



This is a repository copy of *What is the value of orthodontic treatment?*.

White Rose Research Online URL for this paper:
<http://eprints.whiterose.ac.uk/83864/>

Version: Accepted Version

Article:

Benson, P.E., Javidi, H. and DiBiase, A.T. (2015) What is the value of orthodontic treatment? *British Dental Journal*, 218 (3). 185 - 190.

<https://doi.org/10.1038/sj.bdj.2015.43>

Reuse

Unless indicated otherwise, fulltext items are protected by copyright with all rights reserved. The copyright exception in section 29 of the Copyright, Designs and Patents Act 1988 allows the making of a single copy solely for the purpose of non-commercial research or private study within the limits of fair dealing. The publisher or other rights-holder may allow further reproduction and re-use of this version - refer to the White Rose Research Online record for this item. Where records identify the publisher as the copyright holder, users can verify any specific terms of use on the publisher's website.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

BDJ Themed Issue Article

What is the value of orthodontic treatment?

Philip E Benson PhD FDS (Orth)

Academic Unit of Oral Health and Development, School of Clinical Dentistry, University of Sheffield, S10 2TA

Hanieh Javidi BDS, MFDS, MDPH

Academic Unit of Oral Health and Development, School of Clinical Dentistry, University of Sheffield, S10 2TA

Andrew T Dibiasi BDS, MSc, FDS (Orth)

Orthodontic Department, Kent and Canterbury Hospital, East Kent Hospitals University NHS Foundation Trust, Canterbury, Kent, CT1 3NG.

Address for correspondence:

Philip Benson

Academic Unit of Oral Health and Development,

School of Clinical Dentistry,

Claremont Crescent

Sheffield

S10 2TA

E-mail: p.benson@sheffield.ac.uk

Tel: 0114 271 7885

Summary

Orthodontic treatment is as popular as ever. Orthodontists frequently have long lists of people wanting treatment and the cost to the NHS in England was £261m in 2013-14 (approximately 11% of the NHS annual spend on dentistry). It is important that clinicians and healthcare commissioners constantly question the contribution of interventions towards improving the health of the population. In this article the authors outline some of the evidence for and against the claims that people with a malocclusion are at a disadvantage compared with those without a malocclusion and that orthodontic treatment has significant health benefits. The authors would like to point out that this is not a comprehensive and systematic review of the entire scientific literature. Rather the evidence is presented in order to stimulate discussion and debate.

Introduction

Orthodontists will tell you that many people, young, middle-aged and old, continue to request (and occasionally demand) orthodontic treatment for themselves or for their children. There is a perception that orthodontics will not only improve their dental aesthetics, but will provide more global benefits in terms of health and well-being. Waiting lists are frequently long and the cost to the NHS in England was £258m in 2010-11 (approximately 10% of the NHS annual spend on dentistry).¹ In a healthcare system where resources are finite and often overstretched, it is important that those who provide, as well as those who commission healthcare, constantly question the contribution of interventions to improving the health of the population.

In this article we aim to outline some of the evidence for and against the claims that people with a malocclusion are at a disadvantage compared with those without a malocclusion and that orthodontic treatment has significant health benefits. This is not a comprehensive and systematic review of the entire scientific literature. Rather the evidence is presented in order to stimulate discussion and debate.

Orthodontic treatment is undertaken to correct malocclusion. The presumed disadvantages of a malocclusion to an individual are that it affects their long term health in three areas:

- Dental health
- Psychological well-being
- Social well-being

Dental Health

A legitimate question concerning orthodontic treatment is 'Do people with a malocclusion have a long-term disadvantage in regard to their dental health'? Certainly, some anomalies, such as palatally displaced maxillary canines can frequently result in damage to the roots of surrounding teeth² and more rarely cyst formation. The sequelae of other more common occlusal traits, such as crowding or an increased overjet are more controversial. While there is evidence that malocclusion has an impact on an individual's oral health related quality of life (discussed later), including function, it is harder to find convincing evidence that orthodontic treatment leads to a significant improvement in the dental health of the population.

Prevention of dental disease

It would seem to make sense that straight teeth are easier to keep clean and indeed there is some evidence to support this.³ There is also an association between an increased overjet and greater plaque scores;⁴ however there does not seem to be a direct relationship between the presence of crowding and susceptibility to caries or periodontal disease in the presence of good oral hygiene.⁵ Primary crowding, caused by an inherent tooth/arch size discrepancy, tends to manifest itself in the incisal region, which is more resistant to caries than the posterior teeth. In addition, the multifactorial nature of dental disease means that the incidence is influenced by numerous factors, including socioeconomic status. Children from more deprived backgrounds tend to not only have higher levels of caries, but generally have poorer access to dental and orthodontic treatment. By the very process of undergoing orthodontic treatment a child is introduced to the concept and

value of good oral hygiene and children who have received orthodontic treatment have been shown to have lower plaque scores.⁶ This might influence the level of dental disease they will experience through life. In addition, they may be more likely to look after their teeth if they are happy with their smile and dental aesthetics following orthodontic treatment. If a family from a deprived background does access dental or orthodontic care in the first place, it is difficult to assess whether it is the presence of the malocclusion or other factors that influence the levels of caries and periodontal disease the children will experience throughout life.

