Nasal airway obstruction and orofacial pain: a multicenter retrospective analysis

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The aim of this study was to investigate the relationship between nasal airway obstruction (NAO) and symptoms of orofacial pain, including temporomandibular joint pathology and primary headaches. This study was a retrospective analysis of consecutive patients seeking care for chronic orofacial pain at 14 North American treatment centers. The standardized evaluation protocol followed for all patients included cone beam computed tomography (CBCT), a comprehensive clinical examination, and a thorough review of the patient's subjective complaints and health history, including pain and sleep pathology. The primary conditions of interest in this study were the following 5 types of NAO: nasal valve compromise (NVC), deviated septum, septal swell body, concha bullosa, and inferior turbinate soft tissue hypertrophy. Descriptive statistics and regression analysis were performed to determine comorbidities between orofacial pain symptoms and NAO observed on CBCT images. The study population consisted of 1393 patients, 253 men (18.2%) and 1140 women (81.8%). The mean age of the patients was 43.3 (SD 18.1) years. NVC was the most prevalent type of NAO found in the study population (n = 1006; 72.2%). NVC showed a statistically significant comorbidity with capsulitis (odds ratio, 3.73) as well as facial and cervical myositis (odds ratio, 6.97). To the author's knowledge, this is first time that these comorbidities have been identified. NAO had a high comorbidity with orofacial pain. Specifically, NVC was a major contributor to NAO. An understanding of the mechanisms of orofacial pain as well as the effects of improper (mouth) breathing, adaptive forward head posture, muscular fatigue, parafunction, and temporomandibular joint pathology will help the clinician to evaluate the role a patient's nose may be playing in orofacial pain.

Received: January 22, 2021
Revised: June 30, 2021
Accepted: August 2, 2021

Keywords: nasal airway obstruction, nasal valve compromise, orofacial pain, primary headaches, temporomandibular joint pathology

It is estimated that 1 in 6 adult patients who visits a general dentist experiences orofacial pain, including temporomandibular joint (TMJ) pathology and primary headaches.[1] Patients visiting general dentists reported pain in the muscles and TMJs as frequently as pain in the teeth and surrounding tissues.[1] A systematic review and meta-analysis showed that the worldwide prevalence of clinical signs of temporomandibular disorders (TMDs) in children and adolescents is 1 in 6.[2] At least 1 sign of TMD is found in 40% to 75% of adults in the United States, and women seek care for chronic pain, including orofacial pain, at a much greater frequency than men.[3-7]

Two signs of TMD, jaw locking and primary headaches, were shown to be 1.39 times more likely to occur in patients with sleep-related fatigue (excessive daytime sleepiness) as measured by an Epworth Sleepiness Scale score of greater than 6.[8] Sleep-related fatigue is more often the result of nasal airway obstruction (NAO) and consequent mouth breathing than it is obstructive sleep apnea.[9] NAO is extremely common; based on 2014 population data from the US Census and the incidence of NAO reported by Stewart et al, it is estimated to occur in 20 million Americans.[10,11] NAO includes anatomical causes such as septal deviation and nasal valve compromise (NVC) (Fig 1).[11] NAO also can occur with soft tissue hypertrophy of the inferior turbinate and vomer.

A study of more than 1900 patients with sinonasal complaints surveyed by 50 otolaryngologists in varying US geographic regions demonstrated the prevalence of NAO.[12] The anatomical prevalence of NAO was 67% for NVC, 76% for septal deviation, and 72% for inferior turbinate hypertrophy. Of 236 patients who had severe or extreme Nasal Obstruction Symptom Evaluation scores despite previous septoplasty and/or inferior turbinate reduction, 82% had NVC.[12]

NAO is a risk factor for sleep-disordered breathing, which occurs disproportionately among patients with idiopathic primary headaches (migraine, tension-type, and cluster) and other headache patterns such as chronic daily headache or morning (awakening) headache, irrespective of diagnosis.[13,14] In addition, sleep bruxism is comorbid with sleep-breathing disorders.[15-20] The association of sleep bruxism and painful TMDs greatly increases the risk for episodic migraine, episodic tension-type headache, and especially chronic migraine.[21] Bektas et al reported a link between NAO and bruxism but did not quantify the frequency with TMD/craniofacial pain.[22] The goal of the present study was to investigate the relationship between NAO and orofacial pain symptoms.

