THE IMPACT OF THE PRESENCE OF AN ANTERIOR OPEN BITE ON THE ORAL HEALTH-RELATED QUALITY OF LIFE IN ADULTS

by

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Abstract

Aims: A prospective cross-sectional survey to evaluate the psychosocial impact of the presence of an anterior open bite in adults. To evaluate whether other factors such as gender, age, ethnicity and depth of open bite have an influence on the oral health related quality of life (OHRQoL).

Method: A total of 71 participants (39 female and 32 male) with an anterior open bite aged from 18-25 years were recruited from Birmingham Dental Hospital and the University Hospitals North Midlands, United Kingdom. The control group consisted of 68 participants (35 female and 33 male) and aged 23-25.5 years. All participants completed an Oral Health Impact Profile – 49 (OHIP-49) Questionnaire which was used as the OHRQoL measurement tool.

Results: Those with an anterior open bite had a consistently higher impact profile score in all seven domains of the OHIP-49 compared to the control group showing a negative impact on the OHRQoL. These differences were statistically significant ($p<0.001$) for both overall Impact Profile score and each of the seven domains. Gender did influence the OHIP-49 scores with females scoring consistently higher than males, which was found to be statistically significant in all of the domains of the OHIP-49 apart from physical disability. The impact on the OHRQoL was found to be independent of ethnicity, depth of anterior open bite and age.

Conclusions: The presence of an anterior open bite can negatively effect the psychosocial well being of adults when compared to a control group. This study furthers our understanding of adult patients with an anterior open bite and supports the need for treatment and further resources for this group.

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1. Literature Review

1.1 Introduction

The phrase “open bite” was first noted as a description of a malocclusion by Caravelli 1842. An anterior open bite (AOB) has been defined as the clear definitive lack of contact between the anterior teeth when the teeth are in centric occlusion. (Parker, 1971; Subtelny *et al*,1964; Huang *et al*, 1990; Shapiro, 2002; Cozza *et al*, 2005). There are however, conflicting views on the definition of an AOB in the literature. Mizrahi (1978) uses the term ‘open-bite’ to describe anything that is less than an average overbite or simply when the incisors are not in contact.

1.2 Prevalence

Variations in the definition of open bite, have inevitably led to a large variation in the reported prevalence. A review of the literature by Wong *et al* (2006) reported that the prevalence ranged from 1.5% to 11% and varied with age and ethnicity. A study by O’Brien (1994) reported that 2-4% of children and 4% of adults presented with an AOB in the United Kingdom (UK).

Other studies have shown a greater prevalence within Chinese, South American and Afro-American populations. Woon *et al* (1989) reported a 6% prevalence in Chinese adolescents aged between 15-19 years. Kelly and Harvey, (1977) found a 10% prevalence in Afro-American youths aged between 12-17 years in the USA. A 4%

prevalence within an Iraqi sample of orthodontic patients aged between 15-30 years was found by Al –Taee (2010).

A gender difference has been reported with a higher proportion of females affected than males (Al-Taee, 2010). This higher prevalence within females was also noted in a study in Brazil conducted by Machado *et al* (2014). However, this may be due to females being more concerned about aesthetics compared to males and therefore more likely to seek treatment.

Thilander *et al* (2001) assessed 4724 children in Colombia and found an 11% in the early mixed dentition and an 8.7% prevalence of an AOB within the permanent dentition. The reason for a higher prevalence of an AOB within the deciduous and mixed dentitions is likely to be due to the natural development of the teeth and the differential eruptive pattern of the anterior teeth. In addition, as the jaw grows to accommodate the soft tissues the tongue may initially lie between upper and lower incisors (Klocke *et al* 2002).

Those with craniofacial disorders are almost always omitted from studies concerning AOBs. This is due to known previous research that has shown a negative impact on the OHRQoL with those with an associated craniofacial disorder (Naito *et al*, 2006). This would detract from the reliability of the results if this cohort were to be included in the study.

1.3 Aetiology of an anterior open bite

AOBs have a multifactorial aetiology but it is widely accepted across the literature that there are two distinct categories of AOBs, those that are of dental origin and those that are attributed to skeletal discrepancies.

1.3.1 Habits (dental origin)

These cases of AOB are often identified in the late deciduous or mixed dentitions. They classically present with a well demarcated open bite that fits around the offending obstruction. In most cases it is a thumb or another digit. The habit is referred to as non-nutritive sucking in the literature and reports suggest that providing the habit ceases before the permanent dentition has established, the open-bite should improve and self correct. Features normally seen with digit habits are proclined upper incisors, retroclined lower incisors and cross-bites due to increased negative pressure and the adaptive lower position of the tongue. The most characteristic feature of an individual with a digit habit is that of an open-bite in the area of where the digit is usually held. Therefore in a large proportion of digit sucking habit cases the open-bite is often asymmetric. (Adair *et al,* 1995; Villa *et al,* 1997).

1.3.2 Tongue thrusting

There is controversy within the orthodontic literature as to whether or not a tongue thrust can be a true aetiological cause of an AOB or whether it is an adaptive manifestation secondary to the presence of an AOB itself. The position of the tongue is likely to have a bearing on the position of the teeth due to the soft tissue equilibrium theory. If the tongue is constantly held in a position above the lower incisors may well prevent the development of a positive overbite. The light continuous force of the tongue on the lower incisors will prevent their eruption and thus prevent contact between the upper and lower incisors. It is proposed that rather than an active thrust it is more likely due to the size and passive position of the tongue that has a bearing on the AOB (Proffitt, 1978).

Tulley (1969) suggested that tongue thrusting was an endogenous habit and looked into the thrusting of the tongue being an adaptive response to myo-facial change and the need to enable a swallowing pattern. Dental features that are likely to be present with an endogenous tongue thrust are a reverse curve of Spee in the lower arch and proclined lower incisors due to the adaptive pressures on the lower dentition.

The presence of macroglossia can also result in an AOB due to the inherent pressure and position of the tongue in relation to the dentition (Wolford and Cottrell, 1996).

1.3.3 Airway obstruction

Patient's with suspected airway obstruction sometimes developed facial features that were described as adenoid faces. An obstruction in the upper airway encouraged them to develop a mouth breathing habit. This was thought to have influenced facial growth resulting in distinct characteristics; holding their mouth open, a dull vacant look, elongated lower face height, narrow nostrils and cheeks (Schendel *et al*, 1976).

Studies looking at upper airway obstruction have found a significant link between the obstruction and the resulting elongated lower face and the presence of an AOB. Linder-Aronson *et al* (1970), showed that the mandible assumed a more backward and downward position and thus elongated the vertical plane of the lower face height and in turn resulted in an AOB.

Mouth-breathing is not an aetiological factor for an AOB. Although a number of mouth breathers have an AOB it is due to the airway obstruction that they have to mouth breath. That is why the airway obstruction is reported as the aetiological factor (Vig, 1998). Studies that have looked at mouth breathing and enlarged adenoids state that adenoidectomies should not be carried out as a prevention of malocclusions but should only be undertaken if medically indicated (Ng *et al*, 2008)

Decreased muscle function due to neurological disorders has also been associated with an AOB. Gershater, (1972) recorded an incidence of AOB of 32.3% in children with such disorders.

1.3.4 Skeletal pattern

An increased lower anterior face height or long face may be due to the position of the mandible in relation to the maxilla. Unfavourable growth of the mandible in a downward and backward rotational pattern would result in exacerbation of the AOB (Mitchell, 2013). This results in an increased distance between the two jaws. This deviation from the norm can be compensated to an extent by over-eruption of the dentition in either jaw until they contact. However, if the underlying position of the dental bases is too far apart then this compensatory dental change will not be sufficient to mask the skeletal defect. This inability for dental compensation to occur often results in a symmetrical AOB.
If the aetiology is skeletal in origin, other skeletal features may also be evident. Cephalometrically, steep inclined condylar head, increased curvature of the inferior dental canal, increased antegonial notching (a sign of unfavourable downward backward growth rotation), increased lower face height, reduced inter-incisal angle, reduced intermolar angle and a retrusive chin may be evident (Burford and Noar, 2003; Davidovitch *et al*, 2015).
If the underlying causative factor of the AOB is of skeletal origin then it is most likely that surgery may need to be considered for correction of the AOB.

