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Does Malocclusion affect Oral Health-related Quality of Life? A Review Of The Literature

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Abstract

Introduction: The provision of orthodontic treatment is often considered on the basis of providing functional and psychosocial benefits to patients. It is important to understand these benefits in order to ensure appropriate use of public and private funds. If orthodontic treatment provides significant long-term psychosocial benefits, efforts should be made to reduce socioeconomic disparities in access to orthodontic care.

Methods: This review considered evidence on whether malocclusion and orthodontic treatment are associated with oral health-related quality of life and psychosocial health. A Medline literature search of scientific articles published from 2000 to 2020 using MeSH terms "Malocclusion", "Orthodontic treatment" "Quality of Life", "Oral Health-Related Quality of Life" and "Psychological" was conducted and these articles were critically reviewed.

Results: The evidence for an association between malocclusion and oral health-related quality of life should be described as 'weak', as it is mostly based on low-level evidence from cross-sectional studies and cohort studies with short-term follow-up. There is some evidence to support specific malocclusion traits as being important for quality of life, however further research is needed to assess the role of potential confounders, such as age and dental health. Specifically, the traits of hypodontia (with loss of deciduous teeth), large (or 'increased') overjet, dental crowding, spacing and class III malocclusion appear to be associated with impacts on oral health-related quality of life. There is a lack of evidence for a psychosocial benefit from correction of malocclusion traits (including class III malocclusion) except for some evidence for benefits to self-esteem from early treatment of class II malocclusion.

Conclusion: Available evidence suggests that malocclusion (and certain malocclusion traits) are associated with poorer oral health-related quality of life, but there is a lack of high quality evidence that orthodontic treatment has OHRQoL benefits and further evidence is required from cohort studies and controlled trials with appropriate long-term follow-up.

Introduction

Dental malocclusion is defined as "a deviation in the relationship of the teeth within each arch to a smoothly curving line of occlusion and between the upper and lower teeth" (Proffit 1986). They are generally attributable to variation in normal development, however they tend not to self-correct (Helm and Petersen 1989). Dental malocclusions affect up to 78% of school-aged children in New Zealand (Johnson and Harkness 2000).

Some malocclusion traits, such as palatally-displaced maxillary canines, can result in damage to adjacent tooth roots (Ericson and Kurol 2008), while dentoalveolar trauma occurs more frequently among those with increased overjet (Järvinen 1978; Koroluk et al. 2003; Shulman and Peterson 2004). The correction of these anomalies may lead to direct benefits to dental health, although there is controversy about other claimed benefits for dental health, such as caries and periodontal disease prevention (Luther et al. 2010; Hafez et al. 2012; Benson et al. 2015). Nevertheless, a possible rationale for the provision of orthodontic treatment is the perceived psychosocial benefits it may provide (Shaw et al. 1980). There is disagreement in the current literature as to whether orthodontic treatment has benefits for long-term oral health-related quality of life.

A global shift towards a more patient-centred approach has been accompanied by increasing acknowledgement of the importance of how people perceive their health. Measures of Oral Health-related Quality of Life (OHRQoL) attempt to approximate the 'impact of oral diseases and disorders on everyday life that a patient or person values, that are of sufficient magnitude, in terms of frequency, severity and duration to affect their experience and perceptions of their life overall" (Locker and Allen 2007). WHO considers having good OHRQoL to be essential for general health and wellbeing (Sischo and Broder 2011).

In order to ensure appropriate use of public and private funds, it is important to understand the benefits of orthodontic treatment, including its purported psychosocial effects (Sischo and Broder 2011; Dimberg et al. 2018). If orthodontic treatment provides a significant long-term psychosocial benefit to patients then it is appropriate that efforts be made to reduce socioeconomic disparities in access to care. There is some evidence that individuals without the opportunity to correct their malocclusion may have poorer employment opportunities later in life based on social judgements and a lack of self-confidence, and this may increase health disparities (Lee 2017). Therefore, the aim of this article is to review current literature on the following questions: (1) Are dental malocclusions (including specific classifications of malocclusion) associated with poor OHRQoL? (2) Is correction of malocclusion through orthodontic treatment associated with lasting improvement in OHRQoL?

Methods

A Medline literature search was conducted of scientific articles published from 2000 to 2020 using MeSH terms "Malocclusion", "Orthodontic treatment" "Quality of Life", "Oral Health-Related Quality of Life" and "Psychological". Abstracts were reviewed and screened by study type, including all meta-analyses, randomised control trials, longitudinal prospective studies, retrospective studies and cross-sectional studies.

Measuring Oral Health-Related Quality of Life

Numerous scales for measuring OHRQoL have emerged, broadly categorised into generic and disease-specific measures (Allen et al. 1999). Generic measures evolved for use across a wide range of diseases and conditions, not purely oral health. These measures can enable valuable comparisons between population groups but their lack of sensitivity to oral health is a substantial drawback (Patrick and Deyo 1989). Specific measures focus on evaluating the psychosocial aspects specifically affected by oral conditions and thus have greater responsiveness (ability to detect small clinical changes) than their generic counterparts.

