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Department of clinical dentistry

Influence of professionally assessed normative orthodontic treatment need on adult OHRQoL

A systematic review

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Table of Contents

List of Tables

List of Figures

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After working with the thesis, we have gained a better insight into orthodontic factors that might influence patients' oral health-related quality of life, and the importance of quality research. Writing a systematic review has been a challenging process, but it has given valuable insight in article evaluation and academic writing.

The process has been a cooperation between the authors where both have been involved in all parts of the thesis. However, the Introduction is mainly written by MD and Materials and methods mainly by AK. Both have been more evenly involved in the Results and Discussion parts, where also our supervisor has been valuable in the interpretation and structuring of findings.

1 Abstract

Introduction: There is an increasing amount of research regarding the impact of malocclusions on OHRQoL. Reviews on this topic has mostly focused on children and adolescents, and therefore the aim of this thesis is to investigate the impact of professionally assessed normative orthodontic treatment need on adult OHRQOL.

Materials and methods: Four electronic databases (PubMed, EMBASE, Cochrane library and Google Scholar) were searched using a search syntax including orthodontic treatment need, malocclusion, OHRQoL. The following inclusion criteria were used: Adult study population, healthy study participants, no previous or ongoing orthodontic treatment, a focus on malocclusion and quality of life, malocclusions assessed by professionals, OHRQoL estimated using validated questionnaires, and full-text articles written in English or in the Scandinavian languages. Methodical quality was assessed according to the Newcastle-Ottawa scale.

Results: A total of 1152 titles and abstracts were identified after duplicates were removed and 11 studies were included for the final analysis. The studies represented a large variation in sample size, methodology and geographical spread and were assessed as being of low to moderate methodological quality. All 11 studies presented significant associations between malocclusion (indices or specific malocclusions) and OHRQoL (domains or total scores). Regression analyses disclosed most of the associations as weak to moderate.

Conclusion: Adults with considerable malocclusions have significantly poorer OHRQoL than people with occlusions near or within norms. Future studies would benefit from longitudinal studies with large representative samples.

2 Introduction

Malocclusions are better explained as deviations in the dentition rather than a disease. Despite this, malocclusion can influence the quality of life and there has long been a demand for orthodontic treatment in the world's population (1, 2). The expression professionally assessed normative orthodontic treatment need can be described as a deviation in the occlusion from standards or norms of a single or several malocclusion traits usually expressed in indices (3). Both morphological functional aspects and aesthetic considerations can be included and assessed by a professional such as a dentist or orthodontist, or in the case of aesthetic considerations by the patient.

2.1 Global prevalence of malocclusion

According to a meta-analysis by Lombardo et al. (2020), 56% of children and adolescents worldwide present some kind of malocclusion, with the highest prevalence seen in Africa (81%) and Europe (71%) and the lowest in America (53%) and Asia (48%) (4). Among adults, the prevalence of malocclusions has been reported to be between 39-66% in reports from USA, Finland, and Iceland (5-7). The most frequently reported malocclusion traits for both young and adults are overbite (11,6-26%), overjet (9,7-27%,), crowding (39%) and posterior crossbite (7-17,9%) (4, 5, 8). A substantial range, due to differences in definition of malocclusions between studies.

2.2 Funding of orthodontic treatment

The meta-analysis by Lombardo et al. (4) suggests that malocclusions appear in more than a half of the world's population, while Richmond et al.'s estimations points to that at least one third of a population has a clear need for orthodontic treatment with substantial variations between different populations (9).

Organization and funding for orthodontic treatment varies considerably between countries. Denmark, Finland and Sweden offers free orthodontic treatment funded by governmental social security systems for approximately 1/4 of child cohorts between 6-18 years of age presenting a malocclusion normatively assessed as treatment need (10).

In Norway up to 50% of children and adolescents in corresponding child cohorts get an orthodontic consultation and/or some kind of orthodontic treatment (10), and about 30% in these cohorts are referred for orthodontic treatment with full or partly financial support from HELFO (Norwegian system for social insurance benefits) (11).

2.3 Orthodontic treatment need indices

To assess orthodontic treatment need and to discriminate individuals with malocclusions entitled of funding, a number of indices can be used (12). Some of the most frequently used globally are Index of Orthodontic Treatment need (IOTN), Index of complexity, outcome, and need (ICON) and Dental aesthetic index (DAI). In Scandinavia indices adapted to the refund systems have been used such as the Need for orthodontic treatment index (NOTI) in Norway and the Swedish medical board index (SMBI) together with the IOTN in Sweden (12, 13).

Most of the indices are normative morphological indices and are used by the dental health professionals to evaluate the patient's normative orthodontic treatment need. Some indices can also be used by the patients themselves to decide more a self-perceived/subjective orthodontic treatment need.

2.3.1 Index of orthodontic treatment need

The IOTN was first described by Brook and Shaw in 1989 (14). It uses two separate components, the dental health component (DHC) and the aesthetic component (AC).

The IOTN-DHC grades need for treatment related to health and function. Five different occlusal traits are assessed: overjet, overbite, crossbites, missing teeth and crowding, together with of craniofacial anomalies (appendix I). The highest scoring malocclusion trait is used to decide orthodontic treatment need, which is categorized as grade 1 (no treatment need), grade 2 (little treatment need), grade 3 (borderline treatment need), grade 4 and 5 (treatment need) (14). The five grades are often categorized into 3 treatment need groups, where grade 1-2 together represents "no treatment need", grade 3 "moderate treatment need" and grade 4-5 representing "definite treatment need".

The IOTN-AC is an is an illustrated 10-point scale, based on 10 photographs (appendix II). The photographs are arranged due to dental attractiveness where number 1 is the most attractive and 10 is the least attractive, and the health professional or the patient match the patient's teeth with one of the photographs. The 10-graded scale is usually categorized in 3 treatment need groups, where photographs 1-4 represents "no treatment need", 5-7 represents "borderline treatment need" and 8-10 represents "definite treatment need" (14, 15).

Both components of the IOTN have shown good validity and reliability (16-18). However, discrepancy between the IOTN-DHC and the IOTN-AC can occur. The IOTN-AC only assesses the malocclusions in the esthetic zone, while the IOTN-DHC also records anomalies

like missing teeth or crossbites, that not necessarily will influence the aesthetics (13). A study from 2011 reported a moderate agreement between the two components (19).

2.3.2 Index of complexity, outcome, and need

ICON was created in 1998 by Daniels and Richmond (20). It was developed from the IOTN index with the desire to develop a measurement tool that, in addition to treatment need, also could assess treatment complexity and outcome. Esthetics were heavily weighted in the development of the index, that consists of 5 components: crossbite, upper arch crowding/spacing, buccal segment antero-posterior relationships, anterior vertical relationship and IOTN's aesthetic component. These traits are given a specific score, multiplied with their respective weighing, and added together. Pre-treatment values above 43 indicated need for treatment and post-treatment values below 31 signified acceptable end occlusion (13, 20). ICON has shown good reliability and validity in assessing treatment need, complexity, and outcome (21-23).

2.3.3 Dental Aesthetic index

The DAI was first described by Jenny and Kohout in 1986 (24) and has been adopted by the World Health Organization (WHO) as an international index. Ten malocclusion traits are assessed, including overjet, overbite, crowding, and missing teeth (appendix III). Unlike the IOTN, the DAI combines aesthetic and physical aspects in one score. A score below or equal to 25 indicates "no treatment need", 26-30 indicates "optional treatment", 31-35 indicates "treatment highly desirable" and a score bigger than 35 indicates "treatment mandatory" (15, 18, 25). Another difference from the IOTN is that the DAI score can be used to differentiate cases within severity levels, unlike the IOTN that only has 5 grades (15). DAI has shown to be a valid and reliable index by several studies (15, 17, 26, 27).