It is likely that an AOB develops due to a combination of the aetiologies mentioned above with the interaction of the skeletal relationship and the surrounding supporting soft tissues with pressures from the lip and tongue.

1.3.5 Iatrogenic

Some adverse effects of orthodontic mechanics can lead to an AOB. Failing to control the eruption of the second permanent molars during bite-plane or functional appliance therapy can create an AOB due to the wedge effect.

Upper arch expansion often results in the palatal cusps of the upper permanent molars moving inferiorly, creating an AOB.

1.4 Management of an anterior open bite

Due to the multifactorial aetiology, the treatment for an AOB cases can be complex and challenging with long-term stability unpredictable.

Treatment of AOBs secondary to a digit habit are relatively more predictable as the majority of the malocclusion will improve and resolve once the habit has stopped in growing patients. There are a number of different methods that can be used to break the habit. In the simplest form education and advice can suffice provided the patient is mature and coherent enough to accept this. The older patient may have more of an

appreciation of being shown the detrimental long term effects that a digit habit can cause.

If education and advice fails then there are techniques, which can be used to discourage the habit. Placing a sock or glove on the offending hand or digit itself has been suggested, particularly in cases where the habit is subconscious and occurs at night. Nail varnishes such as Mavala stop can be applied to the offending digit that provides an unpleasant taste as discouragement.

If this fails, removable appliances with a ‘hay rake’ or some other form of design of auxillary in the palate can be provided as an obstruction to the digit. The obstruction serves not only as a reminder to the patient to not use the digit, but also prevents a seal and thus inhibits the ‘sucking’ habit.

In patients that do not take advice on board and where non-treatment interventions have not worked it raises the question of compliance. Removable appliances may not be worn. Non-compliance appliances can be used which have a similar obstruction in the palate by means of a hay rake or raised button in the palate but fixed in position with bands on the molars.

No further treatment is considered or provided without cessation of the habit due to inhibition of desired tooth movements, lack of stability and the risk of root resorption.

There are three options for managing an AOB; acceptance, orthodontic camouflage or combined orthodontics and Orthognathic surgery.

1.4.1 Acceptance of an anterior open bite

This is a valid treatment option in those cases where the patient is happy to accept the malocclusion and is not motivated or willing to consider other treatment options. In some instances it maybe necessary to accept an AOB due to the unpredictable instability of the resulting closure. Such as those cases where the soft tissues are the main aetiological factor with bimaxillary proclination and hypotonic flaccid lips with or without a strong tongue function (Kuroda *et al,* 2004)

1.4.2 Interceptive treatment

Early treatment of an AOB can be an option and many have tried to redirect or use growth to help guide the skeletal bases and dentition into a more favourable position. Such treatment has the most ideal outcomes if treating cases in the mixed dentition when there is still potential for further growth (English, 2002).

1.4.3 Growth Modification

The methods discussed below are some of the treatment techniques used to attempt to limit the development or progression of an AOB.

1.4.3.1 High pull headgear

The use of headgear to the molars and its effect on the development of the occlusion in different planes has been extensively researched. Studies have shown that the use of high pull headgear with a strap attached to the top of the head rather than the neck, show that it prevents the eruption of the maxillary molars and may even result in molar intrusion. There was also weak evidence suggesting that the use of high pull headgear could result in a clockwise movement of the palatal plane (Jacob *et al*, 2013). The secondary effects of this are that the mandible auto-rotates forwards and upwards and effectively reduces the open bite.

1.4.3.2 Vertical chin cup

This involves a head gear style appliance with the pressure applied onto the chin with a cup. The force is directed in a vertical direction with a view of preventing unfavourable growth in the vertical plane. This type of therapy heavily relies on the co-operation of the patient and where compliance and prolonged wear is maintained it can help reduce the open bite and may provide vertical control of the skeletal pattern and a flattening of the gonial angle (Iscan *et al*, 2002).

1.4.3.3 Posterior bite blocks

There are many different designs and modifications of posterior bite blocks, most are however a solid component covering the occlusal surfaces of the posterior molars. They are used to deliver forces to bring about movements of the teeth. Some derive forces from the stretching of the muscles due to the elevation of the posterior block in the vertical plane (Iscan *et al*, 1997). The force can also be derived from the use of repelling magnets in opposing blocks or spring loaded blocks (Kuster, 1992) to produce an intrusive effect on the molars, extrusion of the maxillary incisors and auto-rotation of the mandible. (Iscan *et al*, 1997; Kuster, 1992;Kiliaridis *et al,* 1990)

1.4.3.4 Functional appliances

Functional appliances used for AOB cases include the Teuscher appliance, which can be combined with high pull headgear in order to bring about an intrusive effect of the maxillary molars; An Open-Bite Bionator and a Fränkel IV regulator. All of these have been shown to reduce the AOB to an extent (Ngan *et al*, 1992; Cozza *et al*, 2007; Fränkel and Fränkel, 1983). However, the use of such appliances are heavily reliant on patient compliance.

1.4.4 Orthodontic camouflage

In cases where the aetiology is not predominantly skeletal it is possible to use orthodontic camouflage to treat the malocclusion by creating dental changes and leaving the underlying skeletal pattern unchanged. There have been various methods reported in the literature on how this can be achieved such as extractions of premolars or molars, inter-arch elastics, Temporary Anchorage Devices and miniplates (Kim, 1987; Jenner and Fitzpatrick, 1985).

1.4.4.1 Use of extractions

Generally it is common practice to extract a single premolar from each quadrant to provide space to allow retroclination of the upper and lower incisors thereby reducing the AOB. Mesial movement of the posterior dentition following the removal of premolar units reduces the wedge effect which allows closure of the AOB (Pearson, 1978).

Extraction of first permanent molars has also been advocated as a treatment method, with the theory that this would enable mesial drifting of the posterior segments and also accommodate counter-clockwise rotation of the mandible. There is disagreement in the literature however that this extraction pattern does not necessarily result in a change in the position of the mandible (Nahoum, 1977)

1.4.4.2 Use of elastics

The edgewise appliance can be modified with a series of gable bends known as the multi-loop edgewise archwire (MEAW). The gable bends are used to attach vertical elastics to create dental movement to close the open bite. Since this is solely reliant on dental movement it needs to be noted that this treatment method is only appropriate where there is scope to lengthen the clinical crown height (Kim, 1987) Counterforce wires have also been known to be used in the treatment of AOBs by placing one with an increased curve of spee in the upper arch and one with an increased reverse curve of spee in the lower arch. It is implicit that an anterior box elastic is used anteriorly to prevent the AOB from worsening. In doing so the AOB is managed by inherent intrusion of the maxillary molars (Berendt *et al*, 1989).

1.4.4.3 Use of TADS and miniplates

Bone plates were first used for skeletal anchorage in 1985 by Jenner and Fitzpatrick. Titanium miniplates which have been recognised as the Skeletal Anchorage System have been used either in the maxilla to aid with intrusion of the molars and in some case have been reported to facilitate intrusion of the molars by 3-5mm (Umemori *et al* 1999). This also allows for extrusion of the incisors and auto-rotation in a clockwise direction of the mandible, both of which enable reduction in the AOB.

The use of mini-screws has increased in recent years and clinicians have found their use beneficial in the treatment of AOBs. Maxillary screws have been able to provide 'absolute anchorage' for intrusion of posterior molars which then results in auto-rotation of the mandible and in extraction cases retraction of the incisors. In combination the mandibular mini-screws provide absolute anchorage for intrusion of the posterior molars by means of forces being applied distal to the first permanent molars and this helps minimise or prevent tipping of the posterior dentition in a mesial direction during space closure. Thus the anterior teeth can be retracted if necessary without space loss from the posterior teeth moving forward due to the absolute anchorage (Park *et al*, 2005; Kuroda *et al* 2004).

