Predictors of epiglottic collapse on obstructive sleep apnea syndrome

Original Article

Authors

João Rainha Fernandes
Unidade Local de Saúde Loures-Odivelas, Portugal

Daniela Serras
Unidade Local de Saúde Loures-Odivelas, Portugal

Constança Oom
Unidade Local de Saúde Loures-Odivelas, Portugal

João Barbosa
Unidade Local de Saúde Loures-Odivelas, Portugal

Bárbara Roque
Unidade Local de Saúde Loures-Odivelas, Portugal

Carlos Macor
Unidade Local de Saúde Loures-Odivelas, Portugal

Correspondence:
João Rainha Fernandes
joaorainhafernandes@gmail.com

Article received on April 14, 2026.
Accepted for publication on July 8, 2026.

Abstract

Objectives: To evaluate whether there is a correlation between the presence of epiglottic collapse and demographic, anthropometric, polysomnographic and Drug Induced Sleep Endoscopy (DISE) derived variables.
Study Design: Retrospective observational study.
Material and Methods: Patients with obstructive sleep apnea who underwent DISE in 2025. The VOTE classification was used, with epiglottic collapse defined as present (E+) if complete collapse (2+) occurred.
Results: Seventy-five patients were included, of whom 27% (n=20) had E+. Significant differences were found in the distribution of Friedman Tongue Position (FTP) between patients with and without epiglottic collapse (p=0.037). In the multivariable logistic regression, only FTP was independently associated with epiglottic collapse (OR 3.39; p=0.011), whereas age, sex, body mass index, neck circumference and apnea/hypopnea index did not show a significant association.
Conclusions: FTP was the only independent predictor, suggesting that a higher tongue position predisposes to epiglottic collapse.
Keywords: Epiglottis; collapse; DISE; OSA; FTP.

Introduction

Obstructive sleep apnea (OSA) is a prevalent disorder characterized by the repetitive collapse of the upper airway during sleep, resulting in total (apnea) or partial (hypopnea) obstruction of airflow. The nocturnal hypoxemia and hypercapnia caused by OSA is associated with repeated microarousals and recurrent sympathetic nervous system activation, leading to nonrestorative sleep. It also contributes to several comorbidities, including cardiovascular disease[1] (such as coronary artery disease, arrhythmias, and hypertension), cognitive decline, and psychiatric disorders (such as major depressive disorder)[2]. The treatment approaches for OSA have traditionally relied on positive airway pressure (PAP) therapy[3]. However, a growing understanding of the pathophysiology of this disease has driven the use of alternative approaches, such as surgical strategies and mandibular advancement devices[4]. The success of these options depends on careful patient selection, grounded in the precise identification of the sites and mechanisms involved in upper airway collapse. In this context, drug-induced sleep endoscopy (DISE) is an crucial tool, providing direct, dynamic visualization of pharyngeal collapse during pharmacologically induced sleep[5,6].

Among the different levels of obstruction, the reported incidence rates of epiglottic collapse range from 16% to 30%, varying widely depending on the definitions used and populations studied[7]. The patterns of epiglottic collapse are classified into two types: 1) anteroposterior (the most common), characterized by glottic closure through posterior epiglottic displacement; and 2) lateral, characterized by a "book-like" closure of the epiglottis—a pattern recently linked to predominantly lateral pharyngeal collapse[8]. Mechanistically, it can be: 1) primary, resulting from an intrinsic epiglottic abnormality; or 2) secondary, caused by posterior tongue base displacement, which causes the epiglottis to collapse over the glottis[9]. The proper characterization of epiglottic collapse is of particular clinical importance, as its presence can lead to the failure of both PAP therapy and upper airway surgeries that do not include procedures to correct it[7]. Therefore, this study aimed to evaluate the association between epiglottic collapse and the demographic, anthropometric, polysomnographic, and DISE-derived parameters in patients with OSA, to identify the predictive factors that could improve patient stratification and guide treatment decisions.

