Institution: Queen Mary University of London		
Unit of Assessment: 3		
Title of case study: Transforming Treatment for Obstructive Sleep Apnoea in the UK		
Period when the underpinning research was undertaken: 05/2000 - present		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
1) Ama Johal	1) Professor of Orthodontics (HCC)	1) 05/2000 - present
2) Joanna Battagel	2) Senior Lecturer	2) 10/1974 - 09/2010
Period when the claimed impact occurred: 2014 - present		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact (indicative maximum 100 words)

Research by Prof. Johal has transformed treatment for obstructive sleep apnoea (OSA), one of the most common respiratory disorders in the UK. OSA involves the repeated collapse of the airway in the throat during sleep, reducing a patient's oxygen levels and disturbing their sleep. It is linked with cardiovascular morbidity and road traffic accidents. Since 2013, more than 11,000 patients in the UK have benefited from Johal's treatment – the introduction of a modified mandibular advancement appliance (MAA) to the UK and his modifications to this device that allow the patient to self-adjust the device themselves. Johal's research has improved understanding of OSA and how to manage it, establishing MAA therapy within sleep care teams in the UK. Johal has also informed new pathways in dental education dedicated to sleep medicine, with thousands of dentists now able to provide more effective treatment for OSA. The manufacture of the modified MAA has generated GBP1,600,000 in turnover for a commercial laboratory, S4S Ltd, a laboratory that Johal helped to establish.

2. Underpinning research (indicative maximum 500 words)

Obstructive sleep apnoea (OSA) is one of the most common respiratory disorders in the UK, affecting approximately 12% of middle-aged adults. OSA involves the repeated collapse of the airway in the throat during sleep, reducing a patient's oxygen levels and disturbing their sleep. If left untreated, OSA causes excessive tiredness during the day, leading to impaired cognitive function, reduced quality of life, and an increased risk of being involved in road accidents and developing vascular disease. Patients with severe OSA are three times more likely than others to develop hypertension over four years. It has been predicted that over 10 years, 23% of patients with severe OSA will have a stroke, and 14% a heart attack.

Research led by Prof. Johal has enriched understanding of OSA and its relationship with a patient's oral and craniofacial features, the anatomical and patho-physiological factors that lead to the collapse of the upper airway (pharynx) and subsequent sleep-disordered breathing. By identifying a significant number of craniofacial and pharyngeal anatomical factors directly related to OSA [3.1], this research has highlighted the positive role mandibular advancement appliances (MAAs) play in preventing airway collapse, including the Sleepwell device. This work has led to a change in clinical practice in the UK, with the introduction of MAAs into multidisciplinary treatment (MDT) clinics, led by sleep physicians or ear, nose, throat sleep specialists [3.1; 3.2].

Supported by MDT pathways and working with specialist ear, nose, throat surgeons, Johal's research has deployed novel methods of airway visualisation to develop a new medical imaging technique using drug-induced sedation endoscopy. Using this technique, a patient is put into a drug-induced state simulating sleep that enables dynamic assessment of the pharyngeal airway and the airway response to mandibular protrusion. The combination of simulation and assessment enables clinicians to successfully predict MAA treatment outcomes and inform treatment decisions, without the need for surgery and its associated risks [3.3-3.5].

The Sleepwell device is one of the most widely used MAAs, and was originally developed in Australia in 2000. In 2004, it was evaluated within an Australian National Institute for Health Research (NIHR)-funded trial and Johal introduced the design to the UK. In response to the

trial outcomes, Johal incorporated a number of design modifications into the Sleepwell device in 2005, which led to its approved use in the UK. These modifications focused on enabling the patient to self-adjust (titrate) the amount of mandibular advancement needed to relieve their symptoms. Drawing on a range of measures assessing the patient's experience, Johal showed that the modified Sleepwell device minimises discomfort and maximises the patient's ability to use the device correctly over the long term [3.2].

