Drug-induced sleep endoscopy completed with a simulation bite approach for the prediction of the outcome of treatment of obstructive sleep apnea with mandibular repositioning appliances

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Mandibular repositioning appliances (MRA) are currently the most widespread and evaluated type of oral appliance used to treat obstructive sleep apnea (OSA). Although oral appliance therapy usually reduces snoring, it is not always as effective in treating OSA. The methods that have been described to predict treatment outcome with oral appliance therapy mostly have relied on retrospective analysis and there is a significant lack of uniformity concerning the predictive models. Therefore, the ability to predict treatment outcome of oral appliance therapy prospectively in the individual patient and, thereby, preselecting suitable OSA patients for oral appliance therapy, is still limited in clinical practice. The site of upper airway obstruction can be assessed by sleep nasendoscopy or ‘drug-induced sleep endoscopy’ (DISE). Generally, a decision is made after performing the so-called ‘chin-lift’ maneuver, whereby the mandible is brought forward maximally. Although allowing for a visual inspection of the effect of mandibular protrusion, the position itself is not reproducible and it remains to be determined to what extent it is physiologically tenable by the patient. Furthermore, the chin-lift maneuver requires a further opening of the mouth simply for allowing the dental sleep professional the possibility to grasp and protrude the mandible. At our multidisciplinary dental sleep clinic at the Antwerp University Hospital, we started using a bite simulation approach to investigate the patient’s protrusive characteristics prior to the modified multipart DISE procedure. This specific technique using a simulation bite, custom-made for each individual patient, during DISE is described in detail in this article.

The current standard for the treatment of moderate to severe obstructive sleep apnea (OSA) is continuous positive airway pressure (CPAP). Since its initial description by Sullivan and colleagues, the effectiveness of CPAP has been demonstrated in several studies. However, compliance

and long-term use with CPAP is yet rather low and the acceptance rate of CPAP therapy remains a problem. Oral appliance therapy has emerged as a noninvasive alternative to CPAP and is indicated in subjects who do not tolerate or comply with CPAP. Oral appliance therapy may also be a first-line treatment in snorers and patients with mild to moderate OSA. Treatment with oral appliances may also be considered as a temporary alternative for CPAP. Finally, oral appliances can be a rescue treatment after upper airway surgery failure.
Mandibular repositioning appliances (MRAs), which are worn intraorally at night to advance the mandible, are the most common class of oral appliances used to treat OSA.12-14 MRAs reduce the severity of OSA to a lesser or a similar extent than CPAP. Nevertheless, MRAs appear to have higher compliance rates and a higher patient preference with fewer side effects and greater satisfaction when compared with CPAP therapy.15

Although oral appliance therapy usually reduces snoring, it is not always as effective in treating OSA. Predictors of treatment outcome would therefore be of primary importance for selecting suitable patients that may ben-

Figure 1  (A) Registration fork with constant thickness, retention holes for the registration paste, extension for measuring calipers, and registration paste applied to the upper arch. (B) Registration fork in situ, with patient in habitual occlusion and sliding calipers fixed in “baseline” position. (C) The patient is then repetitively asked to maximally protrude; this position is referred to as “maximal protrusion.” (D) Thereafter, the patient retracts until the MCP is reached and this position is also registered. (E) After curing, the calipers are removed and the simulation bite is ready for DISE. (F) The simulation bite as used during DISE. (Color version of figure is available online.)

Figure 2  Target-controlled infusion of propofol at the start of the procedure (left panel), and at “plateau” phase during the procedure (right panel). (Color version of figure is available online.)
efit from oral appliance therapy. Many articles address the issue of possible predictors of treatment success with oral appliance therapy. However, most of the reported variables that correlate with increased effectiveness come with significant shortcomings. First, the methods that have been described to predict treatment outcome with oral appliance therapy mostly have relied on retrospective analysis. Second, there is a significant lack of uniformity concerning the predictive models. Therefore, the ability to predict treatment outcome of oral appliance therapy prospectively in the individual patient and, thereby, preselecting suitable OSA patients for oral appliance therapy, is still limited in clinical practice.