1.4.5 Orthognathic surgery

A combined orthodontic and surgical approach may be required in cases where the aetiology is predominantly skeletal and treatment required to correct the AOB is beyond the realms of orthodontic camouflage alone. Without Orthognathic surgery in these cases the outcome may have to be one of limited objectives or the end result may be highly unstable.

It is necessary for the patient to have ceased growth prior to surgical treatment as any future growth is likely to reverse the surgically assisted correction achieved risking the need for further surgery. The surgical movement of choice to reduce the AOB is usually a differential impaction of the maxilla with or without mandibular surgery. The differential

impaction lifts the maxilla posteriorly, effectively having an intrusive effect posteriorly, which then allows auto-rotation of the mandible forwards and upwards to aid the open bite closure (Sarver and Ackerman, 2003).

In those cases where there is a significant step in the occlusion the segmented parts are treated separately with sectional mechanics and then surgical correction is carried out with segmental surgery (Kuroda *et al,* 2007).

Stability of anterior open-bite closure is what poses the greatest difficulty in management of these cases. This is in part due to the difficulty in diagnosing all the aetiological factors involved. Research on the long term stability of anterior open-bites found relapse was present to a degree in both surgical and non-surgical groups with greater relapse in 25% of cases noted in the non-surgical groups compared to 18% in surgical groups (Greenlee *et al*, 2011).

1.5 Quality of Life

The World Health Organisation (1993) defines Quality of Life as an 'individuals' 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.' They state that, 'it is a broad ranging concept affected in a complex way by the person's physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of their environment.

1.5.1 Health related quality of life (HRQoL)

Health as defined by the World Health Organisation is ‘a state of complete physical, mental, and social well-being not merely the absence of disease.’ This definition clearly emphasises that health is multifactorial and is dependant on the state of the mind body and soul. Thus quality of life can be affected by each of these areas this is where the term ‘health-related quality of life’ originates. It encompasses five domains: physical status, psychological status and well-being, social interactions, economic and/or vocational status and factors and religious and/or spiritual status (Cunningham *et al*, 2000).

There are a number of tools available to measure health related quality of life and these have become increasingly popular as an assessment tool to determine the need for treatment and the outcome of treatment. As funding within the NHS is becoming increasingly constrained, policy and budget holders are becoming more and more interested in the findings of these studies.

1.5.2 Health-related Quality of Life measurement tools

The tool of choice for the measurement of the quality of life is primarily a series of questions delivered in the form of a self assessed questionnaire format. HRQoL measurements can either be general or disease specific. Generic measuring tools

provide an overview of the patient's general well-being and although informative it is not sensitive enough to provide specific information about how a disease or ailment affects an individual's life. Examples of generic quality of life measurement tools include SF-36 and the EuroQoL. The latter is a tool created by the collaboration of five multi-disciplinary centres across Europe as a measure of affects of various diseases on the quality of life (EuroQol Group, 1990).

The short-form 36-item Health Survey (SF-36) is a questionnaire made up of 36 questions designed to measure generic health in varying groups of age, ailment and treatment groups. The 36 items are further subdivided into 8 main domains and the end result gives a score for mental and physical health. Studies have shown high levels of validity and reliability (McHorney *et al,* 1994).

Ware *et al* (1996), shortened the 36 item questionnaire to 12 items and published the SF-12 as an assessment tool in 1996, in order for it to be readily and widely used in larger general populations to assess the general state of health.

The Sickness Impact Profile (SIP) is a 136 item self-completed questionnaire, which has two main focuses: physical and psycho-social (Bergner *et al*, 1981). It displayed good levels of reliability and validity however, it is more behavioural based compared to other health profile measuring instruments. A study using the SIP in nursing homes also found it to have a good level of internal consistency and external validity (Gerety *et al*, 1994).

1.5.3 Oral health-related quality of life (OHRQoL)

There has been a 35-year plus interest in the field of health related quality of life. It has expanded into various specific ailments. Recently there have been a number of studies looking specifically at oral health and measuring its effect on the quality of life of individuals. A new range of measurement tools were created as the previous ones available were too generic to truly identify how specific aspects of the individual's oral health affected their well-being.

The Department of Health (1994) defines oral health 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.' They define oral health-related quality of life (OHRQoL) as 'the impact of oral disorder on aspects of everyday life that are important to patients and persons, with those impacts being of sufficient magnitude, whether in terms of severity, frequency or duration, to affect an individual's perception of their life overall.'

Cohen and Jago (1976) were the first to investigate the relation of socio-dental impacts on individual's social well being. Since then further research has been carried out to assess how OHRQoL is affected by different oral features and disease.

Gift and Atchinson (1995), looked at the relationship between oral health and health related quality of life as a combination status of five domains; individual's perception to

health in general, opportunity and resilience of the individual, functional status of the individual, presence of disabilities or disease and duration of life. With the latter taking age of the individual into consideration and balancing it out with the quality of life. They began to look at the effect of the state of the oral health on each of these domains. These outcomes can be measured by specific questions centred around the individual's ability or comfort whilst; smiling, socially interacting, eating, speech, ability to swallow and general self-perception of their state of oral health in relation to their general health and well-being (Gift and Atchison, 1995).

It was recognised that the state of the oral health is influenced the individual's ability to eat and also interact on a social level, which in turn had a bearing on their self-esteem. OHRQoL measures have become increasingly important, being used as a tool to help create policies and to assess treatment need in order to assist with the allocation of funding in a bid to improve the overall quality of life of patients (Cunningham *et al*, 2001).

OHRQoL studies have been carried out in a number of different patient groups including children requiring dental treatment under general anaesthesia (Gaynor and Thomson, 2012), a Chinese adult group suffering with oro-facial pain (Zheng *et al*, 2011), a patient group with implant retained dentures (Grover *et al*, 2014) and many others.

1.5.4 Oral health-related quality of life measurement tools

Since oral health is so different from other diseases and ailments it was necessary to create a specific measurement tool to assess the impact of changes to an individual's oral health in relation to the individual's quality of life. Slade and Spencer (1994) developed the oral health impact profile (OHIP) based on a model suggested by Locker (1988), to measure oral health. The original OHIP of 49 statements that describe the impact of the current state of the patient's oral health to their quality of life in terms of their own perception. The 49 statements cover seven domains; functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. The research concluded that 'The Oral Health Impact Profile offers a reliable and valid instrument for detailed measurement of the social impact of oral disorders and has potential benefits for clinical decision-making and research.' It is generally the more popular choice of measurement tool for assessing OHRQoL. It has been translated into a number of different languages and a shortened version of OHIP involving 14 statements the OHIP-14, that involved two statements relating to each of the seven domains has been developed (Slade, 1997). The shortened version was developed as not all 49 statements would be applicable to all forms of conditions affecting the oral health and so those statements that were generally left blank or had a low level of response in the OHIP-49 were omitted from the OHIP-14 (Slade, 1997).

Furthermore it was suggested that since the statements in the OHIP focus on the negative impacts of oral conditions it is better served as an assessment of the OHRQoL prior to treatment (Liu *et al,* 2011). This is further compounded by the fact that the majority of patients seeking orthodontic treatment are fit, well and asymptomatic and are more concerned by their aesthetic needs (Cunningham *et al*, 2000).

The limitations of the generalized OHIP due to its statements bearing reference to pain and discomfort has encouraged the development of alternative assessment tools that are better suited to the orthodontic patient. One such assessment tool is the Psycho-social Impact of Dental Aesthetics Questionnaire (PIDAQ). It was developed by Klages *et al*, 2005 and assessed patients aged between 18-30 years with varying malocclusions and focuses on four main aspects; dental self-confidence, psychological impact, social impact and aesthetic concern. Since the PIDAQ was developed using a group of adults it was considered that its use on adolescent populations may not be appropriate due to developmental changes that may have a bearing on the psycho-social well-being of adolescents (Klages *et al*, 2005).

