The Influence of Oral Inflammation on Timing of Dental Eruption

BY

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THESIS

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SUMMARY

Nationwide, approximately one-third of children are overweight or obese. Rates are even higher in some regions. In Chicago, nearly 50% of children are overweight or obese. Obesity is a systemic disease with important downstream effects on oral health. Inflammation is associated with obesity, which may lead to increased marginal gingival bleeding, higher plaque scores, increased caries rates and potentially even advanced dental development.

This prospective clinical study assessed the effects of obesity and its involvement in oral health. Thirty-five children ten to twelve years of age were recruited from the University of Illinois College of Dentistry Pediatric department. Panoramic radiographs were obtained from each participant’s dental health records. Plaque index scoring and marginal gingival bleeding were recorded for each participant to assess whether there is a correlation between oral health and obesity. Dental age was calculated to evaluate tooth development. Dental age was then subtracted from patient’s chronologic age, at the time of the radiograph, to obtain the difference in dental development relative to actual age (i.e., average, delayed, precocious).

Obese children showed higher average plaque scores (p<0.001) and a greater frequency of bleeding during treatment (p=0.004). In the current preliminary sample, we found no evidence for a difference in timing of dental development across our two BMI groups (p=0.98). The higher plaque scores and more frequent bleeding during treatment are preliminary evidence that obese children may have more oral inflammation.
I. INTRODUCTION

I.1 Background

Obesity rates in children may lead to earlier onset of puberty. In the context of oral health, tooth eruption rates are linked to obesity. On average, obese children have more erupted teeth at the timing of growth and development. Obesity is also a pro-inflammatory condition, and there is reason to suspect that obese subjects may have higher levels of oral inflammation. Greater oral inflammation likely has downstream effects on the oral cavity. At the molecular level, pro-inflammatory cytokines are involved in the bone/tooth breakdown pathway during dental eruption. It is therefore plausible to hypothesize that early dental eruption in obese children may be related to inflammation.

I.2 The definition of childhood obesity

To obtain a child’s body mass index (BMI), the child’s weight in kilograms is divided by the square of height in meters. For children and teens, BMI is directly correlated with age and sex. Body mass index is a measurement determining if a child is deemed of normal weight, overweight or obese. According to the United States’ Centers for Disease Control, a child is deemed “normal,” or healthy weight, when his/her BMI percentile range is the 5th percentile to less than the 85th percentile. If a child is classified as “overweight,” he or she has a BMI at or above the 85th percentile, but below the 95th percentile for children and teens of the same
age and sex. Obese children are classified as being at the 95th percentile or greater.12–14

I.3 Obesity in the U.S. and Chicago

One third of all U.S. children are estimated to be overweight or obese.15 Obesity rates are sociologically disparate, being higher among minority groups compared to non-Hispanic whites, and increase from younger ages through older ages.1 Differences in obesity rates between minority and non-Hispanic white children is a contributing factor to documented disparities in these children’s oral health.15

Chicago childhood obesity rates are 25-50% above the national average.15 By 6th grade, nearly 50% of Chicago children are overweight or obese. Obesity rates in Chicago are highest among Hispanic and African-American children.15 These are underserved populations in terms of oral health care1 and are well-represented in the patient population at UIC. Thus, Chicago is both an optimal location to conduct such a study and a location where the need for better understanding of the downstream oral health effects of childhood obesity and the development of new patient interventions is particularly high.

I.4 Obesity and dental maturation

Recent studies have reproducibly demonstrated the important association of children body mass index (BMI) and the timing of dental maturation, with nearly all finding an association between being overweight or obese and having precocious dental maturation.6–8,10,16–19 In one of the headlining studies on the topic, childhood
obesity led to an average of a year and a half increase in dental development. What is currently unknown is the biological mechanism which ties obesity with precocious dental maturation and poor oral health.

There is limited discussion in the literature regarding potential causative factors for precocious dental maturation in obese children beyond a hypothesized generic link between precocious maturation and the acceleration of other aspects of growth. It is known that obese children undergo earlier growth spurts in terms of stature and puberty, including a precocious age at first menarche in girls. These changes may be related to hormonal shifts due to obesity.

