), had more often an unfavorable IOTN-AC grade (p-value < 0.001), were more often in need for objective orthodontic treatment (p-value < 0.001) and had lower OHRQoL (p-value < 0.001) than children without or with borderline SOT. There were no significant differences in the other sample characteristics among the SOT groups with differently perceived orthodontic treatment need.

Self-esteem in the association between subjective orthodontic treatment need and OHRQoL

SOT was significantly inversely associated with OHRQoL based on the fully adjusted model (borderline need: β (95%CI) = -0.55 (-0.77, -0.33); definite need: β (95%CI) = -1.61 (-1.87, -1.42)).

SE was not significantly different between the groups based on SOT (p-value = 0.171, table 1). Furthermore, adding SE to the model on the association between SOT and OHRQoL did not attenuate or strengthen the association between SOT and OHRQoL with more than 10% (appendix table S4). However, adding SE to the model on the association between SOT and OHRQoL improved the model significantly (p-values < 0.001, table 2). In the fully adjusted model on SOT and OHRQoL, SE was significantly positively associated with OHRQoL (β (95%CI) = 0.08 (0.06, 0.11)).

Subjective orthodontic treatment need associated with OHRQoL stratified by self-esteem

After stratification for low and high SE, the association between SOT and OHRQoL appeared to be modified by children's SE (table 3). Based on the fully adjusted model, the association between borderline SOT and OHRQoL children was little but significantly stronger in children with low SE (β (95%CI) = -0.56 (-0.81, -0.31)) than in children with high SE (β (95%CI) = -0.51 (-0.97, -0.04)) (p-value = 0.02). In contrast, the association between definite SOT and OHRQoL was more profound, but non-significantly stronger in children with low SE (β (95%CI) = -1.68 (-1.94, -1.42)) than in children with high SE (β (95%CI) = -1.43 (-1.90, -0.95)) (p-value = 0.28)).

Discussion

SE, based on child reports, did not mediate or confound the association between SOT and OHRQoL, which were both based on parental reports. SOT did not influence OHRQoL via SE, however, SE is a determinant for OHRQoL that modified the association between SOT and OHRQoL.

Interpretation of results in relation to the literature

In line with other studies, a significant relationship between SE and OHRQoL was found (13, 14). This confirmed, that SE is one of the psychosocial determinants of OHRQoL as proposed by the

Wilson & Cleary model and described by many other authors (6, 30). Based on the Wilson and Cleary model malocclusion influences OHRQoL via symptom status, functional status and general oral health perception and this pathway in turn should be affected by self- esteem (6). However, there is no evidence yet confirming the relevance of SE in the association between malocclusion and OHRQoL (13, 31). The present study investigated the confounding an mediating role of SE in the relationship between SOT and OHRQoL. This might be different to the role of SE in the association between malocclusion and OHRQoL (see figure 1), as self-perceived and normatively assessed dental needs are suggested to influence OHRQoL differently (32). Still, SE was unrelated to SOT and did not change the effect estimates between SOT and OHRQoL with more than 10 percent. Thus, SE did neither mediate nor confound the association between SOT and OHRQoL. However, SE appeared to be a determinant for OHRQoL. Thus, SE might influence OHRQoL in two ways, namely on the one hand directly and on the other hand as modifier in the association between SOT and OHRQoL.

In contrast to OHRQoL, which is considered to have a dynamic, context-specific character, SE is a relatively stable construct a personal resource that facilitates coping with less favorable conditions, such as poor oral health (9, 31). Therefore, it seems not only coherent that OHRQoL is correlated with SE in our study as well as in other studies, but also that malocclusions are unrelated to SE. High SE is a psychological resource that protects individuals from the effects of deleterious oral conditions, but still children with low SE might be more focused on their malocclusion (12). In line with this, the present finding suggest a modifying role of SE on the relationship between SOT and OHRQoL. The absence of an association between SOT and SE, however, appeared rather surprising, because earlier studies found a relationship between SE and the way people are satisfied with their faces; those with higher SE showed less frequent impacts from their malocclusion, suggesting less perceived orthodontic treatment need (31, 33). But indeed, SE has also been shown to be unrelated to orthodontic treatment seeking (34).