Certain specific occlusal traits, such as a traumatic overbite or an anterior crossbite with mandibular deviation, can be associated with periodontal breakdown and orthodontic treatment in these situations can help re-establish periodontal health.⁷

Improvement in function

Our pre-historic ancestors relied on a good occlusion to function effectively by allowing them to masticate a coarse diet and tear meat from bone. In modern societies, with a much softer diet than previously, an ideal occlusion or indeed teeth are no longer necessary for survival; but it does appear that having a normal occlusion improves mastication and function. By looking at how many chewing cycles it takes to break down a bolus of food, it has been shown that the presence of a malocclusion does reduce masticatory efficiency, especially if it is associated with reduced occlusal contacts.⁸ This will also affect muscle function, which in turn will reduce masticatory efficiency. Functional problems, such as crossbites with mandibular deviation, have also been shown to result in asymmetric muscular activity during mastication and reduced bite force.^{9,10} How much effect this has on everyday life is debatable, but individuals with malocclusions do report a higher impact on their oral health related quality of life in terms of function, than individuals with normal occlusions.¹¹

Certain occlusal traits can make eating difficult or socially embarrassing. These include anterior openbite, which makes incising certain foods almost impossible and is often the patient's main complaint. Nevertheless, while there has been a lot of debate in dentistry about the relative importance of an ideal occlusion, there is little evidence that in its absence there are any long-term health problems.

Prevention and treatment of temporomandibular joint disorders

The influence of occlusion and orthodontics on the health of the temporomandibular joint is an area of controversy. Several large observational studies have linked various occlusal traits with the signs and symptoms of temporomandibular joint disorders, including crossbites, anterior openbite and increased overjets,^{10, 12} however these are based on weak correlations, which in themselves do not prove causation. This is in part because temporomandibular joint disorders represent a complex, poorly understood, collection of conditions, with a multifactorial aetiology. While there is no evidence that orthodontic treatment causes temporomandibular joint dysfunction, conversely it has not been shown that correction of a malocclusion will either prevent or relieve the signs or symptoms of the disorder.¹³ Rather the condition should initially be treated conservatively, using reversible methods, prior to any complex orthodontic treatment.

Prevention of dentoalveolar trauma

A large cross-sectional, observational study undertaken in Scandinavia showed that an increased overjet, associated with a Class II division 1 type malocclusion, increases the risk of dentoalveolar trauma significantly, especially in boys.¹⁴ It is debatable whether early orthodontic treatment carried out in the mixed dentition to reduce an increased overjet is effective in reducing the incidence of new trauma. Data from three large randomised controlled trials looking at early intervention, using either functional appliances or headgear for Class II malocclusions have produced ambiguous results. Taken individually none of these studies found any difference in the incidence of trauma between those patients who had undergone early treatment and patients who had undergone comprehensive treatment in adolescence.¹⁵⁻¹⁷ A recent systematic review has combined the results for the three studies and found a small, but statistically significant difference, with the early treatment group experiencing less trauma;¹⁸ however the authors of one of the original studies noted that most of the trauma experienced was minor and in order to reduce the risk of trauma, orthodontic treatment would need to be started in the early mixed dentition stage, fairly soon after the maxillary incisors had erupted,

in all children with an increased overjet.¹⁵ Considering the greater financial burden it would incur to treat all these children, it is probably not cost effective in the majority of cases. There are, however, some patients who present with gross lip incompetence and very protrusive maxillary incisors who could be considered to be at a higher risk of damaging their incisors, especially if they have a history of trauma. In these cases early intervention to reduce the overjet may be warranted.

Treatment of impacted teeth

After third molars, the commonest tooth to have disordered eruption is the maxillary canine. Palatally displaced maxillary canines are present in about 2% of the population¹⁹ and a significant percentage cause root resorption of the adjacent incisors. When using plain radiographic films, root resorption was found to be present in about 12% of people with palatally displaced maxillary canines;²⁰ however the prevalence of root resorption was found to be much higher when investigated using cone beam CT.² The ultimate sequelae of severe root resorption is mobility and possible loss of the affected teeth if left untreated; however if the ectopic tooth is diagnosed early enough, intervention in the form of surgical exposure of the impacted tooth and orthodontic mechanical traction can prevent this and is usually very successful. If root resorption is present on the adjacent incisors, by moving the ectopic canine away from the teeth, there is cessation of the resorptive process and even incisors with very short roots have been shown to be functionally viable many years later.²¹ Eruption of the maxillary central incisors can also be delayed in the presence of a supernumerary. Again removal of the supernumerary and exposure of the tooth followed by orthodontic traction has a very high success rate.

Management of speech problems

Speech represents a complex interaction between the higher brain functions and the organs of speech (the lips, tongue, alveolar ridge, hard and soft palate, uvula and glottis). Essentially, pulmonary pressure, provided by respiration and phonation, is created by the glottis in the larynx and then modified into vowels and consonants. The production of consonants in particular, requires articulation, and certain sounds such as “t” and “d” are known as dental consonants, as they are articulated with the tongue against the palatal aspect of the upper incisors. It would therefore seem logical that certain types of malocclusion would cause articulatory speech disorders; however as always when dealing with malocclusion it is not a simple case of cause and effect.²²

Certain conditions, such as cleft of the soft palate, can have a profound effect on speech as the palate fails to create a posterior seal on phonation and air escapes up into the nose causing hypernasality of the speech. An anterior open bite is associated with misarticulation of “s”, or a lisp;²³ however with normal oral function, even in the presence of a malocclusion, there seems to be huge potential for compensation and there is little substantial evidence that orthodontic correction, even involving orthognathic surgery for severe skeletal discrepancies, will resolve articulatory problems without the adjunct of speech therapy.²⁴

It would seem, therefore, that the evidence supporting claims of significant dental health improvements following orthodontic treatment are tenuous; however it is increasingly recognised that the health of individuals should be defined, not only in terms of the presence and absence of physical disease and pathology, but more widely in terms of their psychological and social well-being.