Other assessment tools for assessing OHRQoL in children have been developed such as the child perceptions questionnaire (CPQ11-14) for 11-14 year old children. This 37 item questionnaire was specifically designed to measure oral health related quality of life focused on four areas; oral symptoms, functional limitations, emotional and social well-being. Studies looking at this measurement tool found it to have high levels of validity and reliability. It was also found that shortened methods of this tool using

questions that exhibited the highest impact were also valid and reliable assessment tools for OHRQoL (Jokovic *et al*, 2006). It has also been studied to assess its validity when being used to measure the OHRQoL in relation to individual's self-perception of orthodontic changes. The study showed generally positive results although further research was suggested due to some of the study groups exhibiting levels of bias (Locker *et al* 2007).

1.5.5 Control groups in OHRQoL studies

A number of OHRQoL studies have used cross-sectional or longitudinal designs and have omitted or failed to mention the use of control groups within their design Zheng *et al* (2011); Grover *et al* (2014) and Johal *et al* (2007); used a control group of patients that had class I incisal relationship with an overjet no greater than 4mm and only minor upper labial spacing or mal-alignment no greater than 1mm. However, they may have had lower labial segment issues or malocclusal traits associated with the rest of their occlusion. It should also be considered that the control group was derived from a sample of patients who may have attended the hospital seeking orthodontic treatment. One could assume that these patients may have dental concerns that impact on their OHRQoL.

One OHRQoL study that utilised an age-matched control group, looked at those individuals with a lower treatment need and complexity than that of the study group (Kotecha S *et al*, 2013). Thus if assessing the impact of a malocclusion on the OHRQoL

it maybe an option to use a control group with similar socio-demographic backgrounds as the study group but with an IOTN dental health component (DHC) of 2 or below. One way of trying to ensure that the control group is closely matched in terms of age and socio-demographic background is by employing 'friend controls'. However there is a risk of 'over-matching' with this method of control group selection (Wacholder *et al*, 1992), as the authors feel that friends are likely to have a similar interests and outlook on life. In OHRQoL evaluation this would be disadvantageous as it is trying to assess the impact of the condition on the psycho-social well being of the study group and if the control group also have a similar social outlook the results could be at risk of being skewed. One way of over-coming or minimising this risk is by asking for a number of friends and then randomly selecting one (Wacholder *et al*, 1992).

Historic control groups can also be an option provided that the information required for the assessment or data collection is available. National surveys or studies are a good source for historical control groups. The Adult Dental Health Survey is a national survey carried out within the UK every decade. It serves as a means of assessing the dental health of adults within the UK and is carried out every ten years with the first having taken place in 1968. The survey involves the completion of a questionnaire interview and a clinical oral examination. The OHIP-14 was first used as part of the adult dental health survey in 1998 (Nuttall *et al*, 2001).

The Adult Dental Health Survey (1998) found that the OHIP was a suitable and reliable tool to assess the affect that the state of the oral health had on an individual. It

found that changes to the oral health from the norm, mainly physical pain and the psychological effects of the condition, were the main factors resulting in decreased quality of life for individuals. Thus a clear understanding of how the oral conditions that we are treating influence these aspects and subsequently have an effect on the psycho-social well-being of our patients is an important step in being able to holistically treat our patients.

1.5.6 Oral health-related quality of life in Orthodontics

Research by O'Brien *et al* (1998) found that orthodontics as an intervention does not categorically fit into quality of life research as other diseases as it is usually elective. It is a treatment method sought by individuals to improve aesthetics and function. Thus it would be difficult to gain a reliable or valid results from a quality of life study using quality of life measurement tools aimed at assessing disease groups whom are often in some form of pain or discomfort.

The use of QoL as a treatment outcome measure in orthodontics was first popularly applied to orthognathic patients (Bennet and Phillips, 1999). Cunningham *et al* (2000) looked at creating a quality of life measurement tool that is specifically tailored to suit orthognathic patient groups and was named the Orthognathic Quality of Life Questionnaire (OQLQ). Studies previous to this assessing the quality of life of those treated with orthognathic surgery have shown that a positive improvement had been

made in terms of self-perception and self-confidence (Alanko *et al,* 2010; Huang *et al*, 2016)

Liu *et al* (2009) carried out extensive research on the relationship of malocclusion, orthodontic treatment and the need for orthodontic treatment with the various different aspects of quality of life including OHRQoL. Although there was generally a low level of evidence it concluded that there was evidence showing an association between the presence of malocclusion and the need for orthodontic treatment. The majority of the papers included within the systematic review involved child or adolescent age groups. Badran (2010) found that changes in the dento-facial aesthetics particularly impacted on self-esteem of children and elements of bullying due to malocclusion were also noted in these age groups.

Other malocclusions in general have been reported to have a negative impact on the overall quality of life of individuals, both from a health and a psychosocial perspective. A literature review carried out by Zhang *et al* (2006) found that the speech and masticatory difficulties experienced with some malocclusions resulted in a decreased physical health quality of life. It also found that being in active treatment of the malocclusion (wearing appliances) had a bearing on the social acceptance, interactions and 'perceived intelligence' of individuals which resulted in a lower quality of life in relation to their social health.

Wong *et al,* (2006), measured the impact of severe hypodontia on OHRQoL and the affect of the severity of hypodontia. The study found that the presence of hypodontia

had a negative impact on all four domains of quality of life; oral symptoms, functional limitations, emotional and social well-being. And that the extent of hypodontia was also closely correlated with the level of impact on the quality of life.

Johal A *et al,* (2007), found that children with increased overjets and spaced dentitions had significantly negative impacts on their oral health related quality of life when compared to a control group. They identified that any deviation from the norm resulted in a sense of ostracisation from society even at an early age of 13-15 years. It also revealed that the parents of the children with increased overjets and dental spacing also displayed a highly significant impact on the quality of life compared to the parents of the children in the control group.

Masood M *et al,* (2017), looked at a population of Finnish adults to assess the impact of various malocclusions on the OHRQoL using the OHIP-14 questionnaire. They found that an increased overjet was the malocclusion trait that affected the OHRQoL with greatest significance compared to other malocclusions. Psychological disability according to the OHRQoL was affected more so in those individuals with an open bite.

Although there have been studies carried out looking at the OHRQoL of some malocclusions, there is very little reported literature on the effects of the presence of an anterior open-bite on OHRQoL in adult patients. One study looking at the factors affecting the quality of life in pre-orthognathic patients, did however show from one of its findings that that there was a significant association with the presence of an anterior

open bite and the functional domain of the quality of life tool that they had used (Stagles *et al*, 2015) With it being one of the more difficult malocclusions to treat and the high risk of relapse, it would be beneficial to further research this area to help understand this particular cohort's perceptions of their condition.

Chapter Two

Method

2. Method

2.1 Objectives

To evaluate the impact that the presence of an anterior open bite (AOB) has on oral health-related quality of life (OHRQoL) in adults.

2.2 Null hypothesis

There is no difference in the OHRQoL in adults with and without an anterior open bite.

There is no correlation between OHRQoL and the depth of the anterior open bite.

2.3 Study design

This was a prospective longitudinal study involving a cross-sectional survey of adult patients presenting to new patient clinics across participating sites: Birmingham Dental Hospital, and University Hospital North Midlands.
A control group of Business Studies undergraduates without an AOB was utilised.
The Oral Health Impact Profile-49 was used as the measuring tool of choice for the OHRQoL.

Research and development support and approval was gained from the University of Birmingham and Ethical approval was gained from the Research and Ethics Committee 5 West of Scotland (REC ref: 16/WS/0129)

2.4 Sample size calculation

A sample size calculation with power set at 80%, a standardised effect size of 0.5 and significance level set at 5% required 63 participants to be recruited in each group. In order to account for a dropout rate of 10% or incomplete questionnaires a total of 70 participants were recruited.

Although there is limited evidence on what standardised effect size should be used, in quality of life studies it is widely accepted that the standardised effect size should be 0.5 (Cohen and Jago, 1976).