An example of one popular measure of OHRQoL is the Oral Health Impact Profile (OHIP-14). OHIP-14 has been widely used as it is practical for use in epidemiological and clinical research and has good reliability and validity (Zhang et al. 2006). Research participants are asked to report whether they have experienced problems due to their teeth, mouth or dentures during the past 4 weeks, rating each item on a 5-point Likert scale (4, very often; 3, fairly often; 2, occasionally; 1, hardly ever; and 0, never) (Slade 1997). Locker's theoretical model of oral health is used to organise these items into seven domains including functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. A higher overall score indicates a greater impact on OHRQoL (Slade and Spencer 1994).

Another popular measure of OHRQoL is the child perception questionnaire (CPQ_{11-14}) (Cunningham & O'Brien, 2007). The questionnaire consists of 36 items which relate to four major health domains: oral symptoms, functional limitations, emotional well-being and social well-being. Each question asks about the frequency of events in the last 3 months. There are also global ratings of the child's oral health and the extent to which the condition affected oral well-being. This questionnaire was developed for use with 11- to 14-year-olds so has become widely used in orthodontics due to the age group it has been developed for and tested on.

Malocclusion and Quality of Life

The association between malocclusion and quality of life has not been well established, as past research is of low-level evidence, such as cross-sectional studies with a lack of appropriate control groups (Table 1) (Andiappan et al. 2015; Sun et al. 2018). The best available evidence suggests that people with a malocclusion have poorer OHRQoL than those without. A recent meta-analysis reported a standardised mean difference in total OHIP-14 score of 0.84 (95% CI:0.25 to 1.43) between those with malocclusion and those without. According to the Cohen's benchmark values of small (0.20), moderate (0.50) and large (0.80) effect, this would be considered a large effect size; however this should be taken with caution, given the low quality of the evidence available, and the lack of control groups or follow-up assessment (Cohen 1977; Andiappan et al. 2015). The meta-analysis concluded that there are no high quality studies that have investigated the association of malocclusion and quality of life (longitudinal studies) or its associated treatment (randomised control trials). Most of the evidence is cross-sectional and is based on reduced samples of individuals (Sun et al. 2017). Nevertheless, the best current evidence suggests that severity of malocclusion appears to be well-correlated with worse oral health-related quality of life scores.

Another systematic review reported the associations between malocclusion and quality of life to be modest at best, again based mostly on cross-sectional studies (Liu et al. 2009). This review included 19 cross-sectional studies of low-level evidence. There were four longitudinal studies included in this analysis however the heterogeneity of different methods for assessing malocclusion and quality of life meant that no meta-analysis could be conducted. Two of the longitudinal studies were based on the same source of data and suffered poor retention of participants with only 33% returning for 20-year follow up (Table 2) (Kenealy et al. 2007; Shaw et al. 2007). The third study was a validation of the child-perception questionnaire and had a very short follow-up period (O'Brien et al. 2006).

A recent systematic review and meta-analysis by Kragt *et al.* included 40 cross-sectional studies (Kragt et al. 2016). They found that the odds ratio for having an impact on OHRQoL was 1.74 times higher in children with malocclusion than in children without malocclusions and concluded there was a clear association between malocclusion and poor oral health-related quality of life. The strength of the association differed for children of different age groups with children between the age of 11 and 14 being the most likely to have any impacts from malocclusion on OHRQoL whilst children older than 14 showed the biggest impact of malocclusions on OHRQoL. They argued that OHRQoL might be different in children than in adults so they should not be assessed simultaneously. They also showed differences in the association of malocclusion and OHRQoL between the countries of study conduction, which reflects possible societal differences and access to care.

Malocclusions affecting the aesthetic zone are thought to have a more significant impact on the emotional and social aspect of the oral health-related quality of life domains for children and adolescents. These include anterior crowding, midline diastema and increased overjet. This conclusion was based on a systematic review which considered cross-sectional studies to be of high level evidence as long as their design controlled for the four types of bias: selection, performance, attrition and detection bias (Dimberg et al. 2018).

The role of orthodontics in improving oral health-related quality of life has been assessed in a small number of cohort and cross sectional studies (Javidi et al. 2017). A meta-analysis found a moderate improvement in OHRQoL before and after orthodontic treatment (n=243; SMD = -0.75, 95% CI -1.15 to -0.36), particularly in the domains of emotional wellbeing and social wellbeing. The timing of the post-treatment quality of life assessment seems critical in assessing the outcomes. A New Zealand-based study demonstrated that the benefits of orthodontic treatment tend to manifest themselves some months after treatment (Healey et al. 2016).

