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Evidence Supports No Relationship between Obstructive Sleep Apnea and Premolar Extraction: An Electronic Health Records Review

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Objective: A controversy exists concerning the relationship, if any, between obstructive sleep apnea (OSA) and the anatomical position of the anterior teeth. Specifically, there has been speculation that extraction orthodontics and retraction of the anterior teeth contributes to OSA by crowding the tongue and decreasing airway space. This retrospective study utilized electronic medical and dental health records to examine the association between missing premolars and OSA.

Methods: The sample (n = 5,584) was obtained from the electronic medical and dental health records of HealthPartners in Minnesota. Half of the subjects (n = 2,792) had one missing premolar in each quadrant. The other half had no missing premolars. Cases and controls were paired in a 1:1 match on age range, gender, and body mass index (BMI) range. The outcome was the presence or absence of a diagnosis of OSA confirmed by polysomnography.

Results: Of the subjects without missing premolars, 267 (9.56%) had received a diagnosis of OSA. Of the subjects with four missing premolars, 299 (10.71%) had received a diagnosis of OSA. The prevalence of OSA was not significantly different between the groups (OR = 1.14, p = 0.144).

Conclusion: The absence of four premolars (one from each quadrant), and therefore a presumed indicator of past "extraction orthodontic treatment," is not supported as a significant factor in the cause of OSA.

Keywords: obstructive sleep apnea, premolar extraction, polysomnogram, orthodontic treatment, airway space

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Obstructive sleep apnea (OSA) affects approximately 10% to 20% of middle-aged and older adults and is responsible for significant morbidity and mortality.[1] OSA is associated with hypertension, atherosclerosis, cardiovascular disease, and diabetes.[1–7] Individuals with OSA are more likely to die from any cause and more likely to die from cardiovascular disease than those without OSA.[5,6] Daytime sleepiness caused by OSA also can increase the number and severity of motor vehicle accidents and work-related injuries.[1,2]

Several studies suggest an association between OSA and the size and position of soft and hard tissue structures of the oro-facial complex. These include tongue size, adenotonsillar size, soft palate length and thickness, position of the hyoid bone, short mandibular length, long vertical facial height, high mandibular plane angle, and Class II malocclusion, among others.[8–15]

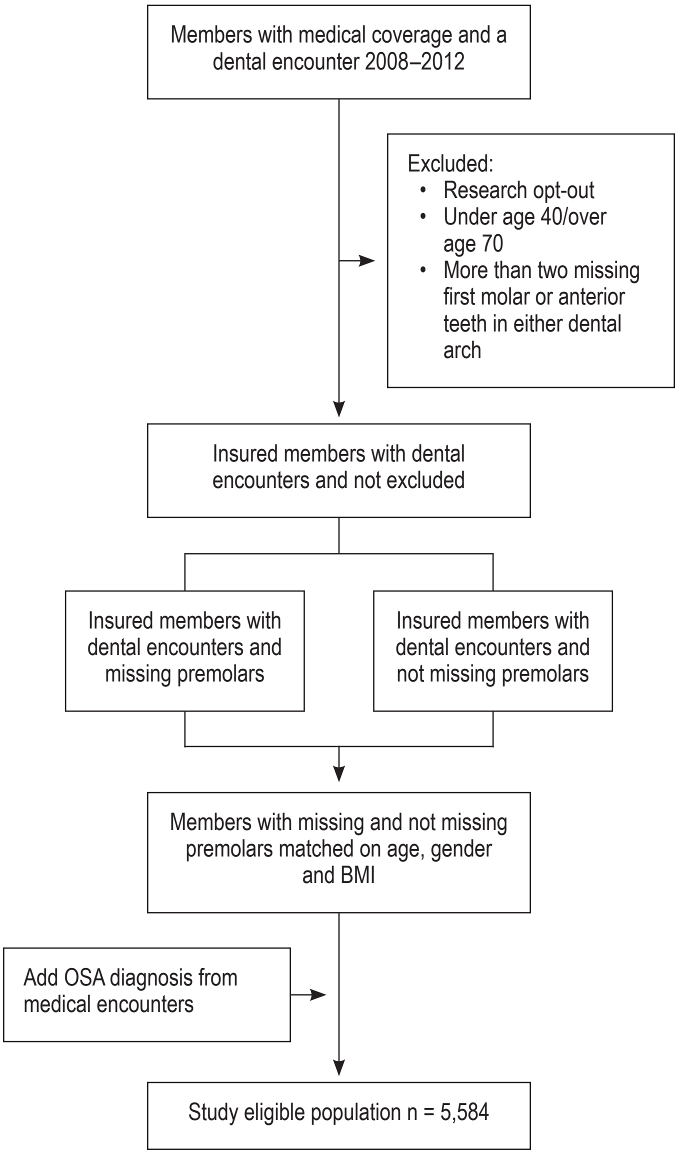
Other studies suggest that changes in airway volume associated with orthognathic surgery or orthodontic treatment may reduce the airway space and contribute to OSA.[16–23] One proposed mechanism is that orthodontic treatment with premolar (bicuspid) extractions can decrease the airway space, due to retraction of incisors, and therefore possibly lead to OSA. Studies examining the change in airway space after extractions for orthodontic treatment have produced varying results. Some authors[18–20] found that orthodontic treatment with premolar extraction does not decrease the intraoral airway space regardless of the amount of incisor retraction achieved. Others[21–23] found a decrease in the airway volume, which depended upon the type of space closure utilized during orthodontic treatment. One limitation of these studies is that while they suggest a mechanism whereby extraction-based orthodontic treatment could contribute to OSA, none have actually examined this association. This study examined the hypothesis that the prevalence of OSA is greater among subjects with a history of missing premolars compared to matched control subjects without any missing premolars, controlling for age, gender, and body mass index (BMI).

