

Chapter 8

Perspectives for the future

In this thesis, chapters 2 to 6 were dedicated to various studies assessing different applications of the mandible movement study, in an automated or visual method.

What can we learn from these studies?

In the automated assessment of sleep disordered breathing:

- There is a significant added value brought by the mandible movement automated assessment (MMAA) to a portable monitoring (PM) device in the screening of OSAS. This was found in both genders, although the SMM-RDI had a lower sensitivity in women in the screening of mild to moderate (≥ 5 and $\geq 15/h$) OSAS.
- Sleep/wake state automated analysis provides an interesting total sleep time (TST) assessment, with a global mean underestimation. This is at least partly explained by the difficulty in detecting and distinguishing quiet sleep/quiet wakefulness at the beginning of the night. As the denominator used in the calculation of AHI is the TST, a sleep/wake recognition is necessary to improve the AHI accuracy.
- In OSAS patients, mouth opening is of 9 mm on average and the average amplitude of mandible movement (MM) is 0.45 mm over the sleep periods (without considering the specificities associated with body position or sleep stages).
- This is different from the behaviour observed under CPAP treatment and in healthy subjects, having a more closed mouth and fewer sharp mouth closures. Therefore, MM could be a simple and reliable

indicator of CPAP effectiveness and a promising method of CPAP titration.

Nevertheless, improving MMAA is necessary. The aim is to develop a multi-signal approach (including breathing effort) to integrate RDB and sleep/wake assessment into a single automated process.

Firstly, as the perspective of use is the unattended screening at home, an “at home” assessment needs to be done.

Secondly, by improving the software, taking into account abnormal breathing patterns in the detected period of sleep (between the “start” and “stop”, which are the lights-out and light-on times), the automated mean value measured will be more accurate. This should allow for a better auto-Jaw CPAP software by defining the automated “normal threshold” values that have to be reached under effective therapy. As body position is detected by the Somnolter®, the influence of this parameter could be considered in the interpretation of the MM signal.

This automated analysis of the Somnolter®, should be compared with the automated or visually analysed PSG and with other PMs (Watch-PAT or PM including the PTT).

To ensure accuracy in the automated method, the addition of visual analysis by trained personnel would be invaluable.

Visual analysis of isolated MMs can successfully diagnose sleep/wake state, normal and abnormal breathing and recognize the presence of respiratory effort. The difficulty in differentiating central events and mixed apnea on the one hand and central events and quiet sleep/quiet wakefulness on the other is linked to the difficulty in defining the limits of an event. Hence these events include the same stable signal. This problem will be overcome by the nasal airflow analysis, a signal included in the Somnolter®. Moreover, the visual control of the trends during the night will first, allow the assessment of the validity of the signal and second, detect

a potential shift in the sensor. This phenomenon is easily identified by trained professionals and has to be considered in the interpretation of average distances provided (mouth opening and peak-to-peak amplitude) by the automated method. If an « abnormal » behaviour is suspected, the first parameter to check is the stability of the mandible movement trend. Is there a shift in the sensor (probably linked to sensor displacement) or is the patient an outlier?

Partial results of a multicentric study demonstrated a good correlation between delta Pes (oesophageal pressure reflecting breathing effort) and mandible excursion (MExc). This prospective, multicentric and visual analysis of the isolated MM will provide information on sub-groups (men/women, subjects with respiratory comorbidities,...) and on factors influencing MExc and total mouth opening during obstructive respiratory events (e.g. neck circumference, maximal mouth opening, sleep-stages, body position,...). An important advantage of this study is the event-by-event assessment.

Some questions remain open and further studies could help to find answers:

- What is the physiological link between salient mandible movement (SMM) and cortical arousal? The exact mechanism of SMM remains incompletely understood. It is supposed to be an active closing movement due to cortical arousal. Some questions are still open about a possible local reflex induced by the mechanoreceptors and/or dilator muscles of the pharynx.
- Could the mandible movement study represent a non-invasive method to improve the analysis of RERA? As breathing effort is well recognized, the understanding of the arousing effect of excessive breathing effort could be studied.
- Does a (non-respiratory) cortical arousal induce a SMM?

- The association of periodic limb movements (PLM) and arousals induced by PLM with SMM should be assessed prospectively and visually.
- To corroborate our hypothesis of a role of more prevalent apnoea and hypopnoea in REM-sleep in women to explain the reduced sensitivity of the Somnolter® (due to REM-sleep muscle atonia), MM in REM-sleep needs to be compared in both genders.
- How to integrate Cheyne Stokes breathing assessment into our algorithm? This is a particular breathing, easily recognized on the mandible movement traces but occurring in wakefulness and sleep. In this case, the recognition of sleep and wake states will probably be less efficient with our automated method.
- In the future, the suprasternal pressure transducer could be compared with the jaw activity as a non-invasive method for breathing effort assessment.

There are many other possibilities of studies exploring the complexity of the mandible movement in the screening of OSAS. This thesis provides a basis for further research.

ANNEX 1

Definitions and methods used in this thesis

The apnoea hypopnoea index (AHI) is defined as the number of apnoeas and hypopnoeas per hour of total sleep time.

The severity of obstructive sleep apnoea syndrome (OSAS) is usually defined by the AHI:

- mild OSAS: AHI = 5-14/h;
- moderate OSAS: AHI = 15-29/h;
- severe OSAS: AHI $\geq$ 30/h.