Psychological well-being

Psychologists have struggled to define psychological health and well-being for many years, but psychologically healthy people are generally considered to be constructive about themselves (a positive self-concept or self-image), value themselves as individuals (positive or high self-esteem) and find life productive and satisfying. Psychological health and well-being should not be confused with mental or emotional disorders or with changes in mood, for example a psychological healthy person can still feel sad or distressed; however they tend to cope effectively with challenges and set-backs. There now appears to be a broad consensus in the

scientific literature that the effectiveness of coping strategies can have a significant influence on health and psychological well-being.²⁵

There has been much discussion amongst psychologists about whether psychological well-being can be considered a *trait*, which remains relatively stable over time, or a *state* that changes in response to situations and the environment. Recent longitudinal research has found that self-esteem shares the characteristics of certain personality traits, including emotional stability, extraversion, and conscientiousness.²⁶ There seems to be agreement that personality can influence psychological well-being, including self-esteem and satisfaction with life; however the debate continues about how much a person's character is determined by their genetics and how much by their environment (nature versus nurture).²⁷

Orth and colleagues²⁶ found no association between self-esteem and various relationship factors, such as relationship satisfaction, marital status and social support, or to stressful life events suggesting that self-esteem is quite a stable characteristic. Chung and colleagues,²⁵ investigating the self-esteem of young people during their college education, found that the participants' relative position within the sample was stable over time, i.e. if the young person started college with high self-esteem this was maintained over four years. They also found a consistent pattern of decline in self-esteem during the first year of college, which then rose during subsequent years to be higher at the end of the course than at the start. They conclude that self-esteem, like other personality traits, shows continuity over time, but that it could also change in systematic ways.

So where does this leave us in regard to the influence of malocclusion on psychological well-being? If an individual's environment (rather than their genetic make-up) has a strong influence on their psychological well-being, then correcting their malocclusion might have a positive effect; however another complicating factor is that orthodontic treatment is frequently undertaken in young people going through adolescence. During this time the young person is gaining physical, psychological and social maturity, as well as developing their own identity and independence, all of which present unique challenges to both patient and clinician.²⁸ It has been shown that self-esteem is least stable during early adolescent, but that stability progressively increases into early adulthood.^{26, 29} This life-span trajectory is influenced by the individual's ethnicity, socioeconomic status, general health, but especially by their level of education, with more highly educated individuals demonstrating higher self-esteem, than did those less well-educated individuals.

The finding of these studies (and many others) suggests to us that psychological well-being, including self-esteem, is influenced by numerous factors in a person's life and is in a particular state of flux during adolescence, when orthodontic treatment is commonly experienced. Shame and embarrassment about the appearance of the teeth is only a small part of these complex inter-relationships for most people. We believe, therefore, it is unrealistic to expect that major long term changes in psychological well-being could be demonstrated as a result of straightening someone's teeth. One randomised controlled trial did find a short term improvement in self-concept when children with a class II division 1 malocclusion were treated early (aged 8 to 10) compared with an untreated control;³⁰ however other studies have found that orthodontic treatment has no effect on the psychological well-being of individuals, and self-esteem in particular, over the long term.³¹⁻³³

This has not been a surprising finding to others either.³⁴ Pitner cites the work of Diener and colleagues, who have studied the ability of people to adapt over time to new situations and extreme life events.^{35, 36} There is evidence that intensive and sometimes prolonged psychological interventions can improve psychological well-being³⁷; however we would be interested to know if this has been claimed for any dental or healthcare interventions, other than orthodontics. We undertook a brief search through the literature and were unable to find anything.

This is not to imply that psychological well-being is not important. Recent research suggests that a person's psychological make-up is an important mediating factor in determining how people respond to their circumstances and to new challenges. Orth and colleagues³⁸ found that better life outcomes were usually a consequence of, rather than a cause of high self-esteem. It has also been found that psychological factors

might explain more about the impact of dental disorders upon individuals than their clinical symptoms³⁹⁻⁴³. In other words, the appearance of an individual's teeth might concern a person with low self-esteem much more than a person with high self-esteem. This will help to explain why some people appear upset about relatively minor abnormalities, whilst others, with much more severe conditions, are not bothered. Further research needs to be undertaken in this area.