2.5 Selection criteria

2.5.1 Inclusion criteria

- Patients over the age of 16 years
- Patients that have not had any active interceptive orthodontic treatment at the time of inclusion
- The presence of an anterior open bite greater than 1mm

2.5.2 Exclusion Criteria

- Patients with cleft lip and palate or craniofacial syndromes
- Non-English speaking subjects
- Patients who have commenced active orthodontic treatment
- Patients who have had previous orthodontic treatment or extensive restorative dental treatment, including fixed appliances, fixed bridges or implants but not removable appliances or restorations.

2.6 Ethical approval

Ethical approval for this study was granted by proportionate review from the West of Scotland Research Ethics Service (REC reference 16/WS/0129). Research and Development approval was obtained from Birmingham Community Healthcare Trust and University Hospitals North Midlands.

2.7 Data collection and analysis

Participants who met the inclusion criteria were invited to take part in the study by the attending clinician. The purpose, nature and outline of the study was verbally explained to each potential participant. Once a willingness to participate was expressed the

patient was given a participant invitation letter (**Appendix 1**) and Patient Information Leaflet (**Appendix 2**). Written informed consent was obtained by the attending clinician (**Appendix 3**)

Patients who provided informed consent were asked to complete the OHIP-49 (**Appendix 4**) at the time of the appointment. Patients were given as much time as required to complete the questionnaire and were reassured of the anonymity of the results. Participants were advised that completed questionnaires would be securely stored as per the Trust's Information Governance policy and the Data Protection Act (2018).

Participants were also requested to complete the following demographic data:

- Age
- Gender
- Ethnicity

The treating clinician utilised a data collection sheet (**Appendix 5**) to record the following clinical parameters:

- Maximum depth of anterior open bite
- Pattern of anterior open bite (symmetrical/asymmetrical)

- The presence of other clinical features; such as spacing, hypodontia and severity of crowding

2.8 Statistical analysis

Participants recruited to the study were given an identifiable number when the data was inputted into a customised Microsoft excel spreadsheet. An identifiable key was created for the various characteristics. The OHIP-49 questionnaire has questions with likert scale answers giving an indication of the extent of the impact of that particular question on the quality of life. Each of the responses was given allocated a score from 0-4 corresponding to the available responses; ‘not at all’ to ‘very often’. The scores for all of the 49 questions were summed and gave an overall Impact profile score out of a possible 196.

Analysis of the data was carried out by inputting the OHIP-49 scores and the descriptive characteristic scores (using the allocated key) into the Stata Statistical Software programme. A Q-Q plot demonstrated that the data was not normally distributed. Therefore, the Mann Whitney U non-parametric statistical test was used to compare both overall impact profile scores and scores from each of the seven domains of the OHIP-49, between test and control group.

Negative binomial regression analysis was utilised to carry out sensitivity testing on each of the other noted variables, including age, gender, skeletal pattern, presence of

crowding, depth and symmetry of AOB. This was carried out for both overall OHIP-49 scores and the seven individual domains. The significance level used for comparison for each of these tests was $p=0.05$.

Chapter Three

Results

3. Results

3.1 Sample characteristics

Participants were recruited between October 2016 and August 2017. Recruitment was stopped once 71 participants within the study group and 68 participants within the control group had completed the paper questionnaire OHIP-49. Three participants from the control group were excluded as their questionnaires were incomplete.

The study sample age ranged from 18-25 years with a median age of 21 years. The control sample age ranged from 23-25.5 years with a median age of 24 years.

The gender split between each group was similar with 32 males (45%) and 39 females (55%) in the study group; 33 males (49%) and 35 females (51%) in the control group.

Due to the ethnic diversity of the area where the participants were recruited from; It was felt that the ethnic breakdown of the groups should be limited to the following groups White British, Mixed, Asian Indian, Asian Pakistani/Bangladeshi, Black Caribbean and Black African.

A sample size calculation carried out prior to commencing the study identified that in order to detect a standardised difference of 0.5 and achieve 80% power a sample size of 63 participants would be required in each group. To allow for a 10% dropout rate or poor participation such as incomplete questionnaires the aim was to recruit 70 participants in each group.

Hence recruitment in both groups successfully satisfied the requirement to achieve an

80% power.

Table 3.1: Characteristics of the sample groups

Factor	Classification	Test	Control
N		71	68
age, median (IQR)		21.0 (18.0, 25.0)	24.0 (23.0, 25.5)
Gender	Male	32 (45%)	33 (49%)
	Female	39 (55%)	35 (51%)
Skeletal Pattern	Class I	29 (41%)	
	Class II	16 (22%)	
	Class III	26 (37%)	
Ethnic Group	White British	40 (56%)	26 (38%)
	Mixed	1 (1%)	0 (0%)
	Asian Indian	7 (10%)	25 (37%)
	Asian Pakistani/Bangladeshi	11 (15%)	8 (12%)
	Black Caribbean	6 (8%)	7 (10%)
	Black African	6 (8%)	2 (3%)

Table 3.1 demonstrates the characteristics of both the study and control groups. There was a larger proportion of Caucasians in the test group (56%) compared to the control group (38%). There was a greater proportion of Asian Indian individuals in the control group (37%) compared to the test group (10%). There were similar proportions of other ethnicities in the test and control group.

Skeletal pattern was recorded for the test group but not the control. There was a similar distribution of Class I (41%), Class III (37%) and Class II (22%) relationships.

Table 3.2: Skeletal and dental features of subjects with an anterior open bite

Factor	Classification	Value
Skeletal Pattern	Class I	29 (41%)
	Class II	16 (22%)
	Class III	26 (37%)
Overjet, median (IQR)		3.0 (0.0, 6.0)
AOB Depth, median (IQR)		4.0 (3.0, 5.0)
Crowding	No Crowding	6 (8%)
	Mild Crowding	42 (59%)
	Moderate Crowding	12 (17%)
	Severe	11 (15%)
AOB Symmetry	Symmetrical	63 (89%)
	Asymmetrical	8 (11%)

The above table 3.2 depicts other variables that were recorded from those participants in the test group.

The median overjet for the group was 3mm with the inter-quartile range from 0-6mm. The median depth of the AOB was 2mm with the overall range from 1.5-11mm with an interquartile range from 3-5mm.

Of those with an AOB 8% had no crowding, 59% had mild crowding, 17% moderate crowding and 15% severe crowding.

89% had a symmetrical AOB and 11% of had an asymmetrical AOB.

3.2 OHRQoL in subjects with an anterior open bite compared to a control group

OHIP scores were calculated by summing up the individual scores from each of the seven domains. This gave an overall OHIP-49 score. Each of the seven questions within the domains had five possible answers to choose ranging from 'Never' to 'Very often' (Appendix 4). The five possible answers were given a value from 0 to 5. The score from each question was summed up to give a separate score for each of the seven domains and an overall OHIP-49 score.

Q-Q plots of the initial data revealed that the data was not normally distributed. Subsequently, non-parametric formulae were utilised to analyse the data. The Mann Whitney U test was utilized to analyse differences in OHIP scores between the study and control groups.

Table 3.3: OHRQoL in AOB subjects compared to a control group

	Test	Comparison	Significance
ohip49, median (IQR)	55.0 (44.0, 83.0)	9.5 (8.0, 13.0)	<0.001
ohip_func, median (IQR)	13.0 (9.0, 18.0)	2.0 (2.0, 4.0)	<0.001
ohip_pain, median (IQR)	7.0 (4.0, 11.0)	3.0 (2.0, 5.0)	<0.001
ohip_psych, median (IQR)	10.0 (7.0, 16.0)	2.0 (1.0, 4.0)	<0.001
ohip_physdisabl, median (IQR)	10.0 (7.0, 16.0)	0.0 (0.0, 1.0)	<0.001
ohip_psychdisabl, median (IQR)	8.0 (5.0, 12.0)	0.0 (0.0, 1.0)	<0.001
ohip_socdisabl, median (IQR)	7.0 (3.0, 11.0)	0.0 (0.0, 0.0)	<0.001
ohip_handcp, median (IQR)	3.0 (1.0, 7.0)	0.0 (0.0, 2.0)	<0.001

Table 3.3 demonstrates the OHIP scores in each of the seven domains; function, pain, psychology, physical disability, psychological disability, social disability and handicap and the total OHIP score. The AOB group was affected in all domains by their

malocclusion. The AOB group scored higher than the control group in all seven domains giving them an overall higher OHIP score than the control group. With a P value of <0.001 in all seven domains the the null hypothesis is rejected suggesting that there is a significant difference between the OHRQoL in adults with an AOB compared to those without.

