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Assessment of Nasal Breathing Using Lip Taping: A Simple and Effective Screening Tool

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Abstract: *Objectives:* Subjective assessment of nasal obstruction with patient-reported outcome measures such as visual analogue scale and NOSE score may be limited in chronic mouth breathing subjects who are not consciously aware of nasal breathing difficulties. This study investigates a simple objective screening tool to assess the capacity for comfortable nasal breathing that is based on sealing the lips and mouth with tape and assessing whether the subject can breathe comfortably through the nose for up to three minutes. *Method:* Cross-sectional, multi-center cohort study with 663 participants (ages: 3-83 years, 50.5% female). Lips were gently sealed using MicroPore paper tape; timer was used to assess how long the participants were able to breathe comfortably through the nose for up to 180 seconds. Other measures included subjective rating of perceived difficulty with nasal breathing (VAS, 0-100) as well as self-assessed reports of mouth breathing. *Results:* There were 9.3% of patients with subjective reports of moderate to severe nasal obstruction (VAS> 50) and 17.2% of patients with predominance of self-reported mouth breathing in this series. Overall, 93.4% of participants successfully passed the nasal breathing test. Among patients with habitual mouth breathing, 83.5% (91/109) were able to breathe comfortably through the nose when instructed to do so for the entire 3-minute duration tested. Similarly, there were 67% (40/59) patients with VAS score >50 who could breathe comfortably through the nose for >180 seconds despite subjective reports of moderate to severe nasal obstruction. Participants unable to breathe exclusively through the nose for 180 seconds had increased likelihood of mouth breathing while awake (OR 4.12, 95% confidence interval 2.14-7.89, p<.0001) as well as increased odds of mouth breathing while asleep (OR 3.05, 95% confidence interval 1.61-5.72, p=0.0003). *Conclusion:* Objectively testing whether a subject can breathe through the nose with the lips and mouth taped for three minutes can identify patients at risk of mouth breathing and is a simple and effecting screening tool to distinguish organic nasal obstruction from functional mouth breathing habit and or nasal resistance.

Keywords: Nasal Breathing, Assessment Tool, Nasal Obstruction, Mouth Breathing, Lip Taping, Lip Seal Test

1. Introduction

Establishment of exclusive nasal breathing is now appreciated as the single most important objective in securing adequate craniofacial and airway development in children [1]. Indeed, chronic mouth breathing in growing children is associated with palatal growth restriction, alterations of craniofacial development, altered head posture, sleep-disordered breathing, and increased risk for obstructive-sleep apnea later in life [2-4]. Nasal breathing in adulthood has many advantages: nasal ventilation filters, warms, and humidifies the air [5]; protects against exercise-induced bronchospasm [8]; reduces snoring, improves daytime energy, and self-reported sleep quality [7, 8]; decreases vocal effort and laryngeal dryness [9]; and facilitates anxiety reduction and deep meditation techniques [10].

Subjective assessment of nasal breathing ability with validated tools such as the Visual Analogue Scale [11] and NOSE [12, 13] score may sometimes be inadequate in chronic mouth breathing subjects who are not consciously aware of problems with nasal breathing.

Furthermore, these tools may prove ineffective in children who cannot accurately articulate difficulties with nasal breathing. Objective tools available for assessment of nasal breathing include peak nasal airflow, acoustic rhinomanometry, rhinomanometry, Odiosof Rhino [14], and computation flow dynamics using CT- generated three-dimensional nasal models [15]. However, these techniques are often cumbersome and time-consuming and may not serve well as a quick screening tool.

As such, there is a need for more easily accessible methods to objectively screen and assess nasal breathing ability. Here we investigate the efficacy of a simple screening tool to assess the individuals' capacity for comfortable nasal breathing that is based on sealing the lips and mouth with tape while simultaneously assessing whether the subjects can breathe comfortably through the nose for a duration of up to three minutes.