Social well-being

Social well-being might be considered distinct from psychological well-being. Whereas psychological well-being reflects how content we are with ourselves, social well-being reveals how we interact with other people and with our community. Several well-designed studies, using qualitative research methods have confirmed that young people with malocclusion, who seek orthodontic treatment, are dissatisfied with and have a sense of shame about the appearance of their teeth.⁴⁴⁻⁴⁶ This perceived feeling of being unattractive and different to other people is made worse by the expression of supposed societal norms, through peer group pressure and images in the media. The awkwardness that young people feel about the appearance of their teeth leads to various coping strategies in social situations, including not showing their teeth when they smile, avoiding having their photograph taken and embarrassment when their photographs are shared through social media. It can also lead to approaches designed to hide their teeth, including placing their hand across their mouth when they smile.⁴⁶

The view of young people that others perceive them differently due to the appearance of their teeth has, to a certain extent, been confirmed by the work of Shaw. Using a technique of altering the arrangements of the teeth on standardised photographs of young people smiling, Shaw and colleagues showed that the appearance of teeth could influence the social judgements made by their peers about the person in the photograph^{47, 48}; however dental appearance did not affect the judgements made by teachers.⁴⁹ The influence of dental appearance could, however, be surpassed by the overall attractiveness of the face.^{47, 48, 50}

Teasing or bullying of young people due to the appearance of their teeth has been reported frequently in the literature, from many different societies and cultures.⁵¹⁻⁵⁷ Victims are particularly concerned when they are teased about the appearance of their teeth⁵¹ and orthodontic treatment can help to alleviate this.⁵⁸

Research is now focussed on ways of measuring the physical, functional, emotional and social impacts of conditions upon a person's daily life through the various concepts of quality of life, health and oral health-related quality of life.

Quality of life

The World Health Organization (WHO) defines Quality of Life as 'an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns'.⁵⁹ The influence of health upon a person's overall quality of life is defined in the concept of health-related quality of life (HRQoL). The impact of oral and dental conditions upon a person's overall quality of life may be summarised using the concept of oral health-related quality of life (OHQoL). This was defined by the Department of Health in 1994 as the 'standard of health of the oral and related tissues which enables an individual to eat, speak and socialise without active disease, discomfort or embarrassment and which contributes to general well-being'.⁶⁰

Researchers attempt to measure HRQoL by asking specific questions about the impact of a condition on a person's daily life. The questions are carefully selected through qualitative interviews of affected individuals and then rigorously tested for validity and reliability, using both qualitative and quantitative research methods.^{61, 62} Several measures of OHQoL have been developed for use with either adults or young people. The most frequently used with young people is the Child Perceptions Questionnaire.⁶³

It could be argued that orthodontic treatment is primarily concerned with correcting variations of an arbitrary norm, with justification of treatment often based on improvements in OHQoL. This concept is well recognised, and academics have emphasised the importance of including not only clinical, but also patient-centred

outcome measures, such as changes in OHRQoL, when carrying out orthodontic research, as the two may not demonstrate a direct correlation.⁶⁴

There are two principal questions regarding the influence of malocclusion and orthodontic treatment on OHQoL, which are:

- Do people with malocclusion have a worse OHQoL than those without malocclusion?
- Does the correction of malocclusion (orthodontic treatment) improve OHQoL?

Numerous studies, from many population groups around the world, using different generic measures of OHQoL, have found that people with a significant malocclusion, (usually defined with a normative measure of treatment need, such as the Index of Orthodontic Treatment Need or IOTN) have worse OHQoL than those with a minor or no malocclusion. This has been found in non-clinical populations (mainly schoolchildren)⁶⁵⁻⁷⁴ as well as young people referred for orthodontic treatment.^{11, 75-85} The principal areas that impacts are registered are in the questionnaire domains that record emotional and social well-being. A systematic review of the literature concluded that the relationship between malocclusion/orthodontic treatment need and OHQoL was moderate;⁸⁶ however due to differences in methodologies between studies, the authors commented that they were unable to undertake a meta-analysis to investigate the statistical relationships more fully.

Recently, various studies have looked at the impact of malocclusion on OHQoL in children and adolescents of differing age groups. A number of studies focusing on pre-school children, often aged 5 years or below, failed to demonstrate an association between the presence of a malocclusion and OHQoL,^{87, 88} whilst other studies based on adolescents between the approximate ages of 11 to 15 years, have found the presence of a malocclusion to have a negative impact on OHQoL.^{74, 89} Various factors may account for the disparity observed in the different age groups. Firstly, the presence of more severe forms of malocclusion, such as severe crowding or severe skeletal discrepancies causing an extreme overjet, often manifest in the mixed or permanent dentition, which may account for the negative impact that malocclusions have on OHQoL in such age groups. Secondly, the lack of impact that malocclusions have on OHQoL in pre-school children may be related to the lack of importance that such age groups give to aesthetics.

Fewer studies have reported evidence that correction of a malocclusion with orthodontic treatment leads to an improvement in OHQoL. Some studies, using a cross-sectional design, have found that individuals who have undergone orthodontic treatment had a better OHQoL than individuals who have not undergone orthodontic treatment.^{65, 90, 91} Other studies have found no difference in the OHQoL between treated and untreated groups.⁹² There have been a small number of longitudinal studies, all of which have found an improvement in OHQoL following orthodontic treatment.^{42, 93-96} Furthermore, a case controlled study also reported fewer physical, psychological and social impacts on daily performance associated with a malocclusion, in patients that had received Orthodontic treatment, compared to those who had not.⁹⁷

There is still a vigorous debate in the research community about the concept of OHQoL, what OHQoL questionnaires measure and how they should be used in the future.⁹⁸⁻¹⁰⁰ Marshman and colleagues¹⁰¹ have expressed concern that generic measures of OHQoL might not fully capture the impact that malocclusion has on young people's daily lives and have suggested the development of a malocclusion specific measure of OHQoL for young people with malocclusion. The use and interpretation of data from generic and/or condition-specific measures of OHQoL continues to be the subject of much debate and research.¹⁰⁰

Conclusions

Correction of a malocclusion can lead to significant short and long-term dental health improvements for individual patients; however it is unlikely that a substantial oral health benefit, from orthodontic treatment, at the population level can be proved. It is also unrealistic to expect that correction of a person's crooked teeth will radically change their psychological make-up, which is complex and subject to many influences, including the personality of the individual.