Accurate information regarding the site(s) of upper airway collapse during sleep can be obtained from pharyngeal pressure measurement or fiberoptic images during sleep studies. Alternatively, the site of upper airway obstruction can be assessed by sleep nasendoscopy or “drug-induced sleep endoscopy” (DISE). This technique was first described in 1991 by Croft and Pringle. DISE requires a pharmacologic induction of artificial sleep, either by midazolam and/or by propofol. The upper airway is visualized using a flexible fiberoptic nasopharyngoscope, providing a direct observation of the localization of flutter and collapse during snoring and sleep apnea that occurs during the drug-induced sleep. The different regions of the upper airway that can be investigated using DISE are the levels of the velopharynx (palate), oropharynx, tongue base, and epiglottis. At each of these pharyngeal levels, the degree of collapse is reported as complete, partial, or none. The pattern of the obstruction is described as being concentric, anteroposterior, or laterolateral. It has been demonstrated that the success rate of uvulopalatopharyng-
goplasty increases upon including DISE in the diagnostic workup. DISE has also been suggested as a valuable prognostic indicator of successful MRA treatment in the individual patient.

Generally, a decision is made after performing the so-called “chin-lift” maneuver, whereby the mandible is brought forward maximally. Although allowing a visual inspection of the effect of mandibular protrusion, the position itself is not reproducible and it remains to be determined to what extent it is physiologically tenable by the patient. Furthermore, the chin-lift maneuver requires a further opening of the mouth simply for allowing the dental sleep professional the possibility of grasping and protruding the mandible. At our multidisciplinary dental sleep clinic at the University Hospital, Antwerp, we started using a bite simulation approach to investigate the patient’s protrusive characteristics prior to the modified multipart DISE procedure, as described below in its different steps.

Technique of DISE completed with a simulation bite approach and chin-lift maneuver

The actual procedure of DISE with simulation bite approach is preceded by the registration of a specific simulation bite, custom-made for each individual patient. A dedicated registration fork was made (Ostron Blue; GCEurope, Leuven, Belgium) (Figure 1A). The thickness of this instrument equals the interincisive distance required for future MRA fitting. First, the upper arch of the fork is covered with a registration material (Futar D; Kettenbach GmbH & Co, Eschenburg, Germany) and left to cure once placed against the upper jaw. On the extension, sliding calipers are then placed and the patient is guided into habitual occlusion and this “baseline” position is marked by fixating 1 caliper (Figure 1B). The patient is then asked to protrude the mandible maximally.
followed by a slow retraction of the mandible until a position is reached that the patient describes as the maximal comfortable protrusive position (Figure 1C, 1D). This is further referred to as the maximal comfortable protrusion (MCP). The measurements are repeated 3 times and averaged. This position is now transferred to the registration fork and fixed by the second caliper. Next the lower surface is covered with the registration material and the patient is guided into the MCP until curing (Figure 1D). The registration bite in MCP is then ready to be used during the DISE procedure (Figure 1E, 1F); thereby, it is guaranteed that it corresponds to a position that the patient is really able to tolerate, and that the DISE is performed at an exact reproducible position while it can still be extended to a maximal protrusion by removing the simulation bite and performing a chin-lift maneuver.

Prior to the start of the DISE procedure, patients are preoperatively examined by the anesthesiologist at the start of their short-stay hospitalization in the day care center. The DISE procedure is performed by the ENT surgeon in a semi-dark and silent operating theater in a multidisciplinary setting together with the dental sleep professional, the operation nurses, and the anesthesiologist. During DISE, the patient is in the supine position and under continuous monitoring of cardiac rhythms and oxygen saturation. Artifical sleep is induced by intravenous administration of midazolam with a bolus injection of 1.5 mg and with propofol using a target-controlled infusion system at a target of 2.0 or 2.5 μg/mL (Figure 2).