2. Methods

2.1. Study Design

Cross-sectional multi-center cohort study of subjects age three and up from the general population surveyed in a standardized fashion by interdisciplinary professionals trained in the evaluation of orofacial myofunctional disorders at 10 sites including researchers in the United States, Hong Kong, Estonia, and Ireland as part of the Functional Airway Evaluation Screening Tool (FAIREST) study. The study was approved by Solutions IRB on 3-16-18; IRB Protocol # 2018/03/4. Data was collected between 3-22-18 and 8-5-18. Subjects recruited include friends, family, colleagues, and private clients of the researchers who volunteered without financial compensation and provided written-informed consent to participate. Exclusion criteria: syndromic craniofacial disorder (e.g. Downs, Treacher Collins, Crouzon, Apert); history of tracheostomy dependence; prior history of laryngeal, subglottic, or pulmonary airway stenosis or surgery; pregnant women; and mentally/emotionally/developmentally disabled; impaired decision-making capacity; and prisoners. There were 21 objective screening-tool items and an 8-item subjective screening tool questionnaire completed by both subject and a FAIREST researcher (See Appendix A for FAIREST Questionnaire).

2.2. Lip Taping Nasal Breathing Assessment

Lips and mouth of the subject were sealed completely with gentle MicroPore paper tape. A timer was used to assess how long the subject could comfortably breathe through the nose for up to 180 seconds with the lips and mouth taped. Subjects were deemed to pass the test if they could successfully breathe through the nose for three minutes. This test is also known as "lip seal test" [16]. See Figure 1 (Photo of individual with lips taped as described).

Figure 1. *Lip Taping Nasal Breathing Assessment: Lips are sealed with MicroPore tape. A timer is used to assess how long the subject can comfortably breathe through the nose for up to 180 seconds with the lips taped.*

2.3. Other Assessments

Other assessments included in the analysis for this manuscript from the FAIREST dataset included: age, gender; subjective visual analogue scale rating of perceived difficulty with nasal breathing ("Rate how difficult it is to breathe

through the nose from 0-100, 0= no obstruction, 100= complete obstruction") [11]; self-assessed reports of mouth breathing when awake and mouth breathing when asleep were graded on 4 point Likert Scale: (Rarely to never, sometimes, often, almost always). For the statistical analysis, reports of "often" and "almost always" were considered positive as an assessment of chronic mouth breathing habit.

2.4. Statistical Analysis

Statistical analyses were performed using JMP Pro 14 (SAS Institute Inc., Cary, NC). Continuous variables are summarized as mean (M) ± standard deviation (SD), standard error (SE) where applicable. Categorical variables are summarized as frequencies and percentages. Univariate analysis with Pearson's Chi Square or independent t-test (continuous variables) was performed to assess for nominal or continuous covariates of *lip taping test: pass vs. unable* including *VAS nasal breathing difficulty score, mouth breathing while awake, mouth breathing while asleep, age-cohort,* and *gender.* Due to the testing of multiple variables for each outcome, a two-tailed p-value <0.01 was selected as the cut-off for statistical significance.

3. Results

There were 633 subjects who participated in the lip taping nasal breathing test including 335 females and 298 males with average age: 21.4 +/- 18.7 years including 315 children (ages 3-11), 71 adolescents (age 12-17), 102 young adults (age 18-35), 126 adults (age 36-64), and 19 seniors (age >65). A total of 591 subjects (93.4%) passed the test as they were able to breathe through the nose with lips taped for at least 180 seconds. There were 42 subjects (6.6%) who were unable to complete the nasal breathing test. Among n=42 subjects unable to complete nasal breathing for 180 seconds, average time to failure was 58.9 +/- 40 seconds (mean +/- SD), median 60 seconds, range 0-150 seconds (Figure 2). There was an increased rate of inability to pass the test among the adolescent age-cohort (15.5%, 11/71) as compared to children (23/315, 7.3%), young adults (4/102, 3.9%), adults (4/126, 3.2%), and seniors (0/19, 0%), Pearson Chi Square, p= 0.0066. There were no significant gender differences.

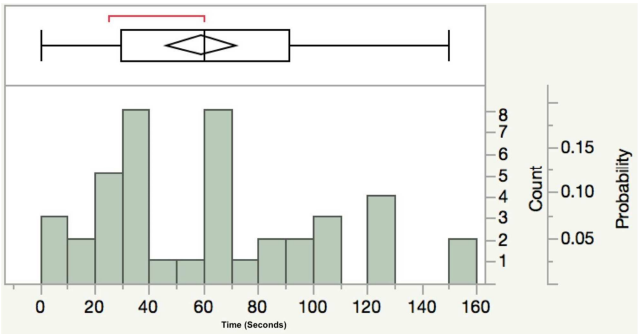

Figure 2. *Distribution of time to failure in seconds among subjects unable to pass the lip taping nasal breathing test. "Pass" was defined as being able to breathe comfortably through the nose with lips taped for the entire 180 seconds tested.*