Materials and Methods

We conducted a retrospective observational study at the Department of Otolaryngology of the Loures-Odivelas Local Health Unit (Unidade Local de Saúde Loures-Odivelas), Lisbon, Portugal. The sample included adult patients with OSA who were diagnosed by Level I polysomnography or a Level III home sleep apnea test and referred for DISE in 2025. Sociodemographic and polysomnographic data were collected from electronic medical records, and clinical and anatomical variables were measured on the day of DISE. The exclusion criteria were age <18 years, primary snoring or upper airway resistance syndrome, and incomplete medical records. To identify the true predictors of epiglottic collapse, we excluded cases of secondary epiglottic collapse. The parameters analyzed were age, sex, body mass index (BMI), neck circumference (NC), apnea–hypopnea index (AHI), Friedman tongue position (FTP), palatine and lingual tonsil grade, and degree/pattern of collapse of the palate (V), oropharynx (O), and tongue base (T). All DISE procedures were conducted on an outpatient basis in the operating room, with the patient supine and the room kept dark and quiet to mimic the sleep environment. Sedation was induced with propofol administered by target-controlled infusion, and the depth of sedation was monitored using the bispectral index (BIS); the examination began once the BIS values reached 50 to 70, a range intended to approximate the depth of natural sleep. Endoscopic evaluation was conducted with a flexible nasolaryngoscope, and the entire procedure was video-recorded. The findings were classified according to the VOTE system in real time by two observers (an attending otolaryngologist and otolaryngology resident), although the specific pair of observers varied across procedures. The VOTE classification[10] (*Velum; Oropharynx; Tongue base; Epiglottis*), widely adopted in clinical practice, standardizes the assessment of collapse at four anatomical levels, assigning each level a degree of obstruction (0 = absent; 1 = partial/vibration; 2 = complete/collapse) and a collapse pattern (anteroposterior, lateral, or concentric). Epiglottic collapse was dichotomized as present (E+ group) when complete obstruction (Grade 2) was observed and absent (E− group) in all other cases. Given the low frequency of the lateral epiglottic collapse pattern, both patterns (anteroposterior and lateral) were grouped together in the E+ group.

The neck circumference was measured in centimeters using a measuring tape at the level of the cricoid cartilage while the patient was seated. The FTP[11] was also assessed with the patient being seated: the patients were asked to open their mouths with their tongues relaxed inside the oral cavity, and FTP was classified as Grade I (complete visualization of the uvula, tonsillar pillars, and palatine tonsils), Grade II (IIa—visualization of the uvula, with the tonsillar pillars and palatine tonsils only partly visible; IIb—visualization of the base of the uvula and soft palate), Grade III (visualization of only part of the soft palate and hard palate), and Grade IV (visualization of the hard palate only). Palatine tonsils were classified as Grade 0 (no tonsillar tissue), Grade I (contained within the tonsillar pillars), Grade II (extending to the tonsillar pillars), Grade III (extending beyond the tonsillar pillars without crossing the midline), and Grade IV (extending to or beyond the midline)[11]. The lingual tonsil was classified as Grade 0 (no tonsillar tissue), Grade I (lymphoid tissue scattered over the tongue base), Grade II (lymphoid tissue covering the entire tongue base, with limited vertical thickness), Grade III (markedly elevated lymphoid tissue covering the entire tongue base, approximately 5 to 10 mm thick), and Grade IV (lymphoid tissue extending beyond the tip of the epiglottis, 1 cm or more in thickness)[12]. Statistical analysis was conducted using SPSS Statistics version 25 (IBM Corp, Armonk, NY; released 2017). The Mann–Whitney, Kruskal–Wallis, and Fisher exact tests were used to assess the associations between variables. Factors independently associated with epiglottic collapse (E+) were analyzed by multivariable logistic regression, with age, sex, BMI, FTP, and AHI included as covariates. The statistical significance was set at $P < 0.05$.