Limitation and Strength

Some limitations of the study have to be considered. First, the OHRQoL questionnaire as well as SOT were assessed with questionnaires addressed to the mothers instead of the children themselves. This might have led to information bias, however several studies discussed maternal reports regarding patient reported oral health outcome measures as valid proxies for children reports (35-37). Second, in the non-response analysis, data were more often missing in children from low socioeconomic position and with caries. This could have caused selection bias, when the association between SOT and OHRQoL and the role of SE in this association is different between the included and the excluded population. However, the conclusion of our findings did not change after adjusting our analysis for socioeconomic status and oral conditions and therefore a selection bias in the present study seems unlikely. Third, although the analysis was adjusted for several factors that are thought to influence OHRQoL, residual confounding might have affected our results as it is a general thread to observational studies. For example, we did not assess whether the children have had previous orthodontic treatment. Finally, SE was the only psychological factor investigated in the present study, thus this study cannot say anything about the influence of other factors related to the children's psychological profile on OHRQoL. However, several studies suggested the relationship between other psychological factors, like sense of coherence, health locus of control and coping beliefs with oral health (related quality of life) (30, 38).

Yet, to our knowledge, this is the first study, which investigates the role of SE in the association between SOT and OHRQoL. The major strength of the study is, that a large population based sample including n = 3849 children instead of a small selected clinical sample was used. Furthermore, objective clinical measures as well as questionnaire data were combined in this study.

Implications of the result for research and practice

Orthodontics is a major oral health problem among children and adolescent, as more than half of the young adolescents have received orthodontic treatment (39-41). As the relationship between subjective and objective orthodontic treatment need is very inconsistent, many different reasons unrelated to the severity of malocclusions seem to exist why to seek or not to seek orthodontic

treatment. The present study clearly indicates that clinical measures are not sufficient to assess the impacts of malocclusions and the objective need for treatment, but subjective measures like OHRQoL need to be included as well. As care givers are not only interested in aligning their patient's teeth, but also in improving their OHRQoL, it is important for them to understand the relationships between clinical indicators and psychological indicators on OHRQoL. The present study is also important for future oral health research as it supports to take SE into consideration when investigating relationships regarding emotional impacts of oral health and OHRQoL.

Conclusion

From the results obtained, SE is a relevant determinant of OHRQoL as proposed by the Wilson and Cleary model, which describes the pathway between biological/physical variables, in this case malocclusions, and OHRQoL. Whereas other studies already suggested SE to be unrelated to malocclusions but to be associated with OHRQoL, based on the present study SE is also unrelated to SOT. Our findings, however, suggest that SE modifies the relationship between SOT and OHRQoL, which has not been established before. Work still needs to be done to understand and explain the role of SE for OHRQoL, as such as well as in relation to oral health perceptions.

Conflict of Interest

Lea Kragt declares that she has no conflict of interest. Eppo B Wolvius declares that he has no conflict of interest. Vincent WV Jaddoe declares that he has no conflict of interest. Edwin M Ongkosuwito declares that he has no conflict of interest.

Funding

This work was supported by the Department of Oral & Maxillofacial Surgery, Special Dental Care and Orthodontics of Erasmus University Medical Centre in Rotterdam, the Netherlands. The Erasmus University Medical Center, Rotterdam; the Erasmus University, Rotterdam; and the Netherlands Organization for Health Research and Development made the first phase of the Generation R Study financially possible. An additional grant from the Netherlands Organization for Health Research and

Development (VIDI 016.136.361 to V.W.V.J.) and a Consolidator Grant from the European Research Council (ERC-2014-CoG-64916 to V.W.V.J.) were received. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