2.4 Health related quality of life

In 1948 the WHO defined health "as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity and not just the absence of disease", and this broad definition has led to a more multidimensional focus on health that includes both physical, mental and social domains (28). Historically there has been a focus on morbidity and mortality when it comes to health research. As the worlds populations health and health care has improved there has been a change from not only saving life, but also improving quality of live (QoL) (29). Quality of life is by the World Health Organization

Quality of Life group defined as: “individuals’ perception of his/her position in life in the context of culture and value systems in which they live…” (30).

Quality of life is often referred to as health-related quality of life (HRQoL). HRQoL is a multidimensional concept where general health is complemented by domains related to social, psychological, or physical functioning. It does not only measure the health status itself, but says more about the health-status influence of a person’s well-being (29). When quality of life is considered in respect to oral health it is called oral health related quality of life (OHRQoL).

2.5 Oral health related quality of life

Oral health related quality of life (OHRQoL) has since 2003 been recognized by the WHO as an important part of the Global Oral Health Program. OHRQoL is like HRQoL a multidimensional concept, based on functional, social, and psychological factors, together with the experience of pain or discomfort. It reflects, among other things, people’s comfort in mastication, social interaction, and self-esteem with regard to their oral health. In other words, it reflects how oral conditions can influence a person’s well-being such as the ability to enjoy a meal, willingness to smile, self-image and confidence (28, 31). Validated questionnaires are widely used to assess OHRQoL. Many questionnaires have been developed and they vary in shape, extent, language, and target population (31).

2.5.1 Oral health impact profile

The Oral Health Profile (OHIP) was first developed by Slade and Spencer in 1994, as a self-reporting instrument to measure the social impact of oral disorders. It is designed as a questionnaire with 49 unique questions that describes different consequences of oral disorders (32). The 49 questions are organized into 7 domains: function limitation, physical discomfort/pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap.

The 7 domains are based on Locker’s conceptional model and are sequentially related together. Malocclusions may lead to functional limitation (e.g., trouble pronouncing word, worsened sense of taste) or discomfort and pain (e.g., painful gum, discomfort while eating). This can again result in physical, psychological, or social disability (e.g., unsatisfactory diet, difficulty relaxing, embarrassment, being irritable and having problems in social contacts). This may again lead to handicap for people (e.g., troubles communicating and in social contacts can make you unable to fulfill the expectations of society and work, embarrassment

with teeth may make you unable to enjoy others company, dissatisfaction with life), which again can impact the quality of life. According to the model, functional limitation and discomfort may also lead directly to handicap (33).

2.5.1.1 Oral health impact profile 14

In 1997, a shortened version of the OHIP was developed; the Oral Health Impact 14 (OHIP-14) and it is a frequently used questionnaire to measure OHRQoL. The OHIP-14 consists of 14 questions, 2 from each of the 7 domains of the original OHIP (34, 35) (appendix IV). Each question is answered in a five-point Likert scale from 0-4, where 0 is never and 4 is often. Domain scores will vary from 0-8 and the maximum OHIP-14 total score is 56. Even though the questionnaire went from 49 to 14 questions it did show the same pattern of variation as the original questionnaire and has proved to have good reliability, validity, and precision (34, 36).

2.5.2 Psychosocial impact of dental aesthetics questionnaire

The Psychosocial impact of dental aesthetics questionnaire (PIDAQ) was developed in 2006 by Klages et al. (37). It consists of 23 questions organized in 4 domains: dental self-confidence (6 questions), social impact (8 questions), psychological impact (6 questions), and esthetic concern (3 questions) (appendix V). Each question is answered in a five-point Likert scale from 0-4 like in the OHIP-14.

The dental self-confidence domain is supposed to reflect “dental aesthetics positive impact on the emotional state of an individual”. The social impact domain investigates “problems in social situations due to a subjective perception of an unfavorable dental appearance”. The psychological impact domain investigates possible “feelings of inferiority and unhappiness, in comparison with others with superior dental aesthetics”. The last domain, esthetic concern, consists of questions “referring to disapproval of one’s own dental appearance when confronted with minor, photographic and/or video images” (37).

PIDAQ has been found to be a stable, consistent and valid instrument for young adults (37), and has also shown to have good psychometric properties in adolescents (38). The instrument has also been translated and validated for adults in several countries (39-42).

2.6 Malocclusion and OHRQoL

During the last decades, a growing interest in the effect of malocclusions on OHRQoL have resulted in a considerable amount of research.

Liu et al.'s systematic review including studies until December 2007, reported that studies generally observed an association between orthodontic treatment need and OHRQoL in adults, adolescents, and children. However this association would at best be considered as modest when taking correlation statistics and regression analysis into account, and the level of evidence from their included studies was relatively low. They also did acknowledge the need to determine appropriate methods to assess malocclusion/orthodontic treatment need and OHRQoL, to enable meta-analysis of their relationship to (43).

Dimberg et al. on the other hand found in their review, including studies until January 2014, cross-sectional studies with a high level of evidence indicating that severe malocclusions, especially in the aesthetic zone (anterior crowding, diastema mediale, increased overjet), had a negative effect on OHRQoL among children and adolescents. Predominantly in the emotional and social wellbeing dimensions. They stated these findings as new and more detailed compared to Liu et al.'s review. However 5 of 6 studies, included in Dimberg et al.'s review, were from Brazil and the results could be different compared to other countries, due to cultural differences. They therefore recognized that there was a need for more geographical spread in future studies, together with more consistent methods and comparable groups, for meta-analyses to be performed (44).

Kragt et al. presented a review and meta-analysis in 2016 including 40 studies, where they concluded that there was a clear but small impact of malocclusions on OHRQoL among children and adolescents (8-18 years of age). They discovered that the strength of the association between malocclusion and OHRQoL was modified by the children's age, where the older the children got, the more the malocclusion effected their OHRQoL. Cultural environment did also seem to modify the strength of association, where the studies performed in Africa (Nigeria/Tanzania) did show the opposite association compared to the general results from the included studies. They discussed that this could be a result of cultural differences leading to differences in the perception of malocclusion and interpretation of OHRQoL. The meta-analysis showed biggest difference in OHRQoL scores between children with or without malocclusion when DAI was used for treatment need assessment. All included studies were cross-sectional of both high and low quality (45).

Sun et al. however, concluded in their 2017 review and meta-analysis including children, adolescents, and adults that untreated malocclusion had an impact on OHIP scores. All domains of OHIP-14 were affected, and more severe malocclusions were associated with

larger effect on the psychosocial domains (psychological discomfort, psychological disability, and social disability) and some physical domains (physical pain and physical disability). They also described results that pointed in the direction that the influence of malocclusion on the OHRQoL may vary in different age groups. 12-15 age group showed the biggest impact, which decreased in the 15-18 age group and further decreased in those older than 18, where the influence seemed to be more stable. No significant gender differences could be found, although significant differences between different countries was found in most domains of OHIP-14. The need for future studies to include representative samples, randomly selected from the general population where highlighted by the authors (46).

All the reviews mentioned above did only include cross-sectional studies. Dimberg et al., Kragt et al. and Sun et al. all commented that longitudinal studies on the topic would be preferable, although that these studies are lacking (44-46). Dimberg et al. also highlighted the ethical consideration in this matter. A longitudinal follow up study of a group of children and teenagers with evident malocclusions without giving treatment would be hard to justify ethically (44).