Among many possible factors affecting tooth eruption in obese children, inflammation stands to be of primary significance. This is based on the documented interplay between oral inflammation and key processes of tooth eruption. Pro-inflammatory cytokines play a role in recruiting osteoclasts/odontoblasts during the process of dental eruption and disease which impede osteoclastogenesis also delay tooth eruption.

### 1.5 Obesity and oral inflammation

Obesity is a metabolic disease that may lead to other systemic comorbidities such as hypertension, type 2 diabetes mellitus, atherosclerosis and cardiovascular disease. Coincidently, studies have shown a predisposition to oral inflammation in the obese population. For the purposes of this document, “oral inflammation” is defined as oral tissues which exhibit an inflammatory response (as measured by presence of pro-inflammatory cytokines or visual signs such as
gingival bleeding). Several lines of clinical evidence suggest a link between elevated oral inflammation and precocious dental maturation. For example, children with oral inflammation (as measured by bleeding upon prophylaxis) had earlier eruption than those without.\textsuperscript{18} Children with the systemic inflammatory condition, juvenile rheumatoid arthritis, also display precocious eruption.\textsuperscript{29}

Oral inflammation is an infectious disorder of the structures supporting teeth, such as marginal gingiva and attached gingiva.\textsuperscript{28,30–33} This occurs as a result of the interaction between pathogenic bacteria such as \textit{Porphyromonas gingivalis} and the host immune response.\textsuperscript{34} Destruction of oral tissues is activated via a host immune response through the release of cytokines, proinflammatory mediators and metalloproteinases.\textsuperscript{28}

There is currently little published data on the relationship between childhood obesity and oral inflammation, and the underlying biological mechanisms remain unclear.\textsuperscript{28} Current available literature has shown that adipose tissue releases proinflammatory cytokines and hormones in which induce inflammation.\textsuperscript{14} To date, there are very few studies analyzing oral inflammation and obesity in children. Reports have been limited to the differences in oral hygiene and oral inflammation between normal weight and obese children.\textsuperscript{35–38} Thus, it is important to observe childhood obesity from not only a systemic standpoint, but also to further analyze its effects on oral health.\textsuperscript{28}
I.6 **Obesity, oral hygiene and oral diseases**

Studies evaluating the relationship between oral health status, oral hygiene habits and periodontal status in obese children are currently limited, with conflicting data thus far.\textsuperscript{30,31,39} As described in detail below, increased evidence has shown that obese children may have greater plaque and poorer gingival health.\textsuperscript{17-19} Thus, it is important to investigate the possible connection. Gingival health discrepancies in obese children and adolescents appears to correlate with nutritional habits. Poor dietary patterns such as low calcium or low vitamin C intake have been reported to affect oral tissues and a child’s overall immune response.\textsuperscript{39}

Oral diseases and obesity appear to share common risk factors, as both are associated with unhealthy dietary habits, especially the intake of high sugary foods, soft drinks and snacks.\textsuperscript{39} High sugary diet contributes to accumulation of dental plaque thus the increase in plaque mass and eventually dental caries. Sugary diet also contributes to high caloric intake and obesity. Diet plays an important role in developing high levels of plaque and obesity. With higher intake of carbohydrates and sugars and the lack of compensatory tooth brushing, poor oral health patterns have been often observed in obese children.\textsuperscript{39}

Periodontal examination conducted in a group of obese versus non-obese children showed that the obese children had a 28.22\% increase in plaque scores for the obese group. The obese population exceeded the normal weight patients in the amount and frequency of poor dietary habits.\textsuperscript{39} This was associated with higher plaque scores and poorer oral hygiene. The results of this study showed that obese children had higher plaque scores and were higher levels of gingivitis.\textsuperscript{39}
Another study reported that pediatric obesity may be an indicator for gingivitis. The study compared 52 obese children and adolescents 11 to 17.9 years old and 52 normal weight children of the same age. It was found that poorer oral hygiene, higher incidence of bleeding upon prophylaxis, and increase in gingivitis were noted in obese children compared to the normal weight group.