BRIEF SUMMARY

Current Knowledge/Study Rationale: There are many sleep medicine practitioners who believe that extraction orthodontic treatment causes obstructive sleep apnea. Some practitioners are utilizing unproven methods, such as re-opening extraction spaces and placing implants, because they believe this will help cure their patients of obstructive sleep apnea.

Study Impact: No statistically significant relationship was found between missing premolars and obstructive sleep apnea. This study provides evidence-based findings that will help guide practitioners to choose treatment modalities that will best serve their patient's needs.

Figure 1—Method used to generate the study sample.



METHODS

We analyzed data extracted from the claims repository and electronic health records (EHR) of HealthPartners, encompassing medical and dental record data. This data included age, gender, BMI, premolars missing or not, and OSA diagnosis or not for each subject. Skeletal classifications and skeletal measurements were not captured systematically in the electronic dental records (EDR), so these data were not used.

Individuals having medical insurance coverage and a dental encounter between January 1, 2008, and December 31, 2012, were selected. The initial data yielded members with some type of medical insurance and at least one dental encounter. Individuals with research opt-out requests were excluded. The study group was limited to those between the ages of 40 and 70 at the end of the study period. This age group was selected based on current reports indicating OSA is most common in these age groups. Next, tooth-charting data were pulled to identify missing teeth. Individuals with more than two missing first molars or anterior teeth in either dental arch were excluded. The remaining individuals were divided into two groups: those who met the criterion of having one missing premolar from all four quadrants (n = 2,792) and those who did not (n = 42,508). The subjects with missing premolars were matched 1:1 to subjects without missing premolars using frequency matching without replacement on age group (40–49, 50–59, 60–70), gender, and BMI group (< 25, 25–29.9, 30+) yielding the final sample of 5,584 subjects (**Figure 1**). Finally, medical encounters with ICD9 codes (**Appendix**) indicating OSA diagnosis (327.20, 327.23, 780.51, 780.53, 780.57) were pulled for the entire sample of 5,584 subjects. This analytic sample was used to test the association between missing premolar status (meets criteria or does not) and presence or absence of an OSA diagnosis.

In order to assess the quality of the data for this study, a data validation process was developed (within the main study) to confirm OSA diagnosis and missing teeth status. The first data validation process took place in the electronic medical records (EMR) to confirm presence or absence of an OSA diagnosis using a randomly selected sample of 300 subjects from the full sample of 5,584. Fifty charts within each of the 5 OSA diagnosis codes and 50 without an OSA diagnosis code were pulled. Each subject's EHR was verified manually for the presence of a polysomnogram (PSG) score and an apnea-hypopnea index (AHI) score ≥ 5. Continuous positive airway pressure (CPAP) was used as a surrogate for OSA if the polysomnogram was not present in the chart, since CPAP is not prescribed unless a PSG has confirmed the presence of OSA. CPAP prescription was only used in this sample for medical data validation (n = 300), not for the entire population of 5,584 subjects. The second data validation process used the EDR to confirm missing teeth. A random sample of 50 subjects meeting the missing premolar criteria and 50 subjects not meeting the missing premolar criteria was selected. For both samples, dental radiographs were reviewed to confirm the number and location of missing teeth. The chart auditor was blinded to the results of the data pull.

