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Over bite status and its association with Oral Health Related Quality of Life in Adolescents and Young Adults

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Overbite Status and its Association with Oral Health Related Quality of Life in Adolescents and Young Adults from Mexico and Peru

by

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THESIS

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DEDICATION

I would like to dedicate this Master's Thesis to my family for all the support they have given me over this long journey. Without their help none of this would have been possible. My dad's passion for his work and my mom's strength to never give up has been vital in helping me get to where I am today.

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by

Andrew Alexander, DMD

ABSTRACT

Background and Objective:
Oral health related quality of life (OHRQoL) is the aspect of one's general well being, which is directly related to the mouth. Burdens on OHRQoL may deleteriously affect one's ability to eat, speak, and socialize without discomfort, or embarrassment. However, different aspects of oral disease weigh against it in different ways. For instance, malocclusion affects different subdomains of OHRQoL than does caries. While the association between crooked teeth and social burdens has been reported, the relationship is unclear about how specific parameters of malocclusion like overbite or openbite may individually affect OHRQoL. Our objectives are to determine, in a sample group of adolescent and young adult subjects from Mexico and Peru: 1) how OHRQoL increases or decreases in relation to overbite; 2) to examine how overbite relates with subdomains of OHRQoL; and 3) to determine how severity on the spectrum of vertical dental relationships (severe deep bite through severe open bite) may alter the relationship between the oral health related quality of life. 4) To determine if there is an association between sleep disordered breathing, speech difficulties and vertical bite status.

Materials and Methods:
This was a cross-sectional, population-based, quantitative, epidemiological study. 2,042 subjects from 5 regions in Mexico and Peru aged 11-20 had their occlusion evaluated via the ICON index. Caries experience was quantified, via visual inspection, using the Decayed, Missing and Filled Surfaces (DMFS) index. Oral health related quality of life was measured with the COHIP-19 questionnaire. Vertical bite status, caries status, and malocclusion severity were analyzed in relation to quality of life, using ANOVA with bonferroni correction's as needed. For dmfs a kruskal-wallis and mann-whitney U tests were used. Finally, a multivariate regression analysis was utilized to account for possible confounding factors as age, sex, and dmfs. Significance set at $p<0.05$.

Results:
51% of the study population was categorized as needing orthodontic treatment. 50% had severe caries experience (DMFS>5). Malocclusion severity was significantly associated with a decrease in OHRQoL ($p<0.001$). OHRQoL was significantly associated with caries in an inverse relationship for overall COHIP and all 6 subscales ($p<0.001$), except UC Emotional Well-Being ($p=0.49$). No significant association was found between vertical bite status and OHRQoL. DMFS for severe open bite subjects was significantly higher (dmfs=10.1 for open bite greater than 4mm) versus deep over bite subjects (dmfs=4.4 for fully covered overbites).

Conclusions: In the regions studied and age group analyzed the following can be concluded. There is no association between overall OHRQoL, the subscales, and severity of vertical bite status in our population. There is a statistically significant decrease in Oral health related quality of life versus malocclusion severity and treatment need. There is a significant decrease in Oral health related quality of life versus caries experience except as it relates to ones attractiveness and confidence (Self esteem). There is a significant relationship between severe open bites and an increased caries experience**.**

Key words: Open bite, quality of life, oral health related quality of life, deep bite, normal overbite, dmfs

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1. INTRODUCTION

1.1 Oral Health Related Quality of Life

The World Health Organization (WHO) defines quality of life as the following: "Health is a state of complete physical, mental, and social well-being and not merely the absence of disease and infirmity (1)." Oral health-related quality of life is defined by the United Kingdom Department of Health as "a standard of health of the oral and related tissues which enables an individual to eat, speak and socialize without active disease, discomfort or embarrassment and which contributes to general well-being (2) ." Oral health is not just being free of dental pain and or dental disease (3). In children and adolescents, poor oral health can lead to pain and problems with the ability to chew, speak, and perform daily activities such as going to and performing well in school (3). Clinically determined poor oral health in children includes the presence of dental caries and malocclusion. Oral health related quality of life encompasses a patient's emotional and psychological perception of their oral health, their own analysis of their discomfort or pain in their mouth, and how their oral health affects their interpersonal communications, to name a few (4). (See figure 1)

In a recent systematic review and meta-analysis (5, 6), it was stated that oral health-related quality of life (OHRQOL) arose in the orthodontic literature to explain the variability in professionally determined (objectively) and patient-determined (subjectively) need for orthodontic treatment. OHRQoL is a patient reported outcome assessed by questionnaires to measure the psychological impact of the dentition. More precisely, OHRQOL is the interplay of oral health variables such as biological and physiological functional status, as well as ones own subjective assessment of their status in their social interactions, their self worth, emotional

health, and self image (7).This systematic review sought to give a complete overview on the influence of malocclusion, assessed as occlusal trait or orthodontic treatment need, on OHRQOL measured with validated questionnaires in children and adolescents (7). An important question that needs more evidence in our literature relates to the relationship between one's own assessment of their health psychologically versus specific objective parameters, as assessed by the orthodontic oral health practitioner, such as overbite, overjet, or sagittal classification.

Previous review papers focused on the population as a whole, or only looked at adults. In that aforementioned review in 2009, it was found that only a modest association between malocclusion and the quality of life among mixed ages could be shown (6). A recent meta-analysis on malocclusions, orthodontic treatment and OHRQOL in an adult population utilizing a slightly different questionnaire called the OHIP-14 concluded that subjects oral health related quality of life improved slightly after orthodontic treatment and the subjects without malocclusion or orthodontic treatment need had a slightly higher oral health related quality of life (8). Being that this population studied in the meta analysis is slightly older than the average age of a patient treated in an orthodontic practice it will be interesting to see how the results would differ in our sample. Furthermore, we would expect to see a different result due to the fact that children and adolescents interpret malocclusions and OHRQoL differently psychologically, socially and emotionally versus adults (9).

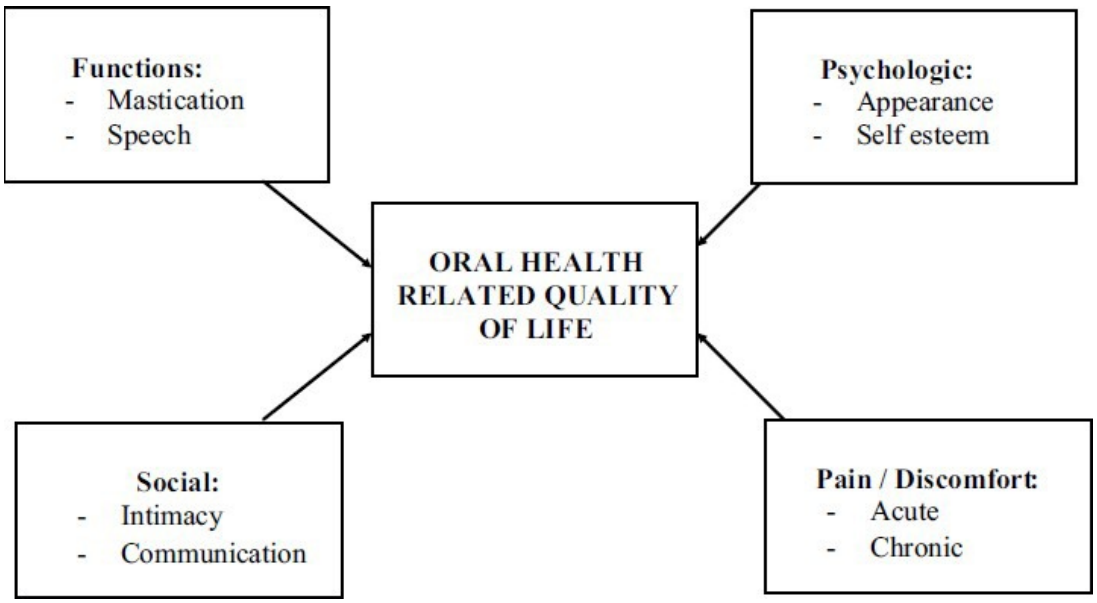


Figure 1: Schematic of the factors that interact to determine the quality of life based on oral health (4)

This systematic review and meta-analysis concluded that children perceive a small impact of malocclusions on OHRQOL, and that the association between malocclusions and OHRQOL is modified by the age of the children and their cultural environment (7). Two interesting findings were also elucidated from this comprehensive review. First, they found that in the continuous as well as in the dichotomous analysis, there was not a significant association of malocclusions and OHRQOL in children of age <8 years, but children between 11

and 14 years old were the most likely to have an impact of malocclusions on OHRQOL. Furthermore, the greatest difference in OHRQOL scores was seen in children older than 14 years old (7). Second, it was shown that children with malocclusion were significantly more likely to have lower OHRQOL than children without malocclusions among all countries, except for the studies conducted in Nigeria/Tanzania, where the association based on the continuous analysis goes in the other direction (7). Therefore, even though our study is primarily of children from the Latin American communities of Mexico and South America, our results concerning their oral health related quality life will offer more insight on the association between malocclusion and the oral health related quality of life of adolescents and young adults. Specifically, our study will allow oral health practitioners to understand how their orthodontic treatment might affect an individual's psychological assessment of their quality of life as it relates to oral health. Overbite is one of the primary goals that orthodontists and dentist alike seek to correct when treating malocclusion. However, the scientific evidence for why it's treated and how it can be associated with quality of life is often overlooked or not completely understood. For instance, overbite is not one of the criteria in the American Board of Orthodontic's objective grading system for orthodontic treatment outcomes (10).

In addition, it has been shown from previous studies that any deviation from the 'norm' can stigmatize a person and potentially make him/her less socially acceptable (11). Evidence suggests that individuals with unpleasant occlusal traits can attract unfavorable social responses, and such experiences early in life can leave an indelible imprint (12, 13). Thus, the perceptions of young patients and their parents regarding malocclusion should not be overlooked (14). Understanding the patient's subjective assessment of their malocclusion can

be just as important as the orthodontist's objective assessment in determining the need/benefit of orthodontic treatment. For example, while the orthodontist prioritizes function and occlusion in consultation, the patient might perceive other factors to be equally important to initiate treatment (15). Interestingly, a proportion as high as 80% of the individuals that attend orthodontic practices disregard structural or functional consideration (16). Another study, observed that subjects defined as having a handicapping malocclusion, which according to Charles Daniels (the creator of the ICON index) as someone with an ICON index score of >43, refuse orthodontics for professionally perceived handicapping malocclusions, while others are keen on undergoing treatment for minor deviations (17). Apparently, the demarcation between acceptable and unacceptable occlusion is largely dependent upon an individuals' judgment (18). While the population studied in our project is not a treatment seeking population, their subjective assessment of their oral health related quality of life could help offer insight into how the general young adult population of Mexico and Peru perceive their treatment need and their esthetic demands. Their objectively graded malocclusions may help clinicians in practice understand more fully the association between what motivates an individual to get treated or what treatment can offer them beyond straight teeth. More importantly, it will help clinicians better understand the association between orthodontic parameters and individuals subjective parameters of oral health.

Therefore, one goal of our study, which takes into account the an individual's subjective perception of their malocclusion, helps provide the orthodontists with essential information about which specific vertical bite patterns may diminish a patient's quality of life compared to a normal overbite status. When this subjective assessment is combined with the objective

assessment it can allow for an ideal diagnosis and treatment plan. Also this paper will include analysis of the severity of vertical bite status versus OHRQoL using new subscales than previously reported in the literature.

1.2 Open/Deep bite prevalence and etiology

The prevalence of open bites has been elucidated in previous studies. In United States children, it was reported at 3.5% in the white population and 16.5% in the Black population (19). Proffit *et al.,* recorded a prevalence of approximately 3.5% in patients from eight to 17 years of age (cite). Deep bite is the most common malocclusion involving children and adults (20). According to a study conducted by Proffit and Fields (2007), "overbite more than 5 mm is found in nearly 20% of the children and 13% of the adults." Severe overbite, considered a clinical problem, should be corrected through orthodontic or orthosurgical intervention. Severe overbite may affect the temporomandibular joint, cause periodontal problems and tooth wearing, as well as traumatize the incisive papilla or interfere with mastication (21).

Open bite has been defined previously as: "open vertical dimension between the incisal edges of the maxillary and mandibular anterior teeth (22)." Deep bite or deep overbite is defined as excessive vertical overlapping of the mandibular incisors by the maxillary incisors in centric occlusion. Normally, the incisal edges of the lower teeth should contact slightly at or above the cingulum of the upper teeth, which is approximately 1-3 mm overbite. Due to differences in the crown lengths of the incisors, normal overbite is about 30% or one third of the clinical crown height of the mandibular incisors (23).