Methods

This study used historical data of consecutive patients seeking diagnosis and treatment for chronic orofacial pain, including face, jaw, mouth, neck, and head pain, at

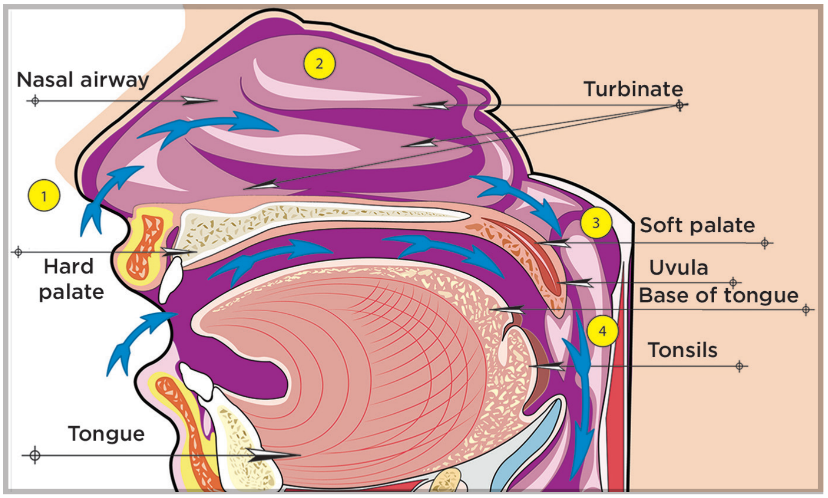


Fig 1. Four points of obstruction to proper nasal breathing: 1, nasal valve; 2, nasal pharynx; 3, velopharynx; 4, oropharynx.