References

1. Locker D. Concepts of oral health, disease and the quality of life. In: Measuring oral health and quality of life (1997).11 - 24.
2. Sischo L, Broder HL. Oral Health-related Quality of Life: What, Why, How, and Future Implications. Journal of Dental Research. 2011;90(11):1264-70.
3. Cunningham SJ, Hunt NP. Quality of Life and Its Importance in Orthodontics. Journal of Orthodontics. 2001;28(2):152-8.
4. Feu D, de Oliveira BH, de Oliveira Almeida MA, Kiyak HA, Miguel JA. Oral health-related quality of life and orthodontic treatment seeking. American Journal of Orthodontics and Dentofacial Orthopedics. 2010;138(2):152-9.
5. Lin F, Ren M, Yao L, He Y, Guo J, Ye Q. Psychosocial impact of dental esthetics regulates motivation to seek orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics. 2016;150(3):476-82.
6. Wilson IB, Cleary PD. Linking clinical variables with health-related quality of life: a conceptual model of patient outcomes. Journal of American Medical Association. 1995;273(1):59-65.
7. Ferrans CE, Zerwic JJ, Wilbur JE, Larson JL. Conceptual model of health-related quality of life. Journal of Nursing Scholarship 2005;37(4):336-42.
8. Tung AW, Kiyak HA. Psychological influences on the timing of orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics. 1998;113(1):29-39.
9. Huang C. Mean-level change in self-esteem from childhood through adulthood: Meta-analysis of longitudinal studies. Review of General Psychology. 2010;14(3):251.
10. Kragt L, Dhamo B, Wolvius EB, Ongkosuwito EM. The impact of malocclusions on oral health-related quality of life in children-a systematic review and meta-analysis. Clinal Oral Investigations. 2016;20(8):1881-1894.
11. 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.The European Journal of Orthodontics. 2015;37(3):238-47.
12. Zhou Y, Wang Y, Wang X, Voliere G, Hu R. The impact of orthodontic treatment on the quality of life a systematic review. BMC Oral Health. 2014;14:66.
13. De Baets E, Lambrechts H, Lemiere J, Diya L, Willems G. Impact of self-esteem on the relationship between orthodontic treatment need and oral health-related quality of life in 11-to 16-year-old children. The European Journal of Orthodontics. 2012;34(6):731-7.
14. Agou S, Locker D, Streiner DL, Tompson B. Impact of self-esteem on the oral-health-related quality of life of children with malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics. 2008;134(4):484-9.
15. Birkeland K, Boe OE, Wisth PJ. Relationship between occlusion and satisfaction with dental appearance in orthodontically treated and untreated groups. A longitudinal study.The European Journal of Orthodontics. 2000;22(5):509-18.
16. DiBiase AT, Sandler PJ. Malocclusion, orthodontics and bullying. Dent Update. 2001;28(9):464-6.
17. Shaw WC, Richmond S, Kenealy PM, Kingdon A, Worthington H. A 20-year cohort study of health gain from orthodontic treatment: psychological outcome. American Journal of Orthodontics and Dentofacial Orthopedics. 2007;132(2):146-57.
18. Bernabe E, Sheiham A, Tsakos G, Messias de Oliveira C. The impact of orthodontic treatment on the quality of life in adolescents: a case-control study.The European Journal of Orthodontics. 2008;30(5):515-20.
19. Agou S, Locker D, Muirhead V, Tompson B, Streiner DL. Does psychological well-being influence oral-health-related quality of life reports in children receiving orthodontic treatment? American Journal of Orthodontics and Dentofacial Orthopedics. 2011;139(3):369-77.
20. Jaddoe VW, van Duijn CM, Franco OH, van der Heijden AJ, van Iizendoorn MH, de Jongste JC, et al. The Generation R Study: design and cohort update 2012. The European Journal of Epidemiology. 2012;27(9):739-56.
21. Kruithof CJ, Kooijman MN, van Duijn CM, Franco OH, de Jongste JC, Klaver CC, et al. The Generation R Study: Biobank update 2015. The European Journal of Epidemiology. 2014;29(12):911-27.