Johal's findings [3.6], systematic review and meta-analysis have demonstrated the clinical effectiveness of his customised Sleepwell device as a non-surgical treatment for OSA. The research is the first trial of an MAA device to assess adherence, preference and comfort with measures specifically designed around the patient. This work has been included in a draft NICE guideline on the management of sleep-disordered breathing (expected publication in November 2020 postponed due to the COVID-19 pandemic).

More recently, Johal's research team has identified the existence of a number of facial features (phenotype) associated with OSA [3.5]. This has significant potential to aid future diagnosis and management, while furthering our understanding of the upper airway dimensions in OSA. Alongside this, the research team are developing and trialling predictors of successful adherence with MAA therapy, and new strategies to help individuals to use this therapy.

3. References to the research (indicative maximum of six references)

[3.1] Johal, A., Patel, S. & Battagel, J. M. (2007). The relationship between craniofacial anatomy and obstructive sleep apnoea: a case-controlled study. *Journal of Sleep Research, 16* (3), 319-326. https://doi.org/10.1111/j.1365-2869.2007.00599.x

[3.2] Johal, A., Jahaur, P., Alqattan, F., Kassim, S. & Mc Cloughlin, K. (2016). The efficacy of mandibular advancement appliances as a treatment alternative to continuous positive airway pressure in moderate OSAHS. *Journal of Sleep Disorders and Management, 2* (2), 013. http://doi.org/10.23937/2572-4053.1510013

[3.3] Johal, A., Gill, G., Ferman, A. & Mclaughlin, K. (2007). The effect of mandibular advancement appliances on awake upper airway and masticatory muscle activity in patients with obstructive sleep apnoea. *Clinical Physiology and Functional Imaging, 27* (1), 47-53. https://doi.org/10.1111/j.1475-097X.2007.00714.x

[3.4] Johal, A., Battagel, J. M. & Kotecha, B. T. (2005). Sleep nasendoscopy: a diagnostic tool for predicting treatment success with mandibular advancement splints in obstructive sleep apnoea. *European Journal of Orthodontics, 27* (6), 606-614. https://doi.org/10.1093/ejo/cji063

[3.5] Agha, B. & Johal, A. (2017). Facial phenotype in obstructive sleep apnea-hypopnea syndrome: a systematic review and meta-analysis. *Journal of Sleep Research, 26* (2), 122-131. https://doi.org/10.1111/jsr.12485

[3.6] Johal, A., Haria, P., Manek, S., Joury, E. & Riha, R. (2017). Ready-Made Versus Custom-Made Mandibular Repositioning Devices in Sleep Apnea: A Randomized Clinical Trial. *Journal of Clinical Sleep Medicine*, *13* (2), 175-182 https://doi.org/10.5664/jcsm.6440

Evidence of quality of the research:

[EQR.1] The use of an adherence monitor in mandibular advancement appliance therapy. (2013). *The Hedley Foundation*. GBP5,000. A principle limitation of MAA use in OSA was the inability to reliably record patient use. This funding helped to introduce and investigate a successful novel method of introducing an objective compliance monitor for use in MAA.

[EQR.2] The role of three-dimensional fluoroscopy as a prognostic indicator in the management of obstructive sleep apnoea. (2005). *European Orthodontic Society*. GBP5,600. This grant permitted a novel dynamic evaluation of the upper airway, overcoming the limitations of previous research evaluating airway dimensions with patients in the standing position and using two-dimensional imaging, which failed to take account of the natural postural change in the airway in response to lying on their back (supine). Thus, a more meaningful measure of the upper airway in three dimensions was made possible,

demonstrating significant airway response to MAA use in the transverse dimension, which had not previously been recognised.

[EQR.3] Evaluation of the Herbst mandibular advancement splint in the management of obstructive sleep apnoea. (2001-2004). *Shirley Glasstone Hughes Award*. GBP21,400. This grant helped fund the first trial in which the MAA was directly compared with a matched untreated population of OSA (control) to obtain a true measure of the benefit of MAA therapy.