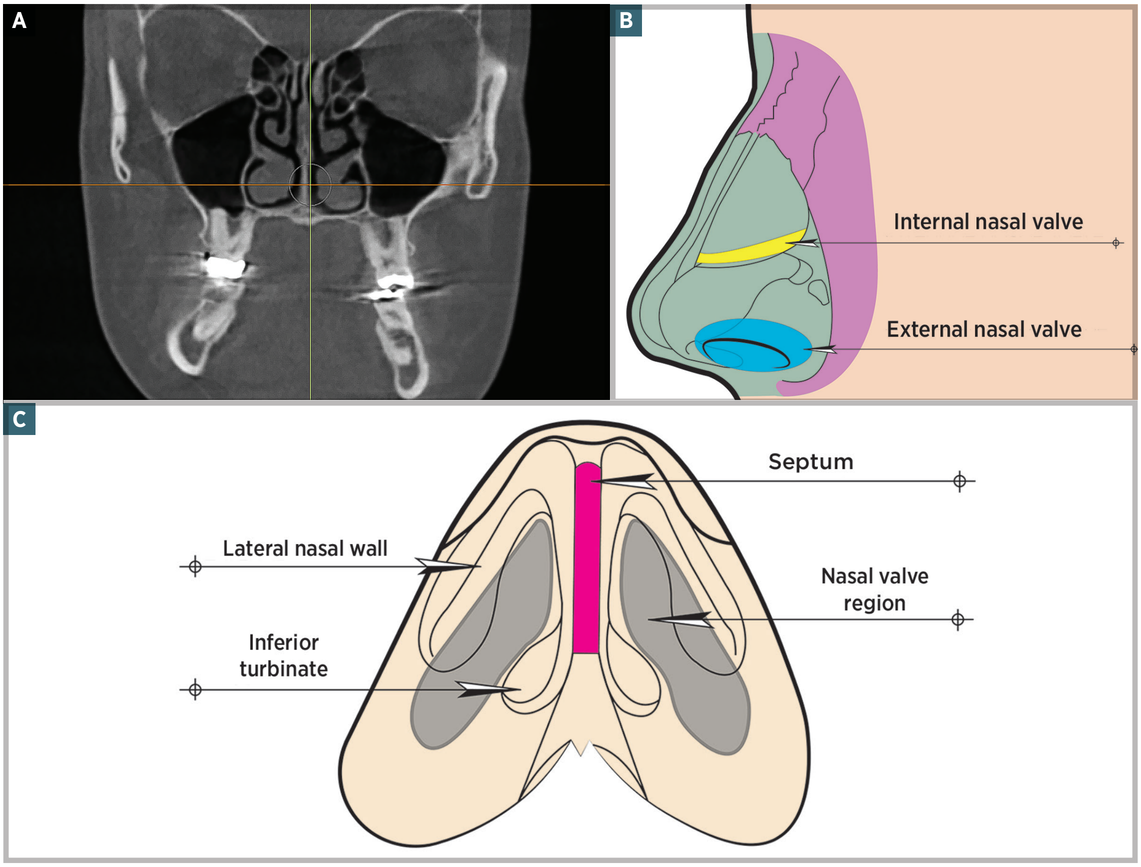


Fig 2. Normal nasal anatomy. A. Frontal view. B. Lateral view. C. Cross-sectional view.

14 North American dental offices (TMJ & Sleep Therapy Centres). An institutional review board (IRB) accredited by the Association for the Accreditation of Human Research Protection Programs, IntegReview IRB, deemed this study compliant with regulations related to the protection of human subjects (45 CFR §46.104).

A standardized protocol was used for the diagnosis and treatment of orofacial pain and breathing disorders. The protocol included a thorough review of the patient's subjective complaints of pain and/or sleep pathology as well as general health, medication, and medical/dental treatment history. Clinical examinations included evaluation of the patient's head and mandibular ranges