Several New Zealand-based studies have assessed the effect of malocclusion and orthodontic treatment on quality of life. A cross-sectional study of adolescents in Taranaki and Otago found that severe malocclusion is associated with poorer OHRQoL of New Zealand adolescent females when controlling for DMFS and socio-demographic characteristics (Ukra et al. 2013). A short-term prospective longitudinal study was conducted across 19 different private orthodontic practices (Healey et al. 2016). The study found that malocclusion significantly affected quality of life before orthodontic treatment and there is a small improvement in OHRQoL immediately at debond with the benefits of orthodontic treatment manifesting themselves some months later (Healey et al. 2016). A hospital-based study found a significant improvement in quality of life for patients with severe malocclusions, including patients with craniofacial abnormalities (Antoun et al. 2015). In the medium-term (5-7 years post treatment), these improvements seemed to diminish according to a 5 year follow up study (Nichols et al. 2018). Finally, a qualitative study assessing the negative impact of malocclusion on quality of life among adolescents found that more than half of individuals with malocclusions hide their mouth in social space and half were being bullied (Smith et al. 2018). The effects of severe malocclusion were also felt by the parent who felt highly "emotional" about the effect that malocclusion was having on their child and guilty for being unable to afford orthodontic care.

Different malocclusion traits are likely to have varying impacts on an individual's quality of life. In the current review, the evidence for the effect of specific malocclusion traits on oral health-related quality of life has been explored more closely.

Hypodontia (Missing Teeth)

'Hypodontia' is the term given for the condition where fewer than six teeth are congenitally absent whilst 'oligodontia' refers to a condition in which six or more teeth are congenitally missing (excluding third molars) (Der Weide et al. 1994). Congenital hypodontia affects between 5.3-7.9% of children and could potentially have an impact on both the functional and psychological domains of OHRQoL (Magnússon 1977; Dhanrajani 2002). Masticatory performance is the ability to break down foods and is directly influenced by the state of the dentition (Owens et al. 2002). From a functional perspective, several studies have shown that the number and size of occlusal contacts are the primary determinants of masticatory function, with the other major factors being maximum occlusal force and amount of lateral excursion during mastication (Yurkstas and Manly 1949; Julien et al. 1996). Certain malocclusions which have a reduced number of occlusal contacts, such as missing teeth, may result in impaired masticatory function (Owens et al. 2002). There are two questions in the OHIP-14 questionnaire dedicated to assessing the perceived effect of the state of the dentition on mastication and these include: "In the past three months, have you had to interrupt meals because of problems with your teeth, mouth and dentures?" and "Because of problems with your teeth, mouth and dentures have you found it uncomfortable to eat any foods?". These questions give an idea of the functional limitations and physical pain experienced by the individual. There is strong evidence that tooth loss is negatively associated with OHRQoL however fewer studies have assessed congenitally missing teeth (Brennan et al. 2008; Haag et al. 2017).

Missing posterior teeth in more than one quadrant has been reported to be strongly correlated with a reduced oral health-related quality of life and perceived chewing ability (Dhingra et al. 2017). The ability of patients with hypodontia to chew is affected by whether the deciduous tooth associated with the missing permanent teeth has exfoliated (Laing et al. 2010). The presence of deciduous teeth in the site where a tooth is congenitally missing appears to have a significant impact on OHRQoL. A Hong Kong-based cross-sectional study including 25 children with hypodontia found an association between congenitally-missing teeth and poor OHRQoL, however this diminished if deciduous teeth were retained in these sites (Wong et al. 2006). The prevalence of impacts reported for patients with hypodontia was high for functional limitations (88%) and emotional wellbeing (88%). A similar study based in Canada at the Hospital for Sick Children, University of Toronto found that 88.9% of children with missing teeth had one or more impacts in the past three months, particularly with regard to functional limitations (Locker et al. 2010). These studies did not use any control groups and were limited in their study design by the use of convenience samples and low sample size. Nevertheless, they suggest a high prevalence of impacts on OHRQoL in patients with hypodontia.

Given the complexity of management of patients with hypodontia, a condition-specific measure of OHRQoL may be more appropriate. A Dutch study assessed the condition-specific OHRQoL in 11-17 year olds patients with untreated oligodontia and included patients with other untreated malocclusions (Filius et al. 2019). Older children with oligodontia tended to have their quality of life more negatively influenced than younger people. The main areas of concern for patients with oligodontia was the overall appearance and the complexity of treatment. This study was based in Holland, where most children have relatively equitable access to orthodontic care in a public setting and patients with oligodontia are treated early in major centres.

Overall, there is sparse high quality literature on the relationship between OHRQoL and hypodontia however the current literature suggests that there may be an impact on both function and psychological wellbeing. The literature has not differentiated missing anterior and posterior teeth which are likely to have varying impacts on quality of life relating to function and aesthetics. The studies demonstrate that the quality of care available is likely to have a large impact on the individuals' perceived quality of life given the complex nature of treatment for patients with hypodontia as well as the presence of a deciduous tooth in that site, particularly for anterior teeth.

Increased Overjet

A dentition where the maxillary incisors are labially inclined and there is an increased overjet is known as a class II division 1 malocclusion with high prevalence (~25%) among those of European ethnic groups (Angle 1899, Bishara 2006). The evidence that an increased overjet adversely affects quality of life is of a higher quality than for other types of malocclusion. It appears that early treatment for patients with an increased overjet may have some psychosocial benefit although these findings are not consistent throughout the literature and may reflect differences in samples, for example between British versus American children (Tung and Kiyak 1998; O'Brien et al. 2003).