22. Kragt L, Tiemeier H, Wolvius EB, Ongkosuwito EM. Measuring oral health-related quality of life in orthodontic patients with a short version of the Child Oral Health Impact Profile (COHIP). Journal of Public Health Dentistry. 2016;76(2):105-12.
23. Geels LM, Hoogstraten J, Prahl-Andersen B. Confirmative factor analysis of the dimensions of the Child Oral Health Impact Profile (Dutch version). The European Journal of Oral Sciences. 2008;116(2):148-52.
24. Wichstrom L. Harter's Self-Perception Profile for Adolescents: reliability, validity, and evaluation of the question format. Journal of Personality Assessment. 1995;65(1):100-16.
25. J.W. Veerman MAES, D.A. Treffers, B.R.H. van den Bergh, L.T. ten Brink. Handleiding competentiebelevingsschaal voor kinderen CBSK. [Manual for the Dutch Version of the SPPC]. Lisse: Swets and Zeitlinger; 1997.
26. Achenbach TM, Ruffle TM. The Child Behavior Checklist and related forms for assessing behavioral/emotional problems and competencies. Pediatrics in Review. 2000;21(8):265-71.
27. Kooijman MN, Kruithof CJ, van Duijn CM, Duijts L, Franco OH, van IMH, et al. The Generation R Study: design and cohort update 2017. The European Journal of Epidemiology. 2016;31(12):1243-64.
28. Elfrink ME, Veerkamp JS, Aartman IH, Moll HA, Ten Cate JM. Validity of scoring caries and primary molar hypomineralization (DMH) on intraoral photographs. European Archives of Paediatric Dentistry. 2009;10 Suppl 1:5-10.
29. Kragt L, Hermus AM, Wolvius EB, Ongkosuwito EM. Three-dimensional photographs for determining the Index of Orthodontic Treatment Need in scientific studies. American Journal of Orthodontics and Dentofacial Orthopedics. 2016;150(1):64-70.
30. Baker SR, Mat A, Robinson PG. What Psychosocial Factors Influence Adolescents' Oral Health? Journal of Dental Research. 2010; 89(11):1230-1235.
31. Benson PE, Da'as T, Johal A, Mandall NA, Williams AC, Baker SR, et al. Relationships between dental appearance, self-esteem, socio-economic status, and oral health-related quality of life in UK schoolchildren: A 3-year cohort study. The European Journal of Orthodontics. 2015; 37(5):481-90.
32. Isiekwe GI, Sofola OO, Onigbogi OO, Utomi IL, Sanu OO, daCosta OO. Dental esthetics and oral health-related quality of life in young adults. American Journal of Orthodontics and Dentofacial Orthopedics. 2016;150(4):627-36.
33. Albino JE, Alley TR, Tedesco LA, Tobiasen JA, et al. Esthetic issues in behavioral dentistry. Annals of Behavioral Medicine. 1990;12(4):148-55.
34. Johal A, Joury E. What factors predict the uptake of orthodontic treatment among adults? American Journal of Orthodontics and Dentofacial Orthopedics. 2015;147(6):704-10.
35. Bos A, Hoogstraten J, Zentner A. Perceptions of Dutch orthodontic patients and their parents on oral health-related quality of life. The Angle Orthodontist. 2010;80(2):367-72.
36. Wilson-Genderson M, Broder HL, Phillips C. Concordance between caregiver and child reports of children's oral health-related quality of life. Community Dentistry and Oral Epidemiology. 2007;35 Suppl 1:32-40.
37. Jokovic A, Locker D, Stephens M, Kenny D, Tompson B, Guyatt G. Measuring parental perceptions of child oral health-related quality of life. Journal of Public Health Dentistry. 2003;63(2):67-72.
38. Gururatana O, Baker SR, Robinson PG. Determinants of children's oral-health-related quality of life over time. Community Dentistry and Oral Epidemiology. 2014;42(3):206-15.
39. Schuller A, Poorterman J, van Kempen C, Dusseldorp E, Dommelen Pv, Verrips G. Kies voor tanden. Een onderzoek naar mondgezondheid en preventief tandheelkundig gedrag van jeugdigen. Tussenmeting 2009, een vervolg op de reeks TJZ-onderzoeken. 2011.
40. Proffit WR, Fields HW, Jr., Moray LJ. Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from the NHANES III survey. The International Journal of Adult Orthodontics and Orthognathic Surgery. 1998;13(2):97-106.
41. Mtaya M, Brudvik P, Astrom AN. Prevalence of malocclusion and its relationship with socio-demographic factors, dental caries, and oral hygiene in 12- to 14-year-old Tanzanian schoolchildren. The European Journal of Orthodontics. 2009;31(5):467-76.