The main value of orthodontic treatment is to allow individuals to cope more effectively in social situations, without concern for the appearance of their teeth. In a health service context this is wholly compatible with the WHO definition of health as 'a state of complete physical, mental and *social well-being* and not merely the absence of disease or infirmity' (authors' italics).

There will be an increasing use of patient reported outcome measures (PROMs), such as OHQoL questionnaires, to assess the need for and the benefits of orthodontic treatment. PROMs should also be used in the future, as the predominant primary outcome in clinical trials designed to investigate differences between orthodontic treatments. This will help to identify the most efficient way of reducing the social impact of a malocclusion with the minimum impact on the patient.

One thing is certain, that with an increasing awareness and emphasis placed on physical appearance, beauty and youthfulness, there appears to be little doubt among the general public concerning the value of good dental aesthetics and an attractive smile. This probably explains the ever increasing demand for orthodontic treatment.

Acknowledgements

The authors are grateful to Professor Donald Burden, Director of the Centre for Dentistry and Consultant Orthodontist, Queen's University, Belfast for reading an initial draft of this manuscript.

References

1. Statistics ND, NHS Dental Statistics for England: 2011/12. In: Issue 2012. Health and Social Care Information Centre, Prescribing & Primary Care.
2. Ericson S, Kurol PJ. Resorption of incisors after ectopic eruption of maxillary canines: a CT study. *Angle Orthod* 2000;**70**:415-23.
3. Addy M, Dummer PM, Griffiths G, Hicks R, Kingdon A, Shaw WC. Prevalence of plaque, gingivitis and caries in 11-12-year-old children in South Wales. *Community Dent Oral Epidemiol* 1986;**14**:115-8.
4. Davies TM, Shaw WC, Addy M, Dummer PM. The relationship of anterior overjet to plaque and gingivitis in children. *Am J Orthod Dentofacial Orthop* 1988;**93**:303-9.
5. Hafez HS, Shaarawy SM, Al-Sakiti AA, Mostafa YA. Dental crowding as a caries risk factor: a systematic review. *Am J Orthod Dentofacial Orthop* 2012;**142**:443-50.
6. Davies TM, Shaw WC, Worthington HV, Addy M, Dummer P, Kingdon A. The effect of orthodontic treatment on plaque and gingivitis. *Am J Orthod Dentofacial Orthop* 1991;**99**:155-61.
7. Seehra J, Fleming PS, DiBiase AT. Orthodontic treatment of localised gingival recession associated with traumatic anterior crossbite. *Aust Orthod J* 2009;**25**:76-81.
8. Magalhaes IB, Pereira LJ, Marques LS, Gameiro GH. The influence of malocclusion on masticatory performance. A systematic review. *Angle Orthod* 2010;**80**:981-7.
9. Sonnesen L, Bakke M, Solow B. Bite force in pre-orthodontic children with unilateral crossbite. *Eur J Orthod* 2001;**23**:741-9.
10. Thilander B, Bjerklin K. Posterior crossbite and temporomandibular disorders (TMDs): need for orthodontic treatment? *Eur J Orthod* 2012;**34**:667-73.
11. Masood M, Masood Y, Newton T. Cross-bite and oral health related quality of life in young people. *J Dent* 2014;**42**:249-55.
12. Mohlin B, Axelsson S, Paulin G, *et al.* TMD in relation to malocclusion and orthodontic treatment. *Angle Orthod* 2007;**77**:542-8.
13. Luther F, Layton S, McDonald F. Orthodontics for treating temporomandibular joint (TMJ) disorders. *Cochrane Database Syst Rev* 2010;CD006541.
14. Jarvinen S. Incisal overjet and traumatic injuries to upper permanent incisors. A retrospective study. *Acta Odontol Scand* 1978;**36**:359-62.
15. Koroluk LD, Tulloch JF, Phillips C. Incisor trauma and early treatment for Class II Division 1 malocclusion. *Am J Orthod Dentofacial Orthop* 2003;**123**:117-25.