Results

A total of 75 patients with OSA who underwent DISE were included; 56 patients (75%) were male, with ages ranging from 18 to 75 years (mean, 47.8 ± 11.9 years). The mean BMI was 27.5 ± 3.4 kg/m², and mean NC was 40.2 ± 3.4 cm. The mean AHI was 17.4 ± 16.5 events/hour; OSA was mild in 59% of patients (n = 44), moderate in 32% of patients (n = 24), and severe in 9% of patients (n = 7).

Epiglottic collapse (E+ group) was identified in 27% (n = 20) of patients. The demographic, anthropometric, and polysomnographic characteristics of the two groups are summarized in Table 1. The E+ group included 16 men (80%), with a mean age of 49.6 ± 11.6 years, mean BMI of 26.7 ± 2.8 kg/m², mean NC of 40.2 ± 3.5 cm, and mean AHI of 16.8 ± 15.1 events/hour; 65% (n = 13) had mild OSA. In the E+ group, the collapse pattern was anteroposterior in 90% of cases (n = 18) and lateral in 10% (n = 2). The E− group included 40 men (73%), with a mean age of 47.2 ± 12.0 years, mean BMI of 27.7 ± 3.6 kg/m², mean NC of 40.2 ± 3.4 cm, and mean AHI of 17.6 ± 17.0 events/hour; 57% (n = 31) had mild OSA.

No statistically significant differences were observed between the groups regarding sex, age, BMI, NC, or AHI.

Regarding DISE findings, complete palatal collapse (Grade 2) was the most common finding in both groups (85% of E+ patients and 80% of E− patients). There were no significant differences in the degree of palatal collapse between the groups, and the anteroposterior pattern predominated in both (70% E+ vs. 60% E−). Oropharyngeal and tongue base collapse also did not differ significantly between the groups. Notably, complete tongue base collapse (Grade 2) was more frequent in the E+ group (35% vs. 22%), although the difference did not reach statistical significance (Figure 1). Palatine and lingual tonsil grades did not differ between the groups.

However, significant differences were observed in the distribution of FTP between the two groups ($P = 0.037$). In the E+ group, no patient had Grade I FTP, and 75% had

Table 1
Demographic, anthropometric, polysomnographic, and DISE-derived characteristics of the sample

	Total (n=75)	E+ (n=20)	E- (n=55)	*p*
Age (years)	47,8 ± 11,9	49,6 ± 11,6	47,2 ± 12.0	0,297[1]
Sex				
Male, n (%)	56 (75%)	16 (80%)	40 (73%)	0,765[2]
Female, n (%)	19 (25%)	4 (20%)	15 (27%)	
BMI (kg/m2)	27,5 ± 3,4	26,7 ± 2,8	27,7±3,6	0,263[1]
BMI Classification				
Normal (18 - 24,9), n (%)	16 (21%)	7 (35%)	9 (17%)	0,204[2]
Overweight (25 - 29,9), n (%)	41 (55%)	10 (50%)	31 (56%)	
Obese (≥ 30), n (%)	18 (24%)	3 (15%)	15 (27%)	
AHI (events/hour)	17,4 ± 16,5	16,8 ± 15,1	17,6 ± 17,0	0,881[1]
OSA severity				
Mild (5–14.9), n (%)	44 (59%)	13 (65%)	31 (57%)	0,322[2]
Moderate (15–29.9), n (%)	24 (32%)	4 (20%)	20 (36%)	
Severe (≥ 30), n (%)	7 (9%)	3 (15%)	4 (7%)	
Neck circumference (cm)	40,2 ± 3,4	40,2 ± 3,5	40,2 ± 3,4	0,627[1]
Friedman Tongue Position				
Grade I / II / III / IV, n (%)	8 (11%) / 28 (37%) / 34 (45%) / 5 (7%)	0 (0%) / 5 (25%) / 12 (60%) / 3 (15%)	8 (14%) / 23 (42%) / 22 (40%) / 2 (4%)	**0,037[2]**
Palatine tonsils				
Grade 0 / I / II / III / IV, n (%)	13 (18%) / 36 (48%) / 25 (33%) / 1 (1%) / 0 (0%)	3 (15%) / 11 (55%) / 6 (30%) / 0 (0%) / 0 (0%)	10 (18%) / 25 (46%) / 19 (34%) / 1 (2%) / 0 (0%)	0,455[2]
Lingual tonsils				
Grade 0 / I / II / III / IV, n (%)	0 (0%) / 14 (19%) / 29 (39%) / 19 (25%) / 13 (17%)	0 (0%) / 3 (15%) / 10 (50%) / 6 (30%) / 1 (5%)	0 (0%) / 11 (20%) / 19 (34%) / 13 (24%) / 12 (22%)	0,845[2]
Palatal collapse (V)				
Grade 0 / 1 / 2, n (%)	2 (3%) / 12 (16%) / 61 (81%)	0 (0%) / 3 (15%) / 17 (85%)	2 (4%) / 9 (16%) / 44 (80%)	1,000[2]
AP / Concentric / Lateral pattern, n (%)	47 (63%) / 27 (36%) / 1 (1%)	14 (70%) / 5 (25%) / 1 (5%)	33 (60%) / 22 (40%) / 0 (0%)	
Oropharyngeal collapse (O)				
Grade 0 / 1 / 2	22 (29%) / 27 (36%) / 26 (35%)	8 (40%) / 7 (35%) / 5 (25%)	14 (26%) / 20 (36%) / 21(38%)	0,407[2]
Tongue base collapse (T)				
Grade 0 / 1 / 2	29 (39%) / 27 (36%) / 19 (25%)	4 (20%) / 9 (45%) / 7 (35%)	25 (46%) / 18 (32%) / 12 (22%)	0,114[2]