4. Details of the impact (indicative maximum 750 words)

Obstructive sleep apnoea (OSA) is one of the most common respiratory disorders in the UK, affecting approximately 1,500,000 adults. According to the British Thoracic Society, up to 85% of these cases are undiagnosed and therefore untreated. This has significant implications for public health as patients with OSA have poorer cardiovascular health, reduced cognitive function and reduced quality of life. Research by Prof. Johal has transformed treatment for OSA in the UK, improving quality of life for patients, informing new pathways in dental education and training dedicated to dental sleep medicine, and creating a deeper understanding of the causes of OSA and how to manage it.

Optimising the use of mandibular advancement appliances to treat OSA

Johal's research has highlighted the positive role mandibular advancement appliances (MAAs), which reposition the lower jaw bone, play in treating OSA. In 2004, Johal incorporated a number of design modifications into the widely used Sleepwell MAA, which led to its approved use in the UK. These modifications enable the patient to adjust the device to relieve their symptoms, making it more comfortable and easier to use. According to Dr. Quinell, the President of the British Sleep Society, "it is now clear that the most basic [MAAs] are not appropriate for OSA treatment" compared to Johal's titratable version [5.1]. The modified device improves outcomes in 70% of patients [3.2]. In contrast, only 52% of patients treated with continuous positive airway pressure (CPAP) – previously thought to be the gold-standard treatment for moderate to severe OSA – showed improved outcomes. CPAP delivers pressurised air to the patient through a mask, preventing the airway from collapsing. Many patients find it hard to tolerate, reporting significant side effects, including discomfort, skin rashes, dry mouth and nose, difficulty sleeping and claustrophobia. The modified Sleepwell device provides physicians with an alternative treatment preferred by patients [3.2; 5.1]. Since August 2013, more than 11,000 patients in the UK have received this treatment.

Developing a new dynamic assessment technique to inform treatment

Working collaboratively with specialist ear, nose, throat surgeons at the Royal National Throat, Nose and Ear Hospital, in 2005 Johal developed a new medical imaging technique that enables dynamic assessment of the upper airway of patients with OSA [3.4]. Patients are put into a drug-induced condition that simulates sleep, enabling clinicians to identify in real-time the part of the throat that collapses during sleep. Clinicians can also assess how a patient will respond to an MAA device. This combination of simulation and assessment has been transformative, enabling clinicians to successfully predict MAA treatment outcomes and inform treatment [5.2]. The new imaging technique has significantly reduced the need for surgery and its associated risks in this group of patients. Where surgery is appropriate, it has led to more targeted interventions. Drug-induced sedation endoscopy applied to OSA and MAA treatment is now a standard investigative procedure, used by specialist sleep centres "both nationally and internationally" [5.2].

Improving quality of life for patients and their families

In 2019, the Care Quality Commission (CQC) inspected The Royal London Dental Hospital [5.3], recognising as "outstanding" the unique contribution to patient care being made through the provision of MAA treatment in Johal's dental sleep clinics and the improved quality of life for OSA patients. Using novel patient-based outcomes [5.4], Johal has shown significant improvements in the wellbeing and quality of life for patients, with a reported 90% treatment acceptance, evidenced by a minimum usage of MAA seven hours per night, seven days per week [3.2; 3.6].

Describing the impact of the treatment, one relative of an OSA patient said: "We have tried everything, including an operation to reduce his snoring but nothing has worked – until he was fitted with Sleepwell. We are amazed by the difference it has made to our lives now that we both don't get woken up every night with his snoring." Another patient said: "Without it, my sleep patterns are all over the place and I am constantly tired during the day, needing a nap most days just to make it through. I am the main carer to our two primary-school-aged children and being tired all day and having to nap has impacted on how much I can do for them too" [5.5].

