Sleep and Breathing (2019) 23:311–317
https://doi.org/10.1007/s11325-018-1763-y

ENT • ORIGINAL ARTICLE

# Epiglottis shape as a predictor of obstruction level in patients with sleep apnea

Matej Delakorda [1,2] • Nina Ovsenik [1]

Received: 24 June 2018 / Revised: 20 November 2018 / Accepted: 22 November 2018 / Published online: 30 November 2018


## Abstract

**Purpose** Despite a broad range of diagnostic methods, identifying the site of obstruction in the upper respiratory tract in patients with obstructive sleep apnea is not always simple and straightforward. With regard to this problem, we present our observations about the specific shape of the epiglottis in patients with obstruction at the level of the tongue base and/or epiglottis.

**Methods** One hundred and forty consecutive drug-induced sleep endoscopy (DISE) video recordings of patients with polygraphy-verified obstructive sleep apnea were analyzed by three independent observers. We compared the levels of obstruction using the VOTE classification and the shape of the epiglottis, both as seen during the DISE investigation and in the awake state. We have calculated the interrater reliability for VOTE classification results and epiglottis shape evaluation by three different observers.

**Results** Out of 140 patients, there were 52 (37.1%) with a flat epiglottis. Within this group, there were only 3 (6%) cases in which obstructions at the tongue base and/or epiglottis level were not found. In the group with normally convex and omega-shaped epiglottis, obstruction at the tongue base level was observed in 28 patients (31.8%); obstruction at the epiglottis level was observed in 5 patients (5.7%); and obstruction at both the epiglottis and tongue base level was observed in 3 patients (3.4%). Interrater reliability for VOTE classification was poor for V (ICC = 0.414) and good for O (ICC = 0.824), T (ICC = 0.775), and E (ICC = 0.852). Additionally, interrater reliability was excellent for epiglottis shape (ICC = 0.912).

**Conclusion** In patients with obstructive sleep apnea, examinations in the awake state and drug-induced sleep endoscopy both showed that in most cases of obstruction at epiglottis and/or tongue base, the epiglottis was flat, i.e., lacking the typical anterior convexity in its upper part. We assume that the change of its shape is a result of degeneration of suspensory apparatus that maintains the shape of the epiglottis and holds it in its position. This could contribute to the better identification of patients with a narrowing at this level, and in turn to better decisions regarding the choice of the most suitable treatment.

**Keywords** Sleep apnea · Diagnosis · Site of obstruction · Epiglottis shape

## Introduction

The awareness of the importance of obstructive breathing disorders during sleep has grown considerably in the last decade. As a result, the number of recognized patients in need of treatment has increased as well. Despite the great progress seen during this time, the knowledge of pathogenesis and therapeutic approaches remains limited. Surgical treatment is gradually gaining recognition and prominence among other established methods of treatment of such disorders [1, 2].

A lot of effort has been invested into identifying the characteristics based on which patients with obstructive sleep apnea (OSA) could be distinguished from the general population and which would allow a reliable identification of the patients who could benefit from surgical therapy [3]. The success of surgical treatment is based predominantly on the selection of suitable patients and the procedure best suited for their condition. This, in turn, is related to the accurate identification of the site, or sites, of obstruction in the upper respiratory tract. Numerous methods have been developed to aid such identification. Some of them are used in the awake state, while others are used during sleep, which can be either natural, or it can be induced as in the case of drug-induced sleep endoscopy

✉ Matej Delakorda
mdelakorda@gmail.com

1 Department of Otolaryngology–Head and Neck Surgery, General Hospital Celje, Oblakova ulica 5, 3000 Celje, Slovenia

2 Faculty of Medicine, University of Ljubljana, Vrazov trg 2, 1000 Ljubljana, Slovenia

(DISE) [4]. Each of the methods has certain strengths and weaknesses [5]. The disadvantage of most of them is that they are time- and labor-consuming and therefore still not accessible to many patients. In the expansive range of diagnostic options, although not ideal [6], DISE continues to play a decisive role [7]. Nevertheless, the disease often remains underestimated and some obstruction sites may be overlooked [8]. It may also be a rather subjective procedure and consequently, a less-than-ideal interobserver agreement was reported in some studies [9, 10].