Abbreviations: BMI, body mass index; AHI, apnea–hypopnea index; OSA, obstructive sleep apnea; AP, anteroposterior.
[1]Mann–Whitney test; [2]Fisher's exact test. Bold: $P < 0.05$.

Grade III or IV FTP (60% and 15%, respectively), compared with 44% in the E− group (40% Grade III and 4% Grade IV). In the E− group, 14% of patients had Grade I FTP (Figure 2).

On multivariable logistic regression analysis (Table 2, Figure 3), with age, sex, BMI, FTP, and AHI included as covariates, FTP was the only variable independently and significantly associated with epiglottic collapse (OR, 3.39; 95% CI, 1.32–8.74; P = 0.011), corresponding to an approximately 3.4-fold increase in the risk of epiglottic collapse for each one-grade increase in FTP. The remaining variables showed no significant association.

Discussion

Identifying the sites of upper airway obstruction is critical for guiding treatment in OSA, particularly for patients seeking an alternative to PAP therapy. Considering the therapeutic challenges inherent in its management, epiglottic collapse is increasingly recognized as an important DISE finding. Till date, no study in Portuguese literature has particularly assessed the predictors of epiglottic collapse in patients with OSA; the present study sought to fill this gap. In our sample, FTP was the only independent predictor of epiglottic collapse, with each one-grade increase conferring a 3.39-fold higher risk of complete primary