In conclusion, the results of obesity on gingival health in young subjects may be due to a combination of factors, such as metabolic and inflammatory profiles, decrease in hygiene procedures at home, and lack of an overall balanced diet. Therefore, it is imperative for clinicians to gain knowledge on obesity and its direct effects on oral health, hygiene status and potential barriers for treatment.

I.7 Study Objectives

The objectives of the study were:

1) To examine whether obese children have poorer oral hygiene (i.e., plaque scores, bleeding upon prophylaxis).

2) To attempt to confirm previous research showing accelerated dental development in our obese pediatric sample.

3) If significant variation in the timing of dental development between obese and normal weight subjects is observed, examine the interaction between obesity, dental development, and oral hygiene status.
I.8 Hypotheses

H$_{01}$: There is no deviation in plaque scores, bleeding upon prophylaxis or oral hygiene measures between obese and non-obese children.

H$_{02}$: Obese children do not have accelerated dental development compared to non-obese children in our population sample.

H$_{03}$: Given the differences in the timing of dental development based upon subject BMI, obese children with poor oral hygiene will show the greatest relative advancement in the timing of dental development.

II. MATERIALS AND METHODS

II.1 Study Approval

This study was approved for exemption by the Institutional Review Board of the University of Illinois at Chicago (IRB #2017-0956), Chicago, IL (Appendix A). The study has been funded by the American Association of Orthodontists Foundation Biomedical Research Award (PI: Nicholas).

II.2 Study Criteria

Thirty-five pediatric dentistry patients from the University of Illinois at Chicago College of Dentistry aged 10-12 years were recruited. We chose this age range because the late-mixed dentition is the period during which other studies have seen the greatest influence of obesity on timing of eruption.$^{10}$ Height and weight were used to calculate BMI (>95$^{th}$ percentile: Obese; 5$^{th}$-85$^{th}$ percentile: normal).
Dental age was assessed from panoramic radiographs using the Demirjian et al., (1973) method. Plaque indices were recorded and bleeding upon prophylaxis was recorded.

**Inclusion Criteria:**

- 10-12 years of age
- BMI in the “normal” (5th-85th percentile) or “obese” (95th+) range for age/sex/height
- Healthy (with no systemic diseases)
- Patient in the Department of Pediatric Dentistry at the University of Illinois at Chicago

**Exclusion Criteria:**

- Poor oral health
- Craniofacial anomalies
- Congenitally missing teeth/extra teeth
- Inflammatory diseases
- Taking prescription medications
- Active carious lesions involving the pulp

**II.3 Methodology**

Body mass index was calculated by dividing weight (Kg) by height (m²) and was adjusted for age, sex, and ethnicity. A panoramic radiograph was captured for each participant. Dental development was measured by a research assistant, Jessica Samawi. Using panoramic radiographs, dental development of the right
mandibular teeth was utilized to calculate “Dental Age.” This was then compared to the actual chronological age of the child. We subtracted chronological age from dental age to calculate a metric of the relative timing of dental development, Delta Age (see Nicholas et al., 2018 for a description). When the child’s dental age is significantly more advanced than their chronological age, the child was deemed “precocious,” or early, dental development, and these individuals thus had a higher Delta Age score. Conversely, if there was a low Delta Age score, the child was deemed as having “delayed” dental development.18

Periodontal health was assessed with each subject. Dental plaque and/or calculus was assessed as presence/absence on the buccal, lingual, mesial and distal surfaces of two molars and two incisors, calculating a plaque index score for each participant (see Appendix C). Bleeding upon prophylaxis was recorded for each patient as having bleeding or no bleeding upon clinical evaluation (Y/N).

All participants were asked to fill out a brief (1 page) questionnaire (see Appendices A and B). The questionnaire covers the following topics: racial/ethnic identity; tooth brushing habits; prior orthodontic treatment; age at first menses (for females).