Diagnosis of vertical bites falls into two major categories in regard to its underlying component. Specifically, open/deep bites can be classified as dental, skeletal, or caused by a combination of both. To differentiate between the two, a skeletal open bite is classified as an open bite caused by a patient having an increased vertical jaw relationship without a dental contribution and a skeletal deep bite is classified as a deep bite caused by a patient having a decreased vertical jaw relationship without a dental contribution (24).

Dr. Ib Nielsen, DDS, the premier figure in orthodontics on growth and development who recently retired from a long successful career in private practice and most recently as faculty in the UCSF orthodontic department eloquently describes how an aberrant condylar growth pattern can lead to an anterior open bite. He states that patients with the so-called, "long face syndrome" and a pronounced increase in lower facial height have a more posteriorly directed growth pattern of the mandibular condyle, which causes the mandible to swing backwards in the face. Furthermore, the result at the level of the chin is mostly vertical growth (Figure 2). In addition, the associated dental eruption of the posterior teeth is generally vertical, and, in some instances, the anterior teeth may become more retroclined with time; leading to crooked teeth over time (25).

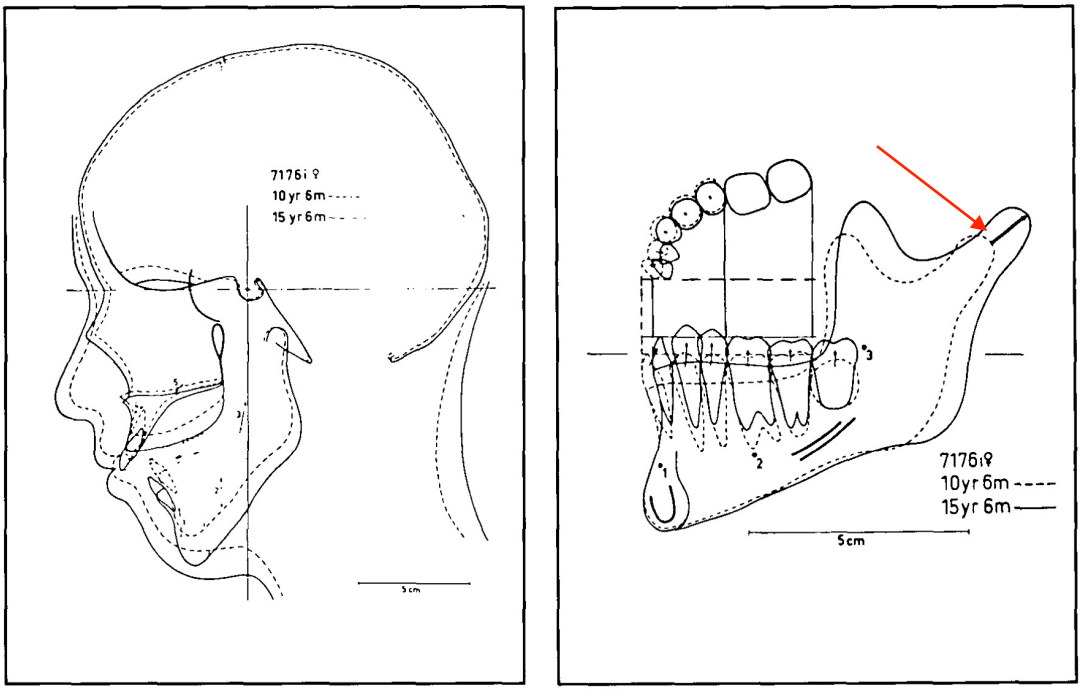


Figure 3A Figure 3B

Figure 2: Schematic of a tracing of a lateral head film at two different time points (3A) with the occlusion's relationship to a lateral view of the mandible (3B) indicating the association between the open bite and the condylar direction of growth.(25). Courtesy of Dr. Ib Nielsen (Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment)

Figure 2 shows a subject with primarily a vertical facial growth pattern. The condylar growth pattern is mainly posterior with a very small vertical component. The direction of the eruption of the teeth is predominantly vertical; thus, leading to a disproportionate relationship between posterior tooth eruption and ramus vertical height increase. When this proportion changes, it can lead to a vertical mandibular growth pattern with a resultant skeletal anterior open bite (25)

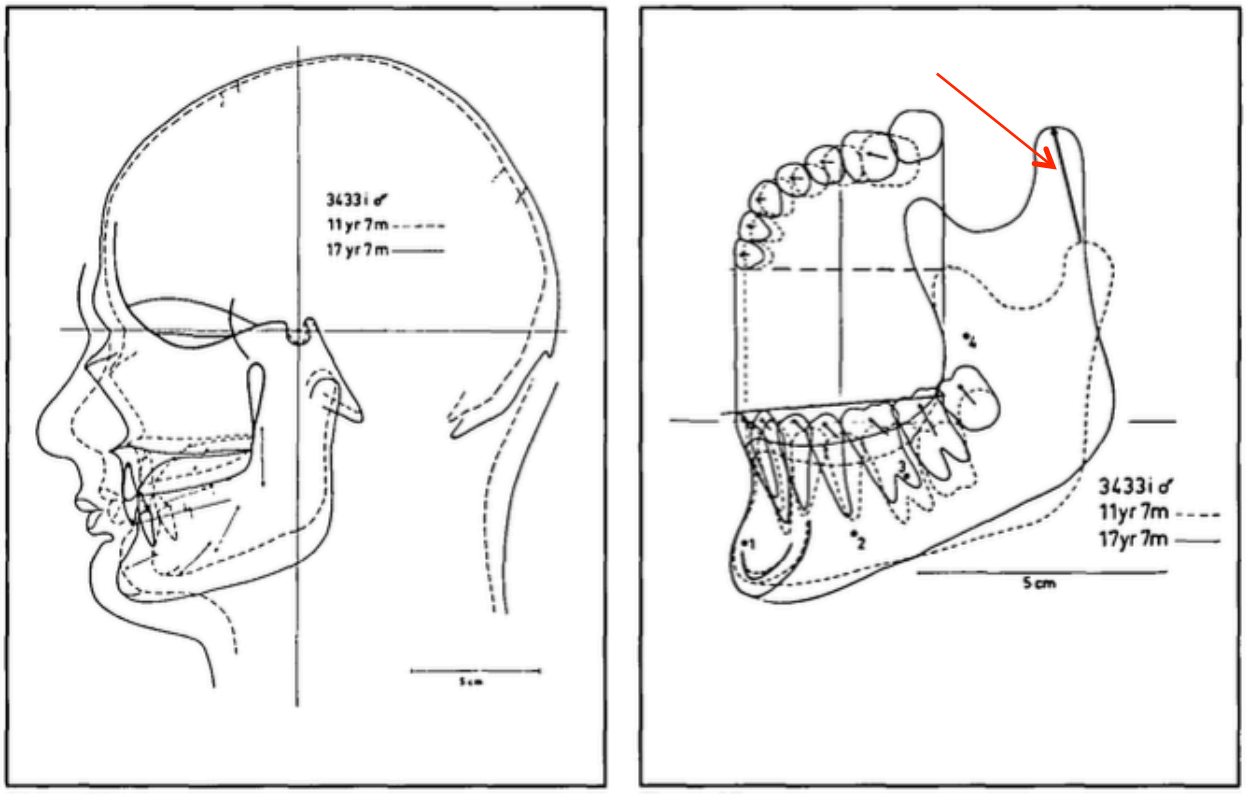


Figure 3 Schematic tracing of a lateral head film (left) indicating a deep bite with the corresponding occlusion and direction of condylar growth (right)(25). Courtesy of Dr. Ib Nielsen (Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment)

In contrast to open bites, patients who develop skeletal deep bites have upward and forward growth of the mandibular condyle as shown in the above figure (Figure 3) resulting in a reduced anterior face height. The resulting malocclusion is almost always characterized by a deep bite (25). As a result of more vertical condylar growth with a slight forward component, and more ramal growth versus eruption of the posterior teeth, the chin is thrust forward giving these patients very strong chins and shorter anterior face heights. Accordingly, these patients

also develop deep over bites if a proper couple with the lingual of the upper incisors is not established earlier on prior to the peak condylar growth spurt.

An additional problem that can lead to an anterior open bite is abnormalities in the upper airway. Patients with skeletally disproportionate long faces are often characterized as adenoid faces: the cheeks are narrow, the nostrils are narrow and pinched, the lips are separated, and often there are exaggerated shadows beneath the eyes (26). The key factor is the timing of the obstruction. Obstructions such as a deviated nasal septum, enlarged nasal turbinates, enlarged adenoids, chronic allergies, or enlarged tonsils that occur during the prepubertal and pubertal growth spurt can be detrimental to the facial growth pattern. This will be explained more thoroughly in section 1.7.

This negative association between openbite and functional health as defined by an objective dental assessment lacks the other half of the equation. Which we would like to show is the importance of the subjective assessment by an individual. More specifically, how having such a malocclusion is associated with one's quality of life.

1.3 Development of the ICON and COHIP Indices

Traditional orthodontic diagnosis is a qualitative, descriptive procedure that it is not well suited to quantification. Several quantitative systems of assessing malocclusion and evaluating need for treatment have been developed since the early 60's (27). Historically, treatment-need indices have been used to plan the provision of orthodontic treatment in European countries such as Norway, Denmark, Finland, Sweden, Holland, and Great Britain, where orthodontic

treatment is subsidized by the government as part of the National Health Service or national health-insurance system (28). However, orthodontic-treatment-need indices are also very useful instruments for assessing the prevalence and severity of malocclusions in epidemiological studies (29, 30). For the proposed project, we will use a validated and highly reproducible index developed by Daniels and Richmond; the Index of Complexity, Outcome, and Need ((31); ICON). This index offers significant advantages over other indices of treatment need: it can be used to assess treatment need as well as to assess treatment outcome. It's unique because it encompasses an esthetic component. In addition it is equally effective with live patients as it is with stone models, and can be used in the most common orthodontic population, ie late mixed or early permanent dentition. It looks at four occlusal and one esthetic parameter: 1) Dental Aesthetics 2) crossbite 3) Anterior vertical relationship 4) Upper arch crowding/spacing 5) Buccal Segment Anterior-posterior relationship. If the score is >43 then treatment is indicated. If the summary score is less than 31 then the outcome is deemed as acceptable.

The subjective psychological impact of malocclusions is an important determinant of treatment need and satisfaction (32). The original Child Oral Health Impact Profile (COHIP) consisted of 34 questions that focused on the following subscales: 1) oral health, 2) functional well being, 3) social/emotional well being, 4) school environment, and 5) self-image (33). In our study, we will be using the short version of the COHIP that consists of 19 questions. Instead of the 5 subscales listed above, our short version of the COHIP has three subscales: 1) UCSF Functional Oral Health subscale 2) UCSF Socio-emotional Well-being Subscale and 3) UCSF Self Image subscale.

This type of short orthodontic related COHIP was recently validated in a study that compared it to the normal 38-COHIP (33). Some of the existing OHRQOL measures from the longer version of the COHIP are usable in an orthodontic setting (34). However, these questionnaires are generally very long and burdensome to respondents, which is one reason why they are not used. The length of the OHRQOL measures makes administration difficult, and the orthodontic literature recommends designing shorter OHRQOL measures (35-37). To make an orthodontic OHRQoL measure, similar items that aren't included in a normal orthodontic diagnosis need to be removed. It also needs to be focused on younger subjects in the range of the average orthodontic patient, which is approximately 12 years old. A study by Kragt et al., took eleven items from the COHIP-38 for the short version of the questionnaire (38). This study concluded that the COHIP-ortho is as valid as the COHIP-38 for assessing OHRQOL in children. The main reasons for it being a valid instrument is due to its shorter version there is less chance of fatigue on the part of the study participants, its cheaper, and because its shorter but equally effective, less time is needed to administer it. Therefore, its acceptance both by practitioners and study participants is anticipated (38).

1.4 Speech disorders associated with anterior open bites

Anterior open bite is the malocclusion characteristic most often implicated in speech misarticulations. One study showed that 63% of those with open bites had defective speech, and only 4% had superior speech (39). In a different study of 437 school children with speech problems that were matched with control children of similar size and age, the study found that speech problems are not related to malocclusion generally except in open bites. The study

found that in this malocclusion trait, there is a strong link with lisping. The study found that out of all the objective orthodontic diagnoses, openbite has the only significant relationship with speech defects. In addition, the more severe the openbite was did not correlate with greater speech difficulty (40). In a similarly designed study, the authors concluded that open bite or edge to edge occlusion was related to defective speech sounds in particular /s/, /z/, /th/, and /l/ (41). Additionally, it was shown that anterior open bite was associated with difficulty of the /s/ sound (42). Finally, in contrast to the previous studies, one researcher found that incisal open bite alone is rarely associated with articulatory speech disorders, and when present, the speech disorders tend to be mild. Although it was shown that when an anterior open bite is combined with other occlusal problems, especially a subject with excess overjet, anterior open bite is more often related to severe problems with speech (43).