A British randomised control trial investigated whether the use of twin block appliances for early correction of an increased overjet among children aged 8-10 years was associated with changes in scores on the Piers-Harris Children's Self-Concept Scale, the Childhood Experience Questionnaire, and the Perceptions of Benefits of Orthodontic Treatment Scale after 15 months of follow-up. Those who received the early intervention (n=174) reported higher self-concepts and more positive childhood experiences than did the controls, who received no orthodontic treatment (O'Brien et al. 2003).

Another prospective study recruited 13-15 year-old patients on the basis of predetermined criteria: increased overjet (>6mm), spaced dentition (>1.5mm and overjet <6mm) and a control group with no malocclusion traits (Johal et al. 2007). The study was based at the Royal London Dental Hospital and the Child Oral Health Quality of Life Questionnaire (COHQOL) was used. The study found that children who presented with an increased overjet or spacing were significantly more likely to have a poorer oral health-related quality of life compared to those with no malocclusion (Johal et al. 2007).

A German cross-sectional study including 1968 individuals assessed the aesthetic impact on quality of life for people with increased overjets and overbites. Individuals with an increased overjet beyond the reference range (greater than 4mm) had a significant aesthetic impairment (Sierwald et al. 2015).

Each of these studies included individuals treated in hospital or university settings which may limit their external validity nevertheless, they are well designed studies which provide relatively high level data to suggest that there is a strong relationship between an increased overjet and poorer oral health-related quality of life.

Reverse Overjet (Class III)

Reverse overjet (also termed 'class III malocclusion') is characterised by either a retrognathic maxilla or a prognathic mandible, or both (Ngan and Moon 2015). This malocclusion is more prevalent among Asian (23%) than Caucasian populations (5%) (Lew et al. 1993). Orthodontic treatment of reverse overjet may follow one of three major therapeutic approaches, namely: (1) growth modification at the pre-pubertal stage, (2) camouflage treatment after the growth spurt, or (3) decompensation and orthognathic surgery (Rezaei et al. 2019). A randomised controlled trial reported no significant improvement in self-esteem among 35 children less than 10 years old who received early correction of reverse overjet relative to 38 children less than 10 years old who did not receive treatment, after 15 months (Mandall et al. 2010), 36 months (Mandall et al. 2012) and 6 years of follow-up (Mandall et al. 2016). This research does not support the claim of psychosocial benefit from early treatment of class III malocclusion; however, the assessment of self-esteem may not be specific enough to measure psychosocial benefit. Self-esteem is generally considered to become established during the early years of life and remain relatively stable thereafter (Huang 2010). This study focused on early correction of class III malocclusions in children less than 10 years old so cannot be generalised to older populations.

A number of the studies of quality of life have assessed the third therapeutic approach where the malocclusion requires orthognathic surgery for correction. An observational cross sectional study assessed the oral health-related quality of life, self-esteem and depression in patients with class II and class III skeletal malocclusions before orthodontic treatment (Frejman et al. 2013). They were compared to a control group of individuals with general harmony of profile and normal occlusion. Individuals with severe class II or class III facial profiles had significantly poorer oral health-related quality of life ($p<0.001$) and self-esteem ($p<0.019$) than individuals with harmonious profiles but no differences for depression. A number of studies have demonstrated statistically significant improvements in OHRQoL after surgical treatment with a transient but significant decline in their quality of life during the decompensation phase of treatment as their malocclusion appears to worsen (Tachiki et al. 2018; Rezaei et al. 2019). Another study assessed the impact of skeletal class III deformity before and after orthognathic surgery using a control group of young female students who had normal occlusion using the OHIP-14 questionnaire (Kurabe et al. 2016). Although the control group was a convenience sample including only females, all of the subscale scores of the patients before surgery were significantly higher than those of the control group in all of the seven subdomains (including functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicapping) (Kurabe et al. 2016). These all significantly improved following surgery.

Increased Overbite (Deep Bite)

An increased overbite occurs when the upper incisors are vertically positioned greater than 40% over the lower incisors (Daskalogiannakis, 2000). The prevalence globally is estimated to be 22% (Perillo et al. 2010). Excessively deep overbites can cause direct trauma to the gingiva from the incisal edges of the mandibular incisors occluding against the palatal mucosa behind the central incisors leading to recession in this region (Zhang et al. 2006). Furthermore, severe class II division 2 malocclusions, where the upper incisors are retroclined and contact the gingiva of the lower incisors, can lead to marginal recession of the labial gingiva of the lower incisors. In less severe cases, the relationship between gingival inflammation and malocclusion is controversial and it is generally accepted that malocclusion is a cofactor which may accelerate the rate of development of an existing periodontal disease (Burgett 1995; Blair et al. 1997; Davies et al. 2001). A study which assessed the oral health-related quality of life of patients with severe malocclusions included deep bites in their inclusion criteria (defined as greater than 4mm vertical overlap of upper central incisor to lower central incisor) (Rusanen et al. 2010). This study indicated both that deep bites did not appear to contribute to poor OHRQoL and that it can be difficult to distinguish which aspect of an individual's malocclusion may affect their oral health-related quality of life given that malocclusion traits tend not to occur in isolation.