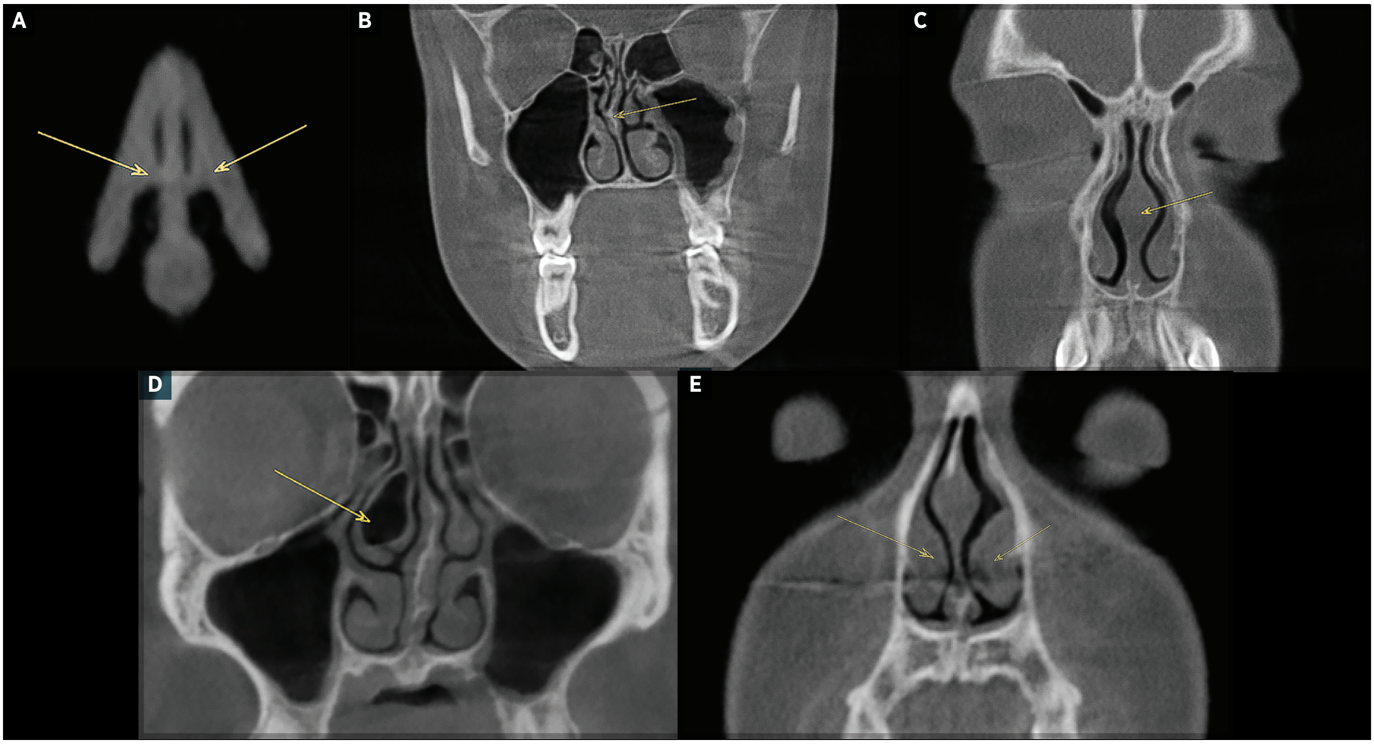


Fig 3. Types of nasal airway obstruction (arrows) investigated in the study. A. Nasal valve compromise. B. Deviated septum. C. Septal swell body. D. Concha bullosa. E. Inferior turbinate soft tissue hypertrophy.

of motion, muscle palpation, cranial nerve examination, photography of the dentition and posture, and joint vibration analysis (Bio JVA, BioResearch Associates). Cone beam computed tomography (CBCT) (i-CAT, Dexis) was performed on all patients.

Normal nasal valve anatomy is shown in Fig 2. The primary conditions of interest in this study were the following 5 types of NAO: NVC, narrowing of the inner/outer nasal valve; deviated septum; septal swell body, soft tissue hypertrophy of the vomer; concha bullosa, pneumatization of the middle turbinate ostium; and inferior turbinate soft tissue hypertrophy (ITSTH) (Fig 3). The patient records were reviewed to collect data on the diagnosis of each individual's chronic pain condition and any findings of NAO. Some patients demonstrated multiple types of NAO.

The degree of pathology for each condition was not documented; obstructive pathology affects flow rate differently in each individual because the volume is different for each person. Patients were not eliminated on the basis of prior nasal surgery because the nasal valve was, until recently, rarely treated. Cosmetic rhinoplasty may narrow the nasal valve, creating mouth breathing. The types of NAO affecting each patient were identified from the CBCT images and recorded in an Excel spreadsheet (Microsoft).