Some more recent studies looking at speech dyslalia and malocclusion showed opposite results to what the last study found in regard to the presence of an open bite solely and speech problems. A large study involving preadolescent Italian children found that the presence of Class III occlusion, diastema, increase in overjet, **presence of open and deep bite**, and an asymmetry, have a high tendency to be associated with speech disorders such as dyslalias (44). In contrast, when some researches looked at a slightly older age group comprised of young adults in the middle east, they found that patients with an actual need for orthodontic treatment had no problems with finding jobs, working effectively and communicating in their day to day interactions amongst both sexes (45). And to further complicate the matter, a smaller study of preadolescent children whom made up an orthodontic treatment seeking population, found no relationship with articulation and malocclusion (46).

Therefore, it appears that the literature is conflicted on how exactly speech is affected by the presence of a specific malocclusion trait. In our study, we would like to create a subscale that included only COHIP question 17. This would allow us to determine if there is an association between the presence of an anterior open bite and the ability to communicate and speak in an adolescent Latin American population.

1.5 Vertical Bite Status and Its Effect on quality of Life

Considering the above effects that anterior open bite can have on speech, it's correlation with sleep disordered breathing, and an individual's own self image, it is time to see how anterior open bite can affect ones quality of life. There have been few studies that have focused specifically on an individual's oral health related quality of life and the presence of an anterior open bite. However, one study in Brazil studied this very topic. This study utilized a different assessment instrument called the ECOHIS. The ECOHIS (Early Childhood Oral Health Impact Scale) is an instrument used to assess the impact that oral health related problems and their treatment have on preschool age children 5 and below (47). The subjects studied included preschool children and their parents. The researchers found a strong association between anterior open bite and a negative impact on quality of life. More specifically, it was shown that preschool children in Brazil having an anterior open bite were twice as likely to have a negative impact on their quality of life versus preschoolers with no anterior open bite malocclusion(48).

In another study in Brazil looking at the same question with a similar population of preschool age children found the converse to be true. This study enrolled a few hundred more subjects versus the previous study and again the B-ECOHIS (Brazilian version) was used to

assess the impact of oral health problems on the parents and children's quality of life. Several objective orthodontic related malocclusion traits were recorded which included items such as overbite, overjet and crossbite. They drew the following conclusion that malocclusion was not associated with a decrease in quality of life; however, parents of children with a positive history of oral pain were associated with a negative impact on OHRQoL. This makes sense because any parent that has to endure observing their child in pain would likely see this as not conducive to an improved quality of life (49).

Another study with a slightly smaller sample size and older population also looked at the same question regarding specific type of malocclusion traits and their effects on the quality of life. What they found coincides with the systematic review described earlier in section 1.1. The sample was comprised of school children aged 8-10 years. Clinical exams were performed using the criteria of the Dental Aesthetic Index (DAI) to determine the presence and severity of malocclusions. The impact on quality of life was assessed using the Child Perceptions Questionnaire (CPQ8-10) (50). Their main results were that malocclusions affected 61% of the children examined. The most interesting result that was obtained from this study in relation to vertical bite status was the fact that they determined that only individuals with an anterior open bite of >2mm displayed a negative relationship with their oral health related quality of life as measured by the CPQ8-10 (50). This is one of the few studies that specified the cut off for an anterior open bite to have an affect on a subject's quality of life. We can help add to the evidence of whether or not severity of open bite is associated with a lower oral health related quality of life. Therefore, one of our main objectives in this study is to determine if the sample

we have from Latin America also has similar dysfunctions in their quality of life with the same, smaller or larger anterior open bites.

1.6 Anterior Open Bite and Self Confidence

One of the main reasons patients seek orthodontic treatment has to do with their self-perception of themselves; specifically, how their smiles affect this self-perception. This was proven with the following conclusion from previous research that orthodontic treatment need is not solely determined by objective malocclusion traits as determined by an orthodontic professional but includes many more broader issues such as financial, social, and one's self image (51). Therefore, during the orthodontic consult it is important for the orthodontist to stress not only functional occlusal improvements for the treated patient but also improvements in quality of life when certain malocclusion traits such as incisor irregularity and anterior open bite are treated. This study was also interesting because similarly to what was shown with the Brazilian 8-10 year olds above, the trend of having a negative impact on oral health related quality of life with an open bite equal to or greater than 2mm was also found in this 12-16 year old population. Indicating that if left untreated the negative consequences of having a poorer quality of life during preadolescence continues into the key maturational teenage years (51).

In our current study we aim to replicate the results of this Brazilian study with a similar age group of Mexican and Peruvian adolescents to determine if both vertical open bite and vertical deep bite negatively affect their oral health related quality of life.

1.7 Anterior Open Bite, Airway, and Sleep Disordered Breathing

Airway, orthodontic malocclusions, and problems sleeping have been linked in previous studies. For example, obstructions of the airway such as large adenoids and tonsils, chronic untreated allergies, nasal deformities ie deviated nasal septum, nasal polyps or tumors, and similar pathologies are related to sleep disordered breathing (52), dentofacial growth characteristics, and malocclusion in children (53). Sleep disordered breathing is common in children, and occurs at all ages, from the neonatal period to adolescence (54). It is estimated that 0.8–24% of children are habitual snorers, and 1–5% have obstructive sleep apnea syndrome (OSAS) (55). Untreated SDB has been associated with serious problems, such as heart disease and possibly death (56), as well as behavioral, neuronal development, and physcological issues, ADHD (57), and systemic inflammation (58). If left untreated in childhood, it can contribute to the development or continuation of hyperactivity in adulthood (59). Some studies have shown that snoring related to sleep disordered breathing results in the symptoms of daytime somnolence, behavioral problems, and underperformance in schoolwork (60).

The mechanism of sleep disordered breathing on the craniofacial growth and development of an affected individual has been demonstrated in several studies. Similarly to the adenoid faces description above its been shown that with obstructive sleep apnea, someone that already has abnormal anatomy such as hypertrophied adenoids or tonsils for example is at an even greater risk of upper airway resistance during sleep due to muscular tonicity being reduced due to the muscular relaxation that occurs with deep REM sleep compared with wakefulness (61). When this upper airway or sleep disordered breathing persists during the growing years pathologic facial growth changes that can lead to the development of a skeletal open bite or dolicocephalic pattern of facial growth can occur. A

recent cephalometric study on 5-year-old children with polysomnographically verified OSA found that OSA children have a different facial morphology compared with age-matched controls. The mandibular plane angle was found to be greater in relation to the anterior cranial base, therefore increasing anterior face height, and decreasing posterior face height due to decreased ramal and condylar height growth, in the OSA children versus the controls (62). This previous description is what underlies a skeletal open bite. One of the reasons for the decreased ramus and condylar height increase during growth in OSA children or children with sleep disordered breathing is related to disrupted growth hormone secretion (63). Following removal of the underlying cause of the sleep disordered breathing such as adenotonsillectomy, a significant increase in the serum levels of GH mediators (insulin-like growth factor 1 and its binding protein) has been shown. Consequently, if the airway obstruction is treated before the pre and adolescent growth period, it has been shown that normal growth can be reestablished (63). Proper growth hormone secretion in airway competent healthy individuals allows endochondral bone formation in the condylar cartilage and bone deposition in the lower border of the mandible (gonial region) that contributes to the normalization of the anterior face/posterior face height ratio. When this ratio is ideal, proper overbite is normally achieved unless other environmental habits are occurring such as finger sucking. (See figure 4 and 5)

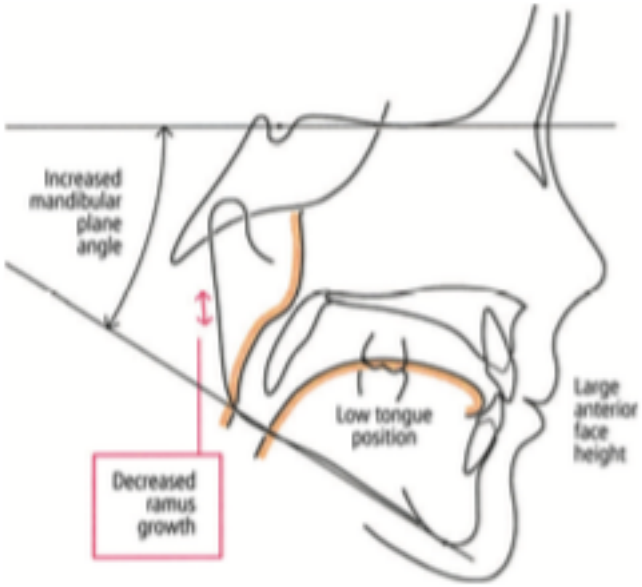


Figure 4- Due to an obstruction in the nasal airway this patient must resort to mouth breathing, which leads to a low tongue posture and abnormal nocturnal growth hormone secretion, which leads to decreased ramus growth in height. (63)

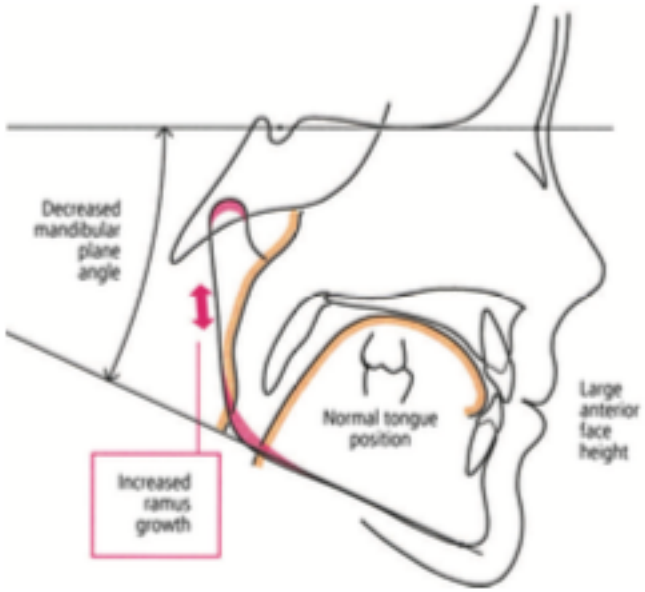


Figure 5- This figure demonstrates what occurs following removal of the airway obstruction. Note the tongue can now be raised because nasal airway patency has been reestablished, and because the sleep disordered breathing has ceased, normal secretion of growth hormone can occur which leads to increased ramus growth and condylar growth which allows normalization

of the AFH/PFH ratio and swinging forward of the mandible to maintain normal overbite development. (63)

A study performed recently helps the dental clinician in predicting which patients may be susceptible to sleep disordered breathing and that require a follow up for an otolaryngology specialist to help determine the cause of the sleep disordered breathing. They sought to determine which dental malocclusion was most related to pre- adolescent children with airway disturbances verified by polysomnography (PSG). The dental malocclusions most predictive of sleep disordered breathing in this sample studied were crossbites and openbites (64). Therefore, this study tends to suggest that if a dental professional encounters a child with either a crossbite or anterior openbite or both then he/she should suspect sleep disordered breathing is also present.

While these studies proved the association between sleep disordered breathing and several different malocclusion traits, it did not focus on the effect these specific malocclusion traits have on the oral health related quality of life of these subjects, specifically anterior open bite. Therefore, one of the objectives would be to determine if subject's with an anterior open bite report trouble with sleeping as asked in the COHIP questionnaire.

1.8 Objectives

1) To determine how the overall oral health related quality of life of the subjects studied varies according to their overbite status and/or caries experience.

2) To determine how overbite status is associated with each of the three subscales of the COHIP-19 questionnaire (Both the UC and Broder Version) and the newly created UCSF open bite and deep bite subscales.
3) To determine how deep bite or open bite severity is associated with oral health related quality of life.
4) To determine if there is an association between sleep disordered breathing, speech difficulties and vertical bite status.

1.9 Null Hypotheses

1) Vertical bite status has no association with OHRQoL
2) Vertical bite status has no association with any of the three subdomains of OHRQoL as measured with the COHIP-19 oral health related quality of life questionnaire or the newly created UCSF open/deepbite subscales.
3) The severity of vertical bite is not associated with any relationship with OHRQoL or any of the subscales.
4) Vertical bite status has no association with sleep disordered breathing or speech difficulties as measured by the COHIP-19.

2. MATERIALS AND METHODS

This is a cross-sectional, population-based, quantitative, epidemiological study. Ethical approval was granted by the Committee for Human Research at University of California, San Francisco (UCSF) and by the universities in each region studied. In addition, this study was

carried out in full accordance with the World Medical Association Declaration of Helsinki. Three validated and reliable instruments will be employed to measure aspects of dental decay, malocclusion, and self-reported Oral Health Related Quality of Life (OHRQoL). The study is designed to observe the relationship between OHRQoL and specific orthodontic problems. We hope to learn how the burden of oral disease is distributed in the sampling areas and how the various subdomains of OHRQoL may be influenced by the overbite status and health of teeth.