For validation of the presence of OSA diagnosis codes or the absence of an OSA diagnosis code, positive predictive values (PPV) and negative predictive values (NPV) were calculated to summarize the confirmation of polysomnography, CPAP prescription, and AHI score ≥ 5 among subjects with and without specific OSA diagnostic codes (**Table 1**). PPVs and NPVs were also calculated to summarize the confirmation of missing premolars by chart review (overall and by quadrant) in a sample of individuals with and without missing premolars according to electronic dental records (EDR) (**Table 2**).

For the total sample size of 5,584, attributes of the subjects with and without missing premolars are described in terms of percentages (**Table 3**). The unadjusted associations between OSA diagnosis status (present vs. absent) and subject attributes of gender, age group, BMI group, and missing premolar status were tested with contingency tables and Pearson χ^2 statistics. A logistic regression analysis using a generalized estimating equations approach tested the association between missing premolar status and OSA diagnosis status, controlling for subject attributes of gender, age group, BMI group, and

Table 1—Confirmation of PSG, CPAP, and AHI score > 5 among subjects with OSA diagnoses (ICD 9 Codes).

ICD 9 Diagnosis Code	PSG	PSG or CPAP	PSG with AHI ≥ 5 or CPAP	PSG with AHI ≥ 5[a]
Positive Predictive Value (95% CI)				
327.20	0.40 (20/50) (0.26, 0.55)	0.54 (27/50) (0.39, 0.68)	0.42 (21/50) (0.28, 0.57)	0.61 (11/18) (0.36, 0.83)
327.23	0.78 (39/50) (0.64, 0.88)	0.84 (42/50) (0.71, 0.93)	0.70 (35/50) (0.55, 0.82)	0.78 (29/37) (0.62, 0.90)
780.51	0.70 (35/50) (0.55, 0.82)	0.84 (42/50) (0.71, 0.93)	0.80 (40/50) (0.66, 0.90)	0.91 (29/32) (0.75, 0.98)
780.53	0.86 (43/50) (0.73, 0.94)	0.90 (45/50) (0.78, 0.97)	0.88 (44/50) (0.76, 0.95)	0.92 (34/37) (0.78, 0.98)
780.57	0.72 (36/50) (0.58, 0.84)	0.82 (41/50) (0.69, 0.91)	0.78 (39/50) (0.64, 0.88)	0.89 (25/28) (0.72, 0.98)
Negative Predictive Value (95% CI)				
No diagnosis for OSA	0.98 (49/50) (0.89, 0.99)	0.98 (49/50) (0.89, 0.99)	0.98 (49/50) (0.89, 0.99)	NA

Medical data validation subgroup, n = 300. [a]Denominators restricted to those with PSG and AHI scores. Col 1: Among the 50 randomly selected patients with a 327.23 diagnosis, 78% (39/50) had PSG. Col 2: Among the 50 randomly selected patients with a 327.23 diagnosis, 84% (42/50) had PSG or CPAP. Col 3: Among the 50 randomly selected patients with a 327.23 diagnosis, 70% (35/50) had PSG with an AHI score ≥ 5 or CPAP. Col 4: Among the 50 randomly selected patients with a 327.23 diagnosis *and* PSG *and* an AHI score, 78% (29/37) had an AHI score ≥ 5. AHI, apnea-hypopnea index; PSG, polysomnogram; OSA, obstructive sleep apnea; CPAP, continuous positive airway pressure; CI, confidence Interval.

Table 2—Validity of electronic health data indicators of missing premolars.

	Meets Missing Premolar Criteria Based on Manual Chart Audit	Proportion with Missing Teeth 1st Quadrant	Proportion with Missing Teeth 2nd Quadrant	Proportion with Missing Teeth 3rd Quadrant	Proportion with Missing Teeth 4th Quadrant
Meets missing premolar criteria based on EHD[a]	1.0	0.96	0.98	0.94	0.94
Does not meet missing premolar criteria based on EHD[b]	1.0	0.97	0.97	0.95	0.97

Dental data validation subgroup, n = 100. [a]Values shown in this row are positive predictive values. Denominators are limited to those having full radiographic data, n = 40, 47, 48, 47, 47. [b]Values shown in this row are negative predictive values. Denominators are limited to those having full radiographic data, n = 44, 37, 36, 37, 37.

accounting for the 1:1 matching of subjects in the construction of the analytic sample (**Table 4**).