Gingival crevicular fluid was obtained from each subject at time of data collection. Levels of pro- and anti-inflammatory biomarkers (e.g., IL-4, IL-6, IL-8) and biomarkers involved in induced osteoclast activity (e.g., MMP8, RANK-L) will be obsessed from these samples. Our plan is to analyze these samples for future investigation to observe the level of local inflammation. GCF samples were collected using Periopaper strips on the facial and lingual sites of two posterior and
two anterior teeth for 30 seconds. Each sample was then immediately quantified using the Periotron 8010 Instrument. The samples were frozen at 80 degrees Celsius.

II.4 Statistical analysis

The mean difference and standard deviation for our key variables (plaque score, bleeding, difference in dental development) was computed for each BMI group (normal weight, obese). Data was analyzed utilizing R software using two-tailed T tests and Chi-squared tests.

III. RESULTS

III.1 Study Results

A total of 35 subjects who met our inclusion criteria were enrolled in the study between November, 2018 – November, 2019. We had 15 females and 20 males. Thirteen of our subjects had obese BMIs while 22 had normal BMI’s. The average age of our subjects was 11.14 years of age. Patients reported their race and whether or not they identified as Hispanic/Latino(a). A majority were Caucasian Hispanics (n=20), followed by Black/African-American non-Hispanic (n=6). Caucasian non-Hispanic (n=4). Asian (n=1), Black/African-American Hispanic (n=1), Native American Hispanic (n=1), and unknown race/ethnicity (n=1). Raw
III. 1. A. Descriptive statistics

By restricting our sample to subjects who were Normal BMI or Obese BMI, we had a limited range of BMI’s present (Tables 1 and 2). However, the range of BMI percentile of our Normal BMI subjects spans nearly the full possible range, from the 5\(^{th}\) percentile to the 83\(^{rd}\) percentile. The average BMI of Normal BMI subjects was 17.1 and the average BMI percentile (which is age and sex specific) was 39.63 with a standard deviation of ±29.21. It was apparent that our Normal BMI samples tend to be on the lower end of the BMI range. For our obese subjects, the average BMI percentile (age and sex specific) was 97.42.

Table I. BMI Percentiles by BMI Category

<table>
<thead>
<tr>
<th></th>
<th>Normal BMI (n=22)</th>
<th>Obese BMI (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum</strong></td>
<td>83</td>
<td>99</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>39.63</td>
<td>97.42</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>29.210</td>
<td>1.325</td>
</tr>
</tbody>
</table>
Table II. BMI Scores by BMI Category

<table>
<thead>
<tr>
<th></th>
<th>Normal BMI (n=22)</th>
<th>Obese BMI (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum</strong></td>
<td>20.6</td>
<td>37.6</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>14.6</td>
<td>23.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>17.1</td>
<td>28.2</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>1.896</td>
<td>4.363</td>
</tr>
</tbody>
</table>

When comparing plaque scores across Normal BMI and Obese BMI subjects, we can see that Obese BMI subjects have higher average plaque scores (Normal BMI: 38.41, Obese BMI: 70.76; Table 3). It should also be noted that the maximum and minimum plaque values differed across the groups, with the Obese BMI group having a higher minimum (60) and maximum (90) than the Normal BMI group (15 and 75, respectively).

Table III. Plaque Score by BMI Category

<table>
<thead>
<tr>
<th></th>
<th>Normal BMI (n=22)</th>
<th>Obese BMI (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum</strong></td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>38.41</td>
<td>70.76</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>17.69</td>
<td>8.861</td>
</tr>
</tbody>
</table>

Dental development scores, however, were very similar across the two groups (Table 4). The difference in dental development (chronological age – estimated dental age = Delta Age) was very similar across the two groups, with both showing a tendency towards precocious dental development relative to the Demirjian et al., (1973) reference population of French Canadians.
Delta age (difference in dental age) was calculated by subtracting chronological age from estimated dental age (estimated using Demirjian et al. 1973 method)

III.1.a $H_{01}$: There is no deviation in plaque scores, bleeding upon prophylaxis or oral hygiene measures between obese and non-obese children.