Despite considerable progress, surgery for sleep-disordered breathing, especially in the oropharynx, still involves a possibility of some early and late complications [11]. Therefore, it is important to identify the patients in whom surgical treatment only at this level would not be effective. This applies in particular to patients with obstruction at the level of the tongue base and epiglottis. To date, several morphological characteristics have been described in the population of patients with obstructive sleep apneas, by which they differ from healthy individuals; however, the authors mostly focused on the shape of soft tissue in the oropharynx and the relations between them [12].

The epiglottis is an important anatomical structure that was largely ignored in the early research on obstructive breathing disorders. More recent studies, however, have shown that it plays an important role, either on its own or in combination with other pharyngeal structures [13]. The introduction of routine preoperative assessment, in particular DISE, has shown that obstruction, either partial or complete, often occurs at this particular level in 10–40% of patients [14–16].

In the previous studies, regarding identification the site of obstruction at epiglottis level, the researchers concentrated mostly on the position of the epiglottis (retrodisplacement), or its laxity during examinations of the patients with obstruction at the level of the tongue base and epiglottis. The aim of our study was to find out whether there are any characteristics which could be detected also during mirror laryngoscopy and which could identify the patients with the obstruction at the level of tongue base and/or epiglottis.

## Methods

One hundred and forty consecutive adult patients who were candidates for surgical treatment for OSA without prior surgery for this disease were included in the study. In all patients, a sleep polygraphy on a four-channel polygraphy device with nasal cannula-air flow measurement, pulse oxymetry, and thoracal and abdominal plethysmography sensor (Weinmann Somnolab 2, Germany) was performed to confirm the clinical diagnosis. After the otorhinolaryngological examination with special emphasis on the epiglottis shape that was evaluated while the patient was not phonating, DISE was performed by an experienced specialist. Prior to the investigation, intravenous glycopyrrolate (Rubinol) was administered, no topical anesthesia was given to the nostrils, and the patient was placed in a supine position. Sedation was carried out with propofol administered by an anesthesiologist with the microbolus technique, with the patient under cardiorespiratory monitoring. The depth of sedation was monitored with the BiSpectral Index (BIS) and/or clinically, and obstructions and epiglottis shape were evaluated in medium sedation level. We used the VOTE classification system to describe the level and rate of obstruction [17]. The video recordings were archived for any further analyses.

If the epiglottis closed the airway independently of tongue base, as in cases of floppy epiglottis, then the obstruction was classified as being at the epiglottis (E) level; if the epiglottis was pushed towards the posterior wall of the pharynx by the tongue base, then the obstruction level was classified as tongue base (T). In some cases, we found that the two occurrences, i.e., floppy epiglottis and epiglottis pushed back by the tongue base, alternate in the same patient (TE).

Different shapes of the epiglottis, assessed during DISE, were classified into three groups: 1—omega-shaped (sharply curved) epiglottis (Fig. 1a); 2—normally curved epiglottis shape (Fig. 1b), and 3—flat epiglottis (Fig. 1c). Epiglottis was classified as flat if its medial part lacked the characteristic anterior convexity. Epiglottis was classified as omega-shaped (sharply curved), if the angle between its lateral parts was less than 90°. To aid the classification of different shapes in the three groups, we made a special graphic scheme (Fig. 2).

First, VOTE classification and shape of epiglottis evaluation, using archived DISE recordings, were done by an otorhinolaryngologist who is subspecialized in the field of surgery for sleep-disordered breathing. After that, the same was done by two other otorhinolaryngologists who had no other information about the patients who were recorded. Due to the statistical method used, partial and total obstructions were accounted for separately. The results, i.e., site of obstruction, were compared to the assessed epiglottis shape, determined during DISE.

### Statistical analysis

Categorical variables were described as numbers and percentages. The intraclass correlation coefficient was used to assess the interrater reliability. Differences between two categorical variables were calculated with the chi-square test. All data are presented in tables or graphs. Differences were found to be significant at $p < 0.05$. The data were analyzed using IBM SPSS Statistics v.21 statistical software package for Windows (SPSS Inc., Chicago, IL, USA).


**Fig. 1** Different shapes of the epiglottis. **a** Type 1—omega-shaped epiglottis; **b** type 2—normal concave epiglottis shape; **c** type 3—flat epiglottis

## Results

### General clinical data

The study includes 140 consecutive patients whom we treated for previously observed obstructive sleep breathing disorders determined by sleep polygraphy. Sample characteristics are presented in Table 1.