Acknowledgements

We gratefully acknowledge the contribution of the participants, general practitioners, hospitals, midwives, and pharmacies in Rotterdam, the Netherlands. The Generation R Study was conducted by the Erasmus Medical Center, Rotterdam, the Netherlands, in close collaboration with the School of Law and Faculty of Social Sciences of Erasmus University, Rotterdam; the Municipal Health Service, Rotterdam area; the Rotterdam Homecare Foundation; and the Stichting Trombosedienst & Artsenlaboratorium Rijnmond, Rotterdam.

Figure and Table legends

Figures

Figure 1 Relationships between objective and subjective oral health measures based on the Wilson and Cleary model. Grey lines indicate relationships suggested by Wilson and Cleary, Black lines indicate the associations investigated in this study, and dotted black lines indicates relationships investigated in other studies, but not proven yet. Self-esteem is depicted as one of the individual characteristics in the model, malocclusions is depicted as a biological/physiological variable.

Tables

Table 1 Characteristics of the study population (n = 3849).

Table 2 Associations between SOT[1] and OHRQoL[2] by subjective orthodontic treatment need2 and the role of SE[3] in this association (n = 3849).

Table 3 Association between subjective orthodontic treatment and OHRQoL by SE (n = 3849).

Tables

Table 1 Characteristics of the study population (n = 3849)

	Subjective orthodontic need			
	No n = 1075	Borderline n = 980	Yes n = 1794	p-value
Family characteristics				
Maternal education level				
Low (n (%))	385 (35.8)	298 (30.4)	576 (32.1)	
High (n (%))	609 (56.7)	616 (62.9)	1115 (62.2)	0.011
Paternal education level				
Low (n (%))	358 (33.3)	283 (28.9)	572 (31.9)	
High (n (%))	572 (53.2)	566 (57.8)	1017 (56.7)	0.077
Household income				
≤ 2000€ (n (%))	184 (17.1)	144 (14.7)	240 (13.4)	
> 2000€ (n (%))	749 (69.7)	693 (70.7)	1291 (72.0)	0.036
Marital status				
Married (n (%))	889 (82.7)	809 (82.6)	1505 (83.9)	
No partner (n (%))	107 (10.0)	103 (10.5)	178 (9.9)	0.852
Child characteristics				
Age				
mean±SD	9.87±0.37	9.82±0.34	9.86±0.37	0.007
Gender				
Boy (n (%))	577 (53.7)	510 (52.0)	827 (46.1)	
Girl (n (%))	498 (46.3)	470 (48.0)	967 (53.9)	0.000
Ethnicity				
native Dutch (n (%))	671 (62.4)	676 (69.0)	1267 (70.6)	
non Dutch (n (%))	388 (36.1)	285 (29.1)	501 (27.9)	0.000
Caries experience[2]				
0 (n (%))	585 (54.4)	562 (57.3)	1011 (56.4)	
> 0 (n (%))	195 (18.4)	175 (17.9)	340 (19.0)	0.759
Tooth brushing				
Once or less a day (n (%))	214 (19.9)	167 (17.0)	287 (16.0)	
Twice or more a day (n (%))	854 (79.4)	808 (82.4)	1498 (83.5)	0.025
Dental visits				
> 1 year ago (n (%))	26 (2.4)	15 (1.5)	33 (1.8)	
< 1year ago (n (%))	1047 (97.4)	958 (97.8)	1756 (97.9)	0.329
Aesthetic orthodontic need				
No (n (%))	604 (56.2)	512 (52.3)	568 (31.7)	
Borderline (n (%))	178 (16.6)	232 (23.7)	588 (32.8)	
Yes (n (%))	17 (1.6)	20 (2.0)	208 (11.6)	0.000
Objective orthodontic need				
No (n (%))	656 (61.0)	587 (59.9)	648 (36.1)	
Yes (n (%))	170 (15.8)	205 (20.9)	764 (42.6)	0.000
OHRQOL				
median (90% range)	51.0 (45.0 - 53.0)	50.0 (44.0 - 53.0)	49.0 (41.0 - 52.0)	0.000
SE overall				
median (90% range)	47.0 (37.0 - 52.0)	46.0 (38.0 - 51.0)	46.0 (37.0 - 52.0)	0.171