Establishing a highly successful commercial laboratory to manufacture MAAs

Having established the evidence base for the benefits of the modified Sleepwell device, Johal worked with an experienced hospital technician to set up a new independent dental laboratory (S4S Ltd) to meet the demand for the modified MAA devices. Johal introduced the design to the UK in 2004, and modification of the Australian-made devices began in 2005 in limited quantities. In February 2013, Johal helped move manufacture of the modified device to the UK. In August 2013, S4S employed 12 staff and occupied a 1,100 sq. ft. factory unit. Now, in 2020, they are in a 9,000 sq. ft. unit, and employ 50 staff. Over the past seven years, the company has manufactured more than 11,000 Sleepwell devices and has a turnover of GBP1,600,000, with sales growing each year [5.6]. S4S received the 'Best UK Dental Laboratory' award in The Laboratory Awards in 2014 and 2015 and was shortlisted in 2016 [5.7]. It was the only laboratory to specialise in snoring appliances and devices to treat OSA.

Pioneering sleep medicine in dental education and raising public awareness

In the UK, Johal's work has had a significant impact on dental education and training. Since August 2013, more than 2,500 dentists in the UK have attended his educational seminars, with two-thirds going on to provide Sleepwell devices for their OSA patients. Johal's research has provided the evidence informing a new educational programme promoting dental sleep medicine and better management of OSA [5.2]. Working with the British Thoracic Society and British Sleep Society, Johal has developed an introductory training course for dentists and a specialist sleep medicine care pathway, endorsed by a range of professional dental indemnity organisations, including the Medical Protection Society [5.8] and CFC Underwriting Ltd [5.9]. In 2018, Johal was invited by the British Society of Dental Sleep Medicine to co-author and adapt his sleep medicine care pathway [5.2; 5.4; 5.10]. Johal's research has also informed the first international distance-learning diploma in dental sleep medicine, launched by Barts and The London School of Medicine and Dentistry in December 2020, and designed to meet the high demand for this knowledge [5.11].

Johal's work has also raised public awareness of the role of MAA therapy in treating OSA. For example, he was a major contributor to the OSA section of the British Orthodontic Society website, which was viewed 309 times in three months (April-July 2018) [5.12]. The evidence provided by Johal in favour of customised MAA versus ready-made has been welcomed and accepted by a number of independent patient charities such as the British Sleep Society [5.1].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] T. G. Quinnell. President. *British Sleep Society* (testimonial letter, 25 July, 2018). [Corroborator 1]

[5.2] A. Dhesai. President. *British Society for Dental Sleep Medicine* (testimonial letter, 18 July, 2018). [Corroborator 2]

[5.3] CQC. (2019). *Barts Health NHS Trust - Inspection report*. https://api.cqc.org.uk/public/v1/reports/41950b1b-448c-4e49-a3a1-ba73108616d3?20210115064757

[5.4] Management Protocol and care pathway. *British Society for Dental Sleep Medicine*.

[5.5] National MAA patient testimonials. Patient 1 (August 2019), Patient 2 (August 2019), Patient 3 (April 2014), Patient 4 (September 2015).

[5.6] N. Bullement & M. Everatt. Managing Directors. *S4S Ltd*, (testimonial letter, 30 November, 2020). [Corroborator 3]

[5.7] Best UK Dental Laboratory awards [2014-2016]. *The Laboratory Awards*.

[5.8] Dental Protection. (2014, 03 April). *Snoring and Obstructive Sleep Apnoea Syndrome (OSA)*. https://www.dentalprotection.org/uk/articles/snoring-and-obstructive-sleep-apnoea-syndrome. Accessed 28 December 2020.

[5.9] J. Clift. Medical Malpractice Underwriter. *CFC Underwriting Ltd* (testimonial letter, 25 July, 2018). [Corroborator 4]

[5.10] Training of dentists [CPD feedback]. *British Dental Association*. (10 March, 2017).

[5.11] Market research for Queen Mary University of London Masters programme in *Dental Sleep Medicine*. (2018).

[5.12] P. J. Sandler. President. *British Orthodontic Society* (testimonial letter, 23 July, 2018). [Corroborator 5]