16. O'Brien K, Wright J, Conboy F, *et al.* Early treatment for Class II Division 1 malocclusion with the Twin-block appliance: a multi-center, randomized, controlled trial. *Am J Orthod Dentofacial Orthop* 2009;**135**:573-9.
17. Chen DR, McGorray SP, Dolce C, Wheeler TT. Effect of early Class II treatment on the incidence of incisor trauma. *Am J Orthod Dentofacial Orthop* 2011;**140**:e155-60.
18. Thiruvengkatachari B, Harrison JE, Worthington HV, O'Brien KD. Orthodontic treatment for prominent upper front teeth (Class II malocclusion) in children. *Cochrane Database Syst Rev* 2013;**11**:CD003452.
19. Bishara SE. Impacted maxillary canines: a review. *Am J Orthod Dentofacial Orthop* 1992;**101**:159-71.
20. Ericson S, Kurol J. Radiographic examination of ectopically erupting maxillary canines. *Am J Orthod Dentofacial Orthop* 1987;**91**:483-92.
21. Becker A, Chaushu S. Long-term follow-up of severely resorbed maxillary incisors after resolution of an etiologically associated impacted canine. *Am J Orthod Dentofacial Orthop* 2005;**127**:650-4; quiz 754.
22. Johnson NC, Sandy JR. Tooth position and speech--is there a relationship? *Angle Orthod* 1999;**69**:306-10.
23. Laine T. Associations between articulatory disorders in speech and occlusal anomalies. *Eur J Orthod* 1987;**9**:144-50.
24. Hassan T, Naini FB, Gill DS. The effects of orthognathic surgery on speech: a review. *J Oral Maxillofac Surg* 2007;**65**:2536-43.
25. Chung JM, Robins RW, Trzesniewski KH, Nofle EE, Roberts BW, Widaman KF. Continuity and Change in Self-Esteem During Emerging Adulthood. *J Pers Soc Psychol* 2014;**106**:469-83.
26. Orth U, Trzesniewski KH, Robins RW. Self-Esteem Development From Young Adulthood to Old Age: A Cohort-Sequential Longitudinal Study. *J Pers Soc Psychol* 2010;**98**:645-58.
27. Hahn E, Johnson W, Spinath FM. Beyond the heritability of life satisfaction - The roles of personality and twin-specific influences. *J Res Pers* 2013;**47**:757-67.
28. Christie D, Viner R. Adolescent development. *BMJ* 2005;**330**:301-4.
29. Trzesniewski KH, Donnellan MB, Robins RW. Stability of self-esteem across the life span. *J Pers Soc Psychol* 2003;**84**:205-20.
30. O'Brien K, Wright J, Conboy F, *et al.* Effectiveness of early orthodontic treatment with the Twin-block appliance: a multicenter, randomized, controlled trial. Part 2: Psychosocial effects. *Am J Orthod Dentofacial Orthop* 2003;**124**:488-94.
31. Kenealy PM, Kingdon A, Richmond S, Shaw WC. The Cardiff dental study: a 20-year critical evaluation of the psychological health gain from orthodontic treatment. *Br J Health Psychol* 2007;**12**:17-49.
32. Shaw WC, Richmond S, Kenealy PM, Kingdon A, Worthington H. A 20-year cohort study of health gain from orthodontic treatment: psychological outcome. *Am J Orthod Dentofacial Orthop* 2007;**132**:146-57.
33. Arrow P, Brennan D, Spencer AJ. Quality of life and psychosocial outcomes after fixed orthodontic treatment: a 17-year observational cohort study. *Community Dent Oral Epidemiol* 2011;**39**:505-14.
34. Pitner L. Psychological outcomes (Letter). *Am J Orthod Dentofacial Orthop* 2007;**132**:716.
35. Diener E, Lucas RE, Scollon CN. Beyond the hedonic treadmill: revising the adaptation theory of well-being. *Am Psychol* 2006;**61**:305-14.
36. Diener E, Seligman MEP. Beyond money: toward an economy of well-being. *Psychol Sci Public Interest* 2004;**5**:1 - 31.
37. Bolier L, Haverman M, Westerhof GJ, Riper H, Smit F, Bohlmeijer E. Positive psychology interventions: a meta-analysis of randomized controlled studies. *BMC Public Health* 2013;**13**:119.
38. Orth U, Robins RW, Widaman KF. Life-span development of self-esteem and its effects on important life outcomes. *J Pers Soc Psychol* 2012;**102**:1271-88.
39. Baker SR, Mat A, Robinson PG. What psychosocial factors influence adolescents' oral health? *J Dent Res* 2010;**89**:1230-5.
40. Nammontri O, Robinson PG, Baker SR. Enhancing oral health via sense of coherence: a cluster-randomized trial. *J Dent Res* 2013;**92**:26-31.
41. Agou S, Locker D, Streiner DL, Tompson B. Impact of self-esteem on the oral-health-related quality of life of children with malocclusion. *Am J Orthod Dentofacial Orthop* 2008;**134**:484-9.