Interrater reliability was poor for V (ICC = 0.414) and good for O (ICC = 0.824), T (ICC = 0.775), and E (ICC = 0.852), according to latest guidelines [18]. Additionally, an interrater reliability was excellent in case of epiglottis shape (ICC = 0.912) (Table 2).

In assessing the rate of obstruction as per the VOTE classification, we identified partial or total obstruction at the level of the soft palate in all examined patients. Distribution of other sites of obstruction is shown in Fig. 3. In 14 patients, we observed two different alternating mechanisms of narrowing at the level of the tongue base and epiglottis (TE). In all groups, regardless of the site of obstruction, we furthermore classified the epiglottises in terms of their respective shape (shape 1, 2, or 3) as assessed during DISE. We did not notice any substantial changes in the shape of epiglottis during the DISE investigation in correlation to a depth of sedation. When comparing epiglottis shape assessed by the first observer, during DISE and during an examination in the awake state, sitting up, we found no differences.

### Epiglottis shape vs. site of obstruction

Out of 140 patients, there were 52 (37.1%) with a flat epiglottis (type 3). Within the latter group, there were 13 (25%) patients with obstruction only at the epiglottis level (E), 25 (48%) patients with obstruction only at the tongue base level (T), and 11 patients (21%) with obstruction at the tongue base and epiglottis (TE). In the flat epiglottis group (type 3), obstructions at the tongue base or epiglottis level were not found in only 3 patients (6%) (Fig. 3). Normally, convex epiglottis (type 2) and omega-shaped epiglottis (type 1) were observed in 88 (62.9%) of our patients. In this group, there were 36 cases (40.9%) with obstruction at the level of epiglottis and/or tongue base. Of these, the obstruction was observed at the tongue base level in 28 patients (31.8%), at the epiglottis level in 5 patients (5.7%), and at the epiglottis and tongue base level in 3 patients (3.4%). In 52 patients (59.1%), there was no obstruction at these levels. The difference between the groups was significant ($\chi^2 = 6.460$, $p = 0.040$) (Table 3).

### Site of obstruction vs. epiglottis shape

We then determined the shares of patients with respective epiglottis shapes within the group of patients with obstruction at the epiglottis level (E, TE). Out of 140 patients, we observed obstruction at this level in 32 (22.7%) patients. Within this group of patients, a flat epiglottis (type 3) was

**Fig. 2** Scheme for epiglottis shape evaluation. I—omega-shaped epiglottis, II—normal concave epiglottis shape, III—flat epiglottis, α—angle between lateral parts of the epiglottis

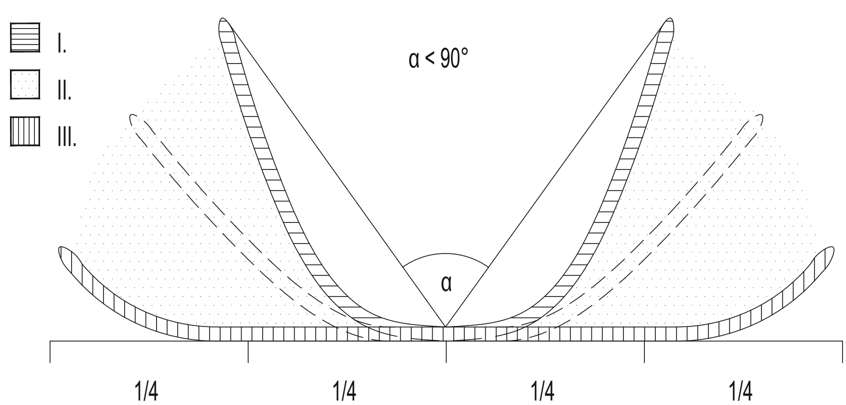

**Table 1** Sample characteristics

| | Sample characteristics |
|---|---|
| Male:female | 109:31 |
| Age (years) | 52 ± 12 |
| BMI (kg/m$^2$) | 30.84 ± 4.64 |
| AHI, events/h | 23.19 ± 21.50 |