Most of the reviews on this topic involves children and adolescents, which is reasonable since they make up most of the orthodontic patients, but the amount of adults seeking orthodontic treatment has been increasing (47). Therefore, the aim of this thesis is to investigate the influence of professionally assessed normative orthodontic treatment need on adult OHRQoL.

3 Materials and methods

We conducted a wide literature search to identify studies evaluating impact of malocclusions on OHRQoL published the last decade, 2010-2020. Four electronic databases (MEDLINE via PUBMed, EMBASE, Google Scholar and Cochrane library) were searched using following search syntax: "((orthodontic treatment need) OR (malocclusion)) AND ((quality of life OR oral health-related quality of life OR QoL OR OHRQoL)) NOT ((orthognathic surgery OR cleft lip))". A filter for articles in English, Swedish or Norwegian was applied. The computerized search was done individually by AK and AS the same day, and then compared to ensure the same search syntax and number of articles. Removal of duplicates was done by a function in Endnote, and cross checked individually before the screening process. Articles published in different journals with a slight title change were identified both before and during the screening process.

Prior to reading the retrieved titles, abstracts and articles, the inclusion criteria selected was inspired by a systematic review by Dimberg et al. (44) with adjustments made more suitable for our aim. Consensus was reached on the following inclusion criteria:

- Adult study population, with majority of participants 18 years or older
- Healthy study participants without syndromes or severe illness
- No previous or ongoing orthodontic treatment
- Focus is on normative orthodontic treatment need and quality of life
- Categorization of malocclusions should use either of these indices (DAI, ICON, IOTN, PAR, NOTI, SMBI) or a malocclusion described in one of these indices
- Self-assessed OHRQoL estimations should use validated age adequate questionnaires (such as: OHIP, OHIP-14, OASIS, OIDP, PIDAQ)
- Indices and malocclusions should be assessed by a dentist or orthodontist
- Full-text articles written in English or the Scandinavian languages

The two researchers (MD and AK) determined the admissibility of the studies. The titles and abstracts of the retrieved articles were independently reviewed, and in case of inter-examiner disagreement a third party (AS) acted as a facilitator to reach consensus. Full text articles corresponding to the selected abstracts were retrieved. Each full text version was evaluated again with regards to inclusion criteria and use of adequate data variables. The articles remaining after this screening was graded using the Newcastle-Ottawa Scale (NOS).

A recent study compared Appraisal Tool for Cross-Sectional Studies (AXIS) and Newcastle-Ottawa Scale (NOS) and concluded that there was no clear difference between the two for evaluating methodical quality in cross-sectional studies (48). NOS is an ongoing collaboration between the universities of Newcastle in Australia and Ottawa in Canada. It was originally created to evaluate case-control and cohort-studies (49), but has been adapted to assess cross-sectional studies in addition (50) (appendix VI). The adapted version of NOS has a score range from 0-10 and has three dimensions; Selection which can give a maximum of five stars, Comparability and Outcome that can give a maximum of two- and three stars, respectively. Three of the excluded studies was used for calibration of the researchers (MD and AK), and consensus was reached during discussions with AS on how to interpret each of NOS's items(appendix VII). Each of the included studies was analyzed by the two researchers independently, and then the scores of each study were compared. In case of disagreement, a third party (AS) had the final decision.

All articles included in the final evaluation were based on cross-sectional studies. This type of study design aims to take a "snapshot" of a situation at a particular point in time. Researchers collects an appropriate sample of individuals whom they then can study. Data on one or more variables are collected only once from each participant. These individuals will often already be in touch with the health service in some way, or they may be drawn from the general population, or from registers or patients records (51). Analytical cross-sectional research investigates the association between two or more related or unrelated parameters. The association can be assessed with the correlation coefficient and regression analysis is often used to adjust for confounders. Correlation coefficient is a measure of the average distance of all the points in a scatterplot from an imaginary straight line drawn through the scatter. The correlation coefficient can vary from -1 indicating a perfect negative association, 0 indicating no association and +1 indicating a perfect positive association (51). Values between 0-0.3 indicate weak positive linear relationship, 0.3-0.7 a moderate relationship and 0.7-1.0 strong positive relationship (52). The risk ratio (RR), also called relative risk, is the chance of a risk factor (exposure) leading to an outcome (condition). RR <1, is a beneficial risk factor less likely to lead to the outcome. RR= 1, no difference and RR>1, more likely to lead to the outcome (51). Odds ratio can describe the odds for an event happening in one group compared to another (53), and effect sizes have been suggested: OR=1.5 weak association, OR=2,5 moderate association, OR=4 strong association, and OR=10 very strong association (54).

4 Results

4.1 Search results and study characteristics

The electronic database search produced 1817 titles and abstracts. Full-text versions of 31 articles were extracted and analyzed in compliance with the selection process and resulted in 11 articles for the final analysis (55-65). A quality assessment using the NOS scale for cross-sectional studies revealed a range of 5-7 points on a 0-10 scale indicating a low to moderate methodological quality (66).

Articles were primarily excluded due to not focusing on professionally assessed normative orthodontic treatment need and to a lesser extent due to different non-validated indices and OHRQOL questionnaires. The selection process is presented in the flow chart (figure 1).

All 11 articles included in the final analysis presented results from cross sectional studies. Seven of the studies were performed in Asia, 3 in Europe and 1 in Africa.

The OHRQoL questionnaires used in the studies were OHIP-14 (9 studies), PIDAQ (2 studies) and OHIP (1 study). One study included both OHIP-14 and PIDAQ.

Seven studies used orthodontic indices (IOTN-DHC, IOTN-AC and DAI) for professional (dentist or orthodontist) assessment of normative treatment need and 4 studies evaluated specific malocclusion traits such as overbite (open bite/deep bite), overjet and posterior crossbite (table 1).

Three of the 11 studies presented gender separated results (59, 60, 65), while 7 studies tested gender as a confounding factor (56, 59, 61-65). Six studies tested age (58, 59, 61-64) and 4 studies tested education (58, 61-63) as confounding factors.

Table 1. Main characteristics for the eleven evaluated articles.

Authors	Year	Journal	Country	Participants	N	Age	OTN	OHRQOL	Statistical methods	NOS
Isiekwe et al. (55)	2016	AJODO	Nigeria	Undergraduate university students	375	18-30	IOTN-AC	OHIP-14 PIDAQ	Chi square, Fisher exact tests Kruskal-Wallis test	5
Chakradhar et al. (56)	2017	Int J of Adolescent Med and Health	India	Young adults of degree college	306	18-23	DAI	PIDAQ	Pearson's correlation, Multiple linear regression	6
Ashari et al. (57)	2015	Angle Orthod	Malaysia	Adolescents and adults attending primary dental care	150	12-19, 20-35	DAI	OHIP-14	Spearman rank correlation	7
Choi et al. (58)	2015	AJODO	Korea	Young adults seeking oral health screening or education	429	18-32	IOTN-DHC	OHIP-14	Multiple logistic regression, Kruskal-Wallis test; Mann-Whitney U-test	7
Dalaie et al. (59)	2018	Eur J of Dent	Iran	Young adults attending orthodontic clinics	126	18-25	IOTN-DHC	OHIP-14	Chi square test, Logistic regression analyses	6
Hassan et al. (60)	2010	AJODO	Saudi Arabia	Young adults seeking orthodontic treatment	366	21-25	IOTN-DHC	OHIP-14	Chi Square test	7
Masood Y et al. (61)	2013	Health quality life outcomes	Malaysia	Young adults attending orthodontic clinics	323	15-25	IOTN-DHC	OHIP-14	One-way ANOVA with Tukey Post Hoc test, Bivariate and multivariate linear regression	7
Masood M et al. (62)	2014	J of Dent	Malaysia	Young adults attending orthodontic clinics	143	15-25	Crossbite	OHIP-14	Students t-tests, Bivariate and Multivariate linear regression	6
Masood M et al. (63)	2017	Co. Dent Oral Epidem	Finland	Adults living in Finland	4711	≥30	Overjet, overbite, crossbite	OHIP-14	Multivariate Poisson (ZIP) regression, Mann-Whitney U-test	7
Sierwald et al. (64)	2014	J orofac Ortop	Germany	Secondary data analysis from three German studies	1968	16-90	Overjet, overbite	OHIP questions regarding esthetics	Multivariable regression analysis	6
Silvola et al. (65)	2019	EJO	Finland	Subjects from the Northern Finland Birth Cohort 1966	1885	46	Overjet, overbite, crossbite	OHIP-14	Multivariate Poisson regression	6