Our study population compromised approximately 2,042 children, adolescents, and young adults aged 11-20 from 12 different regions of Mexico and Peru. When missing data was encountered for age, dmfs, or COHIP score the value was imputated by a single imputation method, which involved taking the average for each value by school and using the average value for the missing data (44/2042= 2% of the data was imputed). If a subject was missing values for sex, ICON score, or site location then that subject was excluded.

The locations studied were categorized into 5 geographic regions. Region 1 included Merida, Mexico. Region 2 included 7 sites in and around Monterrey, Mexico (Apodaca, Colegioingles, Montemorreles, Santacacarina, Technica Medica, Colegio Comercial Linda Vista, Colegio Cultural Mexico Americano). Region 3 contained Chiapas, Mexico. Region 4 contained Lima and Lima Reino, Peru. Region 5 included Cuzco, Peru. Human research approval was granted by the University of California, San Francisco (UCSF) institutional review board (IRB) and corresponding universities in Mexico (Universidad Autónoma de Nuevo Leon, Universidad Autónoma de Yucatan, and Universidad de Montemorelos) and Peru (Universidad Peruana Cayetano Heredia).

2.1 Inclusion and exclusion criteria

Inclusion criteria:

1) Individuals between the ages of 11-20 years.
2) At least one parent is self-identified as Mexican or Peruvian.
3) Parent and child are able to understand English or Spanish.

Exclusion criteria:

1) Parent cannot provide written consent
2) Previous orthodontic treatment for child
3) Previous orthodontic consult for child
4) Child has syndromic conditions affecting the mouth or face
5) Child has mental developmental disability

2.2 Populations and Study Design

Overbite status was divided into 3 different groups. The normal overbite group consisted of subjects with ICON 4a/4b scores of 0. Therefore, this included subjects with an edge-to-edge bite, which is equal to an ICON4a score of 0, and subjects with 1/3 coverage of the upper and lower incisors, which is equal to an ICON4b score of 0. The open bite group consisted of subjects with ICON 4a scores of 1-4. The ICON 4a 1-4 groups were defined as follows: A score of 1 for ICON4a meant an open bite of <1mm (N=77), a score of 2 for ICON4a meant an open bite of 1.1-2mm (N=58), a score of 3 for ICON4a meant an open bite of 2.1-4mm (N=31), and a score of 4 for ICON4a meant an open bite >4mm (N=18). The deep overbite

group consisted of subjects with ICON 4b scores of 1-3. The ICON4b groups were defined as follows: A score of 1 for ICON4b meant a deep bite between 1/3 to 2/3 overlap of the upper and lower incisors (N=641), a score of 2 for ICON4b meant a deep bite between 2/3 to fully covered upper and lower incisors (N=181), and a score of 3 for ICON4b meant a deep bite consisting of full overlap or full coverage of the lower incisors by the upper incisors (N=45). Subjects with values greater than 0 for both open and deep bite (ICON4a and ICON4b) were excluded. In total, our study contained 991 subjects classified as normal over bite, 184 subjects classified as having an open bite, and 867 subjects classified as having a deep bite. Caries severity was classified as follows: DMFS = 0, no caries; DMFS = 1–5, moderate caries; and DMFS > 5, severe caries (65). Our study contained 277 subjects classified as DMFS=0, 751 subjects classified as having a DMFS ranging from 1-5, and 1,014 subjects as having a DMFS greater than 5. Descriptive statistics included the following: DMFS, age, sex, and distribution of the bite classes by location. (Table 1 and 2 below)

2.3 Data Collection-

The students were examined at each school in a quiet classroom without external interference. The dental examination was comprised of an extraoral assessment and an intraoral examination of the teeth and occlusion. The examination lasted approximately 15 minutes per child, following WHO (1985) guidelines. No radiographs, loupes or magnification,

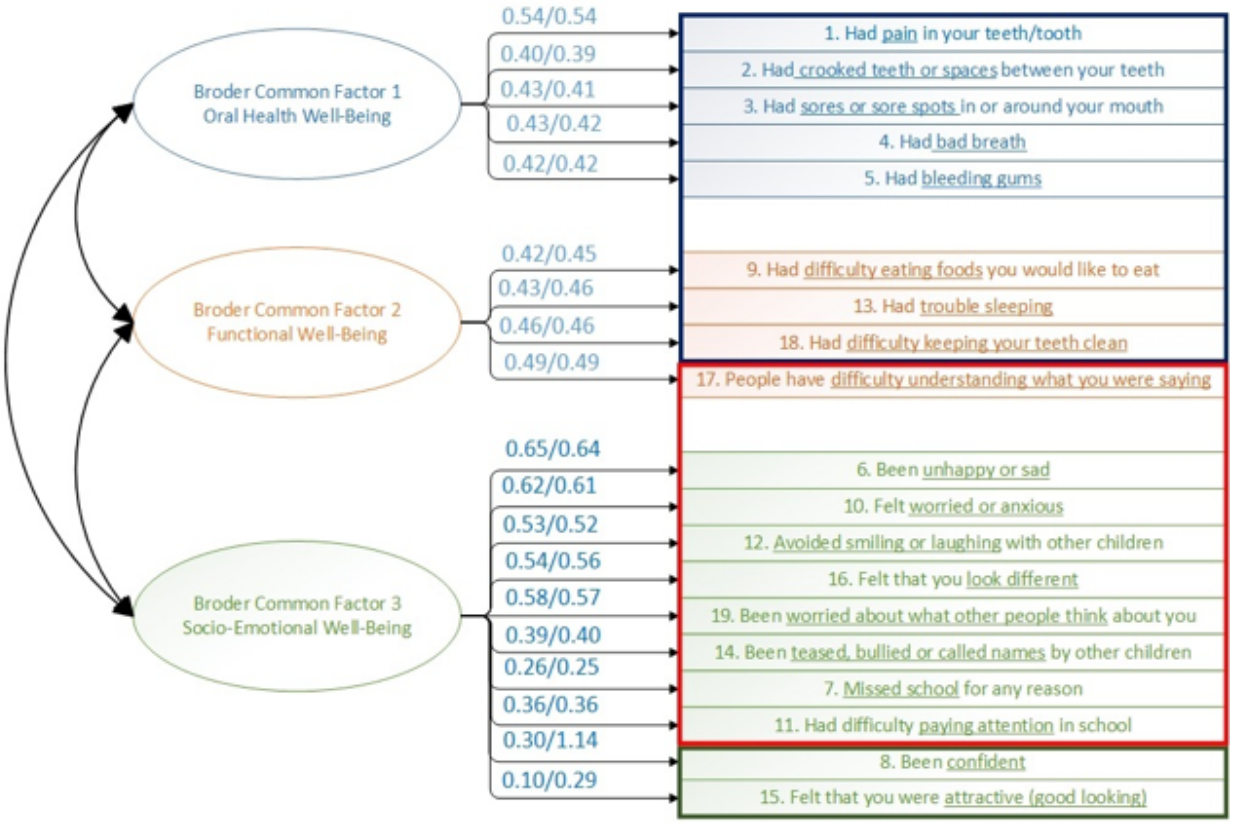
study casts, or previous written records were used. Demographic data and information about orthodontic treatment were obtained directly from the students. Dental-examiners determined treatment urgency based on oral disease present at the exam using a scale ranging: (1) “See a dentist immediately”, (2) “See a dentist within two weeks”, (3) “See a dentist at earliest convenience” [greater than 2 weeks], (4) “Continue with routine care”(CDC). Each participant was given a toothbrush and oral hygiene instructions. The families were informed about their children’s oral health status. Three examiners performed clinical examinations, after having previously undergone calibration to standardize their procedures. Calibration exercises for raters of the number of decayed, missing, or filled permanent tooth surfaces (DMFS) index and the orthodontic index of complexity, outcome and need (ICON) (66) were performed using 10 casts and photos from UCSF orthodontic clinic patients that were not participating in the study. Intra- and inter-rater reliability was assessed using 10 additional casts and photos from the UCSF orthodontic clinic patients that were not part of the calibration exercises. These records were used to test and retest each examiner at least three times, at 3-4 weeks apart between retests. All exam data were directly entered into an electronic form on an encrypted laptop and securely transmitted to UCSF.

2.4 Study Instruments

The COHIP-SF19 consists of 19 items forming three subscales: Oral Health (five items), Functional Well-Being (four items), and Socio-Emotional Well-Being (10 items). Response options for each item were recorded as “never”=1, “almost never”=2, “sometimes”=3, “fairly often”=4, and “almost all of the time”=5 in Spanish (Appendix 1). Inter-item correlations were estimated. All 19 items except item 8 and item 15 were reverse-scored so that higher COHIP

scores reflect better OHRQoL. A standard overall health self-rating with “poor”, “fair”, “good”, “very good”, or “excellent” overall health was recorded as the twentieth item. Descriptive statistics summarized the participants’ characteristics in terms of location, gender, DMFS scores, and age. The DMFS index assessed the presence of dental caries, and the ICON score assessed malocclusion (31). Descriptive statistics including medians, quartiles, frequencies, and percent’s were calculated to summarize the general characteristics of the participants.

The COHIP-19 as defined by Broder has within it subscales that seek to define different parameters of OHRQoL. The subsclaes are as follows: 1) Oral Health 2) Functional well-being and 3) Social/Emotional well-being (33). The following diagram courtesy of Dr. Kjeld Aamodt from his paper titled, “Are Quality of Life Instruments the Same Across Borders,” helps explain which questions from the COHIP fall into Broder’s subscales and which COHIP questions make up the newly created UCSF subscales (See figure 6). In addition to the above subscales, we created two new open bite subscales and one deep bite subscale. To create these subscales Dr. Kjeld Aamodt and I used our knowledge of orthodontics and evidence from previous literature. UCSF open bite subscale 1 comprises COHIP questions 9, 12, 13 and 17. The UCSF deep bite subscale comprises COHIP questions 3, 14, and 16. The UCSF open bite sleep subscale comprises only question 13 from the COHIP. The three corresponding subscales that were formed from Broder’s subscales are the 1) Functional oral health 2) Socio-emotional well-being and 3) Self image. (see figure 6)



(Figure 6)

Broder's oral health subscale included COHIP questions (1, 2, 3, 4 and 5); Functional well-being subscale included COHIP questions (9, 13, 17 and 18); Socio-Emotional well-being subscale included COHIP questions (6, 7, 8, 10, 11, 12, 14, 15, 16 and 19).

The newly created UCSF subscales are called the same but boxed outline in blue defines the Oral health subscale, the box in red defines the functional well-being subscale, and the box in green defines the socio-emotional well-being subscale.

2.5 Data Analysis

A one way ANOVA analysis was used to determine statistical significance between bite groups and age. Once it was determined that age was statistically different between the bite groups, two sample t-tests were used along with the Bonferroni correction to determine which specific bite groups were different from each other according to age. Statistical significance for all tests was set at $p \leq 0.05$. For DMFS (decayed missing filled surfaces), we determined the overall difference between the bite groups using a Kruskal-Wallis test. Once it was determined that a difference existed among the three bite groups, multiple Mann-Whitney U-tests were used with the Bonferroni correction to determine which bite groups differed by DMFS. To determine overall difference between sex and bite group, and location and bite group, a chi-square test was used. To check for a statistical difference between any of the subscales and bite class or caries class, an ANOVA was performed. If a statistical difference was found then two sample t-tests with the Bonferroni correction were performed. To account for the possible confounding variables of age, sex, dmfs and location a multivariate regression analysis was run that also clustered by region. All analyses were conducted with STATA (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP.)