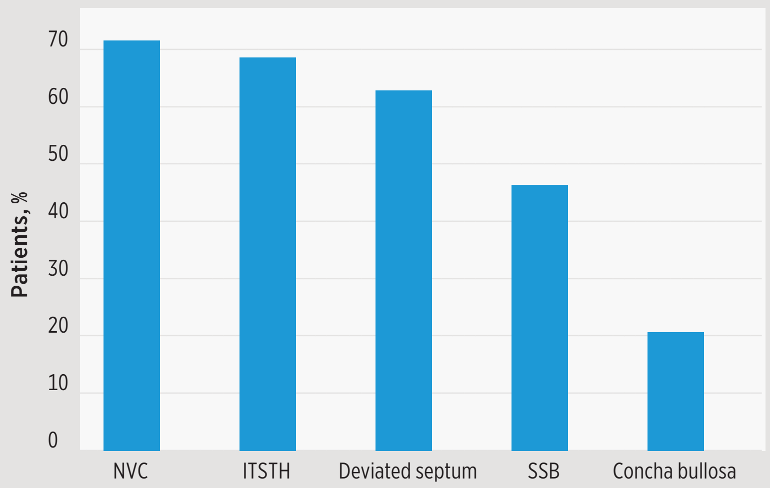
The demographic characteristics of the sample were analyzed using descriptive and frequency statistics. The prevalence of each of the 5 types of NAO under study was calculated using frequency and percentage statistics. Chi-square analysis was used to test for significant associations between potential predictor variables and the types of NAO. Frequency and percentage statistics were reported and interpreted for the chi-square analyses. When a significant effect was found using chi-square, an unadjusted odds ratio (OR) with 95% CIs was calculated to measure the strength of association. Statistical significance was assumed at $\alpha = 0.05$, and all analyses were performed using SPSS statistical software (version 26, IBM).

Results

The study included 1393 patients, 253 men (18.2%) and 1140 women (81.8%). The average age of patients was 43.3 (SD 18.1) years. Based on the CBCT images, 95.3% of the patients in this study had some form of NAO. The CBCT images revealed that NVC was the most prevalent type of NAO, found in 1006 patients, or 72.2% of the sample (Chart 1). The following prevalence rates were found for the other types of NAO: ITSTH, n = 964 (69.2% of the study population); deviated septum, n = 883 (63.4%); septal swell body, n = 652 (46.8%); and concha bullosa, n = 291 (20.9%).

Analysis of the relationships between potential predictor variables and the types of NAO revealed significant associations between 4 different predictor variables and NVC (Chart 2). The rate of NVC was significantly higher in women than in men ($\chi^2_1 = 3.89$; $P = 0.049$; OR, 1.34; 95% CI, 1.001-1.801). In addition, a statistically significant association was detected between an absence of TMJ pain and NVC ($\chi^2_1 = 5.57$; $P = 0.018$; OR, 0.71; 95% CI, 0.53-0.94). There was also a statistically significant difference between patients who did or did not have facial and cervical myositis and the presence of NVC ($\chi^2_1 = 138.53$; $P < 0.001$; OR, 6.97; 95% CI, 4.88-10.0) and between those who did or did not have capsulitis and the presence of NVC ($\chi^2_1 = 91.86$; $P < 0.001$; OR, 3.73; 95% CI, 2.82-4.94). No other statistically significant associations were detected between any predictor variables and the other investigated types of NAO.

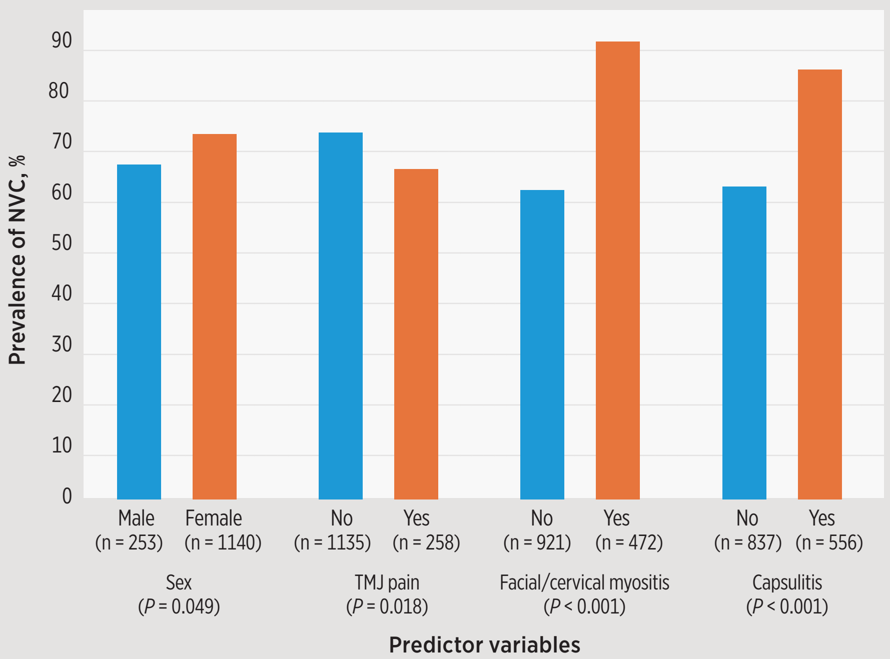
Chart 1. Prevalence of various types of nasal airway obstruction (N = 1393).