The relationship between deep bites and oral health-related quality of life was assessed as part of a large cross-sectional study based on 4711 Finnish adults (Masood et al. 2017). As part of a nationwide survey to assess dental health in Finland (n=8028), a total of 4711 people over the age of 30 agreed to complete a questionnaire, home interview and clinical examination. In this study open bites and traumatic deep bites were included together in one category representing vertical problems however these malocclusions are distinct in the effects they may have on the individual. The study found that the mean scores for functional limitation, psychological discomfort and psychological disability were significantly higher for individuals with increased overbites or open bites than those with normal overbite. After undertaking a multivariate regression analysis, they found that the psychological disability domain was the only domain affected by an increased overbite or open bite.

Overall, there have been very few studies conducted to assess the effect of deep bites on oral health-related quality of life. There appears to be little evidence that deep bites are associated with poor OHRQoL.

Anterior Open Bite

Anterior open bites occur when there is an absence of vertical overlap of the upper incisors relative to the lower incisors (Daskalogiannakis, 2000). The prevalence of an anterior open bite varies between age groups given its association with thumb sucking; however it is one of the more prevalent conditions affecting around ~8% of individuals (Onyeaso 2004; Carvalho et al. 2013).

Anterior open bites are rarely associated with speech problems however if combined with an increased overjet, there is some evidence to suggest an association with pronunciation disorders, however this remains controversial (Laine 1992). Anterior open bites have been reported to have little effect on aesthetic-related OHRQoL (Sierwald et al. 2015). Studies of masticatory performance have demonstrated that anterior open bites are not associated with impaired masticatory function however this remains an area of debate among clinicians and it is likely that patient factors such as, adaptability and personality traits play a role (Costa et al. 2019; Piancino et al. 2017). A randomised control trial assessed the effect of correction of anterior open bites on OHRQoL for 8-10 year old children (Pithon et al. 2019). The correction of an anterior open bite was associated with an improvement in OHRQoL however the results may not be generalisable to other age groups.

Crowding and Spacing

Dental crowding occurs due to a discrepancy in tooth size and jaw size that results in a misalignment of tooth positions (Lestrel et al. 2004). Spacing is characterised by interdental spaces and lack of contact points between teeth and generally occurs due to local factors such as missing or small teeth, hypertrophic frenal attachments, periodontal disease, tongue dysfunction/anomalies and sucking habits (Gkantidis et al. 2007). A midline diastema is spacing that occurs between the central incisors (Gass, 2003). Crowding and spacing are commonly reported as the most prevalent malocclusions among school aged children (Ajayi 2009; Shivakumar et al. 2009; Anthony et al. 2018). A cross-sectional study of school children aged 12-14 assessed the role of different malocclusions on quality of life (Anthony et al. 2018). Crowding, diastema and spacing showed significant impacts on OHRQoL after controlling for sex, age and socioeconomic status and with increasing age, malocclusion has a greater effect on OHRQoL. Children with crowding, diastema and spacing were four times more likely to report impacts on OHRQoL than children without malocclusions. A systematic review also showed that crowding and diastema were associated with bullying and lower self-esteem and consistently showed negative effects on OHRQoL (Dimberg et al. 2018). The main impacts appear to be on the patient's self-concept and psychological functioning and there is relatively strong evidence that dental spacing has a negative impact on QoL for both the child and the parent (Johal et al. 2007).

Craniofacial Anomalies

Craniofacial orthodontics involves caring for patients with severe developmental malformations, such as cleft lip and/or palate. A New Zealand hospital-based longitudinal study assessed the medium-term changes (5-7 years) in oral health-related quality of life of patients with severe malocclusions (Nichols et al. 2018). This study assessed patients with severe malocclusions (DAI score >36) and included cleft and orthognathic patients as three

comparative groups. The study found that orthodontic treatment was associated with significant improvements in oral health-related quality of life, particularly in the social and psychological domains. This finding is supported in other literature assessing masticatory function in patients with severe malocclusions (Choi et al. 2010). The study also found that the perceived beneficial effects of orthodontic treatment on oral health-related quality of life gradually diminished over time however in most patients this was to a level which was still better than their pre-treatment quality of life. It is unclear whether this is due to a shift in the patients' attitudes, relapse of the malocclusion, or other contributory factors, such as, tooth loss or decay (Nichols et al. 2018).

Conclusion

There is some evidence that malocclusion may be associated with a poor oral health-related quality of life. The timing of treatment, age of the patient and type of malocclusion appears to have an effect on reported OHRQoL. Specific malocclusions, such as missing teeth in the presence of no retained deciduous teeth, increased overjet, surgical class III, spacing, crowding and craniofacial anomalies have all been demonstrated in the literature to show some impact on oral health related quality of life however this is generally based on low quality research with small sample sizes. The treatment itself, particularly for orthognathic surgery patients, leads to a transient decline in OHRQoL and the effects of treatment on OHRQoL may become more apparent several months after it is completed. There is a need for much stronger evidence, such as prospective longitudinal studies which assesses the effect of specific malocclusions on oral health related quality of life in both individuals with and without malocclusions in order to understand the role that specific malocclusions play in determining an individual's oral health-related quality of life.