An OSAS is defined as an AHI > 5/h associated with clinical symptoms (daytime sleepiness or a minimum of 2 of these complaints : gasping during sleep, un-refreshing sleep, fatigue, fragmented sleep, cognitive troubles).¹ Alternatively, when a polysomnography recording shows an AHI $\geq$ 15/h, and no clinical signs of OSAS, the diagnosis of OSAS is accepted.²

RERA : a clear drop in inspiratory airflow (remaining above 70 % of the reference value) occurs concurrently with increased respiratory effort on the belts, with associated respiratory effort related arousals (RERAs, a brief change in sleep state – arousal). The upper airway resistance syndrome (UARS) is defined as the presence of more 15 RERAs/h and/or the presence of a flattening of the inspiratory flow curve on the nasal airflow signal during more than 20 % of total sleep time, associated with symptoms as proposed in the International Classification of Sleep Disorder.³

PSG registration modalities, sleep staging and arousal definitions are defined in each chapter.

Oesophageal pressure (Pes), which is a reflection of pleural pressure, is the gold standard to measure intrathoracic pressure and breathing effort.

Table 1 : respiratory events during sleep – definitions used	
Type	Definition
Obstructive apnoea	A cessation of airflow amplitude, below 20% of the reference value for 10 seconds or more and characterized by persistent and increasing breathing effort on thoracic and abdominal belts.
Central apnoea	A cessation of airflow amplitude for 10 seconds or more, characterized by absent breathing effort on thoracic and abdominal belts.
Mixed apnoea	A cessation of airflow amplitude for 10 seconds or more that can be divided into 2 parts : first a central event and finally an obstructive event with occurrence of breathing effort.
Hypopnoea	A reduction of airflow (10 seconds or more) below 70% of the reference value, provided that it is associated with oxygen desaturation $\geq 4\%$ and/or with a cortical arousal.
Single sleep snoring (SS)	A regular respiratory noise, emitted in the upper airway, and modulated by uninterrupted breathing cycles.

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List of publications, abstracts and oral presentation related to the thesis work.

Publications:

- The Sleep/wake state scoring from mandible movement signal. F. Senny, **G. Maury**, L. Cambron, J. Destine and R. Poirrier. Sleep Breath. 2012; 16(2): 535-542.
- Added value of a mandible movement automated analysis in the screening of obstructive sleep apnea. **G. Maury**, Cambron L. Cambron, J. Jamart, E. Marchand, F. Senny, R. Poirrier. J Sleep Res. 2013; 22(1): 96-103.
- Mandible movement in obstructive sleep apnea patients under CPAP treatment. F. Senny, **G. Maury**, L. Cambron, J. Destiné and R. Poirrier. The open sleep journal 2012; 5: 1-5.
- Added value of a mandible movement automated analysis in the screening of obstructive sleep apnea: is there a gender influence? **G. Maury**, L. Cambron, J. Jamart, E. Marchand, F. Senny, R. Poirrier. J Sleep Disor Treat Care 2013, 2:3.
- Mandible behavior interpretation during wakefulness, sleep and sleep-disordered breathing. **G. Maury**, F. Senny, L. Cambron, A. Albert, L. Seidel, R. Poirrier. J Sleep Res. 2014. DOI: 10.1111/jsr.12180

Abstracts :

“Disappearance of mouth openings and mouth oscillations during sleep in OSA patients: a marker of efficient nCPAP treatment”. G. Maury, R. Poirrier, Laurent Cambron, P Ansay, E Graas, F Senny Biowin day 2010. LLN Poster session.

“ Added value of a mandible movement automated analysis to a type 3 portable monitoring in the diagnosis of obstructive sleep apnea”. G Maury, R.Poirrier, L. Cambron, F Senny. Thematic poster session. Annual meeting of the European Respiratory Society Amsterdam 2011.

“Comportement de la mandibule chez les patients souffrant d’un syndrome d’apnées obstructives sévère et traités sous CPAP ”. F.Senny, G.Maury, A.Leroux, L.Cambron, J.Destiné, R.Poirrier. Thematic poster session Strasbourg 2011

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“Mandible behavior during wakefulness and sleep-disordered breathing: intra- and inter-scorer variability for the visual recognition of the mandible movement isolated”. G.Maury, F. Senny, L. Cambron, A Albert, L. Seidel, R. Poirrier Thematic poster session. World Congress on Sleep Medicine, sept 2013, Valencia, Spain.

Oral presentations:

“Mandible movement analysis in obstructive sleep apnea: screening for breathing effort and breathing arousal”. G. Maury Belgian Association for Sleep research and Sleep medicine (BASS) meeting. 02/06/2012. Liège.

“Added value of a Mandible Movement Automated Analysis in the screening of Obstructive Sleep Apnea: analysis according to gender.” G. Maury, L. Cambron, J. Jamart, E. Marchand, F. Senny, R. Poirrier. GSK Clinical Awards; 27/03/2013, organized by the Belgian Pulmonary Society.

“Mandible behavior during wakefulness and sleep-disordered breathing: intra- and inter-scorer variability for the visual recognition of the isolated mandible movement” G. Maury IREC PhD Day 26/09/2013 Bruxelles.

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