OTN, Assessment of orthodontic treatment need.

NOS, Newcastle Ottawa Scale score (0-10).

Figure 1. Selection process of collecting information through the different phases of the systematic review.

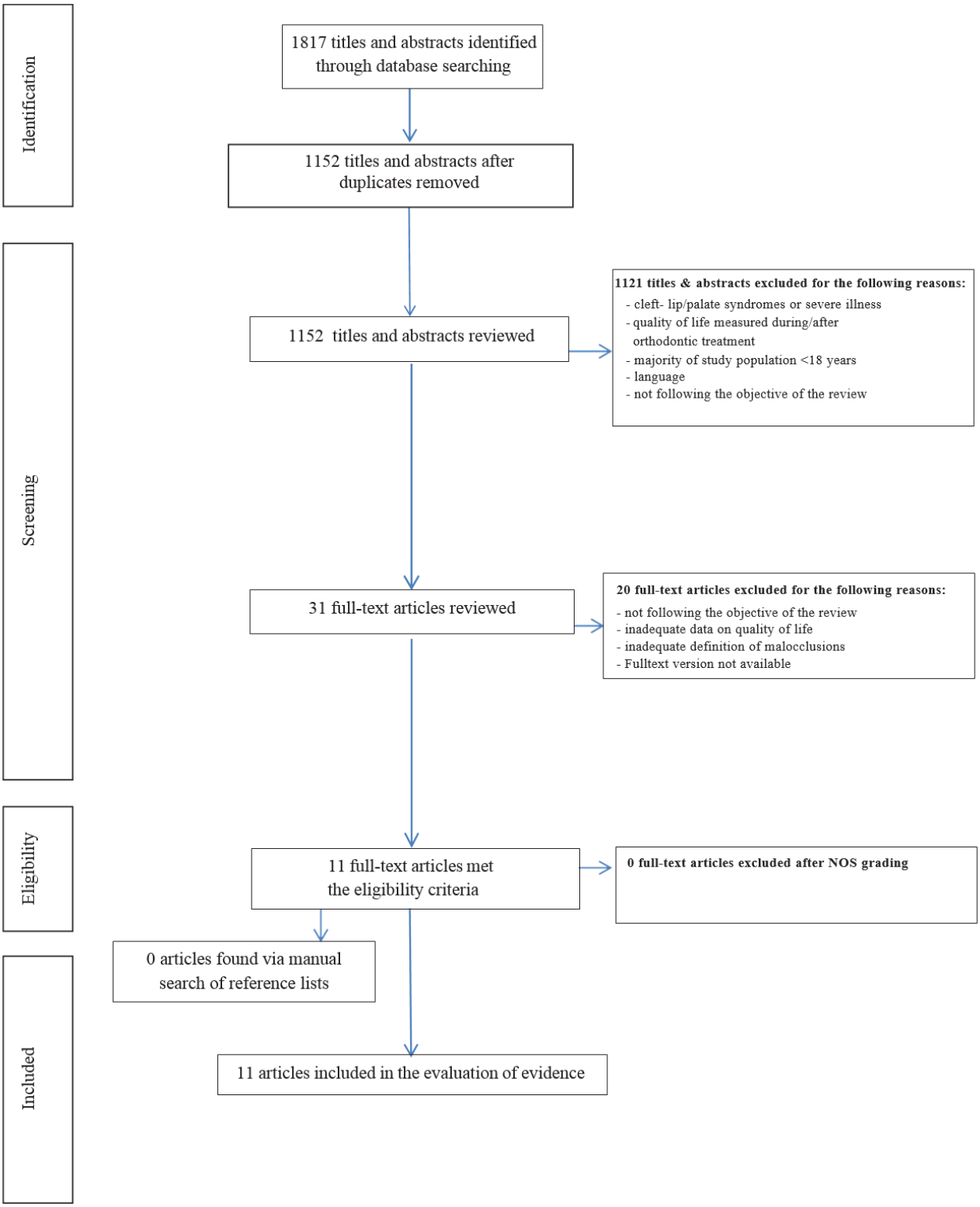

Table 2. Distribution of gender and orthodontic treatment need.

Authors	N (male/female)	Assessment of orthodontic treatment need	Severity of Orthodontic treatment need	N (male/female)	%
Isiekwe et al. (55)	375 (200/175)	IOTN-AC	Grade 1-4 Grade 5-7 Grade 8-10	324 46 5	86,4 % 12,3 % 1,3 %
Chakradhar et al. (56)	306 (213/93)	DAI	Grade 1 (<25) Grade 2 (26-30) Grade 3 (31-35) Grade 4 (>36)	101 66 77 62	33,0 % 21,6 % 25,1 % 20,3 %
Ashari et al. (57)	150 (48/102)	DAI	Grade 1 (<25) Grade 2 (26-30) Grade 3 (31-35) Grade 4 (>36)	30 40 37 43	20,0 % 26,7 % 24,7 % 28,7 %
Choi et al. (58)	429 (328/101)	IOTN-DHC	Grade 1-2 Grade 3 Grade 4-5	185 108 136	41,1 % 25,2 % 31,7 %
Dalaie et al. (59)	126 (27/99)	IOTN-DHC	Grade 1-2 Grade 3 Grade 4-5	17 30 79	13,4 % 23,8 % 62,7 %
Hassan et al. (60)	366 (153/213)	IOTN-DHC	Grade 1-2 Grade 3 Grade 4-5	54 205 107	14,8 % 56,0 % 29,2 %
Masood Y et al. (61)	323 (132/191)	IOTN-DHC	Grade 1-2 Grade 3 Grade 4-5	158 80 85	48,9 % 24,8 % 26,3 %
Masood M et al. (62)	143 (56/87)	Crossbite	Absent Present	72 73	50,3 % 49,7 %
Masood M et al. (63)	4711 (1855/2230)	Overjet (negative or positive)	Absent Present	3768 317	91,6 % 8,4 %
		Crossbite	Absent Present	3095 990	75,7 % 23,6 %
		Overbite (deep bite or open bite)	Absent Present	3917 268	93,6 % 6,7 %
Sierwald et al. (64)	1968 (593/1375)	Overbite	≤-1 mm 0-1 mm 2-3 mm 3-4 mm ≥6 mm	33 302 799 605 208	1,7 % 15,5 % 41,0 % 31,0 % 10,7 %
		Overjet	≤-1 mm 0-1 mm 2-3 mm 3-4 mm ≥ 6 mm	26 283 985 464 192	1,3 % 14,5% 50,5 % 23,8% 9,9 %
Silvola et al. (65)	1885 (882/1003)	Overjet	≤0 mm 1-6 mm ≥7mm	67 (48/19) 1705 (787/918) 93 (37/56)	3,6 % 91,4 % 5,0 %
		Overbite	<0 mm 0-6 mm ≥7mm	21 (13/8) 1760 (806/954) 85 (54/21)	1,1 % 94,3 % 4,6 %
		Crossbite	Absent Present	1455 (798/927) 414 (220/194)	77,8 % 22,2 %

4.2 Impact of malocclusions assessed by indices on OHRQoL

All 3 studies investigating the impact of orthodontic treatment need assessed by IOTN-DHC on OHIP-14 total score found a positive correlation (58, 59, 61) (table 3).