3. RESULTS

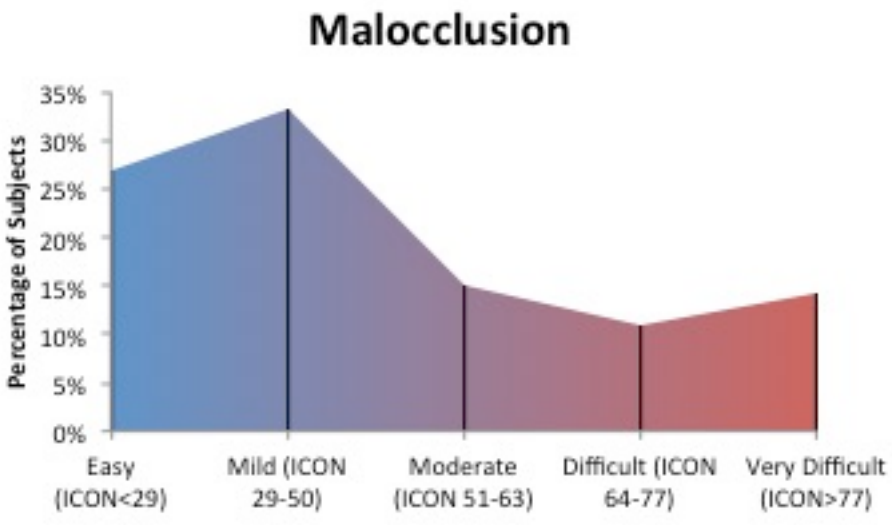


Figure 7- Prevalence of Malocclusion categorized by severity as measured by the Index of Complexity, Outcome and Treatment Need (ICON)

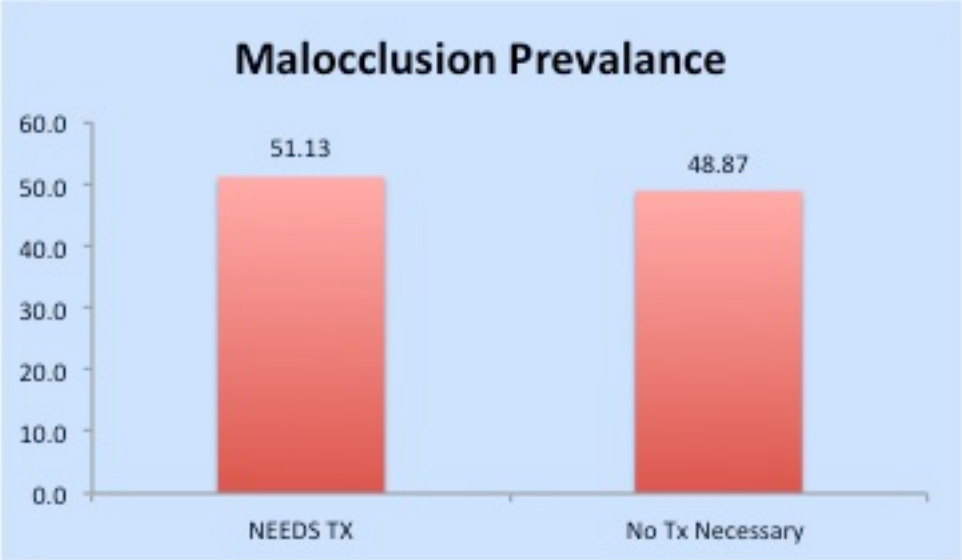


Figure 8- Malocclusion prevalence dichotomized by treatment need. > or = to a score of 43 denotes Need Tx. < 42 denotes No Tx Necessary

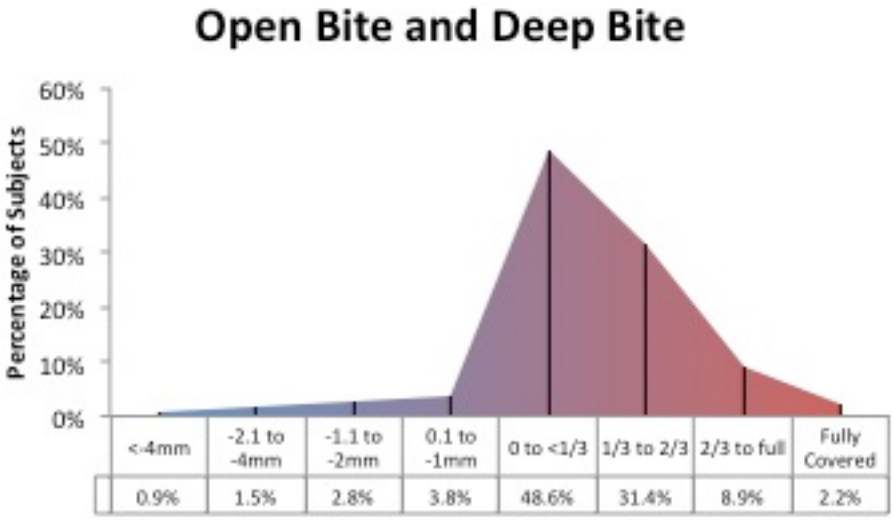


Figure 9- Prevalence of Vertical Bite status. Category 0 to <1/3 overlap of the upper and lower incisors denotes the normal overbite category.

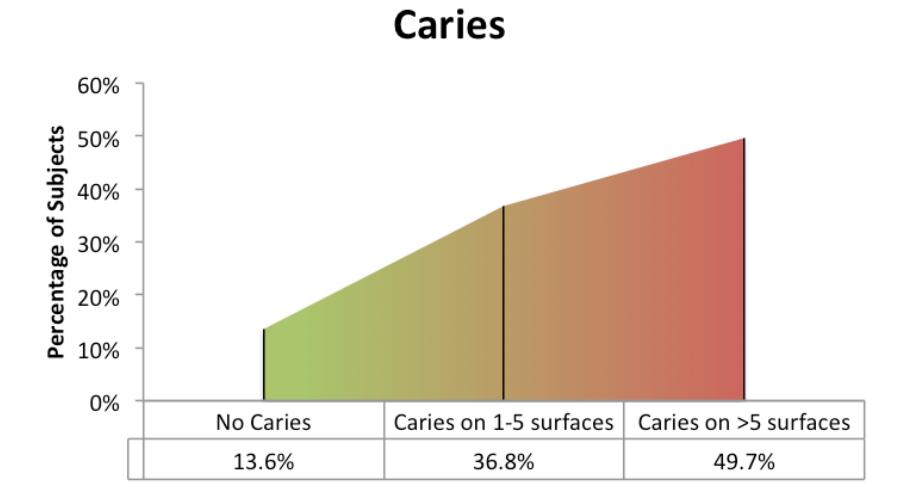


Figure 10- Prevalence of caries experience by dmfs (decayed missing filled surfaces) categories.

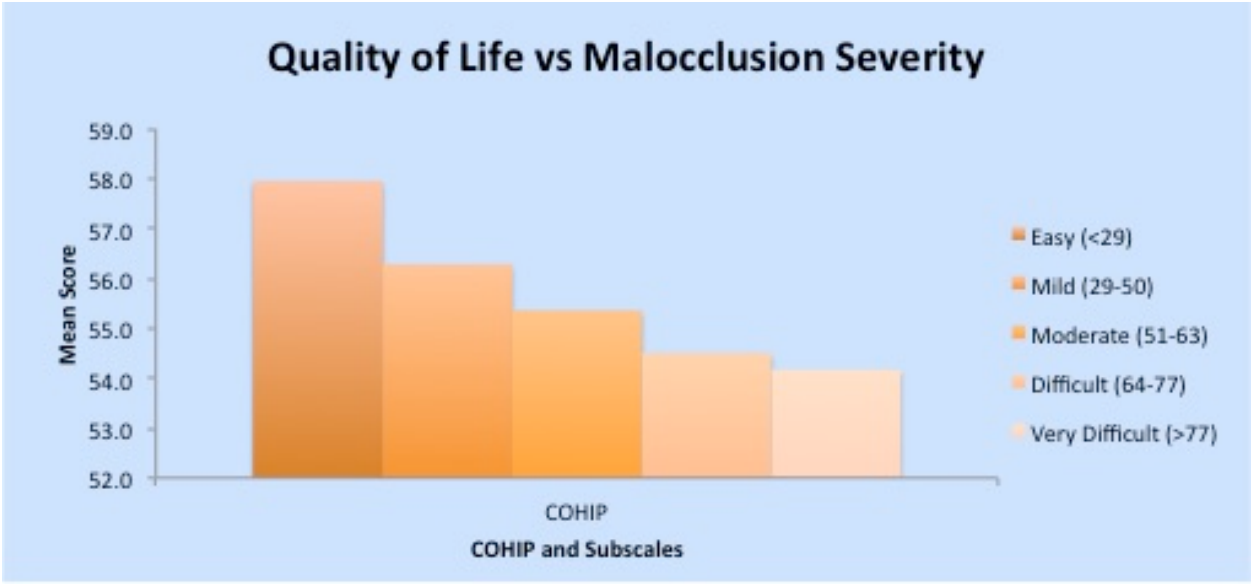


Figure 11- Mean overall Oral Health Related Quality of Life score as measured by the COHIP (Child Oral Health Impact Profile) questionnaire versus malocclusion severity as measured by the Index of complexity, outcome and treatment need (ICON). As the severity of malocclusion increases there is a significant drop in OHRQoL. ($p<0.001$)

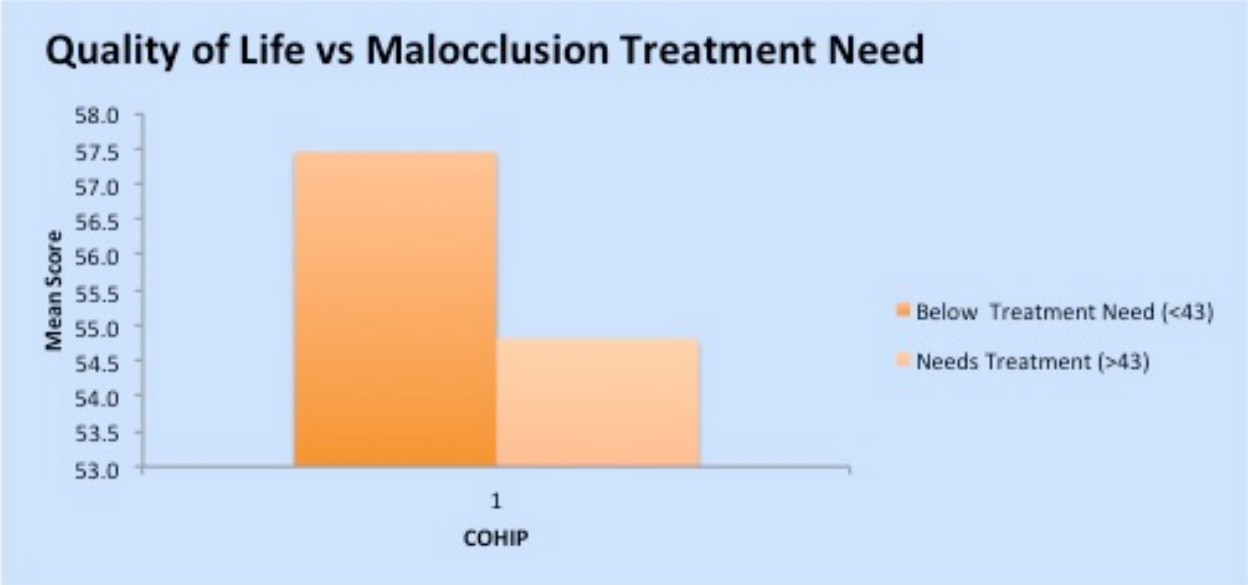


Figure 12- Dichotomizing malocclusion into treatment need versus COHIP. Treatment need group has a significantly lower OHRQoL. ($p<0.001$)

Demographics	Overall	Normal	Openbite	Deepbite	P value
Overall	N=2042	N=991	N=184	N=867	
Age	14.1 SD=1.7	14.4 SD= 1.7	14.6 SD=1.6	13.8 [ab] SD=1.6	p< 0.00 [1]
Sex F/M	51.5/48.5	56.0/44.0	56.5/43.5	45.3/54.7 [ab]	p< 0.00 [1]
DMFS	6.4 SD= 5.6	7.0 SD= 5.6	7.5 SD= 5.4	5.4 [ab] SD= 5.4	p< 0.00 [1]

[Table 1]
(1=There is a statistically significant difference between the bite classes; superscript a= normal and deep bite are significant $p<.05$; superscript b= open and deep bite are significant $p<.05$)

Regions	Overall	Normal (total,%)	Openbite (total, %	Deepbite (total, %
Overall	2042	991, 48.5%	184, 9.0%	867, 42.5%
Merida Mexico	331	60.1%	3.9%	36.0%
Monterrey Mexico	593	35.9%	9.1%	55.0%
Chiapas Mexico	348	60.9%	17.8%	21.3%
Lima Peru	472	44.7%	6.6%	48.7%
Cuzco Peru	298	52.4%	8.0%	39.6%

[Table 2]
(All regions were statistically significantly different from eachother in relation to the proportion of the three bite classes $p<0.05$).