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Table 1: Summary of Systematic Reviews

Study	Design/type	Intervention & Follow-up	Main outcome measure	Main findings
Andiappan et al., 2015	Systematic review and meta-analysis	25 studies using OHIP-14 with individuals 15 years and older	Standardised mean difference in OHIP-14 for: Studies comparing the same group before and after treatment Studies comparing groups with and without malocclusion	Oral health related quality of life improved after receiving treatment Oral health related quality of life was better in individuals without malocclusion compared to those with malocclusion. There was a lack of standardisation in study design and reporting of OHIP-14 score and overall poor evidence.
Lui et al., 2009	Systematic review	23 studies published between 1960 and 2007 on malocclusion and quality of life. The populations ranged from child/adolescent (18) and adult (5). Malocclusion classified based on index of orthodontic treatment need.	Child Perception Questionnaire (CPQ) Oral Impact on Daily Performance (OIDP)	Too much variation in assessment methods to conduct meta-analysis Association was shown between malocclusion, orthodontic treatment and QoL ($p<0.05$). Strength of correlation ranged from 0.15-0.45. Strength of association after adjusted linear and logistic regression was >4.0 in some studies.
Kragt et al., 2016	Systematic review and meta-analysis	40 cross sectional studies	Child Perception Questionnaire Oral impact on daily performance Early Childhood Oral Health Impact Scale Child Oral Health Impact Psychosocial Impact of Dental Aesthetics Questionnaire Oral Health Impact Profile (OHIP-14)	Children with malocclusions are 1.74 times morelikely to have an impacted OHRQoL than children without malocclusion.
Javidi et al., 2017	Systematic Review and Meta-analysis	9 cohort, 3 cross-sectional, 1 case-control study. The population included individuals aged <18 years who underwent non-orthognathic/ cleft orthodontic treatment were compared before- and after- orthodontic treatment and/or with non-orthodontic controls	Child Perception Questionnaire Oral Health Impact Profile (OHIP-14)	A moderate improvement in OHRQoL was observed after orthodontic treatment (n = 243 participants; SMD =-0.75, 95% CI -1.15 to -0.36) particularly in the dimensions of emotional well- being (n = 213 participants; SMD = -0.61, 95% CI -0.80 to -0.41) and social well-being (n = 213 participants; SMD = -0.62, 95% CI -0.82 to -0.43). More high quality evidence is needed.
Dimberg et al., 2018	Systematic review	6 publications were included, all of cross-sectional design	Child Perception Questionnaire Oral Health Impact Profile (OHIP-14) Dental Aesthetic Index	There is strong evidence that malocclusion in the aesthetic zone has a negative impact on quality of life, predominantly in the dimensions of emotional and social wellbeing.

Table 2: Summary of Key Studies

Study	Country	Design/type	Intervention & Follow-up	Main outcome measure	Main findings
Malocclusion and Quality of Life					
Kenealy et al., 2007 Shaw et al 2007	Wales	Prospective longitudinal study	Individuals aged 11-12 at baseline (n=1018) in 1981 in Cardiff. 337 individuals (33% or original sample) were followed up at age 30-31.	Pre-treatment orthodontic need Rosenberg Self-esteem scale Radloff, 1977 Satisfaction with Life Scale (Diener 1985) World Health Organisation WHOQOL-BREF Quality of Life Scale, Generalised Self-Efficacy Scale (GSES), Life Events Inventory Health status and OHRQoL Dental Health Beliefs, SF36v2 Health Survey Self-ratings of attractiveness Satisfaction with appearance Judged assessment of facial and dental attractiveness Awareness and satisfaction with dental status Perception of general oral health Aesthetic appearance of teeth Need for orthodontic Treatment (ICON)	The observed effect of orthodontic treatment on self-esteem at outcome was accounted for by self-esteem at baseline. Prior need for treatment assessed in childhood made a small contribution to the prediction of self-esteem in adulthood. When prior need for treatment was taken into account, there was little objective evidence to support the assumption that orthodontics improves long-term psychological health
Masood, 2013	Malaysia	Cross sectional study	323 individuals aged 15-25 attending an orthodontic clinic.	Oral Health Impact Profile (OHIP-14) Index of Orthodontic Treatment Need – Dental Health Component (IOTN-DHC)	Malocclusion has a significant negative impact on OHRQoL, particularly in the psychological domain.
Ukra et al., 2013	New Zealand	Cross sectional Study	783 individuals were examined and completed questionnaires.	Clinical Examination Dental Aesthetic Index (DAI) Child Perceptions Questionnaire (CPQ) Decayed Missing Filled Surfaces (DMFS)	Severe malocclusion appears to have a negative impact on the OHRQoL of New Zealand adolescents when controlling for DMFS and sociodemographic characteristics.
Healey et al., 2016	New Zealand	Longitudinal study	174 individuals aged 10-17 years who underwent orthodontic treatment in 19 specialist orthodontic practices around New Zealand. Patients were assessed before treatment, at debond (n=152 87.4%) and 21 months post debond (n=104 59.4%)	New Zealand Socioeconomic Index Child Perception Questionnaire Dental Aesthetic Index	There is a very small improvement in OHRQoL immediately at debond however this increased with time, with the benefits of orthodontic treatment for OHRQoL manifesting themselves some months later.
Hypodontia					
Dhingra et al., 2017	India	Cross-sectional study	300 individuals attending a private clinic had their chewing ability assessed using a questionnaire and OHRQoL assessed using OHIP-14.	Eichner Index (occlusal support) Perceived chewing ability questionnaire Oral Health Impact Profile (OHIP-14)	Missing posterior teeth in more than one quadrant is strongly correlated with a reduced quality of life and perceived chewing ability (r=0.31 p<0.0001)