All 5 studies using IOTN-DHC, or IOTN-AC found positive correlation between orthodontic treatment need and 6 or more domains of OHIP-14 (55, 58-61), however Choi et al. found only 3 of these domains significantly correlated after multivariate regression (58). Ashari et al. found a weak positive correlation between DAI score and 2 domains of OHIP-14 (57), while Chakradhar presented a negative correlation between DAI score and all PIDAQ domains except for the dental self-confidence (56). Isiekwe et al. using IOTN-AC found a significant positive correlation for the psychological impact and esthetic concern domains, and a negative correlation for the dental self-confidence domain of PIDAQ (55) (table 3-4).

The most common domains in OHIP-14 showing a significant positive correlation with orthodontic treatment need indices (IOTN-DHC and DAI) were physical pain, psychological discomfort, and social disability (55, 58-61). The most common domains showing correlation for PIDAQ were psychological impact and aesthetic concern (55, 56) (table 3-4).

4.3 Impact of specific malocclusions on OHRQoL

Three studies investigated the impact of overjet on OHRQoL (63-65). Masood M. et al. (2017) found a significant positive correlation between overjet and OHIP-14 total score and the physical disability domain (63). Sierwald et al. concluded that an overjet of 4-5mm and ≥6mm was significantly associated with esthetic impairments of OHRQoL (64). Silvola et al. stated that negative overjet was significantly associated with a higher OHIP-14 total score and the handicap domain score, among females. Overjet on the other hand was associated with lower OHIP-14 score for females compared to males, who showed higher OHIP-14 score in the psychological disability domain (65) (table 5).

Overbite was not found to be “significantly or relevantly” associated with OHRQoL in the studies of Sierwald et al. and Masood M. et al. (2017) (63, 64), except for a positive correlation between “significant open bite or deep bites” and the psychological disability domain (63). Silvola et al. analyzed genders separately and found that deep bite was associated with higher OHIP-14 total score for males and open bite for females in all domains except the handicap domain (65) (table 5).

Table 3. Distribution of significant correlations between OHIP-14 total score, domains and malocclusions assessed by orthodontic indices.

Author	Treatment need index	Statistical methods and groups compared	Functional limitation	Physical pain	Psychological discomfort	Physical disability	Psychological disability	Social disability	Handicap	OHIP-14 Total
Isiekwe et al. (55)	IOTN-AC	Fisher exact test	**MF**	**MF**	**MF**	**MF**		**MF**	**MF**	**X**
Ashari et al. (57)	DAI	Spearman rank correlation			**MF** r= 0.268				**MF** r= 0.238	**X**
Choi et al. (58)	IOTN-DHC	Multivariate regression (NTN= reference group)	**MF** BTN: OR=2.48 DTN: OR=3.01	**MF** BTN: OR=2.56 DTN: OR=2.82				**MF** DTN: OR=1.79		**MF** DTN: OR=2.74
		Significant difference in mean score between NTN- and DTN group	**MF**	**MF**	**MF**	**MF**	**MF**	**MF**		**MF**
Dalaie et al. (59)	IOTN-DHC	Chi square test Total: Logistic regression (NTN=ref group)	**M**	**M, F**	**M, F**		**M, F**	**M, F**	**M, F**	**MF** BTN: OR=5.1 DTN: OR =21.6
Hassan et al. (60)	IOTN-DHC	Chi square test	**M**	**M, F**	**M, F**	**M, F**	**M, F**	**M, F**	**M, F**	**X**
Masood Y et al. (61)	IOTN-DHC	Significant difference in mean score between NTN- and DTN group Total: Multivariate linear regression	**MF**	**MF**	**MF**	**MF**	**MF**	**MF**	**MF**	**MF** R^2=0.16

OR= Odds ratio

r= Correlation coefficient

R^2= R-squared

NTF= No treatment need, **BTN**=Borderline treatment need, **DTN**=Definite treatment need.

MF= Significant positive correlation (p=<0.05) for both genders as one group

M= Significant positive correlation (p=<0.05) for males

F= Significant positive correlation (p=<0.05) for females

X= Not investigated by the study.

Dalaie et al, Hassan et al, and Isiekwe et al only had statistical results for each question but not domains. In this table, if one of two questions had significant result, the domain was deemed significant correlated.

Table 4. Distribution of significant associations between PIDAQ total score, domains and malocclusions assessed by DAI and IOTN-AC.

Author	Treatment need index	Statistical methods	Dental self-confidence	Social impact	Psychological impact	Aesthetic Concern
Chakradhar et al. (56)	DAI	Domain: Pearson's correlation		**MF**	**MF**	**MF**
Isiekwe et al. (55)	ITON-AC	Significant difference in mean score between NTN- and BTN group	**MF**		**MF**	**MF**

NTF=No treatment need, **BTN**= Borderline treatment need.

MF= Significant correlation for both genders as one group. **Red** indicates significant negative correlation.

X= Not investigated by the study.

Table 5. Distribution of significant associations between OHIP-14 total score, domains, and specific malocclusions.

Author	Statistics and groups compared	Specific malocclusion	Functional limitation	Physical pain	Psychological discomfort	Physical disability	Psychological disability	Social disability	Handicap	OHIP-14 Total
Masood M et al. (2014) (62)	Significant mean score difference between crossbite group and control group	Crossbite	**MF**	**MF**	**MF**	**MF**	**MF**	**MF**	**MF**	**MF**
Masood M et al. (2017) (63)	Multivariate Poisson (ZIP) regression (present vs absent)	Overjet (<0, >6)				**MF** IRR=1.56				**MF** IRR=1.09
		Open bite/ Deep bite					**MF** IRR=1.26			
		Crossbite						**MF** IRR=0.75		
	Significant mean score difference between groups with or without specific malocclusion	Overjet (<0, >6)			**MF**		**MF**		**MF**	**MF**
		Open bite/ Deep bite	**MF**		**MF**		**MF**			
		Crossbite								
Silvola et al. (65)	Poisson regression	Overjet (≥7)		**F** RR=0.67		**F** RR=0.36	**M** RR=1.67			**F** RR=0.69
		Overjet (≤0)					**M** RR=0.53		**F** RR=2.20	**F** RR=1.34
		Open bite	**F** RR=6.80	**F** RR=2.17	**F** RR=2.55	**F** RR=4.22	**F** RR=3.23	**F** RR=6.66		**M, F** RR=0.51, 2.89
		Deep bite	**F** RR=2.02							**M** RR=1.23
		Crossbite	**M** RR=1.53			**F** RR=0.60	**M** RR=1.29			**F** RR=0.80

IRR= Incidence rate ratio.
RR= Relative risk.
MF= Significant correlation (p=<0.05) for both genders as one group.
M= Significant correlation (p=<0.05) for males.
F= Significant correlation (p=<0.05) for females.
Red indicates significant negative correlation.
The article by Sierwald et al. is not included in the table because the esthetic questions of OHIP does not fit in the table with OHIP-14 domains.