Figure 1
Collapse grades at the other VOTE levels

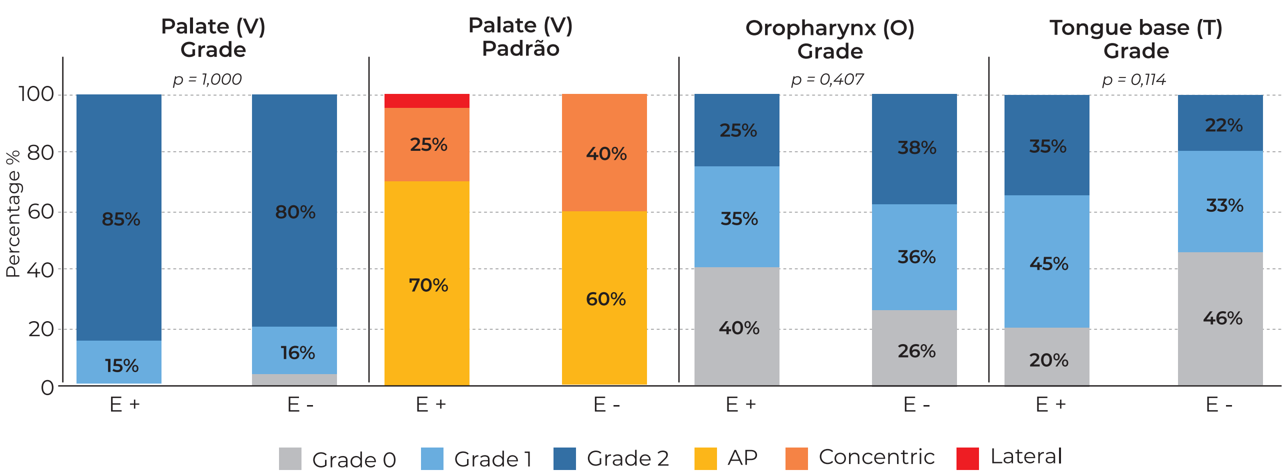


Figure 2
FTP distribution in the E+ and E− groups

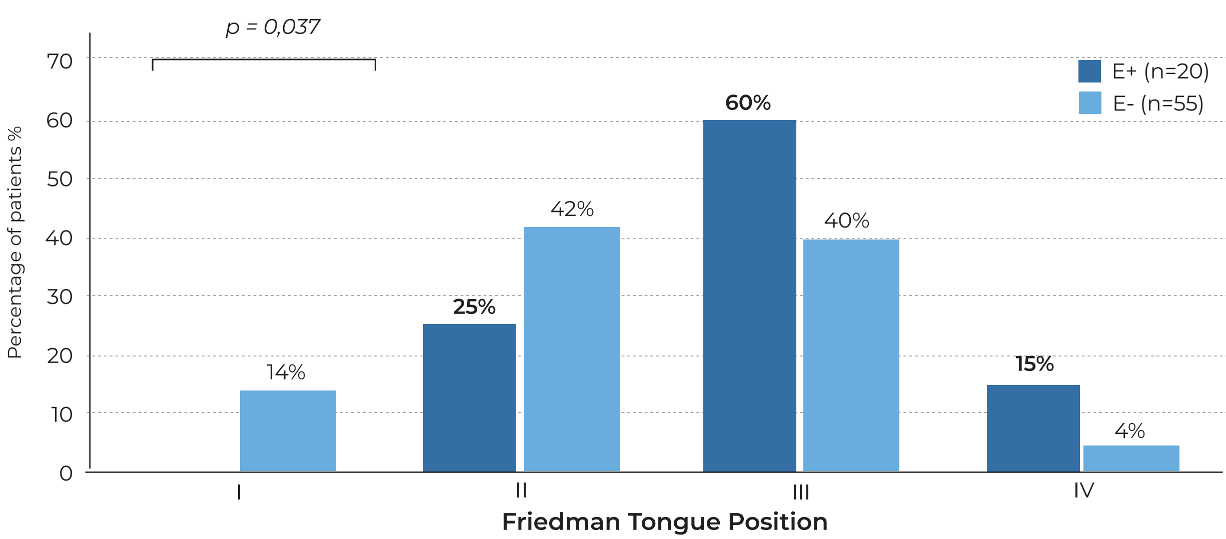
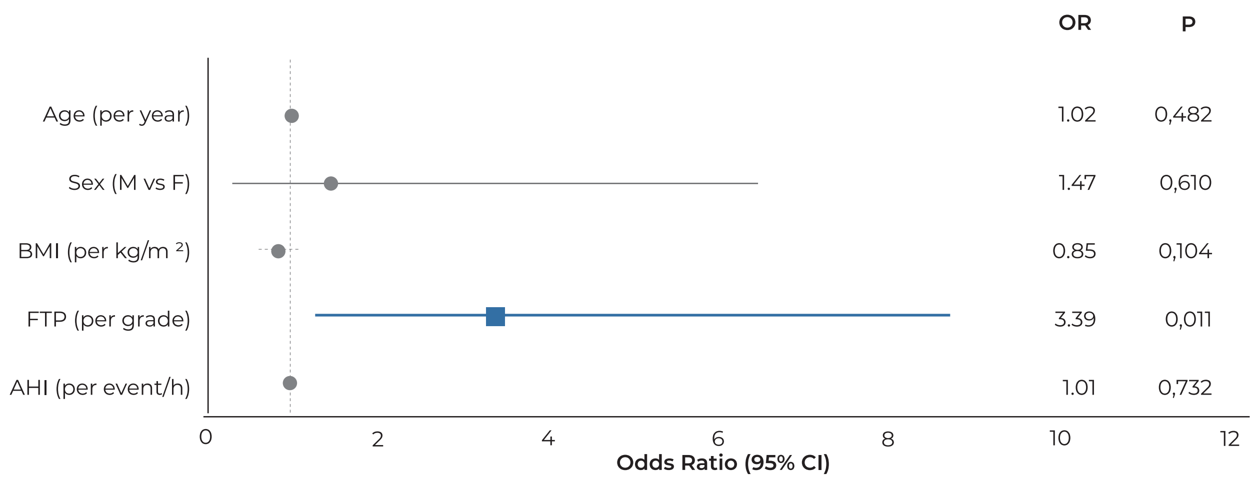