*BMI* body mass index, *AHI* apnea-hypopnea index

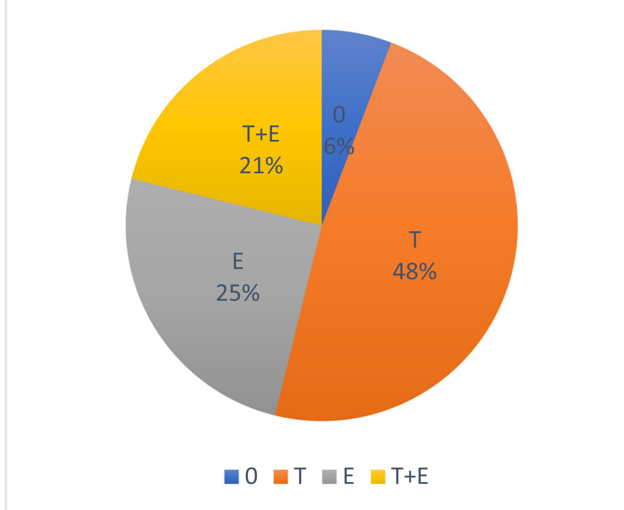


**Fig. 3** Distribution of obstruction levels in the group of patients with a flat epiglottis shape (type 3). E obstruction at the epiglottis, T tongue base, TE epiglottis and tongue base level, 0 no obstruction

observed in 72.2% of patients with obstruction at the epiglottis level only (E) and in 78.6% of patients with obstruction at the level of tongue base and epiglottis (TE). Other two epiglottis shapes were found in considerably fewer patients within this group: 6 cases (18.75%) of epiglottis of normal convex shape (type 2) and 2 cases (6.25%) of the omega-shaped epiglottis (type 1). Type 3 shape was also predominant in patients with obstruction at the tongue base level, as it was observed in 25 patients (47.2%). Omega-shaped epiglottis (type 3) was observed in 16 of the 140 patients (11.4%). In this group, obstruction at the level of epiglottis was only observed in 2 patients (12.5%).

Within the group of patients with a flat epiglottis, we observed a particular feature occurring in 23 patients (16.4%): a pronounced anterior bend of the upper epiglottis edge (Fig. 4). In this sub-group, obstruction at the level of epiglottis was less frequent relative to the entire group with a flat epiglottis as it only occurred in 4 patients (17.4%), while in the other 19 patients (82.6%) in this sub-group, the epiglottis-level obstruction was not observed.

## Discussion

Only in recent years have some studies shown that epiglottis is often the cause for obstructive sleep breathing disorders; therefore, solid knowledge of its role is important for the comprehensive understanding of such disorders and development of new surgical procedures. It is important to identify an obstruction at the level of the epiglottis and tongue base, because the most commonly used surgical procedures conducted in cases of obstructive sleep breathing disorders, i.e., the single-level uvulopalatopharyngoplasty (UPPP), cannot be expected to be effective in these patients. Catalfumo demonstrates that the epiglottis is often the cause for unsuccessful treatment, since retrodisplacement of epiglottis was found in more than 10% of patients in whom UPPP had not been effective [14]. Identification of pathology at the level of the epiglottis is also important in view of some reports in which applying the CPAP therapy in such patients was found to be difficult or even impossible [19]. Lax epiglottis has been described in relation to laryngomalacia as the cause of obstructive breathing disorder in child population [20]; however, for the adult population, such accounts are much fewer [21] and the authors most commonly focused on the position rather than the shape of the epiglottis [3, 22, 23]. In addition to the retrodisplaced epiglottis, voluminous tongue, or elevated tongue base, one characteristic known to us and described to date in clinical examination of patients with obstruction at epiglottis level is that no changes typical for patients with obstructive sleep breathing disorders were observed in the

**Table 2** DISE interrater reliability

| | ICC single measure, value (95% CI) | ICC average measures, value (95% CI) |
|---|---|---|
| V | 0.190 (0.089, 0.299) | 0.414 (0.227, 0.561) |
| O | 0.610 (0.523, 0.689) | 0.824 (0.767, 0.869) |
| T | 0.535 (0.429, 0.630) | 0.775 (0.693, 0.836) |
| E | 0.658 (0.571, 0.734) | 0.852 (0.800, 0.892) |
| Epiglottis | 0.777 (0.711, 0.830) | 0.912 (0.881, 0.936) |

Levels of upper airway obstruction (VOTE classification): *V* velum, *O* oropharynx, *T* tongue base, E epiglottis

**Table 3** Site of obstruction as a function of epiglottis shape

| | Type 1 + 2 | Type 3 | Total | $\chi^2$ | $p$ |
|---|---|---|---|---|---|
| T | 28 (52.83%) | 25 (47.17%) | 53 (100%) | 6.460 | 0.040 |
| E | 5 (27.78%) | 13 (72.22%) | 18 (100%) | | |
| TE | 3 (21.42%) | 11 (78.57%) | 14 (100%) | | |
| Total | 36 (42.35%) | 49 (57.64%) | 85 (100%) | | |