We examined our dataset for variation related to socioeconomic status, classified based upon parental education and household income. We found no difference in subject BMI or plaque scores ($p>0.05$). We therefore did not include SES as a covariate in our subsequent analyses. To examine the relationship between BMI and oral hygiene, we compared plaque scores (0-100) across our two BMI groups using Chi-squared. We found that obese subjects had higher average plaque scores ($p=0.004$; Figure 1 and 2). Based upon our parental survey data, where we asked about frequency of the child’s tooth brushing (3 times per day, 2 times per
day, once per day, a few times a week, rarely, never), there was no difference in tooth brushing between the normal and obese groups (p=0.497).

**BLEEDING UPON PROPHYLAXIS**

**OBESE BMI**

![Pie chart showing the percentage of obese group subjects with bleeding upon prophylaxis vs. no bleeding upon prophylaxis.]

Figure I. Pie chart showing the percentage of obese group subjects with bleeding upon prophylaxis vs. no bleeding upon prophylaxis.
Figure II: Box plot showing plaque score (%) of the normal weight vs. obese subject groups. Plaque scores represent the amount of surfaces covered by plaque accumulation (See Appendix C)—this difference was statistically significant (p=0.004).

As a proxy for oral inflammation, bleeding upon prophylaxis was recorded at time of appointment. We compared presence/absence of bleeding upon prophylaxis in our two BMI groups using a Wilcoxon Rank Sum test and found that obese subjects were more likely to have bleeding (p<0.001; Figure 3).
III.1.b. $H_{02}$: Obese children do not have accelerated dental development compared to non-obese children in our population sample.

To examine our second aim, to develop an understanding of the relationship between obesity and dental development, we ran two additional analyses. First, we ran a test of dental development by BMI group. We found no statistically significant difference between the two groups ($p=0.98$). We then compared relative timing of dental development based upon subjects who did or did not have bleeding upon prophylaxis, also using Wilcoxon Rank Sum, and found no association ($p=0.189$). We further found no association between Delta Age and plaque score ($p=0.22$).
III.1.c. $H_03$: Given the differences in the timing of dental development based upon subject BMI, obese children with poor oral hygiene will show the greatest relative advancement in the timing of dental development.

Finally, because we found no association between BMI and dental development in the current sample, we were unfortunately unable to test Hypothesis 3 and examine the combined relationship between BMI, timing of dental development, and indicators of oral hygiene.

IV. DISCUSSION

IV.1 Childhood obesity and dental intervention

As the prevalence of childhood obesity has been rising in the United States, with an increase of about 17 percent of children and adolescents between the ages of 2-19 being obese within the past decade, early intervention is important. Thus, it is imperative for children to have not only routine medical assessments, but also oral evaluations with a dentist. The role of a dentist in preventing childhood obesity includes education, providing preventative measures, and consulting with parents and the children to obtain a history of dietary habits and behaviors.

Childhood obesity is a multifactorial disease. This includes the families’ awareness, lifestyles, beliefs and overall food consumption timings and patterns within the child’s home. Quality of school lunches, children’s access to healthy
foods and safe environments for children to participate in physical activity also contribute to the multifactorial etiologic cause of childhood obesity.  

Oral health professionals are in a unique position to be one of the first medical providers to provide nutrition recommendations to prevent chronic disease. In conjunction, the American Dental Association and the American Association of Pediatric Dentistry have policies related to encouraging healthy food choices that follow national guidelines to reduce consumption of added sugar. Specifically, high sugary beverages and snacks and the frequency of their consumption, are some of the major factors of childhood obesity and oral diseases. While not reported in this study, we have collected dietary recall data using the Block Food Frequency Questionnaire, which allowed us to provide dietary modifications and advice for both parents and children to prevent and reduce childhood obesity.