There was a wide range of scores for the overall OHIP scores in the test group compared to the control group. The greatest difference in median scores for each domain between test and control groups was within the functionality group where the test group scored 11 points higher than the control group. The physical disability domain scored 10 points higher by the test group compared to the control. The psychological disability domain and psychological well-being domains both scored 8 points higher by the test group compared to the control. Social disability scored 7 points higher by the test group compared to the control group. Handicap disability scored 3 points higher in the test group compared to the control group.

The control group scored 0 overall for the following domains; physical disability, psychological disability, social disability and handicap.

3.3 Regression analysis

Other recorded variables were individually scrutinized using a multivariate regression model and keeping other variables as a constant it revealed that they did not generally have statistically significant effect on the change in OHIP-49 scores.

Table 3.4: Multivariate regression model

OHIP49	Coef.	Std. Err.	t	P>|t|	95% Confidence Interval	
Age	0.7	0.76	0.91	0.360	-0.83	2.21
Gender						
Female	20.87	8.81	2.37	**0.02**	3.23	38.51
Ethnicity						
2	5.29	9.65	0.55	0.59	-14.04	24.62
3	-0.42	11.22	-0.04	0.97	-22.89	22.06
Skeletal Pattern						
Class II	-18.41	12.19	-1.51	0.14	-42.83	6.01
Class III	-30.01	11.7	-2.56	0.01	-53.45	-6.58
Overjet	-2.09	1.25	-1.68	0.1	-4.6	0.41
Depth of AOB	1.86	2.01	0.92	0.36	-2.17	5.89
No Crowding						
Mild Crowding	-0.33	15.46	-0.02	0.98	-31.28	30.62
Mod Crowding	9.2	17.57	0.52	0.6	-25.99	44.39
Sev Crowding	10.08	18.04	0.56	0.58	-26.05	46.2
Symmetrical AOB						
Asymmetrical AOB	-10.36	13.58	-0.76	0.45	-37.55	16.82

Table 3.4 shows multivariate regression model of the differential that each of the variables recorded makes to the overall OHIP-49 score. For every year the age increased the overall score increased by 0.69 which was not statistically significant.

Females compared to males consistently scored at least 20 points higher on the impact profile, which was statistically significant with a p value of 0.02. Ethnic variation was given the following code; 1- Caucasian, 2-Asian (Indian, British-Indian, Pakistani and Bangladeshi) and 3- Black (African, Caribbean, Afro-American).
There was no statistically significant difference in OHRQoL according to ethnic group.
The influence of the skeletal pattern OHIP-49 scores were assessed taking the median score of those with a skeletal class I pattern as the baseline score. It shows that both class II and class III skeletal patterns scored less and those with a class III skeletal pattern scored significantly less than those with a skeletal I pattern, which was statistically significant.

An increase in overjet resulted in a lower overall score and an increase in depth of AOB meant an increase in overall score but both by minimal amounts and neither were statistically significant.

Taking those with well aligned arches as a baseline OHIP-49 score those with mild crowding scored insignificantly less and then the overall score increased by 9 and 10 points for moderate and severe crowding respectively. Again these were not statistically significant.

Those with an asymmetric AOB scored consistently 10 points less than those with a symmetrical one, but this was not statistically significant.

Table 3.5: Negative binomial regression of overall OHIP-49 testing age and gender

OHIP49	IRR	Std. Err.	z	P>|z|	95% Confidence Interval	
AOB Group	5.18	0.52	16.44	0.000	4.26	6.31
Age	1.01	0.01	0.59	0.55	0.98	1.03
Gender						
Female	1.36	0.13	3.24	**0.001**	1.13	1.64
_cons	1.74	0.62	1.56	0.12	0.87	3.49
/lnalpha	-1.30	0.14			-1.57	-1.04
alpha	0.27	0.04			0.21	0.35

Table 3.5 is a negative binomial regression analysis, carried out to see how age and gender had an affect on the oral health related quality of life score in subjects with an AOB.

The only independent variable to have a significant effect on the OHIP-49 score when all other variables were taken as a constant was the gender of the participant. The table above depicts that Females with an anterior open bite consistently scored higher than their males counterparts and the means ratio (IRR) shows that they were on average 36% higher than the males' score. With a p value less than 0.001 this is statistically

significant. Conversely the age variable which is also shown on the above table shows that there is no statistically significant difference between OHIP-49 scores and age.

Table 3.6: Negative binomial regression of individual domains testing age and gender

	Functional limitation		Physical Pain		Psychological discomfort		Physical disability		Psychological disability		Social disability		Handicap	
	IRR (CI)	p value	IRR (CI)	p value	IRR (CI)	p value	IRR (CI)	p value	IRR (CI)	p value	IRR (CI)	p value	IRR (CI)	p value
Gender														
Male	_	_	_	_	_	_	_	_	_	_	_	_	_	_
Female	1.19 (1.02-1.39)	**0.02**	1.45 (1.16-1.81)	**0.001**	1.28 (1.03-1.58)	**0.02**	1.24 (0.94-1.63)	0.12	1.51 (1.17-1.96)	**0.001**	1.68 (1.13-2.51)	**0.01**	1.81 (1.12-2.92)	**0.02**
Age	1.02 (1.00-1.03)	0.06	1 (0.98-1.03)	0.82	1 (0.98-1.02)	0.69	1.01 (0.98-1.04)	0.65	1 (0.98-1.03)	0.64	1.02 (0.97-1.06)	0.41	1 (0.95-1.06)	0.97

Table 3.6 shows negative binomial regression analysis of age and gender and their effect when assessed in isolation on each of the seven domains of the OHIP-49 questionnaire. Significant p values are highlighted in bold. Females had a statistically significantly highe impact profile score in all of the seven domains apart from the physical disability domain.

Chapter Four

Discussion

4. Discussion

4.1 Discussion

This study was a cross-sectional prospective survey looking to assess the presence of an AOB in adults and its impact on the oral health related quality of life. The oral health related quality of life was measured with the use of the Oral Health Related Impact Profile – 49 questionnaire since it is a well known tool in quality of life studies and has also been proven to be a valid one (Liu *et al,* 2011).
Recruiting an appropriate control group in quality of life studies is challenging, particularly when resources are limited.

It would be extremely difficult to find the perfect control group to compare the test group to especially with limited resources available. Thus the main parameters for the control group were set at being greater than 16, not having had or seeking any orthodontic or extensive restorative treatment. In order to find the closest match of a varied mix of gender and ethnicity and socio-economic background the Higher Education Statistics Agency database was consulted. It revealed that the degree intake for 2014/2015, with the most varied and equal mix of gender and ethnicity was Business Studies. Hence the control group participants were recruited from those undertaking a Business Studies degree at the University of Birmingham. It is appreciated that there are limitations in using a control group; as a gold standard control group would be one that has no oral disease and a perfect class I Andrews six keys occlusion. It is appreciated that this is an ideal theoretical concept rather than a practical reality. However, it would be extremely difficult to recruit 63 such participants that are willing to partake in the study in a timely manner. The control

group did not have a dental assessment and may well have had other degrees of malocclusion but were not actively seeking or considering treatment for these at the time of recruitment.

71 participants were recruited to the test group and 71 participants in the control group. Since the sample size calculation required a minimum of 63 participants both groups met this requirement. Three participants were omitted from the findings in the control group, due to incomplete questionnaires, thus leaving the total participants in the control group as 68. Although a number of previous quality of life studies have not involved a control group (Zheng *et al*, 2011; Grover *et al,* 2014**)** it was important in this study to a control to provide some basis for comparison. Although previous studies have also been lacking in priori calculations, which are carried out to determine the required sample size (Hashem *et al,* 2013) it is generally accepted that studies on quality of life should be designed to detect a minimum effect size of 0.5 (Cohen *et al,* 1976). Data collection of the test group took longer than anticipated and this is likely due to the relatively low prevalence of an AOB of 4% in the adult population in the UK (O'Brien, 1994).