Obstruction at the *T* tongue base, *E* epiglottis, *TE* epiglottis and tongue base, type 1 + 2—omega-shaped epiglottis and normally concave epiglottis shape, type 3—flat epiglottis

oropharynx [24]. Only a few authors have also described typical shapes of epiglottis in adult patients with OSA [22, 25]. In all such cases, they observed the closed, omega-shaped epiglottis (like type 1 in our study). Some have found that epiglottis of such shape, and obstruction at this level, could be at least to some extent related to excessive body weight [26]. In our study, we also found 16 (11.4%) cases of omega-shaped epiglottis (type 1). Among these cases, obstruction at the level of epiglottis was only present in 2 patients (12.5%). However, we also describe the other, much more common case, when the epiglottis in patients with regular obstructions at the tongue base or epiglottis level is flat. In most of these cases, we also observed that the epiglottis lost a slight concavity in the anteroposterior axis, towards the tongue. We believe both cases involve a disorder or disproportion in the function of the lateral and medial part of the anterior suspensory apparatus.

We are familiar with a more recent study, similar to ours, which, however, describes the position of the epiglottis relative to the tongue base in sedated patients in the supine position. In that study, tongue base was in contact with the epiglottis, defined as type 3, in 12.14% of examined patients. This, in turn, was related to the narrowing at the level of epiglottis and/or tongue base [27]. In our analysis, the share of patients with obstruction at this level was much higher—85 patients (60.7%). It should be noted that the characteristics of some anatomical structures and relations between them are not necessarily the same when the patient is asleep and when the patient is awoken. This may be the case especially for obstruction at the level of tongue base/epiglottis [15]. It is also important to distinguish between an epiglottis-level obstruction

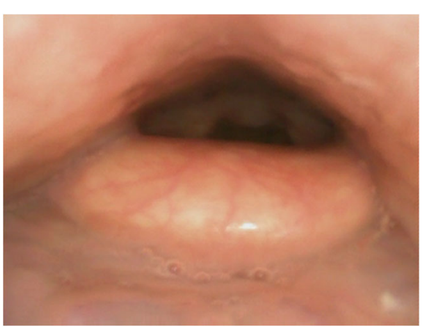

**Fig. 4** Epiglottis with a prominent anterior bend

resulting from the pressure from the tongue base and an isolated epiglottis collapse; i.e., in the former case, any procedure solely on epiglottis would not have been successful.

In the assessment of epiglottis shape, we focused on its medial part because this is where changes in shape are the most obvious. We found that the typical anterior convexity in the upper part of the epiglottis, i.e., at the site where the medial part of the hyoepiglottic ligament attaches to the epiglottis, is predominantly lost in patients with obstructions at the level of tongue base and/or epiglottis. In case of a flat epiglottis, the results allow predicting a more than 90% probability of occurrence of obstruction at the level of tongue base and/or epiglottis. The probability is particularly statistically significant in case of obstruction involving the epiglottis (independently or in combination with the tongue base), as in this case, we detected obstructions in around three fourths of all cases with a flat epiglottis. In our analysis, we did not distinguish between partial and total obstructions, as we believe that even a reoccurring partial obstruction causes a disorder that should be considered in the treatment plan.

We believe the change in the epiglottis shape is a consequence of degeneration and the resulting extension of the medial hyoepiglottic ligament that otherwise maintains its anterior convexity. Degenerative changes to this suspensory apparatus with histologically proven reduction of collagen, elastic, and muscular fibers have already been described [28]. Another possibility is that this is a result of a change in the position of the hyoid bone, as already indicated by some cephalometric studies [29]. Our observations seem to confirm this thesis, as we find that epiglottises that were previously flat partially return to convex shape when performing Esmarch's jaw thrust maneuver during DISE. When the tongue was pulled from the mouth during indirect laryngoscopy, the shape of the epiglottis did not change, i.e., the epiglottis remained flat. The cause for such degeneration in ligamentary apparatus could be repeated pressure or thrusts of the tongue base towards the posterior wall of the pharynx during obstruction events at this level. We have found epiglottis shape did not differ when patients were awake and in the upright position, or when they were sedated. This is an important finding, as it allows an assumption about obstruction at this level based solely on laryngoscopy conducted during a basic otorhinolaryngological examination. It also means that the flat shape of the epiglottis, which is also evident when the patient is in the upright position, is not merely a consequence of posterior tongue pressure, but also a result of changes in the suspensory ligaments. Contrary to the studies published to date, we find that obstruction at the epiglottis level occurs rather rarely in patients with omega-shaped epiglottis.