The impact of crossbite on OHIP-14 was investigated by three studies (62, 63, 65). The study by Masood M. et al. (2014) found a significant positive correlation between crossbite and OHIP-14 total score and all domains. The highest degree of impact was on the functional limitation and psychological discomfort domains (62). Masood M. et al. (2017) found no association with crossbite, except for a significant negative correlation with the social disability domain (63). Silvola et al. found a significant negative correlation between crossbite and the OHIP-14 total score and the social disability domain for females. However,

presented a significant positive correlation between crossbite and the functional limitation and psychological disability domains for males (65) (table 5).

4.4 Impact of gender and age on OHRQoL

In five of the studies, females generally tended to report higher impact scores (OHIP-14, OHIP) than males, but the difference between the genders was not found to be statistically significant (58, 59, 61, 62, 64).

Masood Y. et al. (2013) described significantly lower OHIP-14 total score levels for older age groups (19-21y and 22-25y) compared to younger (15-18y) using IOTN-DHC in evaluating malocclusions (61). Masood M. et al. (2014) presented significantly lower OHIP-14 total score levels for older compared to younger age groups diagnosed with cross bites (62).

5 Discussion

The wide search strategy in four major databases resulted in 1817 titles and abstracts, narrowed done by the inclusion criteria to eleven full-text articles in the final analysis, which can be regarded as a customary number in systematic reviews concerning this subject. The selection process was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), but no detailed protocol of excluded articles was used which is a weakness. However, reasons for exclusion were recorded and are presented in the flow chart. Double-checking of and discussion around search data, applicability to inclusion criteria and assessment of methodological quality have most likely contributed to minimize search errors and improved the study.

The studies included in this systematic review reveled a large variation in number of subjects, ethnicity, and methodology, which made interpretation of outcomes and conclusions challenging. Furthermore, the methodological assessment of the eleven cross-sectional studies revealed a low to moderate quality. Since no interpretation of grading for cross-sectional studies was available the verbal assessments was based on the results from a systematic review using NOS for Cohort studies, and defined the quality of the Cohort studies as low if the NOS score was <6, moderate between 6-7 and high for 8-9 (66). Additionally, the reliability and validity of the NOS scale have been questioned (67). Still, a NOS assessment offers a reasonably objective complement to subjective evaluation of methodological quality. Yet, when evaluating the results, in this kind of studies, it is important to remember the inherent weaknesses of cross-sectional studies, such as the need to select a sample of subjects

from a large and heterogeneous study population to limit bias, when a proper control group cannot be supplied. The variety of outcome variables engaged in the articles also puts high demands on the statistical methods used to avoid confounding factors.

All studies except Masood M. et al. (2017) (63) used convenience sample which reduces generalizability, in that sample estimates may not reflect true effects among the target population. Yet, the large geographical spread makes the results more international. The fact that four of the studies used samples from young adults seeking orthodontic treatment could have resulted in higher OHRQOL scores according to authors, due to more focus on the dental occlusion in this group (61, 62). On the other hand, Espeland and Stenvik reported no significant difference in the perceptions of occlusion between treated and untreated groups among young adults (68).

Outcome of OHRQOL was evaluated with OHIP-14 questionnaires in nine of the eleven investigated studies and PIDAQ were used in two. This probably had an impact on interpretation of the results since the PIDAQ scale was designed to assess the psychosocial impact of dental aesthetics (37), and the OHIP-14 was intended for assessing the impact of oral health on daily activities and functions (34). Nevertheless, a moderate association ($r=0.482$, $p<0.01$) between these two scoring systems was found by Kang et al. (69). Unfortunately, no comparison is presented in the included study by Isiekwe et al. who used both questionnaires (55).

With this in mind, we have made the following interpretation of the results and conclusions from the studies investigated.

The fact that all studies presented at least some and most studies several significant associations between professionally assessment of orthodontic treatment need (indices or specific malocclusions) and OHRQoL (domains or total scores) clearly indicates that malocclusions have an influence on OHRQoL. To what extent is more difficult to conclude because of dissimilar methodology, presentation of results and conclusions in the 11 studies reviewed.

Correlation between orthodontic treatment need assessed with IOTN-DHC and OHIP-14 total score indicated a moderate association (58, 61), however Dalaie et al. (59) reported a disparate strong association. A moderate association is in line with the review of Liu et al. who have reported a “modest association at best”, including all age groups (43), and a study

by Clijmans et al. have reported a modest to weak association between treatment need (IOTN-DHC) and OHRQoL, among adults. Clijmans et al.'s study was not included in our review, due to a large number of orthognathic patients (70). Despite the moderate association, the two studies referred to above concluded that "malocclusion is a key factor associated with poor quality of life" and "has a significant negative impact on OHRQoL" which is somewhat confusing (58, 61).

The most common OHIP-14 domains relating to orthodontic treatment need were physical pain, psychological discomfort, and social disability, which is in line with the review by Sun et al. (46) including all age groups.

The totally separate deductions between the two studies (56, 57) using the DAI index is rather confusing. Chakradhar et al. comes to the conclusion that "Early preventive or interceptive procedures should be carried out to prevent further psychosocial impacts on human life" and despite that their results points in the opposite direction (56). Ashari et al. on the other hand, concludes that "the DAI score does not predict the effect of malocclusion on the OHRQoL" (57). This may to some extent be the result of the different design and intentions with the OHIP-14 and PIDAQ questionnaires and is to some extent supported by Liu et al. who stated that "IOTN-DHC and ICON, were more useful indices in identifying greater differences in OHRQoL", compared to DAI (71).

The three largest studies by far investigated specific malocclusions in relation to OHRQoL, using OHIP-14 or esthetic questions of OHIP (63-65). Masood M. et al. (2017) and Sierwald et al. reported a clear association between overjet and OHRQoL (63, 64), while Silvola et al.'s gender specific analysis reported a remarkably low influence on OHRQoL (65). Sierwald et al. concluded that a substantial increase was needed to affect OHRQoL and only then very likely to be clinically relevant (64).

Overbite on the other hand was not found to be "significantly or relevantly" associated with OHRQoL by Masood M. et al. (2017) and Sierwald et al. (63, 64). Silvola et al. on the other hand, found deep bite associated with higher OHIP-14 total score, but only for males and open bite only for females. However, the small open bite sample reduces reliability (65) (table 2).

Impact on OHIP-14 from crossbite was investigated by 3 studies (62, 63, 65). Masood M. et al. (2014) found a significant positive correlation between crossbite and OHIP-14 total score

and all domains (62), while Masood M. et al. (2017) found no positive correlation with crossbite (63). The totally different samples regarding number, ethnicity, and age, is possibly the explanation to the disparity. Another explanation could be the different statistical methods used. When Masood M. et al. (2014) continued their analysis with multivariate regression models, controlling for confounding factors, they found that crossbite only accounted for 11% of the variation in OHIP-14 score (62). Silvola et al. found conflicting gender differences that are difficult to explain also for the authors (65). This shows that confounding factors are important to consider when the association between malocclusions and OHRQoL are assessed. These results indicate that crossbite at best had a weak influence on OHRQoL and the clinical relevance must be considered as low.

The studies investigating the influence of specific malocclusions on OHRQoL did demonstrate more diverse results compared to those using indices, at least IOTN-DHC. This may also be a result of the differences regarding number, ethnicity and age, or statistical methods used. But, investigating the impact from specific malocclusions on OHRQoL should provide more detailed and clinically relevant information compared to indices since the number of confounding factors are fewer.