Among subjects who passed the nasal breathing test, mean +/- SD report of nasal breathing difficulty on the visual analogue scale (0-100) was 8.28 +/- 18.8. Among subjects who were unable to complete the lip taping nasal breathing test, mean report of nasal breathing difficulty was 41.6 +/- 26.3 (p<0.0001) (Figure 3). Subjects who could not complete the nasal breathing tape test had increased odds of mouth breathing while awake (OR 4.12, 95% confidence interval 2.14-7.89, p<0.0001) as well as increased odds of mouth breathing while asleep (OR 3.04, 95% Confidence Interval 1.61- 5.72, p=0.0003).

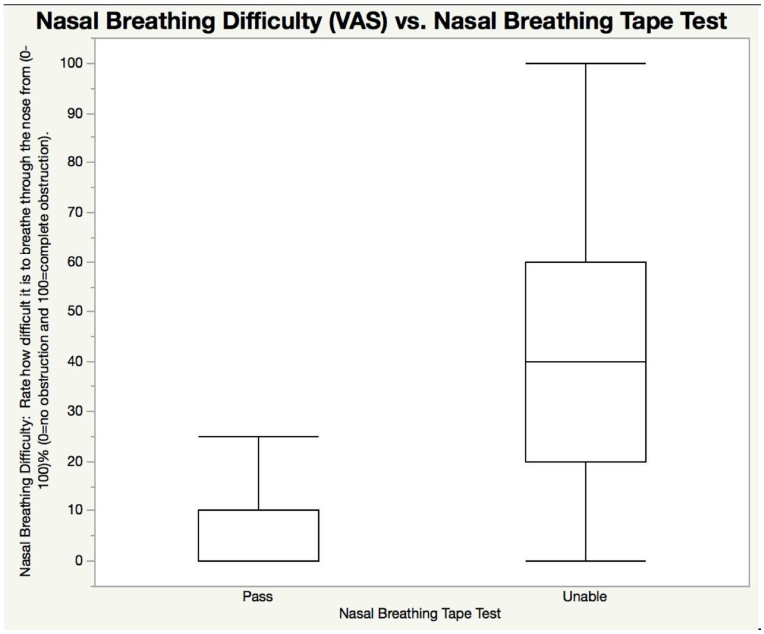

Figure 3. *Box and whisker plot of perceived nasal obstruction (Visual Analogue Scale, 0-100) among patients able and unable to pass the lip taping nasal breathing test.*

There were 17.2% (109/633) patients with reports of a predominance of mouth breathing ("often" or "almost always" mouth breathes) while awake in this series. Among these patients with habitual mouth breathing, 83.5% (91/109) were able to successfully pass the lip taping nasal breathing test. There were only 16.5% (18/109) of mouth breathers who physically could not tolerate breathing through their nose for 3 minutes duration. Similarly, there were 67% (40/59) patients with moderate to severe difficulty breathing through the nose (VAS score >50) who could still tolerate lip taping for >180 seconds despite subjective reports of moderate to severe nasal obstruction.

4. Discussion

This study supports the use of the lip taping nasal breathing test as an effective screening tool in the assessment of mouth breathing and nasal breathing difficulty. Subjects who could not complete the nasal breathing tape test had a four-fold increased likelihood of mouth breathing while awake and three-fold increased likelihood of mouth breathing during sleep. The lip tape test for nasal breathing was found to be a safe, simple, inexpensive, and rationale tool that offers excellent utility in bringing nasal obstruction and/or mouth breathing habit to the forefront of a subject's awareness.

Although physical examination of the nasal cavity can provide accurate information as to the cause of nasal obstruction and potential treatment options, previous studies have shown that physical exam findings (including septal deviation, turbinate hypertrophy, and internal nasal valve collapse) do not accurately correlate with patients' subjective awareness and report of nasal obstruction [17, 18]. This highlights the controversy seen regarding the correlation between changes in objective and subjective outcome measures of nasal obstruction [19]. Given the lack of correlation found between objective and subjective nasal obstruction outcome measures, clinical consensus [20] has focused on assessing the efficacy of nasal breathing interventions on patient-reported outcome measures such as the Visual Analogue Scale [11], Nasal Surgical Questionnaire [21], Nasal Obstruction Septoplasty Effectiveness [22], and Nasal Obstruction Symptom Evaluation [12], among others [19].