Data may not add up to n = 3849, because they are based on the non - imputed data set. Missing values: maternal education: 6.4%, paternal education level: 12.5%, household income: 14.2%, marital status: 6.7%, ethnicity: 1.6%, caries experience: 25.5%, toothbrushing: 0.5%, dental visits: 0.1%, aesthetic orthodontic need: 23.9%, objective orthodontic need: 21.3, SE total: 6.4%; p-value is based on chi -square test for categorical data and UNIANOVA or Kruskall- Wallis-test for continuous data. OHRQOL = oral health related quality of life, dmft= Diseased, missing and filled teeth index, SE=self-esteem

Table 2 Associations between SOT[1] and OHRQOL[2] by subjective orthodontic treatment need2 and the role of SE[3] in this association (n = 3849)

		OHRQOL[2] (β (95% CI)[4]		
		Basic model	Model 1	Model 2
Step 1	Subjective orthodontic need			
	borderline	-0.54 (-0.77 - -0.31)	-0.60 (-0.80 - -0.36)	-0.55 (-0.77 - -0.33)
	yes	-1.77 (-2.00 - -1.54)	-1.78 (-2.00 - -1.57)	-1.65 (-1.87 - -1.42)
Step 2	Subjective orthodontic need			
	borderline	-0.51 (-0.73 - -0.30)	-0.55 (-0.77 - -0.34)	-0.53 (-0.74 - -0.31)
	yes	-1.71 (-1.93 - -1.49)	-1.74 (-1.95 - -1.53)	-1.61 (-1.84 - -1.39)
	SE	0.10 (0.07 - 0.12)	0.09 (0.06 - 0.11)	0.08 (0.06 - 0.11)
R^2 change[5]		0.02	0.02	0.01
p-value[6]		< 0.001	< 0.001	< 0.001

[1] SOT = subjective orthodontic treatment need [2]OHRQOL = oral health related quality of life;;[3]SE= self-esteem;[4] beta and 95% confidence interval (β (95% CI)) obtained from weighted least square linear regression models. [5]Change in R^2 between step 1 (SE not included) and step 2 (SE included), [6]p-value for significance of R^2 change. Basic model adjusted for age and gender only, model 1 additionally adjusted for paternal education level, household income and ethnicity; model 2 additionally adjusted for caries experience, aesthetic orthodontic need and objective orthodontic need.

Table 3 Association between subjective orthodontic treatment and OHRQOL by SE (n = 3849)

		Low SE	High SE
		N = 3146	N = 703
		β (95% CI)	β (95% CI)
Basic model			
	borderline	-0.52 (-0.79 - -0.26)	-0.56 (-1.04 - -0.08)
	yes	-1.81 (-2.06 - -1.55)	-1.48 (-1.95 - -1.01)
Model 1			
	borderline	-0.58 (-0.83 - -0.33)	-0.52 (-0.98 - -0.06)
	yes	-1.85 (-2.09 - -1.60)	-1.43 (-1.88 - -0.98)
Model 2			
	borderline	-0.56 (-0.81 - -0.31)	-0.51 (-0.97 - -0.04)
	yes	-1.68 (-1.94 - -1.42)	-1.43 (-1.90 - -0.95)
p-value for borderline*		**0.020**	
p-value for yes*		**0.280**	

[1] OHRQOL=oral health related quality of life; [2]SE= self-esteem; Beta and 95% confidence interval (β (95% CI)) obtained from weighted least square linear regression models. Basic model adjusted for age and gender only, model 1 additionally adjusted for paternal education level, household income, marital status and ethnicity; model 2 additionally adjusted for caries experience, aesthetic orthodontic need and objective orthodontic treatment need. * obtained from interaction term entered into the basic model.