Since crowding is one of the most common malocclusions it is surprising that it is only represented in the indices and not investigated as a single deviation and properly stratified. Probably, anterior crowding has a large impact on both OHIP-14 and PIDAQ scores, which could not be clearly stated from this review.

Five of the studies (58, 59, 61, 62, 64) in our review did not find a significant statistical difference between the genders. This is consistent with the systematic-review performed by Sun et al. (46). Conversely, Silvola et al. found that specific malocclusion traits affected males and females differently. However low prevalence of some malocclusion traits and thereby small sample sizes together with all participants being 46 years old somewhat reduces the generalizability.

Masood Y. et al. (2013) and Masood M. et al. (2014) both indicated a diminishing impact on OHRQoL with age (61, 62), and Silvola et al. concluded that most of the adults with malocclusions seem to adapt to their condition (65). The sample size in the two first studies hardly allow age stratified evaluations and Silvola’s study comprised of 46-year-olds only. So, any age dependent assessment should be interpreted with caution. Furthermore, using the

definition “Adult study population, with majority of participants 18 years or older” must be regarded as a “convenience criterium” and is a weakness of this study in that OHRQoL is likely to change with age.

6 Conclusion

The results in this review clearly demonstrate associations between malocclusions and poor OHRQoL, especially for more severe malocclusions. However, many of the associations must be considered as weak to moderate. The methodological variability and inconsistency in conclusions between the studies makes it hard to evaluate the presented results. Attention should therefore be directed to collecting large, age stratified, representative samples and use of adequate common statistical methods to enhance interpretation of the results. Furthermore, longitudinal studies would give more precise results compared to cross sectional studies.

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Appendix I

Dental health component of the Index of orthodontic treatment need (IOTN-DHC) (72).

GRADE 5 (Need treatment)	
5.i	Impeded eruption of teeth (except for third molars) due to crowding, displacement, the prescence of supernumerary teeth, retained deciduous teeth and any pathological cause.
5.h	Extensive hypodontia with restorative implications (more than 1 tooth missing in any quadrant) requiring pre-restorative orthodontics.
5.a	Increased overjet greater than 9 mm.
5.m	Reverse overjet greater than 3·5 mm with reported masticatory and speech difficulties.
5.p	Defects of cleft lip and palate and other craniofacial anomalies.
5.s	Submerged deciduous teeth.

GRADE 4 (Need treatment)	
4.h	Less extensive hypodontia requiring prerestorative orthodontics or orthodontic space closure to obviate the need for a prosthesis.
4.a	Increased overjet greater than 6 mm but less than or equal to 9 mm.
4.b	Reverse overjet greater than 3·5 mm with no masticatory or speech difficulties.
4.m	Reverse overjet greater than 1 mm but less than 3·5 mm with recorded masticatory and speech difficulties.
4.c	Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact position and intercuspal position.
4.l	Posterior lingual crossbite with no functional occlusal contact in one or both buccal segments.
4.d	Severe contact point displacements greater than 4 mm.
4.e	Extreme lateral or anterior open bites greater than 4 mm.
4.f	Increased and complete overbite with gingival or palatal trauma.
4.t	Partially erupted teeth, tipped and impacted against adjacent teeth.
4.x	Prescence of supernumerary teeth.

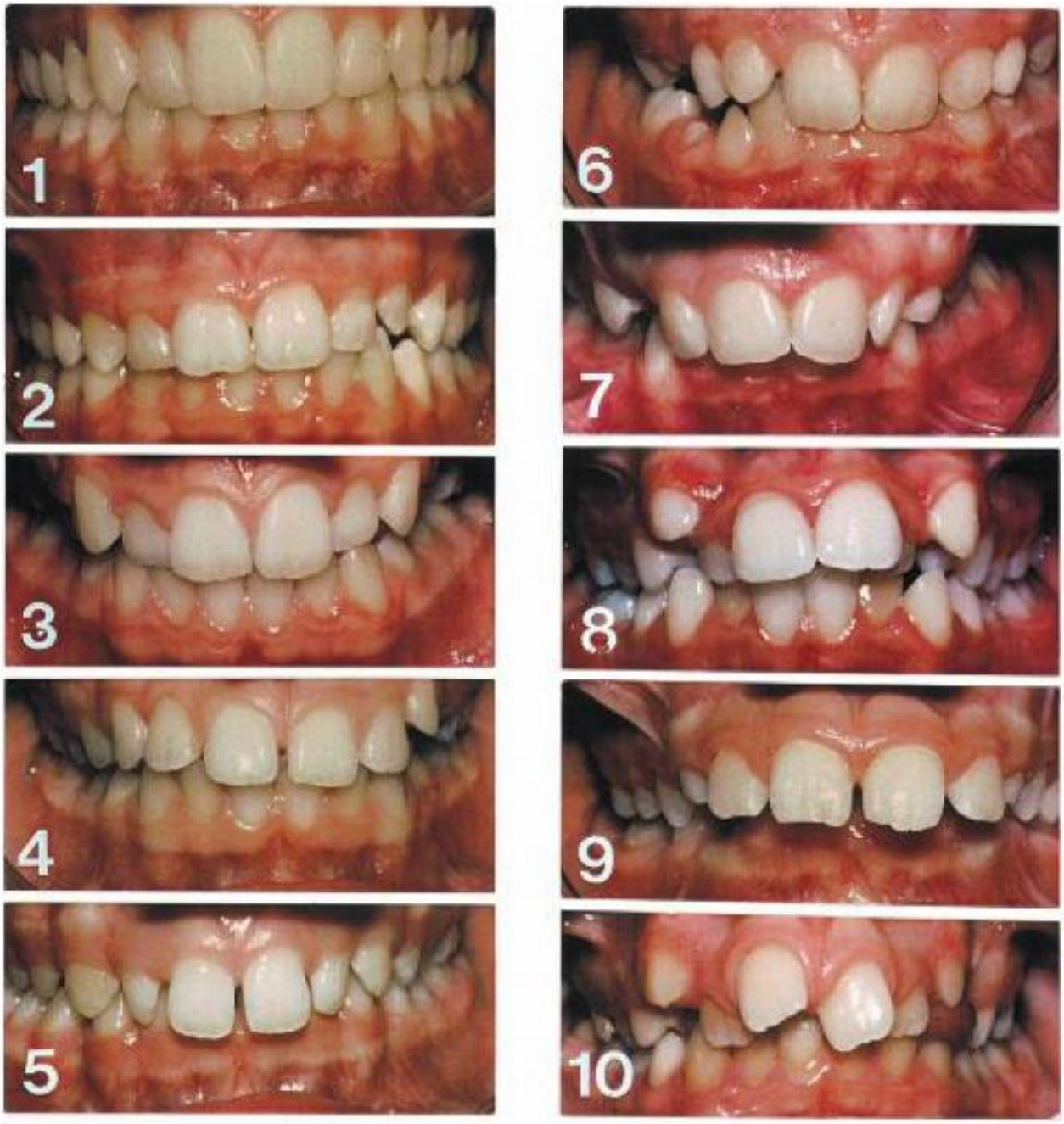
GRADE 3 (Borderline need)	
3.a	Increased overjet greater than 3·5 mm but less than or equal to 6 mm with incompetent lips.
3.b	Reverse overjet greater than 1 mm but less than or equal to 3·5 mm.
3.c	Anterior or posterior crossbites with greater than 1 mm but less than or equal to 2 mm discrepancy between retruded contact position and intercuspal position.
3.d	Contact point displacements greater than 2 mm but less than or equal to 4 mm.
3.e	Lateral or anterior open bite greater than 2 mm but less than or equal to 4 mm.
3.f	Deep overbite complete on gingival or palatal tissues but no trauma.