IV.2 Effects of childhood obesity on oral health

Currently, there are few studies that address the association of childhood obesity and its effects on oral health. In our present study, we focused on assessing oral trends in our obese and non-obese subjects. We focused specifically on the presence of dental plaque and bleeding upon prophylaxis in our pediatric study population. We have found that the obese children had overall significantly higher average plaque scores than the normal weight children (p=0.004). We also found that the obese population had a higher scoring of bleeding upon prophylaxis (p<0.001).
Other studies have evaluated the presence of gingival bleeding in overweight children. One such study was conducted by Sfasciotti et. al. in 100 obese and non-obese school children between the ages of 7 and 12 years of age. The periodontal examination revealed a full mouth plaque score equal to 21.86% in the non-obese population and 50.08% in the obese population. A similar cross-sectional study in 1211 children aged 8 to 12 years recorded mean and median values of gingival bleeding sites. Results showed that the male obese children had the highest rates of gingival marginal bleeding.

In our study, we did not note a significant difference in gender or socioeconomic status of bleeding scores. Should we continue this study and recruit more study subjects, we will analyze the trend of obesity and its effect on oral inflammation and gingival bleeding.

A number of studies have assessed whether obese children have higher plaque levels. A recent meta-analysis of 7 studies found a positive association between overweight/obesity and periodontal disease (as characterized by plaque score, gingival bleeding index, etc.) in pediatric patients. Thus our results fall in line with prior literature and add to a growing body of evidence for an association between obesity and greater plaque accumulation.

Despite a growing body of evidence suggesting a link between childhood obesity and periodontal health, the physiological mechanism which connects these two phenomena has not yet been identified. Reasons for observing the trend of higher plaque scores and bleeding upon prophylaxis in our obese population could be due to poor hygiene habits at home, frequency of consumption of foods high in
sugar and carbohydrates, or the lack of motivation to brush after eating. However, we noted no significant difference in parent-reported frequency of tooth brushing between our obese and non-obese subjects (p=0.497). Further investigation is warranted.

There are various factors that may contribute to increased levels of plaque and oral inflammation in obese children vs. non obese children. Diets high in carbohydrates and sugars can directly cause plaque accumulation and inflammation. Obesity is also a pro-inflammatory disease, with a bi-directional relationship between increased gingival inflammation and plaque accumulation. While we collected dietary data, this dataset has yet to be analyzed. In the near future, we hope to be able to better address some of these questions regarding the potential causative link between obesity and plaque.

IV.3 Dental age estimation in obese children

Dental and skeletal maturation have been studied in orthodontic patients. It was found that higher rates of childhood obesity led to greater dental and skeletal development. A similar study by Omar et al. showed a statistically significant difference in delta calculations among different BMI categories. Obese patients were significantly more dentally advanced compared to normal weight and underweight patients. One potential component of advanced dental age in the obese population includes an increase in adipose tissue and its effects on metabolism and hormonal changes on children. This might explain the effect of high BMI on accelerated maturity in children, including advanced dental age.
In our study, we utilized the method by Demerjian et al. to calculate dental age in comparison with chronological age\textsuperscript{23}. This method has been a source to assess the age of a child based solely on the panoramic radiograph. Although this method has been utilized in previous studies for the evaluation of dental age, there are some reported discrepancies. A study conducted by Kermani et al. demonstrated acceptable accuracy in the majority of the patient populations, but more precise studies were needed to analyze children of the Iranian descent due to conflicting results\textsuperscript{47}.

In our study population, we did not find significant results for accelerated dental age in the obese population (p=0.98). This could have been due to a variety of factors. One factor is the limited number of subjects and panoramic radiographs that were assessed. As recruitment for the broader study is ongoing, we will further investigate panoramic radiographs in the obese and non-obese population to determine if obese children do have accelerated dental age.

IV.4 Dental development, obesity, and oral hygiene status

As we found no association between dental development and obesity in our sample, we were unable to test our third hypothesis regarding whether obese subjects with poorer oral hygiene (potentially indicative of greater oral inflammation) are those most likely to have accelerated dental development. However, in the current sample, we see no association between dental age and
plaque score (p=0.22) or gingival bleeding (p=0.189). Future work with a larger sample size will be necessary to resolve this question.