Table 2
Multivariable logistic regression analysis

Variable	OR	95% CI	P
Age (per year)	1.02	0.97–1.08	0.482
Sex (M vs. F)	1.47	0.34–6.42	0.610
BMI (per kg/m2)	0.85	0.69–1.03	0.104
FTP (per grade)	3.39	1.32–8.74	**0.011***
AHI (per event/hour)	1.01	0.97–1.05	0.732

Abbreviations: OR, odds ratio; CI, 95% confidence interval; BMI, body mass index; FTP, Friedman tongue position; AHI, apnea–hypopnea index. Dependent variable: complete epiglottic collapse (E+). Bold values indicate statistical significance ($P < 0.05$).

Figure 3
Multivariable logistic regression analysis



epiglottic collapse. A higher FTP grade corresponds to a more cephalad and posterior position of the tongue base relative to the palate. This configuration can lead to greater retroflexion and narrowing of the supraglottis, exposing it to stronger inspiratory suction forces, as explained by the Bernoulli effect,[13] and thereby facilitating epiglottic collapse during sleep. This relationship is more direct in anteroposterior collapse, which was the predominant pattern in our sample (90%, n = 18). Lateral collapse, which is associated with lateral pharyngeal collapse patterns[8], was rare (10%, n = 2), thus precluding any comparison between subtypes. The association between posterior epiglottic position and epiglottic collapse is supported by Kezirian,[14] who identified this finding on awake flexible nasolaryngoscopy as an independent predictor of both anteroposterior and lateral epiglottic collapse.

FTP is therefore an easily assessed clinical sign that can aid in stratifying patients with OSA. Identifying FTP as a possible predictor allows clinicians to include this information into treatment planning and to offer patients an individualized approach that accounts for the possibility of epiglottic collapse. However, to our knowledge, this association has not been reported previously.

Additionally, we found no differences in the palatine or lingual tonsil grade between patients with and without epiglottic collapse. Huang et al.[15], in a study of 119 DISE procedures, reported that patients with smaller palatine tonsils were more prone to collapse at the tongue base and epiglottis. This discrepancy may stem from the different definitions of epiglottic collapse used: the prevalence of E+ in their sample was higher than that in ours because their E+ group also included patients with partial epiglottic collapse.