Abbreviations: NVC, nasal valve compromise; ITSTH, inferior turbinate soft tissue hypertrophy; SSB, septal swell body.

Some patients demonstrated multiple types of nasal airway obstruction.

Chart 2. Significant associations of predictor variables and NVC.



Abbreviations: NVC, nasal valve compromise; TMJ, temporomandibular joint.

Chi-square analysis (α = 0.05).

Discussion

The sex representation in this study—a 4:1 ratio of women to men—is reflective of that which would be expected in a population of patients seeking care for chronic orofacial pain.[23,24] In general, women report more severe pain, more frequent pain, and pain of longer duration than men.[4] In the present study, women had a higher rate of NVC (OR, 1.34), the most common type of NAO found in the study population. Likewise, the mean age of participants in the present study, 43.3 years, corresponds to previous findings of higher rates of orofacial pain in middle-aged adults.[23-25]

Having a chief complaint of TMJ pain was not linked to the presence of NVC (OR, 0.71). This is explained by patients' greater awareness of muscle pain than TMJ pain. Inflammation of the TMJs (capsulitis) predates orthopedic dysfunction. In this study, NVC showed a significant comorbidity with capsulitis (OR, 3.73), and facial and cervical myositis (OR, 6.97). This is the first time, to the author's knowledge, that these comorbidities have been identified. Whereas normal nasal breathing is a comfortable position with relaxed muscles, mouth breathing secondary to NAO results in fatigue of the elevator and suprahyoid muscles holding the mouth apart. The muscle spindles of the temporalis and masseter muscles are stretched, producing contraction (clenching), possibly the result of the stretch or myotatic reflex. Stretching of the masseter activates the muscle spindle afferents. The result is reflex masseter contraction and jaw closing.[26] The muscular changes that occur as a result of mouth breathing could account for the comorbidities in this study.

Many patients seeking care for orofacial pain also have cervical and extensor muscle pain at the base of the occiput.[27-29] The most common symptom of TMJ disc displacement with inflammation, affecting 94% of patients in one study, is occipital cephalgia.[30] This pain is often caused by a decreased craniovertebral angle (forward head posture). Poor posture contributes to chronic pain by overloading orthopedic structures (muscles, joints, ligaments, and tendons). Forward head posture and reduced cervical ranges of motion are predictive factors for neck pain in adults.[31] Patients with capsulitis/synovitis of the TMJs have forward head postures that can be uprighted with daytime decompression appliances.[32]

The relationship between cervical spinal disorders and orofacial pain is explained by the close coupling of the cervical spine and mandible in the stomatognathic system. Changes in the activity of the neck muscles and head position influence the activity of the masticatory muscles and jaw function, and vice versa.[33-36] Cervical posture parameters may also indicate existing obstructive sleep apnea, which occurs in many patients with NAO. Forward head posture increases with worsening obstructive sleep apnea severity.[37]

Forward head posture has been found to be correlated with bruxism in children.[38] A study by Grechi et al showed that bruxism occurred in 65.22% of children with NAO.[39] In adults, sleep bruxism has been correlated with hypopnea and may function as a mechanism to increase airway patency.[40,41] Sleep bruxism is defined as a repetitive activity of the jaw muscles, characterized by clenching or grinding of the teeth and/or bracing or thrusting of the mandible.[42,43] Sustained bruxism/clenching is the most detrimental activity for the disc of the TMJ.[44] Studies have shown a link between NAO and bruxism but have not quantified the frequency with TMD/orofacial pain.[44] Awake bruxism has different etiopathogenesis than sleep bruxism.[41,45,46]