In 23 cases with a distinct forward bend of the superior edge (Fig. 4), obstructions at the epiglottis level, despite its flat shape, were observed more seldom, than in other patients with a flat epiglottis (17.4% vs 72.2%). We believe that such shape allows closer contact between the epiglottis and the tongue base, which renders obstructions with epiglottis less likely. Such curve conforms to the distribution of elastic fibers that run horizontally in the upper part [30]. It is also a possibility that such cases are a transitory form, before the epiglottis becomes fully flattened in the superior part.

The complex structure of the epiglottis in relation to the ligaments attached to it allows complex motion that has been rather thoroughly researched and explained in the context of the swallowing mechanism. On the other hand, its role in the occurrence of sleep breathing disorders has not been fully elucidated. It appears that changes in this complex apparatus can manifest in the very shape of the epiglottis. The hyoid bone and its position in the neck or its relation to other structures of the pharynx is most likely the central factor to the occurrence of obstructions at the tongue base and/or epiglottis level. The fact that narrowing at this level can be effectively treated by changing the position of the hyoid bone (e.g., hyoidthyroidpexia) also supports this assumption. Further studies will be required in the future to clarify the role of such changes. To the best of our knowledge, this is the first study focusing on such shape of epiglottis, which can also be observed in an indirect laryngoscopy in patients with airway obstruction at the level of tongue base and/or epiglottis.

Study limitations involve bias due to only one observer accessing epiglottis shape in the awake state; however, all observers were blinded to the baseline characteristics of the participants, so one should not expect the influence of confounding variables, such as AHI or BMI on the results.

## Conclusion

1In our research, we show that assessment of the epiglottis shape allows identifying an obstruction at the level of tongue base and/or epiglottis with considerable probability; i.e., in such cases, the epiglottis predominantly has a flat shape, without the characteristic anterior convexity in the medial part. This characteristic, which can be observed with an examination of the upper respiratory tract both in the awake state and in sedation, can contribute to an easier decision about other potentially required diagnostic procedures, and it brings to the clinician's attention the fact that extra care is required regarding the decision about the best treatment. With normal or omega-shaped epiglottis, obstructions at this level are much less common. Identification of a flat epiglottis may also be useful in patients seeking help in otorhinolaryngological practices due to problems other than sleep breathing disorders. With such clinical status and focused medical history, more reliable assumptions can be made about the possibility that patient is suffering from sleep breathing disorders as well.

**Acknowledgements** The authors wish to acknowledge Prof. Dr. Irena Hočevar Boltežar for her contribution to the article and Dr. Andrej Florjan for his evaluation of DISE recordings.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have 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** For this type of study, formal consent is not required.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

## References

1. Certal V, Nishino N, Camacho M, Capasso R (2013) Reviewing the systematic reviews in OSA surgery. Otolaryngol Head Neck Surg 149:817–829
2. Rotenberg BW, Vicini C, Pang EB, Pang KP (2016) Reconsidering first-line treatment for obstructive sleep apnea: a systematic review of the literature. J Otolaryngol Head Neck Surg 45:23
3. Goldberg AN, Schwab RJ (1998) Identifying the patient with sleep apnea: upper airway assessment and physical examination. Otolaryngol Clin N Am 31(6):919–930
4. Charakorn N, Kezirian EJ (2016) Drug-induced sleep endoscopy. Otolaryngol Clin N Am 49(6):1359–1372
5. Woodson BT, Naganuma H (1999) Comparison of methods of airway evaluation in obstructive sleep apnea syndrome. Otolaryngol Head Neck Surg 120(4):460–463
6. Blumen MB, Latournerie V, Bequignon E, Guillere L, Chabolle F (2015) Are the obstruction sites visualized on drug-induced sleep endoscopy reliable? Sleep Breath 19(3):1021–1026
7. Eichler C, Sommer JU, Stuck BA, Hörmann K, Maurer JT (2013) Does drug-induced sleep endoscopy change the treatment concept of patients with snoring and obstructive sleep apnea? Sleep Breath 17(1):63–68
8. Wirth M, Schramm J, Bautz M, Hofauer B, Edenharter G, Ott A, Heiser C (2018) Reduced upper obstructions in N3 and increased lower obstructions in REM sleep stage detected with manometry. Eur Arch Otorhinolaryngol 275(1):239–245
9. Altintaş A et al (2018) Interobserver consistency of drug-induced sleep endoscopy in diagnosing obstructive sleep apnea using a VOTE classification system. J Craniofac Surg 29(2):140–143
10. Carrasco-Llatas M, Zerpa-Zerpa V, Dalmau-Galofre J (2017) Reliability of drug-induced sedation endoscopy: interobserver agreement. Sleep Breath 21(1):173–179
11. Tang JA, Salapatas AM, Bonzelaar LB, Friedman M (2017) Long-term incidence of velopharyngeal insufficiency and other sequelae following uvulopalatopharyngoplasty. Otolaryngol Head Neck Surg 156(4):606–610
12. Oliveira MC et al (2015) Systematic evaluation of the upper airway in a sample population: factors associated with obstructive sleep apnea syndrome. Otolaryngol Head Neck Surg 153(4):663–670