RESULTS

Data Validation Results (Chart Review)

Table 1 summarizes confirmation of PSG, PSG or CPAP, PSG with an AHI score ≥ 5 or CPAP, and PSG with an AHI ≥ 5 among 5 samples of subjects defined by their OSA diagnosis, and one sample having no OSA diagnosis (n = 300). PPVs were ≥ 0.70 for all OSA diagnoses except ICD 9 Code 327.20, therefore ICD 9 Code 327.20 was not used for this study. NPVs all exceeded 0.97, indicating that PSG, CPAP, and AHI ≥ 5 were not found among subjects not having an OSA diagnosis.

Table 2 illustrates that electronic identification of individuals with and without missing premolars in all 4 quadrants was perfectly confirmed by manual chart audit (PPV = 1.0, NPV = 1.0). At the level of individual quadrant, the electronic data and manual odontogram review yielded PPV and NPV ≥ 0.94 for presence or absence of missing premolars.

Table 3—Subject characteristics for the matched cohort of subjects missing premolars and those not missing premolars (n = 5,584).

	n (%)
Female	1,932 (34.6%)
Age group (years)	
40–49	2,402 (43.0%)
50–59	2,244 (40.2%)
60–70	938 (16.8%)
BMI group (kg/m²)	
< 25	1,452 (26.0%)
25–29	1,436 (25.7%)
≥ 30	1,312 (23.5%)
Unknown	1,384 (24.8%)

Due to 1:1 matching, subject attributes are identically distributed among those with and without missing premolars.

Study Results

Table 3 summarizes the subject characteristics of the combined sample of 2,792 individuals with missing premolars and 2,792 individuals without missing premolars.

Table 4—Logistic regression results predicting OSA diagnosis (n = 5,584).

	OR (95% CI)	p
Gender		< 0.001
Male	1.94 (1.61–2.32)	
Female (reference)	–	
Age group		< 0.001
40–49 (reference)	–	
50–59	1.56 (1.28–1.91)	
60–70	1.72 (1.34–2.20)	
BMI group (kg/m^2)		< 0.001
< 25 (reference)	–	
25–29	1.84 (1.34–2.53)	
≥ 30	5.58 (4.18–7.45)	
Unknown	2.09 (1.52–2.87)	
Missing premolar status (1 premolar missing from each of 4 quadrants)		0.14
Yes	1.14 (0.96–1.37)	
No (reference)	–	

OR, odds ratio; CI, confidence interval.

In the total matched sample, 566/5,584 (10.1%) had a diagnosis of OSA. An OSA diagnosis was more likely in subjects who were older (8.0% with a diagnosis code of OSA for age group 40–49, 11.1% for age 50–59, 13.3% for age 60–70, $p < 0.001$), male (14.0% for male, 8.1% for female, $p < 0.001$), and with higher BMI (4.1% for BMI < 25, 8.4% for BMI 25–29.9, 20.1% for BMI ≥ 30, $p < 0.001$).

The prevalence of OSA in subjects with and without missing premolars was nearly identical. In the unadjusted analysis, 10.7% of those with missing premolars had an OSA diagnosis compared with 9.6% in the group without missing premolars ($p = 0.16$). In the logistic regression analysis, controlling for gender, age group, BMI group, and accounting for the matching by missing premolar status, the odds of having an OSA diagnosis among those with missing premolars were 1.14 times higher than in the group without missing premolars (95% CI: 0.96–1.37, $p = 0.14$) (**Table 4**). Associations between gender, age group, and BMI group remained statistically significant in the adjusted multivariable model.

DISCUSSION

This retrospective study utilized data from HealthPartners' claims repository and EHR. Matching of the sample groups by age, gender, and BMI statistically adjusted for these important confounding factors. The data validation process supported the quality of the data. No statistically significant relationship was found between missing premolars and OSA in this patient population.