IV.5 Limitation of the Study

- Small sample size of 35 subjects were collected for our preliminary data, thus, expected outcomes may not correlate with the existing known literature.
- Tooth brushing frequency was reported by the parents, not the subjects, and thus may or may not accurately reflect tooth brushing habits.
- While dietary data has been collected, it has not been analyzed yet. It is possible that diet is an important confounding variable.

IV.6 Future Studies

There is significant need for future studies in this particular topic of assessing oral hygiene trends and eruption patterns in obese children. As literature has highlighted, many factors play a role in oral inflammation and hygiene trends in children. Possibilities for future assessment may include a blind study observing hygiene trends in children, to analyze if children are accurately reporting the amount of time spent practicing adequate oral hygiene. Continuing this study in different geographic areas may strengthen our results, as we can compare different
regions and increase the sample size to analyze dental exfoliation patterns and oral hygiene trends in the obese population versus normal weight children.

V. Conclusion

Obese children have higher rates of oral inflammation and bleeding upon prophylaxis in comparison with non-obese children. At this time, our sample does not show a difference in timing of dental development between obese children and non-obese children. We were therefore unable to evaluate whether obese subjects with advanced dental development also tended to have poorer oral hygiene and/or greater oral inflammation. Future work will be needed to address these questions.

Our study confirmed prior studies that showed that children with high BMI tend to have poorer oral hygiene. Nutritional counseling, oral hygiene instructions and proper education may help reduce obesity and inflammatory disease in children. Oral health clinicians play an important role in the education, prevention and evaluation of health patterns in children. They are essential evaluating and providing awareness for health and oral hygiene in our future generation.
REFERENCES


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APPENDIX A: PARENTAL QUESTIONNAIRE - ENGLISH

Questionnaire

Demographic/Health History Questionnaire
Please help us by telling us current information about your household’s socioeconomic status and your child’s dental health. The information will be extremely helpful in comparing the results of our study with other studies in both the U.S. and abroad. As always, when we use the information, we will remove any personal identifiers and only report group summary information (your name and other identifying information will not be linked to the answers to these questions).

1. What is your child’s race/ancestry? (you may circle more than one)
   a. Black/African American
   b. White/Caucasian
   c. Asian
   d. Native American
   e. Other _____________________

2. Is your child Hispanic/Latino?
   a. Yes
   b. No

3. What is the highest level of education achieved by the parents/guardians of your child?
   a. Parent/guardian 1:              b. Parent/guardian 2
      (if applicable)
      i. Some high school              i. Some high school
      ii. High school diploma or GED   ii. High school diploma or GED
      iii. Some college               iii. Some college
      iv. 2 year degree, technical/beauty school
teaching/technical school
      v. Bachelor’s degree             v. Bachelor’s degree
      vi. Post-graduate or professional degree
         or professional degree

4. Which of the following best describes your total household income for the last year before taxes (include salaries, wages, tips, interest, etc.)?
   a. Less than $20,000 per year
b. $20,000 – $39,999 per year
c. $40,000 – $59,999 per year
d. $60,000 – $79,999 per year
e. $80,000 – $110,000 per year
f. More than $110,000 per year

5. How often does your child usually brush his or her teeth?
   a. Never
   b. Rarely
   c. A few times a week
   d. 1 time a day
   e. 2 times a day (morning and night)
   f. 3 times a day

   [MORE QUESTIONS ON BACK OF PAGE]

6. Has your child ever been treated by an orthodontist (a dentist who does braces/Invisalign)?
   a. Yes
   b. No

7. Is your child a diabetic?
   a. No
   b. Yes – Type 1 diabetic
   c. Yes – Type 2 diabetic

8. If your child is female, has she had her first menses/first menstrual period?
   a. Yes
   b. No

   6a. If yes, please indicate approximately what age she was when her first menstrual period occurred _________________
Questionnaire

Cuestionario historial de salud /demográfico
Por favor ayúdenos con la información actual sobre el socioeconómico de la gente que vive con usted en su hogar y la salud dental de su hijo/a. La información adquirida será de gran ayuda para comparar los resultados de nuestro estudio con otros estudios que se han realizado en los E.E.U.U y en el extranjero. Como siempre, la información que usted nos provee no tendrá ningún vínculo con su persona y solo se presentara la información como un resumen de todos los cuestionarios que se han repartido (Su nombre y su información proveída no será vinculada con sus respuestas dadas en el cuestionario).