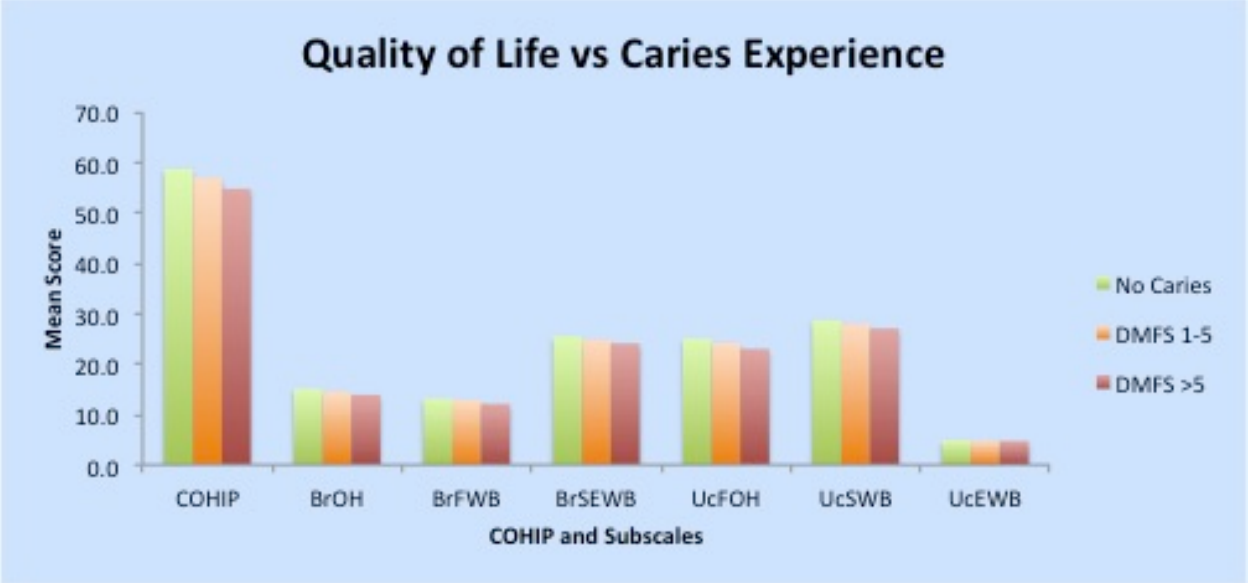


Figure 13- Quality of life broken down by total cohip score and the Broder/UCSF subdomains versus caries experience. There is a significant negative association between increasing caries experience and quality of life (See table 3 $p<0.001$) except for the UC Emotional Well Being Subdomain.
BrOH=Broder Oral Health; BrFWB=Broder Functional well-being; BrSEWB=Broder Socio-emotional well-being; UCFOH= UCSF Functional oral health; UCSWB= UCSF Social well-being; UCEWB= UCSF Emotional well-being

OHRQoL Instrument	DMFS=0 N=277	DMFS=1-5 N=751	DMFS>5 N=1014	P Value
totalcohip	58.7 (SD 9.1)	57.0 (SD 9.2)	54.8 (SD 9.3)	<0.001
UC_SWB	28.7 (SD 5.2)	28.0 (SD 5.5)	27.0 (SD 5.5)	<0.001
UC_FOH	25.1 (SD 4.4)	24.2 (SD 4.5)	23.0 (SD 4.6)	<0.001
UC_EWB	4.9 (SD 2.3)	4.8 (SD 2.1)	4.7 (SD 2.1)	0.49
BR_OH	15.1 (SD 3.1)	14.5 (SD 3.2)	13.9 (SD 3.2)	<0.001
BR_FWB	13.2 (SD 2.3)	12.8 (SD 2.5)	12.1 (SD 2.7)	<0.001
BR_SEWB	25.5 (SD 4.8)	24.9 (SD 4.9)	24.1 (SD 4.9)	<0.001

[Table 3]
(All the OHRQoL measures were highly statistically significantly associated with caries experience p<.001 except the subscale UC-Emotional well-being)

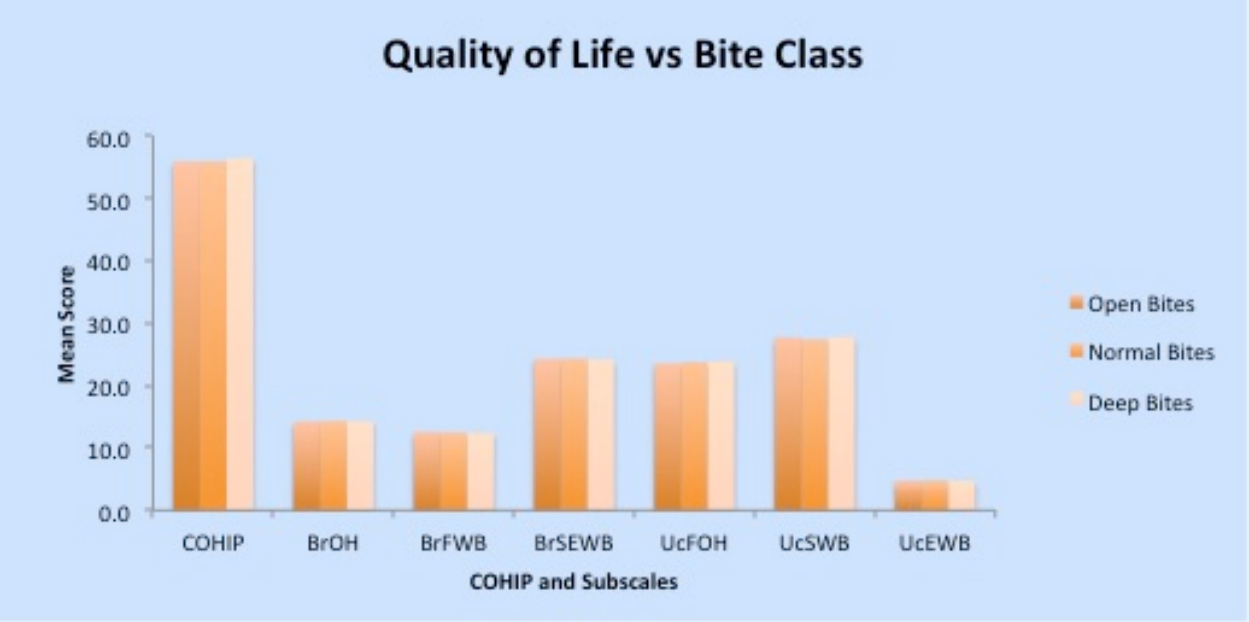


Figure 14- Oral Health Related Quality of life and its subdomains as measured by the COHIP questionnaire versus the Vertical Bite Spectrum displayed no significant relationships (See table 4).

OHRQoL instrument	Normal Bite N=990	Open bite N=184	Deep Bite N=866	P Value
totalcohip	55.8 (SD 9.4)	55.9 (SD 8.8)	56.4 (SD 9.4)	0.38
UC_SWB	27.3 (SD 5.5)	27.7 (SD 5.2)	27.9 (SD 5.5)	0.07
UC_FOH	23.7 (SD 4.6)	23.7 (SD 4.3)	23.7 (SD 4.7)	0.99
UC_EWB	4.8 (SD 2.1)	4.5 (SD 2.1)	4.8 (SD 2.1)	0.29
BR_OH	14.3 (SD 3.1)	14.2 (SD 3.1)	14.3 (SD 3.3)	0.86
BR_FWB	12.5 (SD 2.7)	12.7 (SD 2.4)	12.6 (SD 2.6)	0.50
BR_SEWB	24.3 (SD 5.0)	24.5 (SD 4.6)	24.9 (SD 5.0)	0.06
UC_Open bite	13.0 (SD 2.8)	13.1 (SD 2.5)	13.1 (SD 2.7)	0.45
UC_Deep bite	9.4 (SD 2.1)	9.6 (SD 2.0)	9.4 (SD 2.0)	0.64
UC_Open bite (sleep)	3.6 (SD 0.8)	3.6 (SD 0.7)	3.6 (SD 0.8)	0.79

[Table 4]
(Cohip score and all the subscales that measured different aspects of oral health related quality of life were not statistically significantly associated with any of the three vertical bite classes)

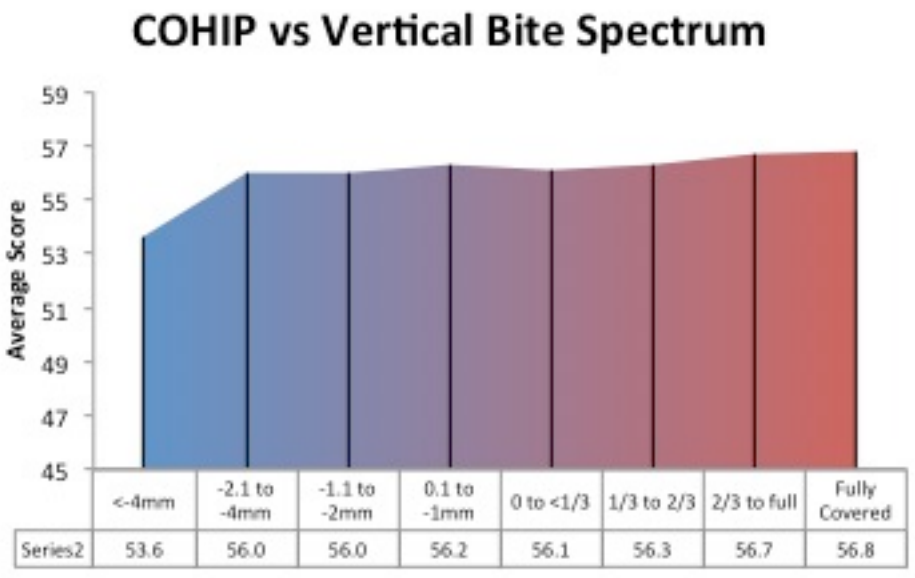


Figure 15- Total oral health related quality of life versus the vertical bite spectrum-Vertical bite categories and mean COHIP score are shown on the x-axis) No significant relationship found (p>0.05)

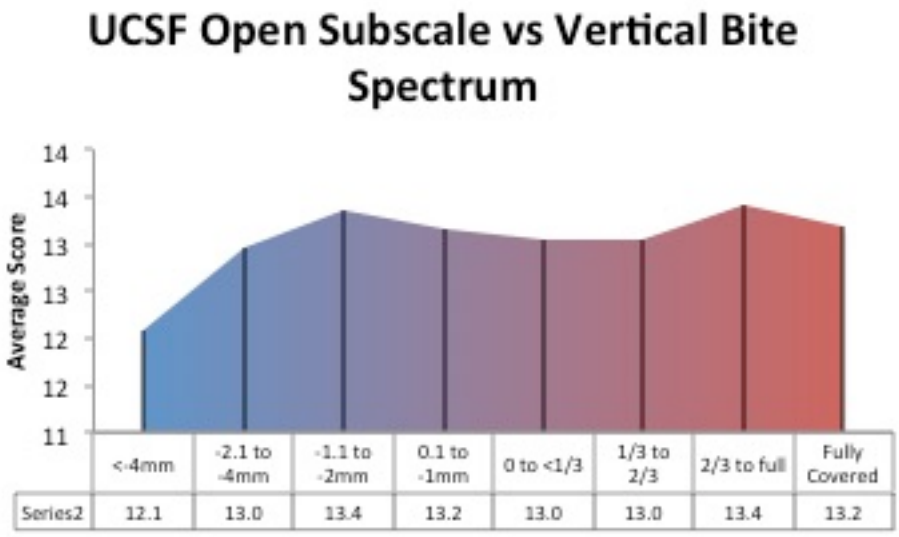


Figure 16- UCSF Open bite subscale 1 versus vertical bite spectrum (p>0.05) (Table 5)

Severity of Open bite N total=184	< 1mm N=77	1.1-2mm N=58	2.1-4mm N=31	>4mm N=18	P Value
UC_Open bite	13.2 (SD 2.6)	13.4 (SD 2.4)	13.0 (SD 2.7)	12.1 (SD 2.1)	0.30

[Table 5](The severity of open bite was not statistically significantly associated with our newly created UCSF open bite subscale 1)

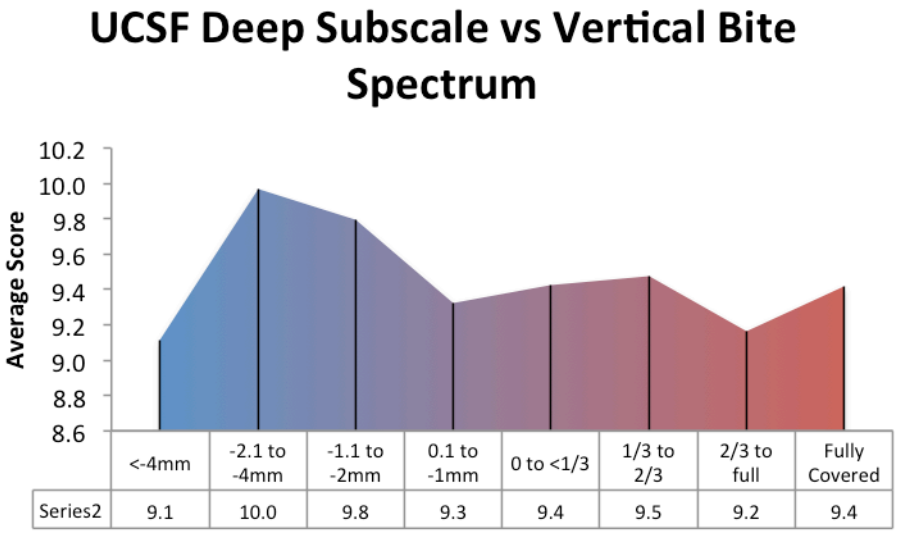


Figure 17- UCSF Deep bite subscale versus vertical bite spectrum (p>0.05) (Table 6)