42. Agou S, Locker D, Muirhead V, Tompson B, Streiner DL. Does psychological well-being influence oral-health-related quality of life reports in children receiving orthodontic treatment? *Am J Orthod Dentofacial Orthop* 2011;**139**:369-77.
43. Foster Page LA, Thomson WM, Ukra A, Farella M. Factors influencing adolescents' oral health-related quality of life (OHRQoL). *Int J Paediatr Dent* 2013;**23**:415-23.
44. Trulsson U, Strandmark M, Mohlin B, Berggren U. A qualitative study of teenagers' decisions to undergo orthodontic treatment with fixed appliance. *J Orthod* 2002;**29**:197-204; discussion 195.
45. Josefsson E, Lindsten R, Hallberg LR. A qualitative study of the influence of poor dental aesthetics on the lives of young adults. *Acta Odontol Scand* 2010;**68**:19-26.
46. Taghavi Bayat J, Hallberg U, Lindblad F, Huggare J, Mohlin B. Daily life impact of malocclusion in Swedish adolescents: a grounded theory study. *Acta Odontol Scand* 2013;**71**:792-8.
47. Shaw WC. The influence of children's dentofacial appearance on their social attractiveness as judged by peers and lay adults. *Am J Orthod* 1981;**79**:399-415.
48. Shaw WC, Rees G, Dawe M, Charles CR. The influence of dentofacial appearance on the social attractiveness of young adults. *Am J Orthod* 1985;**87**:21-6.
49. Shaw WC, Humphreys S. Influence of children's dentofacial appearance on teacher expectations. *Community Dent Oral Epidemiol* 1982;**10**:313-9.
50. Kenealy P, Frude N, Shaw W. Influence of Childrens Physical Attractiveness on Teacher Expectations. *J Soc Psychol* 1988;**128**:373-83.
51. Shaw WC, Meek SC, Jones DS. Nicknames, teasing, harassment and the salience of dental features among school children. *Br J Orthod* 1980;**7**:75-80.
52. Helm S, Kreiborg S, Solow B. Psychosocial implications of malocclusion: a 15-year follow-up study in 30-year-old Danes. *Am J Orthod* 1985;**87**:110-8.
53. Zammit MP, Hans MG, Broadbent BH, Johnsen DC, Latimer BM, Nelson S. Malocclusion in Labrador Inuit youth: a psychosocial, dental and cephalometric evaluation. *Arctic Med Res* 1995;**54**:32-44.
54. Onyiaso CO, Sanu OO. Psychosocial implications of malocclusion among 12-18 year old secondary school children in Ibadan, Nigeria. *Odontostomatol Trop* 2005;**28**:39-48.
55. Rwakatemba DS, Ng'ang'a PM, Kemoli AM. Awareness and concern about malocclusion among 12-15 year-old children in Moshi, Tanzania. *East Afr Med J* 2006;**83**:92-7.
56. Seehra J, Fleming PS, Newton T, DiBiase AT. Bullying in orthodontic patients and its relationship to malocclusion, self-esteem and oral health-related quality of life. *J Orthod* 2011;**38**:247-56.
57. Al-Bitar ZB, Al-Omari IK, Sonbol HN, Al-Ahmad HT, Cunningham SJ. Bullying among Jordanian schoolchildren, its effects on school performance, and the contribution of general physical and dentofacial features. *Am J Orthod Dentofacial Orthop* 2013;**144**:872-8.
58. Seehra J, Newton JT, DiBiase AT. Interceptive orthodontic treatment in bullied adolescents and its impact on self-esteem and oral-health-related quality of life. *Eur J Orthod* 2013;**35**:615-21.
59. World Health Organisation. WHOQoL: Measuring Quality of Life. 1997. Online information available at http://www.who.int/mental_health/media/68.pdf (accessed May 2014).
60. Department of Health. An Oral Health Strategy for England. 1994. London. Online information available at http://www.erpho.org.uk/topics/Oral_health/ (accessed May 2014).
61. Guyatt GH, Bombardier C, Tugwell PX. Measuring disease-specific quality of life in clinical trials. *CMAJ* 1986;**134**:889-95.
62. Juniper EF, Guyatt GH, Jaeschke R. *How to develop and validate a new Health-Related Quality of Life instrument*, in *Quality of life in Pharmacoeconomics in Clinical Trials*, B. Spilker, Editor. 1996, Lippincott-Raven Philadelphia.
63. Gilchrist F, Rodd H, Deery C, Marshman Z. Assessment of the quality of measures of child oral health-related quality of life. *BMC Oral Health* 2014;**14**:40.
64. Cunningham SJ, Hunt NP. Quality of life and its importance in orthodontics. *J Orthod* 2001;**28**:152-8.
65. de Oliveira CM, Sheiham A. The relationship between normative orthodontic treatment need and oral health-related quality of life. *Community Dent Oral Epidemiol* 2003;**31**:426-36.