The limitations of retrospective electronic health records data analysis are well recognized.[24] One limitation is sample bias. It is estimated that 80% to 90% of patients with OSA are undiagnosed.[2] Reasons for this are varied and include absence of symptoms and/or lack of financial resources to obtain medical care. All of the patients in this study were able to afford, or were provided, medical insurance due to their employment. Therefore, these patients were more likely to see a physician regularly, have their symptoms noted by their physician, and have a PSG. Theoretically, this would limit the percentage of patients in our study with undiagnosed OSA. Ideally, all patients would undergo a PSG to rule out undiagnosed OSA. According to Young et al., obesity (as measured by BMI) is a major factor in the development of OSA.[2] Other common predictors are age group and gender. Our study further confirmed these known risk factors (**Table 4**). This supports the validity of our study model and raises confidence that our OSA diagnosis is not flawed. It also raises confidence that the absence of four premolars is not supported as a predictor of the development of OSA.

As noted by Balk et al.," obstructive sleep apnea affects approximately 10% to 20% of middle-aged and older adults."[1] Our results also show that approximately 10% percent of the patients in both groups had OSA. Our finding of 10% in this age group is consistent with previous studies and therefore shows that ours is a typical sample.

Premolars could be missing due to decay, agenesis, periodontal disease, or trauma, but it is reasonable to assume that if one premolar is missing from each of the four quadrants and most or all of the other teeth are present, those premolars were extracted for orthodontic treatment. Previous studies suggested that decreased airway space from extraction orthodontic treatment might contribute to the development of OSA. The amount of change in airway space following orthodontic treatment involving the extraction of four premolars varies according to the amount of crowding and/or protrusion of the teeth and the type of mechanics used to close the spaces.[16–23] One limitation of these studies is that, although they measured changes in airway space, none examined this relationship to OSA. Other variables that should be considered but were not available include skeletal characteristics of the subjects[8–15] and which individuals had or had not undergone orthodontic treatment.

Patients in either group could have undergone orthodontic treatments that widen the pharyngeal airway and theoretically might decrease the incidence of OSA.[13,17,25–28] These include palatal expansion, mandibular growth modification (e.g., Herbst type appliances, similar to mandibular advancement devices, but used in growing patients as a means to stimulate more growth from small mandibles), maxillary and/or mandibular advancement surgery, or other treatments with or without full orthodontic treatment. Since these treatments are often used with and without extractions, patients in both groups could have had them.

Several studies suggest an association between OSA and certain skeletal characteristics. These include short mandibular length, long vertical facial height, high mandibular plane angle, and Class II malocclusion, among others.[8–15] These data should be considered in future studies, although they were not available to us.

Our study supports the conclusion that extraction of four premolars does not increase the incidence of OSA. However, there remain many unanswered questions regarding the interaction of the anatomy and physiology of the oro-facial region and development of OSA.

CONCLUSION

The absence of four premolars (one from each quadrant), and therefore a presumed indicator of past "extraction orthodontic treatment," is not supported as a significant cause of OSA.

ABBREVIATIONS

AHI, apnea-hypopnea index
BMI, body mass index
CPAP, continuous positive airway pressure
EDR, electronic dental record
EHD, electronic health data
EHR, electronic health record
EMR, electronic medical record
NPV, negative predictive value
OSA, obstructive sleep apnea
PPV, positive predictive value
PSG, polysomnogram

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APPENDIX

According to the World Health Organization (WHO):

"The International Classification of Diseases (ICD) is the standard diagnostic tool for epidemiology, health management and clinical purposes. This includes the analysis of the general health situation of population groups. It is used to monitor the incidence and prevalence of diseases and other health problems, proving a picture of the general health situation of countries and populations. ICD is used by physicians, nurses, other providers, researchers, health information managers and coders, health information technology workers, policy-makers, insurers and patient organizations to classify diseases and other health problems recorded on many types of health and vital records, including death certificates and health records. In addition to enabling the storage and retrieval of diagnostic information for clinical, epidemiological and quality purposes, these records also provide the basis for the compilation of national mortality and morbidity statistics by WHO Member States. Finally, ICD is used for reimbursement and resource allocation decision-making by countries."

ICD 9 Code	Definition
327.20	Organic Sleep Apnea, unspecified
327.23	Obstructive Sleep Apnea (Adult) (Pediatric)
780.51	Insomnia with Sleep Apnea, unspecified
780.53	Hypersomnia with Sleep Apnea, unspecified
780.57	Unspecified Sleep Apnea