The gender split of the test group was that there were more females than males and this also supports findings from previous studies showing a greater prevalence in females compared to males (Machado *et al*, 2014; Al-Taee, 2010). The minimum age of the participants was set at 16 years to ensure that the sample size was met within a timely manner. Those who had undergone previous treatment, individuals with cleft lip or palate or craniofacial deformities were excluded from the group as previous studies had shown that these factors have an affect on the OHRQoL. This

would aim to limit the influence of these confounding factors on the final results. (Naito *et al*, 2006; Jokovic *et al,* 2006).

The majority of the study group were Caucasian (56%) with the second most prevalent groups being Asian Pakistani/Bangladeshi and Asian Indian (15% and 10% respectively), and the least prevalent were Black Caribbean and Black African both 8%. This is related to the area of the data collection and the ethnic diversity of the region of the West Midlands. However, it goes against the prevalence trends of the presence of AOBs and its association with different ethnicities. This contradicts previous research that revealed that Afro-American populations had the highest prevalence of AOB at 10% (Kelly and Harvey, 1977) and a UK based study where the sample population were predominantly Caucasian found the prevalence of an AOB to be 4% (O'Brien, 1993).

Oral Health related Quality of Life has recently increased in popularity as an outcome measure justifying or assessing treatment outcome. Thus there has been a large amount of research into this area to see how various malocclusions have affected the OHRQoL of individuals. The study showed that the median of the overall OHIP-49 score achieved for test group (55) was relatively comparable to a previous study involving hypodontia and amelogenesis imperfecta (61) (Hashem *et al*, 2013). The control group in their study however scored higher overall, with an OHIP-49 score of 31 compared to the control in the present study whose median OHIP-49 score was 10. However, this is likely to be due to the difference in control characteristics as in the Hashem study the control group was recruited from the dental record database which would infer that they would likely be seeking treatment of sorts. Interestingly

the AOB group's median scores for all seven domains were similar to those achieved by the amelogenesis and hypodontia groups in the study by Hashem *et al* (2013). A study looking into the affects of periodontitis on the oral health related quality of life also found similar results with the overall OHIP-49 score as 49 for the test group.

OHIP-49 is a Quality of life measurement tool that has been used in a number of previous studies and for a number of years. It was originally developed by Slade and Spencer (1994) as it was felt that oral disease and its manifestations have different affects on individual's lives than other disease. Forty nine statements cover seven domains and it had been suggested that the questions focused on the negative impacts of oral health on an individuals' life hence it is best served as a measurement tool to assess their quality of life prior to treatment (Liu *et al,* 2011). This was one of the justifications for using the OHIP-49 in this particular study. This was supported by research by O'Brien *et al* (1998) suggesting that orthodontics as an intervention did not categorically fit into quality of life research compared to other diseases. It is difficult to use other non-oral health specific questionnaires to determine a valid and reliable result of the affect on the quality of life as most focus on discomfort and pain of which there is unlikely to be much at all in a healthy individual seeking an elective procedure to correct their malocclusion.

The choice of OHIP-49 as the measurement tool of choice of this study is one of the limitations of this study. Since there are condition specific oral health measurement tools available there are no tools that have been developed specifically to assess an AOB.

The Psycho-social Impact of Dental Aesthetics Questionnaire (PIDAQ) developed by Klages *et al* (2005), was viewed by its developer to be a better suited measurement tool for those undergoing orthodontic treatment. It was felt to be superior to the OHIP questionnaire in assessing those during orthodontic treatment as the OHIP has questions focusing on pain and discomfort, which are not necessarily applicable to this cohort of patients. However, PIDAQ does not have questions relating to functionality or functional limitations, which is of interest when assessing patients with an AOB. Thus it was felt that the OHIP-49 was better suited to this study. The recent Malocclusion Impact Questionnaire (MIQ) may potentially have been better suited (Patel *et al,* 2016).

Within the seven domains that the OHIP-49 assesses it was found that the greatest difference of scores between test and control group lay with the functional domain. This has been previously reported on as a finding when looking at regressional analysis of co-variants assessing which particular factor affect the quality of life in orthognathic patients by Stagles *et al*, (2015). They had found that the presence of an AOB or an increase in overjet was associated with a statistically significant increase in quality of life score in the functional domain, which supports the results achieved from this study.

The negative binomial regression analysis showed that only gender had a statistically significant affect on Impact Profile scores as an isolated co-variant. This is supported by literature from previous studies although direct comparison is limited due to the study having used the OHIP-14 a shortened version of the questionnaire

and the Orthognathic Quality of Life Score (OQLQ) (Feu *et al*, 2010; Stagles *et al*, 2015).

The other co-variants that were recorded did not make a statistically significant difference to Impact Profile scores. Although age did show that with every increase in year the overall OHIP-49 score increased by 1. Although this is not clinically or statistically significant it can be deduced that a general increase in age does negatively impact on the Oral Health related Quality of Life to an extent. Other studies have shown that an increase in age does have an increasing effect on the score (Steele *et al*, 2004)**.** This maybe attributed to the change in life-style and increasing social interactions that we experience as we age. In the age of social media where society appears to be increasingly driven by image maybe a large contributing factor to patients' increased quality of life scores.

Although this study did not detect a significant affect on the OHIP score when looking at over-jet as an isolated co-variant other studies conversely found that it did have a significant difference to quality of life scores (Johal *et al*, 2007). The same study also assessed quality of life in relation to spacing and also found this to have a negative effect on the quality of life and more so than changes in over-jet. Although it is appreciated that the spacing that was assessed was due to hypodontia and AOB is a form of spacing in the vertical plane. So this may loosely support the overall significant difference between quality of life scores seen between the AOB group and the control.

The lack of further subjects may have meant that the other co-variants that were looked at (depth of AOB, extent of crowding, symmetry of AOB) were not shown to have a significant effect. The depth of AOB would have been a useful co-variant to further analyse as it may have given an indication as to whether or not the current IOTN scoring system is valid or not. Since the cut off between the provision of treatment and no treatment on the National Health Service is a matter of a 1mm (4e = >4mm and 3e 2-4mm open bite). However the present study did find a relationship between depth of AOB and the OHIP score. The median value of the depth of AOB for the group was 4mm and thus 50% of the sample would not have qualified for orthodontic treatment in terms of the dental health component (DHC) solely on their AOB. Table 3.6 shows OHIP-49 score increased by 1.86 for every 1mm increase in AOB, which although not statistically significantly does show a valuable trend. This may support the the Index of Orthodontic Treatment Need (IOTN) Dental Health Component (DHC) increasing with an increase in depth of AOB.

Class III patients had significantly lower OHIP scores compared to those with a Class I and Class II skeletal pattern. This is contrary to previous literature, which that showed that class III patients are more concerned by their appearance. (Gerzanic *et al*, 2002). Additional studies have also shown a class III skeletal pattern with a reverse overjet to negatively impact on the oral health related quality of life of individuals (Stagles *et al*, 2015). Even though a similar proportion of the sample group were Class I and Class III the relation of the quality of life scores and the presence of a class III skeletal pattern maybe due to sample size limitations when looking at specific co-variants.

Although, there have been a number of studies on various maloclussal traits and their association with oral health related quality of life, a recent systematic review by Kragt *et al*, (2016), has shown that the presence of hypodontia had the greatest significant effect on the oral health related quality of life in children. Even though this is an alternative age group that was investigated, the malocclusal traits that were covered in the systematic review did not include AOBs. This study adds to the evidence available to suggest that AOBs an individual malocclusal trait is likely to significantly negatively impact on the oral health related quality of life of individuals. It is appreciated that the external and to an extent the internal validity of this study maybe questioned since a more condition specific quality of life measurement tool was not used. In addition, an AOB rarely occurs in isolation and so it would be difficult to ascertain whether the extent of the negative effect on the oral health related quality of life was solely due to the AOB. Thus the various limitations of this study mean that the results achieved and interpretation of these should be taken bearing the limitations in mind.