Study	Country	Design/type	Intervention & Follow-up	Main outcome measure	Main findings
Laing et al., 2010	England	Cross-sectional study	123 individuals with either hypodontia or another malocclusion of similar severity (IOTN DHC 4 or 5) without hypodontia were assessed.	Child Perception Questionnaire Global health questionnaire	No significant difference in the CPQ scores for patients with hypodontia compared to other routine orthodontic groups however severe hypodontia was significantly associated with poorer chewing ability in patients who had lost deciduous teeth in the position of the missing adult tooth.
Wong et al., 2006	Hong Kong	Cross-sectional study	25 individuals with severe hypodontia (4 or more missing teeth) aged 11-15 recruited from a hospital setting.	Child Perception Questionnaire Clinical exam and OPG	There was a moderate correlation between presence of missing teeth and CPQ score with an overall CPQ score (r=0.54), OS (r=0.41), FL (0.52), EWB (0.52), SWB (0.49). There were at least one of more impacts reported by each individual. The retention of a deciduous anterior tooth in the position where a permanent tooth was missing strongly affected the correlation between CPQ and number of missing teeth.
Locker et al., 2010	Hong Kong	Cross-sectional study	36 individuals aged 11-14 years with oligodontia recruited as a convenience sample from orthodontic clinics in hospital settings.	Child Perception Questionnaire	Children with oligodontia experience significant functional and psychosocial impacts. There was a relatively weak correlation between the emotional wellbeing subscale and missing teeth number (r=0.22).
Filius et al., 2019	Holland	Cross-sectional study	28 individuals with oligodontia (>6 missing teeth) aged 11-17 were consecutively recruited to undertake condition-specific OHRQoL assessments. 23 orthodontic patients without any missing teeth aged 11-17 years were used as a control.	Child Oral Health Quality of Life Questionnaire	Older oligodontia patients (13-17 years) tended to have poorer OHRQoL than younger patients (11-12 years) (p=0.048).
Increased overjet					
O'Brien et al., 2003	United Kingdom	Multicentre randomised control trial	174 individuals aged 8-10 years with class II division 1 malocclusion. Individuals were randomly allocated to receive treatment with a twin block (growth modification appliance) or no treatment. Data was collected at start of study and 15 months later.	Piers-Harris Children's Self Concept Scale Clinical Examination	Early treatment with twin block resulted in an increase in self-concept and reduction of negative social experiences. The twin block group showed significantly better self-concept scores when controlling for baseline score (an increase in total score by 4 points p<0.005)
Tung and Kiyak 1998	United States of America	Cross-sectional study	148 individuals aged 9 to 12 years, 37 individuals of the same age who had been examined by an orthodontist an orthodontic clinic.	Expectations from treatment Childs body image Self-concept Perceptions of malocclusion	A low percentage of children perceived a need for treatment if they had an increased overjet.
Johal et al., 2007	England	Cross-sectional study	90 individuals aged 13 to 15 were recruited from a hospital setting. 13-15 years olds with increased overjet (>6mm), space dentition (>1.5mm) and other malocclusion group.	Child Oral Health Questionnaire (COHQoL)	An increased overjet has a significant impact on quality of life compared with other malocclusion traits (p<0.05)