Severity of Deep bite N total=867	1/3-2/3 (overlap of U/L incisors) N= 641	2/3-fully covered (overlap of U/L incisors) N= 181	Fully covered N= 45	P Value
UC_Deep bite	9.5 (SD 2.0)	9.2 (SD 2.1)	9.4 (SD 2.3)	0.20

[Table 6]
(The severity of deep bite was not statistically significantly associated with our new created UCSF deep bite subscale)

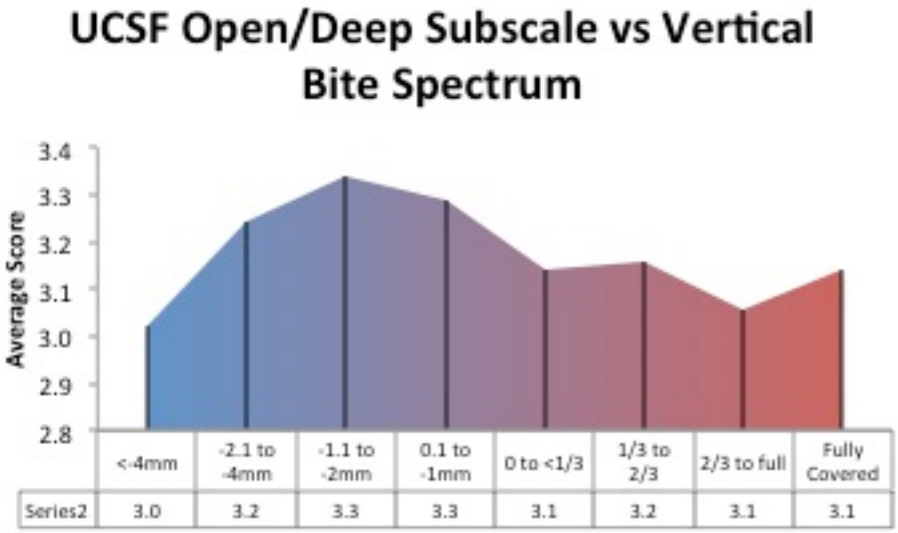


Figure 18- Normalized Open/Deep bite subscale versus Vertical Bite Spectrum

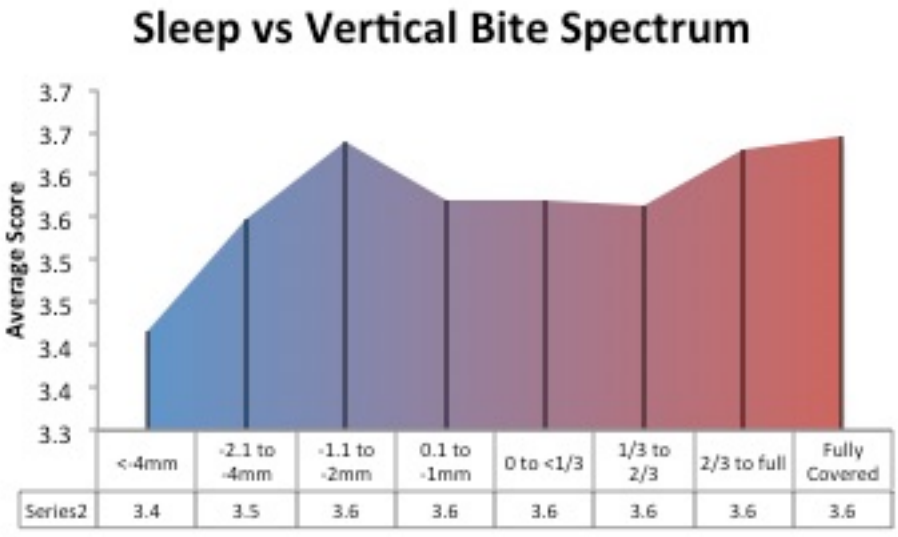


Figure 19- COHIP question 13- Had trouble sleeping due to your mouth, teeth, or face versus vertical bite spectrum ($p>0.05$)

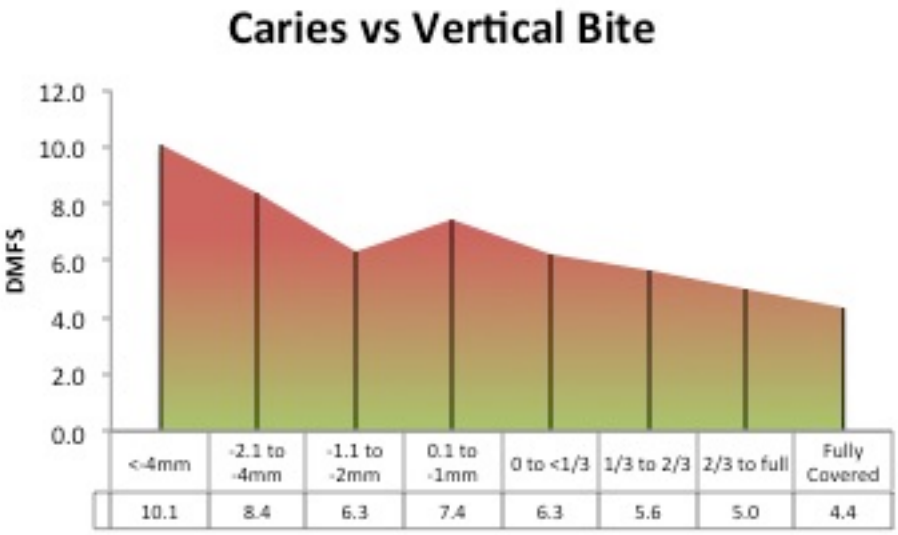


Figure 20- Caries status (dmfs) versus vertical bite spectrum ($P<.001$) normal and open being significantly more afflicted than deep bite.

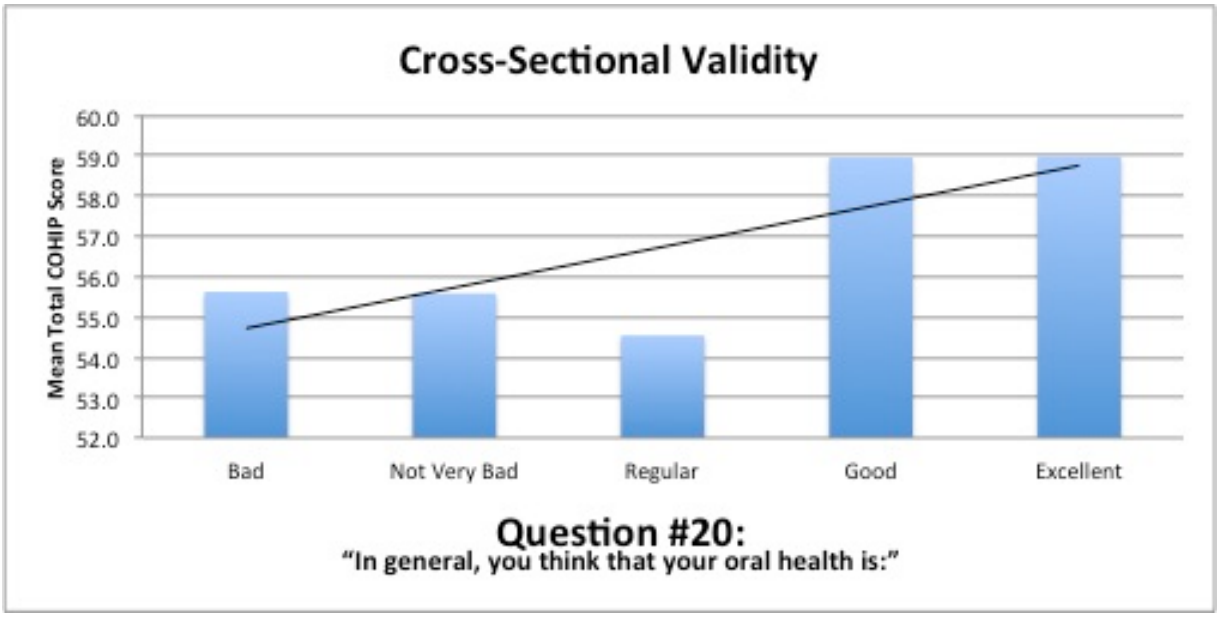


Figure 21- Cross-sectional validity of the COHIP questionnaire.

Total COHIP	Coefficient	95% Confidence interval	P value
Open Bite	-0.25	(-1.31-.81)	0.65
Deep bite	-0.11	(-1.13-.92)	0.84
UC Open Bite	Coefficient	95% Confidence interval	P value
Open Bite	0.09	(-.25-.44)	0.6
Deep bite	-0.01	(-.25-.24)	0.9
UC Deep Bite	Coefficient	95% Confidence interval	P value
Open Bite	0.05	(-.22-.32)	0.7
Deep bite	-0.08	(-.22-.07)	0.3
BR Oral health	Coefficient	95% Confidence interval	P value
Open Bite	-0.1	(-.38-.17)	0.5
Deep bite	-0.19	(-.39-.01)	0.06
BR Functional Well-being	Coefficient	95% Confidence interval	P value
Open Bite	0.20	(-.2-.59)	0.3
Deep bite	-0.06	(-.28-.16)	0.6
BR Socio-emotional well being	Coefficient	95% Confidence interval	P value
Open Bite	-0.08	(-.83-.68)	0.8
Deep bite	0.08	(-.45-.62)	0.8
UC Functional Oral Health	Coefficient	95% Confidence interval	P value
Open Bite	0.00	(-0.40-0.40)	1
Deep bite	-0.27	(-.57-.03)	0.1
UC Social Well-being	Coefficient	95% Confidence interval	P value
Open Bite	0.00	(-.70-.70)	1
Deep bite	0.10	(-.47-.68)	0.7
UC Emotional Well-Being	Coefficient	95% Confidence interval	P value
Open Bite	-0.28	(-.70-.20)	0.2
Deep bite	0.05	(-.25-.36)	0.7

Table 7- Multivariate analysis controlling for confounding variables age, sex, and dmfs. All coefficients not significant ($p>0.05$)

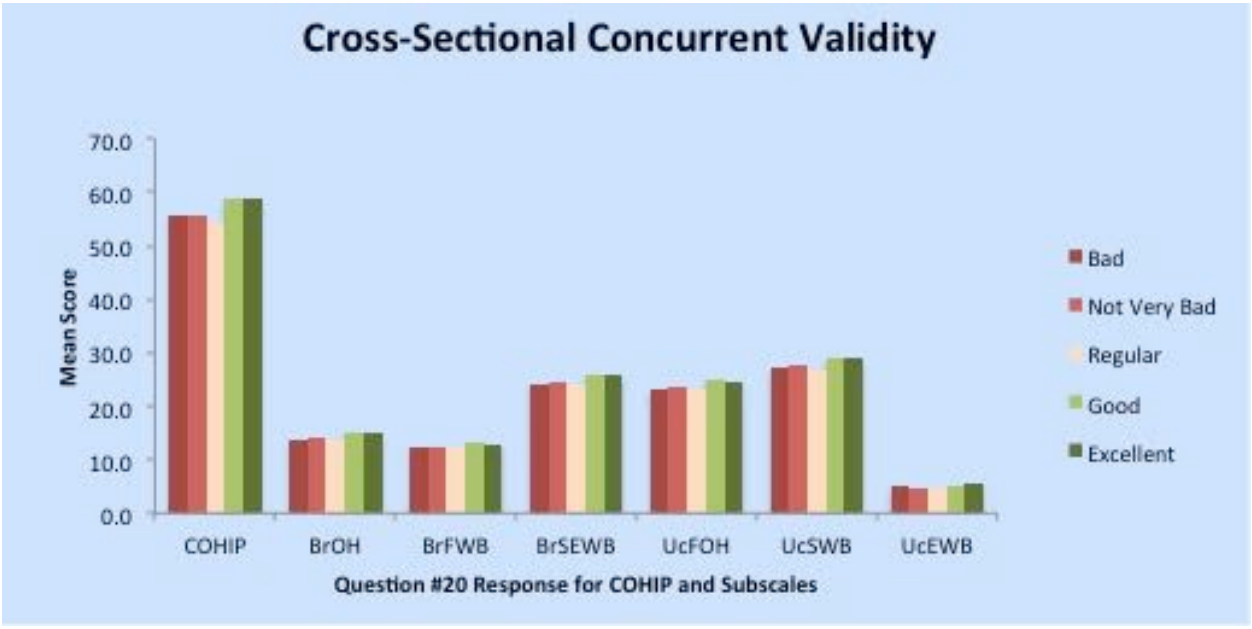


Figure 22- Cross-sectional concurrent validity for total cohip and all the subscales

3.1 Descriptive Statistics

Our data set contained 2,042 subjects, with a mean age of 14.1. When these 2,042 subjects were classified by biteclass, the following results were obtained: Normal overbite 991 subjects; Open bite 184 subjects; and deep overbite 867 subjects. Therefore, normal overbite comprised 48.5 %, open bite 9.1%, and deep overbite 42.5%. Next, we sought to determine if there was a statistically significant difference between the bite classes according to age. We determined that between normal overbite and open bite subjects there was no statistically significant difference in age. However, when comparing normal overbite subjects with deep bite and openbite with deepbite subjects a statistically significant difference in mean age was found. The mean ages were as follows: 14.4, 14.6, and 13.8 for normal, open, and deep bites, respectively. (Table 1)

For Decayed missing and filled surfaces (DMFS) we found that the average value for our studied population was 6.4, which places them in the severe caries class as described earlier.