GRADE 2 (Little)	
2.a	Increased overjet greater than 3·5 mm but less than or equal to 6 mm with competent lips.
2.b	Reverse overjet greater than 0 mm but less than or equal to 1 mm.
2.c	Anterior or posterior crossbite with less than or equal to 1 mm discrepancy between retruded contact position and intercuspal position.
2.d	Contact point displacements greater than 1 mm but less than or equal to 2 mm.
2.e	Anterior or posterior openbite greater than 1 mm but less than or equal to 2 mm.
2.f	Increased overbite greater than or equal to 3·5 mm without gingival contact.
2.g	Pre-normal or post-normal occlusions with no other anomalies (includes up to half a unit discrepancy).

GRADE 2 (Little)	
1.	Extremely minor malocclusions including contact point displacements less than 1 mm.

Appendix II

Aesthetic component of the Index of orthodontic treatment need (IOTN-AC) (72).



Appendix III

Dental aesthetic index (DAI) (73).

DAI component	Regression coefficient	
Weight	Actual weight	Rounded
Number of missing visible teeth (incisors, canines and premolars in the maxillary and mandibular arches)	5.76	6
Crowding in the incisal segments: 0=no segment crowded; 1=1 segment crowded, 2=2 segment crowded	1.15	1
Spacing in incisal segments: 0=no spaced, 1=1 segment spaced, 2=2 segment spaced	1.31	1
Midline diastema in mm	3.13	3
Largest anterior irregularity on the maxilla in mm	1.34	1
Largest anterior irregularity on the mandible in mm	0.75	1
Anterior maxillary overjet in mm	1.62	2
Anterior mandibular overjet in mm	3.68	4
Vertical anterior open bite in mm	3.69	4
Antero-posterior molar relation: Largest deviation from normal either left or right: 0=normal, 1=half cusp either mesial or distal, 2=one full cusp or more, either mesial or distal	2.69	3
Constant	13.36	13
Total	DAI score	

DAI = Dental aesthetic index

DAI score	Severity levels
≤25	Minor or no anomaly: No treatment need
26-30	Definite malocclusion: Elective treatment
31-35	Severe malocclusion: Highly desirable treatment
36-70	Handicapping malocclusion: Mandatory treatment

DAI = Dental aesthetic index

Appendix IV

Oral health impact profile 14 (OHIP-14) (34, 35).

During the last 12 months, how often has the following occurred?		
Dimension	**Question**	**Weight**
Functional limitation	Have you had trouble *pronouncing any words* because of problems with your teeth, mouth or dentures?	0.51
	Have you felt that your *sense of taste* has worsened because of problems with your teeth, mouth or dentures?	0.49
Physical pain	Have you had *painful aching* in your mouth?	0.34
	Have you found it *uncomfortable to eat any foods* because of problems with your teeth, mouth or dentures?	0.66
Psychological discomfort	Have you been *self-conscious* of your teeth, mouth or dentures?	0.45
	Have you *felt tense* because of problems with your teeth, mouth or dentures?	0.55
Physical disability	Has your *diet been unsatisfactory* because of problems with your teeth, mouth or dentures?	0.52
	Have you had to *interrupt meals* because of problems with your teeth, mouth or dentures?	0.48
Psychological disability	Have you found it *difficult to relax* because of problems with your teeth, mouth or dentures?	0.60
	Have you been a bit *embarrassed* because of problems with your teeth, mouth or dentures?	0.40
Social disability	Have you been a bit *irritable with other people* because of problems with your teeth, mouth or dentures?	0.62
	Have you had *difficulty doing your usual jobs* because of problems with your teeth, mouth or dentures?	0.38
Handicap	Have you felt that life in general was *less satisfying* because of problems with your teeth, mouth or dentures?	0.59
	Have you been *totally unable to function* because of problems with your teeth, mouth or dentures?	0.41
Responses are made on a 5-point scale, coded 0=never, 1=hardly ever, 2=occasionally, 3=fairly often, 4=very often.		

Appendix V

Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ) (37).

Dental Self-Confidence

- I am proud of my teeth.
- I like to show my teeth when I smile.
- I am pleased when I see my teeth in the mirror.
- My teeth are attractive to others.
- I am satisfied with the appearance of my teeth.
- I find my tooth position to be very nice.

Social Impact

- I hold myself back when I smile so my teeth don't show so much.
- If I don't know people well I am sometimes concerned what they might think about my teeth.
- I'm afraid other people could make offensive remarks about my teeth.
- I am somewhat inhibited in social contacts because of my teeth.
- I sometimes catch myself holding my hand in front of my mouth to hide my teeth.
- Sometimes I think people are staring at my teeth.
- Remarks about my teeth irritate me even when they are meant jokingly.
- I sometimes worry about what members of the opposite sex think about my teeth.

Psychological Impact

- I envy the nice teeth of other people.
- I am somewhat distressed when I see other people's teeth.
- Sometimes I am somewhat unhappy about the appearance of my teeth.
- I think most people I know have nicer teeth than I do.
- I feel bad when I think about what my teeth look like.
- I wish my teeth looked better.

Aesthetic Concern

- I don't like to see my teeth in the mirror.
- I don't like to see my teeth in photographs.
- I don't like to see my teeth when I look at a video of myself.

Appendix VI

Newcastle Ottawa scale (NOS) (50).

S1 Text
NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
(adapted for cross sectional studies)

Selection: (Maximum 5 stars)

1) Representativeness of the sample:
   a) Truly representative of the average in the target population. * (all subjects or random sampling)
   b) Somewhat representative of the average in the target population. * (non-random sampling)
   c) Selected group of users.
   d) No description of the sampling strategy.
2) Sample size:
   a) Justified and satisfactory. *
   b) Not justified.
3) Non-respondents:
   a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *
   b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.
   c) No description of the response rate or the characteristics of the responders and the non-responders.
4) Ascertainment of the exposure (risk factor):
   a) Validated measurement tool. **
   b) Non-validated measurement tool, but the tool is available or described.*
   c) No description of the measurement tool.

Comparability: (Maximum 2 stars)

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
   a) The study controls for the most important factor (select one). *
   b) The study control for any additional factor. *

Outcome: (Maximum 3 stars)

1) Assessment of the outcome:
   a) Independent blind assessment. **
   b) Record linkage. **
   c) Self report. *
   d) No description.
2) Statistical test:
   a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). *
   b) The statistical test is not appropriate, not described or incomplete.

Appendix VII

Our procedure for assessment with NOS.

In the selection section a sample size was justified and satisfactory if the study had 100 participants or more and awarded a point. Only one (63) of the articles was rewarded a point for representativeness of the sample, while another (64) combined three study samples, one being randomized, but didn't receive a point. If the article used one of the indices mentioned in our inclusion criteria, it would be awarded two points. One point was awarded for non-validated measurement tools if it was available or described, for instance if the article measured a well-known malocclusion trait such as overjet, overbite etc. In the Comparability section the most important confounding factor was either gender or age. But confounding factors such as caries, socioeconomic and periodontal disease also added a point, in this section a maximum of two points. Confounding factors adjusted for using restriction in the study design also gave points if necessary. In the outcome section all our articles received a point for self-report and a point for appropriate and clearly described statistical test used to analyze data with accompanying p-values or confidence intervals.