Step 1: Simulation bite approach

The first step of our modified multipart DISE procedure contains the particular part of the sleep endoscopy with intraoral positioning of the simulation bite. The main reason for this order of rank is that in the opposite rank, wanting to have the simulation bite intraorally in

Figure 7  Multipart DISE procedure (at the level of the epiglottis). Baseline (A): complete anteroposterior collapse of the epiglottis, with simulation bite approach; (B) significant reopening of the upper airway at the level of the epiglottis, performing chin-lift maneuver; (C) relief of the epiglottis collapse. (Color version of figure is available online.)
the second part of DISE, the teeth, and dental arches might be clamped making placement and positioning of the simulation bite more intrusive with the inherent risk of waking up the patient.

Prior to the intravenous administration of the sedative drugs, the simulation bite is fitted into the mouth of the conscious patient by the dental sleep professional (Figure 3). Thereafter, the dental sleep professional gently holds the lower jaw against the simulation bite to avoid the patient opening the mouth while falling asleep. Meanwhile, the ENT introduces the flexible fiberoptic nasopharyngoscope before the patient is completely unconscious to avoid irritation.29 Once the plateau phase of propofol is reached, the upper airway collapse is investigated endoscopically during at least 5 consecutive minutes with the simulation bite in situ (Figure 4). Meanwhile the images are continuously recorded using digital video recording and, in addition, diagnostically relevant image stills are captured.

**Step 2: Baseline DISE**

After the first part of the procedure, DISE with simulation bite approach, the simulation bite is removed by the dental sleep professional. The simulation bite is only removed out of the mouth of the patient once the patient has remained sufficiently long on the “plateau” phase, and meanwhile, the flexible fiberoptic nasopharyngoscope is kept in place.

Doing so, the effects on the upper airway can be studied in a normal baseline setting without any mandibular repositioning. Again, during this second part of our multipart procedure, upper airway collapse is assessed and analyzed according to the classical grading systems. During this part of the DISE procedure, the upper airway collapse at the different pharyngeal levels can be visualized and examined without the mandibular protrusion effect, again during at least 5 consecutive minutes of plateau phase of propofol.

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**Figure 8** Multipart DISE procedure (level of the tongue base). Baseline (A): complete anteroposterior collapse of the tongue base, with simulation bite approach; (B) partial reopening of the upper airway at the level of the tongue base, performing chin-lift maneuver; (C) relief of the tongue base collapse. (Color version of figure is available online.)
Step 3: DISE with chin-lift maneuver

Preferably during an obstructive apnea, the dental sleep professional finally brings the mandible in the maximal protrusive position (Figure 5), again with the flexible fiberoptic nasopharyngoscope in place but without simulation bite. This part allows studying the effect of maximal protrusive positioning on the upper airway collapsibility. However, the increased vertical opening of the mouth due to the positioning of the fingers of the dentist lingually of the lower jaw incisives should be taken into account.

Step 4: Decision-Making

The final step of DISE completed with simulation bite approach provides the use of a reliable and reproducible mandibular position during the examination. A major advantage of the excellent reproducibility is that the simulation bite approach is made applicable for use during other investigations with possible clinical utility in predicting the outcome of treatment of OSA with oral appliance therapy. Therefore, the simulation bite approach can be used, not only during DISE, but also during nasopharyngoscopic evaluation during wakefulness,33,34 or during functional imaging studies using computer methods for the evaluation of the upper airway in patients with sleep-disordered breathing.35,36

The described technique of DISE completed with simulation bite approach provides the use of a reliable and reproducible mandibular position during the examination. A major advantage of the excellent reproducibility is that the simulation bite approach is made applicable for use during other investigations with possible clinical utility in predicting the outcome of treatment of OSA with oral appliance therapy. Therefore, the simulation bite approach can be used, not only during DISE, but also during nasopharyngoscopic evaluation during wakefulness,33,34 or during functional imaging studies using computer methods for the evaluation of the upper airway in patients with sleep-disordered breathing.35,36

References


Figure 9 Flow chart on the decision-making performing DISE with bite simulation approach including chin-lift. (Color version of figure is available online.)