When classified by biteclass, the following values for DMFS were found in our population: 7.0, 7.5, and 5.4 for normal, open, and deepbite respectively. Therefore, we determined that there was no statistically significant difference in DMFS scores between normal and open bite groups but when normal was compared to deep bite subjects as well as open bite compared to deep bite subjects, there was a statistically significant difference found. Open bite subjects had on average 2 more surfaces affected with caries and normal over bite subjects had on average 1.5 more surfaces affected by caries.(Table 1)

Overall our sample comprised slightly more females than males 51.5/48.5%. Both normal and open bite groups had a significantly higher ratio of female to male subjects when compared to the deep bite group. The normal overbite group had a ratio of 56/44% (female/male), the open bite group had a ratio of 57/43% and the deep bite group had a ratio of 45/55% (female/male). No difference was found between normal and open bite subjects in regard to the ratio of female to male subjects. (Table 1)

3.2 COHIP, the Subscales, and their relationship to overbite status

Total COHIP score showed no statistically significant association with the different bite classes. The following mean scores were found: 55.8, 55.9, and 56.4 for normal, open and deep bite respectively. When COHIP was broken down into the different UCSFS and Broder subscales and compared with over bite status, no statistically significant association was found. The only subscale that showed a trend and was close to significance was the UC Socio-emotional well-being and its counterpart the Broder SEWB subscale. For the UCSF SWB subscale the following

scores were obtained 27.3, 27.7, and 27.9 for normal, open and deep bite respectively (p=0.07). For the Broder SEWB subscale the following scores were obtained 24.3, 24.5, and 24.9 for normal, open and deep bite, respectively (p=0.06). (Table 3)

3.3 COHIP the Subscales and their relationship to caries status

When examining the relationship between caries status, total COHIP and the subdomains we found a statistically significant association between all of the subdomains and total COHIP except for the UC Emotional well being, which comprised questions 8 and 15. With total COHIP and all the subdomains it was found that with each increase in caries class there was a statistically significant decline of oral health related quality of life ($p<0.001$). (Table 4)

3.4 UC Deep/Open Bite subscales and severity of Open/Deep Bite

We found that as the severity of open bite increased there was no statistically significant association to oral health related quality of life as defined by the UCSF open bite subscale, which comprised questions 9, 12, 13 and 17. (Table 5) When analyzing the deep bite subjects in a similar manner, we found no statistically significant association between the severity of deep bite and oral health related quality of life as defined by the newly created UCSF Deep bite subscale, which comprised questions 3, 14 and 16. (Table 6)

3.5 Multiple Regression analysis clustered by region versus total COHIP

When controlling for the possible confounding factors age, sex, and dmfs as determined in table 1, there was still no statistically significant association between total cohip and the bite classes (table 7). Our analysis showed that there was a statistically significant association between total cohip, dmfs, and sex. When a subject's dmfs increased 1 unit there was a decline in oral health related quality of life of -0.15 ($p<0.001$) (Table 7). Adjusted for other variables, being female was associated with 1.26 greater oral health related quality of life score compared to being male ($p<0.006$). Similarly, a change in gender from female to male corresponded to an decrease of 1.26 score in oral health related quality of life (Table 7).

4. DISCUSSION

Malocclusion, caries, and quality of life were analyzed in our sample comprised of approximately 2000 individuals with an average age of 14 that were non treatment seeking and came from 3 different regions of Mexico and 2 regions of Peru (See Table 1 and2). Initially to determine if our sample displayed what many previous studies have demonstrated regarding an increase in malocclusion severity and a corresponding decrease in Oral health related quality of life (7, 67, 68), we looked into our demographic characteristics. We first wanted to understand if our population showed a similar trend. We started by looking at the distribution of minor to severe malocclusions as defined by the ICON index. At first look it appears that our population is skewed towards having relatively mild malocclusions (Figure7). But when the malocclusions are dichotomized into those who need treatment and those that do not, we see

a nearly 50/50 ratio of subjects in each group (figure 8). This tells us that about half of our sample presents with a malocclusion that would be classified as needing treatment, but among those, severe malocclusion is not as common. Therefore, this allows us to draw conclusions on relationships between severity of malocclusion and quality of life. Our results our in agreement with many previously published papers as to the relationship between malocclusion severity and quality of life. We found that as ones ICON score increases from mild (denoted as ICON score <29) to severe (denoted as ICON score >77) there is a significant decrease in their quality of life (figure 11). Similarly, when analyzing the difference in oral health related quality of life between the two dichotomized groups we find a significantly better OHRQoL in subjects with no treatment need versus subjects defined as needing treatment (Figure 12).

In our population caries status was measured using DMFS (Decayed missing filled surfaces). The results demonstrate that our population has a very high prevalence of caries. Nearly 50% of the entire subject population fell into the severe caries category (Defined as a dmfs >5) (Figure 10). Next we sought to determine the relationship between our sample's OHRQoL and caries status. A statistically significant inverse relationship between caries experience and overall quality of life, as well as all the subdomains of OHRQoL (except for UC Emotional well being), was shown (Figure 13 and table 3). This is in agreement with previous studies linking caries and poor oral health related quality of life (69). The UC Emotional well being subscale relates to confidence and attractiveness (See figure 6). One possibility as to why our population did not show a significant inverse relationship between caries experience and the UC emotional well-being subscale could be related to the fact that we overlooked how self esteem can actually be a protective factor. People with higher self-esteem see themselves

as more attractive and confident regardless of whether or not they are severely afflicted with caries. And since that subscale only dealt with factors related to self-esteem such as attractiveness and confidence it could be possible that we overlooked self-esteem as a confounding variable (70).

Next we wanted to determine how specific aspects of malocclusion related to the OHRQoL in our population studied. Specifically, we were interested in vertical bite status. Our vertical bite spectrum was divided into three groups: Normal, Open and Deep bite. Their prevalence in our population was 48.5, 9, and 42.5%, respectively (See figure 9 and Table 2). We found no significant association between overall OHRQoL, the subscales, and vertical bite severity (Figure 14, 15, Table 4, 5 and 6). Therefore we did not find sufficient evidence to reject our null hypotheses. This is in disagreement with a previous study in Brazil looking at the association between quality of life and malocclusion in 3-5 year olds. They found that anterior open bite, caries experience, and mother's schooling was significantly associated with a lower quality of life (48). This can be explained by the fact that our population studied had an average of 14, comes from a different culture, and that this study evaluated parents perceptions of their children's quality of life via the ECOHIS questionnaire. We may have had a different result if parents were also asked to evaluate their child's perceived oral health related quality of life. This is important because the teenagers and young adults studied could have been biased by the predominant tendency to answer things based off of short term memory, the lack of a long term understanding of the effect of their malocclusion, and reading ability with a written questionnaire (71).

Furthermore, our results in relation to the relationship between OHRQoL and severity of vertical bite status are in disagreement with another previous Brazilian study looking at 8-10 year olds. They dichotomized the open bite groups into those with > or equal to 2mm and those less than that. The group that had the more severe open bite had significant associations on the CPQ (8-10) questionnaire with toothache, bad smell in mouth, biting or chewing difficulty, and in the social well being domain they tended to stay out of games with their peers more often than not (50). One way we measured quality of life in relation to severity of vertical bite status, was to use the newly created UCSF open and UCSF deep bite subscales created by Dr. Kjeld Aamodt and me. The UCSF open bite subscale used to measure an association between bite severity and quality of life incorporated question 9 from the COHIP, which specifically asks about difficulty eating foods because of your mouth, face or teeth. Although that question was included, we found no significant association with bite severity.

Possible explanations related to why we found differing results than the Brazilian study could be related to the fact that our population on average was much older with a mean age of 14.6 (table 1) and therefore had already adapted to having the open bite to the point where it no longer affected their quality of life. Perhaps if we would have administered the questionnaire to the same subjects in our open and deep bite categories when they were between 8 and 10 we could have had different results. Because it has been shown that many psychological aspects of children's development occur at approximately six years of age and at around 8 years of age a child's knowledge about how they appear to their peers is similar to that of an adult (50).

The fourth and final hypothesis we sought to determine in our sample related to whether increasing severity of vertical bite status was significantly associated with sleep-disordered breathing. We analyzed this relationship by specifically creating a subscale incorporating only question 13 from the COHIP questionnaire that specifically asks if ones mouth teeth or face has caused difficulties sleeping. We found no significant relationship between vertical bite severities and sleep disordered breathing. Therefore, our final hypothesis is confirmed. This is in disagreement with a study that used PSG (polysomnography) to verify sleep disturbances and found crossbites and open bites to be most predictive (64).

One possible explanation as to why we found did not find a significant relationship could be related to the fact that our population did not understand the questionnaire. Question 20 on the COHIP questionnaire was a question meant to analyze how well they felt their overall oral health was. This allowed us to determine if respondents understood the questionnaire. If subjects consistently entered scores indicating a poorer quality of life on questions 1-19 but then put a higher quality of life score for question 20 it could indicate the questionnaire was not understood. When we graphed these results we can see that the mean quality of life scores and the global answer relating to overall quality of life do not coincide (Figure 20 and 21). Therefore, we can conclude that there was not cross sectional concurrent validity in relation to vertical bite status and overall quality of life (72). Another limitation and reason as to why our study found no significant relationship between OHRQoL and vertical bite status concerns sample size. As discussed in section 1.2 of this paper, open bite malocclusions are very rare in proportion to the other malocclusions. The same was found for our population studied, which only had 9% (See table 2). Although the relationship was not statistically

significant, an inverse trend in relation to quality of life can be seen as our populations vertical bite went from deep to severely open (Figure 15, 16, 17, and 18). A future study that could incorporate more subjects in the most severe open bite group and with a power analysis designed to detect a significant difference in quality of life between severe open and normal bite subjects may find a significant association between OHRQoL and vertical bite status (73, 74).

While not directly linked to one of the main objectives of our study, the high caries rate in anterior open bite patients deserves attention due to its proven affect on OHRQoL. However, it was interesting to see in our population studied, that caries experience as measured by DMFS was statistically significantly higher in the open bite group and least in the deep bite group (See table 1). While not all open bite malocclusions are due to airway problems, the following has been demonstrated: mouth breathing has been shown to be associated with open bite malocclusions the most (75). Individuals who are mouth breathers end up with severely dry mouths (76-78). The reason why this is important is because saliva contains numerous anticariogenic factors such as salivary lysozyme, lactoferrin, and peroxidases, which have bactericidal and bacteriostatic effects (79). Therefore, in our population studied there is a very high association between having an anterior open bite and having a high caries experience (Figure 19 and Table 1). This is important to the clinician because it will alert them to a risk factor associated with caries. In addition, our study and many previous studies have shown a decreased oral health related quality of life with increasing caries experience (Table 4) (80).

Although the present study offers originality and provides important evidence regarding the influence of specific aspects of malocclusion, specifically vertical bite status, on the quality of life of children between eleven and twenty years of age, it is a cross-sectional study. Therefore, longitudinal studies are needed to assess the long-term effect of malocclusion on quality of life of children.

5. CONCLUSIONS

In the regions studied and age group analyzed we can conclude the following associations:

1) There is no association between overall OHRQoL, the subscales, and severity of vertical bite status in our population.
2) There is a significant decrease in Oral health related quality of life versus malocclusion severity and treatment need.
3) There is a significant decrease in Oral health related quality of life versus caries experience except as it relates to ones attractiveness and confidence (Self esteem).
4) There is a significant relationship between severe open bites and an increased caries experience.

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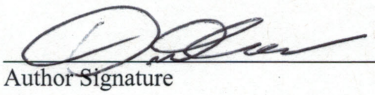

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