Epiglottic collapse was identified in 27% of our sample, consistent with the values most commonly reported in the literature. In the systematic review by Torre et al.[7], the incidence ranged from 12% to 74%, reflecting the heterogeneity of the populations studied and definitions used as well as the subjectivity inherent in endoscopic assessment of the upper airway. No significant differences were observed between the groups regarding demographic, anthropometric, or polysomnographic variables (age, sex, BMI, or OSA severity). Previous studies by Kezirian[14], Kim et al.[16], and Wong et al.[17] reported that older age, male sex, lower BMI, and less severe OSA were associated with a greater predisposition to epiglottic collapse—a finding that was not reflected in our results. This discrepancy may be explained by our small sample size and the skewed distribution of OSA severity, with most patients in both groups having mild OSA, which limited the variability of the factors analyzed and reduced the statistical power to detect smaller differences.

Regarding the other VOTE levels, no significant differences were observed in the degree of palatal, oropharyngeal, or tongue base collapse between the groups. However, the E+ group showed a trend toward greater tongue base collapse (35% with complete collapse vs. 22%), although the difference did not reach statistical significance. This trend, albeit nonsignificant, may reflect an association between tongue position and the predisposition to epiglottic collapse. A high FTP indicates an anatomical configuration in which the tongue base occupies a more posterior and superior position, narrowing the supraglottis without necessarily involving a secondary mechanism of epiglottic collapse. This result is supported by Kim et al.[16], who likewise found epiglottic collapse to be associated with a greater degree of tongue base obstruction in a series that, like ours, included only patients with primary epiglottic collapse. This study has several drawbacks that should be acknowledged. Its retrospective design precludes the establishment of causal relationships; therefore, only associations can be identified. DISE was conducted under propofol sedation, which, despite being the most widely used agent, does not faithfully reproduce physiological sleep and may affect the upper airway muscle tone and, consequently, the collapse patterns observed. DISE evaluation was performed by alternating pairs of observers, which may have introduced interobserver variability into VOTE scoring. Additionally, this is a single-center study, which may limit the generalizability of the results to other populations.

Conclusion

The results of this study indicate that FTP may be an independent predictor of primary epiglottic collapse in patients with OSA, indicating that a higher tongue position may contribute to the narrowing of the supraglottis and increase its propensity to collapse.

However, these results should be interpreted with caution, considering the limited sample size, retrospective design, and potential variability inherent in DISE assessment. Therefore, a causal relationship cannot be established, and further validation in larger prospective studies is needed.

However, identifying an association between FTP and epiglottic collapse may be clinically relevant. It indicates that simple anatomical parameters evaluated in the outpatient clinic may contribute to patient stratification prior to treatment, allowing for a more targeted, individualized therapeutic approach, which is essential in all medical conditions, particularly OSA.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Data Confidentiality

The authors declare having followed the protocols in use at their working center regarding patients’ data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the 2013 Helsinki Declaration of the World Medical Association.

Privacy policy, informed consent and Ethics Committee Authorization

The authors declare that they have written consent for the use of photographs of patients in this article.

Funding Sources

This work did not receive any contribution, funding or scholarship.

Availability of scientific data

There are no datasets available, publicly related to this work.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used Claude to review the language and create images. After using this tool/service, the authors reviewed and edited the content as necessary and take full responsibility for the content of the publication.