13. Torre C, Camacho M, Liu SY et al (2016) Epiglottis collapse in adult obstructive sleep apnea: a systematic review. Laryngoscope 126(2):515–523
14. Catalfumo FJ, Golz A, Westerman ST et al (1998) The epiglottis and obstructive sleep apnoea syndrome. J Laryngol Otol 112:940–943
15. Cavaliere M, Russo F, Iemma M (2013) Awake versus drug-induced sleep endoscopy: evaluation of airway obstruction in obstructive sleep apnea/hypopnoea syndrome. Laryngoscope 123: 2315–2318
16. Woodson BT (2015) A method to describe the pharyngeal airway. Laryngoscope 125:1233–1238
17. Kezirian EJ, Hohenhorst W, De Vries N (2011) Drug-induced sleep endoscopy: the VOTE classification. Eur Arch Otorhinolaryngol 268(8):1233–1236
18. Koo TK, Li MY (2016) A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med 15(2):155–163
19. Maurer JT, Stuck BA, Hein G, Hörmann K (2000) Videoendoscopic assessment of uncommon sites of upper airway obstruction during sleep. Sleep Breath 4(3):131–136
20. Grzegorowski M, Pucher B (2000) Congenital laryngomalacia in children. Otolaryngol Pol 54:561–565
21. Hey SY, Oozeer NB, Robertson S, MacKenzie K (2014) Adult-onset laryngomalacia: case reports and review of management. Eur Arch Otorhinolaryngol 271:3127–3132
22. Rowe-Jones J, Moore-Gillon V, Hamilton P (1993) Acquired laryngomalacia: epiglottis prolapse as a cause of airway obstruction. Ann Otol Rhinol Laryngol 102(6):485–486
23. Woo P (1992) Acquired laryngomalacia: epiglottis prolapse as a cause of airway obstruction. Ann Otol Rhinol Laryngol 101(4): 314–320
24. Woodson BT, Wooten MR (1994) Comparison of upper-airway evaluations during wakefulness and sleep. Laryngoscope 104(7): 821–828
25. Gazayerli M, Bleibel W, Elhorr A, Maxwell D, Seifeldin R (2006) A correlation between the shape of the epiglottis and obstructive sleep apnea. Surg Endosc 20:836–837
26. Gazayerli M, Bleibel W, Elhorr A et al (2006) The shape of the epiglottis reflects improvement in upper airway obstruction after weight loss. Obes Surg 16(7):945–947
27. Li S, Wu D, Jie Q, Bao J, Shi H (2014) Lingua–epiglottis position predicts glossopharyngeal obstruction in patients with obstructive sleep apnea hypopnea syndrome. Eur Arch Otorhinolaryngol 271: 2737–2743
28. Sawatsubashi M, Umezaki T, Kusano K, Tokunaga O, Oda M, Komune S (2010) Age-related changes in the hyoepiglottic ligament: functional implications based on histopathologic study. Am J Otolaryngol 31(6):448–452
29. DI Venere D et al (2017) Obstructive site localization in patients with obstructive sleep apnea syndrome: a comparison between otolaryngologic data and cephalometric values. Oral Implantol 10(3):295–310
30. Vandaele DJ, Perlman AL, Cassell MD (1995) Intrinsic fibre architecture and attachments of the human epiglottis and their contributions to the mechanism of deglutition. J Anat 186:1–15