Study	Country	Design/type	Intervention & Follow-up	Main outcome measure	Main findings
Overbite (anterior open bite and deep bite)					
Rusanen et al., 2010	Finland	Cross sectional study	92 females, 59 males with a mean age of 35.5 who had been referred for orthodontic or orthognathic treatment in a hospital setting.	Oral Health Impact Profile (OHIP-14) Clinical exam	Subjects with an open bite reported discomfort more often when eating foods (p-0.020) compared with those who had normal vertical overlap or deep bites.
Masood et al., 2017	Malaysia	Cross sectional study	4711 individuals aged >30 were included from the Health 2000 Survey, Finland.	Oral Health Impact Profile (OHIP-14) Clinical Exam	The mean OHIP score was higher (worse) in people with an increased overjet but not significantly different in people with crossbite/scissor bite or increased overbite/ open bite. Following regression analysis, the psychological disability domain was the only domain affected by increased overbite.
Reverse overjet					
Mandall et al., 2010	United Kingdom	Multicentre randomised control trial	73 individuals with reverse overjet aged less than 10 years at baseline were included: 35 intervention group, 38 control. 15 month follow up after early correction of reverse overjet with facemask device.	Piers-Harris score Oral Aesthetic Subjective Impact Score (OASIS)	There was no increased self-esteem for treated children compared to controls (p-0.22) however there was a reduced impact of malocclusion (OASIS) for the treatment group (p=0.003) suggesting treatment resulted in slightly less concern about tooth appearance.
Mandall et al., 2012	United Kingdom	Multicentre randomised control trial	73 individuals with reverse overjet aged less than 10 years at baseline were included: 35 intervention group, 38 control. 36 month follow up after early correction of reverse overjet with facemask device	Piers-Harris score Oral Aesthetic Subjective Impact Score (OASIS)	There was no increase in self-esteem for treated individuals compared with untreated controls at 3 year follow up
Mandall et al., 2016	United Kingdom	Multicentre randomised control trial	73 individuals with reverse overjet aged less than 10 years at baseline were included: 35 intervention group, 38 control. 6 year follow up of early correction of reverse overjet with facemask device	Piers-Harris score Oral Aesthetic Subjective Impact Score (OASIS)	There was no statistically significant difference between the protraction facemask and control group for skeletal/occlusal improvement, self-esteem or oral aesthetic impact.
Frejman et al., 2013	Brazil	Cross-sectional study	34 individuals with 'dentofacial deformities' (88.2% class III) and 34 without 'dentofacial deformities'. Mean age 27.6	Oral Health Impact Profile (OHIP-14) Rosenberg Self-Esteem Scale (RSE) General Hospital Depression Scale	Individuals with dentofacial deformities had significantly poorer oral health related quality of life and self-esteem compared with controls. No association was found between depression and dentofacial deformities.
Rezaei et al., 2019	Iran	Cross-sectional study	112 skeletal class III individuals (M=39, F=73) divided into 3 groups (pre-treatment, undergoing orthodontic treatment prior to surgery, after surgery) completed questionnaires.	Oral Health Impact Profile (OHIP-14) Orthognathic quality of life questionnaire (OQLQ)	OHRQoL scores were significantly better in the group after orthognathic surgery compared to pretreatment group.
Tachiki et al., 2018	Japan	Longitudinal study	20 class III orthognathic surgery patients completed the questionnaire pre-treatment, pre-surgical orthodontic treatment and post-surgical orthodontic treatment	Orthognathic quality of life questionnaire (OQLQ)	OHRQoL worsens significantly during the decompensation phase of orthodontic treatment prior to surgery.

Study	Country	Design/type	Intervention & Follow-up	Main outcome measure	Main findings
Crowding and Spacing					
Anthony et al., 2018	Zambia	Cross-sectional study	384 individuals aged 12-14 years assessed clinically and completed a questionnaire.	Child Oral Health Impact Profile-Short Form (COHIP-SF19) Clinical Examination	Crowding, diastema and spacing showed significant impacts on OHRQoL and the strength of the impacts increased with increasing age.
Johal et al., 2007	England	Cross-sectional study	90 individuals aged 13-15 years were recruited if they had an increased overjet (>6mm), spaced dentition (>1.5mm) or no malocclusion (control group)	Child oral health quality of life questionnaire (COHQoL)	OHRQoL was significantly worse for the spaced group and increased overjet groups compared to the control group.
Craniofacial anomalies					
Nichols et al., 2018	New Zealand	Longitudinal study	Longitudinal study of cleft (n=19), surgery (n=22) and standard (n=16) patients consecutively recruited from a hospital setting. OHRQoL was assessed pretreatment, post-treatment and 5 year after treatment.	Oral Health Impact Profile (OHIP-14) Dental Aesthetic Index	An overall reduction in OHIP-14 score (improvement in QoL) occurred after orthodontic treatment however this deteriorated over time. Relative to baseline, the OHRQoL had still improved at 5 year follow up for the surgical group (-57.4% $p<0.05$) but not for the standard group (-24.2% $p>0.05$) or cleft group (40.2% $p>0.05$).
Choi et al., 2010	Hong Kong	Cross-sectional study	472 individuals with a mean age of 21.1 were assessed at a dental hospital and private clinic setting.	Oral Health Impact Profile (OHIP-14) Subjective food intake (FIA) Index of Orthodontic Treatment Need – Dental Health Component	As malocclusion severity increased, OHRQoL worsened and masticatory efficiency reduced.
Antoun et al., 2015	New Zealand	Longitudinal study	83 individuals undergoing treatment in a hospital setting with severe malocclusions (DAI score greater than 32). 30 adolescents with severe malocclusions, 24 adolescents had cleft lip and palate, 29 adults had severe skeletal discrepancies requiring orthognathic surgery OHIP-14 was completed prior to and immediately following orthodontic treatment	Oral Health Impact Profile (OHIP-14) Dental Aesthetic Index Sociodemographic	There was a significant improvement in all of the OHIP-14 domains for patients undergoing orthognathic surgery ($p<0.05$) with a large effect size (1.25-2.73). Standard malocclusion patients experienced significant improvements in physical pain, handicap, psychological discomfort and psychological disability domains ($p<0.05$). The largest effect size was in the psychological discomfort (1.21) and disability (1.15) domains. Cleft lip and palate patients experienced no significant changes between baseline and post treatment mean OHIP-14 scores in any of the 7 subscales.