66. Foster Page LA, Thomson WM, Jokovic A, Locker D. Validation of the Child Perceptions Questionnaire (CPQ 11-14). *J Dent Res* 2005;**84**:649-52.
67. Marques LS, Ramos-Jorge ML, Paiva SM, Pordeus IA. Malocclusion: esthetic impact and quality of life among Brazilian schoolchildren. *Am J Orthod Dentofacial Orthop* 2006;**129**:424-7.
68. O'Brien K, Wright JL, Conboy F, Macfarlane T, Mandall N. The child perception questionnaire is valid for malocclusions in the United Kingdom. *Am J Orthod Dentofacial Orthop* 2006;**129**:536-40.
69. Bernabe E, de Oliveira CM, Sheiham A. Condition-specific sociodental impacts attributed to different anterior occlusal traits in Brazilian adolescents. *Eur J Oral Sci* 2007;**115**:473-8.
70. Bernabe E, Tsakos G, Messias de Oliveira C, Sheiham A. Impacts on daily performances attributed to malocclusions using the condition-specific feature of the Oral Impacts on Daily Performances Index. *Angle Orthod* 2008;**78**:241-7.
71. Bernabe E, Sheiham A, de Oliveira CM. Impacts on daily performances attributed to malocclusions by British adolescents. *J Oral Rehabil* 2009;**36**:26-31.
72. Marques LS, Filogonio CA, Filogonio CB, et al. Aesthetic impact of malocclusion in the daily living of Brazilian adolescents. *J Orthod* 2009;**36**:152-9.
73. Foster Page LA, Thomson WM, Ukra A, Baker SR. Clinical status in adolescents: is its impact on oral health-related quality of life influenced by psychological characteristics? *Eur J Oral Sci* 2013;**121**:182-7.
74. Ukra A, Foster Page LA, Thomson WM, Farella M, Tawse Smith A, Beck V. Impact of malocclusion on quality of life among New Zealand adolescents. *N Z Dent J* 2013;**109**:18-23.
75. Brown A, Al-Khayal Z. Validity and reliability of the Arabic translation of the child oral-health-related quality of life questionnaire (CPQ11-14) in Saudi Arabia. *Int J Paediatr Dent* 2006;**16**:405-11.
76. Wong AT, McMillan AS, McGrath C. Oral health-related quality of life and severe hypodontia. *J Oral Rehabil* 2006;**33**:869-73.
77. Johal A, Cheung MY, Marcene W. The impact of two different malocclusion traits on quality of life. *Br Dent J* 2007;**202**:E2.
78. O'Brien C, Benson PE, Marshman Z. Evaluation of a quality of life measure for children with malocclusion. *J Orthod* 2007;**34**:185-93.
79. McGrath C, Pang HN, Lo EC, King NM, Hagg U, Samman N. Translation and evaluation of a Chinese version of the Child Oral Health-related Quality of Life measure. *Int J Paediatr Dent* 2008;**18**:267-74.
80. Zhang M, McGrath C, Hagg U. Orthodontic treatment need and oral health-related quality among children. *Community Dent Health* 2009;**26**:58-61.
81. Feu D, de Oliveira BH, de Oliveira Almeida MA, Kiyak HA, Miguel JA. Oral health-related quality of life and orthodontic treatment seeking. *Am J Orthod Dentofacial Orthop* 2010;**138**:152-9.
82. Locker D, Jokovic A, Prakash P, Tompson B. Oral health-related quality of life of children with oligodontia. *Int J Paediatr Dent* 2010;**20**:8-14.
83. Martins-Junior PA, Marques LS, Ramos-Jorge ML. Malocclusion: social, functional and emotional influence on children. *J Clin Pediatr Dent* 2012;**37**:103-8.
84. Dawoodbhoy I, Delgado-Angulo EK, Bernabe E. Impact of malocclusion on the quality of life of Saudi children. *Angle Orthod* 2013;**83**:1043-8.
85. Masood Y, Masood M, Zainul NN, Araby NB, Hussain SF, Newton T. Impact of malocclusion on oral health related quality of life in young people. *Health Qual Life Outcomes* 2013;**11**:25.
86. Liu Z, McGrath C, Hagg U. The impact of malocclusion/orthodontic treatment need on the quality of life. A systematic review. *Angle Orthod* 2009;**79**:585-91.
87. Carvalho AC, Paiva SM, Viegas CM, Scarpelli AC, Ferreira FM, Pordeus IA. Impact of malocclusion on oral health-related quality of life among Brazilian preschool children: a population-based study. *Brazilian dental journal* 2013;**24**:655-61.
88. Sousa RV, Clementino MA, Gomes MC, Martins CC, Granville-Garcia AF, Paiva SM. Malocclusion and quality of life in Brazilian preschoolers. *Eur J Oral Sci* 2014;**122**:223-9.
89. Scapini A, Feldens CA, Ardenghi TM, Kramer PF. Malocclusion impacts adolescents' oral health-related quality of life. *Angle Orthod* 2013;**83**:512-8.

90. de Oliveira CM, Sheiham A. Orthodontic treatment and its impact on oral health-related quality of life in Brazilian adolescents. *J Orthod* 2004;**31**:20-7.
91. Palomares NB, Celeste RK, Oliveira BH, Miguel JA. How does orthodontic treatment affect young adults' oral health-related quality of life? *Am J Orthod Dentofacial Orthop* 2012;**141**:751-8.
92. Taylor KR, Kiyak A, Huang GJ, Greenlee GM, Jolley CJ, King GJ. Effects of malocclusion and its treatment on the quality of life of adolescents. *Am J Orthod Dentofacial Orthop* 2009;**136**:382-92.
93. Wood W, Lenk MD, Bomeli PD, Beck FM, Firestone AR. Orthodontics: Effects On Oral Health-related Quality Of Life. *Eur J Orthod* 2007;**29**:e40 (Abstract 90).
94. Agou S, Malhotra M, Tompson B, Prakash P, Locker D. Is the child oral health quality of life questionnaire sensitive to change in the context of orthodontic treatment? A brief communication. *J Public Health Dent* 2008;**68**:246-8.
95. Chen M, Wang DW, Wu LP. Fixed orthodontic appliance therapy and its impact on oral health-related quality of life in Chinese patients. *Angle Orthod* 2010;**80**:49-53.
96. Feu D, Miguel JA, Celeste RK, Oliveira BH. Effect of orthodontic treatment on oral health-related quality of life. *Angle Orthod* 2014;
97. Bernabe E, Sheiham A, Tsakos G, Messias de Oliveira C. The impact of orthodontic treatment on the quality of life in adolescents: a case-control study. *Eur J Orthod* 2008;**30**:515-20.
98. Locker D, Allen F. What do measures of 'oral health-related quality of life' measure? *Community Dent Oral Epidemiol* 2007;**35**:401-11.
99. Sischo L, Broder HL. Oral health-related quality of life: what, why, how, and future implications. *J Dent Res* 2011;**90**:1264-70.
100. Tsakos G, Allen PF, Steele JG, Locker D. Interpreting oral health-related quality of life data. *Community Dent Oral Epidemiol* 2012;**40**:193-200.
101. Marshman Z, Gibson BJ, Benson PE. Is the short-form Child Perceptions Questionnaire meaningful and relevant to children with malocclusion in the UK? *J Orthod* 2010;**37**:29-36.