1. ¿De que raza es su hijo/a? (Puede circular más de una)
   a. Negro/ Afro-americano
   b. Blanco/ Caucásico
   c. Asiático
   d. Indígena nativo americano
   e. Otro ___________________

2. ¿Su hijo/a es hispano/latino?
   a. Sí
   b. No

3. ¿Cuál es el nivel más alto de educación que han recibido los padres/guardianes de su hijo/a?
   a. Padre/ custodio 1:
      i. No completo la segundaria
      ii. Completo la segundaria o recibió un GED
      iii. no completo la Universidad
      iv. certificado de colegio
      v. completo la Universidad
      vi. completo un pos-grado o certificado
   b. Madre/ custodio 2:
      i. no completo la segundaria
      ii. complete la segundaria o recibió un GED
      iii. no completo la Universidad
      iv. certificado de colegio
      v. completo la Universidad
      vi. completo un pos-
4. ¿Cuál de las siguientes cifras describe el total de su salario anual del año pasado antes de la deducción de impuestos (incluye salario, propinas, beneficios, etc.)?
   a. Menos de $20,000 anual
   b. $20,000 – $39,999 anual
   c. $40,000 – $59,999 anual
   d. $60,000 – $79,999 anual
   e. $80,000 – $110,000 anual
   f. Más de $110,000 anual

5. ¿Con que frecuencia su hijo/a se cepilla los dientes?
   a. Nunca
   b. Con poca frecuencia
   c. Algunas veces por semana
   d. 1 vez al día
   e. 2 veces al día (mañana y noche)
   f. 3 veces al día

6. ¿Su hijo/a ha recibido tratamiento de un especialista en ortodoncia (un odontólogo que aplica braquetes/Invisalign)?
   a. Sí
   b. No

7. ¿Su hijo/a es diabético/a?
   a. No
   b. Sí - diabetes tipo 1
   c. Sí - diabetes tipo 2

8. ¿Si su hija/o es del género femenino, ha comenzado a menstruar/ha tenido su primera menstruación?
   a. Sí
   b. No

8a. Si su respuesta fue sí, aproximadamente a qué edad su hija comenzó a menstruar/rebió su primera menstruación?
APPENDIX C: Plaque Scoring Method Description

Plaque Scoring Method:

1. Four teeth were assessed for the presence or absence of plaque (two posterior molars, and two anterior incisors).

2. Plaque was observed to be present or absent on the four following surfaces: Mesial, distal, facial and lingual.

3. The number of surfaces with a presence of plaque were summed together and divided by total number of surfaces.

4. For example: 8 total plaque surfaces out of 16 total surfaces = 8/16 = 0.5 = 50% plaque score for the patient.
APPENDIX D: Raw Data – Normal BMI subjects

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APPENDIX E: Raw Data – Obese BMI subjects

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VITA

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PRESENTATIONS: Poster Presentation, University of Illinois at Chicago, College of Dentistry, Clinic and Research Day, March 22, 2019
Title: The Influence of Oral Inflammation on Timing of Dental Eruption: A Review of the Literature.
Co-authors: Ghandeer Thalji, Afsar Naqvi, Christine Wu, Sahar Alrayyes, Christina Nicholas
Poster Presentation, University of Illinois at Chicago, College of Dentistry, Clinic and Research Day, March 22, 2020
Title: The Influence of Oral Inflammation on Timing of Dental Eruption
Co-authors: Ghandeer Thalji, Afsar Naqvi, Christine Wu, Sahar Alrayyes, Christina Nicholas

Poster Presentation, American Academy of Pediatric Dentistry (AAPD) 73rd Annual Session in Nashville, TN, May 22, 2020
Title: The Influence of Oral Inflammation on Timing of Dental Eruption
Co-authors: Ghandeer Thalji, Afsar Naqvi, Christine Wu, Sahar Alrayyes, Christina Nicholas