Further research into this area would be encouraged using condition specific questionnaires such as the orthognathic quality of life questionnaire or the recent Malocclusion Impact Questionnaire (MIQ) to see how the OHRQoL differs between the two (Cunningham *et al,* 2000; Patel *et al,* 2016). Since the handicap domain was not generally scored highly it could suggest that a condition specific questionnaire created for those with an AOB could omit this domain entirely. The potential questionnaire created may want to further explore and expand on the domains that had the biggest difference between the two groups; function, psychological, physical disability and psychological disability.

4.2 Conclusions

The presence of an AOB negatively impacts on the oral health related quality of life in adults. This difference was statistically significant when compared to a control group. Females consistently scored higher in the impact profile scores when compared to other variables in isolation. The impact on the OHRQoL was also independent of the size of the AOB.

This study also provides OHIP-49 scores from a substantial control group that could be used to compare future studies against.

Since there were some limitations to investigating variables such as depth of AOB due to a lack of sample size number and variability it would be interesting to do a further study to investigate this. Future studies could also look at the change in OHIP-49 scores during and after orthodontic treatment of this particular cohort of patients.

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Appendices

Appendix 1: Invitation letter to participants

Invitation letter to participants

Letter inviting subjects to take part in a study to assess the impact of anterior open bites on the quality of life v1.5 24/06/2016

Dear Patient,

I am a qualified dentist in training for Orthodontics and as part of my studies I am undertaking a project into the problems of anterior open bites (space between the top and bottom front teeth when the back teeth are biting together).

I am asking whether you would be willing to be involved in this study as your top and bottom teeth do not meet together fully.

If you agree to take part you will be asked to complete a questionnaire. The answers you provide to the questions will not be shown to anyone else and will not affect your treatment. At no point will your name or contact details appear on the forms. I hope this serves as reassurance that the information gained will be kept safe.

You do not have to take part if you do not wish to do so and this will not affect your treatment. However we hope that you will choose to take part and help us to learn more about the impact that open bites may have.

This project is being supervised by Ms Kotecha, Consultant in Orthodontics and Professor Dietrich, Consultant in Oral Surgery and Academic Supervisor. If you would like to know more about the study, please do feel free to ask me any questions.

Thank you in advance for your help.

Yours sincerely

Anish Patel
Specialist Registrar in Orthodontics

Appendix 2: Participant information sheet

Participant information sheet IRAS: 200948

PARTICIPANT INFORMATION SHEET v1.5 30/09/2016

We would like to invite you to take part in a research study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish.
(Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study).

Title: A study to investigate the impact of the presence of an anterior open bite on the oral health related quality of life

PART 1: The project

Why are we doing this research?

Many people suffer with an anterior open bite (space between the front teeth when your back teeth are biting together). There has been a lot of research into the causes and treatment of an anterior open bite but the profession have not considered the impact that this has on the way individuals feel as a result of their anterior open bite.

Why have you been asked to participate?

We are inviting you to take part in this study because you have an anterior open bite. Participation is entirely voluntary and your treatment will not be affected if you decide not to participate.

Do I have to take part?

No, if you don't want to participate then you do not need to complete the questionnaire. However your participation would be appreciated to contribute to this important research subject.

What is involved?

Once you have verbally agreed to participate we will ask you to sign a form as agreement to taking part in the study. You will then be asked to complete an anonymous questionnaire. A member of the research team will be available if you have any questions. No additional appointments are required and answering the questionnaires will take a maximum of 15 minutes.

At no point will any treatment be withheld. You may withdraw yourself from the study at any time without consequence to the quality of care you will receive.

Appendix 3: Patient consent form

IRAS: 200948

PATIENT CONSENT FORM v3 30/09/2016
(to be completed by the participant)

A study to investigate the impact of the presence of an anterior open bite on the oral health related quality of life

Please initial each box and then sign at the bottom of this form ☐

1. I confirm that I have read and understood the information sheet dated 30.09.2016 (version 1.5) for the above study. ☐

2. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

3. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason, without the treatment offered to me or my legal rights being affected. ☐

4. I know that my medical notes may be looked at by responsible individuals from the research team where it is relevant to my taking part in this research. I give permission for these individuals to have access to these records. ☐

5. I agree to take part in the above study.

_____	_____	_____
Name of Patient	Date	Signature

_____	_____	_____
Name of Person taking consent	Date	Signature

When completed, 1 for patient; 1 for researcher site file; 1 (original) to be kept in medical notes

Appendix 4: Oral health impact profile – 49 questionnaire

Oral Health Questionnaire Version 1.0

1. Have you had difficulty chewing any foods because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

2. Have you ever had trouble pronouncing any words because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

3. Have you noticed a tooth that doesn't look right?

Never Hardly ever Occasionally Fairly often Very often

4. Have you felt that your appearance has been affected because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

5. Have you felt that your breath has been stale because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

6. Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

7. Have you had food catching in your teeth or dentures?

Never Hardly ever Occasionally Fairly often Very often

8. Have you felt that your digestion has worsened because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

9. Have you felt that your dentures have not been fitting properly?

Never Hardly ever Occasionally Fairly often Very often

10. Have you had painful aching in your mouth?

Never Hardly ever Occasionally Fairly often Very often

11. Have you had a sore jaw?

Never Hardly ever Occasionally Fairly often Very often

12. Have you had headaches because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

13. Have you had sensitive teeth, for example, due to hot or cold food or drink?

Never Hardly ever Occasionally Fairly often Very often

14. Have you had toothache?

Never Hardly ever Occasionally Fairly often Very often

15. Have you had painful gums?

Never Hardly ever Occasionally Fairly often Very often

16. Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

17. Have you had sore spots in your mouth?

Never Hardly ever Occasionally Fairly often Very often

18. Have you had uncomfortable dentures?

Never Hardly ever Occasionally Fairly often Very often

19. Have you been worried by dental problems?

Never Hardly ever Occasionally Fairly often Very often

20. Have you been self conscious because of your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

21. Have dental problems made you miserable?

Never Hardly ever Occasionally Fairly often Very often

22. Have you felt uncomfortable about the appearance of your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

23. Have you felt tense because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

24. Has your speech been unclear because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

25. Have people misunderstood some of your words because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

26. Have you felt that there has been less flavour in your food because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

27. Have you been unable to brush your teeth properly because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

28. Have you had to avoid eating some foods because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

29. Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

30. Have you been unable to eat with your dentures because of problems with them?

Never Hardly ever Occasionally Fairly often Very often

31. Have you avoided smiling because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

32. Have you had to interrupt meals because of problems with your teeth, mouth or dentures?

Hardly ever Occasionally Fairly often Very often

Never

33. Has your sleep been interrupted because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

34. Have you been upset because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

35. Have you found it difficult to relax because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

36. Have you felt depressed because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

37. Has your concentration been affected because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

38. Have you been a bit embarrassed because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

39. Have you avoided going out because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

40. Have you been less tolerant of your spouse or family because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

41. Have you had trouble getting on with other people because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

42. Have you been a bit irritable with other people because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

43. Have you had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

44. Have you felt that your general health has worsened because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

45. Have you suffered any financial loss because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

46. Have you been unable to enjoy other people's company as much because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

47. Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

48. Have you been totally unable to function because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

49. Have you been unable to work to your full capacity because of problems with your teeth, mouth or dentures?

Never Hardly ever Occasionally Fairly often Very often

Appendix 5: Data collection sheet

Anterior Open Bite Data Collection Proforma

Version 2 Dated: 03.02.16

Demographic details

Patient number	.....
Gender	.....
Age (yrs & months)	.....
Ethnicity	.....

Dental assessment:

Skeletal pattern	.....
Overjet	……...
Depth of AOB	……...
Severity of crowding	Mild/ Mod/ Severe
Symmetry of AOB	Symmetrical/ Asymmetrical
Previous treatment	.....

Other features (Including microdontia, spacing, midline diastema, hypoplasia, hypodontia)**:**

.....