References

1. Cowie MR, Linz D, Redline S, Somers VK, Simonds AK. Sleep disordered breathing and cardiovascular disease: JACC State-of-the-Art Review. J Am Coll Cardiol. 2021 Aug 10;78(6):608-624. doi: 10.1016/j.jacc.2021.05.048.
2. Kerner NA, Roose SP. Obstructive sleep apnea is linked to depression and cognitive impairment: evidence and potential mechanisms. Am J Geriatr Psychiatry. 2016 Jun;24(6):496-508. doi: 10.1016/j.jagp.2016.01.134.
3. Gambino F, Zammuto MM, Virzì A, Conti G, Bonsignore MR. Treatment options in obstructive sleep apnea. Intern Emerg Med. 2022 Jun;17(4):971-978. doi: 10.1007/s11739-022-02983-1.
4. Abid R, Zhang L, Bhat A. Non-CPAP therapies for obstructive sleep apnea in adults. Mo Med. 2024 Sep-Oct;121(5):385-390.
5. Hybášková J, Jor O, Novák V, Zeleník K, Matoušek P, Komínek P. Drug-induced sleep endoscopy changes the treatment concept in patients with obstructive sleep apnoea. Biomed Res Int. 2016:2016:6583216. doi: 10.1155/2016/6583216
6. Carrasco-Llatas M, Matarredona-Quiles S, De Vito A, Chong KB, Vicini C. Drug-induced sleep endoscopy: technique, indications, tips and pitfalls. Healthcare (Basel). 2019 Jul 24;7(3):93. doi: 10.3390/healthcare7030093.
7. Torre C, Camacho M, Liu SYC, Huon LK, Capasso R. Epiglottis collapse in adult obstructive sleep apnea: a systematic review. Laryngoscope. 2016 Feb;126(2):515-23. doi: 10.1002/lary.25589.
8. Wang TY, Huyett P, Yang H, Sumner J, Aishah A, Gell L. et al. Lateral epiglottic collapse in obstructive sleep apnea is associated with laterally directed pharyngeal collapse. J Clin Sleep Med. 2025 Apr 1;21(4):649-654. doi: 10.5664/jcsm.11478.
9. Francia C, Lugo R, Moffa A, Casale M, Giorgi L, Iafrati F. et al. Defining epiglottic collapses patterns in obstructive sleep apnea patients: Francia-Lugo classification. Healthcare (Basel). 2023 Oct 31;11(21):2874. doi: 10.3390/healthcare11212874.
10. Kezirian EJ, Hohenhorst W, De Vries N. Drug-induced sleep endoscopy: the VOTE classification. Eur Arch Otorhinolaryngol. 2011 Aug;268(8):1233-1236. doi: 10.1007/s00405-011-1633-8.
11. Friedman M, Salapatas AM, Bonzelaar LB. Updated Friedman staging system for obstructive sleep apnea. Adv Otorhinolaryngol. 2017:80:41-48. doi: 10.1159/000470859.
12. Friedman M, Yalamanchali S, Gorelick G, Joseph NJ, Hwang MS. A standardized lingual tonsil grading system: interexaminer agreement. Otolaryngol Head Neck Surg. 2015 Apr;152(4):667-72. doi: 10.1177/0194599815568970.
13. Kang YJ, Park CS. Mechanisms and management of obstructive sleep apnea: a translational overview. Clin Exp Otorhinolaryngol. 2025 Nov;18(4):296-305. doi: 10.21053/ceo.2025-00071.
14. Kezirian EJ. Anteroposterior and lateral epiglottis-related obstruction in adult obstructive sleep apnea. JAMA Otolaryngol Head Neck Surg. 2025 Oct 1;151(10):984-991. doi: 10.1001/jamaoto.2025.2051.
15. Huang Z, Bosschieter PFN, Aarab G, van Selms MKA, Vanhommerig JW, Hilgevoord AAJ. et al. Predicting upper airway collapse sites found in drug-induced sleep endoscopy from clinical data and snoring sounds in patients with obstructive sleep apnea: a prospective clinical study. J Clin Sleep Med. 2022 Sep 1;18(9):2119-2131. doi: 10.5664/jcsm.9998.
16. Kim HY, Sung CM, Jang H Bin, Kim HC, Lim SC, Yang HC. Patients with epiglottic collapse showed less severe obstructive sleep apnea and good response to treatment other than continuous positive airway pressure: a case-control study of 224 patients. J Clin Sleep Med. 2021 Mar 1;17(3):413-419. doi: 10.5664/jcsm.8904.
17. Wong SJ, Luitje ME, Karelsky S. Patterns of obstruction on DISE in adults with obstructive sleep apnea change with BMI. Laryngoscope. 2021 Jan;131(1):224-229. doi: 10.1002/lary.28777.