There is a link between forward head posture and mouth breathing caused by NAO in children.[47] A more anterior and downward head posture and kyphotic neck have been found in children with bruxism.[38] Transverse expansion of the maxilla by 1 mm has been shown to increase nasal airway volume by 2.35% in patients aged 8 to 22 years, and an increase in nasal valve volume resulted in improved Nasal Obstruction Symptom Evaluation scores in children.[48,49] In another study, maxillary expansion resulted in increased nasopharyngeal airway in girls aged 8 to 15 years, uprighting their head posture.[50] An ongoing reduction of forward head posture may be the result of a change in the mode of breathing from oral to nasal as a result of maxillary expansion.[51]

The nose accounts for more than 50% of the total upper airway resistance and plays an important role in establishing physiologic functions such as humidification, heating, and air filtration.[52,53] The nasal mucosa is a dynamic organ controlled by the autonomic nervous system. Periodic nasal congestion and decongestion have been termed the *nasal cycle*.[54] In patients with permanent unilateral NAO, the nasal cycle may contribute to a significant increase in total airway resistance.[55] NAO is a risk factor for sleep-disordered breathing.[13] Corrective nasal surgery has been demonstrated to significantly improve subjective sleep quality.[56]

The primary cause of all pain, whether muscular (myositis), orthopedic (capsulitis/synovitis), or neural (neuritis), is inflammation. Inflammation should be of primary interest in the treatment of orofacial pain and finding the origin of parafunctional movements of the mandible, as in this study of respiratory-related mandibular oral parafunction.

Conclusion

In the present study, NVC was the most common nasal pathology that led to nasal obstruction in the patient sample. NAO was found to have an extremely high comorbidity with orofacial pain. Understanding the mechanisms of orofacial pain as well as the results of improper (mouth) versus proper (nasal) breathing, adaptive forward head posture, muscular fatigue, parafunction, and TMJ pathology will help clinicians direct attention to the nose when treating orofacial pain. Further large-scale studies that screen for NAO and orofacial pain are needed to confirm these findings. In addition, further research that measures nasal flow rates using rhinomanometry may establish a level that results in an increased risk of orofacial pain.

To the author's knowledge, this is the first published study to identify specific structures of NAO and find comorbidities with orofacial pain. The clinical impact of these findings could be profound, shifting focus to the structure and function of the nose as a way to improve outcomes with current treatment programs. Interdisciplinary care is necessary in the treatment of chronic pain patients, and these findings show that a close interaction between otolaryngologists and dentists is essential.

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Acknowledgments

The author thanks Cathie Bellingham, PhD, for medical writing assistance. The author is grateful to the following TMJ & Sleep Therapy Centre clinicians for contributing patient data: Dr Roman Sadikoff, Chesterfield, Michigan; Dr Brandon Brunner, Milwaukee, Wisconsin; Dr Brad Campbell, Charlottetown, Prince Edward Island, Canada; Dr Thomas Harter, Ocala, Florida; Dr Lynn Lipskis, Chicago, Illinois; Dr Casey Morris, Natchez, Mississippi; Dr Kevin Mueller, Phoenix, Arizona; Dr Daniel Klauer, Granger, Indiana; Dr Shab Krish, Flower Mound, Texas; Dr William Ledford, Kansas City, Missouri; Dr Tammy Neugebauer, Reno, Nevada; Dr Edmund Liem, Vancouver, British Columbia, Canada; Dr Schuyler Van Dyke, Great Falls, Montana.

Disclaimer

Steven R. Olmos is the founder of TMJ & Sleep Therapy Centres; however, neither he nor any of the clinicians who contributed patient data received compensation from any entity for any part of this study.

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