Whereas these tools are effective in helping those patients who proactively report problems with and seek intervention for nasal obstruction, they do not address the needs of mouth breathing patients who do not acknowledge, or may be unaware of a problem with nasal breathing. Other tools investigated for the assessment of nasal patency in the clinical recognition of mouth breathing among this population of patients include the Glatzel mirror test and water-retention test. [23, 16]. In the Glatzel mirror test, also called nasographic mirror, a cold mirror is placed under the nostrils and the subject is asked to inhale and exhale through the nose. If moisture condenses on the mirror, this demonstrates that the patient has successfully exhaled through the nares. However, prior studies have shown that the Glatzel mirror test lacks inter-trial reproducibility and does not correlate with other objective and subjective measures of nasal patency [24]; moreover, it was deemed a poor assessment tool in detecting patient-reported improvements in breathing following rhinoplasty [25]. The water retention test, on the other hand, is an effective alternative to the lip taping test in which approximately 15 ml of water is placed in the mouth and the subject is asked to hold it for three minutes. A prior study shows similar distribution of results and efficacy between the water retention test and the lip taping test for assessment of nasal versus mouth breathing [23].

The most interesting finding of this study is that the majority of patients with self-reported mouth breathing and/or subjective reports of moderate to severe nasal breathing difficulty were still physically able to breathe comfortably through the nose for at least three minutes duration when instructed to do so in this study. This is consistent with prior studies on mouth breathing and nasal disuse which show that oral breathing route may persist even after structural obstructions for nasal breathing have been removed and that nasal breathing re-education plays an important role in the treatment of mouth breathing [26-28]. According to the Proceedings of the Royal Academy of Medicine in 1957, it had been widely appreciated that: "Nasal breathing depends on the patency of the nasal passages and on the orofacial muscles closing and sealing off the oral cavity from the nasopharyngeal airway. Mouth breathing due solely to gross nasal obstruction is comparatively rare… [whereas] mouth breathing due to failure of the orofacial muscles is relatively common" [29]. Since that time, models of oro-nasal rehabilitation have been developed and incorporated into myofunctional therapy programs to address the functional aspects of mouth breathing with a high degree of success [28, 30]. Therapeutic mouth and lip-taping during the day as well as overnight while asleep has been shown to be helpful in re-educating nasal breathing [31] as well as in improving symptoms of mouth breathing, snoring, and obstructive sleep apnea [32]. Assessment of nasal breathing ability with the lip tape test can help identify patients with organic structural obstructions who would benefit from interventions for nasal obstructions, as well as to distinguish patients with functional deficits who may benefit from re-education of nasal breathing with myofunctional therapy, oro-nasal rehabilitation programs, or simple lip taping to encourage and reinforce nasal breathing as a long-term habit.

5. Conclusion

Proper breathing, specifically exclusive nasal breathing, is essential to the health and development of children. Children who are unable to breathe well through the nose compensate by breathing more through the mouth. This not only negatively impacts their current health but may also lead to detrimental issues in adulthood. Early detection of improper breathing is therefore vital. Current methods for assessing

nasal breathing capacity such as visual analogue scale and NOSE score are subjective and may be limited in chronic mouth breathing subjects who are not consciously aware of nasal breathing difficulties. This paper advances the field of research by introducing a novel method for assessing nasal breathing. Specifically, objectively testing whether a subject can breathe through the nose with the lips and mouth taped for three minutes is a safe and effective screening tool for the assessment of nasal obstruction and mouth breathing habit.

Compliance with Ethical Standards

Conflict of Interest: Soroush Zaghi declares that he has no conflict of interest. Cynthia Peterson declares that she has no conflict of interest. Shayan Shamtoob declares that he has no conflict of interest. Brigitte Fung declares that she has no conflict of interest. Daniel K. Ng declares that he has no conflict of interest. Triin Jagomagi declares that she has no conflict of interest. Nicole Archambault declares that she has no conflict of interest. Bridget O'Connor declares that she has no conflict of interest. Kathy Winslow declares that she has no conflict of interest. Zahra Peeran declares that she has no conflict of interest. Miche' Lano declares that she has no conflict of interest. Janine Murdock declares that she has no conflict of interest. Sanda Valcu-Pinkerton declares that she has no conflict of interest. Lenore Morrissey declares that she has no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study. The subjects who are portrayed in the photos provided consent to have these photos submitted and published by the journal.

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